5TH INTERNATIONAL CONFERENCE
OF THE EUROPEAN SOCIETY FOR THE HISTORY OF SCIENCE

SCIENTIFIC COSMOPOLITANISM AND LOCAL CULTURES: RELIGIONS, IDEOLOGIES, SOCIETIES

Proceedings

ATHENS, 1-3 NOVEMBER 2012

ESHS European Society for the History of Science

ΕΘΝΙΚΟ ΙΔΡΥΜΑ ΕΡΕΥΝΩΝ 1958
National Hellenic Research Foundation

HELLENIC REPUBLIC
National and Kapodistrian University of Athens

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Logo designed by

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Published by

National Hellenic Research Foundation/Institute of Historical Research/ Section of Neohellenic Research/ Programme of History, Philosophy and Didactics of Science and Technology

Section of Neohellenic Research/IHR/NHRF, Series Conference-Symposia 2.8

ISBN 978-960-98199-3-0

Athens, 2014

Table of Contents

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Introduction

Welcome to the 5th International Conference of the European Society for the History of Science *"Scientific cosmopolitanism and local cultures: religions, ideologies, societies"*

Science as practice and culture has an international and ecumenical dimension. The Science of the Ancient Greek world dissipated in the Roman Empire and later in the Islamic world and Medieval Europe, the Science of the Islamic world was spread over Medieval Europe and Asia and in turn European science all over the world. The diffusion of scientific ideas is associated with scholars' mobility. Scholars travel to teach, to learn or exchange ideas, often during periods when their homelands are in war with those visited. Byzantine astronomers were found in caliphs' courts and Arab astronomers to Byzantine emperors' courts during the Arab-Byzantium wars, Arab scientists travelled all over the Iberian Peninsula during the Islam-Christian conflicts, Catholic and Protestant scientists travelled all over Europe during the Religious Wars, French and British scientists maintained contacts during the wars between France and Britain etc. From the birth of science and all over its history, scientists in their majority seem to feel members of an international community. They seek for interlocutors without consideration of nationality or religion beliefs.

This scientific cosmopolitanism often comes in conflict with local cultures. Greek science was considered as a vector of paganism by certain Fathers of Christian Church, European science was faced with suspicion in China, Japan or Eastern Europe. Traditional societies came often in conflict with new scientific ideas, originating mainly from Europe. Despite its cosmopolitan character, nationalism is not absent from science. Byzantine scholars felt proud to be the inheritors of Greek science, Chinese astronomers promoted their methods as part of the tradition, German, French or British scientists debated for the parentage of scientific discoveries.

The theme of the 5th International Conference of the European Society for the History of Science aims to discuss all these topics from an interdisciplinary point of view. It is organized jointly by the National Hellenic Research Foundation and the National and Kapodistrian University of Athens, two prominent scientific institutions that fostered the development of History of Science in Greece in the last decades.

The logo of the Conference represents the Antikythera mechanism, this almost mythical instrument considered as the first computer in human history. During the Conference, an exhibition takes place at the National Archaeological Museum of Athens about the Antikythera shipwreck and an important section is devoted to the Mechanism.

It is our pleasure, in our capacity as local organizers of this important event, to welcome all the participants in the city of Athens.

Just opposite the National Hellenic Research Foundation are the ruins of the Lyceum of Aristotle, found some years ago by Greek Archaeologists. We wish you a nice and productive stay and many cosmopolitan contacts!

On behalf of the LOC and all the colleagues who participated in the organization of the Conference,

Efthymios Nicolaidis and **Constantine Skordoulis**

Plenary lecture

The Reception of Darwin in Greece

Costas B. Krimbas
Academy of Athens, Athens, Greece

It is remarkable that the debate on Darwinism started in Greece rather late, at the beginning of the decade of 1870. There are two obvious reasons for this.
The first is the lack of interest by Greek Public about the natural world and thus its evolution. As other Mediterranean people, Greeks were mainly interested in human affairs in cities and in politics. As a case in point one could note that six Greek students audited the lectures delivered by Lamarck at the Paris Museum in early 19th century. Despite of that and of the fact that one of them (I.Kokkonis) became later an influential educator in the Greek state, no mention of Lamarck ever appeared in Greece until 1870s.
The second reason was that Greeks were mostly preoccupied with the formation and conservation of their national identity. After four centuries of ottoman rule they achieved the status of an independent state, but the independence was highly depended on the good will of their three protective great powers at the time (England, France and Russia) which were under strong and highly popular philhellenic movement that demanded the formation and support of the new Greek state. This philhellenic movement arose also from the belief among cultured Europeans that Greeks were the descendents and heirs of the ancient Greeks of classical times, whom they admired as exemplary models. Any attempt to disrupt that link between ancient and modern Greeks was perceived as an inimical act directed towards Greece (as was the doctrine of Falmereyer according to which modern Greeks were not descending from the ancient Greeks but from some later Slavic invaders). As an interesting case of preoccupation was whether the climate of Attica has changed, because it was widely believed that the climate shapes intelligence and the mental capacity. Any such change might diminish the mental capacities of the modern Greeks rendering then unworthy of their ancient ancestors. Thus D. Aiginitis, Professor of meteorology, published in 1906 a study according to which the climate has not changed from the classical time, since the dates of harvest remained the same since then to the present.
In order to form a national identity in a presumed politically, socially and culturally heterogeneous state, different elements were put together in such a way as to display a harmonious ensemble, by smoothing edges and eliminating discordant points. This is illustrated by the four statues of important men decorating the front of Athens University, the centre where the Greek identity was forged:
At the left Rigas Feraios, a revolutionary agent and partisan of the French Enlightenment and, in a symmetrical to him position to its left, the statue of Gregory the 5th, Patriarch of Constantinople, who excommunicated him. In their front two other statues of arch enemies are found, Adamantios Corais, a scholar and the most representative member of the Greek

Enlightenment and symmetrical to him I.Capodistrias, the first Greek Governor, ex minister of foreign affairs of the Russian tsar. In order to achieve a unified and broad national identity all disparate and contradictory elements should participate. These included (a) the Church, which preserved, during the ottoman, occupation the religion and language, that is the main characteristics of the identity of the Greek people, (b) the followers of the Enlightenment which inspired the revolutionary movement (actually the Greek Enlightenment was the mildest possible when compared to those of the other Western European countries - the most extreme representative being Pamblekis), and (c) the conservatives, who were trying to create an organized state from the ruins the war for independence left. Any attempt to question or to attack any one of these elements would be considered as a threat to national identity. Thus the idea of man descending from a brute in opposition to what the Bible says, was attacked not only for religious reasons but also as diminishing the status of a Greek citizen! A small piece of evidence pointing to this direction will be quoted. In 1880 a University student, Ilias Liakopoulos, in a pamphlet, protested against the Darwinian teachings of I. Zohios, Professor of Human Physiology at the Medical Faculty of Athens University. He argued that, in case Darwinism was finally found to be correct, it would later dominate in University teaching but at the present time it was improper to introduce it in Greece, a small state just newly formed. Newborns, he wrote, should not eat excessively heavy food, it might cause them indigestion and even fatal illness.

> [Εάν αι θεωρίαι του Δαρβίνου είνε ορθαί, θα κατισχύσουσι και παρ ημίν, εστέ βέβαιοι! Αλλά προς Θεού! Μην έρχεσθε την μεθεπομένην ημέραν της εν πανωλεθρία γεννήσεως ενός κρατιδίου, να το θρέψετε με βόϊον κρέας, να το ποτίσητε με το βαρύ της θαλάσσης ύδωρ! Μη! διότι ακουσίως το ωθείτε εις αυτοχειρίαν, το ωθείτε κατά κρημνών, θα το ρίψητε εις τον Κεάδα και θα παρασυρθήτε βεβαίως και υμείς μετ’ αυτού του αθλίου…]

In 1888 a minor poet, Panagiotis Synodinos, published a poem the very day of the National Holiday (the 25th of March) in a newspaper, in which he exhorted young Greeks to avoid and to deny western attitudes and fashions and to return to their old traditions: down with Strauss and Darwin and hurrah for our national feast and Hellenism, he exalted! Strauss was a theologian who, in his book The Life of Jesus, examined in a critical way (as was the case for German philologists) the written texts on the life of Jesus, an attempt considered impious and atheistic.

> Κλαίει ο κόσμος την Ελλάδα
> πουλημένη, φθισική
> στα χειρόκτια, στη βελάδα
> μασκαράτα φραγκική
>
> Νεολαία φραγκευμένη
> γύρισε στο μονοπάτι
> που η Χάϊδω με φυσέκια
> στην ποδιά της επερπάτει
> ………………………………..

Κάτω ο Στράους κι ο Δαρβίνος
Κάτω κάθε ξενισμός
Ζήτω του Μαρτιού ο κρίνος
Ζήτω κι ο ελληνισμός

That things have not changed radically for more than hundred years can be seen when a textbook on Biology was published for students of the Greek Gymnasium (the book by C.Krimbas and I.Kalopisis of 1977) Many identical telegrams were sent to the Prime Minister and the Minister of Education in protest, making the point that it is shameful for young Greeks to be told that they originate from beasts and requesting no less than the withdrawal of the book. Apparently young Germans or English were permitted to learn it, but not the Greeks.

*

The most significant event in the decade of 1870s regarding the reception of Darwinism in Greece was the exchange of letters between Darwin and Theodor von Heldreich, a German born but hellenized botanist, Director of the botanical garden of Athens University. It is a correspondence of four letters, two from Heldreich and two replies from Darwin. Heldreich studied in France, at the University of Montpellier and then at the University of Geneva, Switzerland, where he was a student of the Swiss botanist Alphonse de Candolle, an enthusiastic Darwinist. In his last letter Heldreich announces to Darwin that Spyros Miliarakis had recently published a Greek translation of Darwin's study "A biographical sketch of an infant" and he sends to Darwin a copy of the journal ESTIA (1877) where this translation appeared. This was actually the first translation of a work by Darwin in Greek. Heldreich noted that the translation was from the German ["Biographische Skizze eines kleinen Kindes" appearing in the journal KOSMOS] and that Miliarakis, Heldreich writes, was a young physician who admired Darwin and one of the very few in Greece not afraid to show publicly this admiration for Darwin in spite of the fact that the circumstances in Greece were not favorable for these ideas and you need a certain courage to do it. He finally expressed the hope that this will gradually change and truth will finally prevail!

Actually Miliarakis (1852-1919) was a Cretan physician who afterwards studied botany in Würzburg under the guidance of the famous Professor Julius Sachs. During his entire scientific carrier, as Professor of Botany at Athens University, Miliarakis published articles on Darwin and also a translation of Darwin's biography written by the German Professor Preyer. His last book published posthumously in 1926, "The Psychological characteristics of animals", is obviously inspired from Darwin's book, The expression of emotions in man and animals. Miliarakis knew of Darwin's book from a German translation, this language being the only foreign language he could use. Around the end of 19th century one of the main sources on Darwinism in Greece came through German texts. Preyer was also the thesis director ("Doctor Vater") of Emil Valaoritis, the son of one of Greece's national poets. Preyer himself was a student of Ernst Haeckel, the leading German Darwinist. Valaoritis was also a Darwinist but he died quite young in Madeira from tuberculosis and Preyer took care for the posthumous publication of his thesis.

Miliarakis is not the first to publish in Greek on Darwin and on his evolutionary theory. With the exception of scattered short remarks, mostly sarcastic and downgrading, the publication of the second important evolutionary book of Darwin on the “Origin of man”, in 1871, triggered an amount of supportive but also of inimical publications. In 1871 G.Apostolides (for whom I lack any additional biographic information) gave a lecture at the club Parnassos in Athens about Darwinian theory and published it afterwards in a series of articles in the journal Ilissos. It is obvious that he used French sources. In 1873 at the same club Leandros Dosios gave a lecture on the struggle for life and afterwards published it. Both these talks are supportive of Darwinian ideas. But not that by Spyros Soungras, privat docent of theology at Athens University, who in 1876 published an over 250 pages book attacking the Darwinian theory with the title “The newest phase of materialism, Darwinism, and its lack of substantiation”. Soungras was well prepared for that, he used numerous German and French sources of various authors and repeated their arguments. His book served as a source material for subsequent anti-Darwinian authors less learned and probably having no direct access to foreign literature (as S.Vlastos and P.N.Trembelas). This is obvious by the few typographic errors of names in Soungras text which are reproduced in the booklets of these later authors.

Now the scene was set: the University Professors of the Sciences and Medical Faculties at Athens University (the only existing Greek University at that time) defended Darwinism, whereas theologians, at least some of them, were extremely critical and negative to it, demanding that the theory be condemned and banned from teaching.

I. Zohios, Professor of physiology at the medical Faculty of Athens University, mentioned briefly in his lectures the theory of evolution. The students were deeply interested and asked for more information. Following these demands Zohios decided, in 1880, to develop the subject in a series of six lectures which became very popular to the point there were not enough seats for the students in the lecture room. The Faculty of Theology was disturbed by these events and protested with vehemence: Professors N.Damalas, N.Kalogeras and Zikos Rossis addressed a complaint to the University Senate. A pamphlet protesting these events was also published by a student named Liakopoulos, already mentioned. But Zohios was not left alone, neither Miliarakis. To their side was also Constantinos Mitsopoulos, the Professor of Geology, also a specialist in Paleontology and an outspoken Darwinist. Mitsopoulos was the one who conducted excavations at the location Pikermi in Attica, where a multitude of fossil mammals, now extinct, was discovered such as machairodonts, monkeys, small horses (hipparions) and many others.

Alfred Gaudry, who was favorably mentioned by Darwin in the “Origin of Species” was also excavating at the same site. Gaudry was annoyed by the presence of Mitsopoulos and asked him to stop excavating otherwise he would ask the French ambassador to oblige the Greek Minister of Education to release Mitsopoulos from his professorial duties! The impudence of foreign scientists towards their Greek colleagues is legendary and shows that they considered it natural to have de facto the upper hand in Greece.

During a two years period (1890-1891) Mitsopoulos also published a scientific journal also addressed to a wider public, PROMETHEUS, aided by his students, the brothers Valvi and N.Germanos. This journal defended Darwinian theory and published for the first time the translation in Greek of the work of Haeckel “The history of the natural creation”. This translation was the first extended version of the theory of evolution that reached the wider public in Greece. It is significant that the Greek translations of the main works of Darwin were delayed in comparison to other countries. The : “Origin of Species” was for the first time translated in Greek by N.Kazantzakis in 1915! Two other translations succeeded, one in the fifties and another in the eighties.

Of course Haeckel's translation triggered offensive replies by Ioannis Skaltsounis (1821-1905) that appeared in the Christian journal ANAPLASIS. This journal which first appeared in 1886 originated from a group of Christian believers influenced by the teachings of a peculiar theologist Apostolos Makrakis (1831-1905). These anti-Darwinian replies were also followed by others from M.Galanos. Skaltsounis was a knowledgeable person with some knowledge of natural sciences, who studied law at the Ionian Academy of Corfu, and then obtained a Doctors degree in Piza, Italy where he made and retained several connections. He also served as consultant to the Prince George, head of the independent hegemony of Crete and completed its local code of laws. In Italy he published a book in Italian that was never translated in Greek, ("L'uomo e il materialismo") and afterwards several apologetic works, as "Religion and Science" (Trieste 1884, Athens 1899), "Psychological Studies" (1890), "On the origin of Man" (1893), "Harmony between Religion and Science" (1900) and others.

The main German sources of information on Darwinism used by Greeks were Haeckel's works. According to Grigorios Xenopoulos, an influential writer on matters of literature, at the beginning of the 20th century "Greece was an intellectual province of France". But no so for the sciences where the German influence prevailed in the last decades of the 19th century. This was because most Greek academics had studied in Germany, the University of Athens was formed according to German Universities and, least but not last Otto, the King, and his Court (until the middle of the 19th century) were German, Bavarian. Ernst Haeckel (1834-1919) was the most influential, articulate and fanatic supporter of Darwin in Germany, the great defender of Darwin's theory. Romantic, with an immense love for nature, friend of voyages to remote lands and explorer of the sea fauna which he studied with great persistence and depicted in drawings black and white and in coloured drawings (he was also a talented painter) he adopted the evolutionary theory not only quite early but also made significant contributions to its development. His ideas departed somewhat from those of Darwin but the great master never complained in public for this, for political reasons. Darwin badly needed supporters in Germany and in continental Europe in general, since France for national reasons was inimical to his ideas. In a letter to him, Darwin expresses his appreciation for his improvements and extensions of his theory. It is obvious that he relied on Haeckel for the dissemination of his ideas in Germany. Other important Darwinists in Germany were Carl Gegenbauer, close friend of Haeckel and also Professor of anatomy in Jena, Heinrich G.Bronn, Professor, paleontologist and translator of Darwin, Wilhelm Preyer, whom already mentioned, and August Weismann.

Haeckel played an important role in the dissemination of Darwinian ideas in Greece. Two small books of his have been translated in Greek before any important book of Darwin himself, "Monism" and the "Origin of Man" both by Andreas Farmakopoulos whereas, as mentioned earlier, Darwin's "Origin of Species" appeared in Greek translation only in 1915. Among the students and auditors of Haeckel in Jena we find three friends, George Papanikolaou, Alexandros Delmouzos amd George Skliros. The first (Papanikolaou) is the well known physician who discovered the technique for diagnosing early presence of cancer cells at the women genital tract, by collecting cells in smears and studying them by microscope, the well known "Pap test". The technique is known by the name of exfoliating vaginal cytology. Early diagnosis increases the chances of cure. Papanikolaou started as an adept of Nietzsche, later he followed during three months the lectures of Haeckel. He did not get satisfaction from them and for three more months he followed Weismann's lectures in Freiburg im Bresgau. Among Darwinists Weismann was the extreme selectionist. In 1883 he started radicalizing the theory by excluding the inheritance of acquired characters and accepting selection as the sole evolutionary force. Mendelian genetics three decades later validated Weismann's views. The neodarwinian synthesis in 1937, a synthesis of Darwinian evolutionism and Mendelian genetics, adopted Weismann's views. Papanikolaou was not also satisfied from Weismann and he arrived to Munich where he started and completed a Doctor thesis in the laboratory of Richard Hertwig under the direct guidance of Richard Goldschmidt, both of them well known and respectable biologists. His thesis raised some interest and when Papanikolaou emigrated to USA the great Morgan himself organized a reception in his honor. The opinion of Papanikolaou for the evolutionary theory was not disseminated, he was himself more interested in basic research. This was not, however, the case for his two other friends.

Both Alexandros Delmouzos, a well known specialist in education and fervent defender of the demotic language (of the spoken language by the people, presented as a desirable and valuable alternative to the already used pure language- the Katharevousa), and George Skliros, a Greek from Egypt and an early communist, author of the book "Our Social Problem" (1907), were both under the spell of Darwinism and introduced connections between Darwinism on one hand and radical social movements on the other, the later being the issue of language (a controversial subject, connected by many to a replacement of the idea of our national identity) and that of a social reform promoted by Marxism. This was an undesirable move since Darwinism was already considered revolutionary by itself and care was given to disconnect it from any other radical and atheistic tendency. It is well known that Darwin himself followed the policy of distancing himself from radical movements and refused to accept the dedication of a book presented to him by Aveling, the son in law of Karl Marx and a known social agitator.

The translation of books promoting materialism increases these times: the book of Louis Büchner Force and Matter, The Man Following Science both translated in 1910 by A.Farmakopoulos edited by Fexis, Darwinism (in 1911 also by Farmakopoulos and published by Fexis) and of the French atheist philosopher-biologist Félix le Dantec Atheism (translated by Aristos Kampanis published also by Fexis).

This is what happened in Jena in 1907. With the trio of friends, we mentioned, was in touch a group of Greek students studying in Berlin: Fotos Politis. Dimitris Glinos, Constantinos Hatzopoulos and Alexandros Papanastasiou, well known personalities who played important roles in cultural and political affairs in Greece The connection to socialist movement is evident, Hatzopoulos and Papanastasiou were the leaders of the socialist movement and in 1908 Hatzopoulos published the translation of the Communist Manifesto. Other students influenced by Haeckel are the poet Aristomenis Provelegios, Krontiropoulos and Constantinos Delta, the physician and brother of the husband of the well known writer Penelope Delta. Constantine Delta was a Greek from Egypt, admirer of Haeckel, and wrote Haeckel's obituary when he died in 1919.

In Athens University in addition to Miliarakis, Zohios, and Mitsopoulos, there were also N.H.Apostolidis, the Professor of Zoology (who maintained stand for Darwinism but was not a strong supporter) and personalities from the Medical faculty such as the Professor of physiology Rigas Nikolaidis and the Professor of Anatomy George Sklavounos. Both studied in Germany, Nikolaidis was a student of Emil du Bois Reymond, a well known agnostic. In his books Nikolaidis discusses Darwinism (1906) (some wrote that he has copied part of Weismann's book in the third volume of his "Physiology of Man". Sklavounos on the other hand was not the first anatomist mentioning Darwin in Greece. One of his predecessors in the chair of anatomy, Loukas Papaioannou, in his book "Anatomy" has based his lectures on comparative anatomy on the Darwinian theory.

During the years between the two World Wars those defending the religious arguments against evolution reorganized their campaign. A new group of theologians departed from Apostolos Macrakis and his other followers, who were accused for their heretic doctrines and thus persecuted by the official Greek Church. These theologians founded a new organization called ZOI (meaning Life). In 1923 the Greek Church stopped persecuting them. ZOI became very popular: in 1927 ZOI founded and financed seven Sunday schools, the number of these schools multiplied the following years and in 1940 they reached the number of 494 attended by 60000 children. In 1952 the number of schools climbed to 2000! In 1950 the organization had already 170,000 members. Within the realm of ZOI other organizations belonging to it appeared, in 1937 the "Christian Union of Scientists" publishing the journal "Aktines", also two youth organizations (XAN and XEN), and others. In 1950 "Aktines" were selling 40,000 copies.

During this interwar period in "Aktines" and in other similar journals several anti-Darwinism papers appeared and they continued appearing until the end of the civil war, in 1949. This long time period was one of wars and political instability during which the influence of the communist party increased starting from the years of the German occupation during the second World War (1941-1944). The only real ideological adversary to counteract the Communist influence was the Christian movement. The Royal Court, after the end of the Second World War maintained excellent relations with this Christian organization. In 1946 a Declaration of the Christian Scientists appeared containing also an anti-Darwinian paragraph. It was signed by many scientists and also by some Darwinists, the mild ones sure enough, who judged more important to support this Christian anti-communist movement in view of the declining political influence of the democratic parties.

During the interwar years and those following them, a small number of papers and books appeared defending Darwinism. George Pantazis (1906-1973) Professor of Zoology in Athens University, in his introductory lecture (1934) mentioned Darwinism by citing the usual general notions and generalities. In 1936 we witness a protest from the part of the Synode of the Greek Church addressed to the Minister of Education, N.Louvaris, complaining that Pantazis was teaching the theory of evolution at the University, but no further action was taken in that case. Thrasivoulos Vlisides, Professor of General Biology at the University, published several books and shorter pieces regarding evolution and its philosophical implications (e.g. "Darwinism, Materialism and the Moral Law" 1934). He was also the first to write a book of Biology for Gymnasium students including in it a chapter presenting all evolutionary theories discussed in the interwar period. More important was the contribution of Stelios Papadakis, published at the journal "Archives of Philosophical and Theoretical Sciences" directed by P.Kanellopoulos, J.Theodorakopoulos and C.Tsatsos entitled "The post-Darwinian theory of evolution" (1932-1933). The "Archives" played an important ideological role introducing the neo-Kantianism in Greece.

In this respect it should be noted that after the year 1920 in other European countries Darwinism was experiencing an eclipse due to the fact that several alternative evolutionary theories were competing and the concept of evolution lacked clarity and unification. This period ended in Greece in 1961 with the presence in the country of the first Greek evolutionists that were educated in USA and taught at the University level the synthetic (neo-Darwinian) theory of evolution which is the synthesis of Mendelian Genetics with Darwinian selectionism.

This version of Darwinism is connected with Theodosius Dobzhansky (1900-1975), the Russian born and after, in the 1920's, American citizen, who combined for the first time at the experimental level the Russian tradition of Darwinism with the findings of the genetics school of T.H.Morgan, in whose group he worked for nearly ten years. In his book, Genetics and the Origin of Species (1937), he outlined a program of experimental research for studying evolutionary phenomena at the genetic level, and thus he initiated the field of "population genetics".

This domain was already theoretically explored using mathematical models by the three mathematical geneticists, the Englishmen Ronald Fisher and J.B.S.Haldane and the American S.Wright. In his book Dobzhansky presented and discussed numerous cases and showed the richness of explanations offered by the neo-Darwinism regarding the mechanism of species formation.

Dobzhansky's contribution was followed by the contributions of two others: Ernst Mayr, the German by birth and later American taxonomist and philosopher, and G.G.Simpson, the leading American paleontologist.

We should also mention the contributions in the same direction of the German B.Rensch, of the Englishmen J.Huxley and E.B.Ford and of the American botanist G.L.Stebbins.

Dobzhansky's influence played an important role in Greece. He had two Greek students who later made their carriers in this country, Costas Krimbas (worked in Dobzhansky's lab from 1958 to 1960 as a postdoctoral researcher) and Costas Kastritsis (in the same lab from 1965-1966). Krimbas has studied biology in Switzerland followed by post graduate studies of Genetics in France. After his stay in the States he was elected Professor of Genetics at the College of Agriculture in Athens (1961) a position he held until 1993, more than three decades. His chair was the first University chair of Genetics in Greece. Kastritsis studied biology in Athens, then he obtained a Ph.D. degree in Austin, Texas. After his stay in Texas he worked as a postdoctoral fellow in Dobzhansky's lab. He was elected in 1972 Professor of General Biology at the University of Thessaloniki, as a successor of Antonis Kanellis. But the influence of Dobzhansky was also indirect: Michael Kambysellis, Professor at New York University, was a student of Poulson, Professor at Yale, one of the first students of Dobzhansky. Eleutherios Zouros, student of Krimbas, was also a student of Lewontin, one of the most eminent students of Dobzhansky. Zouros served as Professor in Dalhousie University in Canada and then at the University of Crete. A minor source of influence came from England: M. Pelekanos, student of Kanellis, made postgraduate studies in England before becoming Professor of Genetics at the University of Patras. Kanellis had spent all the years of the Second War at the laboratory of Timofféef-Ressovsky in Berlin.

Dobzhansky continued being in touch with his former students and collaborators. He was able to secure an important sum of money from the Rockefeller Foundation to furnish with instruments the laboratory of Genetics of Krimbas. In general, Dobzhansky's students in a broader sense continued working on his agenda, the Greeks together with some other European labs focussed their attention in the study of a European species of Drosophila belonging to the obscura group, to the same group as those studied by Dobzhansky and his American students.

European population geneticists (Spanish, Austrian, Greeks, Yugoslaves and others) had some successes in their research activities. Dobzhansky visited Greece four times. In 1963 accompanied by Krimbas he travelled in Crete, Peloponnesus, Thessaloniki and the Holy Mountain. In the Russian Monastery of Athos (the Holy Mountain), Saint Panteleimon, Dobzhansky received the Holy Communion. He said that this entire atmosphere, a cultural fossil retaining intact a remote past, reminded him of his years in Russia when he was a child. Two other times he came as a guest participating at the Delos Symposia organized by Constantine Doxiades, the influential city planner. In these symposia the flower of international intelligentsia participated, among others Arnold Toynbee, the British historian, Margaret Mead, the American anthropologist, C.H.Waddington, the English embryologist and evolutionist and many others. In one symposium Dobzhansky presented a paper examining the result of natural selection in man in urban environments, in particular what characters were expected to be selected in such environments. His last visit to Greece, in 1969 remains the most interesting because it obliged him to participate in a debate with a Greek theologian defending the view that evolutionism was incompatible with what the Bible contained. He was indeed invited to an international Congress in Delphi organized by the Greek Humanistic Society and he accepted despite the objections raised by his student Krimbas because that society was politically suspect, being financed by the Greek dictators (the junta). This is how things happened according to Dobzhansky's narration:

> "Yet some people feel more confortable believing that the states of the human and the world systems always were and will be the same as they are now. Alas, not all such people are ignorant fundamentalists from the backwoods.
> As an illustraton, let me report to you in a kind of Bishop Wilberforce – T.H. Huxley confrontation in miniature. In September 1969, an International Humanistic Symposium was organized by the Hellenic Society of Humanistic Studies amidst the gorgeous scenery of Delphi, Greece. My role there was to give what I naively believed an uncontroversial account of human evolutionary origins. Not so to the Greek theologians. In the role of Wilberforce was Marcos Siotis, Professor of theology, University of Athens. In a letter dated December 16th, he explains that he felt obliged to rebut the view that mankind evolved from brute animal ancestors, since this view contradicts Genesis 1, 27-8 and 2, 7. I was unable to rise to the occasion in T.H.Huxley style, and could only protest in a double capacity, as a scientist and a communicant of the Eastern Orthodox Church. Fortunately the hidebound rigidity of the Greek section is not shared by the Eastern Church as a whole. Man was and is being created in God's image by means of evolutionary development".

I saw Dobzhansky when he got back to Athens, after the Symposium: he was furious because the organizers did not let him reply immediately and asked me to type a letter to Siotis which contained the reply he was not permitted to deliver by Professor Vourveris presiding that session. He was upset for some time and he narrated the event in a paper published in Teilhard Review because Dobzhansky was a believer in Eastern Church and served as president of the American branch of the Association of the Friends of PéreTheilard de Chardin. At the same Symposium V.Kiortsis, Professor of Zoology and believer delivered a paper on the evolutionary aspects of Theilard.

The Greek evolutionists apart from their research activities published also essays, the texts of oral presentations and books addressed to the general public. Thus several essays were written by the scientists who established the synthesis (Dobzhansky, Mayr, Simpson, Maynard Smith, Jacob, Lewontin with an introduction of Krimbas) were translated and published in an issue of the philosophical magazine Deukalion. Kastritsis with his collaborators translated the classical work of Dobzhansy Genetics of the Evolutionary Process (this was a new edition of his seminal book Genetics and the Origin of Species, which made already by then three editions) in order to use it as a textbook. In 2009 Krimbas published a voluminous book Darwinism and its history until now and Zouros the book Let us make peace with Darwin, make peace with nature and make peace with our nature. Also we should add the appearance of some essays on methodology by Krimbas on the notion of Adaptation and on that of Fitness, in English and in specialized evolutionary and philosophical journals.

However the big fight was focused to the content of text books for the Gymnasium and Lyceum students. After some failed attempts to publish a Gymnasium textbook by Krimbas and his collaborators (it did not succeed because of the advent of the dictatorship of the colonels) the textbook on biology was finally written by I.Oikonomidis, a well educated biologist and believer on physical theology, who was presented to the colonels by V.Kiortsis. After the establishment of democracy a book written by Krimbas and I.Kalopisis was approved as the official book of biology for students. In this book a detailed presentation of the synthetic theory was given for Gymnasium students. However several objections were raised by Christian Associations, mentioned previously. But this reaction was really less important compared to that raised against the book of the Greek-American historian L.Stavrianos on the history of the mankind which was also intended to be a textbook for the Gymnasium. Perhaps the severity of the reaction had to do with the fact that this book displayed a distinct Marxist flavor.

In 1996 the Academy of Athens signed together with numerous other Academies a petition asking the teaching of evolution in Gymnasium schools. During the year 2009, an anniversary year for evolutionism (150 years from the publication of the “Origin of Species” and 200 years from the birth of Darwin and the publication of “Zoological Philosophy” of Lamarck) numerous celebration events took place, more than 30 in Greece! This shows that at least in the academic environment and that of the cultured people the atmosphere in Greece has radically changed into being strongly pro-evolution and Darwinian.

SYMPOSIA

Ancient Astronomy and its Later Reception

Organizers
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Alexander R. Jones
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The Symposium will be devoted to the studies in the history of astronomy in ancient cultures, especially in Greece and the whole Mediterranean region, as well as of the later development of the ideas in medieval and early modern science.
The astronomy is commonly said to be the oldest science because it ever led mankind to search for laws of nature and their quantitative formulation. Astronomy thus became a prototype of exact sciences. Based on earlier Babylonian roots, astronomy was advanced a great deal in ancient Greece, from where the first theoretical models of planetary system based on geometry are known. A dissemination of these ideas in Arabic and Christian cultures and their boost from Renaissance resulted in the development of contemporary science and technology. It is thus of general importance for the history of science to study this development in time, to follow the spreading of ideas to different cultures and to compare their mutual influences with the cultures of the societies.
These topics are to be subject of the proposed Symposium. The contributions will be based on studies of both the preserved texts and artifacts. A traditional example of relevant problems are the roots of Copernican revolution in the ancient planetary theories. Another related subject is the development of astronomical instruments, e.g. the astrolabes dated back to Ptolemy's Planisphaerium or the recently revived study of the Antikythera Mechanism and its analogies in medieval astronomical clocks. Yet another example worth to deal with, is the development of Greek textual tradition in treatises on astronomy, e.g. on stars and their influence on the globe-making.

Ptolemaic Eccentricity of the Superior Planets in the Medieval Islamic Period

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Introduction

In the Ptolemaic models of the superior planets and Venus, the centre *C* of the epicycle revolves around the earth on a circle (the so-called deferent, *ACΠ* in Figure 1) whose centre *O* is at an eccentricity $OT = e_1$ from the earth at *T*, but its motion is uniform with respect to the point *E* (the so-called equant) removed from *O* by an eccentricity $EO = e_2 = e_1$ (all the dimensions of the model are expressed in terms of the radius of the deferent $R = 60$). *TE* extended in both directions intersects the deferent at Apogee *A* and Perigee *Π*. Ptolemy's method of the determination of the eccentricity of the superior planets in *Almagest* X.7, XI.1, XI.5 (Toomer 1998, 484–498, 507–519, 525–537) requires the observations of three oppositions of a planet to the mean sun and then doing a set of the iterative algorithmic calculations (Pedersen [1974] 2010, 271–83; Neugebauer 1975, 1: 172–9; Swerdlow and Neugebauer 1984, 1: 317–9; Duke 2005, 179–87). Abū al-Ray<.>hān al-Bīrūnī (973–1048) proposed an alternative to Ptolemy's method, in which the observations of the two pairs of oppositions to the mean sun symmetric with respect to the planet's apsidal line are needed (Mozaffari 2013).[1] However, this method is practically inapplicable (Swerdlow 1987). Ptolemy's iterative method was employed in the (presumably) only surviving account of the determination of the eccentricities of the superior planets from the medieval Islamic period, by Mu<.>hyī al-Dīn al-Maghribī (d. 1283); and there seems little doubt that the other values given for the eccentricities of the exterior planets in this period, for which no account containing the related observations and calculations has been preserved, were obtained by means of Ptolemy's method.

These medieval values are dealt with in this article, and our main concern here is to determine their accuracy. To this end, it is first necessary to establish a criterion meeting the condition of having sufficient adequacy and precision to evaluate them.

Geocentric from Heliocentric Eccentricities

Since the time of Johannes Kepler (1571–1630) it has been known that the geocentric eccentricity of the planets in the ancient astronomy is mostly the effect of combining the eccentricity of their heliocentric elliptical orbit and that of the earth. Figure 2 shows a simple

[1] It was later adopted or maybe independently invented by Jābir b. Afla<.>h of Seville in the first quarter of the 12th century; cf. Swerdlow 1987.

NOTE for Typesetting: Throughout the paper, "<.>" denotes that a dot should be placed below the next letter; e.g., "<.>t" means a dot below "t".

schematic view of some orbital elements of a superior planet and the earth with respect to each other. The sun is at *S*. $A_0\Pi_0$ displays the direction of the semi-major axis (the apsidal line) of the elliptical orbit of the earth around the sun with its centre at *T*, and so $TS = e_0 a_0$ where e_0 is its eccentricity and a_0, its semi-major axis (≈ 1 astronomical unit, AU). In the same fashion, $A'\Pi'$ is the direction of the heliocentric apsidal line of a superior planet, which is inclined to the orbital plane of the earth (the ecliptic) at an angle *i*. The centre *P* of the elliptical orbit of the planet is at the distance $PS = e'a'$ and its projection onto the ecliptic, *O*, at the distance $SO = e'a' \cos i$ from *S* where e' and a' denote, respectively, the eccentricity and the semi-major axis of the elliptical orbit of the planet. Then *O* can be assumed as the centre of the geocentric orbit of the planet with the earth at *T*. It is evident that the distance *OT* (the equivalent of *OT* in Figure 1) is the vector sum of *SO* and *ST*, and its extension to both the directions will define the geocentric apsidal line $A\Pi$ of the planet. Also, $TO = OE$, as is in Figure 1. If the longitudes of the heliocentric perigees of the planet and the earth are indicated as Π' and Π_0, then the angle $OST = \Delta\Pi = |\Pi' - \Pi_0|$. Thus, the geocentric eccentricity of the planet can be computed from

$$e = \tfrac{1}{a'}\left((e_\circ a_\circ)^2 + (e'a'\cos i)^2 - 2\cdot(e_\circ a_\circ)\cdot(e'a'\cos i)\cdot\cos\Delta\Pi\right)^{1/2}. \qquad (1)$$

Note that $i = \sin^{-1}(\sin i' \sin(\Omega' - \Pi'))$ where i' is the maximum inclination of the orbital plane of the planet to that of the earth and Ω', the longitude of its ascending node. The value of *e* resulted from (1) should be multiplied by 60, according to the Ptolemaic norm. The formulas for the heliocentric orbital elements in (1) referred to the mean dynamical ecliptic and equinox of date can be found in Simon *et al.* (1994, 678–9) in the form of polynomials as a function of the time elapsed from 1 January 2000. Substituting them in (1) and then expressing the resultants again as the polynomials will boil down to the following formulae:

Mars:
$e = 0.100321 + 0.000549\cdot t - 0.000005\cdot t^2$
Jupiter:
$e = 0.048514 + 0.001686\cdot t - 0.000051\cdot t^2$ (3)
Saturn:
$e = 0.053820 - 0.003429\cdot t - 0.000063\cdot t^2$,

in which $t = (\text{JD}-2451545.0)/365250$ is the time measured in thousands of Julian years from 1 January 2000 (JD 2451545.0). It is evident that the geocentric eccentricity of Mars changes +0.003 in a century, Jupiter's +0.01, and Saturn's –0.02 ($R = 60$). Figures 1–3 depict the graphs of *e* plotted against the Julian years from 1 to 2000 AD.

Two notes are worth considering here: In (1), we assumed that the radius of the geocentric orbit of the planet (regardless of whatever its shape may be, circular or elliptical) will remain as same as the semi-major axis of its heliocentric elliptical orbit. This assumption seems safe, since the angle *SOT* between the heliocentric and geocentric apsidal lines (Figure 2) is sufficiently small for all the three superior planets.[2]

[2] Factually, this angle changed in the two recent millennia from 5.13° to 5.02° for Mars, 4.28° to 3.79° for Jupiter, and 0.44° to 0.32° for Saturn.

Another note is related to the assumption of the geocentric orbit being an ellipse; if we take it that the planet has the Keplerian motion in its geocentric elliptical orbit and this is represented as the equant motion in a circular orbit, according to Ptolemy's model, then the two eccentricities e_1 and e_2 in Figure 1 will no longer be equal; rather, they hold the ratio 5 to 3. As a result, this will produce a theoretical deviation between the eccentricities obtained for the two models from the same, ideally error-free, set of three observations. It can be shown that the maximum value of this deviation amounts to $\pm{}^{1}/_{4}e^{2}$, where e is the elliptical eccentricity; *i.e.*, about ±0.15 for Mars, ±0.04 for Jupiter, and ±0.05 for Saturn.[3] These are larger than the errors in the majority of the historical values considered here.

Medieval Values for the Eccentricities of the Superior Planets

These values are mainly connected with Ibn al-A'lam's observations in Baghdad (before 985), al-Maghribī's observations in the Maragha observatory (1262–1274), the observations by the Iranian astronomers in the service of the Mongolian dynasty of Yuan in Beijing, China (*c*. the 1270s), and those done in the Samarqand observatory (*c.* 1420–1449).[4] No account of the observations and calculations leading to these new values have been given or survived, except in the case of al-Maghribī who explained his sets of the trio observations and iterative computations related to the eccentricity measurements on the superior planets in Book VIII of the treatise *Talkhī<.>s al-majis<.>tī*, "Compendium of the *Almagest*" (fols. 123r–126v, 128r–131v, 132v–134v; Saliba 1983, 175–6, 1986; the equation tables in his last *zīj*, *Adwār al-anwār*, CB: fols. 82v–85r; also preserved in Wābkanawī, T: fols. 157r, 158r, 159r and Kamālī, fols. 244r–248r). The values from the other astronomers are extracted from their tables of the planetary equation of centre.[5]

Ibn al-A'lam's *'A<.>dūdī zīj* is now lost, but part of its underlying parameters were restored by Kennedy (1977) and Mercier (1989). The equation tables are preserved in the *Ashrafī zīj*, a comparative *zīj* written in Shiraz, Iran, about the turn of the fourteenth century (Kamālī, fols. 233v–234r). The observations in the Islamic Astronomical Bureau founded on by the Mongols in Beijing in the 1270s were done by a certain Jamāl al-Dīn Mu<.>hammad b. <.>Tāhir b. Mu<.>hammad al-Zaydī of Bukhara. The original work, composed using a set of new parameter values observed in the Bureau, is not extant but is apparently preserved in the *Huihuili*, a Chinese translation of a Persian *zīj* from the Bureau, prepared in Nanjing in 1383. These new parameters have also been incorporated in the *Sanjufīnī zīj* written by a certain Sanjufīnī in Arabic in Tibet in 1366 (Dalen 2002a, esp. 336–9, 2002b; Yabuuti 1987, 1997, 33; Sanjufīnī, fols. 47v and 48v). The new eccentricities obtained in the Samarkand observatory have been employed in Ulugh Beg's *Sul<.>tānī zīj* (the equation tables: P1: fols. 141r, 138r, 135r; P2: 158r, 155r, 152r).

[3] To demonstrate the existence of this deviation and its amount is beyond the scope of this article, but these issues will be discussed in a forthcoming paper by the present author.

[4] For the values observed for the eccentricity of the sun/earth in the Islamic period, cf. Mozaffari 2013b.

[5] For the medieval Islamic astronomical tables, cf. Kennedy 1956, 1983; King *et. al.* 2001.

These medieval values are as follows. For Saturn:

Ptolemy	Ibn al-A‘lam	Al-Maghribī	Persian astronomers in China	Ulugh Beg
3.42 [3.60]	3.04 [3.44]	3.25 [3.38]	3.31 [3.38]	3.48 [3.34]

Table 1

They are also illustrated in Figure 3 (except Ibn al-A‘lam’s) along the graph of the geocentric eccentricity of the planet drawn from the corresponding formula set forth earlier.
The values for the geocentric eccentricity of Jupiter are displayed below (also see Figure 4). The value from Western Islamic astronomy (Spain and northwestern Africa) refers to that utilized by Ibn Is<.>hāq (d. 1222), Ibn Raqqām (d. 1315), and Ibn al-Bannā (d. 1321) (Samsó and Millás 1998, 272–273). The source of this value is not known, but it might come back to Ibn al-Zarqālluh (d. 1100) (*ibid*, 259/273). Consequently, since the time of the measurement is unknown and may be between the mid-11th century and the early 13th century, the range of the true values for this period is given below.

Ptolemy	Ibn al-A‘lam	Western Islamic astronomers	Al-Maghribī	Persian astronomers in China	Ulugh Beg
2.75 [2.71]	2.90 [2.80]	2.98 [2.82±0.01]	2.75 [2.84]	2.66 [2.84]	2.78 [2.85]

Table 2

The values for the geocentric eccentricity of Mars are given in the next tabulation (cf. Figure 5). The value from Kūshyār b. Labbān (*c*. 1000) is extracted from his *Jāmi‘ zīj* (Brummelen 1998, 269). Concerning Abu al-<.>Hasan of Yazd, it is merit mentioning that among the *zījes* considered in the *Ashrafī zīj*, Kamālī (X.8 and X.9: fol. 230v) informs us of the two (apparently, lost) *zījes* called *Razā’ī zīj* and *Muntakhab zīj* authored, respectively, by a certain Abu al-<.>Hasan and by a certain Muntakhab al-Dīn, both from Yazd (central Iran). Both *zījes* appear to have been written about the mid-13th century. We are told that in the two, the equation of centre of each superior planet are identical and that the equation of centre of both Jupiter and Saturn are borrowed from Ibn al-A‘lam. In addition, the anonymous *Sul<.>tānī zīj*, compiled about the 1290s in Yazd (not confused with Ulugh Beg’s and Wābkanawī’s *zījes* with the same title), also contains the parameter values and tables of some *zījes* from the late Islamic period; from the tables associated with Abu al-<.>Hasan’s *Razā’ī zīj* on fols. 120v–121v, it is easily verified that the underlying values for the eccentricity of Saturn and Jupiter in his *Razā’ī zīj* are Ibn al-A‘lam’s, in accordance with Kamālī’s saying mentioned above, but the derived value for that of Mars is 6.22. This value was not known in any text prior to the *Razā’ī zīj*. It is also noteworthy that a very close value e = 6.25 is mentioned in the *Ashrafī zīj* (III.9.2: fol. 51r) where Kamālī lists the planetary eccentricities. These are also near the value adopted in Ulugh Beg’s *Sul<.>tānī zīj* about two centuries later.

Ptolemy	Kushyār b. Labbān	Abu al-<.>Hasan of Yazd	Al-Maghribī	Ulugh Beg
6.0 [5.96]	6.04 [5.99]	6.22, 6.25 [5.99]	6.0 [6.0]	6.23 [6.0]

Table 3

Conclusions

The most critical change in the geocentric eccentricity of the superior planets is the case with Saturn while the eccentricity of Mars changed very slightly during the two past millennia. Consequently, Kūshyār and al-Maghribī's determinations of the eccentricity of Mars could solely confirm the correctness of Ptolemy's value, and that no new value for the eccentricity of the planet was reported from Ibn al-A'lam and the Persian astronomers in China might indicate that, as expected, their measurements did not arrived at any new value. The values observed by Abu al-<.>Hasan of Yazd and Ulugh Beg have the same error ~ 4%. In the case of Saturn, al-Maghribī and the astronomers in Beijing and Samarqand observed a bit more exact values (errors ~ 2–4%) than Ptolemy's (error 5%) while the error in Ibn al-A'lam's is comparatively high (~ 12%). In contrast, Ptolemy has a more precise value for the eccentricity of Jupiter (error ~ 1%) than his medieval followers; the relatively accurate medieval values for the eccentricity of the planet are those obtained by Ibn al-A'lam (error ~ 4%), al-Maghribī (error ~ 3%), and the astronomers in Samarqand (error ~ 2%).

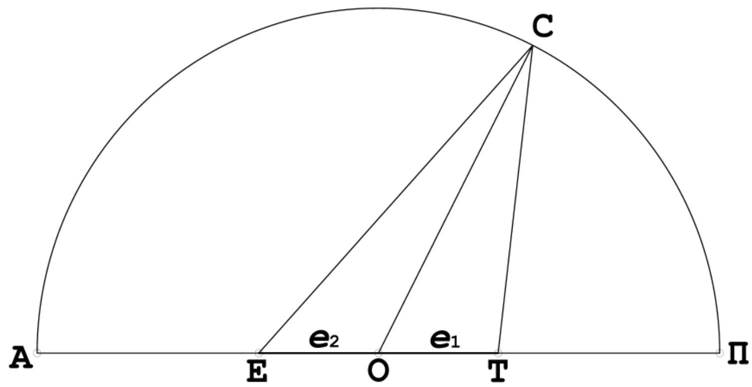

Figure 1: *The deferent of the superior planets and Venus in Ptolemy's circular equant model*

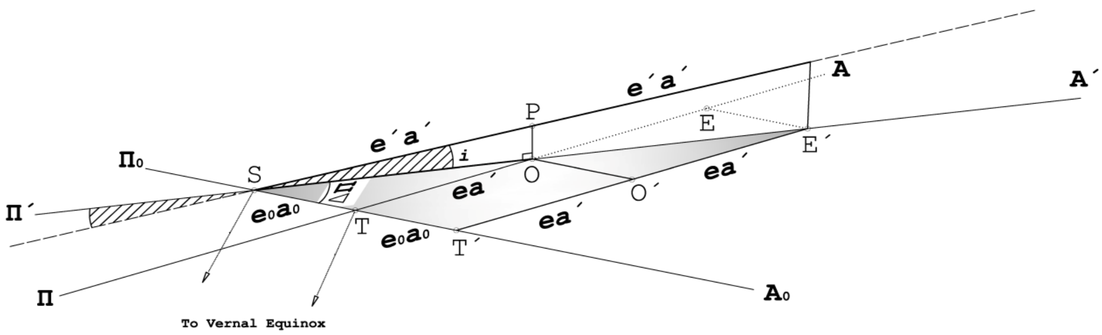

Figure 2: *The transformation of the heliocentric to the geocentric eccentricities*

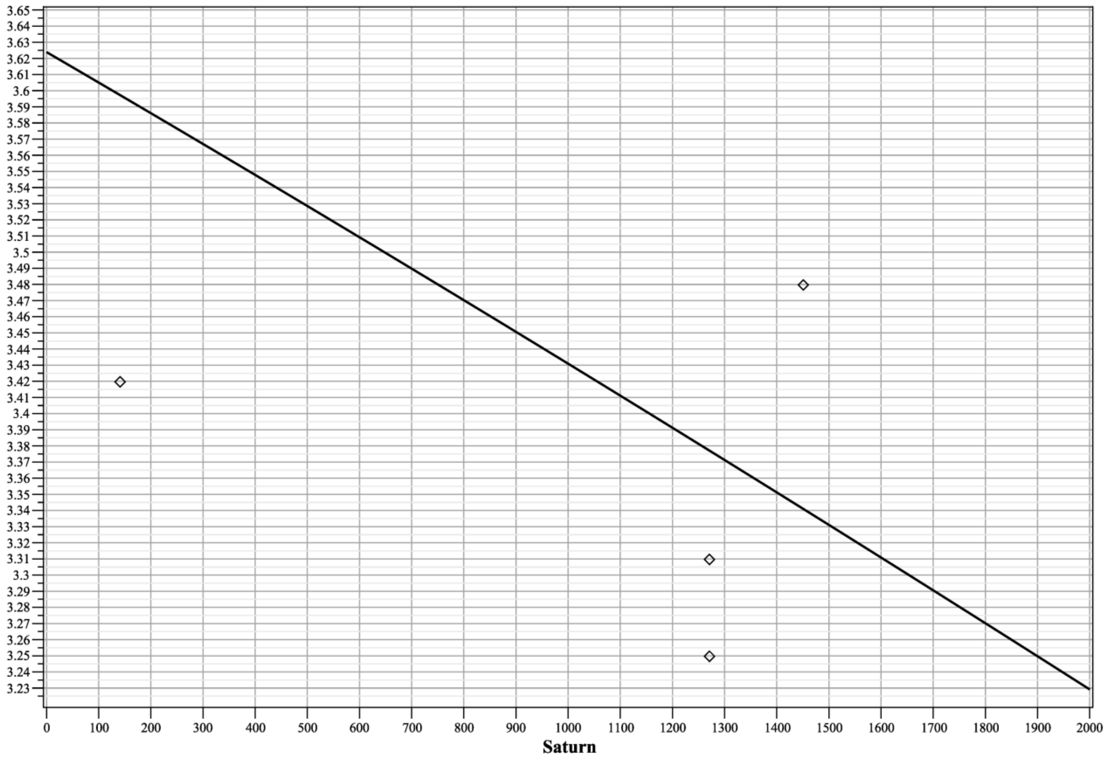

Figure 3: *The graph of the geocentric eccentricity of Saturn. ◊: Historical values except Ibn al-A'lam's*

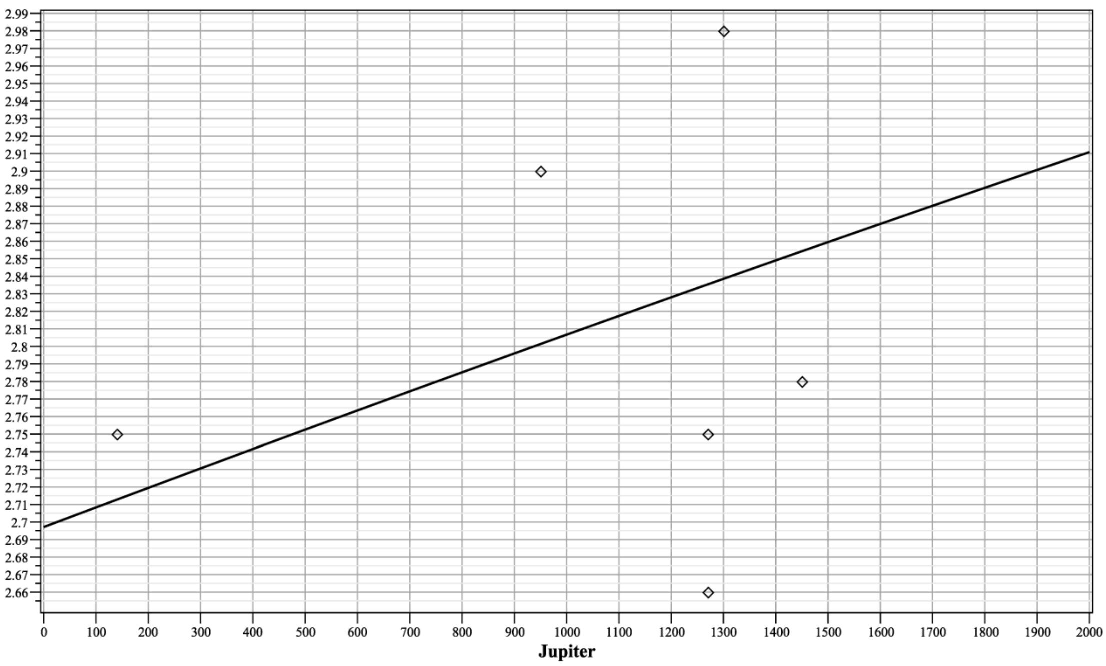

Figure 4: *The graph of the geocentric eccentricity of Jupiter. ◊: Historical values*

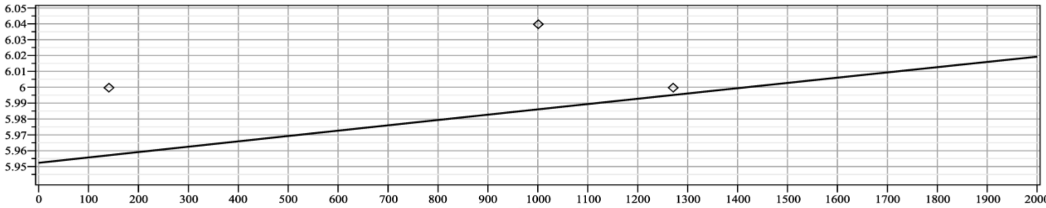

Figure 5: The *graph of the geocentric eccentricity of Mars. ◊: Historical values from Ptolemy, Kushyār, and al-Maghribī*

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Acknowledgements
The author notes with the best thanks and gratitude the suggestions and comments of Dr. Benno van Dalen (Germany), Prof. Alexander Jones, and Prof. Noel Swerdlow (United States). He would also like to thank Mr. Mike Frost (England) for his help in improving the English of the paper.

On the Sphere of Anaximander

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Diogenes Laertius ascribes to Anaximander the creation or use of several concrete objects. In his report on Anaximander, we find also a remarkable note, which at first glance seems to concern a construction of a physical model: "...and he also fashioned a sphere" (Diogenis Laertii Vitae philosophorum II,2 Marcovich = Diels, H. and Kranz, W. (2004/2005), Die Fragmente der Vorsokratiker. Griechisch und Deutsch. Zurich: Weidmann [hereinafter: DK] 12 A 1).[1] Yet though it may seem clear that this refers to a visual aid that helps describe movements in the skies, it is in fact not at all clear what Diogenes had in mind. In the present study, we shall therefore investigate what this aforementioned 'sphere' may have represented.

First of all, one needs to take into account the context, in which Diogenes includes his report. In particular, Diogenes' understanding of Anaximander's necessarily influenced even various individual parts of his description:

> "(1) Anaximander, son of Praxiades, of Miletus. He said the source and element was the boundless, not defining it as air or water or anything else. And the parts change, but the totality is changeless. [The earth lies in the middle occupying the place of the centre, being spherical (σφαιροειδῆ); the moon is a pseudo-luminous body illuminated by the sun; the sun is not less than earth in size and of completely pure fire.] He first discovered the gnomon (γνώμονα) and set one up at the Sundials [?] in Sparta, as Favorinus says in his *Miscellaneous Studies*, to mark solstices and equinoxes; and he constructed hour-indicator (ὡροσκόπια). (2) And he first drew a map of the earth and sea, and he also fashioned a sphere [of the heavens] (σφαῖραν κατεσκεύασε). A summary exposition of his views was made by him, which Apollodorus the Athenian presumably came across. He says in his *Chronicles* that in the second year of the 58th Olympiad [547/6] he was sixty-four years old and he died soon after (he flourished around the time Polycrates ruled Samos)" (Diogenis Laertii Vitae philosophorum II,1-2 Marcovich = DK 12 A 1).

Let us leave aside the beginning of the fragment, which deals with the issue of Anaximander's principle, and its very end, which speaks of the historical reality of Anaximander's treatise, the time of the Milesian's life, and includes a biographical 'piece of gossip'. For our purposes, we should start by paying attention to the first mention of Anaximander's link with particular material aids. It concerns the philosopher's alleged 'invention' of a gnomon and its positioning in Sparta. The remark about 'inventing' a gnomon is certainly an anachronism because this device is one of the oldest astronomical instruments of all. Perhaps we should rather understand Diogenes as intending a reference to an important use of a gnomon by Anaximander. The use of a gnomon as an astronomical

[1] Unless expressly stated otherwise, translations are taken from Graham 2010.

instrument is much broader that just its application as part of sundial. This is also how we could understand Diogenes' comment that the gnomon 'marked solstices and equinoxes' and the distinction between this and the 'hour-indicator'. Diogenes' enthusiasm regarding the attribution of invention of various material objects to Anaximander does not, however, stop with the gnomon and a sundial. Just a little later, he ascribes to him also a primacy in drawing 'the outline of earth and sea', that is, one of the first maps of the world. Even disregarding the reference to Anaximander's treatise as the truly last material artefact, just before this note, Diogenes also includes the 'fashioning' of yet another object, namely, a sphere. But what hides behind his words? What does it mean that Anaximander 'fashioned a sphere'?

A sphere is also found in the lexicon Suda, but there it appears in the context of writings ascribed to Anaximander:

> "Anaximander, son of Praxiades, of Miletus, the philosopher, was kinsman, student, and successor of Thales. He first discovered the equinox and the solstices and sundials, and that the earth lies in the middle. He introduced the gnomon and produced a general outline of geometry. He wrote On Nature, Map of the Earth, On the Fixed Stars, Sphere [of the Heavens] (Σφαῖραν), and some other treatises" (Suda, entry ᾿Αναξίμανδρος = DK 12 A 2).

The term σφαῖρα has a number of possible meanings. Among others, it can refer to a sphere as a geometrical shape, a globe or sphere in the sense of a celestial sphere. Given the context in which the term is used in Diogenes, that is, the fact that it is immediately preceded by information about Anaximander drawing 'a map of the earth and sea', we could suppose that it may refer to a globe of the Earth. This hypothesis is further supported by the fact in the introduction Diogenes clearly states his starting point, namely, a supposition that Anaximander postulated Earth having a round, spherical shape. Other doxographic reports, however, clearly support a conclusion that Anaximander thought Earth was flat. It had a shape of a low cylinder and was likened to a stone pillar. That should not, however, be taken to mean an entire column: we should rather imagine a segment of a temple pillar, a drum, from which a pillar is subsequently put together (Couprie 2011, 121).

But it could also be a 'celestial globe', that is, a spherical model of the sky. If that were so, it could have depicted constellations of stars. But in such case, we would have to admit that Anaximander worked with the notion of a spherical universe. Moreover, he also would have had to know about the stars of the southern hemisphere. What Diogenes is perhaps most likely to have in mind is an armillary sphere, that is, a model of orbits of celestial bodies, a system of circles, which with their incline and position depict celestial equator, ecliptic, horizon, meridian, and other important circles. Such type of a model would have been one of the first ones of its kind. But as we shall see further on, other possibilities also need to be considered (Couprie 2003, 179; 2011, 121).

In our investigation of what Anaximander's sphere was supposed to represent, we should first of all have a brief look at his concept of a universe. Based on doxographic reports, we can assume that Anaximander's idea of the universe was based on a notion of concentric circles of celestial bodies around a low cylinder of the Earth placed at their centre. The Sun and the Moon are then thought of as circles of fire surrounded by air/fog, which revolve around the Earth. A vent into the foggy shroud reveals the fire inside and is *de facto* thought of as the Sun and the Moon we see in the sky. Based on a few hints, we may suppose that the nature of fixed stars is analogical to the Sun and the Moon. What is remarkable is the alleged position of individual celestial bodies. Doxographers agree that closest to the Earth are the fixed stars and planets, while the circle of the Sun is the farthest removed. But if each fixed star and planet is one circle, they could jointly create a virtual sphere around the cylinder of the Earth (Aetius, Placita philosophorum II,15,6 Mansfeld–Runia = DK 12 A 18; Hippolytus, Refutatio omnium haeresium I,6,5 Marcovich = DK 12 A 11).

But even if we viewed the circles of fixed stars as creating the shape of a virtual sphere, we could not well claim that Anaximander's universe is spherical. That would be possible only if the fixed stars were at its edge. According to Anaximander, however, they were supposed to be the closest to the Earth. Given that the furthest celestial body is supposed to be the Sun, sources indicate that Anaximander's conception does not assume any sort of celestial sphere in which the universe would be contained. The issue of space beyond the sphere of the Sun, however, unfortunately cannot be decided (Couprie 2003, 167; 2011, 121).

II

Surprisingly enough, Diogenes' anachronistic notion that in Anaximander's view the Earth is spherical may prove to be major stumbling block in trying to solve the puzzle. We can only guess to what extent the whole 'spherical approach' is actually in the background of the mention of the sphere. And is this perhaps not just a textual illusion? Diogenes obviously presents a much later view of astronomy. After all, even his subsequent remark on the substance of the Moon, which was supposed to be illuminated by the Sun, contrasts with other doxographic reports, which speak of a similarity between of the Sun and the Moon. Similarly anachronistic is in all likelihood also the late Byzantine lexicon Suda, which among allegedly Anaximander's writings lists treatises such as Map of the Earth, On the Fixed Stars, and Sphere. One could suppose that names of particular writings in fact relate to particular subjects treated in one or another of Anaximander's writings or that they represent particular material instruments the Milesian used or created (Guthrie 1985, 73; Heidel 1921, 241-242, 252; Kirk, Raven and Schofield 102).

One should not forget, however, that Diogenes Laertius mentions Anaximander 'fashioning' or 'making' a sphere. He thus makes a remark on a particular material aid, model, or drawing. If we take Diogenes seriously at this point and disregard his anachronistic cosmological notions, we could try to reconstruct the situation to some extent. In particular, one can suppose that what we are dealing with is, indeed, Diogenes' projection of Anaximander's model. If Anaximander made a map of the world, he could have also similarly created a representation of the entire universe.

III

Let us first consider the possibility of Anaximander creating an actual three-dimensional model. In such case, it may have been a model of circles of celestial bodies around the Earth. Couprie, however, rejects the possibility of making such a model because Anaximander would have had to notice that in his conception of a flat Earth, the Sun is never at zenith. In such case, it would have to be closer to the Earth and smaller than Anaximander had thought. One can, though, suppose that he was acquainted with the fact that as one travels south, the shadow of the gnomon is getting shorter. In Syen (Aswan) in Egypt, at noon of the summer solstice, the gnomon casts no shadow at all. The model could certainly have been

just a rough representation. Even so, it clearly did not lead to any revision of the shape of the Earth, the shape of celestial bodies, or of the entire universe (Couprie 2011, 134-136; Guthrie 1985, 74; Hahn 2010, 160-165; Heidel 1921, 246-247).
However, next to the possibility of a three-dimensional physical model, it can also be hypothesised that what is meant is a two-dimensional drawing. Extant doxographic reports, in which descriptions of the Moon or the Earth prevail, seem to suggest that what would have been of interest was a depiction of daily and annual trajectories these bodies take while circling the Earth. In a different sense − and in analogy with later depictions of the zodiac − one could consider even a simple sketch on a flat board that outlined concentrically ordered circles or strips around the pole. On the other hand, Anaximander's astronomy was based mainly on measurements by gnomon during daylight, that is, on observations of the circling of the Sun (Couprie 2011, 122; Kahn 1960, 89).
In connection with the map of the world, one could also consider a map of the entire universe. And indeed, if Anaximander chose in construing the map of the world a particular manner of geometrical projection, it is likely he would have also used it in creating a plan or map of the universe. If the map of the world had represented a plan view of the Earth, a map of the universe could have analogically depicted concentric circles of celestial bodies around the Earth. This would, however, imply that the incline of those circles would have been neglected. A plan view of the universe could have helped to solve various problems of Anaximander's cosmology, including, for example, the reason for placing the Earth in the centre of the universe for the sake of balance or rather equidistance from everything else, that is, symmetry. If a cylindrical Earth is placed at the centre of concentric circles of celestial bodies, then though the virtual sphere of the circles of the fixed stars is still emphasised, the argument can be partly met in a plan view (for the horizontal movement of the Earth). The same could also hold of the identical size of the Sun and the Earth since in this connection, what is meant by the Sun does not need to be the entire circle of the celestial body or the vent into the foggy casing through which the Sun is visible in the sky. Within the framework of so-called 'Anaximander's numbers', this would mean the width of the wall of the solar circle, that is, an important parameter in drawing the map. In a similar spirit, we could read reports of boundless, equidistant worlds. Although Anaximander is often linked to a teaching about boundless worlds, it is possible, however, that this is an erroneous reading of parameters used in drawing a map of the universe, that is, of mutually equidistant circles of celestial bodies (Cornford 1934, 12; Couprie 2011, 131-133; Hahn 2001, 198–200; Kahn 1960, 50; O'Brien 1967, 427).
Reports of later authors perhaps support this line of interpretation and can be read as reflecting on the original parameters of Anaximander's map of the universe, to which they add an anachronistic understanding of his cosmology. We cannot, however, be certain of it. In any case, in applying geometry, Anaximander discovered the very possibility of such depictions. Anaximander could have expressed his experience of cyclic changes using geometry, which enables such constructions, that is, not only certain grasp of the entire habitable world in the form of a map but analogically also a map of the universe. The most apparent motions in the sky − movements of the Sun and the Moon − could have served as a framework for such geometrical expression.

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Acknowledgments

This study was supported within the project of Education for Competitiveness Operational Programme (OPVK), Research Center for the Theory and History of Science (Výzkumné centrum pro teorii a dějiny vědy), registration No. CZ.1.07/2.3.00/20.0138, co-financed by the European Social Fund and the state budget of the Czech Republic.

A Map for Aratus

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This paper introduces some reflections on the role of illustration in the Greek and Latin manuscripts of the *Aratean* tradition and especially on the illustration of Aratus' *Phaenomena,* the text that is at the origin of the *Aratea*[1].
Despite the great number of illustrated manuscripts of Latin translations of Aratus, there is little evidence of the illustration of the Greek original, the most important of which are the remnants of an illustrated and commented edition of the *Phaenomena* called F by Martin and dated to the III/IV century[2].
The role of illustration in the Greek Aratus is still an open question: was it thruly common to illustrate Aratus? Did the poem need illustration? How much of the rich series of images illustrating the manuscripts of the Latin *Aratea* could we say to come from editions of the Greek Aratus? Do we find evidence of the astronomical science of his time (the III sec. B.C.) in the images of the Latin *Aratea*?
I would like to call attention to a special kind of celestial map, a planisphere from the Vat. gr. 1087, f. 310v.

My studies on the illustrated *Aratea* are possible thanks to the Saxlproject of Kristen Lippincott (http://www.kristenlippincott.com/the-saxl-project/) and the Digital Database of the Warburg Institute (http://warburg.sas.ac.uk/library/links/orientation/astrology-astronomy/#c1016). The portal *Certissima signa* (Certissimasigna.sns.it) also contributes to the research with information about the manuscripts and useful links to their digital reproductions.
[1] *Aratea* is *corpus* including Latin translations of Aratus' *Phaenomena* (Cicero, Germanicus, *Aratus Latinus*, primitive and revised version), commentaries, glosses and derived texts (as *De signis coeli* or *De ordine et positione stellarum in signis*); among all these materials we need to mention the most important to the history of constellation images: the extracts from an astronomical work of Eratosthenes of Cirene, conventionally called *Catasterismi*); LES BOURDELLÈS 1985, 15.
[2] Martin 1956 recognised a Latin translation of F in the mss. of the *Aratus Latinus*; two different versions of F in Martin 1974,v.

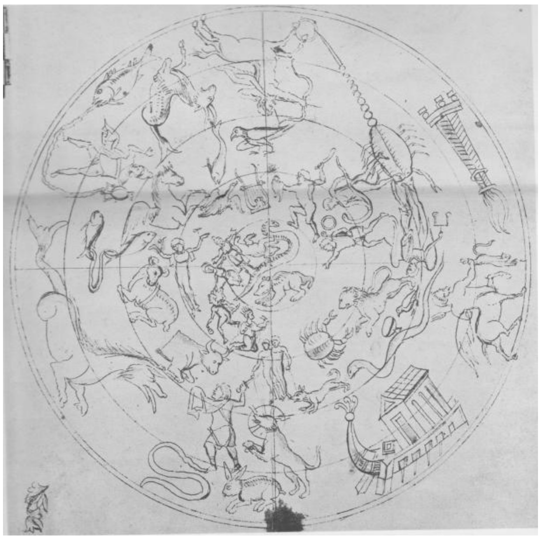

Figure 1: *Planisphere from the Vat. gr. 1087, f. 310v*

I would suggest that this kind of map could be considered an original graphic companion to the poem. This would explain why in the Latin manuscripts some exemplars of the planisphere show the sky according to the time of the latin translators (I/II sec. d.C. and later), but in others they preserve original characteristics of the Aratean sky.

The poem

Before discussing the role of illustration in the *Phaenomena*, we need first describe the poem itself, its characteristics and its structure.

A life of Aratus tells us that the king Antigonus gave Aratus a text of Eudoxus and suggested that he put into verse what the astronomer had written in prose, in order to make him *eudoxoteron* (more famous).[3] There is something true in this anecdote: Aratus is a poet, not an astronomer[4]; he composes his verses for a restricted and cultivated public that appreciated science and sofisticated literature; he had good astronomical sources, probably not only Eudoxus[5], as Hipparchus believed[6]. The *Phaenomena* are in a state of limbo between sofisticated poetry and science, as was his public: not only professional astronomers like Hipparchus, or erudite poets like Callimachus. With this mixture of sofisticated and allusive poetry and simplified astronomy, Aratus hightened the fame of Eudoxus and his own. Since their appearance, the *Phaenomena* had an enthusiastic reception. In the Latin world they were translated many times[7]. It is noteworthy that the only surviving work of Hipparchus, the greatest in the Greek astronomers, is his *Commentary* on the sky of Eudoxus and Aratus. Centuries before the recovery of Ptolemy's *Almagest*, the

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[3] *Vita Arati (Vita 1), Schol. Arat. vet.*, 8 Martin

[4] Cf. CIC., *Or*. 1.69 "..ignarum astrologiae ornatissimis atque optimis versibus Aratum de caelo stellisque dixisse"; Aratus himself admit his limits when he writes on the movement of planets: "I am not at all confident in dealing with them" v.460.

[5] Martin 1998, LXXXVI-XCVII.

[6] Hipparch. 1.2.1.

[7] Translators of Aratus poem were too numerous to be counted, cf. HYERONIM., *In Tit*. I 12 (PL 26, col. 572b).

Latin versions of the *Phaenomena* and its commentaries contributed to the survival of the knowledge of the pagan sky in many parts of the western world in the early middle ages.
As a poet Aratus did not simlpy translate his astronomical sources, but conceived a poem with the aim to describe the love of God (Zeus) to man through the signs himself had fixed in the sky to help human activities (agriculture, sailing) and adapted his sources information to the aim. The poem has two parts: 1. The sky 2. The weather signs.

Phaenomena

1 – 18 *Proem* : Hymn to **Zeus**

19 – 732 First part**.** *Phaenomena*
The Sky
19 – 25 Celestial globe, **axis and poles**;
26- 454 **The Constellations**, **from Ursae to Antecanis**
451- 453 *Conclusions.*
454 –461 P**lanets**
The time
462 -558 the time considering the constellations, the **Sun** and the **Moon**
the **Circles**: the **Milk Way** 462-69; Tropics 480-510; Equator 511-524; Ecliptic e **Zodiac** 525 -558 .
559-732 Raising and Fall of constellations and the Zodiac signs.

733- 1154 - Second part*. Diosemeia*
733- 757 months and year
758 – 1141 *Signs*
758-777 *Second proem****:*** the time on the sea and how to recognise the signs;
Signs from the **Moon** (778-818),
Signs from the **Sun** (819-891),

Signs from the **Praesepe** (892-908)
Signs from the **Wind**s rains, clouds, birds and other animals (903-1043)
Signs of the **Seasons**, plants, comets; from birds in the summer; bad time from animals. (1044-1141)
1142-1154 *Conclusions*

Table 1

The role of illustration
The first part of the poem (vv. 26- 454) includes a complete description of the sky with all the constellations Aratus knew of. It represents the very heart of the poem, the most popular one.
In many Latin manuscripts (and also in the Vat. gr. 1087) this section is copiously illustrated, but the greater part of these illustrations, individual constellation images, are to be connected to commented editions, not strictly to the *Phaenomena*.
In the edition F, Eratosthenic extracts were inserted into the poem to complete the Aratean text with two kind of information: myths of origin and star catalogues, two subjects Aratus

does not consider, if not occasionally, in his constellation treatment. In this case the image of the individual constellation follows the star catalogue at the end of the extract[8] and its role is essential: it allows the illustration of the astrotesia, the position of all the stars on the figure. Individual constellation figures probably entered into the tradition of the *Phaenomena* toghether with the Eratosthenic extracts.

But the Aratean description of the sky does not need this sort of illustration. Reading Aratus we have to confirm what the manuscript tradition suggests: most copies of the Greek poem were not illustrated. If we consider its content, the only graphic tool essential to the comprehension of this part of the text, is a celestial map. In his verses in fact Aratus guides the reader on a tour of the starry sky, describing all its constellations; sometimes he mentions some special star or some character of a constellation (great, small, bright, etc.) and in a very few cases[9] he stops the tour to tell a catasterism, but he never remiss to relate the position of a constellation to some others.

Moreover the Aratean description doesn't follow a clear, regular path, as the astronomers generally do. Eratosthenes and Hyginus, for example, start from the noth pole and describe all the constellations grouped together according to the celestial circles: from the Arctic Circle to the Tropic of Capricorn (in clockwise or counter-clockwise direction). It easy to follow such a sequence, and even to memorize it, if you want. Aratus, instead, describes some groups of constellations from the north to the south, but with breaks: starting from Ursae and Draco he touches Engonasi, Corona, Ophiuchus and reaches the zodiac with Scorpio and Chelai, but then he comes to Booes and then back to the zodiac with Virgo, Gemini, Cancer and Leo, after that again to the north: Cepheus, Cassiepeia, Andromeda, Equus and so forth[10]. The reader must go back and forth, he has to skip from one part to another of the sky in following the verses of the poet. That is why a graphic celestial map was essential to follow his itinerary and to reach a synthetic and complete view of the sky. No doubt Aratus himself needed a map as well when he traced his route through the stars. According to Cicero[11], Eudoxus was the first to create a celestial globe with all the constellation images and Aratus described this globe in his verses. If it was really so, Aratus had to turn each constellation image from globe-view to sky-view, because in his poem the figures are described in sky-view[12], i.e. just as we see them from the earth, not as we see them (righ and left reversed, like in a mirror) when we look at a celestial globe. The choice of sky-view allows to Aratus to imagine that he is looking at the sky and to invite his public to do the same. Sky-view was the right choise to help people recognise the stars in the sky (not on a globe) so they could distinguish the signs of Zeus, which is the real aim of the poem. Also for a reader, a globe with all the constellations could be an excellent companion to Aratus' verses[13]. Ancient sources write of Aratean globes[14] and some chacteristics of the planisphers point to a central role of globes in the origin of the Aratean illustration.

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[8] See ttp://digidol.llgc.org.uk/METS/AST00001/frames?div=43&subdiv=0&locale=en&mode=reference .

[9] *Ursae*, *Virgo*, *Equus*.

[10] More or less regularly Aratus seems to take the zodiac as a point of reference, Martin 1998, li-lxi; cf. also Kidd 1997, 5-7.

[11] Cic., *Rep*. 1.14.22.

[12] Martin 1998.

[13] Dekker 2013, 67.

[14] Leontius, VII cent., Peri; kataskeuh`~ jArateiva~ sfaivra~, 561-567 Maass.

But globes are exclusive and expensive objects and not every reader of Aratus could afford one.

Back to the planisphere

A bidimensional map was cheaper, more practical and, as we might to say, userfriendly. In the codices it is a simple *folio* and can be placed at the begining or at the end of the text.

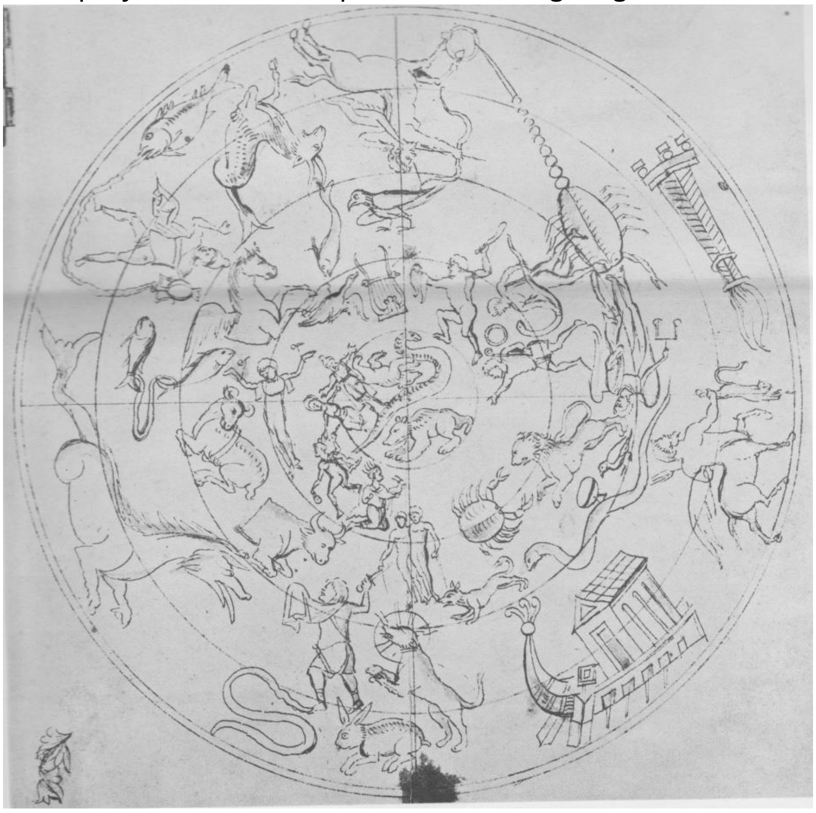

Figure 2: *Città del Vaticano, Biblioteca Apostolica Vaticana, gr. 1087, f.10v*
from Boll F., Sphaera, Leipzig 1903

The codex Vat. Gr. 1087 was copied in the circle of Nicephorus Gregoras and was revised and annotated by Gregoras himmself; it dates to the first quarter of the XIV cent.[15]. It is a codex of Byzantine Astronomy, contains Metochites *Astronomikè Stoicheiosis*, Gregoras *Treatise on the Astrolabe*, fragments of Theon *Commentary on the Almagest*, and also some folios with extracts from the *Catasterisms* and images with *scholia* (ff. 300r – 318r), which are the remnants of a F edition of Aratus. The selection of the extracts suggests that the reasons for the interest of the Byzantinians in copying them are probably to be found in their love of mythographic eruditon and in the exceptional beauty of the images more than in the old astronomic information they could find in Aratus. The original of the Aratean extracts dates to the III/ IV cent. A.C. on textual[16] and iconographic[17] evidence.
The planisphere is centered on the northern pole and allows the visualisation of all the Aratean constellations (the Southerns included) in a single sheet; the reader does need any other tool to follow the words of the poet, the finger on the map. All the Aratean

[15] Pontani 2013, 9-1; Menchelli 2013, 17-56.
[16] Martin 1956.
[17] Guidetti 2013, 113-142.

constellations are on this planisphere, two only missing: Triangulum and Sagitta; it is easy to forget them during the transcription, because they are quite small and of little relevance. There is also a small group of anonymous stars (now Corona Borealis) that Aratus places at the "anterior feet" of the Sagittarius [18]. Sagittarius is designed like a Centaur and has four legs[19], according to the *Phaenomena.*

It shows the old 11 figure zodiac, the huge Scorpius still covering two signs with its great *Chelai*. The whales in the hand of the Virgo refer to Aratus original catasterism which identifies this constellation with Dike, the Justice[20]. The whales have not yet taken the place of the *Chelai*[21]. This is the zodiac of Aratus and Eratosthenes time.

A sky with a 12 figure zodiac is represented in Vat. gr. 1087 by two hemispheres (summer and winter) which originally illustrated an introductory astronomical commentary[22]. In the folios they precede the planisphere, and the last concludes the illustration series.

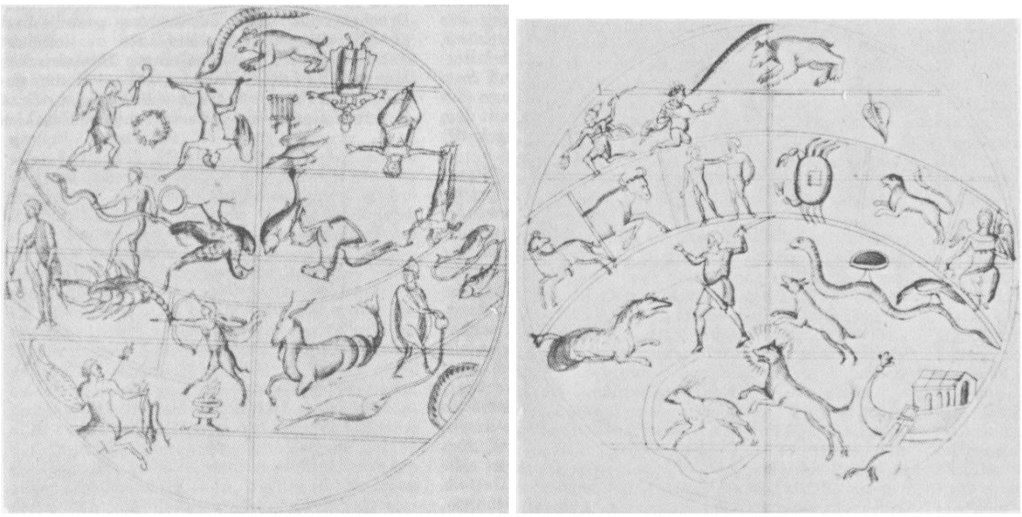

Figure 3a: *Vat. gr. 1087, f. 309v, winter hemisphere*; Figure 3b: *Vat. gr. 10871, f. 310r, summer hemisphere, from Roscher W.H., Ausfürliches Lexikon der Greichiscen und Römischen Mythologie, Leipzig 1884-1937*

In a more ancient manuscript containing Ptolemy's *Handy Tablets*, the Vat. gr. 1291, VIII/IX sec, ff. 2v; 4v., we find an elegant exemplar of the same hemispheres, where the exclusive image of the Ivy (*Kissinou Phyllon*) and of the Curl (*Plokamos*), represented together in a single constellation, points to their Ptolemaic model[23].

[18] *Phaen*. 399-410.

[19] In *Cat.*, cap. 28, it is a sort of Silen. The two iconographies coexist in many illustration series.

[20] *Phaen*., vv. 96-136.

[21] On *Libra* see Le Boeuffle 1977, 171.

[22] Martin 1998, I, CXXIX.

[23] *Synt.*, 1.2.100-101 Heiberg. Our Vat. gr. 1078 copist forgets, or does not recognise the curl: he only reproduces the ivy leaf; later Medieval copists do not know the asterism at all: they transform the figure into a familiar vase emitting steam or a sort of *turibulum,* Sangall. 902, p.76, see http://www.e-codices.unifr.ch/it/csg/0902/76/medium .

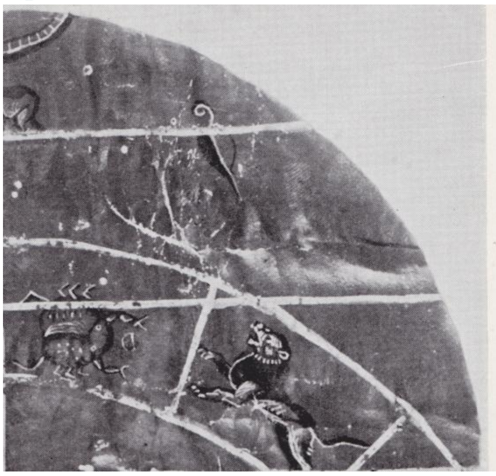 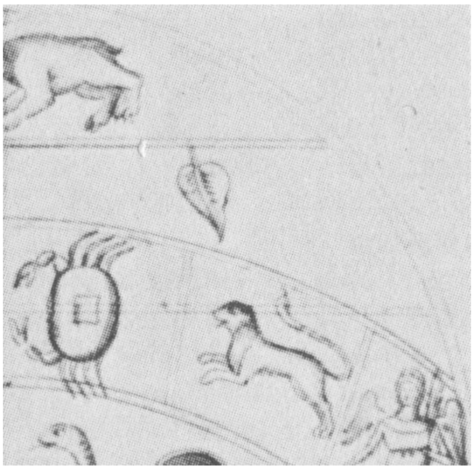

Figure 4a: *Vat. gr. 1291 f. 2v, Ivy and Curl*; Figure 4b: *Vat.gr. 1087, f. 310r, Ivy*

The planisphere was a much more ancient companion to the *Phaenomena* than the two hemispheres. It does not know *Libra*, nor *Plokamos* (nor *Kissinou Phyllon*), just as Aratus text doesn't. It is preserved in manuscripts of all the branches of the *Aratea*[24], that highlights its essential role and basic function in the Aratean illustration: Germanicus[25], Cicero[26], *Aratus Latinus*, primitive[27], *De signis*[28]; *De ordine*[29]. Different exemplars can show astronomical, iconographic, stylistic differences, according to which scholars organize them into groups in order to clarify their traditions. Generally speaking, the individual history of each exemplar is not always clear in its details.

But it is interesting to note that also if many of them show the updated 12 zodiac sky[30], as we should expect in Latin versions of the *Phaenomena* starting from the I cent. B.C./I cent. A.D., some still preserve the Aratean 11 figure zodiac. These planispheres illustrate different texts: *Aratus Latinus* primitive, Basil. AN IV 18, f.1v; *De signis*, El Burgo de Osma, 7, f. 92v; Germanicus and *Basileensia*, Aberystwyth, NLW C 735, f. 10v; Germanicus and *Strozziana,* a group of ornate mss.*, recentiores, sed non deteriores*, copied in Italy in the XV cent. from an ancient archetype: Bodm. 7, f. 2v and others[31]. They all are in globe-view (the order of the zodiacal constellation is counter-clockwise), unlike all the planispheres with the Libra are in sky-view[32]. This suggests the importance of the globe in their origin[33].

[24] Dekker 2013, 142-180; 227-249.
[25] With different iconographic traditions: Bonon. 188, f.20r and Bern. 88, f.11v, X /XI sec.; Aberystwyth, NLW 735C, f.10v, ca. 1000; the Italici.
[26] Harl. 647, IX sec.
[27] Basil. AN IV 18, f.1v, first half IX sec.
[28] El Burgo de Osma, Archivio de la Catedral, 7, f.92v, XII sec.
[29] Monac. Clm 210, f. 113v, 818-820: the map precedes the *Excerptum de Astrologia* and *De ordine et positione stellarum in signis*, two texts we always find together, cf. Dell'Era 1974.
[30] Bonon. 188 and Bern. 88; London, Harl. 647; Monac. Clm 210; Vat. Reg. lat. 123.
[31] Dekker 2013, 176-180
[32] Except Berlin, Staatsbibliothek zu Berlin-Preussicher Kulturbesitz, lat. 129 (Phill. 1830), ff.11v-12r, IX sec.; its connection with an Aratean text is not clear.
[33] Thiele 1898, 168.

They all preserve the image of the tail of Draco which ends at the head of the Great Ursa, as Aratus describes it[34]. Other ancient Aratean characteristics can be found in these mss. In Aberystwyth, NLW 735C, f.10v and in Basil. AN IV 18, f.1v, *Virgo* is without wings, just as it was in Aratus verses[35]. The exemplar in the Aberystwyth, NLW 735C, f.10v[36] shows constellation images that match the description of the *Catasterisms*, like the rare old *Equus* without wings[37].
Bodm. 7, f. 2v[38] depicts Hercules as Engonasi, without the lion skin and the club, just as Aratus insists it had to be considered: "No one is able to say definitely what it is...the figure looks like a man crouching. From both his shoulders arms are raised ..." (tr. Kidd 1997)[39].

Conclusions

As we said this planisphere was the most practical and affordable graphic tool a reader could find to understand the Aratean description of the sky. Its reproduction was also easier than that of a globe. It was well concieved and it never really missed its scientific function. It could offer such a complete syntesis of the sky that could support other astronomic documents extracted from the Aratean materials, as the constellation catalogues *de signis* and *de ordine.*
In a manuscript of Cicero *Aratea*, the planisphere[40] has been added at the end from a different source and contains a *subscriptio*:

> "Ista proprio sudore nomina unoquoque propria ego indignus sacerdos et monachus nomine Geruvigus repperi ac scripsi. Pax legentibus."

These words point to the real function of the planisphere; as beautiful they could be, these maps were scientific illustrations: readers look to them for help with the text and its content. Geruvigus could be proud of his labour: labelling each constellation with its proper name he gave a further device to the Christian readers of his time for the comprehension (and the survival) of the ancient pagan sky described in the text.
In its different exemplars, this kind of celestial map preserves precious fossils of a pre-tolemaic astronomical and mythological image of the sky. Archaic structural characters like the 11 figure zodiac suggest that the planisphere should be linked to the *Phaenomena* at a very early age, earlier than the commented and illustrated editions of the IV cent. It is the more ancient evidence of a graphic companion to Aratus.

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[34] Dekker 2013, 171.
[35] *Phaen*. 138 is a later interpolation; Cic., *Arat*. 26, Kidd 1997, 231-232.
[36] Aberystwyth, NLW 735C, f.10v, ca. 1000 http://digidol.llgc.org.uk/METS/AST00001/frames?div=43&subdiv=0&locale=en&mode=reference .
[37] *Cat*.. cap. 18; Santoni 2009.
[38] http://www.e-codices.unifr.ch/en/cb/0007/2v/medium.
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Reflection of Ancient Greek Tradition in the 13th c. Premyslid Celestial Globe Saved in Bernkastel-Kues

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The aim of this contribution is to introduce the oldest medieval celestial globe originating in Christian Europe and to point out its close connection with ancient Greek tradition in description of constellations. We investigate this remarkable artefact in the framework of our project *Sphaera octava* intended originally to deal with study and Czech translation of Hyginus's treatise *De astronomia* (or *On astronomy*), its sources *Katasterismoi* (or *Constellations*) by Pseudo-Eratosthenes and *Fainomena* (or *Phaenomena*) by Aratos and their later reflections in medieval scholia, commentaries and treatises on constellations. In the course of our project, when the translations were basically finished, the globe was borrowed from Cusanusstift in Bernkastel-Kues to an exhibition in Prague, where we had a possibility to investigate it in more details.[1] It appeared immediately, that the drawings of constellations on the globe and their mutual relations are practically the best available illustrations to the ancient textual tradition on this subject. Moreover, the unique construction of the globe as the universal precession globe described in Ptolemy's *Almagest* (which we shall deal with in our subsequent contribution), together with a lack of Arabic influence in the iconography revealed that the globe represents a valuable remnant of the tradition of ancient Greek mathematical astronomy persisting in Europe till the Middle Ages.

The celestial globe of 27 cm in diameter is made of birch wood, covered by fine canvas and plaster into which positions of stars, drawings of constellations and some coordinate circles are engraved. The stars are marked with small holes in the upper layer of the globe. The holes were coloured in red, and the figures in dark brown, which was softened with the white in some places. However, this fact is known to us from the literature only,[2] because nowadays only some traces of the red colour are discernible. The globe is assumed to be formerly a part of the Prague royal-court collection in possession of Premysl Ottokar II (1233–1278), King of Bohemia from the Premyslid dynasty, or his son and successor Wenceslas II (1271–1305; Wenceslas II was the father of Czech Queen Elisabeth, who later became the mother of the Emperor Charles IV).[3]

In 1444, Nicolaus Cusanus bought the globe along with two other astronomical instruments (astrolabe and torquetum) and with 16 astronomical and astrological manuscripts for his own collection. From that time the majority of his collection (including the celestial globe) is saved in Cusanusstift in Bernkastel-Kues on the Moselle River near Trier in Germany (Bernkastel-Kues, Bibliothek des St. Nikolaus-Hospital). The globe has no inventory number.

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[1] Hadravová and Hadrava, 2011; 2012.
[2] Hartmann 1919.
[3] Vaníček 2002, 344.

Concerning the manuscripts purchased for Cusanus collection, it should be noticed that they contain texts and marginal notes referring to the events of Bohemian history[4] (e.g. the manuscript Cus. 211 shows astronomical tables compiled for Nuremberg and Prague, the manuscript Cus. 208 alludes to the death of King Wenceslas II and the murder of Wenceslas III; the codex Cus. 207 contains the astronomic-astrological treatise *Liber de signis* by Michael Scot, which was chosen – along with two other manuscripts – by Silke Ackermann as a basis for her recently published critical edition of the tractate[5] etc.).

On the globe there is no letter, number or any other sign, which would enable a palaeographic dating and its universal construction also does not provide a unique dating (contrary to the islamicate globes constructed in equatorial coordinates to a particular epoch). The "great helm" drawn on the head of Perseus yields a possibility of dating to the end of 13th century according to Hartmann,[6] however, it should be noted, that similar types of helmets were worn in the Mediterranean even earlier. It is claimed in the older literature, that the globe was a gift to Premysl Ottokar II from his cousin, the King of Castile and León Alfonso X the Wise, who was not only a great maecenas, but who was also personally engaged in astronomy. However, as noted by Mercè Comes,[7] the iconography of the constellations on the Premyslid globe does not agree with recommendations to globe builders by scholars at the court of the King Alfonso the Wise, which are obviously influenced by the Arabic tradition. She convincingly argued, that the globe could not have originated at Alfonso's court. We can confirm her conclusion. The fact, that the construction of the Premyslid globe as well as its iconography reveals strong ancient Greek influences, which were not mediated by Arabian environment, leads us to a hypothesis, that the globe was made in connection and tradition of the Hohenstaufen Sicilian court at Palermo.[8]

The Premyslid globe features all forty-eight Ptolemaic constellations (northern, ecliptic, and southern ones). The constellation of Scorpius is depicted on the ecliptic in its older variety, i.e. the claws of the Scorpius overlap the space of the previous zodiacal sign, which was later filled by the zodiac constellation of Libra. All the constellations on the globe are drawn by a very nice, elegant black line following the direction of the view from above the sphere of sky. Apart from all the Ptolemaic constellations, the basically complete list of stars from Ptolemy's *Star Catalogue* is depicted on the globe. The layout and mutual positions of constellations and stars agree with the tradition documented in texts, such as Aratos, known in the Middle Ages thanks to the Cicero's and Germanicus's translations from Greek to Latin, (Pseudo)-Eratosthenes, and Hyginus. When comparing the positions of constellations on the globe to the description in these sources, the astonishing precision of correlations emerges. It is only important to be aware of the side orientation of the constellations in the texts and on the globe. Similarities also prevail when comparing the stars depicted on the globe to their counterparts in Ptolemy's *Catalogue.*

Let us show several examples of the correlations between old texts and drawings on the globe now:

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[4] Panušková 2011.

[5] Ackermann 2009.

[6] Hartmann 1919, 11.

[7] Comes 1987.

[8] Let us note, that the Emperor Frederick II of Sicily, patron of the above mentioned Michael Scotus, was cousin of mothers of both kings Alfonso X and Premysl Ottokar II, who both tried to follow his example in political carrier as well as in supporting of culture.

According to Hyginus, “Dragon touches the head of Great Bear by the end of his tail”.[9] We can find a similar text already in Hipparchos’s work *In Arati et Eudoxi Phaenomena Commentariorum libri III*,[10] assumed to come from an Eudoxos’s unpreserved work: “The tail of Dragon passes between Bears; the star on Dragon’s end is located directly above the head of Great Bear.” Both texts are exactly documented by image on the globe. The drawings reflect remarkable ancient Greek influences. This can be also seen in some elegant lines of drawings, showing a good knowledge of anatomy, shaping the muscles (e.g. in the front leg of Ursa maior).

The head of Medusa the Gorgon, which Perseus holds, has the form of a girl’s head, and thus refer to ancient rather than Arabic paradigms; the Arabs depicted the head of Medusa in the form of a devil’s head, as the Algol.

The literary tradition corresponds well also with the drawing of Taurus on the globe, up to a mirror reflection: “The left horn is connected to the right foot of the one, who is called Auriga” (Hyginus, *De astronomia* 3,20);[11] other place: “Right feet of Charioteer (Auriga) shares one star with left horn of the Bull” (Hyginus, *De astronomia* 3,12);[12] “there is a Charioteer staying on the top of the horn of the Bull” (the last citation is derived from Vitruvius, *De architectura* IX 4,2).[13] The described star common to the Charioteer and the Bull is β Tauri. According to Hyginus, “Orion... is depicted fighting with Bull... He holds a club in his right hand and he is belted by a sword. He looks towards the west” (3,33).[14] The purpose of the imaginary kneeling figure of Orion, with legs bent at a right angle, is not to express the static position, such as the kneeling figure of Hercules (named *Engonasin*, i.e. “Kneeler, Kneeling Man” from the time of Aratos and elder times), but, based on the Greek art of depicting running and flying figures, shows the movement of Orion. Orion has a sword attached to the waist, which corresponds with the Germanicus’s description in his translation of Aratos’ *Fainomena* (*Aratea* 332), with Hyginus (*De astronomia* 3,33), and Manilius (*Astronomica* I, 391). Ovidius in *Metamorphoses* 8,206–207 describes the unsheathed sword of Orion. Statius also describes this act (*Silvae* I, 1,43–45).

Cancer (Crab) is depicted in the Mediterranean look of a sea crab. It includes among others two stars called Aselli (γ and δ Cnc). According to Hyginus, “Crab is divided to halves by summer tropic and he is looking towards Lion and the East. He is located nearly above the head of Hydra.” (Hyginus, *De astronomia* 3,22).[15]

Lion (Hyginus, *De astronomia* 3,23) “is placed above the body of Hydra and it is looking towards the West. It stretches from above Hydra’s head, with adjacent Crab, and extends to

[9] “Draco... cauda autem flexa caput maioris (Arcti) adtingere” (Hyginus, *De astronomia* 3,2).

[10] Hipparchus 1894.

[11] “Cornu sinistrum... coniungitur cum dextro pede eius, qui Auriga appellatur” (Hyginus, *De astronomia* 3,20).

[12] “Huius (= Heniochi) dexter pes Tauri sinistro cornu stella coniungitur una” (Hyginus, *De astronomia* 3,12).

[13] “E regione capitis Septentrionis transversus ad pedes Geminorum Auriga stat in summo cornu Tauri” (Vitruvius, *De architectura* IX 4,2).

[14] “Hunc (Orionem) a zona et reliquo corpore aequinoctialis circulus dividit, cum Tauro decertantem conlocatum, dextra manu clavam tenentem et incinctum ense, spectantem ad occasum” (Hyginus, *De astronomia* 3,33).

[15] “Hunc (Cancrum) medium dividit circulus aestivus ad Leonem et ad exortus spectantem, paululum supra caput Hydrae conlocatum” (Hyginus, *De astronomia* 3,22).

the middle of her body. The middle of Lion is crossed by a summer circle, therefore its front legs are situated below the circle."[16] Again, the description accurately corresponds to the depiction of the constellation on the globe.

Regarding the Cepheus constellation, there are also similarities with Hyginus and Aratos: "Cepheus is depicted with both his arms stretched out" (Hyginus, *De astronomia* 3,8).[17] "Cepheus himself is like a man stretching out both his arms" (Aratos, *Fainomena* 183).[18] As it was written already, the Arabian influences are not very significant on the globe, but some traces may be indicated for instance by protuberant abdomens of some figures like Cepheus. On the head of the Andromeda constellation the bright star α And (Sirrah) can be seen, which is common to the abdomen of Pegasus, therefore called δ Peg (Alferaz) in the past. Hyginus (*De astronomia* 3,10) says: "Andromeda's head touches the lower belly of Pegasus. Their common star is thus called lower belly of Pegasus and the head of Andromeda."[19] And one extract from Aratos in the English translation by Douglas Kidd: "Now the monster Horse is actually pinned to her head by its lower belly: there shines a star that is common to its navel and the head at her extremity"[20] (Aratos, *Fainomena* 205–207). Cf. also Vitruvius, *De architectura* IX 4,3: "A very bright star terminates both the belly of the Horse and the head of Andromeda."[21]

The figure of Hercules is depicted from the front; the figure is thus reversed in comparison with the external view on the globe. This picture thus coincides with text by Aratos, who writes in the verse 70, that Engonasin stands with his right foot on the head of Dragon (δεξιτεροῦ ποδὸς ἄκρον). However, this orientation of the Hercules's figure is incorrect and Hipparchos (I 2,6) already knew about it: he pointed out that the mistake was done already by Eudoxos and that the reversed figure is explicable by the view to the atlas, which paints the constellations from the Earth. Germanicus in his *Aratea* corrected this Aratos's mistake (Germanicus's correction was probably based on his reading of Hipparchos), so in the verse 69 we can read Germanicus's corrected translation, that Hercules presses the Dragon's head by left foot (*Serpentis capitis figit vestigia leva*). Avienus in the verses 192–193 remains indebted to the original Aratos and Eudoxos conception, so "his" Hercules is pushing down on the bowed head speckled Dragon by right foot (*dextraque dehinc impressio plantae / tempora deculcat maculosi prona Draconis*). Hercules is drawn in typical genuflection on the globe; it gave a Greek name "Engonasin" to this constellation. His picture is thus in keeping with our texts, from which Hyginus's *Astronomy* is the most comprehensive: "while the dragon has an upright head, Heracles kneeling on the right knee and left foot trying to press the right side of his head; he raises his right hand to strike, the left is stretched out with a

[16] "Leo, spectans ad occasum, supra corpus Hydrae a capite, qua Cancer instat, usque ad mediam partem eius constitutus, medius aestivo circulo dividitur, ut sub ipso orbe priores pedes habeat conlocatos" (Hyginus, *De astronomia* 3,23).

[17] "Cepheus autem manibus utrisque proiectis figuratus" (Hyginus, *De astronomia* 3,8).

[18] Aratus 1997, 87.

[19] "Cuius (= Andromedae) caput equi Pegasi ventri coniungitur; eadem enim stella et umbilicus Pegasi et Andromedae caput appellatur" (Hyginus, *De astronomia* 3,10).

[20] Aratus 1997, 89.

[21] "Cuius ventris lucidissima stella finit ventrem Equi et caput Andromedae" (Vitruvius, *De architectura* IX 4,3).

lion's skin, so it seems to be in a big fight" (2,6);[22] the second extract: "both feet and right knee of Hercules rests on the Arctic Circle, ... and so, that while the tip of the fingers of the right foot form a circle, the whole of his left foot is trying to push the head of Dragon" (3,5).[23] The same situation is described in Pseudo-Eratosthenes's *Katasterismoi* 4: "the man, who is standing on the Dragon, has one knee bent, while the other foot prints Dragon´s head. His right arm is outstretched holding a club, as if to strike, his left hand wraps lion skin."[24]

In the Bootes constellation (Boo) the main star Arcturus (α Boo) is located in the waist according to Aratos and Hyginus, while other sources (Pseudo-Eratosthenes, Geminos, Ptolemy, star no. 110, Premyslid globe) localize the star between the knees of Bootes. We can read the description of Hyginus: "he has one star in the waist, which shines more than others: the star is called Arcturus;"[25] in Pseudo-Eratosthenes's characteristics we read "one very bright star is between the knees of Bootes, this star is Arcturus."[26]

Similarly the position of the constellation of Cetus (Whale) on the globe is in fact parallel to the Hyginus's description (*De astronomia* 3,30): "Whale is divided by the winter tropic in the middle of its tail… and its maw nearly touches the back leg of Aries."[27]

Entirely consistent with literature descriptions is also mutual position of all other constellations.

These first findings of exact correlations between the ancient texts and more than a millennium younger medieval drawings yielded the textual-iconographic motivation for us to develop exact mathematical methods of measurement of the globe. Their application described in our subsequent contribution proved that the globe also fits with the ancient Greek tradition in mathematical astronomy.

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[22] "Habet enim Draco caput erectum, Hercules autem dextro genu nixus, sinistro pede capitis eius dextram partem obprimere conatur; dextra manu sublata ut feriens, sinistra proiecta cum pelle leonis, ut cum maxime dimicans apparet" (Hyginus, *De astronomia* 2,6).

[23] "Utrisque pedibus et dextro genu, quem ante diximus, arcticum circulum finit ita tamen, ut dextro pede prioribus digitis circulum terminet, sinistro autem toto caput Draconis obprimere conetur" (Hyginus, *De astronomia* 3,5).

[24] "Habet autem serpens caput erectum, qui vero ei superstat, unum genu flectit, altero autem pede eius caput premit et percutienti similis dextera manu extenta clavam tenet, sinistrae manui pellem leoninam circumvolvit" (Pseudo-Eratosthenes, *Katasterismoi* 4).

[25] "Habet... in zona unam clarius ceteris lucentem: haec stella Arcturus appellatur" (Hyginus, *De astronomia* 3,3).

[26] "Habet... inter utraque genua unam splendidissimam, quae est Arcturus" (Pseudo-Eratosthenes, *Katasterismoi* 8).

[27] "Pistrix a cauda media dividitur ab hiemali circulo, ... rostro prope posteriorem Arietis pedem iungens" (Hyginus, *De astronomia* 3,30).

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Ackwnowledgments
This work was supported by the grant GAČR 405/11/0034.

Mathematical Investigation of the Premyslid Celestial Globe Saved in Bernkastel-Kues

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The Premyslid celestial globe, introduced in our previous contribution, corresponds not only to the ancient texts on constellations by its iconography, but it also fits by its construction with the Ptolemy's universal precession globe, as it is described in his *Almagest* VIII,3. According to this description, the positions of stars are drawn on the spherical body of the globe in ecliptical coordinates, which are given in the Star catalogue in *Almagest*. The Sirius (α CMa) as the brightest star is to be chosen as a reference star placed on the great circle drawn through the poles of ecliptic, from which the differences in ecliptical longitudes of other stars are counted. On the Premyslid globe we can really see a great circle perpendicular to the ecliptic, which crosses a great star in the mouth of Canis maior. The principle of the universal globe consists in the fact that the polar axis is not fixed to its position in a particular epoch as it is common on the oldest islamicate, later European as well as our contemporary celestial globes, but it is placed on a ring with the scale of ecliptical latitudes, which rotates around the ecliptical poles, at a distance from them equal to the inclination of the equator with respect to the ecliptic. This ring made of metal can be seen on photos of the Premyslid globe published by Hartmann in 1919. The polar axis on the globe can thus follow the precession cone of the Earth's axis on the sky and be fixed to the globe for an arbitrary equinox. A trace scraped by the pegs of the polar axis to the spherical surface is visible on the Premyslid globe in the parts of the precession cone corresponding to the historical epochs, for which the globe was obviously used. This polar axis then rotates in another outer ring, which represents a local meridian and can be placed at any altitude of the pole in a stand with a ring corresponding to the horizon. The globe can thus model the rises, culminations and settings of any star or point of the ecliptic at any geographic latitude in any epoch.

To identify, which stars were marked on the Premyslid globe, to find what is their precision, and to document the drawings on the globe we have developed a method of measurement of the stars and lines from digitalized photographs of the globe. Our method follows in its principle the methods of CCD astrometry or photometry; we define a small slit around each mark of a star and calculate coordinates of its centre as a mean weighted by an excess of the darkening in each pixel above a background level. Free parameters of transformation between the measured coordinates of the stars in the plane of the photograph and their ecliptical coordinates given in the Ptolemy's catalogue are then fitted by least-squares method. This transformation is based on simplifying assumptions of the ideal spherical shape of the globe and its simple 'pin-hole' projection on the plane of photograph. These assumptions are obviously violated, because the Premyslid globe has several cracks with some distortions and depressions and a real photographic camera has some aberration. However, in practice an extrapolation of this projection fitted in one part of the globe usually corresponds satisfactorily even behind the mentioned cracks. The projection has nine free parameters, so that measurement of five stars is sufficient to find their values. Once these values are estimated, the transformation is used to find the positions of other stars and their measurements are used to improve the precision of the transformation and to stretch its validity on a larger part of the photograph. Comparison of results in overlaps of different photographs provides a check of internal precision of the method.

For our measurements we used first the eight photographs published by J. Hartmann in 1919. During the exhibition of the Premyslid globe in Prague, Mr. M. Frouz made a large set of digital photographs, which cover also the parts of globe missing on the historical photographs. From a simple comparison of these two sets of photographs, it is obvious, that the globe lost a lot in its contrast and hence the historical photographs are still and will be for future a valuable documentation of the globe. This fact also gives a warning to our generation, that the globe should documented by all available methods (e.g. 3D-scanning etc.) to save its unique information for future. Based on these two sets of photographs we have measured up to now (i.e. till summer 2013) 718 stars. There are some more stars visible on the globe, but it was not possible to measure their position reliable, because they are either partly hidden by the rings holding the globe, or they are blended mutually or with the drawn lines, the cracks or other defects of the globe surface. Only in a few cases there was no trace of a star in the position, where it should be according the Ptolemy's Star catalogue, or there were some marks so distant, that their identification was uncertain. There are also some holes resembling marks of stars in places, where should be no star. These could be either due to a mistake during the construction or caused later by using of the globe with compasses. The root-mean-square error in positions of the measured stars is about 0.44°. Regarding the diameter of the globe, this error corresponds approximately to 1 mm, which is also a typical size of the marks. Moreover, a part of this error is an internal error of our measurements. From about 700 repeated measurements of the same stars in more photographs we can find the internal error about 0.2°, which is, however, an upper estimate, because many of these measurements are at edges of the photographs, where the precision is lower. The distribution of the errors is not Gaussian – it rather corresponds to a superposition of two Gaussian distributions with errors about 0.22° for more than two thirds of the stars and 0.46° for the rest. In any case, these results show, that the globe was constructed as a precise instrument for astronomical purposes and not as a mere decoration, what could be a case in a royal collection.

We have used a procedure similar to the measurement of star positions also to measure coordinates of points on the lines in drawings of the constellations and the coordinate lines present on the globe. In this way we generated a digital sketch of the drawings, which can be depicted in any chosen projection. The parameters of transformations between the planes photographs and the spherical coordinates on the globe were also used to interpolate the local greyness on the photographs into a chosen coordinate grid on the globe and thus to produce its digital facsimile. From this dataset, arbitrary part of the surface of the globe can be depicted in any required projection.

More details about our investigation of the Premyslid globe can be found in publication Hadrava and Hadravová (2012). It will also be a subject of our monograph which is currently in preparation.

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Acknowledgments

This work has been supported by the grant 405/11/0034.

An Arabic Ephemeris for the Year 1026/1027 CE. in the Vienna Papyrus Collection

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In the history of Ancient Greek astronomy, papyrus documents play an eminent role. A first landmark in this field was the book “Greek Horoscopes” (Neugebauer et al. 1959). Forty years later, a second landmark were the two volumes “Astronomical Papyri from Oxyrhynchus” (Jones 1999). Most of these astronomical documents were found in the dry soil of Egypt. They form a small part of about 150'000 Greek documents, which are preserved in Papyrus collections all over the world. It may be less known that an approximaltely equivalent number of Arabic documents on papyrus and paper are kept in the same collection. They cover a time-span from the 7th to the 15th century.
In contrast to the well established disciplin of Greek Papyrology, the sister discipline Arabic papyrology played a marginal role within Arabic Studies despite the enduring efforts of a handful of pioneers, but in recent years important steps towards institutionalsation were made. Research groups are based in Zurich, Munich, Vienna and Leiden. But this research is focused on letters and administrative documents, and the history of science is not on the top of the agenda.
Some years ago, a search for astronomical documents was started in the Vienna Papyrus collection and a few other collections. This task turned out to afford much patience, since astronomical items are extremely rare among Arabic papyri and paper documents. In this paper a fragment of an astronomical ephemeris will be presented. Hopefully, it will be shown, that even such a tiny piece of paper can cover a gap in our image of the history of astronomy in Egypt.
In order to estimate the significance of the Arabic astronomical documents from Egypt one has to bear in mind that the tradition of mathematical astronomy broke off in the Mediteranean in the 7th century. The revival of mathematical sciences took place in the extreme East of the Islamic World after the middle of the 8th century. The earliest astronomical works in the Arabic language were translations from Sanskrit and Pehlevi. Only two generations later, Greek astronomical works were translated into Arabic and astronomers in Baghdad started with new observations. Most of these scholars came from Central Asia, Afghanistan and Iran to the center in Iraq, while Egypt played no role at all. First evidence of astronomical activities in Islamic Egypt is a horoscope on papyrus probably cast for a date in the year 894 CE (Thomann 2012). This fragment does not contain any positions in degrees, and therefore, nothing can be said about the underlying technique. The same is true for an astronomical almanach for the year 910 CE (Thomann 2014b). More informative is an ephemeris for the year 931 CE (Thomann 2014a). Its analysis has shown, that outdated astronomical tables were used, which yielded considerable errors in the position. As it seems, these tables were calculated for the meridian of Merw in Turkmenistan and were compiled at the beginning of the 9th century. This sheds no favorable light on the level of

knowledge in Egypt at that epoch, and suggests that the more advanced works of Ḥabash and al-Battānī were not know there.
In the decennies to follow, the advent of the Fatimids caused groundbreaking changes in Egyptian society and culture. New institutions of learning were created (Halm 1997), and under the rule of al-Ḥākim Ibn Yūnus compiled astronomical tables which were much admired in later time (King 1972). It would all the more important to have documentary evidence on how all this affected astronomical practice. Luckily, the ephemeris presented here fullfills this purpose perfectly.
The document P. Vind.Inv. A.Ch. 25613 g is a small piece of paper containing the top left corner of a table on the recto, and the top right corner of the following table on the verso. On the verso the headers of the calendarium and the first three lines are peserved containing the dates of the first three days of the month. In the headers the four calendars are named: (i) *fārsī*, the Persian calendar, (2) *suryānī*, the Syriac calendar, (3) *qibṭī*, the Coptic calendar, and (4) ʿ*arabī* , the Islamic calendar.
The Persian calendar was base on a wandering year with a constant length of 365 days without intercalation, similar to the ancient Egyptian calendar. The first year of the reign of the last Sassanian king Yazdgird III was used as the epoch, and its beginning fell into the Julian year 632.
The Syriac calendar was equivalent to the Julian calendar, but used the Syriac names of the months, and was based on the Seleucid era.
In Coptic calender the names and lenghts of the months corresponds to those in the Ancient Egyptian calendar, but an intercalation of one day every four years was used.
The Islamic calendar was a Lunar calendar based on the observation of the Lunar crescent, but in astronomical works a cyclical system of 30 year periods was used as an approximation. Day-numbers in all four calendars even without the names of the months are sufficient for a sure absolute dating (Thomann 2014a). The first line corresponds to the ninth of May 1026 CE. The column to the left contains the days of the week, encoded in numbers running from 1 to 7. The ninth of April 1026 was a Monday, as indicated by the number 2. All figures are written with Arabic letters in the so-called *abjad* system, which is similar to the Greek system of writing numbers by letters of the alphabet.
There is one seeming irregularity in the calendar data. The dates in the Arbic column are one day ahead in comparision to the most commun calculation scheme for the Islamic calendar. However, already in the 9th century, Ḥabash al-Ḥāsib reported a controvery about the epoch of the calculated calendar and criticized scholars who used an epoch earlier by one day (MS Istanbul Yeni Cami 784 ff. 75v; cf. Debarnot 1985, 39). However, al-Battānī used the earlier epoch in their tables (Nallino 1899–1907, 7–17).
On the recto the upper left corner of the table covering the preceding Persian month is preserved. The lines correspond to dates which preceds the days on the verso by 30 days, starting at the 9th of April 1026 CE. The headers of the last two columns are (i) *irtifāʿāt*, “altitudes”, and (2) *sāʿāt al-nahār*, “hours of the day”. They contain the altitude of the sun at noon and the length of the day. These data provide valuable information on the geographical latitude and the values of the ecliptic longitudes of the sun.
The altitude of the sun at noon is equal to the complement of the polar height plus the declination of the sun. Since there is no a priori knowledge about the geographical latitude for which the table was calculated, the shares of the declinations of the sun are not immediately known. Nevertheless, the daily differences are independent from the

geographical latitude. There were two values of the obliquity of the ecliptic in use, the Ptolemaic value of 23° 51' and the new value of 23° 35' based on observations in the 9th century (Britton 1969, 30; Dalen 2004, 18–21). Consequently, both values must be considered in the analysis. Furthermore, depending on the underlying tables for solar motion a different amount for the daily change in longitude must be assumed. In brief, the analysis shows that the declination of the sun in the middle to the three days must be in the intervall of 8°55' and 10° 32', and therefore the geographical latitude, for which the table was calculated in the interval of 28° 53' and 30° 30'. This makes almost certain that the intended place was Cairo, for which a latitude of 30° 00' was used (Nallino 1899–1907: ii 32). This assumption allows for a more precise estimate of the solar longitudes. Comparing them with the values obtained by the tables of Ptolemy, al-Khwārizmī and al-Battānī, the last tables yield the closest fit (Toomer 1995, 142–143, 167; Suter 1910, 115–116, 132–137; Nallino 1899–1907, ii 10–23, 78–83). However, it seems that the underlying values are even closer to the precise values than those of al-Battānī. Based on this evidence, it seems likely that an advanced astronomical work was used. A promissing candidate are the Ḥākimite Tables of Ibn Yūnus.

Based on the assumed geographical latitude of Cairo, the values for the length of the day can be used for a test if the tables of Ibn Yūnus would have produced these values. The tables themselves are not edited, therefore the parameters mentioned in the earlier chapters were used (Caussin 1804: 216; Delambre 1819: 93–94). The solar longitude on the 9th of April according to a calculation with this parameters was 24° 37', a value 36' less than the value of al-Battānī. The corresponding values for the lenght of the day are 12h 45m and 12h 46m respecively. Ibn Yūnus' value matches exactly the value tabulated in our ephemeris. The difference of one minute is small and more tests have to be made in order to decide which astronomical tables were used in compiling these ephemeris, but at the moment it seems likely that indeed Ibn Yūnus' tables were the basis for calculation.

A priori, it can not be taken for granted that the best available tables were use for calculations. A horoscope for 17th of June 1082, found in the Cairo Geniza, contains an explicit statment that the Sindhind was used for its calcualtion (Goldstein 1977, 116-121). The first explict documentary reference to Ibn Yūnus occurs in a horoscope for 11th March 1122 (Goldstein 1980, 158–160). There, the compiler wrote: “All of it from the Zīj of our master, the Imām al-Ḥākim bi-Amr Allāh, blessings of God upon him.” Goldstein and Pingree made the assumption that two more horsocopes and a group of astronomical almanachs from the time-span of 1132 to 1158 CE were calculated by means of the Tables of Ibn Yūnus (Goldstein 1979, 153). In none of the cases did they provide calculations with different sets of parameters, but they based their assumption on an account of al-Maqrīzī on the founding of the Cairo Obervatory in 1120 CE.

If the analysis presented above is correct, the ephemeris of 1026 CE would shift documentary evidence for the use of the Hākimite tables of Ibn Yūnus back by one century and prove that they were used in practice very soon after their completion.

There is one column left on the recto. Its header indicates that it contains the position of the ascending lunar node, the *jawzahar*. Only the zodiacal sign Scorpion and the values for the arc minutes are preserved. The degrees are missing with the exception of a trace of inc slightly below the writing line. I might have belonged to 6 or 7 as the last digit. If 7 is assumed, the values are very closed to the precise values, but they dont match exactly the values obtained by means of the tables of al-Battānī (Nallino 1899–1907, ii 72–77). In the

edited part of the tables of Ibn Yūnus the mean movement of the lunar node is 19° 19' 44'' 21''' 48'''' in a Persian year (Caussin 1804, 216–217). In the unedited part of the tables, the complement of the longitude of the lunar node at 30 November 1000 CE is referred to as 11^{s} 21° 27' 3'' 33''' (Caussin 1804, 222). However, this last value is less accurate than the value according to a calculation with al-Battānī's table. Therefore, Caussin's reference seems doubtful. An attempt to find this value in the MS Leiden Or. 143 failed, but the question needs further investigation. The marginal notes are difficult to decipher, a situation which is not uncommun in such documents. In the right and the left margin, additional events like religious feasts would be expected, but no clue to the reading of these notes could be found.
The analysis of the document so far alows for a reconstruction of the entire document. Probably it was a booklet of 26 pages at least with tables for the twelve months of the Persian year 395, which corresponds to 10th March 1026 to 9th March 1027. Each bifolium covered one month. It started with the five narrow column for the calendar data, followed by columns for the sun, the moon, Saturn an Jupiter. On the left page of the bifolium followed Mars, Venus, Mercury and the lunar node. At the end were the two colums for the altitude of the sun at noon and the lenght of the day.
There exists a complete copy of an ephemeris of this type for the year 1326/1327 in the Dār al-Kutub in Kairo (King 1986, 132; King 2004–2005, ii 421, erroneously labeled "Ramaḍān 808 H."). It represents a new type since it combines an ephemeris with astrological predictions, the *ikhtiyārāt*. Furthermore, it is organizded by the Islamic calendar. However, for the question, how ephemerides in the classical Islamic period looked like, the study of fragments like the one presented here is indispensible.

iv	iii	ii	i	r°
Al-jusʾu bi-l-*th*awr h *j* [..]				1
	sāʿāt al-nahār	al-irtifāʿ	al-jawzahar	2
			al-ʿaqrab	3
	yb mh	sṭ mʾ	[kz] mw	4
	yb mw	ʿ b	[k]«z» mj	5
	yb mḥ	[ʿ] kd	[kz ..]	6
«...»	[.. ..]	[.. ..]	[kz ..]	7

vi	v	iv	iii	ii	i	v°
ikhrāj rabīʿ al-ākhar ..						1
ay ā m	ʿar ab ī	qi bṭī	su ry	fār sī		2
b	yṭ	yd	ṭ	ʾ		3
i	k	yh	y	b	...	4
[d]	kʾ	yw	yʾ	j		5
[h]	[kb]	[yz]	[yb]	[d]	...	6

r°	I	ii	iii	iv
1	[..] the part in [the zodiacal sign of] Taurus 5° 3'			
2	Lunar node	the altitude	hours of the day	
3	[Zodiacal sign of] Scorpion			
4	[27°] 46'	69° 41'	$12^h 44^m$	
5	[2]«7»° 43'	70° 2'	$12^h 46^m$	
6	[27° ..']	[70°] 24'	$12^h 48^m$	
7	[27° ..']	[70° ..']	[$12^h ..^m$]	«...»

v°	i	Ii	iii	iv	v	vi
1	Beginning (?) of [the month] Rabīʿ I					
2		Persi	Syriac	Coptic	Arabic	Days of Co
3		1	9	14	19	2
4	...	2	10	15	20	3
5		3	11	16	21	[4]
6	...	[4]	[12]	[17]	[22]	[5]

Table 1: *Edition and translation of the document P. Vind. Inv. A.Ch. 25613 g*[1]

[1] Letters in red are underlined, ascendingly slanted words have a line above, and decendently slanted words have a dotted line above. Letters with diacritical dots are in italics. Words within «» are difficult to read.

Figure 1: *recto of Vind.Inv. A.Ch. 25613 g (courtesy Papyrussammlung der Österreichischen Nationalbibliothek)*
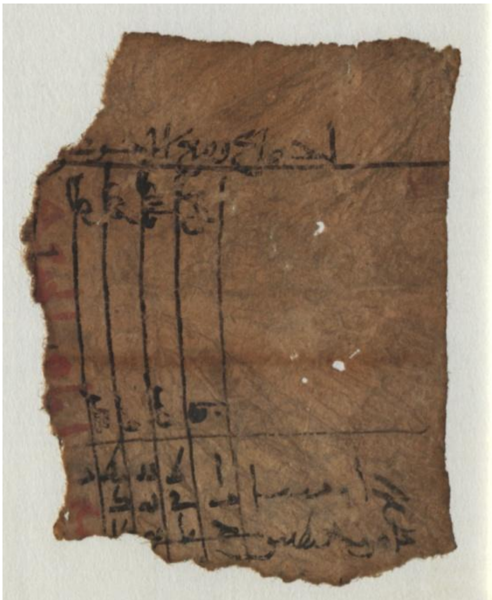
Figure 2: *Verso of Vind. Inv. A.Ch. 25613 g (courtesy Papyrussammlung der Österreichischen Nationalbibliothek)*

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Religion in the Cosmological Ideas in Ukraine (from XI to XVII century)

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Formation and development of outlook in Ukraine has a long history and dated the days when people could not actively influence the nature. People were an integral part of it and completely dependent on it. The biblical texts were of highest importance, but the Holy Scripture did not give answers to specific issues concerning the universe, the properties of things and the origin of phenomena. The sources of information were the works of ancient authors, especially Aristotle. Byzantine culture (IX-X centuries) made great contribution to in systematization of the knowledge available in ancient literature. There was no clean-cut division into specific scientific disciplines. The ancient knowledge is systematized during this period.

Michael Psellus
Michael Psellus (1018-1096) was one of the persons who started to criticise the Christian canons. He had the honorary as Consul of the Philosophers (Hypatos ton Philosophon) M. Psellus did not share the ideas of Aristotle and espoused Neoplatonism system of philosophy stating about the Uniqueness, the World Mind and World Soul. He relied on Ptolemy's concept of the geocentric universe, imagining the universe as a set of celestial spheres rotating around the spherical Earth [Pietsch , 2005; Pavlenko, 2001; Psell , 2003; Svyatski , 1962; Gavryushin , 1983].
Middle the views of M. Psellus were Simeon Seth. In work 'Overview of Natural beginnings' [Gavryushin, 1983] said he that the Earth rotates around the celestial sphere.

Figure 1: *Michael Psellus*

Structure of the World in accordance with the views of Cosmas Indicopleustes
In Ukrainian chronicles (beginning with the XI-XII) was described the structure of the world. There were several options: 'Christian topography' by Cosmas Indicopleustes (Byzantine

cosmography, merchant and later monk), ‘Shestodnev’ by Joseph Bulgarian Exarch, ‘Chronicle’ by George Hamartolus [Shinkaruk, 2001]. The mentioned works influenced considerably on the science in Ukraine. The astronomical interpretation of cosmological ideas, a system of Ptolemy, was stated in treatise ‘Izbornik’. There were two versions of them (in 1073 and 1076) that were the basic source of knowledge for residents of Kievan Rus (Kyivan Rus'). It is believed that these manuscripts were written in Kyiv, Ukraine. The authors by preparation of these works used as the basis the Byzantine texts. The first part of ‘Izbornik’ is analyzed astrological concepts. Its second part is included the information about the chronology of various nations and the names of months. In this work is contained the basic provisions of Aristotle’s Metaphysics [Pavlenko, 2001].

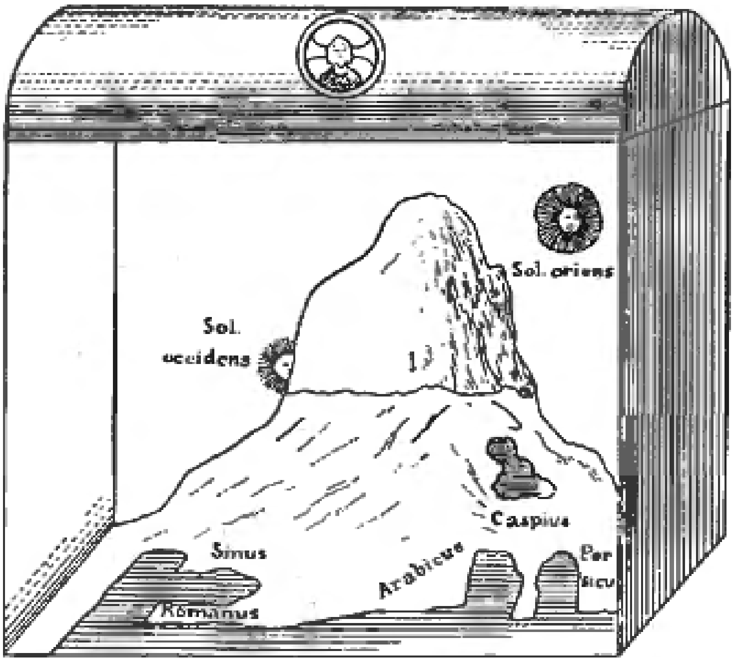

Figure 2: *Structure of the World in accordance with the views of Cosmas Indicopleustes*

Cosmas Indicopleustes rejected the geocentric theory of Ptolemy and a statement that ‘the Earth has a shape of sphere’. He tried to explain his ideas about the world structure on a basis of the Holy Scripture. C. Indicopleustes believed that the Earth has a shape of a flat rectangle. The Sun is behind a hill. The people live on the slopes of this hill. The Sky is solid and transparent. The Sky has a shape of a tent – it is the First sky. The Second Sky looks like a skin that was stretched on the First Sky. The Sun and the Moon are located below. The Moon shines and does not disappear, but hides its light. The Earth and the Sky are unmoved. The stars, the Sun, the Moon are moving lights. According to Indicopleustes, the World is a two-floor ‘building’. The first floor of this building is occupied by the Nature. The Second is separated by the Two-Layer Sky (firmament and water and invisible sky). The Earth looks like the Ark of Noah and the Tabernacle mentioned in the Old Testament. He opposed the ideas of Aristotle and Ptolemy, who believed that the Earth is round [Raikov, 1937, 8].
Not only were the above-mentioned primitive ideas concerning the structure of Universe but also ‘Shestodnev’ by Joseph Bulgarian Exarch was public in Ukraine. ‘Shestodnev’ highlighted the astronomical problems in view of the achievements of antiquity [Barankova, 1978; Shestodnev, 1879]. The first mention about the world appeared in the chronicle of Joseph

(XIII century). In ‘Shestodnev’ is said that the Earth is in the centre of spherical vault, which involves several moving concentric circles. The Circles are attached to the Sun and Moon, five planets ("floating stars") that perform loop-like movements, and unmoved stars. The Sun, Moon, stars and the creation have a shape of ball. The Sun moves along the underground and aboveground floors. Within the year the Sun crosses along 12 zodiacal constellations, moving along ’life-giving’ circle. In ‘Shestodnev’ are contained many astronomical information: data about the size of celestial bodies, explanation such phenomena as equinox and solstice, the change of seasons, deviation in the shadow of the Southern Hemisphere, as well as information related to the climatic zones of the Earth. It contains also information concerning the structure of the world according to Ptolemy and C. Indicopleustes.
Distribution of cosmography tenets is stated in ‘Christian topography’ by Cosmas Indicopleustes and ‘Shestodnev’ by Joseph Bulgarian Exarch allow to state that the astronomy in medieval Ukraine had two trends: one trend – primitive explanation of correspondent tenets of the Holy Scripture, the second one – understanding of astronomical knowledge of the ancient Greece. In spite of the fact that both trends based on Christian tenets, the first one was more fantastic and far from the true picture of the world in compare the second one, which explained its structure using the ancient knowledge.
In the XV century in Ukraine were spread ‘Cosmography’ De-Sakrabosko (John Halifax) and ‘Shestokryl’ Immanuel bar-Jakob (Jewish scholar XIV century). In Ukrainian version of ‘Shestokryl’ is stated that the Earth had a shape of a ball [Golovko, 1998; Shinkaruka, 1987]. In the work also is said that the celestial bodies were moving owing to self –rotating of spheres. There are nine celestial circles. The Author of ‘Cosmography’ said: ‘All sky are situated in each other. This structure is like to an onion’. In the same time ‘The Earth in the centre of the Sky. It does not move.’ [Shinkaruka, 1987, 178].
It is believed that Zachariah (Shariya) (scientist from Kyiv city) translated and disseminated ‘Shestokryl’ that was used for astronomical calculations. The appearance and spreading of ‘Cosmography’ and ‘Shestokryl’ in the second half of XV century can be considered as a new stage in the development of astronomical ideas in Ukraine. In the spirit of scientific traditions Renaissance, educated people had the opportunity to discover and to have a familiarization of Aristotle and Ptolemy’s systems through these works.
The accumulation of physical and mathematical knowledge in Ukraine was favored by the activities of Ukrainian humanists of the period of the end of XV – the beginning of XVI. The ideas of Renaissance came into Ukraine owing to the education of Ukrainian people in the universities of Vienna, Padua, Bologna, Venice, Rome and Krakow. The period of creation of new generation of humanists was the end of XVI – the first half of XVII century. The representatives of humanists organized and took part in the life of cultural and educational centers. The most important among these centers was Ostroh (Ostrog) Academy, which combined the old Ukrainian and Greek-Byzantine traditions of educational achievements of Europe. There were taught ‘seven free sciences’, including mathematics, astronomy and philosophy. Its students studied the works on mathematics, astronomy, philosophy and physics, written mostly in Latin. Among them is ‘Cosmography’ by Bleu I., which contained information about the Copernicus’s ideas about the structure of the world. ‘Cosmography’ by Bleu I. was translated into Russian language by Epiphany Slavinetsky (1645-1647) and was known under the titles ‘Mirror of whole World…’ and ‘astronomical calendar of 1506’ and others.

At the end of the first quarter of the XVII century, Kyiv had a status of the leading orthodox cultural and educational center. Its influence was strengthened by the formation of Bratsk School, printing activity of Kyiv Pechersk Lavra and the activities of the orthodox metropolitan department. At that time, in Kyiv was builded the Kyiv-Mohyla Academy. Its students formed an influential layer of educated clergy, who favored the spread of knowledge. The level of the courses studied in the Academy met the demands of West-European Higher Education. While studying theoretical courses, the main authorities were Aristotle and Thomas Aquinas [Pavlenko, 2001].
At the end of XVII century Kyiv-Mohyla Collegium was achieved the status of the academy. It was introduced the course of theology. Training in Academy in high school lasted six years and involved two-year course of philosophy and four-year course of theology. Philosophy was divided into "natural philosophy" (followed by further in-depth studying of mathematics) and metaphysics. The natural philosophy included physics (cosmogony, meteorology and others) and physiological psychology. Metaphysics considered supernatural phenomena, their causes and general principles according to belief that 'the God creates the world' [Khyzhnyak, 2001; Mankovsky, 2003].
Courses of philosophy that were read in Ukraine in the first half of XVII century were similar to those taught at leading European universities. According to Ukrainian researchers, the lectures of Galileo in Padua University (1592 – 1610) were visited by 52 Ukrainian students. Many Ukrainian men's studied in Rome (among them are Joazaf Krokowski, Theophan Prokopovich, Teofilakt Lopatynskyi, Innokenty Gizel). In the Academy was formed a new philosophical worldview. Today, the researchers of philosophical heritage of Kyiv-Mohyla Academy believe that it had two directions of development of philosophy knowledge. One of them is a research and an education. Its representatives put more emphasis on the development of science, education, crafts, arts and education. It was so-called Peripatetic natural rationalistic line. It was supported by I.Gizel, J. Krokowski, Th. Prokopovich, G. Rodin, M. Kozachynska and others.

Innokenty Gizel

Innokenty Gizel (1600–1683) studied at the Mohyla collegium which later became known as the Kyiv–Mohyla Academy (National University of Kyiv-Mohyla Academy). He studied philosophy, theology, law and other sciences in the Zamojski Academy and at universities in Germany and England [Gorsky, 2002]. I.Gizel included knowledge about all directions of philosophy in his philosophy course 'The work of the whole philosophy' that taught at the Academy in the 1645-1647 [Gizel, 1981; Gizelius 1647]. Chronologically, his work was the first course of Nature Philosophy that was read at the Academy. Besides geocentric world system, I.Gizel studied the system of Copernicus. It was the first mention of the name of N. Copernicus in Ukraine in an educational school.

Figure 3: *Innokenty Gizel*

Professors of the Academy S.Kleshanski, S.Jaworski, I.Popovski were not satisfied with the Aristotle–Ptolemy's theory. So they tried to develop another theory of the world structure. They did not recognize Copernicus' theory correct, but during his teaching, they used Copernicus's tables and drawings. In this way, they gave their students possibility to decide themselves whether the theory was correct or not.

Theophan Prokopovich

Theophan Prokopovich (1677–1736) studied at Kyiv-Mohyla Academy and in the Academy in Rome. He listened to the lectures in the universities of Hale, Leipzig, Hyena and Kongsberg. In 1705–1716 he taught all the higher sciences at the Academy and was the first man who began to acquaint students with the teaching of Descartes, Locke and Bacon. Th. Prokopovich was also the first who gave an explanation of Copernicus's theory. He wrote about physics: "It 'fertilized' all art and considerable favored the life of human race" [Prokopovich, 1980, 115].

He defines the notion 'world' in 'Natural Philosophy or Physics' [Prokopovich, 1980, 113-502]. According to him, the world is the structure that consists of heaven, earth and other elements that are located between the heaven and earth. In other words, the world is 'the order and location of all that is saved God' [Prokopovich, 1980, 283]. Th. Prokopovich acquainted students with all common theories about the universe of that time. At the beginning, he taught the world system of Ptolemy. He mentioned that this theory was offered by Pythagoras. However, being an outstanding mathematician, Ptolemy explained the antique system in more detail [Prokopovich, 1980, 286]. Then, he taught Copernican's system. Th.Prokopovich emphasized that this theory was insufficient to explain the many complexities of astronomy. He also said that the Earth does not move and the Sun moves. Then, he introduced the theory of Tycho Brahe.

Despite the fact that in his course Th. Prokopovich taught various systems of the world, but he believed that the world had been created by God. He mentioned that according to Holy Scripture, the world did not exist forever, 'Heaven and Earth were originally created' [Prokopovich, 1980, 296].

Figure 4: *Theophan Prokopovich*

So, Ukraine scholars knew about all models of the universe that existed at that time. The schools gave students information about all existing at the time cosmological theories. After appearing of heliocentric system, Western Europe suffered the war between science and religion. However, Ukraine students were acquainted with not only with Ptolemy's system and Copernicus's theory, but also Descartes' and Kant–Laplace's one. It should be noted that until the end of the XVIIIth century a key role in explaining the origin and structure of the Universe had a religion and the Bible text.

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The reception of ancient astronomy in the early histories of astronomy

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In the present paper, I would like to explore how 18th century astronomers and historians of astronomy perceived astronomical knowledge of ancient times. In order to use the limited space effectively, I will focus on several issues that I consider crucial: antediluvian astronomy, assesment of the role of Greeks in the history of astronomy, assesment of the ancient heliocentrism and introducing social and cultural factors in the history of astronomy.

Intoduction

In the Early Modern period, many astronomers believed that an extensive astronomical system existed before the biblical Flood. This belief was particularly inspired by an account of antediluvian astronomy provided by the Jewish historian Flavius Josephus (1st century AD). Flavius states that biblical patriarchs who lived before the Flood obtained extraordinary astronomical knowledge. Later, they attempted to pass this knowledge on to their descendants to protect them from the predicted flood. For that reason, the known facts and discoveries were inscribed on a stone and a brick pillar which were expected to survive the deluge (Flavius 1961, 32).

In the 16th and 17th century, many astronomers considered Flavius' account to be true, believing that a developed astronomical system used to exist before the deluge, but was unfortunately lost to a sinful mankind. Furthermore, many astronomers, such as Tycho Brahe, considered antediluvian astronomy to be the ideal and perfect astronomical system, which, although lost hundreds of years ago, mankind should be striving towards. Any development in astronomical theory was therefore not perceived as progress toward new knowledge, but as restoration of the original ideal state of astronomy that had been purged of mistakes (Brahe [1574] 1913, 148; cf. Rose 1975, 1–3, 90f.; Goulding 2010, 19–73, Špelda 2013).

However, 18th century astronomers were highly sceptical of the idea of antediluvian astronomy for the two following reasons: a) They had a different concept of history: They believed that the history of astronomy is characterized by continuous progress. This means that throughout history, astronomy shows continuous improvement – from its crude beginnings, this field of knowledge has developed more or less inductively by moving in small steps toward perfect knowledge. The idea of a restoration of a certain original astronomy existing in the beginning of history is alien to this progressivist thinking (Costard 1767, 27, 302; Estève 1755, 15–18; Montucla 1758, 54f; Weidler 1741, 14–17). b) They questioned the credibility of sources: In the 18th century, biblical history was no longer considered an obligatory frame for historical thought. But historians similarly took a critical approach toward reports by pagan historians. For instance, historians of astronomy accused Flavius of having invented the story of antediluvian astronomical knowledge in order to emphasize the historical importance of his own people. When dealing with the problem of

origin of astronomy, historians of astronomy mostly referred to the fact that nothing certain can be determined regarding astronomical knowledge in the most ancient period of human history, and that any speculation on this issue is useless (Cassini 1740, iv–v; Costard 1767, 29–32; Estève 1755, 17–50; Goguet 1758, vol. I, 1–6, 213–220; Montucla 1758, 58–60; Savérien 1766, 117; Weidler 1741, 17f).
To my knowledge, the last great historian of astronomy advocating the theory of antediluvian astronomy was Jean-Sylvain Bailly. However, Bailly no longer followed the biblical paradigm. Although he was convinced that in the time before the deluge a developed civilization existed that possessed exquisite astronomical knowledge, he believed that this civilization was Atlantis. In Bailly's opinion, the home to this civilization were islands Novaja Zemlja (north of Russia) and, after its destruction, several survivors brought this knowledge to the south. The astronomical knowledge of the inhabitants of Atlantis served, according to Bailly, as the fundamentals of early Asian civilizations in China, India and Chaldea (Bailly 1779, 435–465; Bailly 1777, 136–155; Bailly 1781, 81; Bailly 1782, vol. I, 132, 153–155; cf. Rheina 2003).

Assessment of the role of the Greeks in the history of astronomy
In the 18th century, astronomers and historians of astronomy tended to belittle the importance of classical Greek culture in the history of astronomy.[1] As a positive counterpart to classical culture, they especially praised instead the Hellenistic School of Alexandria whose members were supposed Timocharis, Aristillus, Aratus, Apollonius of Perga, Eratosthenes, Manetho, Aristarchus, and Hipparchus. This negative approach to the classical Greek culture had two main reasons:
a) Historical reason: All of the quoted historians agreed that from the very beginning, the Greeks adopted astronomical knowledge from other cultures: Egyptians, Chaldeans, the Hebrews or Phoenicians. From the start, the Greeks were therefore indebted for their knowledge to other cultures. Classical Greek astronomy was not considered an original but a derived system, which, as such, cannot claim historical authenticity. Thales was only able to predict the eclipse of the sun thanks to Chaldean knowledge. Authentic Greek astronomy did not arrive until the School of Alexandria which was regarded by many authors as a brand new stage in the history of astronomy (Bailly 1787, clxiv–clxxiv; Bailly 1781, 185–197; C. F. G 1792, 17; Costard 1767,80; Goguet 1758, vol. II, 488–59; Montucla 1758, 98f.; Savérien 1766, 117,130; Weidler 1741, 66–68).
b) Methodological reason: The 18th century astronomers and historians of astronomy believed that real progress in astronomy consists only in patient and long-term observations. However, they pointed out that classical Greek astronomy was speculative, not empirical. In the classical period, Greeks constantly failed to separate astronomy from philosophy and were dealing with pointless and redundant issues, elaborating absurd hypotheses, drowning in useless disputes and arguments, were secretive and disrespectful of facts, they were impatient and neglected empirical research. Any Greek discoveries in the classical period, according to historians of astronomy, were made purely by accident or a stroke of a genius – and not as a result of systematic astronomical research. The approach of historians to Greek astronomy, however, changes significantly with the establishment of the School of

[1] The term "classical" culture here stands for the time of Plato, Aristotle, Eudoxus until the death of Alexander the Great.

Alexandria (Bailly 1781, 257–9; Estève 1755, 158–165; Laplace [1796] 1884, 405; Montucla 1758, 215). Astronomical discoveries were no longer made by accident, but by induction from accurate observations. All historians agreed that the Alexandrian tradition culminated in the work of Ptolemy whose work they perceived positively.

Assessment of ancient heliocentrism

Works on the history of astronomy written in the period of Enlightenment provide a different evaluation of the Greek heliocentric system than today's textbooks. Here, I would like to mention three principal issues.

a) The issue of origin: In the 18th century, historians of astronomy believed that the supporters of the heliocentric system were Pythagoras, Philolaus and Aristarchus of Samos. However, according to historians, these astronomers were not the authors of the heliocentric scheme. In line with the assumption that ancient Greek astronomy had been adopted from other cultural sources, 18th century historians believed that Greek thinkers had not invented the heliocentric system themselves. The Greeks had only adopted the original Egyptian idea that inner planets (Venus and Mercury) revolve around the Sun. This system was known in Europe from the descriptions by Capella or Macrobius. According to them, this scheme was adopted and further elaborated by Pythagoras (Goguet 1758, vol. III, 181f; Weidler 1741, 84). Moreover, Bailly, the last advocate of the existence of antediluvian astronomy, was convinced that the Egyptian heliocentric system is only a remainder of the knowledge of ancient Atlantians who had been aware of the true arrangement of the world before the deluge (Bailly 1781, 220f, 413, 449; 1777, 212; 1779,126–129).

b) Persecution of the supporters of heliocentrism: Generally speaking, until approximately the 1750s, books or chapters on the history of astronomy did not, in any way, indicate that Greek supporters of heliocentrism would have been in any conflict with religious authorities. Since the second half of the 18th century, however, the entire culture of Enlightenment was imbued with an anti-clerical spirit. This was also reflected in the history of astronomy: A belief started to emerge that astronomical truth, i.e. heliocentrism, was suppressed by the representatives of religious power (C. F. G 1792, 25; Bailly 1781, 221; 1785, vol. I., 22).

c) The issue of convincingness of ancient heliocentrism: All of the above-quoted authors more or less shared their belief that ancient heliocentrism had not been sufficiently proved. Heliocentrism was only a philosophical opinion not based on observation and, as such, was of no relevance to astronomers. Montucla even expressly states that for contemporaries, the heliocentric theory only had a character of an "paradoxe ingénieux" (Montucla 1758, 212). According to the historians of astronomy, all facts known to astronomers at that time supported the geocentric theory. There was no evidence of heliocentrism that would be convincing in astronomical terms (Estève 1755, vol. I, 250). 18th century historians understood the Greek heliocentrism as a result of philosophical speculation, and not of mathematical calculation and astronomical observation – which was the reason why it had never become a respected theory. Moreover, according to them, geocentrism better corresponded to the immediate sensual experience – and Greek astronomers remained strongly rooted in the realm of sensory experience (Montucla 1758, 205; Savérien 1766, 121; Laplace [1796] 1884, 407). The system devised by Copernicus was believed by 18th century historians of astronomy to be the triumph of modern European mind: Modern heliocentrism is a symbol of supremacy not only of modern astronomy but also of the modern European spirit, which is able to free itself from the shackles of immediate sensory experience (Bailly 1785, vol. I, 24, 348, 364; Goguet 1758, vol. III, 181f).

To sum up, the assessment of heliocentrism corresponds with the general concept of astronomical progress in the Enlightenment period. Astronomical progress is slow, interrupted and based especially on long-term collection of data. The discovery and recognition of the true arrangement of the universe, i.e. heliocentrism, would, in this context, seem rather like an anomaly in the historical development of astronomy because the truth cannot be revealed at the beginning of history. Therefore, according to the historians of astronomy the Greek heliocentrism is an historical paradox: Heliocentrism had been discovered before it should have ever been known: yet only as a result of random philosophical speculation, not genuine astronomical research.

Social and cultural factors in the history of astronomy

The theory of progress in science supported in the period of Enlightenment also included the specification of factors affecting the history of astronomy. Enlightenment scholars defined two basic types of such factors: a) cultural-political; b) climatic:

a) The classical recurring theme in all theories regarding the history of science ever since the 17th century was the emphasis on the role of rulers in the context of the history of astronomy. The Muslim Khalifs of Baghdad and Alfonso X of Castile were oftenly mentioned in books or chapters on the history of astronomy. Enlightenment scholars gradually abandoned this trivial idea of political support. Instead, they developed a theory that knowledge is dependent on political systems and forms of government. They believed that anarchy and despotism hinder the development of science. Anarchy, above all, does not guarantee a secure, peaceful and stable environment, which is a prerequisite for long-term cultivation of science (Hume [1742], 1994, 61–69).

However, Enlightenment scholars considered despotism to be a much worse form of government than anarchy. Political despotism breeds intellectual despotism. Political rule of one authority leads to the worshipping of authorities also in science, resulting in the absence of original research. In the spirit of the strong Eurocentrism of the 18th century, Enlightenment historians believed that large Asian empires did not provide a suitable environment for the development of science and that science could prosper better in smaller democracies or constitutional monarchies of the European type. In such smaller states people are more successful in fighting against the authoritative power and in gaining intellectual freedom that is so beneficial for the development of science (Goguet 1758, vol. I, 258–62; Montucla 1758, 394; Smith [1795] 1982, 51f).

This theory also provided an explanation of the history of astronomy: Astronomy emerged in large Asian empires, because there had been stable political order. However, because of the despotic rule the progress of astronomy in these empires eventually stopped and became fossilized. Then “democratic” Greeks adopted the basic astronomical knowledge of these cultures and improved astronomy considerably and in a highly original way. Whereas Greece saw a boom in astronomy, the arrival of the world-ruling Christian church brought about the dark age of astronomy. Similarly, according to the historians, the Chinese Empire used to have original and innovative astronomical research at the beginning, but today the Chinese themselves do not understand their own astronomy any more – they only use procedures inherited from their ancestors (Montucla 1758, 382–385). Similar conclusion drew Bailly for Indian astronomy (Bailly 1787, lxxiii-vi).

b) Climate: During the Enlightenment, it was widely believed that the form of government is significantly affected by climate. The French philosophers developed a theory on the impact of climate on the nature of individual nations and their political establishments: Northern nations, i.e. Europeans, are rational, laborious, courageous, virtuous and honest. On the other hand, Southerners, i.e. Asians, are permanently exposed to heat; that is why they are licentious, fearful, cowardly, sensual, indolent, lacking self-control and succumbing easily to their passions. They lack tenacity and are unable of long intellectual activities. Northerners live in republics or monarchies, whereas Southerners suffer under despotic regimes because they are too weak, indolent and tired from the heat to be able to fight against authorities. This theory was also reflected in the descriptions of the history of the sciences: Asians are able to pass down discoveries from generation to generation as well as to accumulate data in the long term. However, they lack natural curiosity as well as intellectual persistence and they are unable to overcome the rule of authority. Original ideas were always produced by the creative and laborious Northerners. This was the argument used e. g. by Bailly to explain the supremacy of the School of Alexandria over the astronomical teachings of the Chaldeans and Egyptians. The same explanation was used for advocating the modern European astronomy against admiration for Chinese astronomy: the Chinese are fearful and superstitious and, although they have a long tradition in observation, their intellectual development has come to an end (Bailly 1785, vol. I., 261–281, vol. III, 302, 322; 1781, 104f, 362; 1777, 92–95, 190,198, 261–263).

Conclusion

Historians of astronomy at the time of the Enlightenment appreciated the two steps taken by Greek astronomy in the course of its development: a) in the classical period, the Greeks were able to successfully connect astronomy with geometry; b) in the second step, the School of Alexandria refused all philosophical speculations and decided to follow the line of long-term observation and the inductive generalisation of data. The 18th century historians believed that these were fundamentals of modern astronomy which is where indisputable significance of the Greek astronomy lies. On the other hand, theories developed by Enlightenment historians clearly indicate that they believed that the greatest boom arrived only in the 17th and 18th centuries – i.e. in modern times, when scientists managed to abandon prejudices and restrictions which tied the hands of ancient astronomers. The history of astronomy thus served in a way as a proof of the supremacy of modern times over antiquity.

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Acknowledgements
This study was supported within the project of Education for Competitiveness Operational Programme (OPVK), Research Center for the Theory and History of Science (Výzkumné centrum pro teorii a dějiny vědy), registration No. CZ.1.07/2.3.00/20.0138, co-financed by the European Social Fund and the state budget of the Czech Republic.

Around Henri Poincaré's Centenary: physics, mathematics and philosophy

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Year 2012 will celebrate the centenary of the death of Henri Poincaré (April 29th 1854 in Nancy, July 17th 1912 in Paris), who was one of the last great universal scientists. Not only Poincaré has made important contributions to mathematics, celestial mechanics and mathematical physics, but he was also interested in philosophy, in diffusion of science and (less known) in science teaching.
If everyone agrees to praise Poincaré's works in the field of mathematics, the situation appears to be more contrasted in the field of theoretical physics, due in part to an underestimation of the conceptual role of mathematics in physics and to an abusive recourse to "conventionalism" so as to specify his "philosophy".
We propose to focus this symposium on Poincaré's last works in physics (the dynamics of the electron and the gravitation in 1905, and the quanta in 1911) on which he comes back, with a more philosophical point of view, in Mathematics and Science: Last Essays (1913).
Poincaré's late contribution to the theory of quanta is not well known and his attitude towards relativity theory has suffered from repeated misconceptions concerning, either the Palermo Memoir and its logic, or his scientific popularizing texts which reproduce principally Lorentz' approach with some additional pedagogical remarks, bearing no relation with the Memoir. In this text, the role of the electromagnetic conception of Nature needs to be clarified.
More generally, this symposium aims to associate an analysis of the contents of Poincaré's contributions to modern theoretical physics with a discussion of his scientific methodology, emphasizing his aptitude to operate unexpected relations between e.g. precise mathematical results or concepts and paradigmatic changes in physics.

Poincaré's 1905 Palermo Memoir: analysis of its logic and comparison with secondary texts

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The context: Poincaré confronted to the theoretical physics of his time
(i) The Least Action Principle (LAP).
This principle has dealt for a century with optics and mechanics, beginning with Maupertuis who defines the action *S* as the sum of products Velocity x Length (for the refraction of light) or Mass x Velocity x Length (for collisions). It says that the action should be a minimum during the evolution of an actual system. The formalism is developed further until the beginning of 19th century with Euler, Lagrange and Hamilton, to take its modern so-called Lagrangian form

$$\dot{q} = \partial H/\partial p, \quad \dot{p} = -\partial H/\partial q, \quad S = \int L(q,\dot{q};t)dt, \quad L = p\dot{q} - H, \quad \delta S = 0$$

Throughout the second part of the 19th century, the LAP is extended to hydrodynamics, electromagnetism and even thermodynamics, i.e. to complex systems where it is difficult to determine the physical quantities associated with the *q* (position) and *p* (momentum) variables. In his 1873 famous *Treatise* on electromagnetism, Maxwell introduces a LAP for circuits in mutual induction and interaction, with the electric variables $(\dot{q}, p)$ being identified respectively with current intensities and magnetic fluxes.
Poincaré considers that the LAP was "*Maxwell's major unnoticed contribution*", "*one of the great principles in physics*", independent of any complete mechanical explanation and allowing through variable reductions to get rid of internal variables and microscopic models. In 1899 he already describes Lorentz theory in terms of a LAP involving unobservable ether variables from which the fields depend. It is then not surprising that in the *Memoir* action is omnipresent and electron models, though important in the discussion, play a secondary role.
(ii) Poincaré as a geometer: the key role of groups and the use of active transformations.
As Poincaré repeatedly said "*The object of geometry is the study of a specific group*", geometrical properties being those which are invariant with respect to the group of motions. In the *Memoir*, the group will be Lorentz' one and the dynamics will come out of the invariance of the action with respect to it. The transformations can be either passive (changes of inertial frames in physics) or active (changes of the physical system). In the *Memoir*, Poincaré uses what we call today "boosts" to set the electron into motion or bring it to rest.
(iii) Lorentz 1895: dielectrics in motion and the "*principle of corresponding states*".
By a change of variables (and not of frame) Lorentz brings Maxwell equations for an electromagnetic system in global motion at the velocity *V* in the ether in a form identical to that for the system at rest, at least at first order in *V*/*c*. It allows understanding why the motion of the Earth cannot be detected by electromagnetic experiments. The change for variables and fields differs slightly (but significantly) from a Galilean one (Bracco and Provost 2013a):

$$x' = x - vt; \qquad t' = t - \frac{Vx}{c^2}$$

$$E' = E + V \wedge B; \quad B' = B - \frac{V}{c^2} \wedge E$$

For the Lorentz' *Jubilee* in 1900, Poincaré interprets physically the Lorentz *local time t'* above as the time resulting from the synchronization process of observers who ignore their state of translational motion in the ether and who have synchronized their clocks by using light signals (*c* invariant at first order).

In 1904, Lorentz gives the correct changes (LT) at any order; however only three over four Maxwell equations are invariant. The reason is that Lorentz used a Galilean boost $v = v_0 + V$ (where v_0 is the velocity field of the charges in the system at rest) to define the system in global motion, which is incompatible with the LT. Poincaré has realized it at the very beginning of the *Memoir*: He modifies Lorentz' definition of global motion by introducing active "Lorentzian" boosts on the electron (Provost and Bracco 2006).

(iv) The electromagnetic models of the electron.

In 1900, Poincaré introduces also a momentum density $E \wedge B$ for the electromagnetic field in order to satisfy the "*reaction principle*". In the same *Jubilee*, Wien proposes "*an electromagnetic foundation of mechanics*" which will be developed first by Abraham and soon after by Lorentz. The main tool is the spatial integration of energy $(E^2 + B^2)/2$, momentum $E \wedge B$ and Lagrangian $L = (B^2 - E^2)/2$ electromagnetic densities, in the quasi-stationary regime. But two problems arise. Firstly, which form for the moving electron? It remains spherical for Abraham; it gets contracted along the direction of motion for Lorentz by $\gamma^{-1} = \sqrt{1 - v^2}$, and by $\gamma^{-2/3}$ for Langevin (with a transverse dilation $\gamma^{1/3}$ to keep the volume); Poincaré chooses the only model (Lorentz' one) which obeys the "*postulate of relativity*". Secondly, Hamilton equation $p = \partial L / \partial v$ needs to be satisfied; Poincaré modifies Lorentz' model by introducing the so-called "*Poincaré's pressure*". Let us now comment some noticeable aspects of the *Memoir*.

Four keys to understand the logic of the *Memoir*

In the first section of the *Memoir*, just after having written Maxwell equations and Lorentz force, Poincaré notes that these equations "*admit of a remarkable transformation discovered by Lorentz* [invariance of electromagnetism by LT], *which is of interest because it explains why no experiment is capable making known the absolute motion of the universe* [relativity postulate]"; he writes them in a modern way (which is not that of Lorentz)

$$x' = l\gamma(x + \varepsilon t), \quad y' = ly, \quad z' = lz, \quad t' = l\gamma(t + \varepsilon x); \quad \gamma = (1 - \varepsilon^2)^{-1/2}$$

l is a dilation factor to be specified and ⍰ is a dimensionless speed (Poincaré takes $c = 1$). Many commentators have set $\varepsilon = -v$ to match the above equations with the standard (passive) interpretation of the LT, but this is erroneous since no change of frame is mentioned in the *Memoir*, (see (ii) and (iii) above). The *Memoir*, which is a mathematical setting of Lorentz' work, begins with a kinematical part. Poincaré considers a spherical "*electron in uniform translation*" defined by $(x - v_x t)^2 + (y - v_y t)^2 + (z - v_z t) = r^2$ and notes that "*the transformation will change it into an ellipsoïde* [its image]":

$$\gamma^2 (x' - \varepsilon' t' - v_x t' + \varepsilon v_x x')^2 + (y' - v_y \gamma t' + \gamma \varepsilon v_y x')^2 + (z' - v_z \gamma t' + \gamma \varepsilon v_z x')^2 = (lr)^2$$

This formula already contains the contraction and the composition law for velocities. Together with the invariance of the charge, it allows correcting Lorentz' transformations first for electric densities $\rho, \rho v$, then for forces $f = \rho(E + v \wedge B)$ and $F = f/\rho$ (those for potentials *A*, *V* and fields *E*, *B* being Lorentz' ones). Since *F* enters the equation of dynamics $F = dp/dt$, its transformation law, recovered by Planck only in 1907, is a major result of §1. For $l = 1$, it allows Poincaré suggesting for the first time relativistic gravitational forces in §9.
As well known, Poincaré states in §4 that if *l* depends on ⍰, the "*Lorentz condition*" $l = 1$ corresponds to a group condition for the LT. Why such a group argument? Poincaré's correspondence with Lorentz in May 1905 (Walter et al. 2007) sheds a new light on this question. After having tried $\gamma l = 1$ (conservation of the unit of time) and $\gamma l^3 = 1$ (Langevin's model which satisfies Hamilton equations), he realized that Lorentz' derivation of $l = 1$ (initially obscure to him) dealt with the invariance of the equation of dynamics. That such an invariance called for a group property was natural to Poincaré as mentioned above in (ii).
The LAP (present in §2, 3, 6, 7, 8) and the invariance of action by the LT (considered in §3, 6, 8), both play a strategic role in the *Memoir* (Bracco and Provost 2009). One must first pay attention to the variables which enter the action because Poincaré makes several reductions, from the infinite set describing the fields and charge densities to the three of position of a quasi-punctual electron, i.e. schematically:

$$S_{em} = \int d^3 r \left[\frac{E^2 + B^2}{2} - j.A \right] dt \xrightarrow{\S 3} \int d^3 r \, \frac{E^2 - B^2}{2} dt \xrightarrow{\S 6} S = \int - L dt$$

Secondly, one must take into consideration that the invariance $S = S'$, which is obtained in §3 from the transformations of *E*, *B* is shown, in a remark of §6, to imply that the Lagrangian *L* above must read $L = \gamma^{-1} l L'$. (Primes correspond in §5-6 to an electron at rest and *L'* is a constant). The reason, Poincaré says, is that the LT imply $dt' = \gamma^{-1} l dt$ if *x'*, i.e. $(x - vt)$ is fixed $(dx' = 0)$. If at this stage of the *Memoir*, Poincaré had called for the group condition of §4, he would have obtained immediately the relativistic Lagrangian $L = -A\sqrt{1 - v^2}$ (written in §7), independently of any model.
To understand why Poincaré does not make this simple deduction in the *Memoir*, one must again refer to his correspondence with Lorentz. In his 2nd letter, just after having convinced himself that relativity implies in mechanics $l = 1$, he points out a serious problem: Lorentz' model with $l = 1$ does not satisfy $p = \partial L/\partial v$, whereas Langevin's one (in contradiction with the group argument) does. Therefore a relativistic model of the electron (an existence theorem as mathematicians say) is missing. In a 3rd letter, he announces abruptly that the problem is solved by adding to the electromagnetic Lagrangian *L* a term proportional to the volume of the contracted electron, i.e. to $\sqrt{1 - v^2}$. This term ensures the electron stability in a covariant manner. The thorough discussion by Poincaré of models in §6, in relation to the possibility for *l* to be *a priori* different from 1 and to the electron stability, then appears as a pedagogical attempt to let the reader (Lorentz) realize and overcome the problems he himself has encountered. Lorentz' answer to his reception of the *Memoir* shows that Poincaré has not succeeded (Walter et al. 2007). Nevertheless, his derivation of the relativistic Lagrangian and his proof of the invariance of the equation of dynamics appear to be both general and original. However, relativistic dynamics is not yet achieved since Poincaré does not pay attention to the general correspondence between mass and energy,

which interests Einstein at the same time and which will interest the physicists until 1911 (Provost 2013; Provost and Bracco 2013).

One must finally remark that the *Memoir* ends with an extensive discussion of gravitation, a subject of which Poincaré was a reputed expert. But although he introduced a quadridimensional formalism, he was not able to find an unique solution for gravitational forces. Surely he thought at that time of the perihelion advance of Mercury which he showed to be partly explained in his 1906 lectures (Poincaré [1906b] 1953). As well known, the solution will be given by Einstein in 1915.

Poincaré's positions with respect to relativity

If Poincaré has only published one scientific paper on relativity, he has expressed himself many times from 1908 to 1912, in conferences for a large audience or in books but without mentioning the *Memoir*. In these conferences, either he follows (as he says himself for pedagogical reasons) an historical approach which is Lorentz' one; or he adopts positions with respect to the teaching of mechanics (Bracco and Provost 2013b). One must remind that he collaborated to the 1902 Leygues reform of teaching in France and also members of his family were involved in teaching policy (his cousins Raymond and Lucien respectively as minister of public instruction in the 1890's and general inspector in physics). It is then not surprising to find in (Poincaré [1908] 1914) the warning: "*Suppose that within some years these theories* […] *triumph. Secondary school teaching will be in great danger: some teachers will surely introduce them* […] *Then* [children] *will not get used to ordinary mechanics* […] *Whatever the progress, our cars will never reach speeds where it is no longer valid. The other* [the new mechanics] *is just a luxury and one must think about luxury only when it does not risk to affect the necessary"*. Does it mean that Poincaré doubts of the new mechanics?

One must read (Poincaré [1913] 1963) to apprehend his real position. In particular, in *The evolution of Laws* (1911), he imagines a relativistic world: "*For example, the fundamental laws of mechanics have long been considered as absolute. Today some physicists say that they should be modified* […] *that they would cease to be true at velocities comparable to that of light* […]. *But could we not say with some semblance of logic that as a result of the constant loss of energy the velocities of bodies must have tended to decrease, since their main force tended to be transformed into heat. That by tracing the process far enough into the past we may discover an era during which velocities to that of light were not exceptional, and when as a result the classical laws of dynamics were not yet true".* Surely in such a world, pupils would have to study Lorentz' mechanics at school and not Newton's one!

In *The quantum theory* (May 11th, 1912), Poincaré even wonders whether Lorentz' 1905 mechanics could now be considered as obsolete (in this time of crisis of the physics): "*One may wonder if mechanics is not on the eve of a new commotion* […]. *Does this mean that this mechanics of Lorentz has had only an ephemeral fortune* […]; *Not in the least* […]. *In all instances in which it differs from that of Newton, the mechanics of Lorentz endures. We continue to believe that no body in motion will* […] *exceed the speed of light; that the mass of a body* […] *depends on its speed* […]. *To this strokes of boldness however, we wish to add more and much more disconcerting ones. We now wonder not only whether the differential equations of dynamics must be modified, but whether the laws of motion can still be expressed by means of differential equations. And therein would lie the most profound revolution that natural philosophy has experienced since Newton".*

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Poincaré's Space and Time Conference and his Attitude towards Relativity

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A summary of previous positions (p 15-18)

Poincaré begins his discussion by strongly departing from Kant's philosophy: "*I shall exclude first of all the idea of an alleged sense of space which would locate our sensations in a ready-made space whose notion would pre-exist all experience* […] *and would have all the properties of the space of the geometer* … [It is] *reduced to a constant association between certain sensations and certain movements or to the representation of these movements*". For him, and differently than for Helmholtz, these movements have a mathematical expression, namely the Euclidean group of motions of solids, whose representation occurs not in space but on our retina or through our muscular activity. Space alone may have only general properties such as continuity or topology; (Poincaré was a pioneer of *Analysis Situ*): "*Space is much more relative than we ordinary believe. We can only be aware of modifications of objects which differ from* … [those] *of our measuring instruments … Space is therefore amorphous … It has no properties of its own*". Poincaré then recalls his famous example of the unobservable possibility of a sudden simultaneous dilation of our surrounding world and our instruments, which he says may be extended to any deformation.
Oppositely, geometry originates from an ancestral experience, renewed at each generation, which we have finally raised up to a convention: "*To geometrize is to study the properties of our instruments* […]. *Geometry is a convention, a sort of rough compromise between our love of simplicity and our desire not to go far astray from what our instruments teach us*. *This convention defines both space and the perfect instruments*". One must remind here that for Poincaré a convention endows no arbitrariness; it is this kind of hypothesis which has revealed to be so fruitful, that we take it as a guarantee for our further scientific work.
After having considered space, Poincaré comes to time whose properties are similarly "*those of our clocks*", but clocks need to be compared at different places: "*one event takes place on Earth, another on Sirius; how shall we know whether the first occurs before, at the same time or after the second? This can be so only as a result of a convention*". Remarkably, Poincaré is the first in 1898 to have emphasized the necessity of a convention for the definition of simultaneity, and his first fruitful contribution to relativity has been his 1900 interpretation of Lorentz local time on the basis (convention) that light velocity is taken by all observers to be the same (Poincaré 1900).

A "new" point of view (p. 18-22) …

After this summary of "*fundamental ideas*" discussed in "*previous writings*", Poincaré moves to a "new" point of view which is that of the group invariance of physical laws (a point of view which is present over and over in (Poincaré 1906)): "*But we can consider the relativity of time and space from an altogether different point of view. Let us consider the laws which the world obeys. They can be expressed by differential equations.* […] *not falsified if the* *rectangular coordinates axis are changed* …[translations, rotations or boosts] *nor if we change the origin of time*". As he wants to be clearly understood (having been accused to claim against Galileo that the Earth rotation was a pure convention), he adds immediately: "*Permit me to designate relativity as « psychological » if it is considered from the first point of view and « physical » if it is considered from the second … It was thus that Foucault's experiment demonstrated the rotation of the Earth*". And indeed, this experiment exhibits the non exact Euclidean invariance of physics on Earth.

But then, Poincaré emphasizes an important subtlety concerning the immediacy and the pertinence of these equations (we do not observe equations but rather what we think to represent their solutions, and we have to decide to which system they apply): "*We do not take note directly of the differential equations … we proceed from finite equations … from which the differential equations are derived by differentiation … If we have only one system of laws applicable to the entire universe, observation will provide us with one solution* [and no possibility of differentiation]… *These difficulties will vanish if we do not insist on an absolute rigor* [the interdependence of distant systems] … *Then our equations will break up into separate systems, one applicable only to the terrestrial world, another to that of the Sun … or even to much smaller worlds, like that of a laboratory table*". The hypothesis of independence of these worlds allows verifying that they obey the same type of differential equations (if they are translated, boosted, etc. from each other) or that they do not (if e.g. one world rotates with respect to the others). Then the principle of relativity makes sense and as Poincaré repeats, "*it becomes verifiable*", "*it is no longer a simple convention*", "*it is an experimental truth*", "*it might not be verified*". But, what lies finally in the heart of this principle? Poincaré answers by a series of assertions which would be difficult to understand outside their context: "*We therefore realize the meaning of the principle of physical relativity … It signifies that two distant worlds behave as if they were independent … and we can understand better why the principle of physical relativity is less extensive than the principle of psychological relativity. It is no longer a necessity due to the nature of our intellect… It can serve to define space … It provides us, so to speak, with a new measuring instrument*". For example, he says the equality of two figures, before realized by the motion of solids, can now be ensured by any mechanical system obeying invariant differential equations.

… in "continuity" with the old one (p 22-24)

Being found of seeing in the new theories the skeleton of the old ones (a typical feature of his philosophy due to an exceptional culture), and preferring continuity to rupture, Poincaré continues: "*Do the two conceptions differ essentially from one another? No … To define space in such a way that a solid retains its form when its position is changed is to define it in such a way that the equations describing the equilibrium … are not falsified*… [These equilibrium equations] *are merely a particular case of the general equations of dynamics*". But, he also recalls, geometry was regarded as a convention although it had an experimental basis; what now about relativity? The answer is not surprising; our position will be the same: "*One last remark; the principle of relativity … is an experimental fact … susceptible of constant revision; and geometry must escape this revision. For this to be so, it must be regarded as a convention. We have mentioned what its experimental meaning is* [the independence of distant worlds] … *it is a convention which is suggested to us by experience, but which we adopt freely*".

At this moment of the conference (corresponding to the 8/9th of its length), Poincaré probably realizes that he has told the audience about the most important subjects … excepted that he had no yet said a word on "Lorentz relativity", its content, its philosophy, its teaching, etc. Poincaré must abbreviate his discussion (in the *Last essays*, the end of the conference takes one page): "*What, then, is the revolution which is due to the recent progress in physics? The principle of relativity, in its former aspect has had to be abandoned … it is the transformations of the « group of Lorentz »*[a group and its appellation introduced by him in (Poincaré 1906)] *which do not falsify the differential equations of dynamics".* After exhibiting some features of the new relativity in three short paragraphs dealing respectively with contraction, four dimensional space-time, non causal events, Poincaré concludes like in many conferences addressed to an educated but non-specialist public among which there are many teachers: "*What shall be our position in view of these new conceptions? Shall we be obliged to modify our conclusions*? *Certainly not … Today some physicists want to adopt a new convention … they consider it more convenient; that is all. And those who are not of this opinion can legitimately retain the old one in order not to disturb their old habits*. *I believe, just between us, that this is what they shall do for a long time to come*". Two comments are here in order. First, Poincaré has been unfortunately right concerning the teaching of relativity, which at secondary school is mainly considered as a philosophical topic, and in the first years at university, is often presented as an addendum (the ice on the cake) to Newton's theory. Second, many commentators, who ignored or have not understood the *Palermo Memoir*, have erroneously taken these last words as being Poincaré's scientific position with respect to relativity, without noting that they have no real relation to the subject of the conference.

Remarks on Poincaré's conventionalism and General Relativity

Conventionalism has been attached to Poincaré's position on geometry at the period of the development of Einstein's General Relativity, which essentially tells that the distribution of matter governs the curvature of space-time viewed as a Riemannian manifold. It seemed wrongly to some philosophers in the 1920's (among which Schlick and Reichenbach) that the Riemannian point of view had swept away the group approach because the latter should imply homogeneous manifolds. Today, we know that gravitation is better understood as a gauge theory involving the notion of Lorentz transport which is nothing but an infinitesimal group motion as Weyl already discussed in 1918 (impressing Hilbert). Poincaré would have surely contributed in this « geometrical » direction, which is the one taken by all modern theories of interactions, rather that in the Riemannian one which he considered to be purely "*analytical* " (Poincaré [1902] 1905).

Although Poincaré has not heard of general relativity (GR) since he died at the very moment when Einstein moved from a scalar theory of gravitation to a tensorial one, two links can be underlined concerning *Space and Time* and GR.

(i) General covariance, which is fundamental for GR, is what Poincaré calls "*psychological relativity*", "*a necessity due to the nature of our intellect*". He would never have considered it as a « physical relativity », like today in many textbooks, excepted if topology proved to be relevant. Probably, he would have interpreted it as a supplementary indication that there is no "*alleged sense"* or reality of spacetime by itself (a point of view shared by quantum gravity physicists for whom spacetime is an emergent property).

(ii) By making explicit the relation between global symmetry and the hypothesis of independent worlds, he opens the door to a possible extension of it (remind that he knew that his relativistic approach of gravitation was insufficient). His conventionalism is therefore not sterile; it allows seeing how one can get a step further. For Poincaré "*as science progresses … we can no longer destroy the framework, we must try to "bend" it*" (Poincaré [1913] 1963, 100-101).

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Byzantine and post-Byzantine Alchemy: Principles, Influences and Effects

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Historical research has traced the first written documents of alchemy back in the 3rd century AD. From the 1st to the 4th centuries, alchemical practice develops itself into an art of metallic transmutation and two distinct alchemical “schools” seem to emerge: the one, represented by Ostanes, is still based on the practical knowledge of craftsmen, blacksmiths and dyers, although a shift is being accomplished from “chrysosis” (giving to a base metal the appearance of gold) to “chrysopoeia” (transforming a base metal to gold); the other, represented by Zosimos and Maria the Jewess, assumes a religious, Gnostic orientation, putting the emphasis on the elaboration of distillation techniques. The period of Byzantium is a turning point, not only because there are many commentators of the ancient alchemical texts, but for the attempt, during the 10th century, to collect these texts and to articulate them in a coherent corpus, the surviving manuscript copies of which comprising, to our days, the main evidence for the emergence and the historical development of Greek alchemy.
During the last decades, historians have shown that from the Renaissance onwards a field of knowledge concerning chemical phenomena begun to crystallize itself and to be differentiated from traditional “chrysopoeia”, in the sense that it implies more an experimental research of how physical bodies are composed or decomposed than a quest for the proper process of metallic transmutation. We may denote this field of knowledge by the term “Chymistry”.
Key role in the articulation of chymistry played a kind of occultism which has developed at the end of the 15th century in Florence by Marsiglio Ficino and Giovanni Pico della Mirandola. What we may call “Renaissance Occultism” is the outcome of piecing together the fragments of many different ancient and medieval traditions. The whole construction, though, is a consistent one, aiming at the knowledge of nature in terms of becoming, and thus at the unfolding of the occult life of God, who permeates nature and is regarded as an emanative cause, tending, more and more, to be an immanent cause. Chymistry seems to emerge when this occultism gives an epistemic horizon to the late medieval, and especially Geberian, alchemy, in a way that henceforth the empirical knowledge of substances’ properties and “natural principles” has to be developed into the theoretical knowledge of material transformations.

In this context, we will try to explore in this symposium the relationship between Greek, Byzantine and post Byzantine alchemy, as well the transformation of alchemical principles from Eastern to Western Europe.

John Kanaboutzes' Commentary on Dionysios of Halikarnassos: A Perception of Alchemy in a Fifteenth-Century Greek Text

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In the first half of the fifteenth century John Kanaboutzes wrote a commentary on Dionysios of Halikarnassos (*Roman Antiquities*)[1] and dedicated it to Palamede Gattilusio († 1455), the Genoese lord of Ainos and Samothrace.[2] A nearly two-page reference on alchemy in the edition of his commentary places this work among other texts of various literary genres which show the Byzantines' familiarity with alchemy, in addition to the so-called 'Greek alchemical corpus'.[3]

Kanaboutzes[4] lived in Old Phokaia, an important harbor on the west coast of Asia Minor,[5] one of the possessions of Palamede's brother, Dorino I Gattilusio († 1455).[6] The Genoese Gattilusio, connected by marriage ties with the Byzantine imperial House of the Palaiologoi, became rulers of the island of Lesbos in 1355, and soon extended their control over other places, such as Ainos (in Thrace), Old Phokaia, and Samothrace, until those regions were eventually conquered by the Ottoman Turks.[7]

Not much is known about Kanaboutzes' professional activities. In the dedicatory address of his commentary to Palamede Gattilusio he appears as μάγιστρος, which in this case means 'teacher'.[8] Cyriacus of Ancona, the renowned Italian merchant, antiquarian and humanist, attributes to him the same title (*magister*) in an epistle.[9] In effect, Kanaboutzes' scholarly interests are revealed in several cases: first, in his correspondence with the theologian John Eugenikos;[10] second, by the fact that he guided Cyriacus of Ancona around Old Phokaia and its antiquities in 1446;[11] and, last, in his astronomical work, a compiled

[1] John Kanaboutzes, *Πρὸς τὸν αὐθέντην τῆς Αἴνου καὶ Σαμοθρᾴκης*, ed. Lehnerdt 1890. On the forms and purposes of commentaries, see Goulet-Cazé 2000, where the commentary's important role in various alchemical traditions is also discussed.
[2] On Palamede, see Trapp et al. 1976-1996, No. 3583; Asdracha 1997; Basso 1999b.
[3] Concerning this corpus, see Halleux 1979, 60-62; Mertens 1995, XX-XLIII; Mertens 2006, 207-209, 220-224.
[4] On Kanaboutzes, see Diller 1970; Diller 1972; Trapp et al. 1976-1996, No. 10871; Hinterberger 2002; Efthymiadis and Mazarakis 2009.
[5] On Byzantine and Genoese Phokaia, see indicatively Efthymiadis 2011.
[6] Concerning Dorino, see Trapp et al. 1976-1996, No. 3589; Basso 1999a.
[7] For Gattilusi and their territories, see Mazarakis 1996; Wright 2012.
[8] He makes an allusion to his scholarly activities, when he states: "…this has been said by other Greek chroniclers and historians before me" (Lehnerdt 1890, 36,2-3). Cf. Efthymiadis and Mazarakis 2009, 624.
[9] Bodnar and Foss 2003, ep. 6, p. 28.
[10] See an epistle addressed to Kanaboutzes by John Eugenikos in Lampros 1912-1930, vol. 1, 168-169.
[11] Hinterberger 2002, 409.

astronomy table for the latitude of Phokaia, which can be found in the work of Michael Chrysokokkes dated in 1434/5.[12]

Kanaboutzes' specific relation to the various traditions of alchemy is uncertain. Given his preoccupation with mathematical astronomy, he was most likely exposed to astrology, often used in the preparation of alchemical operations. However, there was no integral relationship between astrology and alchemy in the Middle Ages.[13] Moreover, Magdalino and Mavroudi, as well as Efthymiadis and Mazarakis, referring to McCown's edition of the *Testament of Solomon*, state that Kanaboutzes owned a manuscript containing the *Testament*. This could lead us to assume that alchemy might have been yet another manifestation of Kanaboutzes' pursuit of occult knowledge. However, McCown only notes that cod. *Oxon. Holkh.* 82 (olim *Holkham Hall, Libr. of the Earl of Leicester* 99) contains both the *Testament* and Kanaboutzes' commentary, which was "copied in the same hand".[14] In fact, the scribe of this manuscript was Benediktos Episkopopoulos;[15] as for its ownership, the manuscript once belonged to Mark Morzenos.[16] Therefore, there is no evidence that the manuscript was in Kanaboutzes' possession.

Kanaboutzes' own reference to alchemy in the prooimion of the commentary emerges within the context of *sophia* (σοφία), a godly feature, and its relation to kings and lords, following Plato's view on the benefits for a state whose king philosophizes.[17] For Kanaboutzes, quoting Solomon, God founded the world with *sophia*.[18] It is the kings who most suitably and reasonably share this feature, because apart from being the images of God, they —as God who preserves everything— have to take care of their states and people.[19] Subsequently, Kanaboutzes quotes an epistle addressed to Aristotle by Alexander the Great,[20] the model of all medieval rulers,[21] where it is said that the great teaching of the concealed (ἀποκρύφου) and secret (μυστικῆς) natural philosophy should not be written and be available to all people, but it should be taught orally to a few, and through a teaching process.[22]

Therefore, Kanaboutzes, considering the mention of wisdom to a ruler as appropriate, states that *sophia* constitutes the ornament and the beauty of sovereignty and the state; and he further notices that various kinds of arts are products of *sophia*. In this context, he names certain examples: the laws and judgment, being a prerequisite for the welfare of human forms of government; medicine, the saving and humane art; geometry, which

[12] Diller 1972.
[13] Newman and Grafton 2001, 21 ff.
[14] McCown 1922, 12; Magdalino and Mavroudi 2006, 25-26 and n. 55; Efthymiadis and Mazarakis 2009, 623. In a previous paper of ours we had also erroneously adopted this view (Merianos and Sakorrafou 2013, 57).
[15] On this manuscript and Benediktos Episkopopoulos, see Gamillscheg and Harlfinger 1981, No. 38; also Hinterberger 2002, 407.
[16] Delehaye 1906, 473.
[17] Kanaboutzes (Lehnerdt 1890), 3,4-21.
[18] Ibid., 4,1-4.
[19] Ibid., 4,6-24. On these two characteristics of the 'philosopher-king' in Neoplatonic tradition, see O'Meara 2013, 211.
[20] On this epistle, see Hinterberger 2002, 412-413 n. 28.
[21] Ibid., 411.
[22] Kanaboutzes (Lehnerdt 1890), 5,2-10.

by supplying the vulgar arts, such as masonry and carpentry, with their principles contributes to their foundation and constitution; astronomy, which supplies the tools for navigation, and cartography; the properties of magnetism and the magnetic stone, on which an early example of what we could call a mariner's compass is based. Finally, Kanaboutzes reserves a special place in his catalogue for alchemy, which is defined as the "art of *chymia*" (τέχνη τῆς χυμίας).[23]

Addressing a Latin ruler, Kanaboutzes makes a point of clarifying that *arkymia* (ἀρκύμια)[24] —transliterated into Greek— is a term which some Latins employ speaking vulgarly (βαρβαρίζοντες); they should use instead the term *arte kymia* (ἄρτε κύμια) meaning the "art of *chymia*" (τέχνη τῆς χυμίας).[25] The use of transliterated Latin or Italian terms is presumably related to Kanaboutzes' dedication to Palamede. Furthermore, it implies a degree of Western influence on scholars belonging to the Byzantine tradition, as could be expected for those living in Greek territories under Latin rule. Kanaboutzes has probably come across these terms in a work of Latin origin or in a multi-cultural scholarly milieu.[26]

Moreover, Kanaboutzes states that alchemy dissolves any metal, without heat and fusion (ἄνευ πυρὸς καὶ χωνεύσεως), making it liquefied like water (ὡς ὕδωρ διακεχυμένον ποιεῖ); that is why it is called *chymia* (χυμία).[27] Evidently, Kanaboutzes recognizes that the term *χυμία* derives etymologically from the verb χέω, meaning "pour", "diffuse".[28]

He further employs a traditional definition of alchemy as the art of transmutation of metals (mercury to silver or vice-versa, copper to gold, etc.), of dyeing stones and crystals in every color, and of dissolution and re-composition of pearls. Dissolution of metals describes an operation undertaken during the alchemical transmutation. Transmutation is for him the primary object of the alchemical study. The base metals are transmuted into noble ones by changing their powers (δυνάμεις) and substances (οὐσίας). There is no nature of metal which cannot be transformed, he notices.[29]

Nevertheless, Kanaboutzes does not mention in detail the stages or the objective of the transmutation. Then, he introduces the term "philosophers' stone" (λίθος τῶν φιλοσόφων) to note that this is the crowning act (κεφάλαιον) of alchemy, its perfect creation (τελεία κατασκευή), which performs the transmutation (μεταβολήν) of metals and their outcome. He states that 'philosophers'[30] employed this name in order for the

[23] Ibid., 6,19-10,29. On Kanaboutzes' reference to alchemy, see also the French translation of the corresponding passage by Letrouit 1995, 69-71; the brief presentation by Mertens 2006, 228; and Merianos and Sakorrafou 2013, 55-57.

[24] Cf. the Latin term *archymia*, for which see indicatively Mandosio 2005, 139.

[25] Kanaboutzes (Lehnerdt 1890), 11,1-3.

[26] Concerning the influence of Western alchemy on Byzantine alchemy in general, see Halleux 1979, 62 (and n. 21 about Kanaboutzes); Colinet 2000, XIV. An indicative case is that of two fifteenth-century manuscripts, *Par. gr.* 2419 and *Holkh*. 109, and the Latin origins of certain of their alchemical texts (Colinet 2010: "Introduction", passim; for an overview, XI, XLVIII-XLIX, CV-CVIII). Due to the limitations of the present paper, the influence of Western alchemy on Kanaboutzes shall be discussed in a future article.

[27] Kanaboutzes (Lehnerdt 1890), 11,3-5.

[28] On the etymology of the word χυμία (in its various spellings), see Halleux 1979, 45-47.

[29] Kanaboutzes (Lehnerdt 1890), 11,7-16.

[30] On the use of the term 'philosopher' by alchemists, see Mandosio 2000, 481-482.

uninstructed to be deceived, not understanding the meaning of the expression. Latins following their example name it *lapis philosophorum* (λάπις φιλοσοφόρουμ).[31] Therefore, Kanaboutzes was aware of the celebrated Latin term, which he transliterates into Greek.
The above operative account of alchemical activity tallies with numerous recipes in Byzantine manuscripts, which reflect the practical side of alchemy. It furthermore recalls the familiar technical definition of *chēmeia* (χημεία), as "the making of silver and gold" (ἡ τοῦ ἀργύρου καὶ χρυσοῦ κατασκευή), found in the late tenth-century *Souda* lexicon in a non-specialized context.[32] Yet, Kanaboutzes appears to support a divine origin for alchemy. Once the above-mentioned key-concept of *sophia* penetrates the conception of alchemy, transmutation may also be received as the result of divine inspiration, an after-effect of God's creative wisdom, which is presumably implied when he calls alchemy a "creative art", or when he concludes that alchemy, among other deeds, is "an emanation of God's creative wisdom".[33] Furthermore, he refers to *chymia* as a "mystical" (μυστικήν), "sacred" (ἱεράν) and "ineffable" (ἀπόρρητον) art —which many kings learned from 'philosophers'—[34] reflecting the belief that alchemy has a secret and divine character.
The above point does not necessarily nullify Kanaboutzes' operative description of alchemical activity. He seems to be standing between medieval alchemy and the alchemy of early Renaissance, where Neoplatonic and Hermetic treatises began to have an impact,[35] and the Kabbalah contributed to its mysticization.[36] It is worth mentioning that renowned Kabbalists, better known from their action in Italy or Spain, also taught in the Byzantine Empire.[37] Trends of mysticism travelled across the Mediterranean following the trade routes.
Nevertheless, Kanaboutzes does not explicitly or evidently promote any spiritual aspect of alchemy. He never suggests that the essential purpose of alchemy is to ennoble the man focusing on internal spiritual transformation. According to Kanaboutzes, philosophy, the "love of *sophia*",[38] is defined as "the art of arts and science of sciences".[39] Alchemy is the result of the "sublime and contemplative philosophy of the nature of the beings" (τῆς ὑψηλῆς καὶ θεωρητικῆς τῆς φύσεως τῶν ὄντων φιλοσοφίας).[40] This resembles not only the dominant view in the Middle Ages, that alchemy is considered to be part of natural philosophy (partly because it is tied to Aristotelian and Stoic theories of matter,[41] and the Neoplatonic theory of the cosmic *sympatheia*[42]), but also resembles the emphasis on the natural explanation of alchemical phenomena by earlier Byzantine scholars, such as Michael

[31] Kanaboutzes (Lehnerdt 1890), 11,16-23.
[32] *Souda*, ed. Adler [1935] 1971, entry "Χημεία" (Χ 280).
[33] Kanaboutzes (Lehnerdt 1890), 10,26-27 (δημιουργικὴ … τέχνη); 12,2-4 (…τῆς δημιουργικῆς τοῦ θεοῦ σοφίας εἰσὶν ἀπόρροιαι…).
[34] Ibid., 11,23-26; cf. 10,26-27 (…μυστικὴ καὶ ἀπόκρυφος τέχνη…).
[35] Cf. Newman 1989, 425.
[36] Patai 1994, 522.
[37] Idel 2011, 287-292.
[38] Kanaboutzes (Lehnerdt 1890), 3,12.
[39] Ibid., 9,22-23.
[40] Ibid., 10,26-29.
[41] Newman and Grafton 2001, 15.
[42] Mertens 2006, 206. On the concept of *sympatheia* in Byzantium, and especially in Michael Psellos, see Ierodiakonou 2006.

Psellos in the eleventh century.[43] Its theoretical character is suggested as well when he points out that it is an art taught by 'philosophers'. Kanaboutzes has mentioned earlier that philosophers kept secret the 'know-why', the principles and the cause of any art or science, by providing the artisans with the 'know-how', the practices and usages. The artisans work instinctively (ἀλόγως) and obscurely (σκοτεινῶς) lacking any scientific precision and knowledge.[44] Alchemy's supremacy as a product of *sophia* seems to be based also on the exclusion of the uninstructed from its principles and methods. This is another reason for it being an art for royalty, as we shall later see. For Kanaboutzes *sophia* has two levels: a lower, that constitutes vulgar arts (χυδαίων τεχνῶν σύστασις), and a higher, that discovers the supernatural things (εὑρετὶς τῶν ὑπὲρ φύσιν πραγμάτων);[45] the latter alludes to alchemy.

In Kanaboutzes' commentary it is not immediately apparent why he refers to alchemy. The commentary was written as a favor to "*magister* Zoanes" (John), the physician (φυσικός) of Dorino Gattilusio, in order to satisfy Palamede Gattilusio's interest in the archaeological past of Samothrace (one of his dominions from before 1431).[46] Kanaboutzes undertook a similar task with that of Dionysios of Halikarnassos, as both tried to bring closer their Greek compatriots with their foreign rulers.[47] Dionysios tried to show that the Trojans, the ancestors of the Romans, were Greek.[48] Kanaboutzes, commenting on that, states that being a barbarian is not related to faith, but to descent, language, political order and education.[49] Kanaboutzes probably wanted to flatter the Genoese lord, who spoke Greek, the dominant language in the territories of the Gattilusio in the Aegean.[50]

Addressing Palamede, Kanaboutzes most likely sought to win his favor. Therefore, it is within the context of praising that he compares Palamede to Plato's ideal philosopher-prince, and introduces first the concept of *sophia* and then that of alchemy. The emphasis on the relation between philosophy and kingship is not unprecedented in later Byzantium. In the thirteenth century Nikephoros Blemmydes, for instance, affirms that royalty and philosophy are akin; both portray the majesty of the divine imperium.[51]

It is also within the context of praising that Kanaboutzes states that the art of alchemy was taught by 'philosophers' to great and distinguished kings and queens, such as Cleopatra or Justinian the Great.[52] This comment recalls a common practice of alchemists, who falsely attributed alchemical activity to kings, philosophers and other

[43] Katsiampoura 2008; Magdalino and Mavroudi 2006, 18.
[44] Kanaboutzes (Lehnerdt 1890), 9,23-10,26.
[45] Ibid., 12,8-10.
[46] Ibid., 1,19-2,28; 14,8-15,15; 76,3-5.
[47] Hinterberger 2002, 423-424. See also Efthymiadis and Mazarakis 2009, 623.
[48] Cf. Kanaboutzes (Lehnerdt 1890), 34,23-35,9.
[49] Ibid., 35,15-17. Cf. Kaldellis 2013, 130.
[50] Hinterberger 2002, 420-421 and n. 54, 423-424 and n. 62.
[51] Nikephoros Blemmydes, *Ἐπιτομὴ λογική* [*Epitome logica*], ed. Migne 1885, col. 689A. Cf. Tatakis [1949] 2003, 192-193. In the fifteenth century Cardinal Bessarion puts it bluntly to Constantine Palaiologos, the *despotes* of Morea and future emperor: "…although not being a philosopher you became a ruler, however, being a ruler you philosophized…" (Lampros 1912-1930, vol. 4, 40,18-19).
[52] Kanaboutzes (Lehnerdt 1890), 11,23-12,2.

prestigious figures.[53] Biblical characters, in particular, legitimized alchemical work in the religious-oriented societies of the Middle Ages.[54] But Kanaboutzes' reference to the teaching of alchemy to royalty requires particular attention. Indeed, certain alchemical treatises were attributed not only to Cleopatra and Justinian, but to Herakleios as well.[55] However, 'Cleopatra' was probably either the pseudonym or the real name of another person, a woman alchemist,[56] who was later identified with the celebrated homonymous queen. It is worth mentioning that in a problematic text concerning Comarius the philosopher and Cleopatra one can read: "Comarius the philosopher teaches the mystical philosophy to Cleopatra…".[57] Kanaboutzes' reference to the teaching of alchemy to royalty could therefore have been drawn from a traditional view which is reflected in this text.
This reference reveals the appropriateness of alchemical activity as a royal pursuit. It has been said that references to pseudo-historical examples or even to real cases are not simply rhetorical. They are also a way to remind that not only did the 'philosopher', frequently a courtier himself, need the patronage of a potentate, but also that kings and lords needed the guidance of such 'philosophers' on various matters.[58] Kanaboutzes observes that alchemy is practiced intensely by few as a result of the reduction of *sophia*.[59] His short but comprehensive introduction on alchemy gives the impression that he himself is a 'philosopher' and even knowledgeable of this art; thus, as a scholar or 'philosopher', he could probably teach it to a lord.
Living in a Greek speaking region dominated by Latin rulers, Kanaboutzes addressed his work to a Latin lord who spoke Greek, and tried to make him a participant in Greek civilization, as well as to inform him about the history of one of his dominions. In his attempt to do so, he makes a comment on *sophia*, which stems from God, as well as on the necessity of philosophy to be shared by royalty. Among the whole spectrum of philosophical activity which he projects, alchemy holds the most significant position, although his relation to it is obscure. Yet his familiarity with alchemy is evident by the very fact that he refers to it in a relatively large passage in his commentary. Kanaboutzes stresses the practical character of alchemical activity, but he ensures that it derives from God, and subordinates it to natural philosophy. Moreover, his allusion to certain monarchs, in addition to the aforementioned definition of alchemical activity, probably implies a degree of familiarity with the 'Greek alchemical corpus'.
It could be said that Kanaboutzes represents a case of humanism in late Byzantium. This is implied by his cosmopolitan milieu and contact with different cultures, his astronomical preoccupation, his interest in alchemy, his knowledge of history, and his commentary on Dionysios of Halikarnassos.

[53] On pseudepigraphy in alchemical literature, see Halleux 1979, 97-100.
[54] Patai 1994, 10-11.
[55] See Saffrey 1995, 4-6; Letrouit 1995, 57, 58, 83-85; Mertens 1995, XXIV ff., 124-125, 176-177, 203.
[56] Cf. Charron 2005, 453 and n. 62.
[57] Berthelot and Ruelle [1888] 1967, 290,11-12. The text is taken from cod. *Par. gr.* 2327, copied in 1478. On the problems concerning this text and its editions, see Romano 1995; Mertens 1995, 176.
[58] Mavroudi 2006, 73-79.
[59] Kanaboutzes (Lehnerdt 1890), 11,5-7.

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Athanasius Rhetor: a Greek in Paris, a Priest in Alchemy

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The Greek manuscripts of the National Library of France are divided into three collections: *Ancien Fonds Grec*, *Fonds Coislin* and *Supplément Grec*. A small part of the first collection and most of the manuscripts of the *Fonds Coislin* were collected between 1643 and 1653 by Father Athanasios the Rhetor, on behalf of the Prime Minister, Cardinal Mazarin, and Pierre Séguier, chancellor of France from 1635. The *Fonds Coislin*[1] comes directly from Séguier's own library and this collection gathers today 400 Greek manuscripts; more than 300 were collected by Athanasios himself.

The activities of Athanasios Rhetor in acquiring valuable Greek manuscripts for his French patrons have been noted by scholars since the end of the 19th century[2]. Athanasios has attracted attention too as a theological polemicist and an advocate of Church unification since the same period[3]. His interest in philosophy – in Neo-Platonist philosophy in particular – has been also studied in the 1970's[4]. But it is clear that nobody has paid attention to the chemical works of Athanasios. In the *Supplément Grec* collection are stored four volumes of Athanasios' manuscripts (letters, notes, papers, drafts, texts fragments); two of them concern precisely his chemical works never studied nor read[5].

Athanasios was born in Costanza (near Salamis) in the today illegally occupied part of Cyprus in about 1571, the year of the first Turkish invasion of the Island. At an early age he and his two elder brothers lost their family and relatives. However, he managed to move to Constantinople where he was received and supported by the Patriarchs Neophytos II then Timotheus II. He became himself Protosyggelos and Hieromonachos of the Church of Constantinople. He also attended, at the Patriarchs' expense, the Jesuit school which enjoyed the patronage of the kings of France and the full support of the French Ambassadors in the city. It is certainly under such influences that Athanasios became the staunch defender of Catholic orthodoxy; and he distinguished himself in 1614 in a theological controversy with Hilarion, Metropolite of Heraclea. At about this time, moved by his "love of learning" as he said, Athanasios went to Rome with the hope of attending the Pontifical Greek College of St Athanasius. He was not admitted in the College (he was too old), but stayed none the less in Rome. He was probably in Paris in 1615 and was certainly established there in the 1620's. What happened afterwards is well documented. At about the end of the year 1642, Séguier had the project to enrich his library with Greek manuscripts. For that purpose, he had sent

[1] Omont, 1888, XIII; Astruc, Constyt, 1960.
[2] Among other papers: Omont, 1902, 1-26; Darrouzès, 1950, 162-163; Constantinides, Browning, 1993; de Leeuw, 2000, 59.
[3] Marini, 1898-1899 and 1899; Arabadjoglou, 1933, 73-76 and 1948, 184-189 and 1952, 12-15; Manousakas, 1949, 134-151; Korolevskij, 1932, 1394-1396.
[4] O'Meara, 1977, 483-499; Dalsgaard Larsen, 1977, 1-37.
[5] In their description of the French National Library Catalogue it is just written from time to time "alchemical notes" or "alchemical recipes".

Athanasios to the East. Arriving in Constantinople in August 1643, Athanasios started with no delay his task with the support of the Ambassador of France, Jean de La Haye: 46 manuscripts from Cyprus and 10 from Constantinople had been quickly sent to Séguier. Athanasios shipped then tens of other manuscripts from Thraki, Mount Athos, Thessalia and Makedonia to Séguier until 1653. But in December 1643, Mazarin wrote in his turn to the Ambassador of France in order that he may ask for searching and buying good and rare Greek, Turkish and Arabian books and manuscripts. On April 23, 1644, de La Haye acknowledged receipt of the demand and on the 5th November, he informed the cardinal about the first researches he had confided to a capuchin, Father Romain, and a Greek Catholic priest, Father Athanasios; the first prospecting in the area of Mount Lebanon, and the other in the area of Thessaloniki. On the 25th October 1646, Athanasios was sent by de La Haye to explore the libraries of Mount Athos. De La Haye described him to Mazarin as a man "very capable to carry out his commission perfectly, as he is very intelligent in the knowledge of good books". But the mission is a failure and the return to Constantinople journey took several months; Athanasios was obliged to stay 4 months on Limnos Island, for the lack of boat. In the beginning of May 1647, he sets off to Athos a second time, with, this time, the authorization of the local Turkish authorities. The next month, he had already arrived, but he complained about persecutions by certain religious who were ill disposed towards the Francs and the roman church. On November 30, he announced to the Ambassador his arrival to Limnos with a quantity of valuable manuscripts. But the last part of his journey was not so easy: Venetians were interrupting at this time any connection with Constantinople; and in addition, Athanasios suffered from health problems due to his age (he was already 76 years old). In March 1648, de la Haye was finally able to announce to Mazarin that 150 Greek manuscripts and 16 printed books coming from Mount Athos arrived at last.

In June 1653, Athanasios left Constantinople (where he had been authorized by the Patriarch to preach and teach) for Rome, then Paris; de la Haye announced his departure to both Mazarin and Séguier, the latter had wished to meet him again for a long time. The missions of Athanasios in the East had taken 10 years.

Two years after, in 1655, Séguier – still wanting more manuscripts – arranged the removal of one-hundred and sixteen manuscripts from Athanasios' possession in Paris. Athanasios appealed – in vain – to Séguier, then to Baluze, at the time (1661) working for the bishop of Toulouse Pierre de Marca, and in 1662 to the king himself for compensation[6].

On the 13 march 1663, Athanasios died at the age of 92 years old and was buried at St Etienne-du-Mont in Paris. Remnants of his library went to the library of the Abbey of Sainte-Geneviève (i.e. according to the today catalogue: one manuscript and over fifty scientific, religious, philosophical and historical books). Fifteen days after his death, Séguier was assigned, by the right of escheat ("par droit d'aubaine"), the manuscripts Athanasios had been demanding for eight years which Séguier was keeping, as well as all the belongings of Athanasios which he gave to a musketeer and his servants.

[6] Baluze described him at about this time as "learned, but ragged and poor. However, de Marca did not deem the man contemptible on that account, a man in whom were present, apart from good mind and extensive knowledge of sacred matters and of divine and human philosophy, a modesty worthy of a Christian and a blameless character".

Athanasios published several books; all of them in Paris[7]:

- In 1639 on the knowledge of unchanging realities of God: *P.*[*atris*] A.[*thanasii*] *O.*[*rat*]*oris Opuscula philosophica quatuor: quorum inscriptiones in singulorum videbis principiis*, (Latin and ancient Greek), Paris, dedicated to Séguier.
- In 1639 on the human virtues and vices: *Delitiae animae sive hortus ex iis quae Iamblicho magno elaborate sunt consitus*, (Latin and Greek), Paris, dedicated to Richelieu.
- In 1641 on certain "irreligious" men who had visited Paris "some days" previously, maintaining in debate that the rational soul is mortal and that this was Aristotle's view: *P.*[*atris*] *Athanasii Rhetoris Byzantini. Aristoteles propriam de Animae immortalitate mentem explicans. Opus vere singulare … ex multi sac variis Philosophis collectum Aristotelis ipsius Auditoribus, qui sibi ex ordine successerunt, sententiae dogmatum ipsius initiati, praesertim vero admirabili & magno Iamblichoi,* (Latin and Greek), Paris, volume 1 dedicated to Séguier, volume 2 dedicated to Achille de Harlay, bishop of St Malo and former ambassador in Constantinople.
- In 1655 (1657 for the second edition): an attack on the Paris, 1637, edition of Campanella's *De sensu rerum et magia*, including an *Approbatio* by the theological authorities of the Sorbonne dated February, 1638: *D.*[*octoris*] *Athanasii Rhetoris Presbyteri Byzantini Anticampanella in Compendium redactus adversus librum de sensu rerum & Magia*, (Latin only), Paris, dedicated to Cardinal Spada, Latin Patriach of Constantinople (and to Séguier).

A dozen of unpublished works has also been noticed in Athanasios' manuscripts. Two manuscripts from the *Supplément Grec* collection actually gather together his chemical writings: Suppl. Grec 1027 and Suppl. Grec 1030. The first one which has a parchment binding of the 17th century appeared for the first time in the 16 august 1672 inventory of Séguier's library (made just after his death). The second one which has a simple cardboard binding of the 19th century appeared nowhere before, even if it belonged previously with no doubt to Séguier's library (its content is very mixed and appears to be a remnant that nobody had judged good to bind so as to make a separate entire volume). The chemistry which is presented there relates among other things to the preparation of gold or silver, the fixation of mercury, the extraction of mercury out of certain metals, the philosopher stone, the dyeing of the money, the purification of copper, lead or tin, the preparation of potable gold, quintessence and elixir, the preparation of clay of wisdom, preparation of alkali, oil of tartar, salt of sulphur, elebrot salt, ammoniac salt, or oil of dragon blood, the whitening of coins and some various remedies like those supposed to give strength, to preserve the memory, or against the arthritis, the eyes diseases, or the plague.

The manuscript 1027 is composed of 522 folios, with a number of variable lines, and also variable dimensions of folios. The parts concerning chemistry are generally well written and cover 107 pages. 164 recipes are counted. More than two thirds of the recipes are in Italian, less than one third in demotic and ancient Greek, only two in Latin and one in French, and here and there words in Turkish and more rarely in Arabian are noticed.

The manuscript 1030 is composed of 161 folios of various formats, with many variable lines. 102 folios relate to chemistry. The writing is generally not very neat. Approximately 150 recipes are counted. The texts contain many erasures and glosses. Most of them are

[7] Legrand, t. 1 (1894: 404-405; 416-419), t. 2 (1894: 82-87; 96-98), t. 3 (1895: 417-426), t. 5 (1903: 51).

obviously drafts and notes. The languages used are the same ones and at the same ratios, but this time three recipes are in French and one in Latin.
A short presentation of these manuscripts will be now done.
The chemical notes and recipes which compose the two thirds of the manuscript 1030 are all dispersed in the work. The first chemical folio shows a list of Alexandrian chemistry terms, in which a part of Ps.-Demokritos' *Φυσικά και Μυστικά* sentence is found. Further in this manuscript two recipes deal with partridges like some Alexandrian recipes do.
The manuscript contains a book of 64 pages all written by the same hand, but not Athanasios' hand, and they are all in Italian, except for the first one which is in bad French written by an Italian speaking writer. The most of the recipes of this book, apart from the latter, have been copied almost word for word by Athanasios; those which have not been copied are identified in the original text by the following expression: "*questo not ho scritto*" (Athanasios' writing). Certain sources are quoted: Ramon Lulle, Giovani Battista Birelli, and Archelaus. It also appears that several recipes come from 1561 *Verae Alchemiae Artisque Metallicae* of Guglielmo Gratarolo which Athanasios personally owned; he however copied them.
A French recipe can be read here, not in Athanasios' hand writing, on a sheet used for notes which have nothing to do with the recipe. It is accompanied by its Italian translation by an unknown hand-writing, that Athanasios translated in his turn into Greek. This recipe about the oil of sulphur is in fact drawn from the book of Jean Liebaut (which had been republished a lot of times) *Quatre livres des secrets de médecines et de la philosophie chimique*, of 1573.
Another French recipe signed "Monsieur gras docteur en medecine demeurant chez m^{r} devertrieu en dauphine à seriere" is half translated into Italian and half into Latin. It speaks about vegetable philosopher stones related to a particular planet, the best known is the lunar one, that we can find since the 13th century in Paul de Tarente or Arnaud de Villeneuve, then in the hermetic herbaria. One of the lunar ones, the *borissa* comes from the Alexandrian period. So it is interesting to note that this term appears in Athanasios' text accompanied by its Arabian translation: "borisssa // ζεβετουνιέ //αραβιστί". Furthermore the manuscript contains unidentified drawings of such plants accompanied by a text in demotic Greek. Athanasios carried out sketches of these drawings. In his manuscripts there are in fact several other recipes of this type.[8]
The manuscript contains some names of people, some of them important (like Avicenna or Sendivogius) but they are just a few, and some others unknown but certainly contemporary with Athanasios and supposed to be known to him. For example: "Papas Kyr. Daniel" (Priest Daniel), name associated with a recipe (in Greek with some Latin and Italian words) concerning the transformation of silver to gold, "Mehmet dedé from Kasimpasha" (a place of Constantinople), "Κυρίτζης Νικολάκης", "Andreas Grimaldi, prêtre", "Baltasar Andrigoji", or "Georgakis Kasapoglis from Ex-Marmara" (in Constantinople). The last name appears twice, one time just on a small strip of paper and another time associated with a recipe in the manuscript 1027. Actually, this recipe exists initially in Suppl. Grec 1030 in the form of a draft without title and crossed out with two lines, before being carefully copied and developed in Suppl. Grec 1027.

[8] One of them is rather similar at least in its first part to one of those of Paul de Tarente introduced by Colinet (2010). Half of the recipe is in Athanasios in Greek and the other half in Italian.

The manuscript 1027 now. It begins with a short French recipe having however an Italian title. The author is not Athanasios but he could not be French either. In the 435r folio two very short quotations of Glauber's *Consolatione navigatium* published in 1657, *Prosperitatis Germaniae* by the same of 1656 and his *Pharmacopaea Spagyrica* of 1654, appear[9]. Glauber and Sendivogius are the only references to contemporary famous chemists in all the two manuscripts.
Recipes of the Suppl. Grec 1027 are several times the final version of drafts of the Suppl. Grec 1030 (for one of these Athanasios had completely cut off its alchemical rhetoric). But recipes of Suppl. Grec 1027 can be also the ancient Greek version of well written Modern Greek recipes of Suppl. Grec 1030 (whose original version must have certainly been in Latin or Italian).
The chemical writings of the SG 1027 are actually gathered at the end of the manuscript, starting with a folio which represents a kind of a Greek-Turkish lexicon of chemicals (including 3 Latin occurrences). Turkish words are found elsewhere in the manuscript too; some recipes contain in fact words with their translation in Turkish. Basically, the recipes can be divided in two groups: those where masses are expressed in ounces and pounds and those where masses are expressed in *dramia*. For the latter, Athanasios used the Turkish compounds *nisantiri* (for ammoniac salt), *sεleïma* (for corrosive sublimate) and *kuvergule* (for niter salt) or even *raki*, the alcohol.
No trace of real theoretical elements can be really found to inscribe the content of these two manuscripts in the 17th century Paracelsian western chemistry. But it would be a mistake to just see these papers as the result of a work of a copyist reading old manuscripts. It is not very probable that Athanasios had the ambition to propose an edition of chemical works. He was a man, as he acknowledged it himself, who devoted his whole life to study. The manuscripts reveal that he practiced some of the recipes he wrote, he made some efforts to get recipes and to make the names and symbols of chemical compounds his own. Even more, he expressed on a draft his questions about what he didn't understand in a recipe he had read.
Athanasios was not only trying to join two religions but also two traditions, to make the East and the West join together, as well as the past and the present too: Alexandrian recipes are mixed with French ones, Turkish with Italian, ancient with demotic Greek. Thus Athanasios introduced some new terms in Greek chemistry like "to distillate" or "distillation"[10], even if he had some difficulties to stabilize their writings (sometimes he wrote them in Italian inside a Greek recipe, or he wrote them half in Italian half in Greek, or he dropped the beginning of the word, etc.)[11]. The fact remains that Athanasios belonged to his time, interested in a more and more fashionable science, and not contenting himself with the old writings but frequenting concrete places and living with his contemporaries.

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[9] These quotations do not help us to date the manuscript. However they prove that SG 1027 and SG 1030 manuscripts had not been already taken by Séguier in 1655 (yet Séguier's interest in alchemy is known).
[10] "To distillate" or "distillation" seems to be absent in the 15th century Holkhamicus 109 and Parisianus GR. 2419 (cf. Colinet, 2010).
[11] "να δεστιλλάρη", "να στιλλαρισθή", "διστιλάνδο", "δεστιλλαρισμένο", "διστιλλατζιόνε", "δεστιλλατιονε". Athanasios seems to translate more from Italian than from Latin to Greek.

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Cosmopoiesis as a Chymical Process: Jean d'Espagnet's *Enchiridion Physicae Restitutae* and its Translation in Greek by Anastasios Papavassilopoulos

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An eigtheenth-century manuscript now kept in the National Library of Greece in Athens (no. 1331, ff. 1r-93v, see Sakellion 1892, 241) preserves a copy of an anonymous Latin treatise on natural philosophy translated into Greek by Anastasios Papavassilopoulos of Ioannina (c. 1670-c. 1750). Its full title reads: *Ἀνωνύμου Ἐγχειρίδιον τῆς ἀναζησάσης φυσικῆς φιλοσοφίας, ἐν ᾗ ἡ ἀληθὴς τῆς φύσεως ἁρμονία ἀναπτύσσεται καὶ πλεῖστα τῆς ἀρχαίας σοφίας ἁμαρτήματα διὰ κανόνων καὶ ἄλλων τινῶν ἀποδείξεων λαμπρῶς φανεροῦνται· ὅπερ μετεστρώθη ἀπὸ τῆς λατινίδος ἐπὶ τὴν Ἑλληνίδα διάλεκτον σπουδῇ καὶ πόνῳ τοῦ λογιωτάτου καὶ σοφωτάτου Ἀναστασίου παπᾶ Βασιλόπουλου τοῦ ἐξ Ἰωαννίνων, ἐν τῇ κωμοπόλει Τυρνάβῳ τῆς Θετταλίας διατρίβοντος κατὰ τὸ ᾳψα΄ ἔτος σωτήριον* [=1701], *Μαιμακτηριῶνος ζ΄ ἱσταμένου μηνός* [=November 29]. Two other copies of the same Greek translation have survived to our day: the one is part of the manuscript collection of the Historical and Ethnological Society of Greece, now held in the National Historical Museaum of Athens (no. 34, pp. 216-360, see Lampros 1909-1913, VI: 348), and the other can be found among the Greek manuscripts preserved in the Library of the Romanian Academy in Bucharest (no. 485, see Litzica 1909, 61-62 [no. 106]; Karas 1992-1994, II: 343-344). Neither of these copies bears the exact date of its production, but according to the catalogue descriptions both were scribed sometime in the 18th century.

The headings in two of the three manuscript copies of the work (cod. Atheniensis Bibl. Nat. 1331 and cod. Atheniensis Coll. Societ. Hist. & Ethnol. 34) attest that Papavassilopoulos' translation was completed at the end of November 1701 in the small town of Tyrnavos (Thessaly). At this period, its author worked as a teacher of philosophy and rhetorics at Tyrnavos school, a post he held from the end of 1699, or early in 1700, until 1705 or 1706 (Chatzes 2002, 38-41). The *Ἐγχειρίδιον* was not the only attempt he made to test his translation skills. During his residence in the same town, Papavassilopoulos prepared yet another translation of a work originally published in Latin. It was François Pomey's *Candidatus rhetoricae, seu Aphtonii Progymnasmata in meliorem forman usumque redacta*, whose first edition was published in Lyon by Antoine Molin in 1659[1]. Earlier, Papavassilopoulos had been in the town of Serres, and from 1705 to 1723 he was in Ioannina, where he worked, together with Georgios Sougdoures (1645/7-1725) at the school of Emmanouel Gionma. Then, he passed from Kastoria, where he succeeded Methodios Anthrakites (c. 1660-1748) as a teacher at the ecclesiastical school of Georgios Kyritses, and his final stop was the town of Trikala, in which he stayed from 1728 to 1750 (Chatzes 2002,

[1] For the Latin editions of this book see de Backer and Sommervogel 1890-1900, VI: 981-983. The surviving copies of Papavassilopoulos' translation contain no explicit reference to the name of the original author. Chatzes (2002, 75) was the first to notice that *Λευχειμονοῦσα ῥητορική* was actually a translation.

37-38, 41-48). He was both a priest and a teacher, and during his career, he composed also works on rhetoric and logic. Given the current state of our knowledge, it seems that he was the first to render Descartes' credo "cogito ergo sum" into Greek (as *ἐγὼ ἐννοῶ, ἐγὼ εἰμί*), in his manuscript treatise on logic (see Petsios 1999, 55-56).
Despite the fact that several recent historical studies have delved into, or touched on in passing, the content of the *Ἐγχειρίδιον* (Chatzes 2002, 97-118; Petsios 2002, 220-230; Vlahakis 2010, 130), neither the Latin original nor its author have been identified. Papavassilopoulos himself did not mention the name of the author, and this was not a deliberate omission. As a matter of fact, the book he translated had been published anonymously. Its first edition was printed in Paris by the French bookseller Nicholas Buon, in the Rue St. Jacques "sub signo D. Claudii & Hominis Sylvestris"[2], in 1623, and its full title goes as follows: *Enchiridion Physicae Restitvtae. In quo verus Naturae concentus exponitur, plurimíque antiquae Philosophiae errores per canones & certas demonstrationes dilucidè aperiuntur.* It was bound together with a second treatise entitled *Arcanum Hermeticae Philosophiae Opus: in quo occulta Naturae & Artis circa lapidis Philosophorum materiam & operandi modum canonicè & ordinatè fiunt manifesta. Utrumque opus eiusdem Authoris anonymi*. The motto at the bottom of the frontispiece (Spes mea est in Agno, or 'my hope is in the lamb'), as well as that in the title-page of the *Arcanum* (Penes nos unda Tagi, or 'the waters of the Tagus, in our power'), were presumably intended to function as imperfect anagrams of the name of the author[3], and they actually did so, since, in 1651, Jean Bachou, in his introductory 'Discours' to the French translation of the *Enchiridion*, claimed that he had solved the riddle: Ioannis d'Espagnet, this was the name of the author who was identical with "Monsieur d'Espagnet Président au Parlement de Bourdeau" (Bachou 2007, 16). Parliamentarian (president of the parliament of Bordeaux), state counsellor, and associate of the witch-hunter jurist and demonologist Pierre de Lancre in the repressive campaign of 1609 against the women living in the province of Labourd (see Pearl 1999, 127-147; Duché-Gavet 2012), Jean d'Espagnet (1564 - post 1638 ?)[4] was also a man of letters[5]. After his retirement from public life, in 1616 or 1617, it seems that he devoted most of his time to the study of natural philosophy and alchemy. Diderot, in his manuscript introduction to the lectures on chemistry of Guillaume-François Rouelle, called him the "Cicero of chemistry", extolling thus his rhetorical artistry, and had him ranked among the few remaining adepts or seekers after the philosopher's stone, on the side of Morienus, George Ripley, and Nicolas Flamel. Pierre Bayle, in his *Dictionnaire historique et critique*, described him as one of the 17th century savants[6]. He was an intimate friend of prominent literary figures such as Michel

[2] 'At the sign of St. Claude and of the Woodsman'. The first was the sign of the printing establishment of Nicholas' father, Gabriel Buon, whose shop was on the Rue du Mont-St-Hilaire. The second was the sign of Regnault Chaudière, who was also a bookseller and father of Nicholas' first wife, Blanche (Renouard 1898, 53-54). Nicholas Buon was the printer of Barclay's *Argenis* and of several books of Grotius (see Reeves 1925).
[3] If we put these two anagrams together and pick out from each of them the letters forming the name 'Espagnet', the remaining letters are forming the phrase "Deus omnia in nos" (God, everything in us). See Raimon Arola 2008, 86; D. L. 1815, 317.
[4] On the possible date of Jean d'Espagnet's death see Kahn 2001, 256; 2007a, 529-530 (n. 103).
[5] For d'Espagnet's life see Kahn 2007b, xi-xii, where relevant bibliography is provided.
[6] Henry 1887, 53; Bayle 1715, II: 1117-1118. Didier Kahn (2001, 256; 2007a, 529) first brought to public attention these two references to the name of d'Espagnet.

de Montaigne and Marie de Gournay, who, from 1598 onwards, was pursuing her own experimental path in alchemy, perhaps having been initiated by d'Espagnet, but eventually sharing with him an experience of mutual encouragement and inspiration, as one might guess taking into account her creative thought and her sense of independence (see Secret 1973; Devincenzo 2002; Heitsch 2010).

However forgotten he may be today, the author of the *Enchiridion* was not a minor character in the historical evolution of Renaissance 'chymistry', and, even more broadly, in that of post-scholastic natural philosophy. The book itself enjoyed wide circulation and interest: within a period of just 50 years, it had passed through seven re-editions (1638 – 'secunda editio emendata et aucta'[7], 1642, 1647, 1650, 1653, 1657, 1673), of which the first four were issued jointly with the *Arcanum*. Moreover, it had been included in the two Genevan editions of Nathan d'Aubigné's *Bibliotheca Chemica Contracta* (1653, and 1673). John Everard, an amateur alchemist himself, had translated it into English, and Jean Bachout into French. Both translations had been printed in the same year, 1651. And this was not the end point of its trajectory.

The Christian Kabbalist polymath and religious poet Christian Knorr von Rosenroth published, in 1680, under the pen name 'Christian Peganius' (or in German, 'Rautner'), his own translation into German (see Achermann 2008). At the dawn of the 18th century, d'Espagnet's book was anthologised in the second volume of J. J. Manget's *Bibliotheca Chemica Curiosa* (1702). Finally, in 1718, Johann Ludwig Hannemann, Professor of Medicine at Kiel University, published his own *Commentarius in Physicae Restitutae Enchiridion*, which was reprinted twice, in 1728 and in 1773.

Strictly speaking, the *Enchiridion* was not an alchemical treatise. It was a treatise which utilised alchemy as the bedrock, the most epistemologically advantageous and ontologically productive, experiential terrain, for the renovation of natural philosophy. In fact, it was one of the chronologically first books challenging openly the scholastic natural philosophy as a whole, and programmatically articulating an alternative to it. But what makes it even more intriguing is the fact that the discourse deployed by its author is lodged in the border zone between philosophy and theology. As far as the knowledge of nature is concerned, the Scripture is to be considered of equal authority with the surviving texts of Aristotle or Plato. The reason why the word of God carries so much weight in matters of natural philosophy is that the knowledge of nature is the knowledge of God' activity, who permeates the world, animates the world as an evolving reality, lives in and by the world, setting off and controlling the process of 'naturing', creating and sustaining nature as an evolving whole: whoever fails to fathom God's presence as 'anima mundi' is doomed to stay ignorant of the laws of the universe (d'Espagnet 1623, 4).

The *Enchiridion* can be seen as a good example of the Late Renaissance genre for which Daniel Georg Morhof in his post-humously published *Polyhistoris continuatio* (*philosophicus et practicus*, 1708) coined the designation 'Physica mosaica', and in this regard it could be read side by side with books such as Johann Sophron Kozak' *Physica mosaica* (1637), or the

[7] This edition added nothing to the text of the *Enchiridion*. It was 'corrected' insofar as it introduced the errata changes listed at the end of the 1623 edition (e.g. the correction of the error in the numeration of the paragraph 242 which caused a discrepancy between the total number of paragraphs in the first edition and that of the second), and "augmented" insofar as it included two additional short texts, a poem introductory to the *Arcanum*, and a closing epistle, signed with the pseudonym 'I. C. Chymierastes' (see Kahn 2007b, xiii-xiv).

Physicae ad lumen divinum reformatae synopsis (1633) of Johann Amos Comenius, who actually, in the later stages of his philosophical development, consulted the book of d'Espagnet and drew on its conceptual edifice (see Blair 2000; Červenka 1970a, 1970b). And indeed, Comenius and d'Espagnet were grouped by Morhof under the same entry (Morhof 1708, 167-173), together with many other Christian thinkers of various philosophical allegiances (Aristotelians, Platonists, Cartesians, Kabbalists, Enthusiasts, Rosicrucians). Whatever the merits of such a classification, the version of 'restored physics' expounded by d'Espagnet is something more than a fascinating instantiation of a pious philosophical mentality fixated on the concept of nature.

The interweaving of causal explanations of natural phenomena and speculative inferences about the presence of God in the world becomes possible because, for d'Espagnet, the knowledge of nature amounts to the knowledge of what-can-be, of the potentiality of becoming, not to the knowledge of what-is, of the actuality of being. The empirical knowledge of the properties of natural substances is developed into the theoretical knowledge of material transformations, by means of a quest, not any longer for the philosophers' stone as an entity, but for the knowledge of the real possibilities in nature (how something can be composed, how something can be decomposed), of cosmopoiesis as a transmutational procedure. This is why philosophical atomism, in the *Enchiridion*, coexists with theosophical considerations. The word 'God' points to the creative potential inherent in nature: in d'Espagnet's discourse, God is defined as an emanative cause, tending however, more and more, to operate as an immanent one. Since the emphasis has shifted from being to becoming, and from the mind of God to the activity of God, the thematisation of the active principles in nature, the construction of the concept of 'natural elements', which seen in historical perspective seems to chart a middle course between David Gorlaeus' atomism and van Helmont's chemical philosophy (Lasswitz 1890, I: 235-239), intersects with the thematisation of the latent life of God in nature, the conception of the soul as 'anima mundi', and of man, the partaker of the cosmic soul, as 'microcosm', as a complex of real possibilities (a conception which can be traced back to the theories of the soul as a mediating element enunciated by Marsiglio Ficino and Pico della Mirandola's *Conclusiones Nongentae*). Alchemy can be posited in advance as an exeptionally prolific field of knowledge, and can thus be singled out as an exemplar for the 'restoration' of natural philosophy, because it involves the actualisation of real possibilities, through the active participation of the alchemist in the process of cosmopoiesis: knowing in alchemy is not only contemplating, representing the world-that-is, but also doing, emancipating the world-to-be.

The thumbnail sketch of some of d'Espagnet's major tenets or background assumptions that we have just scratched is nevertheless helpful if we are to answer the question of what makes the story about the manuscript Greek translation of the *Enchiridion* interesting and worthy of deeper examination. The publication of a treatise providing the outline of a natural philosophy 'reformed' through the prisms of alchemy and theosophy was the culmination of persistent efforts, public debates, vehement criticisms and severe controversies the proximate origins of which could be dated to the last quarter of the 15th century: from the *Theologia platonica* of Ficino (printed in 1482), the *Conclusiones Nongentae* and the *Heptaplus* of Pico della Mirandola (1486 and 1489), to the *Libri III de philosophia occulta* of Cornelius Agrippa (1533), and the books of the Paracelsian chemical philosophers Gerhard Dorn (*Clavis totius philosophiae chymisticae*, 1567; *De naturae luce physica, ex Genesi desumpta*, 1583), Heinrich Khunrath (*Amphitheatrum sapientae aeternae*, 1595; *Von hylealischen, das ist, pri-materialischen catholischen oder algemeinen naturlichen Chaos, der naturgemessen Alchymae und Alchymisten*, 1597), and Oswald Croll (*Basilica chymica*, 1608), not to mention the tracts of Jacob Böhme which, untill 1624, were available only through widely circulating manuscript versions , there is a proliferation of written sources interrelating the concept of nature with that of God, interpreting the narrative of Genesis as an account not of the creation, but of the constant renewal of the cosmos, and resignifying the theoretical knowledge of material transformations as pivoting on an open jurisdiction over knowing, as a duty that can be fulfilled through the experimental labour which transmutes actual human impuissance into real power, and as a right that pertains to every human being, since every human being partakes in the Anima Mundi. Modernity, in this context, corresponds to a universal restoration: it is a collective, both educational and experimental, endeavour to re-establish, here, in this world, the affinity between God and human beings, to actualise the creative cosmic potential which is latent in every human being.

Hence a particular question may arise: how an Orthodox priest and scholar, such as Papavassilopoulos, came to translate a text exemplifying this particular notion of modernity? Was the Greek version of the *Enchiridion* a shooting star that momentarily crossed the philosophical firmament in the Greek-speaking communities or was it somehow relevant to philosophical debates which were, at that time and in that milieu, ongoing or still unsettled? By translating the *Enchiridion*, Papavassilopoulos produced the first, as far as we can tell, textbook of early modern, explicitly non-Aristotelian natural philosophy to appear before the Greek-speaking literate audience. The very fact that as early as 1701 a book of this kind was translated into Greek indicates that the process of appropriation of Western early modern literature on physics and chemical philosophy by Greek-speaking scholars was not so much delayed as it has been hitherto assumed to be. D'Espagnet's book was popular and it was possible for any Greek-speaking scholar passing from one of the major intellectual centers of Europe to come across one of its copies, visiting either a personal or a public library. Papavassilopoulos, in his youth, had travelled to Venice, and perhaps to Padua too, in order to continue his studies at a higher level (Chatzes 2002, 34-35). But the answer to the question asked above necessitates even deeper enquiry. We have to position Papavassilopoulos' translation in a nexus of possible relations between cultural developments, as yet historiographically unconnected, if not entirely unexplored, in the Greek-speaking communities during the 17th century and the first half of the 18th, which implicate the possibility of a peculiarly modern, but for all that, not less meticulous, interweaving between theology, philosophy, and science. This is a story still to be told, but perhaps by exploring the hitherto untrodden territory of chemical philosophy or Mosaic physics in the 'East' we will not merely address a gap in the existing literature. We might also be able to re-examine several implicit or explicit assumptions in current historical scholarship on the emergence of 'chymistry' itself in the 'West' .

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Acknowledgements
The research work reflected in this paper was partly funded by SHAC (Society for the History of Alchemy and Chemistry – New Scholars Awards 2011-12). I would also like to thank Didier Kahn and Jennifer Rampling for their generous help.

Chemical Medicine in 16th and 17th c. Europe: Remarks on Local, Religious and Ideological Connections

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The most conspicuous feature of chemical medicine, was the preparations of medicines with (al)chemical methods. This distinguished it clearly from the Galenic medicine, where medicines were prepared by simple 'physical' manipulations of the raw materials. (Al)chemical preparation of medicines was often associated with theories, that human organism functions on the basis of (al)chemical processes or, in other words, like a (al)chemical laboratory.
The roots of chemical medicine could be traced back to alchemists of the Middle Ages, such as Roger Bacon, Petrus Bonus and Johannes de Rupescissa, and also to Arabian alchemists. But its great expansion during the 16th and 17th centuries was based to a great extent on the writings of Paracelsus.

Chemical medicine and Protestantism
The connection between chemical medicine and Protestantism has been repeatedly pointed out. As formulated by William B. Ashworth:

> A Paracelsian revival began around 1580, and most of the first wave of Paracelsians such as Joseph Duchesne and Oswald Croll were Protestants. […] as a result chemistry and chemical medicine in the first decades of the seventeenth century became an exclusively Protestant affair. […]
> […] very few Catholics entered the field of chemistry, and except for the beleagured Helmont, there was no Catholic contribution to the discipline in the seventeenth century. […] [Protestants] were at least able to make a start on the chemical revolution. No Catholic lent a hand. (Ashworth 1986, 150-151)

This picture has of course to be relativized regarding the two principal figures of chemical medicine, Paracelsus and Van Helmont. Paracelsus (1493-1541) never left officially the Catholic Church (although he maintained quite friendly relationships with protestant circles in Strassburg and Basel), he lived the last part of his life in the strongly catholic Salzburg and in his testament he demanded to be buried according to the Catholic ritual. But he was widely regarded as a heretic, especially through his theological works.
Van Helmont (1579-1644) remained a pious catholic during his whole life, although he was against the Jesuits, who had gained power in Holland as a consequence of the Spanish occupation. (Pagel 1982b, 1) In 1625 the General Inquisition of Spain declared twenty-seven propositions in a work of him[1] as suspect of heresy, as impudently arrogant, and as affiliated

[1] *De magnetica vulnerum curatione*

to Lutheran and Calvinist doctrine. As a consequence he lived for a quite long time on house-arrest. (Pagel 1982b, 12-13)

A list of major (i.e. most influential) figures of chemical medicine and their principal publications (that were, to a great extent, used as 'textbooks') during the 16th and 17th centuries could, in my opinion include the following:

Hieronymus Brunschwig, *Liber de arte distillandi* (in German, 1500)
Philipp Ulstad, *Coelum philosophorum* (Fribourg 1525, Strassburg 1526)
Conrad Gessner (1516-1565), *Thesaurus Euonymi Philiatri de remediis secretis, liber physicus, medicus et partim chymicus […]*, (Zürich 1552); *Conradi Gessneri medici et philosophi Trigurini Euonymus, pars secunda […]*, (Zürich (?), repr.: Frankfurt 1576)
Andreas Libavius (after 1555(?)-1616), *Alchemia* (Frankfurt 1597)
Joseph Duchesne (Quercetanus) (1544-1609), *Antidotarium Spagyricum ….. Opera Medica* (including all his main works, Leipzig 1614)
Oswald Croll (1560(?)-before 1609), *Basilica chymica* (Frankfurt 1609)
The London Pharmacopoeia (1618) [Thomas Moffet (1553-1604), Theodore Turquet de Mayerne (1573-1655)]
Johannes Hartmann (1568-1631), *Praxis Chymiatrica* (Leipzig, 1633)
Johann Rudolf Glauber (1604-1670), *Pharmacopoea Spagyrica* (1st part: Nürnberg 654, following six parts: Amsterdam, 1656-1668)

Regarding confession, the first of these figures, Brunschwig, could not be a Protestant, as he flourished before the appearance of Protestantism. Of the rest, except for Ulstad (whose church affiliation is unknown) and Glauber (who seems to keep himself away from the religious conflicts of the time), all were Protestants (Lutherans, Calvinists, Zwinglians or Anglicans).

But, at the same time, some of the most fierce opponents of chemical medicine were also Protestants. The cardinal example is the Swiss Thomas Erastus (1524-1583), professor of philosophy, theology and medicine at Heidelberg. He was a Zwinglian and opposed both Calvinists and Lutherans. (Gunnoe 1998, 50) He is well known as the foremost adversary of Paracelsian teachings.
Some of the main points of his critique on Paracelsus, as summed up by W. Pagel:

- He is a “beast” and “grunting swine”
- The “fatal habit of *contradicting* himself”
- *Ignorance* of the Liberal arts
- He was a “Magus” whose association with the Devil inevitably emerges from his opinions
- “We can grant him that he was a Chemist and a Magus. What else he knew would be difficult to say.”
- Categories did not exist for him (Pagel 1982a, 314)

But apart of such 'general' accusations Erastus goes on to attack the preparation and usage of chemical medicines:

> But how can the spirit and humours of life be restored and augmented by anything that is not assimilable? Metals, including gold, in whatever form of preparation can never be assimilated. Being immutable and incapable of attracting or altering humours, all chemicals do great damage rather than any good. (Pagel 1982a, 326)

Chemical medicine and German-speaking countries

Chemical medicine was connected with German-speaking countries. In the list presented above we see that all books (with the exception, of course, of the *London Pharmacopoeia*) were printed in these countries. In the same countries were printed also many works of authors living mainly outside Germany, as e.g. all the works of the English physician and hermetist Robert Fludd (1574-1637). His works were published at Oppenheim and Frankfurt by different persons between 1617 and 1638.

This does not mean, of course, that all proponents of chemical medicine were German. There were significant French Paracelsians, who had, nevertheless, a difficult time after the condemnation of the Paracelsian medicine by the Paris Medical Faculty and the pogrom against Huguenots. The probably most famous of them, Joseph Duchesne (Quercetanus) lived a part of his life in Germany and his works were mostly published in Germany. Again, Theodore Turquet de Mayerne (mentioned in connection with the *London Pharmacopoeia*) took refuge in Englang. In England there were, besides Robert Fludd and Thomas Moffet , a number of prominent Paracelsians and iatrochemists.

Another factor that made German-speaking countries prominent in the development of chemical medicine was the fact, that several sovereigns in these countries (mainly, but not exclusively, Protestants) supported in various ways alchemists, hermetists and proponents of chemical medicine. The emperor Rudolf II (1552-1612) in Prague, although he remained a Catholic, supported many alchemists (mainly Protestants), not only from German-speaking countries (as Michael Maier, Oswald Croll, Martin Ruland, Heinrich Khunrath, Leonard Thurneysser), but also e.g. the Englishman hermetist and magcian John Dee. Landgrave Moritz (1572-1632), reigned the land Hessen-Kassel between 1592 and 1627. In the context of Protestantism, he regarded the promotion of alchemy (and the related ideas) as a means for a general social and spiritual reformation that could unite European people. He supported alchemists in various ways. On his motivation Johannes Hartmann occupied the chair of *Professor Chymiatriae* in the University of Marburg, the first such university chair in Europe.

Iatrochemists and a separate world view

It should not be supposed that chemical medicine was a unified whole and that its proponents constituted a more or less unified scientific community. In reality, some proponents of chemical medicine attacked fiercely some others.

Conrad Gesner, the 'universal scientist' of 16th century Switzerland and author, as we have seen, of an influential book on chemical medicine, writes for Paracelsus:

> Theophrast Bombast von Hohenheim, […] somewhere he names himself Paracelsus. […] As far as I know, he does not stand out particularly in anything and should be

rather considered as a swindler. […] The art of expression and thoughts [...] are unclear, barbarous, artificial, not of much use. (Milt 1929, 10)

And in a letter to his friend Crato von Krafftheim:

Theophrast was surely no really religious man. He was a magician who associated with demons. […] From the works of Alexander von Suchten and of other disciples of Paracelsus one can easily see that the Theophrastians deny Christus' godly nature. I am sure that Theophrast too was a follower of Arianism. (Milt 1929, 13)

Andreas Libavius, the author of *Alchemia*, functioned, in many aspects, as a main leader of the campaign against Paracelsus and Paracelsians. His main accusations as summarized by Bruce Moran:

- Paracelsians, like Oswald Croll, are guilty of moral cowardice. They use ink not to print words for purposes of clear discourse but, like octopi, to hide hide behind.
- The schools were in peril, especially where princely interests in occult philosophy influenced university curricula, as e.g. in 1609, when Landgrave Moritz appointed Johannes Hartmann to the newly created chair of chemical medicine at the University of Marburg. (Moran 1998, 138-139)

And in his own words:

The fame of our times is better known and more exact, and we are more skilled in preparing and treating because past times have collected knowledge and have passed it on as increased treasure.
True philosophy is not so much an investigation of of hidden and unknown things as it is […] a pounding [of things] to pieces. (Moran 1998, 140)

In this citation Libavius' main point seems to be his objection to the search of hidden (occult) causes and his adherence to an analytical, 'scientific' approach.
In reality, in the times of Libavius, as well as during the 17th century, a quite defined, large and influential group was formed in the context of chemical medicine. This group had its origin in the philosophy of Paracelsus and the foregoing alchemists – and included Paracelsus, the so-called Paracelsians, as well as later influential figures that could not properly be called Paracelsians, e.g Van Helmont, Fludd and their followers. The basic philosophical, worldview or ideological concepts of this group could be summarized as follows:

Processes 'governed' by non-material (spiritual) entities or forces
Cosmic correspondences

- macrocosm-microcosm correspondence
- astral influences
- theory of signatures

Scientific knowledge through 'mens' ('intellectus') rather than ratio

The insistence of Paracelsus on the importance of immaterial (spiritual) entities and forces is expressed again and again in his works:

> What is immaterial (incorporeal), that *is* the disease. And what is material (corporeal), that is *not* the disease. (Sudhoff 1922-33, vol. 8, 161)
>
> The material body (corpus) is not remedy, it is earth. Remedy is what is inside the material body, that which earth, blood and flesh do not know at all. (Sudhoff 1922-33, vol. 11, 171-172)
>
> The remedy lies in spirit and not in the material body. Body and spirit are different. Body is not spirit and only this second is the helper of doctors. (Sudhoff 1922-33, vol. 11, 205)

That is, disease is an immaterial (spiritual) entity that causes symptoms, excretions or collections. Again, the real remedy is not the visible herb or preparation, but an immaterial (spiritual) entity hidden in the material 'envelope'.
The correspondences between the Greater World (macrocosm) and the Lesser one (man or other living beings) are quite clearly described in the work of Oswald Croll:

> The Foundation of this Physick is according to the agreement of the lesser World Man with the greater and eternall world, as we are sufficiently instructed by Astronomy and Philosophy, […] [indeed] Heaven and Earth are Man's Parents, out of which Man last of all was created; He that knows the parents, and can Anotomize them, hath attained the true knowledge of their child Man, […] because all things of the whole Universe meet in him as in the Centre, and the Anotomy of him in his Nature is the Anotomy of the whole world.[2]
> The Members or parts of the great world are the Remedies of the members and parts of man by an agreement between the externall amd internall Anotomy […] And though the hidden virtue of Hearbs, or the Stars of that Physitian Heaven may be known to us, yet the chiefest thing that the Physitian is also to consider is to know the Concordance of Nature, viz. how he may make the Astrum of the Physick or of the magicall Heaven agree with the internall Astrum and Olimpos of Man […][3]

The theory of signatures has been put forth by Paracelsus with some impressive examples:

> The root Satyrion (orchid) is it not formed like a man's private parts? Hence it promises through magic and has been found by magic to restore manhood and sexual desire to man. Also the thistle – do not its leaves prick like needles? Hence there is no better remedy against internal stitches. (Pagel 1982a, 149)

while Oswald Croll has dedicated a whole part of his book on *De signaturis internis rerum*.

[2] Croll, *Basilica Chymica* (as quoted in Debus 1977, 120)
[3] Croll, *Basilica Chymica* (as quoted in Debus 1977, 120)

These ideas on correspondences have provoked reaction even from the side of scholars who do not altogether reject Paracelsian medicine or were rather sympathetic towards Paracelsian ideas; such was the case of Daniel Sennert (1572-1637)[4]:

> Hence we may gather that the analogie of the great and little world is extended too large by the chymists, because they make not an analogie, but an identity, or the same thing. For Paracelsus requires in a true physition that he say this is a saphire in man, this is quicksilver, this cypress, this a walflower; but no Paracelsian ever shewed this.[5]

The knowledge of such occult entities and correspondences required of course, from the side of the scientist, abilities beyond the ordinary ones. In fact, the whole philosophical system of Paracelsian medicine is based on such abilities. Paracelsus is again and again explicit about that.

> So now if the physician is to grow out of nature, what is nature other than philosophy, which is philosophy other than the invisible nature? […] Now that is philosophy: that it stands in the human being as [it stands] outside impalpably.6

In this context can be understood the devaluation of reason, as traditionally conceived, and the insistence, that real knowledge could be achieved only through the higher mental faculties (intellectus or mens). Van Helmont expresses these ideas in a clear (and quite polemical) way:

> Reason endeavours to persuade the higher intellect (mens) that it is its guide, guardian, and nurse, the steering rudder […] However, the intellect challenges the claim of reason. […] Reason, not unlike disease, is a "foreign guest"; it takes possession like a parasite. […] For reason dwells in the lower part of the soul […]. It follows that reason is radically different from truth. […] The only field in which it can convey certainty is mathematics. This, however, is given to measuring measurables and hence is foreign to nature. (Pagel 1982b, 21)

So, within the proponents of chemical medicine, a separate group (a separate 'scientific community') was formed – indeed, from the very beginning of chemical medicine – that acted in a real confrontation to the others. Whether they should be properly called "Paracelsians" or not, all of them shared, more or less, a common set of beliefs and common ways of seeing the phenomena of the world and of human organism. I tried to present this particular way of seeing things by some examples and to summarize schematically its main features in a table. I am not implying of course that all agreed in every detail (e.g. Van Helmont did not accept the macrocosm-microcosm correspondence, but was an advocate of the action at a distance). But it is legitimate to maintain that they belonged to the same 'paradigm'. This appears quite obvious if we take into account that the 'others' disagreed strongly with all the points I have tried to summarize.

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[4] According to W. Pagel, Sennert was a critical defender of Paracelsus (Pagel 1982a, 333ff)
[5] Quoted by Crombie 1994, 672
[6] Quoted by Weeks 1997, 149

So, we could say that, besides the conflict between chemical and Galenist medicine, an equally strong conflict took place within the chemical medicine – a conflict that was centered not so much on technical, confessional, or local, but rather on ideological (or world-view) matters. That this conflict was solved – to the extent that it was solved – rather in favor of the 'others' has been already pointed out by Allen Debus (Debus 1972a, 1972b).

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Byzantine and post-Byzantine Alchemy: a Research Project in Progress

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Our project, under the title "*Digital archive concerning alchemy in Byzantium and in Greek-speaking communities of the Ottoman Empire*", has begun on April 2012, as collaboration of the National Hellenic Research Foundation, the University of Athens and the University of Ioannina.

Objectives

The research project aims to address a significant gap in the current historiography of sciences, by exploring and carefully mapping a large, unsurveyed territory: that of Byzantine and post-Byzantine alchemy. The principal objective of DACALBO project is to reconstruct the history of alchemy in the Medieval and Early Modern Greek-speaking world, through the creation of a comprehensive, open access, digitized, and searchable archive of texts relevant to alchemy, written in Medieval or Modern Greek, from the period of Byzantium to the 18th century. More specifically the project aims to:

a) Identify, collect, digitize, and classify all surviving manuscript primary sources relevant to the study of alchemy during the periods of Byzantium and of the Ottoman Empire.

b) Identify, collect, digitize and classify the printed primary sources that are found to be relevant to alchemy. Thus, texts or passages extracted from texts, whose content is alchemical or at least refers explicitly or implicitly to alchemical practices, will be articulated in a coherent corpus of texts, so as the penetration of alchemical knowledge in different disciplines or arts to be illustrated.

c) Collecting and classifying the secondary bibliography.

d) Create prosopographical entries for every identifiable author, so as to map the actors of the history of alchemy, their roles in this history and the subjective positions pertaining to these roles.

e) Evaluate, on the basis of the collected primary sources, the modifications or even transformations which Byzantine alchemical tradition has undergone through the passage of time, and to ascertain its relations with Hellenistic, Arabic, or (after the 10th century) Latin alchemy.

f) Determine what twists in the development of alchemy have taken place after its introduction in the cultural context of Greek-speaking communities under Ottoman domination, from the 15th to the 18th century.

Additional objectives of our project are the following:

i) The enrichment of the history of Byzantium, drawing lines of connection between the historiography of Byzantine alchemy and that of the natural sciences in South-Eastern Europe.

ii) The production of a historical material that is both profitable in terms of educational applications and suitable for activities tending to promote public awareness of the different temporalities that having been merged in the history of science and render the written monuments of this history tokens of a common cultural legacy.

State of the Art

a) Greek alchemy

The first written documents of alchemy can be traced back in the 3rd century AD. From the 1st to the 4th centuries, alchemical practice develops itself into an art of metallic transmutation and two distinct alchemical “schools” seem to emerge: the one, represented by Ostanes, is still based on the practical knowledge of craftsmen, blacksmiths and dyers, although a shift is apparent from chrysosis (giving to a base metal the appearance of gold) to chrysopoeia (transforming a base metal to gold); the other, represented by Zosimos and Maria the Jewess, assumes a religious, Gnostic orientation, putting the emphasis on the elaboration of distillation techniques. The period of Byzantium marks a turning point, not only because there are many commentators of the ancient alchemical texts, but also due to the attempts of Byzantine scholars, during the 10th century, to collect these texts and to articulate them in a coherent corpus; the surviving manuscript copies of which comprise to our days, the main evidence for the emergence and the historical development of Greek alchemy. The sources which contain the presently known ancient Greek alchemical texts are certain ancient papyri and the Medieval and late-Medieval manuscripts that have been discovered up to now.

The oldest surviving written alchemical monuments are 3 papyri deposited in the Museum of Antiquities at Leyden and dated to about 3rd century AD. They are known as Leyden Papyri V, W, and X respectively, and they are part of a collection acquired in Egypt by the Chevalier d’Anastasi, at the beginning of the 19th century. Another primary source of this kind is Papyrus Graecus Holmiensis, also part of Johann d’Anastasi’s collection, which is preserved in Stockholm. The scribe of this papyrus is the same as that of Leyden Papyrus X.

The first to publish the Stockholm Papyrus was Otto Lagercrantz in 1913, presenting the Greek text with critical commentaries and translating it into German (Lagercrantz 1913). The Leyden Papyri V, W, and X were published for the first time in 1885 by Conradus Leemans in a critical edition with a Latin translation (Lemmans 1885).

Marcelin Berthelot attempted, in 1906, a new edition of Leyden Papyri (Berthelot 1906). In 1981, Robert Halleux offered a modern critical edition of both Stockholm and Leyden Papyri, along with their French translation. This edition is the first volume of the projected series of twelve, intended to encompass the whole corpus of ancient Greek alchemical texts, under the auspices of the Association Guillaume Budé. Still, there exist many Greek alchemical manuscripts, dating mostly from the 16th century onwards. The latest of them are copies of the earlier. On the whole the number of the presently known surviving manuscripts is about 100, covering the period from the 10th to the 19th century. All these manuscripts are listed in the *Catalogue des manuscrits alchimiques grecs* (CMAG), a project patronized by the Union Académique Internationale. Eight volumes were published in this series between 1924 and 1932, and they contain respectively the manuscripts then preserved in the libraries of Paris (I, 1924), in the libraries of Italy (II, 1927), of England (III, 1924), of Germany, Austria, Denmark, Holland, and Switzerland (IV, 1932), of Spain (V,1, 1928) and in the libraries of Athens (V,2, 1928).

The main Greek alchemical manuscripts (dating from the 10th to the 15th century) are the following four:

i) Codex Marcianus Graecus 299 (= M), surviving in the San Marco Library in Venice. It dates from the end of the 10th century or from the beginning of the 11th.
ii) Codex Parisinus Graecus 2325 (= B), surviving in the National Library of France in Paris. It is of the 13th century.
iii) Codex Parisinus Graecus 2327 (= A), surviving also in the National Library of France. Its assigned date is 1478. The first half of this MS. is a copy of the MS. Parisinus gr. 2325, while the second half have been drawn from another, not yet located and identified, source.
iv) Codex Laurentianus Graecus 86,16 (= L), surviving in the Laurentian Library in Florence. It is copied in 1492.
All the other known manuscripts seem to derive from these four manuscripts which contain all the surviving Ancient and Early Medieval Greek alchemical texts. Most of these texts were edited and translated into French by Marcelin Berthelot and Charles-Émile Ruelle in 1887-1888 (Berthelot-Ruelle 1887-1888). Omitted from Berthelot's Collection were the alchemical writings of Stephanus of Alexandria that had already been published by J.I. Ideler in 1842 (Ideler 1842).
There are also a few manuscripts of Byzantine origin whose texts can be dated between the 10th and the 13th century. Yet, the methods described in them and the intellectual climate in which they seem to be situated lead us to Medieval Latin rather than to Hellenistic alchemy. Such texts can be found in the recently discovered codices at Holkham Hall (Holkhamieus 290) and at the Vatican (Vaticanus 1134), which now are preserved in the Bodleian Library in Oxford. Here lies open a promising field forfurther research, since there are also instances where such transmissions of Medieval Latin alchemy to the East are documented. At the beginning of the 14th century, in Southern Italy, a Latin alchemical treatise, ascribed to Arnaldus de Villanova, was translated into Medieval Greek, by an anonymous author. This treatise was first published by C.O. Zuretti in the 7th Volume of *Catalogue des Manuscrits Alchimiques Grecs* (Zuretti 1930). In 2000, it was edited by Andrée Colinet (Colinet 2000).
Albert Severyns, searching in the libraries of Athens for codices where alchemical texts are included, listed the following manuscripts (Severyns 1928, 149-169):
i) National Library of Greece, 1070, ff. 231, 13th century (from f. 219v, change of hand, 14th century).
ii) Library of the Parliament, 126, ff. 46, 18th-19th century (f. 44: αωδ΄ [1804]). It contains, inter alia, alchemical works of Stephanus of Alexandria, Synesius, and Heliodorus.
iii) Library of the Christian Archaeological Society, 321, pp. 64, 18th-19th century. It contains alchemical works of Stephanus of Alexandria, Maria the Jewess, and Synesius.
Examining, also, several catalogues of libraries outside Athens, Severyns listed two more relevant manuscripts (Severyns 1928, 170):
i) Library of the Monastery of Vatopedi on Mount Athos, 665, pp. 140, 18th century. It contains writings of Stephanus of Alexandria.
ii) Library of Zagora, 58, pp. 87, 18th century. It contains writings of Stephanus of Alexandria and of Zosimus.
b) Renaissance alchemy / "Chymistry"
During the last decades, historians as Allen Debus, William Newman, Lawrence Principe, Bruce Moran, and Peter Forshaw have shown that from the Renaissance onwards a field of knowledge concerning chemical phenomena begun to crystallize itself and to be differentiated from traditional chrysopoeia, in the sense that it implies more an

experimental research of how physical bodies are composed or decomposed than a quest for the proper process of metallic transmutation. Following Principe and Newman (Newman-Principe 1998), we may denote this field of knowledge by the term "Chymistry". Key role in the articulation of chymistry played a kind of occultism which was developed at the end of the 15th century in Florence by Marsiglio Ficino and Giovanni Pico della irandola. What we may call "Renaissance Occultism" is the outcome of piecing together the fragments of many different ancient and medieval traditions. The whole construction, though, is a consistent one, being explicitly formulated not as a renovated esoteric tradition, but as a renovative philosophy, with a new conceptualization of the soul (anima) at its centre. The emergence of this new philosophical tradition marks a turn from the knowledge of the ideal attributes of being to the knowledge of nature in terms of becoming, and thus at the unfolding of the occult life of God, who permeates nature and is regarded as an emanative cause, tending, more and more, to be an immanent cause. Some indicative secondary sources concerning Renaissance Occultism are the following: Kristeller 1993, 39-48; Yates, 1964, chapters I-VI; Yates 2001, section I; Merkel and Debus 1988; Idel 1992, 319-351; Walker 2000; Stausberg 1998; Mebane 1989; Collins 1974; Schefer 2001, 13-27;.Allen, Rees, and Davies 2002; Dulles 1941; Wirszubski 1989; Copenhaver 1999, 25-76; Håkansson 2001; Szőnyi 2005.
"Chymistry" seems to emerge when this occultism gives an epistemic horizon to the late medieval alchemy, and especially that kind of alchemical practice codified in the texts of the Pseudo-Geber Corpus (a set of Latin texts falsely attributed to the Arab alchemist Jabir ibn Hayyan). It is due to this conjunction that the empirical knowledge of substances' properties and "natural principles" can be developed into a theoretical knowledge of material transformations. Hence, the overtly theosophical aspects of Renaissance alchemy can be explained, without devaluating its role in the consolidation of early modern sciences. Since God, in this context, is regarded as the inner life of cosmos, the knowledge of material transformations becomes coterminous with the knowledge of the occult powers of God, with the actual participation, that is, in God's living as cosmos. Only recently, in the historiography of alchemy, and generally in that of the sciences, research efforts have been made to shed some light on this fascinating grey zone between empirical knowledge and theosophical speculations. The most insightful of them exemplify how prolific an interdisciplinary approach, combined with a methodology capable to ward off retrospective projections and to reactivate, instead, past discourse strategies, may become in this respect. Works indicative of such an orientation are the following: Vickers 1984; Clulee 1988; Matton 1991; Bono 1995; Gilly 1998; Coudert 1999; Brann 1999; Harkness 1999; Kahn 2007; Forshaw 2006; Forshaw 2008; Forshaw and Killeen 2007.
In contradistinction with that flourishing state of the art in the rest of Europe, Greek historiography has not yet entered into this new and promising field of research. How and whether Renaissance alchemy has been disseminated in Greek-speaking communities is something that up to the present remains totally unexplored. What this absence of a secondary bibliography actually reflects is not the lack of relevant primary sources, but the huge lacuna still gaping in present-day Greek historiography concerning the Renaissance as a European movement having its particular impact on the Greek-speaking communities of the time.

Beyond the State of the Art

We must, at this point, highlight the fact that our research has already been fruitful in disclosing unexamined or unknown primary sources, opening thus a way beyond the state of the art. We have located some relevant to alchemy manuscripts that hitherto have passed unnoticed.

In the library of the Monastery of Olympiotissa, in the city of Elassona, an early Greek alchemical manuscript is preserved. Evangelos Skouvaras (Skouvaras 1967, 375-378) has given a detailed description of this codex. Folios 1-98 are dated to the year 1507, while ff. α΄-ζ΄ and 104-110 are written from another scribe and dated to the year 1741. It contains, inter alia, writings of Zosimus and Synesius. This indicates that during 18th century there existed in Greek-speaking communities authors who, while trying to compile medical and alchemical knowledge into accessible notes, continued to draw their material from the corpus of ancient

Hellenistic alchemy. This codex is not included in Severyns' list, and this shows that the present list of alchemical manuscripts surviving in Greek libraries is far from being complete. Since a significant part of it, dated to the year 1507, contains one of the earliest versions of the corpus of ancient Greek alchemical texts, the Olympiotissa codex must be examined and collated against the four main alchemical manuscripts (Marcianus gr. 299, Parisinus gr. 2325, και 2327, Laurentianus gr. 86, 16).

We have, also, detected a lot of manuscripts that attest the emergence and spread in Greek-speaking communities, from the 17th to the 18th century, of this field of knowledge that we have denoted as chymistry.

Not only there are many manuscript (and printed) translations or compilations of iatrochymical treatises (up to now we have traced 11 preserved texts of this kind), but we have located also and some manuscript texts exemplifying the relation of chymistry to Renaissance occultism. Two such manuscripts, which still wait to be thoroughly examined, and whose relevance to alchemy has been hitherto ignored, are the following:

i) National Library of Greece, Athens, 1331, dated to the year 1701, ff. 1r-98v. It contains a translation in Greek, made by Anastasios Papavasilopoulos, of *Enchiridion Physicae Restitutae In quo verus Naturae concentus exponitur, plurimque antiquae Philosophiae errores per canones & certas demonstrationes dilucidè aperiuntur. Tractatus alter inscriptus. Arcanum Hermeticae Philosophiae opus: in quo occulta nature & Artis circa Lapidis Philosophorum materiam & operandi modum canonicè & ordinate fiunt manifesta*. The earlier preserved edition of Enchiridion is the second, made in Paris in 1638 (for a detailed description and a list of some of its earlier translations, see Ferguson 1906, I, 248-250). Ferguson, probably following Hermann Kopp (Kopp 1886, I, 345), dated the first edition to 1608, but according to Kurd Lasswitz (Lasswitz 1890, 235) the correct date is 1623 (in Paris). The book was anonymously published, and the French alchemist Jean d'Espagnet is its reputed author. During the whole of the 17th century, it was a very popular work, going through several re-editions and translations, and it is highly illustrative of that conjunction between causal explanations of natural phenomena and conceptualizations on God' presence in the world which is typical for Renaissance alchemy. It played also a significant role in the consolidation of early modern atomism. The fact that such a work has been translated into Greek is historiographically important both for the reason that, as far as we know, this is the first textbook of early modern natural philosophy to appear before a Greekspeaking audience and because its translation into Greek is made in a rather early

period (1701), indicating that the process of appropriation of Western early modern scientific literature by Greekspeaking scholars was not so delayed as it has been hitherto assumed to be.
ii) National Library of Greece, Athens, 1113, first half of the 18th century, ff. 1r- 49v. It contains a Synopsis of Chymia, written by an anonymous author. This is the first, as far as we know, chymical treatise written in Modern Greek, and it is also noteworthy that it is not a translation, but an original work.
These two promising indications evince that a thorough investigation, conducted according to our project plan, will enable access to a rich array of hitherto unknown, or unexploited, primary source material.

Importance and Expected Impact
The proposed research project will contribute, in a significant manner, to the advancement of historical knowledge both with regard to alchemy and chemistry in particular and to sciences in general. DACALBO will complete Severyns' list of the Greek alchemical manuscripts preserved in Greek libraries (which remains regrettably incomplete, since it is based only on the examination of the inventories of Athens libraries' collections).Thus it will restore the continuity of an international scholarly effort, for a comprehensive record of the written monuments of Greek alchemy, initiated in the 1920s, under the auspices of the Union Académique Internationale, and halted in the 1930s, owing to the grim situation that prevailed in Europe during the years just preceding the outbreak of the 2nd World War. DACALBO will also thoroughly map the hitherto untrodden landscape of Byzantine alchemy and Greek-speaking early modern chemistry, bridging the gap that still persists between the ancient Greek alchemy, the dispersed monuments of which were articulated into a coherent corpus by Byzantine scholars, such as Michael Psellos, and the "new chemistry" of Lavoisier, with which Greek-speaking scholars were acquainted in the early 19th century, through certain textbooks mostly translated from the French. Involving, moreover, the application of novel methodological tools, the project will have a profound, renovating impact on the community of the historians of science in SE Europe, widening, if anything, the range of the methodological resources, already tested in practice, at its disposal.
On the didactical level, the construction of the proposed historical archive will contribute to a deeper apprehension of the historicity of natural sciences, rendering primary source materials accessible to the educators and the public, and offering, for each entry stored in the archive, information necessary for further study.
On the level of the science of history, the proposed archive will enrich the historiography of Byzantium, and that of the Enlightenment in Europe too, providing a map of historical relations illustrative of cultural interactions between the Byzantium, the Arabic East and the Latin West, as well as of continuities or discontinuities between the Byzantine and the Renaissance, or even Modern, sciences.
From a cultural point of view, our digital historical archive will promote a deeper understanding of the various interactions that can be historically ascertained between the different cultural communities which through the passage of time inhabited the Balkan region, and a greater awareness, on citizens' part, of the significance of the written historical monuments as parts of a common cultural heritage, belonging to a common cultural fabric in which the various undertakings of different generations are creatively combined,

exemplifying thus how human beings can be actively engaged in making their history and the world they inhabit.
Finally, the proposed exhibitions will enrich the understanding of the public understanding about Alchemy, its implications on the societies of the past and its contribution to the birth of Chemistry. They will constitute the base for the organization of events which will take place beyond the proposed project.

Methodology
In order to attain the desired ends, DACALBO will fully exploit the methodological innovations brought forth by the most recent and most comprehensive historical research projects centered on Western Medieval and Renaissance alchemy:
a) It will employ an international interdisciplinary approach that combines paleographical, philological, historical, technological, and core scientific skills. The research team comprises historians (Ancient, Medieval and Contemporary history), philologers-palaeographers, historians of science and technology, chemists, specialists of science education, of communication with the public and web technicians. The need for such a number of disciplines is the reason for the constitution of such a numerous project team. DACALBO implementation will highly profit from the experience and the scholar support of worldwide reputation specialists on the field of Alchemy and of science-religion.
b) Considerable weight will be given to the re-assessment of the historical development of alchemy after a critical review of already known primary sources, and most importantly, on the basis of new historical evidence. At any rate, working with unpublished manuscript material always led to rethinking given historical schemas. In our case, manuscript primary sources constitute the greatest part of all surviving primary textual sources, and the reason is that printing press, available for Greek-speaking scholars, was established in Ottoman territories only at the beginning of 19th century (even though some Greek-speaking communities had been running printing presses outside Ottoman territory from the 16th century onwards). All of them are hitherto unpublished. We have to prepare ourselves for unexpected evidence, or results that do not match with given historical interpretations.
In this respect, a methodological step we have to make is to consider the process of collecting and studying primary sources as an opportunity to test the historical picture we have inherited, and not as an occasion in which we merely add new data to an existing narrative.
c) The range of social and cultural implications of alchemy will be touched upon, since the presented corpus of texts under study will be indicative of how, in any given period, alchemy is being related to other disciplines, how it affects everyday life, what technological applications it brings about, what interactions can be detected between alchemical and medical practices, how much alchemy is invested in the dynamics of poetic language, folk narratives and mythopoetic creativity.
d) The historical reconstruction will methodically avoid any retrospective projections. The extensive use of secondary sources may well guide our research, but we will not let this guidance bias our findings. A crucial methodological assumption, here, is that whenever we study a written monument of the past we have to acknowledge its actual distance from us, to reactivate it as a kind of discourse different from what we have learnt to except from our particular standpoint. This emphasis on the difference in terms of perspective will help us fully appreciate the significance of findings that possibly challenge established historical

interpretations, and will enable us to pose interesting new questions, instigating new research directions and agendas.

e) DACALBO will focus on possible points of contact, zones of tension or areas of overlap, between temporalities that are usually considered as being radically distinct, as for example the temporality of religion and that of science. Renaissance alchemy, invested as it is with strong theosophical overtones, involves multiple intersections where empirical observations meet with Christological suppositions, theological doctrines, and even praise/worship techniques. The historiography of religions, in this case, must communicate with the historiography of sciences. All the more so, when the objects of our research are situated in the cultural, intellectual and geographical space marked by Southeastern Europe, where multiple religions flourished, such as Eastern Christianity, Islam, and Judaism. Crossing the narrowly delineated historiographical borders is yet another innovative methodological stratagem that we intend to use in order to amplify the advantages of cutting-edge multidisciplinary research and at the same time to be able to transcend its possible limitations (for example, the presupposition that the multiple disciplines brought together in a common project are from the outset distinct, self-sufficient entities).

f) The methodological rules that we choose to adopt are not a conclusively defined set of prescriptions.

Generally, while treating the primary source material we intend to collect, our methodology, on account of this material's novelty, will be flexible, permitting us to probe deep into the problems arising as our research proceeds and to effectively question established assumptions, whenever new insights are required to be given.

(DACALBO project is under the patronage of the International Academy of History of Science.

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Acknowledgments
This paper has been produced in the frame of Dacalbo (Digital archive concerning alchemy in Byzantium and in Greek-speaking communities of the Ottoman Empire) project, funded by Thales-National Strategic Research Framework, 2007-2013.

SYMPOSIUM 4

Cartesian Physics and its Reception: between Local and Universal

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In our symposium, we would like to address one of the most important receptions of a system of natural philosophy in the seventeenth century. Namely, we shall focus on how Descartes' physics has been commented and developed in a number of places, including France, Switzerland, the Low Countries, and England. The various ways in which Descartes' philosophy influenced the seventeenth-century thought can hardly be overestimated. However, most of the studies on the reception of Cartesian philosophy in the second half of the seventeenth century focus on Descartes' metaphysics. Our symposium aims at providing a fresh perspective on the reception of Cartesian physics and its development against various backgrounds throughout Europe.

After Descartes' death, new followers of his philosophy began to print their own thoughts; contributing to something that Dennis Des Chene notoriously called "Cartesiomania." Yet, general Cartesian ideas became fertile in particular contexts which clearly influenced the way Descartes' physics was understood, discussed, adopted, and modified, some of its dimensions being highlightened and some others being left in the shadow. Our team will explore several physically oriented Cartesians in an attempt to discern the influence of particular philosophical, political, institutional, and religious ideas upon the evolution of the new physics.

For many of Descartes' own contemporaries, his physics was considered as built upon the atomist theory. Alexandra Torero-Ibad will expose the various contextual reasons for this reception of Cartesian physics as atomism. René Sigrist will discuss the context of Calvinist Geneva, where Cartesian physics came to be adopted in its Académie. The diffusion of Cartesian physics in England through Rohault's *Traité de physique* and its association with Newtonianism will be presented by Mihnea Dobre. However puzzling this association may seem, it will be better understood if other earlier episodes are taken into account. For this, our symposium will discuss two other important contexts: Leibniz's early critique of Cartesianism (by Epaminondas Vampoulis) and Regius' inner development of a more empirical approach to natural philosophy (by Delphine Bellis).

Mixing Cartesianism and Newtonianism: the Reception of Cartesian Physics in England

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Introduction

Traditional histories of both philosophy and science portray some clear-cut divisions in different periods of time. One of the most successful images that we can still find in our textbooks is that of the Scientific Revolution, which emerged at the end of the seventeenth century. Displayed under the form of the struggle of experimental philosophy to free itself from the uncontrolled speculation of the old philosophy, the change that eventually led to our modern disciplines of philosophy and science is still offering today valuable lessons to be learned. And this is precisely the task of the history of science to reassess some of the most important questions raised in the process.

This paper is a sketchy attempt to uncover some historical material that can provide new insights for a classic debate concerning the scientific exchanges between natural philosophers at the end of the seventeenth century. More precisely, I shall discuss the reception of Cartesian physics in England. Quite often, Cartesian philosophy has been considered to represent the paradigmatic case of a speculative construct that can be reduced to the metaphysical mind of its creator. Moreover, it was opposed to the research conducted at the Royal Society, which valued observation and experiment. Twentieth-century historiographies of both science and philosophy grew out of this disparity, focusing on either methodological or epistemological problems.

However, recent studies have challenged it at all levels. From the philosophical point of view, an opposition between Rationalism and Empiricism has become untenable. At the methodological level, new attempts to find more expressive means to describe the various nuanced views has been proposed by the Otago team, for example (Anstey 2012). Even more recently, I have discussed the existence of "Cartesian Empiricisms" (Dobre and Nyden 2013a; 2013b). A careful historical investigation of the late seventeenth-century natural philosophy will, nonetheless, reveal a vast array of philosophers and savants from this period that are escaping from our traditional categories.

One of the most intricate cases is that of the relation between Cartesianism and Newtonianism. To put it briefly, when scholars discuss this relation, they tend to emphasize Newton's reaction against Descartes's imagined hypotheses. While this is an important episode in the history of science, it is not the only one. In the period between Descartes's death in 1650 up to the victory of Newtoniansim in the mid-eighteenth century, followers of Descartes and adherents to Newton's explanations and his style of doing natural philosophy exchanged ideas and shared some common elements. By focusing in this paper on Jacques Rohault and the way his influential treatise on physics has been appropriated by the English universities, I shall raise several questions concerning the more general problem of philosophical reception and combining categories in the history of science.[1] However, due to the limited space, I shall present here only a rough outline.

Rohault as a case study: the challenge to the history of science.

In 1948, the famous historian of science, George Sarton, drew attention to the forgotten importance of the various editions of Rohault's textbook in England. In a sense, his challenge to the history of science with this case study is still valid today. In order to address it, I have to sketch the history of the reception of Rohault's Cartesian physics in England. First, I shall give a brief overview of the context by examining a eighteenth-century source. Then I shall look at some modern studies about Rohault. I shall continue with a discussion of what is at stake, and only after that, I shall attempt to draw some conclusions.

Background: a look at the sources

Although we have available some modern studies on this topic, such as the essays written by Volkmar Schüller and Michael Hoskin, other interesting details can be found by looking at an eighteenth-century book review. In 1706, the *Nouvelles de la République des Lettres* (*Nouvelles de la République des Lettres* 1685) published a large review of a Latin translation of Rohault's *Traité*. The author of the review – most probably Jaques Bernard, the editor of the journal – begins with a short description of the fate of Rohault's writing on physics. He refers to the early Parisian salons, where Rohault presented his Cartesian natural philosophy. Famous for his experiments, Rohault began to host conferences every Wednesday in his own house. According to this book report, Rohault's views circulated for a while in unofficial manuscript forms and Rohault's official text was published only in 1671 as the *Traité de physique* (Rohault 1671).[2]

After Rohault's death in 1672, the treatise knew a period of great glory, being translated and published in a number of places across Europe. The same narrative mentioned earlier presents a German librarian based in Geneva attempting to gain profit from the publication of Rohault's book. Thus, we learn that he commissioned a Latin translation to Théophile Bonet and that it was printed in Geneva in 1674. Many other editions followed. Of some success was Antoine Le Grand's annotated version (London, 1682; Amsterdam, 1691). Eventually, Samuel Clarke made a new translation, which was praised in the *Nouvelles de la République des Lettres*: "we have to admit with Mr. Clarke that this first Translator has done some crass mistakes" (*Nouvelles de la République des Lettres*, 457). Moreover, we find that Le Grand's editions published *cum animadversionibus*, were equally worthy of disapproval. From the *Nouvelles de la République des Lettres*, we find that many of Le Grand's annotations were not important and their replacement with Clarke's own comments in the 1702 edition was a happy choice. The book review ends here, but what is particularly striking with this context is that even after Clarke's "Newtonian" comments, Rohault's treatise was still printed and further annotated. In the 1710 edition of the book, Samuel Clarke added more comments, including the mathematical discussions of various passages, under the

[1] Other example would be Francis Bacon's reception in the mid seventeenth-century France For a discussion of some of the problems in Bacon's scholarship, see (Jalobeanu 2013).

[2] An example of an unofficial text is Rohault's *Physique nouvelle (1667)*, which was published a few years ago ((Rohault 2009).

signature of the Jesuit Charles Morgan. Subsequent Latin editions followed in 1718, 1729, and 1739 – and also in English, in 1723, 1729, and.[3]

Rohault in the history of science

The challenge this case study raises to the historian of science has nicely been summed up by George Sarton: "Now the Rohault-Clarke treatise could be defined not as a Cartesian Newtonian textbook (that would be nonsense) but as a Cartesian textbook including, in the footnotes, a Newtonian refutation" (Sarton 1948, 145). But why would a Newtonian – such as Samuel Clarke – persist in publishing a Cartesian textbook on physics? Moreover, why would he annotate it instead of producing a full Newtonian version?

Such puzzlement can be found in Hoskin, who has produced a wonderful comparative study of the various editions of Clarke's Rohault (Hoskin 1961). Samuel Clarke published his first edition of the *Traité* in 1697. In 1702, he issued a second version of the text, which – according to Hoskin – was annotated with just as much observations relying on Newton as there were comments based on Boyle. From the third edition onwards, the book incorporated more Newtonian explanations and taxonomy. The final form of the text was given in the (first) English edition, which was published in 1723. Important for this paper is Hoskin's conclusion: "The work of Newton's supporters would have been difficult indeed, if Clarke had not returned twice to make a thorough revision of the hesitant and deferential *annotatiunculae* of his early graduate days" (Hoskin 1961, 363).

Schüler also underlines Clarke's contribution: "True, this was no systematic presentation of Newton's ideas, for Clarke's role was always limited to that of a responder to a text designed as a thoughtful exposition of Cartesian physics. Yet he was able to infuse through these annotations a sufficiently coherent picture to serve adequately as a first impression of the new physics" (Schüler 2001, 99). Clarke is presented as a propagandist of Newton's physics – and in fact, he is at times. Take for example, those many places where he simply states the falsity of Rohault's text on the basis of "gravity." But he is not only opposing Newton to Cartesian physics, he is – at other times – sympathetic to Rohault's conclusions, which he accepts, despite claiming to be deduced from wrong premises.[4]

Clarke's Rohault: what is at stake?

But what did Samuel Clarke not comment in his Newtonian annotations? I've tackled that issue in the 4th ESHS conference, arguing that Clarke accepted the experimental method of Rohault and – on its broad aspects – Rohault's method in science was on a par with the one of his English contemporaries; most notably Boyle's.[5]

The contextual aspect

Rohault's activity as a scientist and his engagement in the experimental debates from the seventeenth-century Paris should be traced back to the late 1650s and early 1660s.[6] At that time, he is considered by many of his contemporaries – including Henry Oldenburg and

[3] For a larger discussion of Rohault's life and works, see (Clair 1978).

[4] For both such examples, see (Dobre 2012).

[5] See (Dobre 2012), and especially (Dobre 2013b).

[6] See the argument presented in (Dobre 2013b). It is important to place Rohault's experimentalism correctly, as this gives us a better grasp for the type of experimentation that was available at that time. In my article, I claim that Rohault's experimentalism should be compared with views on experiment from the late 1650s.

Christian Huygens – as a reputed experimentalist and natural philosopher. His joint use of theory and experimentation, with a strong emphasis on hypotheses and probability testify Rohault's departure from some of the traditional Cartesian tenets. At the same time, he comes close to Boyle in a number of issues, including causality and secondary qualities in bodies (Clatterbaugh 1999). Rohault is, thus, one of the first exponents (and the most important Cartesian) of what has been known as the "science of hypothesis" (Laudan 1981). Theory and experimentation are mediated by a constant interplay of bridging "conjectures," which can produce only probable knowledge: "Thus we must content ourselves for the most part, to find out how Things may be; without pretending to come to a certain Knowledge and Determination of what they really are; for there may possibly be different Causes capable of producing the same Effect, which we have no Means of explaining" (Rohault 1987, 14).

Rohault's method

The second aspect I want to discuss before my conclusions relates to Rohault's style of doing natural philosophy. As Trevor McClaughlin convincingly argued, he is an active experimenter, a versed Cartesian natural philosopher, and a propagandist of Cartesianism (McClaughlin 1979; 1996; 2000). In his own-hosted conferences or in the Montmor assembly, Rohault uses large-scale models (e.g., (Oldenburg 1965) describes a very large model of the human eye, which was used by Rohault to introduce his theory of vision), new instruments (he designs a variation of the Pascal's and Roberval's instrument for measuring the weight of the air, which for a while was known as the "chamber de Rohault"; see (Mouy 1934)), and perform experiments (e.g., the various trials with glass drops; see (Dobre 2013a)). In the preface to Rohault's posthumous works, Clerselier describes this laborious activity as an attempt to jointly dazzle the audience with his empirical procedure and convince them of the validity of his explanation (Rohault 1682). This approach has a strong pedagogical component, which will have various influences in the late-seventeenth century. To quickly name just a few, such is the case with the incorporation of some of Rohault's explanations in the physics curricula at the University of Louvain (Vanpaemel 2011) or Burchard De Volder's dedication to teach Cartesian physics at the University of Leiden (Nyden 2013; van Bunge 2013).

Conclusions

There are several claims I've made in this paper and some of them might look at first as unrelated to the others. First, the historical sources I have discussed for the problem of the reception of Rohault's treatise in England – the book review published by the *Nouvelles de la République des Lettres*, Sarton, Hoskin, and Schüler – point to the Newtonianism of Clarke's editions. Second, my brief comments on Rohault's contributions to seventeenth-century natural philosophy focus on the methodological and pedagogical aspects.

Remarkably, the 1706 review of Clarke's annotated version of Rohault is published in the *Nouvelles de la République des Lettres*, which was edited by Jacques Bernard. Several years later, Bernard will replace De Volder as a professor in Leiden. De Volder was one of the most important Cartesian university professors of physics, which, moreover, established at Leiden the first *university theatre of physics* in the world. In Thijssen-Schoute it is claimed that he was giving his physics courses as based on Descartes and Rohault (Thijssen-Schoute 1989). Ruestow completes this picture with the claim that by the end of his life, "In 1705, aged sixty-two and troubled in health, de Volder retired from his duties at the university. He gave his illness as the cause, but Le Clerc later suggested that also among de Volder's reasons for retirement were his weariness with teaching Cartesian physics and metaphysics and his unwillingness to begin building a new system. He had come to recognize how little that was certain the teachings of Descartes and Rohault contained, a loss of faith that had followed from his own reflections, believed Le Clerc, and the influence of the 'clever English'" (Ruestow 1973, 111-112). All these disparate events come to a meeting point: De Volder's unsettling worries about Cartesian physics comes at the same time with Clarke's new annotated translation of Rohault (and Jacques Bernard's extensive review of it). It was the moment when Cartesianism started its descendent path in physics, while Newtonianism was getting – just like Samuel Clarke's notes – more and more support. However, this was a long process on both parts and it was made possible by the existence of this Cartesian physics treatise, which still remains of great interest for the history of science. To conclude, this case study should draw our attention to more mixed disciplinary boundaries and categories in the early modern period than we are accustomed to in our history textbooks of either philosophy or science.

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Cultural Identity and Trans-Nationality in the History of Science

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Studies in the history, sociology and anthropology of science have in recent decades increasingly and convincingly shown that scientific research is based not only on logical reasoning but, like in the practical crafts, at least as much on locally specific and historically contingent pragmatic judgment. Local circumstances and cultures are thus as crucial to the understanding of scientific practices as are the wider shared values and transnational connections that make it possible for these spatially specific ideas, texts, practices, norms, instruments, procedures, protocols, personnel and materials to travel beyond their site of invention to cross and transcend national boundaries to other parts of the globe. Indeed, the very construction of these shared values and transnational connections is itself an integral part of scientific practice and its history as also is the seemingly contradictory strategy of simultaneously seeking to construct national and cultural identities through the very same objects, theories and practices.

Although this question of the mobility of locally shaped knowledge has been the object of much work in recent history and sociology of science, the focus of these studies has been limited preponderantly to Western Europe and North America. Besides, their studies have tended by and large to seek in the objects, practices and norms certain inherent qualities such as fluidity or the appropriate mix of plasticity and robustness that ensure their transnational capacities and cultural specificities.

This symposium will eschew this idea of intrinsic qualities that favour circulation. Based on individual case studies from across a wide range of spaces within and beyond the West, it is aimed at bringing out the methodological and historiographical issues involved in the problematic of circulation, while at the same time attempting to deparochialise the debate.

This symposium is planned and supported by the International Association for Science and Cultural Diversity (IASCUD) and joined by the International Commission on Science and Empire.

Scientific Cosmopolitanism and Local Cultures: Reactions to Symbols, Icons and Advancements of Science in the the Reconcavo Territory, Bahia, Brazil

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Introduction

This paper aims to make a systematization of symbolic elements in religions and its implications to the full acceptance of modern science canons in the ReconcavoBaiano region. The Reconcavo of Bahia has a cultural heritage marked by slavery and colonial past, revealed in the ethnic composition of its population, in baroque architecture, in religion and popular culture. In the center of this region is located the town of Cachoeira, where was conductedthe research. Cachoeira brings more than any other cities the legacy and the culture of colonial period, as a proxy of Reconcavo.

The Cachoeiracity, and its surroundings, play an important role in the history of the colonial period. It became an important sugar production center with access to other places by inland waterway, maritime navigation and railestablishing trade routes towards the hinterland and towards Europe.

The productive activities in the regionincludedprimary as secondary sector, like the manufacture of sugar and cigars. During the sixteenth, seventeenth, eighteenth and half of nineteenth centuries, occurred significant economic growth process.

In the twenties, with the advent of typically capitalist production, both in urban and in rural production, emerge anew social stratification. In that the ruling class and middle strata professed Catholicism and former slaves, adopted African religions professed through the syncretism. Recently, without a compelling reason, Cachoeirahas also become home to other religious manifestations, especially strands of Protestantism. In reason of the presence of various religions living together without apparent conflicts in a limited territory. Then, doubtless,Cachoeira offers an environment of wide religious diversity whit great tolerance among the beliefs,allowing researches about the perception of science by religions.

Science, Religion and Bioethics

There are several possible types of interactions between science and religion (Barbour, 2004), however, it seems that there is usually a predominance or at least more visibility of a specific type of relationship. The interactions between science and religion in bioethics are

fertile ground for expression of differences that will change depending on each particular historical moment, the region and the culture, and also the particularity of each religion.
For Evans (2010, p. 219) discussion about the relationship between science and religion may generate some lessons for bioethics issues. Initially it points to has been a consensus in bioethics that bioethicists and philosophers-theologians moved this debate because their arguments are better. Evans calls the sociology of knowledge to reject this narrative pattern, i.e., the winning group is not having the best arguments but that has more resources to garner fans. So to Evans (2010, p. 221), "If we are to focus on ideas in future analyzes of ethical conflict between religion and science, it not presume that one set of ideas will make more sense to people than another."
Another lesson has to do with another standard narrative in bioethics, which argues that scientific discoveries raise moral issues for which the society must develop ethical systems. Evolutionary psychology attempts to show that human behavior is guided by a moral, but genes generated by millions of years ago through changes in the evolution process. However, to Evans (2010), which undermines that morals of one society are not the discoveries of science but its institutional interests not to let the public be able to discuss the purpose of science.
The last lesson pointed out by Evans is that the conflict between science and religion in bioethics is not so much about epistemology but about values.

Methodology
In the research used questionnaires containing questions related to science, religion and bioethics, structured around three main themes: 1) contraception, 2) genetic research and 3) interventions regarding the end of life. Were interviewed twelve religious leaders and their responses, recorded and represented in charts, expressing the distribution of variables and frequency.
Each question had three possible answers: a) Favorable (when religious belief completely agree with this practice and sees no problem with it) b) Against (when religious belief strongly disagree with this practice), c) Favorable in some cases (when accept only a specific intervention and do not in general procedure). In the table below is showed the profile of the leaders:

Religiousleadership	Age	Gender (male/female)	Time of Performance Leadership (years)	Educationlevel
African 1	74	M	25	elementary
African 2	33	M	15	elementary
Adventist 1	38	M	14	degree in theology
Adventist 2	53	M	22	theology PhD
Catholic 1	40	M	7	degree in theology, philosofy and museology
Catholic 2	41	M	20	theology PhD
Spiritualist	-	F	1.5	degree in education, pedagogy
Neopentecostal 1 world church	45	M	20	degree in physical educator and theology
Neopentecostal 2 universal church	52	M	5	highschool
Mainline Protestants 1 Assemblies of God	61	M	6	degree in theology
Mainline Protestants 2BaptistChurch	38	M	7	degree in theology, philosofy
Jehovah'sWitnesses	43	M	17	highschool

Chart 1: *Profile of the religious leaders*

Analysis and discussion

Contraceptive Methods

Contraceptive methods can be didactically divided in: behavioral, barrier, hormonal and surgical methods. Regarding contraceptive behavior of the "rhythm method", 100% of the interviewed leaders came out in favor of their use, perhaps because it is considered the most natural possible.Regarding the behavioral method of interrupted intercourse, most were in favor, 10 in 12 or 83%. However, two Catholic leaders, 17% were against, and one of them claimed that it is a posture with negative psychological implications for the couple. While some mainline Protestants claimed that this would be a "*unbiblical procedure* " the neo-Pentecostals claimed that it depends on the choice of the couple and the church should not interfere, Chart 2.

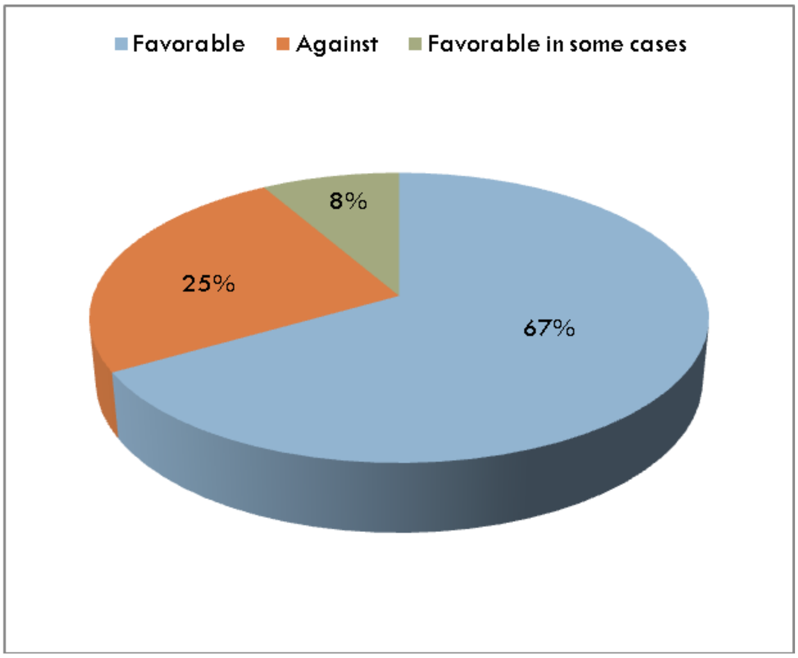

Chart 2: *Behavioral methods - interrupted intercourse. Source: Field Research*

In terms of the behavioral method of sexual abstinence most, 8/12 or 67% were in favor, in favor only in certain cases 3/12 (25%) and against (8%). The only leaders unanimous against the use of this method were neo-Pentecostals and Adventists, see Chart 3.

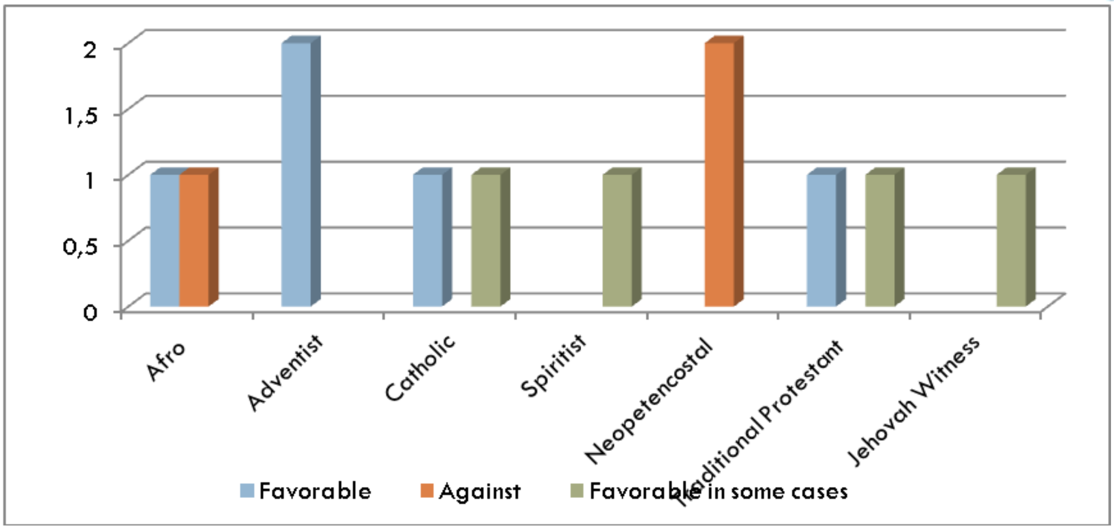

Chart 3*: Behavioral methods - sexual abstinence. Source: Field Research*

It is estimated that both acceptance and denial of this method by the leaders,is basicallyfor the same reason, namely, the preservation of certain purity or chastity, and obedience to God and the Church.

As for condoms, which is a barrier method of contraception, most 9 in 12 or 75%, been in favor, a Catholic and a mainline Protestant leaders came out in favorable in some cases (17%) and other Catholic leader, 8%, was against.The Catholic leader who stood in favor only in certain cases stated that: *[...] in the case of condoms Catholic view is always contrary. But, in some situations the man who contracted AIDS and still have relationship with his wife must use.*

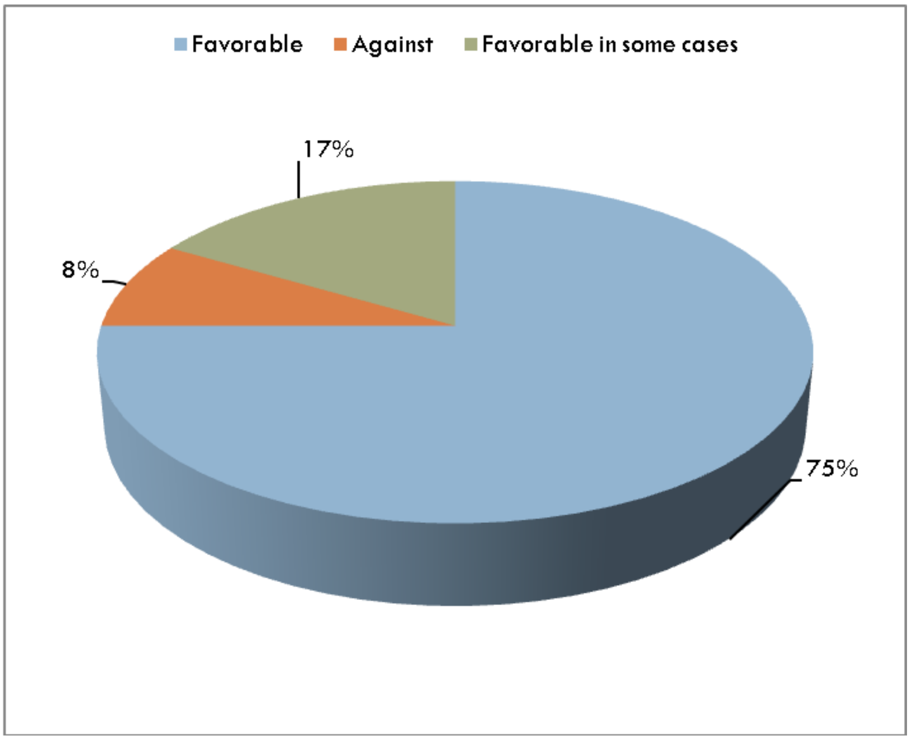

Chart 4: *Barrier methods - "Condom". Source: Field Research*

Regarding the use of the intrauterine device (IUD) half of the leaders is favorable, and the contraries, 4/12, amounted to 34%. The remaining 16% are non-responders or expressed to be in favor only in certain cases, see Chart 5. The only religious affiliation, unanimously against the use of the IUD, was in Catholic.

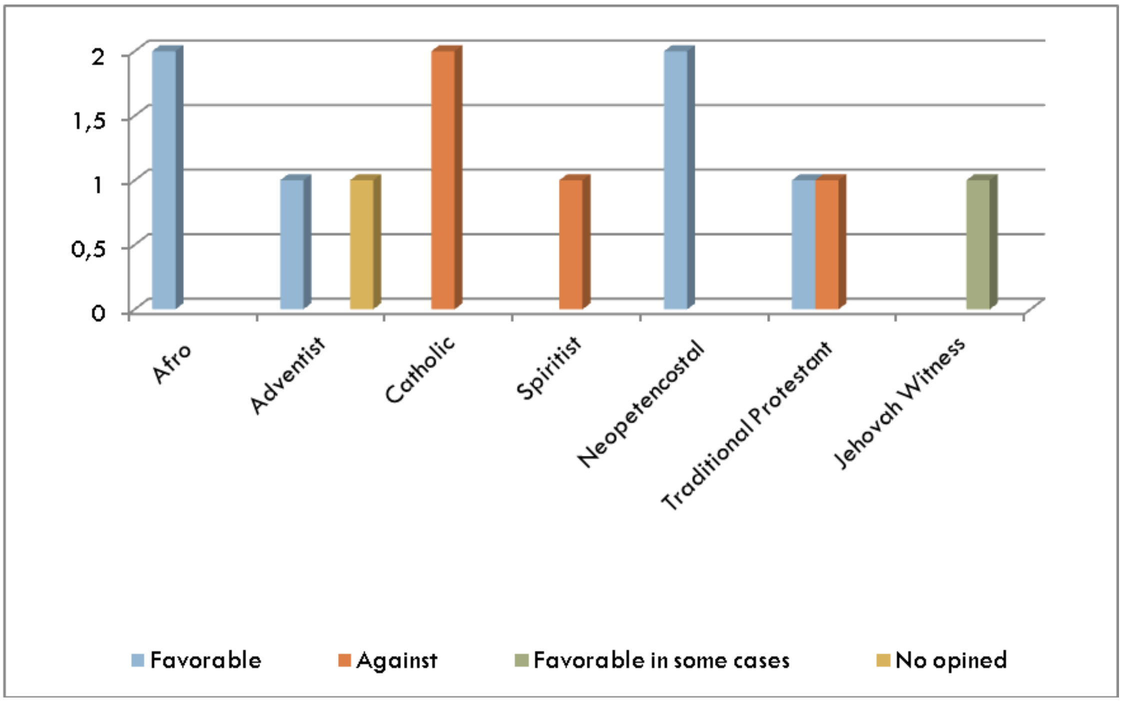

Chart 5: *Barrier methods – intrauterine device. Source: Field Research*

It is interpreted that the support or not to IUD use is related to the perspective concerning the character of the method to be or not to be abortifacient.Regarding the hormonal contraceptives methods, nine in twelve (75%) of respondents leaders came out in favor. Those who were against, only Catholics, were unanimous in their negative use and in the justification for this position they appointed two aspects: a) "moral naturalist", i.e., non-interference in the natural cycle of the human body and b) avoid health problems for women, see the distribution of responses in chart 6 .

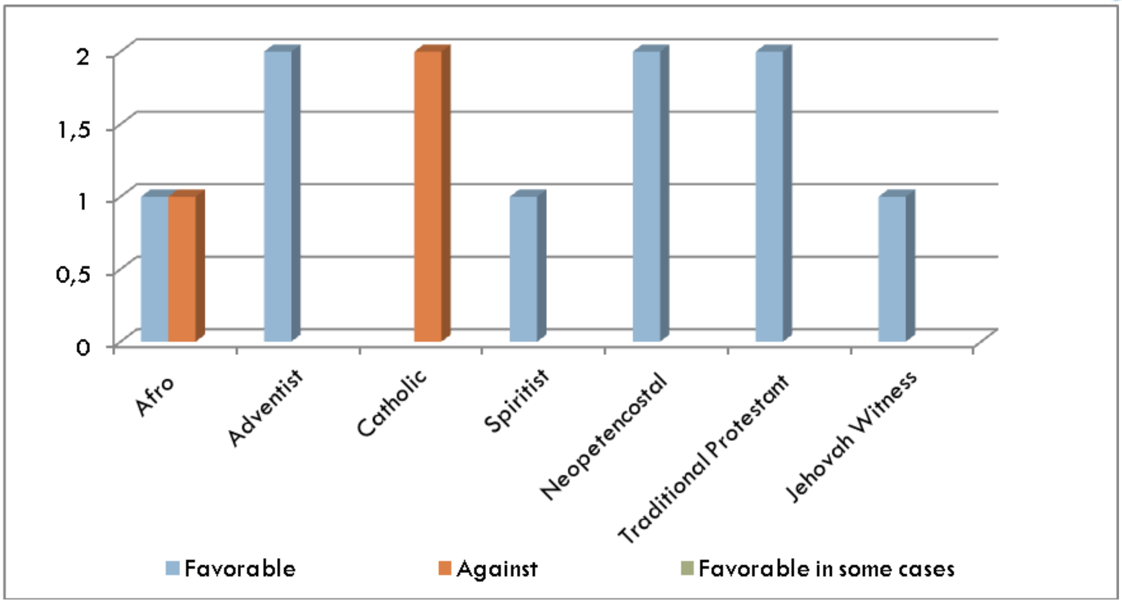

Chart 6: *Hormonal control methods (contraceptive pills). Source: Field Research*

As for hormonal method called the next day pill, half the leaders chose to be against the use of this method. Those in favor were 5 in 12, 42%, and 8% chose "for only in certain cases." Those that were cons associated e next day pill whit an abortifacient method, see chart 7.

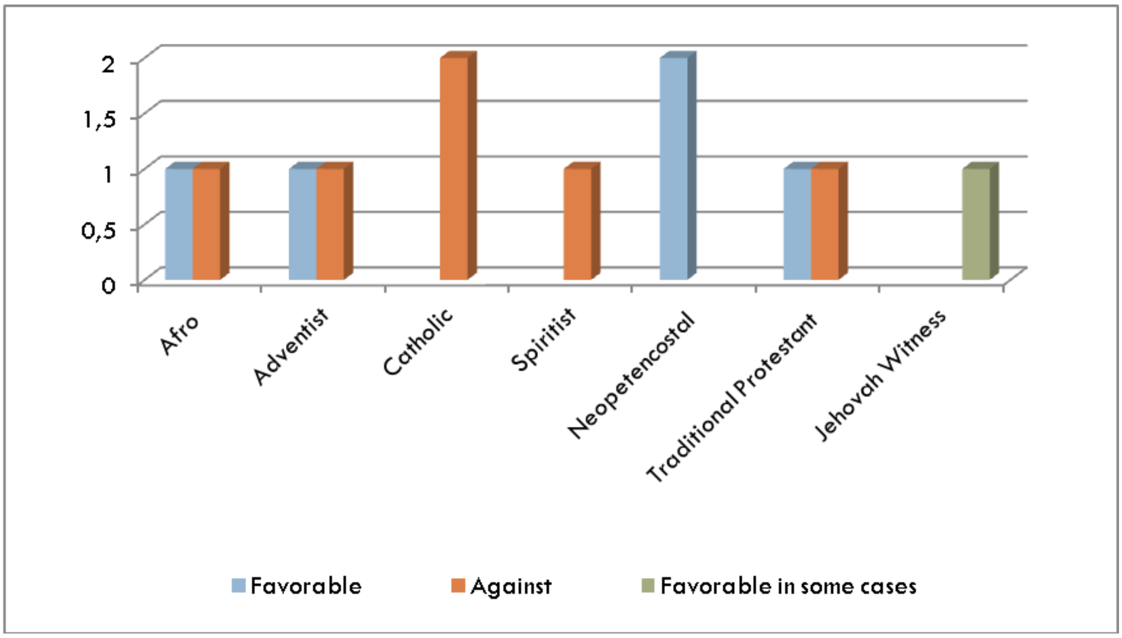

Chart 7: *Hormonal methods (the next day pill). Source: Field Research*

In the case of surgical methods and considering more specifically tubal ligation and vasectomy, 50% agreed and among these, there was unanimity on the part of afros and adventistsleaders. The percentage of the contrary and favorable only in some cases were equivalents, 25% each, as reported in chart 8. Afros leaders presented as justification these next arguments, "*It is good not to have many children and then have no conditions to create them*." (Leader african 1). "*To control the birth rate*". (Leader Afro 2).

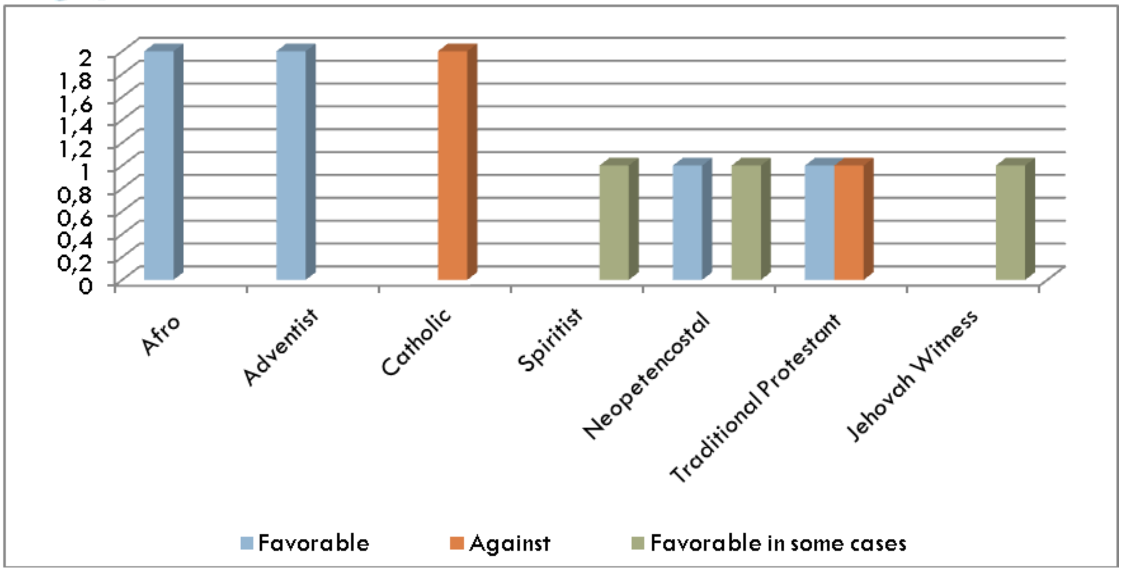

Chart 8: *Surgical Methods (Tubal ligation, vasectomy).* Source: Field Research

The Catholic leaders, who were opposed to these methods, justified this position by invoking a conflict between the subject's will and morale of the church:
Regarding the surgical method of abortion, 58% of respondents were totally cons and 33% were in favor only in very special cases; there is only one position fully favorable. The great majority of religious leaders strongly reacted against this method, as is clear in chart 9.

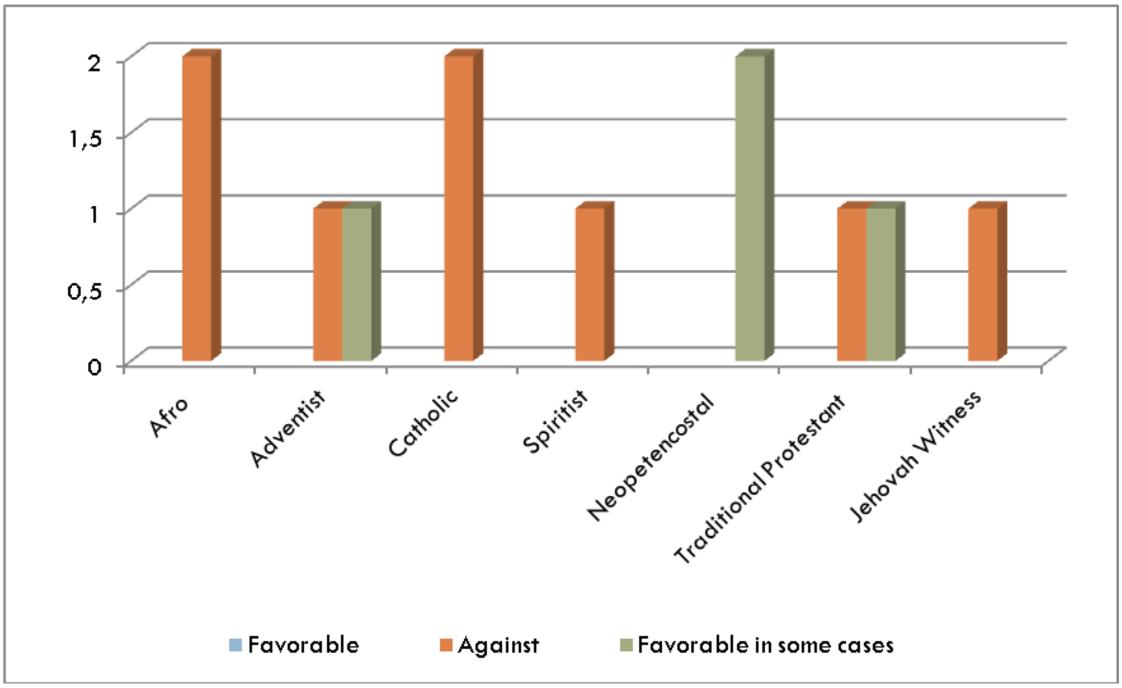

Chart 9: *Surgical Methods (Abortion). Source: Field Research*

The neo-Pentecostal and mainline Protestants, bother justify their positions favorable only in certain cases stating that: "[...] *if there is a genetic deformity Church stands for*."(Pentecostal Leader 1 - World Church). "*Only in cases of rape*." (Pentecostal Leader 2 - Universal Church).

Genetic Research

The questionsin this issue were animal cloning, human cloning, using embryonic stem cells in research, production of human organs in the laboratory and crossing genes between species. Regarding animal cloning half the leaders stood against, 33% in favor and only 17% in favor in certain cases, according to chart 10. Catholics divided between pros and cons. The leader who stood in favor argued that it is: [...] *in favor of cloning animals since science is able to solve some problems in the future as endangered species*. (Catholic Leader 2). Another leader who declared himself in favor stated that: *[...] I favor when you have scientific parameter in favor of good actions and progress for humanity.* (Mainline Protestant Leader 2 - Baptist Church). Among those who say they are in favor only in certain cases, there is the following statement: *[...] favorable when aims to meet preservations of species and do drugs*. (Adventist Leader 1).

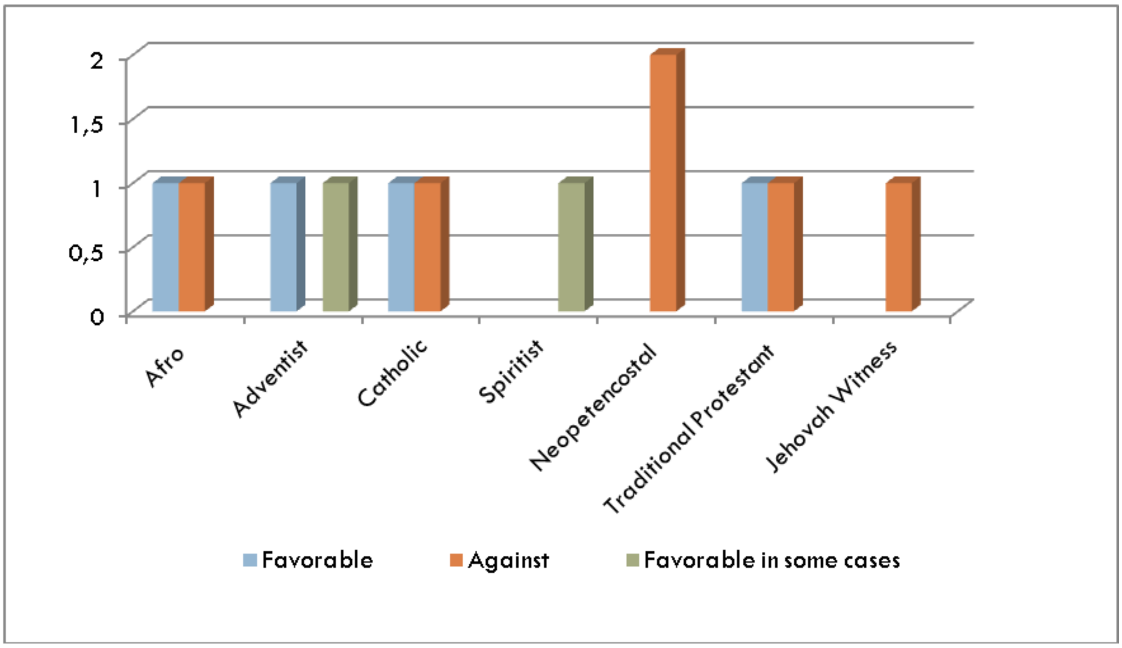

Chart 10: *Animal Cloning. Source: Field Research*

In the case of human cloning, doubtless a complex issue, the vast majority of leaders, 10 in 12, or 83%, was against, see Chart 11. Only one of the leaders stood for (Afro Leader 1) and only one chose in favor only in certain cases (Spiritualist Leader). Among those who were against, the mains arguments were a "moral naturalist"and an inability of science to create a human being endowed with personality, (Neopentecostal Leader 2 - Universal Church)

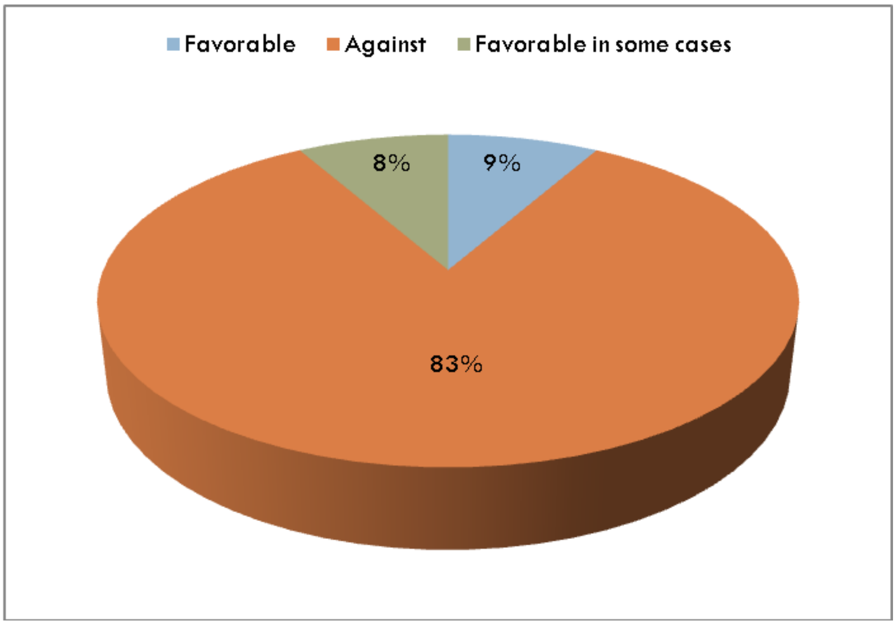

Chart 11: *Human Cloning. Source: Field Research*

Regarding the use of embryonic stem cells in genetic research, there was a great diversity of placements, 42% against, 33% in favor and 25% distributed in no opined and favorable only in certain cases, which can be perceived in Chart 12. The only unanimous position occurred among Catholicsleaders, who were against this type of research.

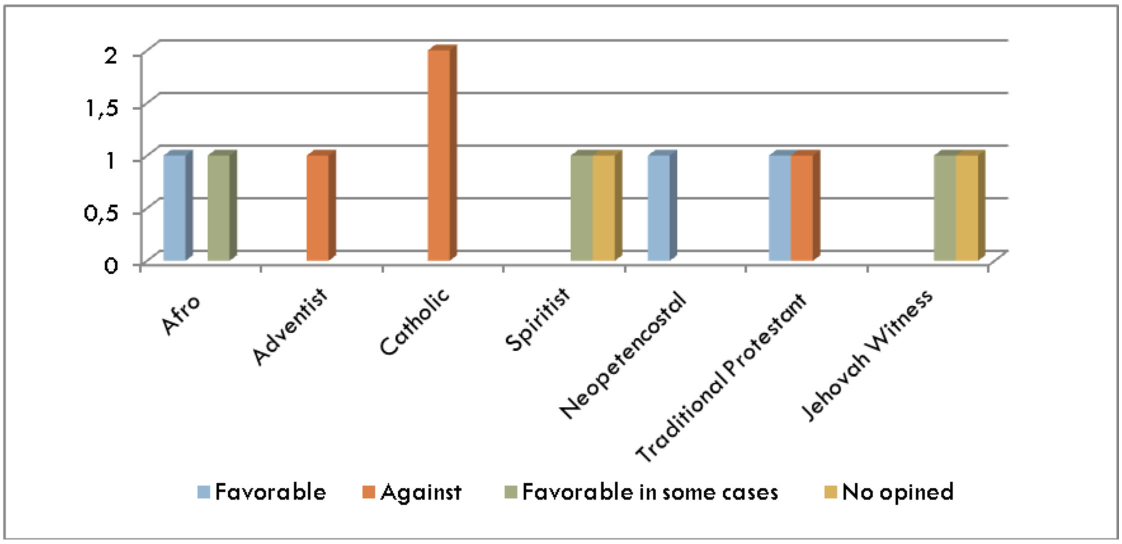

Chart 12: *Use of embryonic stem cell in research. Source: Field Research*

With regard to the production of human organs in laboratories, 42% of leaders were against, 33% in favor and only 25% in favor in certain cases,see the distribution suggested by Chart 13. Among those who agreed, in the case of the afros leaders there was unanimously but they showed no justifications. Catholic leaders were divided between pro and con and their arguments in favor invokes a corrective function of science in front of a nature that is flawed.

The mainline Protestant leaders also divided in response between the pro and con, and their arguments in favor and was very similar to the Catholic leader.

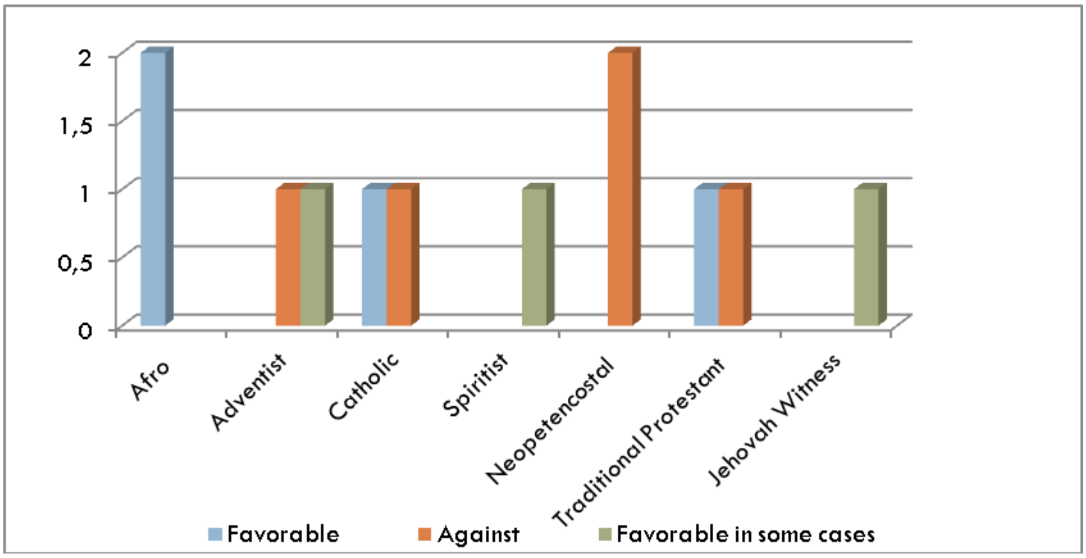

Chart 13: *Production of human organs in the laboratory. Source: Field Research*

Another very controversial issue is induced hybridization between species. An idea of how it were distributed the responses is shown in chart 14, which shows that 75% of respondents were against. Some of the arguments contrary to cross between different species refer to a danger of interfering in a natural order established by God, which somehow contradicts the arguments about the role of science to improve nature.

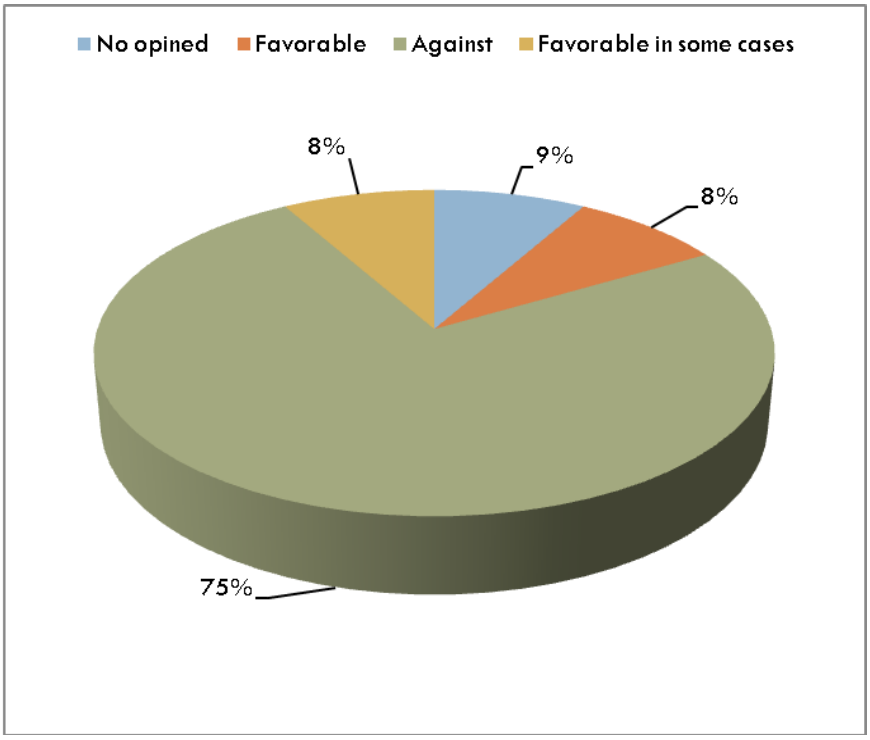

Chart 14: *Crossing genes between species. Source: Field Research*

The only leader who stood strongly in favor (Mainline Protestant Leader 2 - Baptist Church), argued for the benefits of the crossing between species presenting as an example the result of crossing the horse and donkey, mule or donkey

The interventions about the end of life

The theme of the limits of life and health interventions about that limit has raised many questions in the interaction between science and religion. Below are the four main categories of medical intervention on the patient terminal used in the research.
The euthanasia offers patients the opportunity to decide whether to continue living or not. The orthothanasia represents the suspension of procedures or treatments that aim artificially maintain the life of a terminally ill patient. The Dysthanasia, on the other hand, is artificially extend the life of a terminally ill patient with no prospect of cure and, finally, the assisted suicide, when one person helps another to kill herself
On the subject of euthanasia the majority, 75%, is positioned against, as can be seen in charts 15, given below.

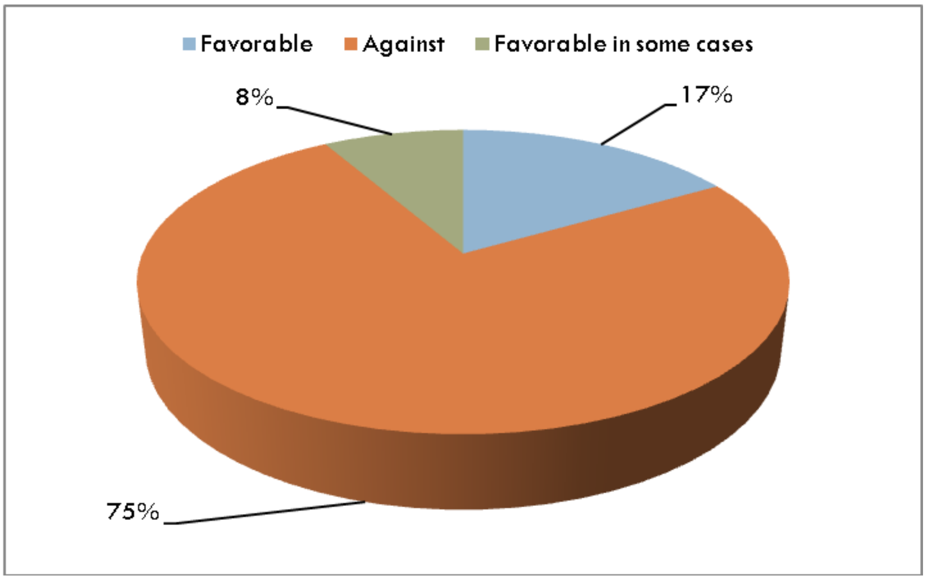

Chart 15: *Euthanasia. Source: Field Research*

Only the afros leaders were unanimously favorable to the use of euthanasia but had no reasons. The God sovereign over the life of the patient is invoked among those who were against.
Regarding the procedure of orthothanasia 42% of the leaders moved against, 42% came out in favor, and 16% choose"favorable only under certain conditions," as it tries to represent the Chart 16.
Afros leaders were unanimous in favor positioning, however, not justified. The neo-Pentecostal leaders were unanimous in positioning against and justified according to the statements below: [...] *only God can give or take the life of any human being*. (Neopentecostal Leader 1 - World Church).
Catholic and Adventist leaders were divided between the positions pros and cons, and one of the Adventist leaders justified its position against interpreting orthothanasia as a synonym

for euthanasia. The mainline Protestants were unanimous in position "favorable only in certain cases" and their positions were based on the doctor's expertise.

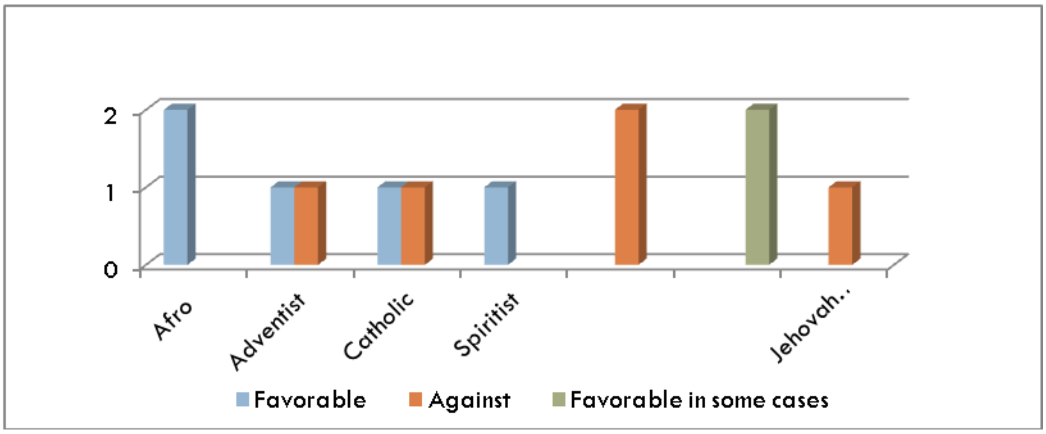

Chart 16: *Orthothanasia, Source: Field Research*

Regarding dysthanasia, half of leaders, 6/12, was against, 25% for, 17% only in certain cases and 8% didn't speak, see Chart 17. Afros leaders were unanimous in their stance in favor. Catholic and Adventist leaders were divided between the positions for and against.

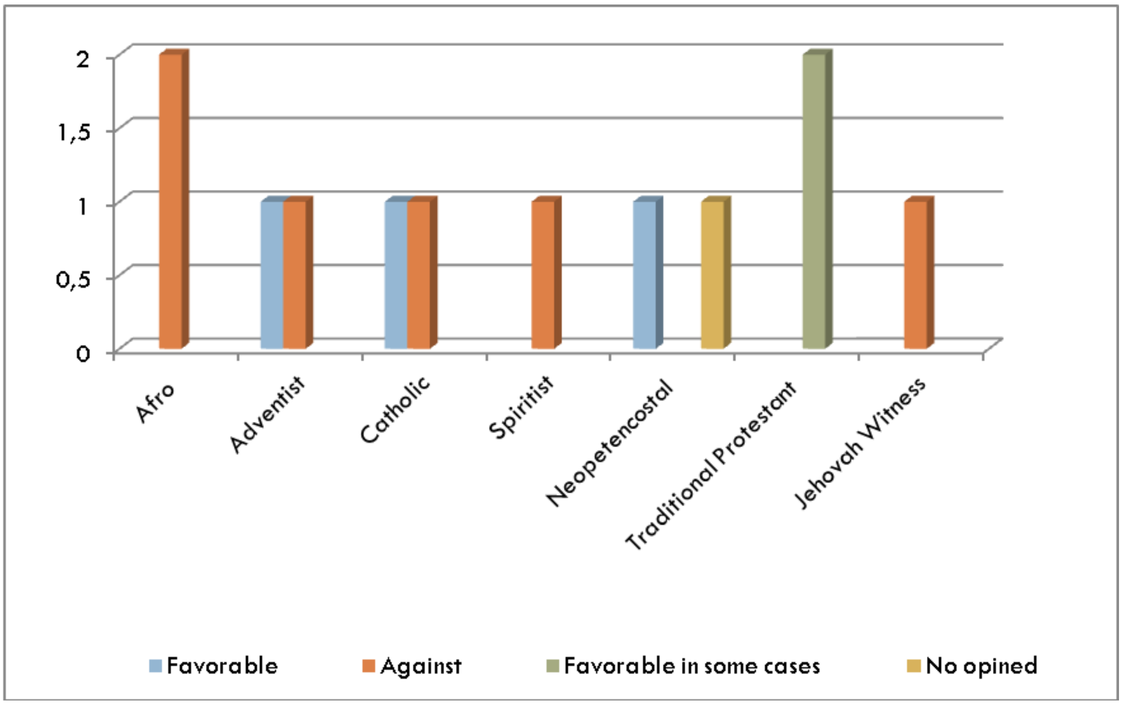

Chart 17: *Dysthanasia. Source: Field Research*

The mains responses cons were based on logical argument and in the evaluation cost effective of palliative care. The mains responses pros are related with the idea that God is the only giver or canceler of life.

Conclusions

There is a supposition that associate he education level and a level of openness in relation to the science achievements. However, the research revealed that the highest level of formal education of leaders, found in the Catholic Church, is associated with conservative positions, probably why Catholic leaders are more concerned to dogmas and hierarchically.

At the other extreme of the education level are afros leaders with the lowest level of formal education because an underprivilegedcondition of black people in Brazil compared with other ethnic groups. The Jehovah's Witnesses and the neo-Pentecostal churches do not require an education specific to constitute a leader of their congregations. It is enoughthe spirituality. Among Protestants and Adventists, to became leaders it is necessary to complete a degree in theology.

Despite the differencesto consider the themes proposed, itis possible observe that the principles behind the positions of all leaders revolve around recognizing God. Seen as the giver of life and responsible by the natural order of the human body and the cycles of the Earth. Then, interfere in these processes is somehow dangerous and should be done with caution, i.e., the science should only change this order when it deviates from a supposed original perfect plan.

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Engineers, Circulation of Knowledge, and the Construction of Imperial and Post-Imperial Spaces (18th-20th c.)

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The circulation of knowledge and the construction of modern structures of government have been identified as key forces that shaped modern profession of engineer. In this session, we would like to take a step further and test the role of engineers as mediators in the transnational circulation of knowledge and skills in a specific political framework: the imperial powers in the margins of Europe. Ruling elites of these empires systematically encouraged the transfer of specific knowledge and skills as they strove to maintain and strengthen the geo-political position of the empire. They framed this effort in the discourses of rattrapage and modernization. Similar discourses and practices were developed by the leaders of political movements that challenged the established regimes, although the territorial unit and the community to be saved and modernized could differ. By the 19th century, the very legitimacy of these empires was challenged and, in the 20th century, at the latest, they had disintegrated and/or transformed into Nation-States.
Besides the states, there were other important frameworks for the engineers' practice: 1) the companies; and 2) the intellectual/expert communities, both being transnational entities that could not be easily linked to a particular country. In these complex settings of highly fluid power structures, the engineers had to negotiate their professional identities and their practice. How was the construction and reconfiguration of professional identities and practice shaped in the changing political and economic frameworks? How did technical knowledge and professional discourses shape the economic and political structures, institutions and practices? Is there a relation between specific patterns of domination and governance, on the one hand, and the construction of modern engineering, on the other? We are particularly interested in late patrimonial empires of the European periphery (Portugal, Spain, Austria-Hungary, the Ottoman Empire and Russia) and the Nation-States that emerged from them (Brazil, Mexico, Cuba, Greece, Serbia, Egypt, etc.). The participants will include comparative and/or transnational perspective. The time span is from the 18th to the 20th century. The papers will be presented in English and French. The session should

provide material for an analysis that would combine history of science and technology, political and economic history as well as sociology of professions.

“Science - for the Glory of the German People”. Construction and Destruction of Scientific Cosmopolitanism by National Ideologies at the Academy of Sciences in Vienna

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Construction and Loss of Internationality

In 1893, the Imperial Academy of Sciences in Vienna and the academies of the German Empire were united to form the “Cartel of German Academies and Societies of Letters”.[1] The networking in common projects allowed a strong representation of 'German' science in Europe. Many of the scientists from the Imperial Academy of Sciences understood themselves as Germans, even if they had a different ethnic background. This national élite co-operated internationally, eg. with the Royal Society, and founded with its partners the “International Association of Academies (IAA)” in 1899.[2]

With the beginning of World War I, international cooperations were limited continuously. The restriction ended in the loss of the scientific superiority in Europe after the defeat of the German Empire and the Habsburg Monarchy in 1918.[3] International congresses were not held in German speaking countries anymore and German as an international language was replaced in scientific journals by English, step by step. Scientists from the allied countries argued, that they were not able to cooperate with the former enemies, who were made responsible for the breaking out of World War I.[4]

By being excluded from international organisations for several years, the “Academy of Sciences in Vienna”, as it called itself after the decline of the Habsburg Monarchy, avoided the term "Austrian Academy of Sciences“. At the meeting of the Cartel in Munich in June 1918,[5] the Viennese Academy was presented a German academy,[6] connected closely with the academies in Germany. When the Academy of Sciences in Amsterdam offered the Viennese Academy to join the Union Académique Internationale (UAI), the International

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[1] Meister, R. (1947), Geschichte der Akademie der Wissenschaften in Wien 1847–1947 (= Österreichische Akademie der Wissenschaften, Denkschriften der Gesamtakademie 1, Wien: Holzhausen), 127.

[2] Grau, C. (1995), Die Wissenschaftsakademien in der deutschen Gesellschaft: Das “Kartell” von 1893 bis 1940, in Seidler, E. (ed.) (1995), Leopoldina-Symposion. Die Elite der Nation im Dritten Reich – Das Verhältnis von Akademien und ihrem wissenschaftlichen Umfeld zum Nationalsozialismus vom 9. bis 11 Juni 1994 in Schweinfurt. Wissenschaftliche Vorbereitung und Organisation: Seidler, E., Scrba, C. J., Berg, W., Organisatorische Leitung: Müller, U., Acta Historica Leopoldina 22 (Halle an der Saale: Deutsche Akademie der Naturforscher Leopoldina): 31–53, here 31.

[3] Seidler, E. (1995), Die akademische Elite und der neue Staat, in ibid.: 15–28, here 18.

[4] Walker, M. (1995), Nazi Science. Myth, Truth and the German Atomic Bomb (Cambridge, Massachussets: Plenum Press), 108.

[5] Meister (1947), 155.

[6] Wahlmüller, M., (2010), Die Akademie der Wissenschaften in Wien. Kontinuitäten und Diskontinuitäten 1938–1945 (Diplomarbeit, Wien: Universität Wien), 19.

Academic Union for the Humanities, in 1922 and in 1923, the Viennese Academy rejected taking over a bridge function to the academies in Germany.[7]

At the meeting of the Cartel in June 1933 the Academy of Sciences in Vienna confirmed its loyalty to German academies and its nationalistic science-policy without hesitation. Confronted with the "Aryan question“, which caused the dismissal of many Jewish scientists at the universities in Germany and Austria, the academies acted now more cautiously in the choice of non-'Aryan' members.[8] The botanist Hans Molisch, a member of the Viennese academy, even encouraged to be strict in this case.[9]

Rapprochement to international scientific networks

In spite of that, the Cartel finally joined the Union Académique Internationale in 1935. The philologist Ludwig Radermacher and the historian Heinrich von Srbik, secretary of the philosophical-historical class of the Academy of Sciences in Vienna since 1933, were elected delegates for the Union,[10] but at the conferences in Brussels in 1936[11] and in London in 1937[12] only Radermacher took part.[13]

The attempt of the Cartel, networking with the Conseil International des Unions Scientifique (International Research Council for Science) failed. Bernhard von Rust, Reich Minister for Sciences, Education and National Education in Berlin, had sent Hans Stille und August Kopff, both of them members of the Prussian Academy of Sciences, to the general meeting of the Conseil International in London, in May 1937.[14] In their report to Rust, they referred to a memorandum of the Royal Academy of Sciences in Amsterdam. It was made up by seven members[15] and signed by 74 internationally acknowledged scientists before the general assembly of the Conseil. It criticised the totalitarian science policy of Germany, Italy and the Russia.[16] The scientists argued, that “the existing political situation in these countries would bind scientists to a far greater extent to their various governments than somewhere else”.[17] In their opinion, scientists needed to be free from political influence and had to stand for

[7] Grau (1995), in Seidler (ed.) (1995), 35.

[8] Walker (1995), Nazi Science, 80.

[9] Grau (1995), in Seidler (ed.) (1995), 43.

[10] AÖAW, Union Académique Internationale, 1/A, 433/1935, letter from president Oswald Redlich to Paul Pelseneer, secretary of the Union Académique Internationale, Vienna, 18 December 1935.

[11] Ibid., 1/B, 209/1936, letter from Heinrich von Srbik to the office of the Federal Chancellor, Executive Board for Public Security, Vienna, 12 May 1936.

[12] Ibid., 1/B, 41/1937, letter from Heinrich von Srbik to the secretary of the Union Académique Internationale, Vienna, 27 January 1937.

[13] Ibid., 1/B, 8/1938, Vienna, 3 March 1938.

[14] AÖAW, general documents, 372/1938, enclosure, Hans Stille and August Kopff, Prussian Academy of Sciences, report from the general assembly of the Conseil International des Unions Scientifique in London, 26 April to 3 May 1937, to the Prussian Academy of Sciences, Berlin 13 May 1937: 1–5, here 1.

[15] Ibid., 2.

[16] AÖAW, general documents, 372/1938, enclosure memorandum, report of the laboratory Voor Aero-En Hydrodynamica of the Technical Hoogeschool to Sir Henry Lyone, secretary general of the International Council of Scientific Unions, Burlington House, London W., Delft, 31 March 1937: 1–6, here 1.

[17] Ibid., report from Hans Stille and August Kopff to the Prussian Academy of Sciences, 26 April to 3 May 1937, Berlin, 13 May 1937: 1–5, here 1.

humanity and peace. The representatives of Germany saw themselves as victims of the "pacifistic opposed world",[18] which presented war as "destructive on the progress of the civilization".[19]
For Minister Rust, the content of this memorandum was "science in the sense of blurred, pacifistic, antimilitaristic ideas". To him it seemed reason enough to refuse the invitation to the conference in Copenhagen in 1940 for the Cartel, explaining, that Germany would not be a member of the Conseil International yet.[20] Egon von Schweidler, secretary general of the Academy of Sciences in Vienna obeyed Rust´s order not to take part at this conference. He informed the Conseil that Vienna would not send send any delegates, too.[21] Long before 1938, all German Academies were synchronised politically in a totalitarian system.[22]

Deconstruction of international relations
After the "Anschluss" of Austria to the German Reich the anatomist Ferdinand Hochstetter was appointed vice president by acclamation and took over the administration of the Academy of Sciences in Vienna.[23] At the general meeting on 18 March 1938, Hochstetter held a speech, which was filled with "German mind [and] German greatness".[24] Proudly he presented a draft of a telegram to Adolf Hitler.[25] Its contents was as follows, "The Academy of Sciences in Vienna, now chair of the Association of German academies [the Cartel], has decided in its general meeting on 18 March, to send respectful greetings to the leader of the united German people and to swear allegiance to him. It promises to serve the German Reich, to which Austria has returned home, to serve with all its spiritual and moral strength

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[18] Ibid., 3.
[19] AÖAW, general documents, 372/1938, enclosure memorandum, report of the laboratory Voor Aero-En Hydrodynamica of the Technical Hoogeschool, 6.
[20] Ibid., letter from the Reich Minister for Sciences, Education and National Education in Berlin to the headmasters of all German universities, including Austria and all administrative authorities of academic institutions, Berlin, 7 October 1938.
[21] Ibid., letter from Egon von Schweidler, secretary general of the Academy of Sciences in Vienna, to the Conseil International des Unions Scientifique, Vienna, 22 October 1938.
[22] Nötzoldt, P. (2000), Strategien der deutschen Wissenschaftsakademien gegen Bedeutungsverlust und Funktionsverarmung, in Fischer, W. (ed.) (2000), unter Mitarbeit von Hohlfeld, R., und Nötzoldt, P. Die Preußische Akademie der Wissenschaften zu Berlin 1914–1945. Interdisziplinäre Arbeitsgruppe Berliner Akademiegeschichte im 19. und 20. Jahrhundert (= Interdisziplinäre Arbeitsgruppen. Forschungsberichte 8, Berlin: Akademie-Verlag): 237–277, here 260.
[23] Matis, H. (1997), Die Akademie der Wissenschaften 1938 bis 1945, in Hittmair, O. und Hunger, H., (eds.) (1997), Akademie der Wissenschaften. Entwicklung einer österreichischen Forschungsinstitution (= Österreichische Akademie der Wissenschaften. Denkschriften der Gesamtakademie XV, Wien: Verlag der Österreichischen Akademie der Wissenschaften): 21–34, here 21.
[24] See AÖAW, protocol book, 144/1938, Ferdinand Hochstetter was elected vice-president of the Academy of Sciences in Vienna, Vienna, 18 March 1938.
[25] Graf-Stuhlhofer, F., Die Akademie der Wissenschaften in Wien im Dritten Reich, in Seidler (ed.) (1995): 133–157, here 135.

and never tyre in the work on the preservation and the rise of German culture, to which it has been devoted all the time.“[26]

For Srbik, meanwhile secretary general of the philosophical-historical class of the Academy of Sciences in Vienna, "the foundation of the German Reich […] was the result of the will of the nation and the unique act of an Austrian“.[27] For the NSDAP he was the ideal candidate for becoming new president of the Academy of Sciences in Vienna. On 1 April he was appointed president, in May, 1938, Srbik joined the NSDAP.[28] Till 1945, Srbik was renominated president twice. In October, 1938, German Reich Minister Rust demanded a constitutional amendment from the German academies, according to the national-socialist "basic beliefs".[29] The new, provisional statutes of the Academy of Sciences in Vienna, approved by Rust already on 22 July 1938, extended their tasks in article one on the fact that science had to be promoted "to the service of the German people“.[30] Hence, the Academy of Sciences in Vienna had to concentrate on 'German' science, done by German scientists, with unquestioning obedience.

Already in May 1938 Srbik had informed the UAI that the Viennese Academy had no more mandate there, because of "the entry of Austria into the German Reich“.[31] In order to represent the Cartel at the Conference of the UAI in London from 8 to 11 May 1939 properly, German Reich Minister Rust nominated Johannes Stroux, member of the Prussian Academy of Sciences and Srbik as delegates of the German Reich.[32] Both, Stroux and Srbik communicated at the international meeting of the UAI in German only, to advance its acceptance as the international language of science.[33]

With the fanatic promoting of the German language and 'German' science, scientific cosmopolitanism diminished step by step. Scientific exchange with academic institutions of hostile countries had to be cancelled at the Academy of Sciences in Vienna at the beginning

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[26] AÖAW, general documents 143/1938, integration of Austria into the German Reich. Telegram to the chancellor of the German Reich, Adolf Hitler and to the German academies of the Cartel, enclosure III, Vienna, 18 March 1938.

[27] Kämmerer, J., (ed.) (1988), Heinrich von Srbik. Die wissenschaftliche Korrespondenz des Historikers 1912–1945 (= Deutsche Geschichtsquellen des 19. und 20. Jahrhunderts 55, ed. Historische Kommission bei der Bayerischen Akademie der Wissenschaften, Boppard am Rhein: Boldt), Srbik, H., letter to Werner Näf, Vienna, 12 April 1938, 487.

[28] Pesditschek, M. (2012), Heinrich (Ritter von) Srbik (1878–1951). „Meine Liebe gehört bis zu meinem Tod meiner Familie, dem deutschen Volk, meiner österreichischen Heimat und meinen Schülern“, in Hruza, K., (ed.) (2012), Österreichische Historiker: Lebensläufe und Karrieren 1900–1945, Band 2 (Wien-Köln-Weimar: Böhlau): 263–328, here 297 f.

[29] Walther, P., Th. (2000), „Arisierung“, Nazifizierung und Militarisierung. Die Akademie im „Dritten Reich“, in Fischer (ed.) (2000): 87–118, here 93.

[30] Provisional statutes of the Academy of Sciences in Vienna, in Almanach der Akademie der Wissenschaften in Wien für das Jahr 1938, 88 (1939): 9–16, here 9.

[31] AÖAW, Union Académique Internationale, 1/B, 176/1938, letter from Heinrich von Srbik to the Union Académique Internationale, Vienna, 7 May 1938.

[32] Ibid., 1/B, 184/1939, letter from German Reich Minister Rust to Heinrich von Srbik, Berlin, 3 April 1939.

[33] Ibid., letter from Heinrich von Srbik and Johannes Stroux, report about the 20th meeting of the Comité of the Union Académique Internationale, 8 to 11 May 1939, Vienna, 22 April 1939: 1–7, here 1 f.

of World War II.[34] The exchange of journals and academic publications, wich was operated before 1938 internationally, focused only upon certain countries from the beginning of World War II. The Société Mathematique in Amsterdam[35] or the University College in London[36] still exchanged journals with the Viennese academy in 1939. The exchange with the Agricultural Experiment Station in Rehovot, Palestine, was dropped in the same year.[37] The national-socialist regime demanded a "reorganisation of the international system“ according to its world view“.[38] Herbert Matis, member of the Austrian Academy of Sciences, sees the loss of academic freedom as the “severest restriction”.[39]

The Reich Academy of 'German' Science

The Nazi regime used the authoritarian structure of society to enforce the 'leader's principle' as a symbol of absolute subordination. In May 1939, Minister Rust had determined Berlin for the permanent venue of the Cartel of German Academies, which first was accepted by the members of the academies.[40] Until 21 August 1940, the Cartel was replaced with the Reich Association of the German Academies of Sciences by Rust, without respecting the autonomy of the German academies.[41] Karl Theodor Vahlen, provisional president of the Prussian Academy of Sciences, representative of the 'German' mathematics and protegé of Rust, was mainly responsible for this loss of academic freedom.[42] Claiming to organize all German academies from the centre Berlin, the Academy of Sciences in Vienna had to report directly to the Ministry of Science, Education and National Education.[43] Srbik welcomed the "narrow connection“.[44]

On 2 September, 1940, Vahlen invited Srbik to Berlin.[45] A day later he was given a preliminary draught of the statutes of a Reich Academy of 'German' Science.[46] They differed

[34] See AÖAW, protocol book, 299, 300/1940, interruption of the delivery of publications, Vienna, 13 September 1940.

[35] AÖAW, protocol book, 83/1939, Writing from the Société Mathematique in Amsterdam to the Academy of Sciences in Vienna, Amsterdam, 8 Februar 1939.

[36] Ibid., 85/1939, Writing from the University College in London to the Academy of Sciences in Vienna, London 8 February 1939.

[37 37] AÖAW, general documents, 86/1939, Writing from the Agricultural Experiment Station in Rehovot, Palestine, to the Academy of Sciences in Vienna Rehovot, 10 February 1939.

[38] Zimmer, M. (2008), Moderne, Staat und Internationale Politik (Wiesbaden: VS Verlag für Sozialwissenschaften/GWV Fachverlage GmbH), 81.

[39] Matis, H. (1997), Zwischen Anpassung und Widerstand. Die Akademie der Wissenschaften 1938–1945 (= Österreichische Akademie der Wissenschaften, Wien: Verlag der Österreichischen Akademie der Wissenschaften), 50.

[40] AÖAW, protocol book 262/1939, letter from Bernhard von Rust to Heinrich von Srbik, Berlin, 22 May 1939.

[41] See Statutes of the German Reich Association of the German Academies of Sciences, in Almanach der Akademie der Wissenschaften in Wien für das Jahr 1941, 91 (1941): 160–162.

[42] Nötzoldt (2000), in Fischer (ed.) (2000), 259f.

[43] AÖAW, general documents, 30/1940, note from Bernhard von Rust to Heinrich von Srbik, Berlin, 2 February 1940. enclosure Reichsgesetzblatt, part 1,9 (1940): 49–56, here 54.

[44] Ibid., wellcome letter from Heinrich von Srbik to Rudolf Mentzel, Vienna, 10 February 1940.

[45] AÖAW, Reich Academy, 296/1940, letter from Karl Theodor Vahlen to Heinrich von Srbik, Berlin, 23 August 1940.

[46] Ibid., letter from Karl Theodor Vahlen to Heinrich von Srbik, Berlin, 3 September 1940.

completely from the preliminary draught of the Reich Association of German Academies and they were drawn up by Vahlen only, the new provisional president of the Reich Academy.[47] Rust had handed over full authority to him and subordinated all German Academies to the Prussian Academy.[48] Referring to Article 1 of the statutes, the Reich Academy should "increase the achievements of German science with all forces, emphasise outstanding individual research and promote the connection of science with the people as well as the understanding of the achievements of science for the people“.[49] In memory of Gottfried Wilhelm Leibniz, "Sozietät of the Reich Academy“ complemented the individual names of the academies.[50] The Reich Academy was planned to become an élite institution of 'German' science and a role model for Europe.[51]

On 22 April 1941, Vahlen sent a new draught of the statutes of the Reich Academy to the German academies.[52] Vahlen´s intention, to divide the academies into four classes – the mathematical-physical class, the biological class, the class for humanities[53] and an additional one for technology - was rejected by the Academies in Goettingen and Vienna.[54] Srbik supported the protest, because the mathematical-scientific class in Vienna had found as well that two classes were sufficient.[55] The Saxon Academy expressed deep concerns about the new statutes of the Reich Academy,[56] especially about introducing a fourth class for technology, as the field of technology was far reaching and not formulated precisely. "Costly experiments“ could claim a large part of the research budget, the Saxon Academy made clear to Minister Rust.[57] Therefore it insisted on the importance of the Reich Association of German Academies apart from the Reich Academy of 'German' Science.[58] Hermann Kees, egyptologist and new president of the Academy of Sciences in Goettingen,

[47] Ibid., letter from Bernhard von Rust to the members of the Reich Association of the German Academies of Sciences, Berlin, 13 September 1940.
[48] Wennemuth, Udo (1995), Die Heidelberger Akademie der Wissenschaften im Dritten Reich, in Seidler (ed.) (1995): 113–130, here 123.
[49] AÖAW, Reich Academy 296/1940, letter from Karl Theodor Vahlen to Heinrich von Srbik, Berlin, 3 September 1940. Enclosure "preliminary draught of the statutes of an German Reich Academy of German Science“: 1–9, here 1.
[50] Ibid., 2.
[51] See AÖAW, Reich Academy, 296/1940, letter from Karl Theodor Vahlen to Heinrich von Srbik, 20 November 1940. Enclosed clips from articles about the Reich Academy of German Science, here Begriff einer Akademie, in Reichsausgabe der Frankfurter Zeitung vom 8. September 1940: 3–4, here 4.
[52] Ibid., 296/1940, letter from Theodor Vahlen to Heinrich von Srbik, Berlin, 22 April 1941: 1–2, here 1.
[53] Ibid., 2.
[54] AÖAW, Reich Academy, 110/1941, letter from Hermann Kees to Theodor Vahlen, Göttingen, 30 April 1941: 1–3, here 2.
[55] Ibid., letter from Heinrich von Srbik to Hermann Kees, Vienna, 9 May 1941. Enclosure Reich Academy of 'German' Science, new draft of the statutes including the comments of the Academy of Sciences in Göttingen.
[56] Ibid., letter from the Saxon Academy of Sciences to the Reich Association of the German Academies of Sciences in Göttingen, Heidelberg, Munich, Prague and Vienna, Leipzig, 13 May 1941.
[57] Ibid., letter from the Saxon Academy of Sciences to the president of the Prussian Academy of Sciences, Leipzig, 13 May 1941:1–2, here 1.
[58] Ibid., 2.

explained to Vahlen that a politically engaged Reich Academy could not operate freely.[59] Concerning innovations, the German Academies agreed in their "guardian's role for 'pure' science“: neither a change to the advantage of sciences, nor to technology was allowed. They insisted on the two class system strongly as they wanted to hold the "parity of humanities and sciences within the members and the decision-making committees“.[60] As a result Vahlen conceded at least the continued existence of the Reich Association as a part of the Reich Academy.[61]

When Vahlen, nevertheless, demanded a written consent to the statutes,[62] Srbik delayed the act.[63] He questioned the Academy of Sciences in Goettingen[64], the Bavarian Academy[65] and the German Academy in Prague.[66] They decided to refuse Vahlen´s order.[67] Srbik was respected among the Academy presidents, more than the "colourless" and strict Nazi Vahlen.[68] The Academy presidents resisted the power of the "leader president" and refused a "Berlin - foreign dominance“.[69]

Vahlen had to inform Minister Rust that the presidents of German academies did not agree to the common statutes of a Reich Academy.[70] A common meeting with a representative of the ministry and the presidents was no longer possible under Vahlen´s presidency. Instead, the ministry informed the German academies, that no budget was planned for a Reich Academy for 1942. The decision was justified with a decree from Hitler, in which he had stated, "that such tasks were not important for the war and had to be put further back“.[71]

In April 1943, Vahlen dropped the presidency of the Prussian Academy of Sciences and vice-president Hermann Grapow took over the leadership of the academy.[72]

In May 1944, Grapow invited the presidents of the German Reich Academy to a last meeting in Weimar.[73] A last intervention of Grapow, asking Minister Rust, the "patron of German

[59] AÖAW, Reich Academy, 110/1941, letter from Hermann Kees to Karl Theodor Vahlen, Göttingen, 24 May 1941: 1–3, here 3.
[60] Nötzoldt (2000), in Fischer (ed.) (2000), 273.
[61] AÖAW, Reich Academy, 110/1941, letter from Karl Theodor Vahlen to the presidents of the "Sozietäten“ of the Reich Academy of 'German' Science, Berlin, 28 May 1941: 1–5, here 2.
[62] Ibid., 5.
[63] AÖAW, Reich Academy, 110/1941, letter from Heinrich von Srbik to Theodor Vahlen, Vienna, 5 June 1941.
[64] Ibid., letter from Hermann Kees to Heinrich von Srbik, Göttingen, 12 June 1941.
[65] Ibid., 110/1941, telegram from Karl Alexander von Müller to Heinrich von Srbik, Munich, 9 June 1941.
[66] Ibid., letter from Otto Grosser to Heinrich von Srbik, Prague, 9 June 1941.
[67] Ibid., letter from Heinrich von Srbik to Theodor Vahlen, Vienna, 20 June 1941: 1–3, here 1.
[68] Boehm, L. (2000), Langzeitvorhaben als Akademieaufgabe. Geschichtswissenschaft in Berlin und in München, in Fischer (ed.) (2000): 391–434, here 418.
[69] Matis (1997), 60.
[70] Nötzoldt (2000), in Fischer (ed.) (2000), 269.
[71] Ibid., 270.
[72] Mommsen, Wolfgang, (2000) Wissenschaft, Krieg und die Berliner Akademie der Wissenschaften. Die Preußische Akademie der Wissenschaften in den beiden Weltkriegen, in Fischer (ed.), (2000): 3–23, here 20.
[73] AÖAW, general documents 145/1944, letter from Karl Theodor Vahlen to Heinrich von Srbik, Berlin, 4 April 1944:1–5, here 1.

science“, for a budget, had remained unsuccessful.[74] Till 1944, the correspondence of the presidents of the German academies and the Ministry of Science and Education in Berlin further on named Berlin as the central city for the German academies[75] and showed letterheads with "Sozietät of the Reich Academy“,[76] connected to the names of the academies. Only the end of World War II finished the National-Socialist vision of a Reich Academy of 'German' Science as the headquarters of science organisation in Europe.
To win its own national identity again, the Academy of Sciences in Vienna was renamed 'Austrian Academy of Sciences' in 1947.[77]

Conclusion

The history of the Reich Academy of 'German' Science mirrors the political situation of the 20th century. The trauma of being excluded from European politics after the loss of World War I, and isolated from international developments, ended in nationalistic visions, hoping to be fullfilled in the Nazi-regime. The cosmopolitism of science was neglected and research was concentrated on topics which served the German people. The wish of building a new Europe with 'German' Science was the result of these nationalistic ideas, which had marked the socialisation and academic carriers of the members of German Academies since the 19th century. They were driven fanatically by the idea of gaining the leading position in international science again as they had before World War I. So they didn´t really try to resist the totalitarian science policy. The Viennese historian Herbert Matis observes a sharp political turning point at the Academy of Sciences in Vienna from 1938 to 1945.[78] It is important, he stresses, that neither a fact is "varnished", nor a "guilt assignation“ is made[79] as science was put "in the service of a brutal, criminal regime“.[80]

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[74] Ibid., 5.
[75] See AÖAW, general documents 145/1944, writing from Heinrich von Srbik to Fritz Knoll: "Überblick über Stand, Aufgaben und Bedeutung der Akademie der Wissenschaften in Wien“, Vienna, 4 September 1944.
[76] See ibid. 155/1942, letter from Heinrich von Srbik to Theodor Oelenheinz, 1 June 1942.
[77] Graf-Stuhlhofer (1995), in Seidler (ed.) (1995), 148.
[78] Matis (1997), in Hittmair and Hunger, (eds.) (1997), 21.
[79] Ibid., 10.
[80] Ibid., 7.

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SYMPOSIUM 7

Exact Sciences in Habsburg Monarchy in 18th century (on 300th Anniversary of Boscovich's Birthday)

Organizers
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The physics and astronomy lectures following the introduction of Boscovich's aspects of Newtonian physics in Habsburg Monarchy will be described. Boscovich personally visited Mid-Euroipean Towns at least three times on his way from Vienna to Venice and back. Boscovich traveled in early April 1757 on his way to Vienna where he took care for the first edition of his main work. On his return trip to Italy he was kindly welcomed in Ljubljana Jesuits' house and slept there on March 9, 1758. T In early June 1763 Boscovich visited Mid-European towns again just before he was appointed mathematical chair of Pavia in November 1763.

The high Nobles were frequently extremely interested in Boscovich know-how because Boscovich was always welcomed in their meetings. The Counts Cobenzls (Kobencl) from Ljubljana and Brussels were Boscovich's personal friends and helped him a lot, acting from their influent positions in Brussels where Johann Karl Philip Count Cobenzl was the Empress' omnipotent minister for Habsburg Belgium. The development of Mid-European Jesuit physics and astronomy did not suffer much after the suppression of the Jesuit order because just the Jesuit theology professors lost their positions, but the chairs connected with mathematical sciences were occupied by Jesuits for next three decades. There were just no other professors to replace the former Jesuits.

After the introduction of Boscovich's way of Newtonian physics in Mid-European higher studies the local professors there were among the greatest promoters of Boscovich's views in their physics and mathematics lectures. Boscovich was very popular among the Mid-European Jesuits, and his fame did not fade in the early 19th century.

The Franciscans also liked Boscovich's work. Boscovich's popularity amongFranciscans went hand in hand with Boscovich collaboration with French Franciscan teaching in Italian colleges, as were Thomas Le Seur of Roman La Sapienza in Parma or François Jacquier who got the former Boscovich's chair of mathematics in Collegio Romano in 1773. Joseph Xavier Liesegang, Karl Scherffer, Paul Mako von Kerek-Gede, and other Boscovich's Mid-European Jesuit friends' books were also widely read among Franciscans and Capuchins.

The Ljubljana Rector and later Viennese Professor Anton Ambschell promoted Boscovich in his textbooks which were famous for Ambschell and his teacher Herbert's very first comparatively exact measurement of the water compressibility. The suppression of the Jesuit order obstructed the development of Boscovich's ideas but in no way removed them from the scientific or students' scene. The Boscovich's followers and their students were able to develop strong high-schools supporting of Boscovich, who kept his great influence in 19th century and paved the way for the modern use of Boscovich's ideas in Faraday-Maxwell's electromagnetism, Kelvin's atomism, and Bohr-Heisenberg's quantum mechanics. Boscovich's ideas were never forgotten somewhat northern in Mid-European textbooks. Boscovich legacy also became strong among the Beijing Jesuits. The suppression of the Jesuit order prevented Boscovich's physics from becoming the standard textbook frame worldwide, but at least second generation of his students still followed Boscovich's ideas in the 19th century. Therefore Boscovich's ideas did not need any reintroduction via John Robison's Scottish university students into Mid-European milieu of 19th century because Boscovich fame never faded among the Mid-European scientists.

Boscovich's North Italian Predecessors and his Followers in Ljubljana

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Introduction

The manuscripts of two Italian authors from the Oklahoma University History of Science Collections are put in the limelight. The older, written on paper of Florentine origin between 1657 and 1659, was previously owned by Valentino Paolitto. The future archbishop Zacco wrote his student's notes in the other one.

When?

Paolitto's first book about earth with hydrodynamic conclusion was eventually the first of three Tractates. The second tractate dealt with the air (gases and meteorology), and the third-last tractate discussed the sky (astronomy ending with astrology). Therefore Paolitto's writer all but abandoned Ancient theory of four elements.

In *Caput quartum* he spoke on *Terrae Immobilitas*, and discussed Philosophers-Astronomers' perpetual silence considering Copernican views put forward in the previous century. On this occasion the writer, surprisingly, paid no attention to Copernicus's later critics and followers including Tycho Brahe, Galileo, or Kepler. The author focused quarrel between the Aristotelians and Copernicans, but Galileo as the central Catholic figure of the dispute was not explicitly mentioned there which indicated that the author probably did not work in somewhat more liberal Venetian milieu, but somewhere more on the South of today's Italy, probably in Florence. On the other hand, the writer's fascination with the late Padua professor of mathematics Andrea Argoli's (1570-1657) astrology indicated Venetian or Habsburgs' connection. Argoli taught many famous students from Habsburg Monarchy, among them the law student Ditrih Auersperg (1578-1634) of Ljubljana, Ditrih's friend Albrecht Wenzel Eusebius Wallenstein(1583-1634), and also Wallenstein's astrologer Giovanni Battista Zenno (Senno according to Mann, Senius-Seni according to Schiller, 1600/1601 Padua-1656 Genoa). The counts of Zeno were Venetian patricians but their male branch soon died out. Zenno published David Origanus' (Tost,1558-1628) Astrology in Marseilles seventeen years after the author's death, described himself as an amateur astronomer in the ten-page introduction, wrote his own supposedly successful foretelling of Wallenstein's death in twenty-nine pages of appendix, and added twenty-nine pages of his own improvement of Origanus' text including three horoscope diagrams of unnamed persons for conclusion (Origanus 1645, 7-8 (unpaged foreword),434,435,436,440; Mann 1976; Schiller 2010).

Paolitos' author illustrated the hydrodynamic paradox while discussing hydrographic and geographic works of the moderns conveniently called *recentiores* (Paolitto's 1657-1659, 7r,23v). That phrase was very common in the Jesuit and similar literati's discussion of the era, to distinguish the contemporary authors from the classic Antic literati or their medieval

commentators. Paolitos' text even ended with:"Ad Maiore Dei, Dei pereg Virginis sine/Labe conceptus gloria VV/Finis" which resembles usual Jesuits' phrase "Ad Maiore Dei Gloriam". Next was the *Tractatus Secundus–De Aere–Caput Primum–Aeris Locus,et motus*, with a figure of barometer, probably filled with water and not with mercury because just water was mentioned in the explanation although the proportions of pictured barometer fits more the usage of mercury. The effect of vacuum in barometer was not caused by violent motion. It was attributed to the force of rarefaction invented ad hoc. The recipient noted with letter B was immersed into the water reservoir marked with letter A. The water was actually filled with ink of some particular color. Enclosed up air in the recipient B diluted and therefore ascended the water through the proper shepherd's pipe pointed with a letter C. Simultaneously the air was lifted up in recipient B because the rising water pushed it upwards. In the next Chapter 2, author's notes on gases skipped to the motion which became violent because the winds agitated it. As the prelude introducing explanation of fire, the atmospheric air was divided into three enumerated parts, the outermost very warm one eventually belonged to the comets which were therefore still discussed as the sub-lunar phenomena in spite of the contrary profs of Tycho Brahe, Kepler, Hevelius, or Argoli's (1653, 293,297) point of the sub-lunar comets unobservable from India. On the other hand the sub-lunar misplacement of comets was Aristotelian-Copernicus-Galileo-Liceti's error.
According to Galileo's telescopic observations Copernicus' system was pictured before Tycho's and Argoli's system. Argoli's system with Mercury-Venus revolving around the Sun and Sun itself circulating the Earth (1653) was similar to Ricciolis'(1651) one and the fact that author used Argoli's name for the last=best system suggests that he was not a member of Jesuit Riccioli's Bologna milieu.
Galileo's lunar telescopic observation was put in the limelight including few observable points on the dark side of the Moon, two pictures of Lunar Craters and Seas. The figures of Lunar Surface resembled Jan Hevelius' (or his wife's) style of *Selenographia* published in Gdansk(Danzig) in 1647. Paolitto's last lunar paragraph discussed the volume of the moon. After lunar discussions, the solar ones began with the magnitude of Sun.
We could fairly date Paolitto's manuscript with a little help of its Caput XI focusing Saturn. Kircher pictured Saturn's rings as two small ellipses flanking the planet. In his *Ars Magna* of 1646 he draw two versions of Jupiter's ancient markings after observations with his fellow Jesuit Giovanni Battista Riccioli(1598-1671) through Riccioli's telescope in Bologna in 1643. Planet's radiuses were calculated as multiplication of earth's radiuses according to Kircher's comparatively high estimation of the radius of earth being just five times smaller than the radius of the sun. The writer cited Kircher's astronomical measurements of planets, Earth, Moon, and Sun, probably from Kircher's *Itinerarium* ([1656]1671), and he also mentioned Galileo and barometer invented in 1644. Therefore the manuscript must have been written after Kircher's *Ars* first edition of 1646, after the fourth astrological section of Kircher's *Oedipus* dedicated to Ditrih Auersperg's son Prince Johann Weikhard in 1654, or at least after Kircher's *Iter* of 1656/1657 (Paolitto's 1657-1659, 25r,25v,37r,38r,39-40,43r,45r-47,48v-49,56,57r,58r,59r,85r; Kircher -1654, 139).
Kircher's schema of Saturn was eventually acceptable until the Dutch Christiaan Huygens used better homemade telescope in 1643 and published his discoveries soon after Kircher's (Huygens 1659). Besides somewhat older Argoli, Kircher and his opponent Galileo were certainly the main sources for Paolitto's writer but it seems that he was unaware of Huygens' work. That enables us to date the manuscript between the years 1657-1659.

Where?
Paolitto’s paper 19.2 cm x 12.8 cm had laid vertical lines with a millimeter distances in-between perpendicularly crossed by seven horizontal lines per sheet with mutual distances 2.6 cm. The watermarks had a singular circle with the diameter of 14 cm with stylized long-tail bird on the left central inside part, standing on the three half-balls representing eggs, the middle one slightly erected above the others. The big circle touches much smaller moon, actually a letter G with a diameter of 0.5 cm. The central of the seven horizontal lines per sheet crosses the letter G on its right ending and the bird through its center. The bird facing the upper part of the paper shows tail vividly separated from its wings as if it was about to fly. The bird had feet shaped in detail as none of Heawood’s examples, although it best fits Heawood’s No.166 attributed to Holland papermaker before 1724 or attributed to Roman papermaker of 1646. Paolitto’s writer eventually used a letter G on the top while Heawood’s examples used the letter F. All Paolitto’s watermark figures were 54 mm high and 43 mm wide. The similar watermarks were described as bird on "*trimontium*" enclosed within a circle produced in 1635-1700 for Italian manuscript held in Berkeley, or bird(dove) atop three mounds, within a circle above which is the letter "F", watermark depicting a bird atop a *trimontium* enclosed in a circle with a "G" above, or the circle with enclosed bird standing on top of three mounds. That kind of bird-related watermarks belonged to the Florentines Sermartelli as principal printers for the Duke and his Academy, Donni, Giunti who published Sacrobosco’s Sphere in 1571 and 1579, or Marescotti(Marescot). In those times the printers were not properly distinguished from their paper-markers or booksellers. The similar Paolitto’s bird on "*trimontium*" enclosed within a circle was used in huge manuscript copies of Florentine Strozzi Family’s history of(Italian) world (http://ou.worldcat.org/title/miscellanea-of-discourses-dialogues-treatises-summaria-and-relazioni-concerning-politics-in-europe-during-the-first-half-of-the-thirty-years-war/oclc/84650562&referer=brief_results; Briquet 1968,"Oiseau" No.12250; http://ou.worldcat.org/title/parafrasi-de-salmi-penitenziali-di-lodovico-adimari-da-lui-donata-alla-signora-laura-sersali/oclc/48584220&referer=brief_results; http://ou.worldcat.org/title/collection-of-letters-concerning-various-religious-and-political-matters-between-italy-and-spain/oclc/85182517&referer=brief_results; Delfiol 1977, 149,170; Camerini 1979, 41,72,102-103;Folger Shakespeare Library,201 East Capitol Street,SE,Washington,D.C.20003,Strozzi Family MSS.W.b.132 vols.1-10).

Zacco’s Physics
From Paolitto’s author we move somewhat northwards in space and add two decades of time to reach his younger contemporary, Zacco. Zacco used the paper 10.2 cm x 7.2 cm with watermarks. On left corner of the final page a quarter cut from circle with approximate diameter 16 cm without recognized inside motive is observable. On some samples one could see the lily touching the circle, the stylized lily holding a circle, or ring with a lily placed as precious stone (Briquet[1907]1968, 48; Berlan 1887, 30; Duboin 1849, 16:1269).

Zacco’s paper has vertical lines with a millimeter distances in-between perpendicularly crossed by four horizontal lines per sheet on mutual distances 2.8 cm. Two first and two last sheets were thicker and had four horizontal lines per sheet on mutual distances 2.9 cm. The excellently preserved red and white threads were used for binding. Zacco discussed the Pythagoras’ views of love, and eventually endorsed the opinion of Thomas Aquinas. The 7th Aristotle’s book of Meteorology discussing minerals was used and the titles of eight

Aristotle's books of physics was provided. The relations between physic and medicine or even the *Magia Naturalis* was put in the limelight. Zacco supported atomic world view, but later also favorably discussed Aristotle's doctrine of four elements water, air, earth, and fire as did Paolitto's author. Zacco did not decide between possible spherical, triangular, oblong, or square forms of the invisible atoms attributed to some recent unnamed sources. The atoms certainly existed in spherical universe. Zacco connected the salt of stones with fire. In the second Aristotle's Physics book of Nature and artificial, Zacco discussed the magic of (Kircher's?) snake poison remedies, horology, chemistry, and alchemy with some alchemistic symbols included. Zacco used arsenic or sulfur agents, solar natural heat, and connected alchemy of metals, serpents, and lions with natural magic. He discussed tides as the practical natural motion. Here Zacco provided one of his rare marginal notes in his own text. He discussed heat and fire in connection with the Angels. He endorsed the modern principle of siphon with natural water emerging into capillary(fistula) to leave the vacuum behind itself, and he noted the mineral and solar rays which supposedly generated fire. The Solar and Lunar bright light was discussed on instrumentation paragraph, probably indicating that Zacco didn't quite accept Galileo's proofs against the Aristotelian Fortunio Liceti's(1577-1657) lunar phosphorescence (Zacco 1680/81, 1:1,2r,3v-4r,5r,8v-10,19,20v,115r, 2:40,41,43r,44r,45v,50r-50v,55,57v,59v).In fifth book Zacco discussed violent motion with *motus ignis motus lapidis* as did Pseudo-Avicenna before him. In 6th book on infinite divisibility and penetrability Zacco allowed himself to cross out few lines on the bottom of page and the beginning of next one, indicating that he was not sure how to express himself. Zacco discussed the spontaneous generation. As usual, Zacco devoted special paragraph of 6th book to the maxima and minima. In 7th book he compared motion with mobility. Zacco discussed the movement of water which we now call hydrodynamics. The gravity (or levity) caused velocities which could live vacuum behind the moving body. Besides projected movement of water he added the air movement with some military implications included. In conclusion remarks on instant motion according to the Saint Thomas Aquinas' *Natura abhores vacuo*, the air immediately filed the spaces left void after heating. In conclusion of the 7th book Zacco endorsed the Biblical notes on Babylonian fire (Zacco 1680/81, 5:106v, 6:114,118v, 121r, 7:126r,127v,128v,130r-130v,131v,133r,136v, 8:144r).
Zacco listed the sources he used for his presentation of Aristotle's physics, among them Didacus Masius (Diego Mas, 1553-1608) with his Comments on Aristotle's physics of 1628. Mas began his studies in Valencia, and continued between the years 1576-1579 in Salamanca with the Dominicans Bartoloméo de Medina (1527-1581) and thomist Domingo Báñez(1528-1604), therefore Mas became the Dominican. After 1581 Mas lectured in University of Valencia and he made his doctoral dissertation in theology in 1588. Zacco praised other influential thinkers of Salamanca School, the Jesuit Francisco de Suárez(1548-1617), although in 1679 the Pope Innocent XI(1611-1689) publicly condemned sixty-five propositions taken chiefly from the writings of Suárez and other mostly Jesuit casuists. Other Zacco's Dominican sources included Petrus Martyr Bertagna (Antonio of Verona,†1697) who was ordained on December 15, 1660, appointed the president of Dominican Monastery St.Secundi in 1672, and later lived in Venetian monastery of Santo Rosario. Zacco used Dominican Michael Zanardi's (1570 Urgnano-1642 Milano) books published in Köln in 1622. Zanardi was a nephew of Bergamo chronicle writer Paolo Zanchi (†1520 Bologna), a relative of Augusto Zacco. Zanardi taught philosophy in Milano and theology in Milano, Verona, Cremona, and Venice Dominican Colleges until he became the

rector in Bologna University. In 1617 he published Disputations of elementary Universe on alchemistic backgrounds. Zanardi stated that the resistance is not the only cause of motion, therefore the bodies in medium without resistance do not move instantly which opened the possibility for the existence of vacuum although the first experiments with barometer were accomplished only two years after his death. He made funny experiments with fire and eventually still insisted on Aristotelian error of sub-Lunar comets belonging to the meteorological sciences. Zacco preferred Dominican especially Salamanca school texts, instead of his neighbor Elena Lucrezia Cornaro Piscopia(1646-1684) who gained the first woman Doctor of Philosophy degree with the University of Padua after acclamation following her verbal discussion in presence of her promoter Galileo's friend Carlo count Rinaldini(1615-1698) and Augusto Zacco's father Francesco on 25/6/1678.

The writer Augusto Antonio Maria Zacco (Zacchi, 10/11/1662 Padua-18/2/1739 Treviso), was a son of Pirro's daughter Imperatrice Malfatti and Padua noble Francesco Zacco (18/3/1621 Padua-16/1/1694). They married in 1651 and had eight children. After Augusto's early baptism at home the ceremony was repeated in Venice church of Sant'Angelo on 21/5/1663.

Augusto was ordained priest on June 1, 1678 by Venetian Patriarch Alvise Sagredo (1617-1688) and two years later he was accepted into Padua association of canons. In May-June 1687 Augusto received the holy orders and diaconate by Sagredo (Bonora 1988, 33,37). On 15/11/1706 he was appointed Archbishop of Corfu (Corfù,Krf) in northern part of the almost lost Venetian Greece after the war for Candia(Crete) in 1669. The family name Zacco-Zacho is common in Ionian Islands, including Corfu or Lefkas. Corfu was a gateway to Venetian gulf as *La Serenissima* liked to call the Adriatic Sea. Less than a decade after Zacco's appointment the second great Turkish siege of Corfu took place as soon as the Sultan Ahmed II appeared in Butrinto on Albanian mainland just opposite to Corfu Island in 1716. On 8/7/1716, an Ottoman fleet carrying 30,000 men sailed across to Corfu from Butrinto and landed on the island to establish a beachhead. On the same day the Venetian fleet engaged the enemy fleet off Channel of Corfu and gained an important victory which postponed the Ottoman attack. On July 19, the Turks reached the hills to the west of the town and laid siege to it. The time had come for the New Corfu Fortress and Archbishop Zacco to show their strength. On 22/11/1723 Zacco was transferred back home to mainland and appointed the Archbishop of Treviso as personal title. He left at least four other later manuscripts besides the one kept in Oklahoma University. One of them is in Bibliotheca Antoniana of Padova, other in Venice, and in Treviso they keep Zacco's multipage letter of March 1728 (Binotto 1996, 593; Abate&Luisetto&Avril&d'Arcais&Mariani Canova 1975, 2,609).

Conclusion

Italian late 17th century scholarship produced Paolitto and Zacco's manuscripts which indicates the error of the present note of Oklahoma University History of Science Collections dating Paolitto's manuscript in 1620-s. The manuscripts represent the notebooks on applied mathematics (*Spherae*) and on Aristotle's physics respectively. Both reflect the turbulent years after Galilean attack on Aristotelian science which led to Boscovich's synthesis in the same North-Italian-Habsburg milieu which was cut short after the suppression of Jesuit order, but survived in Habsburg monarchy. Industrialization of those decades transformed science from the philosophic search for knowledge into its sale, recently also into big business where money surpassed ideas. Who was the true victim of waking imperialistic

European scientific technology: the confined Galileo or disillusioned Science? The historian's moral judgement of past must disable the immoral scientists of future.

Figure 1: *Watermark of the bird over 3 mountains in Paolitto's manuscript (Paolitto's 1657-1659. Photo Taisija Štupar with courtesy of Oklahoma University History of Science Collections).*

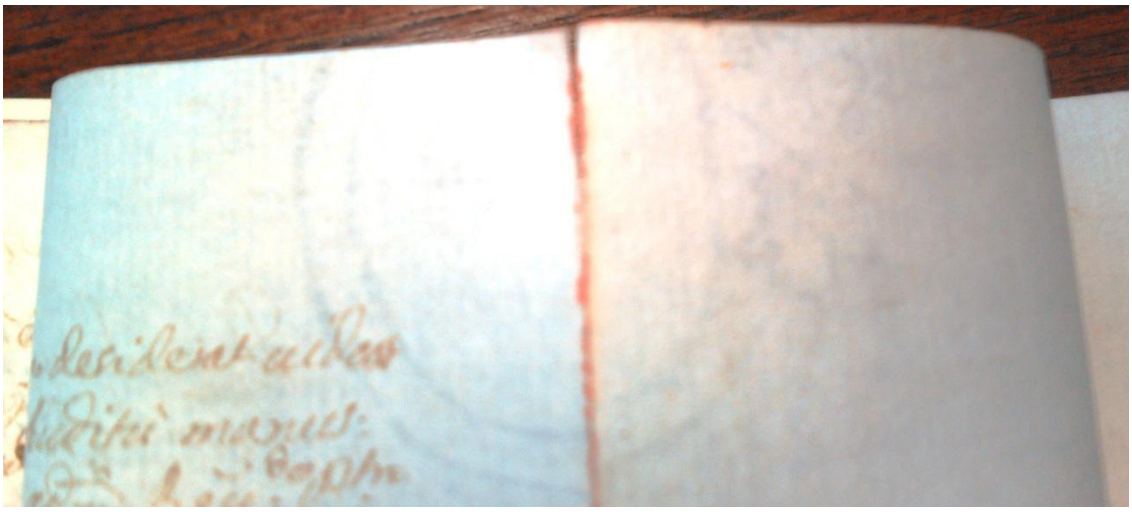

Figure 2: *Watermark of the ring in two corners of Zacco's manuscript (Zacco 1680/81. Photo Taisija Štupar with courtesy of Oklahoma University History of Science Collections).*

Ancestors of Zacco's contemporaneous branch of Galilei's family in Carniola, Venetia and Florence

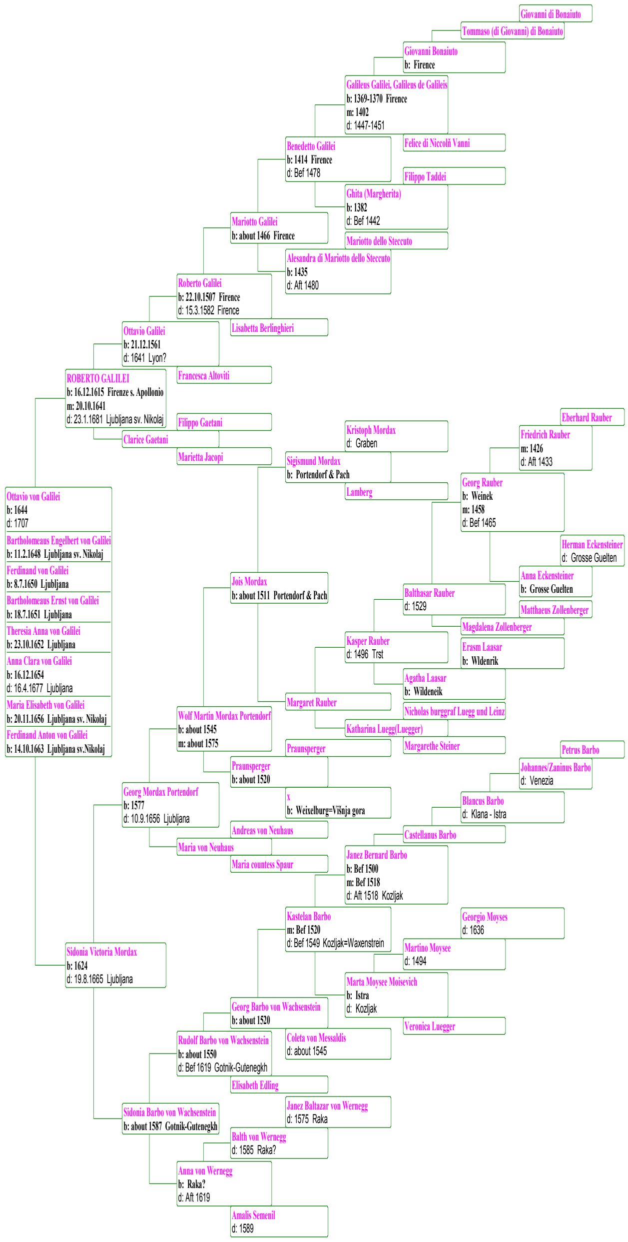

Figure 3

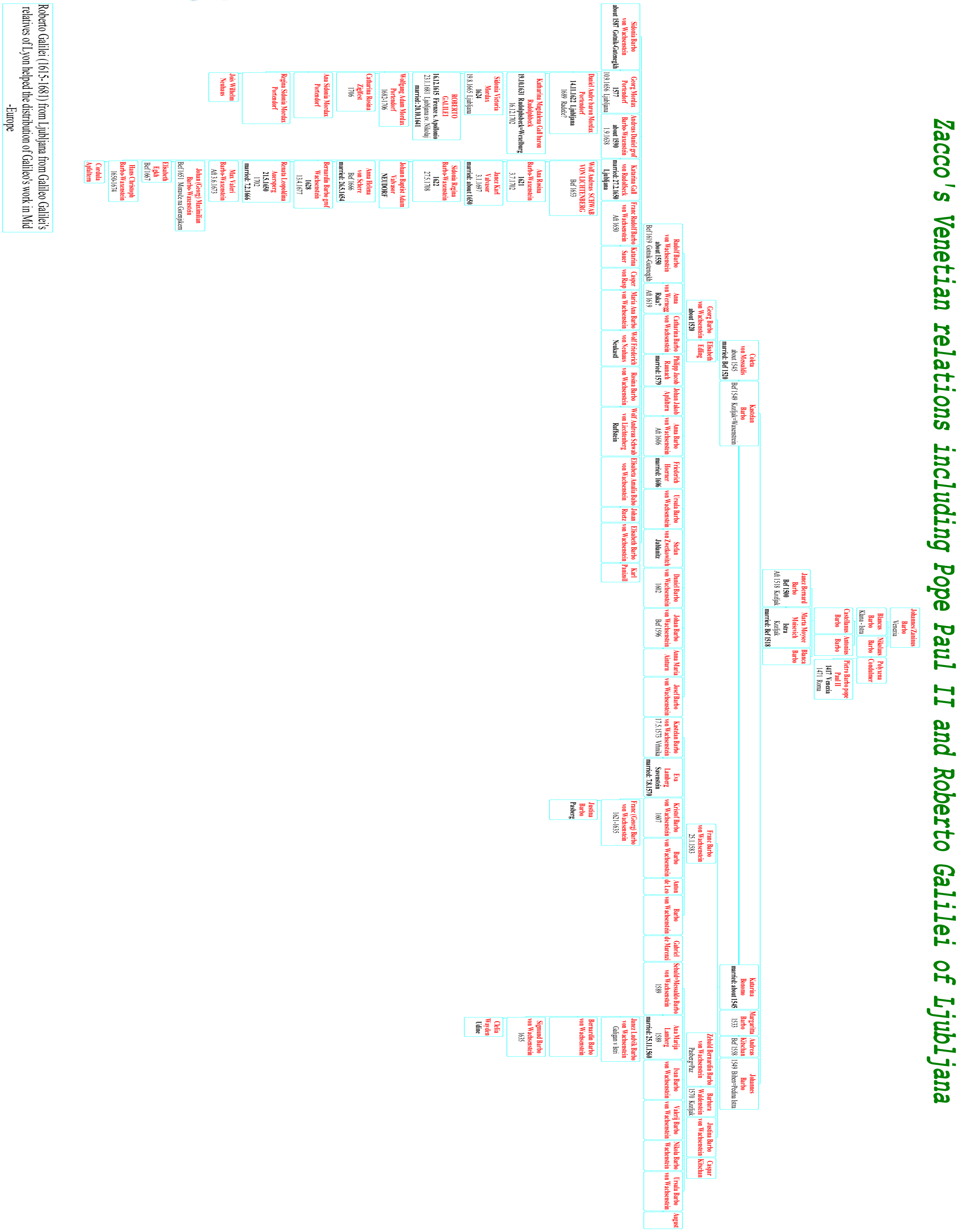
Zacco's Venetian relations including Pope Paul II and Roberto Galilei of Ljubljana
Roberto Galilei (1615-1681) from Ljubljana from Galileo Galilei's relatives of Lyon helped the distribution of Galileo's work in Mid-Europe

Figure 4

Galileo's relative Roberto Galilei of Ljubljana and their descendants in times of Paolito and Zacco

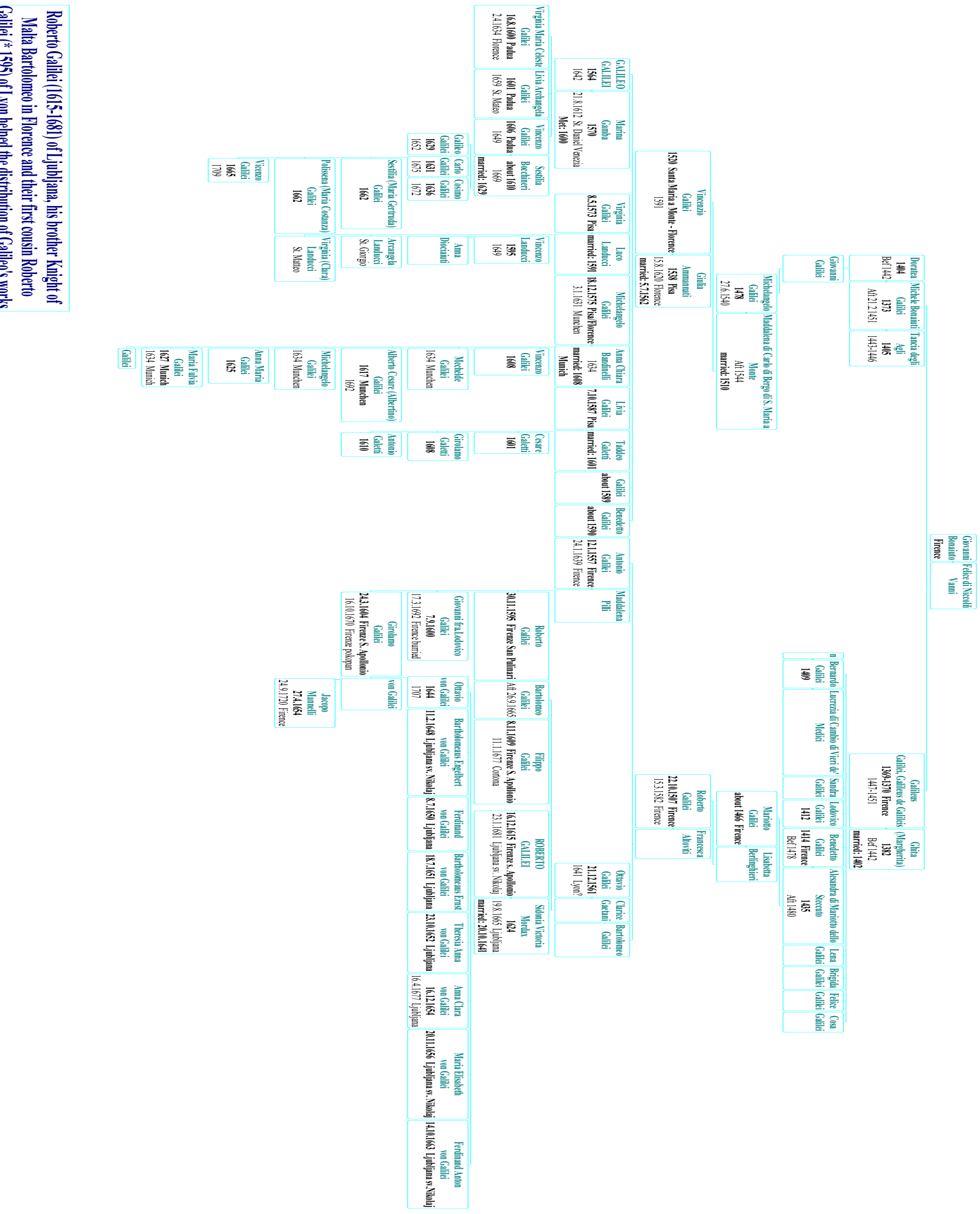

Figure 5

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Acknowledgements
Taisija Stupar accomplished the readings of watermarks.

"Ruggero Giuseppe Boscovich and his Giornale di un viaggio da Costantinopoli in Polonia". A travel diary through Eastern Europe with original scientific observations

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The *Giornale di un viaggio* by Ruggiero Giuseppe Boscovich, Jesuit abbot and scientist from Ragusa of Dalmatia, published in 1784 in Italian from a previous French version[1], covers the period from 24th May to 15th July 1762 describing in details the journey from Costantinople to Poland (the last leg seems to be Cameniec, in Poland, towards Warsaw), made by Boscovich with the English ambassador in Costantinople, James Porter[2]. In fact, after staying in Costantinople from November 1761 to May 1762, where he had arrived driven by the scientific aim of observing and describing the passing of the planet Venus, Boscovich, at that time in bad health conditions, began a difficult as well as fascinating journey back through Thrace, Rumelia, Bulgaria and Moldavia to finally reach the polish territory. This unusual route was determined by the war conditions, which actually prevented the delegation from crossing the Hungarian territory.

In fact, he Seven Years War, broken out between France and Austria on one side against Prussia and England on the other, had made it impossible to follow the usual route. As the ambassador was not going to travel by sea, the only terrestrial route which could still be followed implied crossing the Ottoman Empire and Poland to finally reach the Prussian territories and, from there, head for England. Moreover, once arrived in Warsaw, Boscovich, had not been for the worsening of his health conditions, would have travelled to Russia, to reach Saint Petersburg where, in January 1760, he was admitted among the foreign members of the Scientific Academy along with Euler and Voltaire[3].

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[1] The French diplomat P.M. Hennin (1728-1807) friend to Boscovich had accompanied Minister De Broglie in Poland, where, from 1764 he became resident minister and, when in Warsaw, in a night he had copied the journal written by Boscovich. Translated into French the *Giornale* was then published in Switzerland, in Lausanne in 1772 with the title *Journal d'un voyage de Costantinople en Pologne fait à la suite de Son Excellence M.J. Porter ambassadeur d'Angleterre par le R.P. Joseph Boscovich de la Compagnie de Jesus en 1762* and with a dedication to de Vergennes, without the scientist from Ragusa knowing it. In 1779 a German version was published in Liepzig and finally, in 1784 Boscovich published the document in Italy for Remondini di Bassano. The reference Italian edition preceding the digital publication of texts and works written by Boscovich in the *Edizione Nazionale* edited by E. Proverbio is the following: *Giornale di un viaggio di Ruggiero Giuseppe Boscovich*, Milan, 1966.

[2] James Porter, ambassador of England in Constantinople from 1747 to 1762. He was a member of the Royal Society as Boscovich was.

[3] See Paoli, G. (1988), *Ruggiero Giuseppe Boscovich nella scienza e nella storia del '700. Scritti e documenti VIII. Documenti boscovichiani* II, (*Ruggiero Giuseppe Boscovich in the Science and in the History of '700*). Rome, 159-167 and Proverbio, E. (2011), *Giornale di un viaggio da Costantinopoli in Polonia dell'abate Ruggiero Giuseppe Boscovich* (*Journal of a Voyage from Costantinople to Poland*) in Edizione Nazionale delle Opere e della Corrispondenza di Ruggiero Giuseppe Boscovich, vol. XVII/II, 2011, i-xiv.

The account of this journey is undoubtedly to be considered an historical document of a great significance and interest as it represents a rare and detailed autoptic testimony of those Eastern European Countries that, in the XVIII century, were little or not known by western travellers.

Boscovich can be duly included in the rich seventeenth century tradition of travel writers and his geographic and ethnographic descriptions, combined with brilliant linguistic and cultural considerations, stand out thanks to their accuracy, originality and subtlety[4].

The work by Boscovich describes, with a care typical of the scientist, a turkish-slavic-rumenian reality that, in the middle of the eighteenth century was still completely marginal and remote to the eyes of a European traveller, whether cultivated, and that was until then devoid of careful observers. Only another work, in fact, preceding the journal by the scientist from Ragusa, the famous *Viaggio in Dalmazia* (*Travels in Dalmatia*) written by the abbot Alberto Fortis from Padua (published in Venice in 1774) had provided the European audience with a broad and accurate description of the customs and cultural identities of the peoples from Dalmatia and, in particular of the Morlachs living in the inland of Central Dalmatian, soon becoming an extraordinary international literary case and arising a surprising interest in the short term. Thanks to the interest it had arisen and the numerous translations into the main European languages, the *Viaggio* by Fortis was largely widespread, allowing for western Europe to approach the culture of the Balkan world (and Slavic in general, even though it is commonly understood as "Illyrian") and effectively contributed to the rapid circulation of a great number of information and literary suggestions connected to that unexplored geographical area. In particular, Fortis provided for a rich material for the creation, on a European scale, of the myth linked to the Illyrian primitivism or morlachism, interpreted and idealised in a romantic rendering with a philosophical-anthropologic interest along with a strong tendency to the poetical and narrative literary exotism[5].

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[4] Make reference to the *Viaggi di Russia* by Francesco Algarotti made in 1739 and published in the 1764 edition, to Giambattista Casti, author of a *Viaggio da Venezia a Costantinopoli* in 1788 and published in 1802, to *Viaggio in Grecia* by Saverio Scrofani (1794-1798) and published in 1799 and to *Viaggio curioso scientifico ed antiquario per la Valachia, Transilvania, Ungheria fino a Vienna* by Domenico Sestini made in 1780 and published in 1815. See Bonora, E. (1951), *Letterati memorialisti e viaggiatori del Settecento (Cultured men, memoirs writers and travellers in XVIII century*), Milan-Naples, 1951 and the recently published Clerici, L. (2008), *Scrittori italiani di viaggio* (Italian Travel Writers), Vol. I 1700-1861, Milan.

[5] For a broad overview on the cultural and customary phenomenon of the “morlaccomania” see Štoiković, M. (1929), “Morlakizam”, Hrvatsko Kolo, X: 254-273, Cronia, A. (1958), La conoscenza del mondo slavo in Italia. Bilancio storico-bibliografico di un millennio (The Knowledge of Slavic World in Italy). Padova, 303-309 and 331-333 and Viani, E. (1987), Alberto Fortis. Viaggio in Dalmazia, Venice, 9-32 (introduction by G. Pizzamiglio). Make reference to the partial or integral translations of *Viaggio in Dalmazia* by Fortis, all written within three years from 1775 to 1778, and the various imitations drawing on the ethnographic parts on the Morlachs, such as: the arcadic-ossianic novel written by Countess Giustiniana de Wynne-de Rosenberg Orsini *Les Morlaques* (1788), subsequently translated into Italian in 1798, for which make reference to Maixner, R. (1955), “Traductions et imitations du roman Les Morlaques”, Revue des études Slaves 32: 64-79, to *Corinne* (1807) by Madame de Staël, the adventure novel *Jean Sbogar* by Charles Nodier (1818) set in Illyria, the *Guzla* by Prosper Mérimée (1827) and other tales of Illyrian, dalmato-croatian-herzegovese settings, as well as the successful and famous versions of the ballad *Hasanaginica* composed by Herder in his *Volkslieder*, as know also by Goethe, by the brothers Grimm and Walter Scott, until the historic-philological

Even though the journey made by Boscovich certainly did not share both the success and the extent of the fortisian account, the documentary value of the *Giornale di un viaggio* and of the testifies it contains is significant: from the description of Greek and Bulgarian villages or of the countries administered by the Ottoman Sublime Door, from the Moldavian coasts of the Black Sea to the borders with Poland. The *Relazione delle rovine di Troia*, visited by Boscovich in the month of September 1761, long before the travels made by Lazzaro Spallanzani and Jean-Baptiste Lechevalier and one hundred and ten years before the celebrated archaeological discoveries of Heinrich Schliemann, is of a great interest and can be considered as a sort of cultivated appendix to the text. In this short but meaningful archaeological note, we find a precise analysis of a Latin epigraph found in the site of Alexandria of Troas whose text is included in the *Corpus Inscriptionum Latinarum* (CIL III 1)[6]. The *Giornale di un viaggio* has manifold reasons of interest.

The first is certainly a geographical one. As it presents, step by step, the journey made with the aid of the maps drawn by the geographer and cartographer Rizzi Zannoni[7] from Padua, the strictly diaristic structure in which the Giornale is written provides the reader with a detailed picture of regions and lands administered by the Sublime Door, or rather the various Greek and Bulgarian *vilajet* as well as the formally autonomous territories which were actually vassals and tributary to the Sultan as the Principality of Moldavia. It represents a unique path, at least for this marginal part of Europe and the continuous mentioning made by Boscovich of the time of departure and arrival for every single step of the journey, as well as the precise indication of the distances between a place and another have a great value. Moreover, the travel journal contributes to fill gaps and inaccuracies concerning the historical and toponomastic geography of these areas. It is not certainly out of place remembering that also the Encyclopaedia by Diderot and Dalambert states, for example, with a certain surprise, that Herceg Novi, the first village at the entrance of Bocche di Cattaro, south of Dubrovnik, is mistakenly considered as the regional capital of Herzegovina! The descriptive confidence of Boscovich, combined with his manifold interests, account for the easiness with which he passes from the description of the rosaries of Rodope to the vineyards in Bulgaria, to the flowers and hives of Moldavia, to observations of far a different tenor with an historical-etymological interest[8]. The accurate observations it contains

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collections of the scholar from Split Giulio Bajamonti. See in particular the wide and documented essay by Wolff, L. (2001), Venice and the Slavs. The Discovery of Dalmatia in the Age of Enlightenment, Stanford, (Italian edition: Venezia e gli Slavi. La scoperta della Dalmazia nell’età dell’Illuminismo, Rome, 2006).

[6] See Ciardi, M. (2000), “Spallanzani, Lechevalier e le rovine di Troia: un capitolo delle relazioni tra storia della scienza e storia dell’archeologia”, in La sfida della modernità. Atti del Convegno Internazionale di Studi nel bicentenario della morte di Lazzaro Spallanzani (edited by W. Bernardi and M. Stefani), Florence, 241-262

[7] Giovanni Antonio Rizzi Zannoni (Padua, 1736 – Naples, 1814) was a cartographer famous all over Europe (in fact he worked in Poland, Denmark, Sweden, Prussia, and then in Paris where he also worked as hydrographical engineer. Once back to Italy, in Padua, in 1776 he conceived the great project of drawing a general map of Italy on astronomic-geodetic basis and published a monumental *Atlante geografico del Regno di Napoli*, where he had moved in 1781. His works were used for the route described in the *Giornale di un viaggio.*

[8] Boscovich notices, in fact, that the name of the Bulgarian village of Burgas, in ancient times the town of Arcadiopolis, should be explained by the phenomenon of corruption of the Greek term pyrgos (tower), as in the past the town hosted a fortalice or a castle and in Turkish territory, always

concerning the various social and cultural aspects can be considered as true ethnographic reports. From the pages of the diary come to life the arrangement and organisation of travel hans, a sort of eastern counterpart of a European *commenda*, of an evident steppe origin, that is a pavilion designed to shelter and assist travellers and to ensure the safety of their provisions. And the descriptions of the humble dwellings of country *papas*, the small churches of the Greek community in Thrace and Bulgaria, the pitiless system of duties and tolls imposed by the Turkish officers, the arbitrary and vexing one of the local taxes, the imposition by the *Michmadar* (the ottoman officer in charge of collections) of payments and services and the village justice, the *Cadì* who intervenes in case of abuses by the officer in charge against the village communities.
The dramatic condition of the streets covered with mud and of the communication roads in general, the constant difficulty to find drinkable water or the effort made by the buffalos employed to pull the chariots out of swamps and canals during the tiring legs of the journey and the notes on the coarseness and excesses of the Turkish *arabagisti*, the carters hired for the journey: all this stands out in the narration with vivid and incisive images.. Along with this short note we read other and numerous references to country dances performed by young women, to fairs and markets, taxes on plantations of tobacco and circulating shows of gipsies and wanderers. It also contains accurate references and quotations of Greek and Latin authors such as Herodotus, Pliny the older, Ptolemy, Pomponius Mela, Strabo and Scilace di Carianda, ideal and reassuring travelling companions.
The attention Boscovich paid to the ethnographic description finds an often timely confirmation further corroborating it even in other author and which left valuable substantiations regarding social and extremely similar cultural realities, as well as historical periods contemporary or subsequent to Boscovich. Starting from Matjia Mažuranić, a croatian patriot that, between 1839 and 1840 engaged in an adventurous travel to the Ottoman Bosnia, a near region which was still *terra incognita* and that he described in his *Pogled u Bosnu (A Glance at Bosnia* of 1842), and then Ivan Kukuljević Sakcinski, another Croatian, author of *Putovanje po Bosni* (*A Travel in Bosnia* of 1858) and Sir Arthur Evans, an outstanding witness of the Bosnian revolt against the Turks in 1875, author of an interesting travel journal and a journalistic reportage entitled *Through Bosnia and Herzegovina on foot, during the Insurrection of 1876* and the Russian Vasilji Malinovskij, diplomat and author of a short ethnographic note on Moldavia, added to his travel account *A Russian Man in England* of 1796 entitled *Notes about Moldavia* del 1797[9].
Boscovich also showed a great linguistic interest. As for Bulgarian, for example, defined as “un dialetto della lingua slava” and considered having a similar sound, given the very words of the scientist from Ragusa: “(simile) alla mia naturale (lingua) di Ragusa per cui ho potuto farmi intendicchiare da loro e intendere qualche cosa di quello che dicevano”. This clearly

according the testimony of Boscovich - at least three hundred places with this toponym could be found.

[9] See Matija Mažuranić, Sguardo in Bosnia ovvero Breve itinerario in quella regione, compiuto nell’anno 1839-1840 da un patriota (Glance on Bosnia), edited by Diddi, C. (2003). Lecce; Leto, M.R. (1989), “Ivan Kukuljević Sakčinski viaggiatore nella Bosnia ottomana” (“Ivan Kukuljević Sakčinski traveller in Ottoman Bosnia”), in Europa Orientalis 8: 123-134; Evans, A.J. (2005), A piedi per la Bosnia durante la rivolta (Through Bosnia and Herzegovina on foot, during the Insurrection of 1876), edited by Berber, N., Santa Maria Capua Vetere; Malinovskij, V. (1999), Un Russo in Inghilterra. Note sulla Moldavia (A Russian Man in England. Notes about Moldavia), edited by Ferretti P., Pavia.

shows the awareness of the connection and similarity to croatian and Bulgarian due to the common Slavic matrix, and in particular southern Slavic, reinforced by means of interesting examples. Making reference to an officer, he writes: "*Voivoda* come *dux belli*, poichè *voj* o *boj* significa guerra e *vodit* condurre, quindi governatore".
Again as for the Rumanian language, Boscovich states that he can neither speak nor understand the Moldavian language (a variation of Rumanian) and concerning the term *bojari*, the first rank of Moldavian nobility, he notices that its etymology derives from the name undoubtedly taken from the Slavic word *boj* (war) to indicate, in a neo-latin context contaminated by Slavic influences, the local military aristocracy. As for the Moldavian village of Birlat, Boscovich affirms that when he named it using the term *sello*, that is village (in croatian and Serb *selo*), they replied *maisto*: a term by which, he observes, in that place, as well as in Poland, they meant towns and not villages[10].
As for a living room, that is a *conak* in the house of a Walachian family, Boscovich underlines that "quei cristiani parlavano la lingua valaca che è assai diversa dalla bulgara. Essa è un miscuglio di varie lingue, massime dell'italiana e latina". He also acknowledges that the language spoken by Valachian and Moldavian is a combination of Slavic and Turkish, but it also shows important components of latin and Italian lexicon. The observations according to which the latin words in the Moldavian language did not derive from latin, but from a direct influence of the Italian language as they would have been introduced with phonetic and semantic changes inspired by Italian is of a great interest: "Questo mi fa credere che l'origine della tanta affinità della loro lingua colla latina non si deve prendere dalle antiche colonie romane, o dai loro esuli, o dai primi secoli della Chiesa, come ivi molti vi affermavano, ma piuttosto dal commercio, che vi hanno avuto gli italiani pochi secoli addietro, e dalle loro colonie[11]."
The discovery of Genoese inscriptions at Jassi, the Moldavian capital and towards the west mainly in Suciya with the insignia of the Republic of San Giorgio is a significative example.[12].
On the Bulgarian Moldavian border, the village of Mocrova, on an island in the middle of the Danube, inspires this linguistic reflection: the name undoubtedly derives from *mocro* meaning war in Slavic languages and *starosta* , the provincial governor in Moldavia is called by this name as "in Polonia i Governi si chiamano *Starostie*", affirms Boscovich, and moreover "si riteneva ancora quel nome, il quale peraltro viene dalla lingua slava, in cui *Starost* significa vecchiaia; onde se si dovesse guardare la forza della parola, dovrebbe piuttosto lo *Starosta* corrispondere al Senatore dei romani."
The *Giornale* proves a valuable catalogue of Turkish lexicon, mastered with confidence, doctrine and expertise and present with a rich vocabulary concerning the military, administrative and cultural field, represents an irreplaceable resource for the reconstruction

[10] Note that in Serbian the word *mesto* means place and the same *mjesto* in croatian, and not town (*grad*), while in polish *miasto* is the town with the same semantic meaning found in czech (*město*) and Slovenian (*mesto*).
[11] See Stavinschi, M. (1990), "Joseph Boscovich in Romania" ("Joseph Boscovich in Romanai"), in Memorie della Società Astronomica Italiana, vol.61 – n°4: 973-979 and R. Tolomeo, "Spunti e riflessioni sulla Moldavia dal Giornale di viaggio di Ruggiero Boscovich" ("Starting points and observations about Moldavia from the Giornale di un viaggio di Ruggiero Boscovich"), in Romània orientale, XI, Rome, 1999, pp. 243-263.
[12] See in general on Genoese colonies and markets in the Black Sea from the Romanian western coasts to Crimea (Azov Sea) Pistarino, G. (1990), Genovesi d'Oriente. Genoa, 122-141.

of the Balkan ottoman environment. Such terms as *sofà*, *arabas*, *besestein*, *Cioadari*, *gebegì*, *madricè*, *Calarasch*, *Ciorbagì*, *Sardar*, *Cuftlik*, *minarè*, *Giamì*, *ceflik*, *caftan*, only to give a few examples, are all translated and explained and it is uncommon that an ethnographic account also includes such accurate references and timely linguistic reflections[13].
Boscovich pays a certain attention to matters that can be, to some extent, ascribable to a badly hidden willingness to engage in a religious and cultural debate. This debate is addressed against the Greek orthodox clergy that, according to him, does not even know the *Pater noster* and shows more superstition than a real Christian faith, as well as against the barbarousness and savageness of the Turkish soldiers, not without references to the outstanding example of humanity sometimes shown in a few occasions by ottoman officers. It is a sort of necessary narrative contrast used by the traveller to reassert an irretrievable alterity of the Turkish world from the European canons of behaviour. It is also clear the use of category archetypes already present in the western ethnographic literature to describe some distinctive features of the cultural (and therefore religious) alterity: westerners consider Turkish as violent, irascible, unreliable and idle and they think the same of Greeks and Bulgarians (orthodox), described as lazy, debased by poverty and by the vassalage to the Turkish, often crafty and exploiter. Christianity, as existential category, is opposed to the Turkish and orthodox world as a civil and ordered reality embracing a geographical and spatial dimension of Europe, which is also and mainly spiritual and psychological[14].
One of Boscovich interests is strictly scientifical, of course, and in the *Giornale di un viaggio* there are three scientific descriptions: the first is about the measuring of the geographical latitude and longitude of the port of Gallaz in Moldavia to define a new accurate geographical map of that area, the second one is the description of a type of telescope named Dollond from the name of its inventor and the last one is a very short note about the measuring of the height of the Sun on the horizon in the noon to calculate the latitude in a lake near the Moldavian capital city Jassy.
The author then observes that the holy books of Moldavian churches are all written in Greek characters and are printed in Venice and that, following the rite and the ancient tradition, all churches are turned from west to east. In the frenzy swarm of goods along the Danube towers the figure of Isaac-Agà, jewish Customs Officer of Constantinople, shipowner of caravels for the navigation on the Black Sea whose base and warehouses are located at the confluence of the Prut River with the Danube[15]. The sound of the name *Lacul Ovidilui*[16] gently echoes, as a poetic suggestion, the memory of Tomi and the exile of Ovid.

[13] For the Turkish terms used and explained by Boscovich see its extremely rich lexicon Škaljić, A. (1985), Turcizmi u srpskohrvatskom-hrvatskosrpskom jeziku (Turkish Words in Serbian and Croatian Language). Sarajevo, clearly showing the Turkish-ottoman cultural unity of the numerous Balkan regions and of the Eastern Europe subject to the Turkish domination, through linguistic borrowings in the corresponding local languages.
[14] See Wolff, L. (2006), Boscovich in the Balkans: A Jesuit Perspective on Orthodox Christianity in the age of Enlightenment, in The Gesuits II. Cultures, Sciences, and the Arts, 1530-1773, Toronto, Buffalo London, 738-757.
[15] Of a great interest are the descriptions of the sephardite jewish communities in Bosnia and in Sarajevo in Evans, A. Through Bosnia and Herzegovina on foot, quotation, 113-123 and to this purpose see the short and harsh description of Moldavian Jews in Malinovskij, V. A Russian Man in England, quotation, 129-130.

Among endless conflicts of competences and jurisdictions between Moldavian *starosti* and ottoman officers, local commissioners and government officers, jewish and Armenian merchants work without rest. At Hagì Oglù Bazargìk you can buy a French set of cards, while askhenazis dressed in black with a leather cap live along people victim of the humiliating extortions by the janissaries. The description of Formosa, the residence of the Prince of Moldavia, the munificent host of Boscovich delegation, is extremely evocative and contrasts with the humble lodgings assigned to the travellers as a shelter on the previous Greek Bulgarian part. The arrival and the end of the journey both take place by the river Niester that represents the border between the Ottoman Empire and Poland at Zaleschzik, the town founded by Count Poniatowski, whose family hosts Boscovich during his stay in Poland[17]. From the borders, Boscovich heads for Cameniec, then the English ambassadors leaves for Leopolis, while Boscovich has to stop for a month due to the worsening of his health conditions. Once recovered, he heads for Warsaw, the reassuring end of an adventurous and uncomfortable journey after, to use the author very words, "un tratto così lungo d'incolta barbarie"[18].

To conclude, the quoted Report on the ruins of Troy, visited in 1761 following the Venetian Cavalier Pietro Correr, bailo at Costantinople: long before the journeys made by Lazzaro Spallanzani and Jean-Baptiste Lechevalier and nearly a century before Schliemann[19]. The report was added to the *Giornale* and Boscovich observes that despite what the previous travellers had reported, the ruins did not belong to the Homeric Troy, but to the so called New Troy or New Ilion, built by the Romans and quoted among the others by Strabo, Titus Livy and Pliny the Older. In the Dictionary edited by the French scholar De la Martinière, in the item *Troye* it is noted that Alexander the Great started the foundation of this urban centre, widened by Lisimaco and then become a roman colony. Boscovich briefly describes the ruins, dwelling on the triumphant arcs, the holy buildings, the remains of a theatre with its cavea and tiers of seats, underlines the absence of Greek epigraphs, but engages in a learned analysis of a latin inscription discovered in New Troy (then named Alexandra of Troas)[20].

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[16] As it is known, in 8 AD Ovid was condemned to be exiled by Emperor Augustus and sent to Tomi, on the western coast of the Black Sea, now Romania, where he died in 17 AD after about a 10 years confinement.

[17] As for the house of Poniatowski, of an Italian origin, see Paoli, G. Ruggiero Giuseppe Boscovich, quotation pp. 161-163 and p.166 n. 8

[18] Moreover, this expression by Boscovich refers to the subject and the content, both rich and documented, of the recent essay by Jezernik, B. (2010), Europa selvaggia. I Balcani nello sguardo dei viaggiatori occidentale (Wild Europe. Balkans in the glance of Western Travellers), Torino, 2010 efficiently showing the persistence in the European imagery until today of the distinctive, or at least this is how it is perceived, of this "incolta barbarie" already found by the scientist from Ragusa in his journey.

[19] See Schliemann, H. (1995), La scoperta di Troia (The Discovery of Troy). Turin e Ciardi M. (2008), edited by, Esplorazioni e viaggi scientifici nel Settecento (Exploration Travels and Scientific Travels in XVIII century). Milan, 227-254 on Spallanzani and Lechevalier.

[20] The commented inscription is reported in CIL (Corpus Inscriptionum Latinarum) III, 1 Inscriptiones Asiae, p.75.

The well-known traveller Pietro della Valle had already noticed that the Troy he had visited in 1614 could be identified with the Homeric town[21]. Boscovich, instead, is of a different opinion and he does not think that the remains he visited are those of the Troy of the Homeric *epos* and he is convinced that Alexandria of Troas and New Ilion are the same town. Therefore, thanks to his clever observations, he can be duly included among those travellers who, before Schliemann, wrote descriptions of Troy and of the sites that were then attributed to some extent to the ancient and legendary town of Troy.

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[21] Pietro Della Valle (Rome, 1586 – Rome, 1652) was a great traveller and explorer. He made a long journey from Egypt to Mesopotamia, then across Persia and in India, to Calcutta. During the outward journey, before reaching Costantinople, he visited a site by the Aegean coast near the town of Troy.

SYMPOSIUM 8

From Cameralism and Natural Philosophy to Applied Biology: Agriculture and Science in the 19th-20th c.

Organizers
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Some scholars in science policy studies have recently argued that late twentieth and early twenty-first century research is distinctive from preceding forms of knowledge production, as it is typically driven by particular problems arising in the context of applied research. These problems, emerging in the 'real world', require multidisciplinary approaches, they define the agenda of research, and the type of specialists assembled to solve them. However, it can be plausibly argued that historically this type of research was the original mode of science before its academic institutionalization and professionalization in the nineteenth century. At the same time, it was never extinct even in the period when 'pure' academic research fragmented along disciplinary divisions that strove to establish themselves as science par excellence. It is rather the dominant ways of writing the history of life sciences that has been focused on their progressive disciplinary diversification and therefore has obscured the actual operation of the life sciences within society. The symposium aims to re-examine the history of life sciences by exploring the history of complex relations between science and agricultural practices in modernizing societies of the nineteenth and twentieth centuries. It will explore the role of economic, political and cultural contexts in the making and unmaking of distinctive disciplinary fields and their institutional infrastructure, the circulation of ideas and practices among academic communities, governmental boards, local authorities, voluntary societies, landlords, farmers and peasants, the professionalization of research, and the connections between material aspects of agricultural practices and scholarly ideas about nature and its cultivation. We are also interested in the transfer of ideas across national cultures, and in the role of local milieu in the 'scientization' of agriculture and related fields.

Gregor Johann Mendel between *Naturphilosopie* and Positivism[1]

Jiří Sekerák
Mendelianum Musei Moraviae, Brno, Czech Republic

The way of Gregor Mendel (1822-1884) to his famous discovery of particulate inheritance has been a good summary of his consuming knowledge gathered from cameralism to experimental and applied nature science. Mendel's discovery has been connected with the Association for the Improvement of Agriculture, Nature Science and Knowledge of the Country (henceforth Agriculture Association) and the breeding and hybridization of ornamental plants carried out by Moravian gardeners.

The Agriculture Association was a practically oriented society of Moravia that originated through the ideas of Cameralism and unification of private initiatives of feudal landlords and farmers concerning the improvement of their farming estates. It published journals on practical achievements in different fields of agriculture improvement.[2] In 1817 the Agriculture Association (hereinafter referred to as AA) founded the first Moravian museum (then Franzensmuseum) and merged with it officially.[3] The word Nature Science in the name of the AA symbolizes a new approach to studying and understanding nature as a „real" world. Mendel was named a member of the Natural Science Section of the AA on January 1855. According to the statutes its task was to investigate and spread knowledge on botanical, zoological, mineralogical and geological conditions of Moravia. At that time Mendel was a substitute professor of physics and nature science. In teaching physics and nature science he supported the modern trend of implementation of real subjects into the educative process.

The AA underwent structural reform after the 1848 revolutionary events developing specializations in horticulture, vini- and pomiculture, beekeeping, history, statistics and forestry. Mendel took active part in the transformation of the youngest natural science section into the Nature Research Society in 1861 that organized his famous lecture in 1865 and published his discovery lecture in 1866. The word research in the Nature Research Society title stressed the novel role of experimentation of the material substance of Nature.

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[1] This work appears trough financial support provided to the Moravian Museum by the Ministry of Culture of the Czech Republic as part of its long-term conceptual development programme for research institutions (ref. MK000094862).

[2] See Matalová, A. (2003), „Počátky studia živých systémů na Moravě a ve Slezsku" („Beginning of the study of living systems in Moravia and Silesia"), in Květ, R. and Matalová, A. (eds.), Hledání kontinuity vědeckého poznání na Moravě a ve Slezsku, Sborník kolokvií 1996–98 (Searching the continuity of scientific knowledge in Moravia and Silesia, Proceedings of the 1996-98), Brno, Mendelianum Moravského zemského muzea v Brně a Společnost pro dějiny věd a techniky, 16–18.

[3] About the history of the Moravian Museum see also Brodesser S., Břečka J. and Mikulka J. (2002), Serving Understanding and Glory of the Land... History of the Moravian Museum. Brno: Moravian Museum. ISBN 80-7028-187-1.

Mendel was best equipped for experimental research as a student of Doppler´s practical courses at the Institute of Physics at the University of Vienna that opened at the Viennese university in 1851 to introduce the experiment into the educative process at high school and gymnasia. In 1858 Mendel was given a special mention for his teaching real subjects thus helping to equalize the real subjects with humanities.[4]

Impetus

In the first paragraph of his discovery paper on the Experiments in Plant Hybrids Mendel remarks: *Artificial fertilization undertaken on ornamental plants to obtain new colour variants initiated the experiments to be discussed here.* (Mendel 1866, 3)

The experiments referred to were not made by Mendel himself, but Mendel had the possibility to know them from the Moravian ornamental plant breeders organized in the Horticulture Section of the AA. Mendel worked in the AA from 1854 till the end of his life. The dream of a gardener at that time was to achieve a new colour variant that would breed true. Such a new variant line could be registered as a novelty and sell at a high price. But the new variants achieved through artificial pollination were not constant and reverted to their predecessors.

Mendel considered this phenomenon so important that he decided to study it experimentally: *The striking regularity with which the same hybrid forms always reappeared whenever fertilization between like species took place suggested further experiments whose task it was to follow the development of hybrids in their progeny.* (Mendel 1866, 3)

Academic Sources

Mendel was resistant to academic theories on fertilization in higher plants all of which one were generated under the influence of the prevailing *Naturphilosophie.* He opposed the role of vital forces and essences in the process of fertilization that drew from philosophy of nature. Academic teaching of his teacher Fenzl on the embryo sack of the mother plant giving only nutrition to the pollen grain is falsified in Mendel’s discovery paper in a footnote. (Fenzl was Mendel’s examiner in Mendel’s unsuccessful examination.)[5]

Implausibility of Mendel’s discovery in the mainstream of science

The recipients of Mendel’s view on constant hybrids were the gardeners, plant breeders and improvers. Hybridists concerned themselves predominantly with the progressive role of hybrids in evolution. The secretary of the Nature Research Society G. Niessl was of the opinion that Mendel’s work was neglected for 35 years because the mainstream of science worked in support of Darwin’s theory of descent with modification. Darwin’s concept of evolution included the Lamarckian teaching on the inheritance of acquired characters and found great echo in the *Naturphilosophie* in Germany. Later in the 20th century it became significant that *Naturphilosophie* was not compatible with Mendel’s theory. This controversy resulted into a clash of ideas in the post-war era of Lysenkoism.[6]

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[4] Orel, V. (2003), Gregor Mendel a počátky genetiky (Gregor Mendel and the beginnings of genetics). Praha: Academia, 26–9.

[5] See Klein, J. and Klein, N. (2013), Solitude of a Humble Genius – Gregor Johann Mendel: Volume 1. Formative Years. Berlin, Heidelberg: Springer- Verlag, 364-5. ISBN 978-3-642-35253-9

[6] See Matalová, A. and Sekerák, J. (2004), Genetics Behind The Iron Curtain. Brno: Moravské zemské muzeum, 119. ISBN 80-7028-246-0. See also: Sekerák, J. (1996-1997), “So-called vegetative

Mendel knew that his experimental data would not be plausible for the mainstream of science.

> *I knew that the results I obtained were not easily compatible with our contemporary scientific knowledge, and that under the circumstances publication of one isolated experiment was doubly dangerous; dangerous for the experimenter and for the cause he represented.*[7]
> *(…) I am not surprised to hear your honor speak of my experiments with mistrustful caution; I would not do otherwise in a similar case.*[8]

Mendel expected that he would not find support in the academic society. In Mendel's paper the hybrids were reversible, reverted to the old types of their forebears and had a zero significance for evolutionary concept of change.
However, the Moravian gardeners understood the significant role of reversion and its practical meaning. The Horticulture Section of the AA appreciated Mendel's experiments in plant hybrids as époque making already in 1884. Their evaluation was the only one single response to Mendel's discovery in the 19th century.[9] The academic science accepted Mendel's work until 35 years later.
Were Mendel not elected abbot in 1868, he would have continued in looking for the so-called constant hybrids. Mendel even elaborated a theoretical explanation of the so-called constant hybrids if their existence would be proven.

> *It was proven experimentally that in Pisum hybrids form different kinds of germinal and pollen cells and that this is the reason for the variability of their offspring. For other hybrids whose offspring behave similarly, we may assume the same cause; on the other hand, it seems permissible to assume that the germ cells of those that remain constant are identical, and also like the primordial cell of the hybrid. According to the opinion of famous physiologists, propagation in phanerogams is initiated by the union of one germinal and one pollen cell into one single cell, which is able to develop into an independent organism through incorporation of matter and the formation of new cells. This development proceeds in accord with a constant law based on the material composition and arrangement of the elements that attained a viable union in the cell. When the reproductive cells are of the same kind and like the primordial cell of the mother, development of the new individual is governed by the same law that is valid for the mother plant. When a germinal cell is successfully combined with a dissimilar pollen cell we have to assume that some*

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hybridization as a means of achieving genetic change tested on animals in Prague", Folia Mendelaina 31-32: 29 – 32.
7 From Mendel's second letter to Nageli, 18 April, 1867. The English translation published in Stern, C. and Sherwood E. R. (eds.) (1966), The Origin of Genetics. San Francisco and London: W. H. Freeman and Company. 60.
8 Ibid. 61.
9 See the obituary of 10 January (1884), Monatsberichte der Obst-, Wein- und Gartenbausektion der k. k. Mähr. Schles. Gesellschaft zur Beförderung des Ackerbaues, der Natur- und Landeskunde. (Monthly reports from the fruit, wine and horticulture section of the Imperial Moravian and Silesian Association for the Improvement of Agriculture, Nature Science and Knowledge of the Country) Brno.

compromise takes place between those elements of both cells that cause their differences. The resulting mediating cell becomes the basis of the hybrid organism whose development must necessarily proceed with a law different from that for each of the two parental types. If the compromise be considered complete, in the sense that the hybrid embryo is made up of cells of like kind in which the differences are entirely and permanently mediated, then a further consequence would be that the hybrid would remain as constant in its progeny as any other stable plant variety. The reproductive cells formed in its ovary and anthers are all the same and like the mediating cell from which they derive. (Mendel 1866, 41)

Conclusion

After 1848 a school reform was carried out, which considerably influenced the AA. In 1861, after the ending of Bach's autocracy, the independent the Nature Research Society (Naturforschender Verein) was established by Mendel and other members of the natural-scientific section of the AA. This section was dominated by aristocrats and landowners, and had ceased to reflect the interests of several young natural scientists who strove for greater independence.

The Nature Research Society strove to apply new trends in scientific positivism, which was reflected in a complex approach to the natural sciences as a whole, from mathematics and physics through meteorology, astronomy, chemistry, mineralogy, geology, and geography up to botany, entomology, zoology, palaeontology and archaeology.[10] From the organisational point of view it provided an important communications and discussion platform in the programme of regular sessions of the Society and publication of its member's research results. But the positivistic spirit of modern natural sciences in the programme of the new Brno Society is perhaps best exemplified by a celebratory poem which was composed and presented by the physician C. Allé at the inaugural meeting on 21 December 1861:

We wish only to explore matter and its powers,
Metaphysics stands fully apart from that activity;
To reveal the rules and states of matter,
That is our future serious goal.[11]

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[10] Everything should have been subordinate to the spirit of Galileo's motto: Measure the measurable, make measurable which is not measurable!

[11] *Wir wollen nur den Stoff und seine Kraft ergründen,*
Die Metaphysik bleibt ganz aus dem Spiel;
Die Regeln fuer den Stoff und seinen Wechsel künden,
Das ist das ernst uns vorgesteckte Ziel.
Maybe for safety's sake, to not provoke too much the Austrian conservative quarters, these verses were inserted one loose paper sheet only in a few copies of the first volume of the Society's journal Verhandlungen.

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SYMPOSIUM 11

Historical Narratives of Cold War Science

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During the last twenty years the historiography on Cold War science has developed substantially. Following the pioneering work of Paul Forman, historians of science have discussed the cogency of the "distortionist hypothesis" coming to a variety of interpretations and broadening the analysis further. In particular, the geopolitical and diplomatic components in the shaping of Cold War science have come to the fore suggesting that while military interests existed, the promotion of science created important synergies within the Western and Eastern blocs and beyond. Several scholars have argued that scientific collaborations allowed the Superpowers to administer relations with Cold War allies in Europe. The implications of using science in international relations with a number of countries – especially in Latin America and Southern Asia- have been revealed. The critical role of science in the colonization and administration of Polar Regions has also been investigated. Thus traditional studies of Cold War research as a national endeavor consistent with military goals have coupled with new work focusing on science as a tool to gain influence internationally, transnationally and globally.
Episodes of international scientific collaboration have been singled out as particularly revealing. Often depicted as the result of openness and tolerance allowing a freewheeling debate amongst participants, they embedded national ideologies and interests. This collaboration entailed the sharing of values and the definition of cultural commonalities. It was consistent with the effort to better integrate defence alliances (e.g. NATO). It had implications for control of distant territories and entailed the appropriation and re-appropriation of strands of knowledge consistently with the ambitions of governmental agencies.
This symposium aims to explore the richness and variety of narratives discussing Cold War science and answer to sets of related questions including: what factors were decisive in shaping Cold War science? How can we frame the role of prominent scientists in the new

funding regime that the confrontation between Superpowers defined? Does the analysis of international scientific work help to appraise dominant views? Are we satisfied with the existing narratives and periodization of Cold War science or should we strive for new interpretations?

The Pontecorvo Affaire Reappraised. Five Decades of Cold War Spy Stories (1950-1998)

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On August 31, 1950, in the middle of a holiday in Italy, the physicist Bruno Pontecorvo abruptly left Rome for Stockholm with his wife and his three sons, apparently without leaving any trace. He was expected to come back to England in a few weeks, since he was appointed to the chair of experimental physics at the University of Liverpool, which was due to take up in January, 1951. Hypotheses and suspects frantically followed one to another in the next months, especially on British and Italian newspapers: kidnapped by Soviet agents because of his work on the Anglo-Canadian atomic project? A deliberate defection to the USSR across the Baltic sea or the Finnish-Russian boarder, maybe bringing top-secret documents with him? Anyway, no doubt that he was on the other side of the Iron Curtain. Pontecorvo was the youngest member of the “Via Panisperna boys”, the research group on atomic physics led by Enrico Fermi in Rome from 1929 to 1938. In 1934 he contributed to Fermi’s famous experiment showing the properties of slow neutrons, which led to the discovery of nuclear fission. As he would have told in several interviews after 1990, Pontecorvo felt increasingly oppressed by the fascist regime and scared about the idea of an alliance between Italy and Nazi Germany.

Figure 1: *Bruno Pontecorvo (1913-1993)*

Figure 2: *From left to right: Ettore Majorana, Emilio Segrè, Edoardo Amaldi, Franco Rasetti, Enrico Fermi. Photo by Bruno Pontecorvo*

In 1936 Pontecorvo moved to Paris to work with Irène and Frédéric Joliot-Curie on the effects of collisions between neutrons and protons by studying radioactive isotopes and isomers. During this period, his leftist ideas turned into an open adhesion to communism, also because of Joliot-Curie's influential personality as socialist physicist. In 1938 he knew Marianne Nordblom, a young communist student from Sweden, who would have become his wife. Being of Jewish origins, Pontecorvo was unable to come back to Italy because of the "racial laws" approved by the fascist government in the same year. In 1939 he met Luigi Longo and many other political refugees from Italy, joining the clandestine Italian Communist Party (PCI). He remained in Paris until 1940, when the Nazi occupation forced him to move to Spain and shortly after to the United States.
At that time America was still a neutral country with the largest Italian community living abroad, while Great Britain was facing the threat of a German invasion, dealing with the problem of "enemy foreigners" on its territories. For an Italian refugee it was definitely easier in 1940 to establish in the US. Furthermore, the British intelligence service had already opened a file on Bruno Pontecorvo. This early report of the MI5 defined Pontecorvo as anti-fascist but «moderately unwelcome», because he belonged to Joliot-Curie's leftist entourage.
Thanks to Emilio Segrè, who had moved to Berkeley in 1938, Pontecorvo was recommended to Serge Alexander Scherbatskoy and Jacob Neufeld at the Well Survey Incorporated in Tulsa (Oklahoma), a pioneer company engaged in the application of nuclear physics and geophysics to mineral prospection and well-logging. Since the very beginning of his scientific career, Pontecorvo was interested in the interactions between nucleons and atomic/molecular structures. The idea of studying the absorption and scattering of slow neutrons to detect the physico-chemical properties of different geological layers occurring in an oil well came directly from his previous work in Rome and Paris. The combination of electron, gamma-ray, and neutron well-logging could provide a much more accurate prospection, also for deposits of radium and uranium (Bonolis 2005).

Pontecorvo worked at the WSI for two years, before shifting his attention from the geophysical applications of radioactive sources to the sources themselves and their detection, visiting different laboratories of the East Coast and meeting Fermi in Chicago. Despite his close friendship with Fermi, Pontecorvo was not called upon to take part to the Manhattan Project, probably because of his committed socialist beliefs. On September 25, 1942, Pontecorvo's house in Tulsa was accurately inspected by two FBI agents, since Pontecorvo had become "enemy foreigner" even in the US and he was working on strategic subjects. During the inspection they found Marxist literature and pro-communist leaflets, which were the origin of a second, much more important file on the Italian physicist. This American "Pontecorvo dossier" is still today classified and all we know about comes from the declassified documents of the British intelligence.
In 1942 Fermi and Pontecorvo had several occasions to confront their data on the propagation of neutrons across different materials, but as far as we know Fermi never told him why he was so interested in the subject. We do not even know if the FBI itself prevented Fermi from involving Pontecorvo in the American atomic programme, but Fermi must be informed of their recent visit to his friend's house and he was very cautious about such issues. However, in 1943 Pontecorvo was invited to join the Montreal and Chalk River Laboratories in Canada, where he concentrated on prospection of strategic minerals, design of nuclear reactors moderated by heavy water, and safety issues related to anti-radiation shields. He was also interested in theoretical particle physics, cosmic rays, neutrinos, and the decay of muons.
Pontecorvo was thoroughly examined during a preliminary interview by the security board responsible for Tube Alloys, the nickname of the Anglo-Canadian atomic project, but nothing really suspicious was found. On the contrary, he seemed to be the right person in the right place. His leftist views were after all a guarantee of active collaboration against Nazi-fascism, without considering that the Soviet Union was still an allied country at that time.
In 1945 Igor Gouzenko, former employee at the Soviet embassy in Ottawa, confessed to the Canadian authorities that he was part of an international espionage network made of NKVD officers and Western scientists which had infiltrated Tube Alloys. It came out very soon that the atom spies were not "enemy foreigners" but British and French physicists, like in the famous case of Alan Nunn May, arrested in 1946. Nunn May's claim that helping the USSR to develop its own nuclear programme was vital to defeat Germany, as later Robert Oppenheimer's concern that only the end of the Anglo-American monopoly on nuclear technology would ensure world peace through atomic deterrence, was not necessarily connected with communist beliefs and pro-Soviet feelings.
This would have become less and less obvious after 1945. One usually says that Hiroshima and Nagasaki were at the same time the last act of WWII and the first act of the Cold War. The collective hysteria raised by the "Red Scare" in McCarthy's era was functional to Henry Truman's containment policy against the USSR and its new allies: the communist block would have been able to overcome the military and political supremacy of the "free" world only by means of its spies and collaborators disseminated in the West.
The hunt for the "fellow travellers" did not affect Pontecorvo yet, because of his fundamental contribution to Tube Alloys, but he felt more and more upset by the security restrictions imposed by James Chadwick to all the physicists working in the programme, after the Gouzenko and the Nunn May affaires. In 1948 he obtained the British citizenship (maybe helped by Fermi) and was invited by John Cockcroft to join the Nuclear Physics

Division in Harwell to contribute to the British atomic bomb project at the AERE secret laboratories.
As far as we know from documents declassified in the 1990s, Scotland Yard and the MI5 had been informed in the meanwhile by their FBI counterparts that Pontecorvo was a member of the PCI since 1939, even if he did not seem to be actively involved in communist propaganda. Despite his socialist commitment, Pontecorvo seemed to be trustworthy enough to work for the Royal Army, even if he was constantly surveyed by the secret services, as many other nuclear physicists in Great Britain at that time. The information evidently came from the FBI dossier opened in 1942, enriched with new details about the pro-communist activities of other members of the Pontecorvo family who lived in Italy, like Bruno's youngest brother Gillo and his cousin Emilio Sereni. Both were former communist partisans during the Nazi occupation and had a prominent role in the post-war PCI.
Of course none of these things was known to the general public, at the time. Anyway, Pontecorvo's position was becoming more and more difficult in an age of anxiety, suspicion, and paranoia, especially after another famous case of atomic espionage, that of Klaus Fuchs in 1948-1950. Differently from Nunn May, Fuchs was precisely the kind of "enemy foreigner" the allied military services were so afraid of during the first years of WWII. Moreover, there was no doubt that his spying activity, begun in 1942 when he joined the Manhattan Project, was due to a strong and aware commitment with the Soviet system, dating back to his youth as KPD militant in the late Weimar Republic.
From this point of view, Fuchs was the first atom spy of the Cold War who deliberately acted as such, being recruited in Chicago as formal collaborator of the NKVD. Furthermore, it was the first case of atomic espionage which really attracted the attention of the media at international level, shaping in different but complementary ways the collective imaginary of both sides of the Iron Curtain. After 1948 atomic secrets, "fellow travellers", and spy-stories related to them became key issues of public domain, in the political debate as well as in popular culture. The Fuchs affaire was by the way the *casus belli* of an underground war between officially allied intelligence services, which was also an invisible war between the two founders of the NATO, with their divergent political visions (Williams 1987; Friedmann 2006).
Great Britain had developed a much more pragmatic attitude towards the Soviets, because of its geopolitical closeness to Europe, while the Americans blamed this accommodating policy as inadequate to ensure security in the new world scenario. Furthermore, the British claim for strategic independence from the USA was regarded by the American administration as a sign of unreliability, when unity, loyalty, and transparency were indispensable to fight against the "Red Threat". The high permeability of Tube Alloys to the Soviet espionage was a serious failure for the British intelligence and might turn into a great scandal. Security controls and investigations must be stricter, following the example of Herbert Hoover's anti-communist campaign as executive director of the FBI. Scotland Yard could not risk a Pontecorvo case, after that of Klaus Fuchs. What was just suspicious, before 1950, was now sufficient to prevent a nuclear physicist from working on secret projects. Pontecorvo was actually removed from all his duties in Harwell, his access to classified files denied. Cockcroft wanted to avoid any publicity to the whole thing, so he strongly recommended Pontecorvo for the chair of experimental physics in Liverpool, which was to become a high-rank research centre for theoretical and particle physics, but with no direct link to the British atomic programme. Pontecorvo was appointed ordinary professor in

Liverpool in July 1950, despite the opposition of some members of the evaluation panel, who would prefer a British physicist and did not understand Cockcroft's personal interest in his nomination. He was free to work at his best topics, i.e. neutrinos, mesons produced by colliding nucleons, cosmic rays, and particle astrophysics, with no secrecy issues.
However, Pontecorvo seemed to be very unhappy with this solution, which sounded more like a confinement after an arbitrary condemnation. It was clear to him that Liverpool would have been a hostile environment for a Jewish-Italian scientist suspected of being a communist spy. Moreover, in 1948 he had joined the collective legal action carried on since 1946 by Fermi, Amaldi, Segrè, and Rasetti against the American Government to claim for their rights and for adequate royalties upon any nuclear technology patented in the US which was based on the properties of slow neutrons. A former refugee and maybe a "communist traitor" who was openly accusing the US administration of having tricked the Italian physicists exploiting their work for free because of the urgent needs of the war: another good reason for the British and American intelligence to put him under surveillance. The action would have only come to an end in 1951, with a refund of almost 300.000 $: far less than the sum originally asked by the "Via Panisperna boys". In the meantime, it had assumed the meaning of a scientific, economic, and diplomatic controversy between Italy and USA.
On July 24, 1950, Pontecorvo wrote to James Mountford, rector of the University of Liverpool, that he would have travelled across Italy to visit his relatives and friends. His sudden flight from Rome to Stockholm on August 31 could be explained as an unforeseen stay in his wife's hometown, right before coming back to the UK. The day after, however, the Pontecorvos moved to Helsinki and then vanished. Their abrupt disappearance soon became an international affaire in a period of increasing tensions between the two blocks, causing much concern to the British and American intelligence, who was worried about the escape of atomic secrets to the Soviet Union. Initial rumours about Pontecorvo being kidnapped by the KGB quickly turned into the open suspicion that he had deliberately moved to the USSR, probably helped by Soviet agents.
Facing the embarrassing possibility that Pontecorvo was really a communist spy defected to the Soviet Union, maybe bringing classified material along, the British authorities immediately pointed out that he had had very limited access to secret subjects. Even later no official allegation of transferring military secrets to the Soviets was made against him (Turchetti 2007), but in the meanwhile Pontecorvo had already become a second Fuchs case, with the exceptional case of a Western nuclear physicist who had managed to cross undisturbed the Iron Curtain.
By the way, there are two different versions of his travel, which are still nowadays controversial: 1) he moved from Stockholm to Helsinki by plane and from Helsinki to Leningrad by train, after a short transfer from the airport to a Russian base in Finland on a Soviet diplomatic car; 2) he went directly from Stockholm to Leningrad on the boat *Belostrov*. The circumstances of his hasty departure are obscure because Pontecorvo never wanted to tell them in detail: something that raises many questions, even today. Did Pontecorvo need to protect someone who had helped him during his travel by keeping his identity secret? Was he instructed or even forced by the KGB to behave in this way? We know for sure from the registers of the bureau of Scandinavian Airlines in Rome that he paid 602 $ for the tickets: by cash and with six banknotes of 100 $. At that time they were not available at any bank, only at embassies and consulates, like the Soviet embassy in Rome.

Combining this information with that coming from the secret archives of the former PCI, now accessible to historians, we are able to provide a plausible reconstruction of those events. Pontecorvo's cousin, senator Emilio Sereni, was a very important figure of the PCI under Palmiro Togliatti's secretaryship, at least until the "de-Stalinization" of the Party after 1953. Today we know that he was member of a secret security commission (together with Pietro Secchia and Giulio Seniga), headed by Togliatti himself and unknown to the rest of the Central Committee. They coordinated the activities of a clandestine network, later known in Italy as "Red Gladio" and directly connected with the KGB. This paramilitary structure had already helped many Italian communists to emigrate to the East between 1945 and 1950, providing false passports and safe passages through the Iron Curtain, mainly across the Austrian-Czechoslovakian boarder. It must be ready to take over the Central Committee, if the survival of the largest communist party in the West was in danger (Mafai 1983; Caprara 1996; Caprara 1997a).

Pontecorvo's hurry in those days leads to the conclusion that his defection was not prepared from long time, but decided just a few weeks before. Since he met his cousin Emilio Sereni during a brief stay on the Dolomites, right before going to Rome, he probably discussed with him the possibility of becoming a Soviet citizen. Pontecorvo and his family were also close to the Partisans of Peace, a pacifist organization which was quite similar to the Pugwash movement, but part of the Comintern (Cominform) and led by Sereni himself. Joliot-Curie was among its most active members. As already noticed by Albert Einstein in his last years, however, the Partisans of Peace were "pacifist" in a very particular sense: they strongly criticized the Western nuclear policies as the aggressive, neo-colonial side of capitalism, but they tended to justify the Soviet atomic programme as the inevitable response to them (Giacomini 1984).

Historians actually agree that Pontecorvo was helped by Emilio Sereni, who contacted the Soviet embassy in Rome and organized the whole operation, providing him with the money he needed. Probably he never mentioned the role played by Sereni to protect his cousin, his own family, and the "Red Gladio" from a political scandal in Italy (Caprara 1997b; Donno 2001; Turi 2004). Nevertheless, the Pontecorvo affaire assumed since the beginning a particular significance in the Italian political debate, so strongly polarized between pro- and anti-communists, especially after 1948. The local newspapers soon raised the question of the alleged support given by the PCI to Pontecorvo in his defection to the East, claiming that this strong suspect might seriously affect the diplomatic, political, and economic relations between the young Italian Republic and the other NATO countries, destabilizing its inner and foreign policy.

In the USSR Pontecorvo was welcomed with honour. He was given many privileges usually reserved to the Soviet *nomenklatura* and awarded the Stalin Prize in 1953, the membership of the Soviet Academy of Sciences in 1958, and two Orders of Lenin. Anyway, he was isolated from the rest of the world for many decades, a part from one official press conference on March 1, 1955, when he was authorized to appear in public for the first time after his defection in order to explain to Western journalists the reasons of his choice. According to him, he had moved to Russia because he rejected capitalism and wanted to live in a socialist system. He would have reached such a decision after having left Canada in 1948, abhorring the idea of working for the sake of Anglo-American imperialism. Having been one of Fuchs' closest friends in Harwell, he did not want to live as renegade in a paranoiac society obsessed by communist traitors.

Of course we must be very careful about statements like these, which might have been "suggested" in some way. The 1955 press conference was an international event which immediately gave the Western media the occasion to speculate about what was "behind the scenes", the true reasons of such a long silence before announcing to the world that he had become a Soviet citizen. Pontecorvo always denied of being a spy recruited by the NKVD (later KGB) and informed about Fuchs' activity, as well as he always maintained to work exclusively on high energy particles and oscillating neutrinos, denying any direct involvement in the Soviet atomic programme. This last statement seems to be another half-truth. If it is so, why did the Soviets confine him and his family in a hotel room in Leningrad for several days, before transferring them to Moscow and then to Dubna? Did they want to make sure about his reliability? Did they interrogate Pontecorvo on his previous research activity? They could take a great propagandistic advantage from presenting him immediately as the great physicist, former member of Fermi's group in Rome, who had chosen to support the "right side" of the Cold War. They could also compare him to the "socialist hero" Klaus Fuchs and to many other victims of anti-communism campaigns in the West. Why did they wait five years?

Even more important: did Pontecorvo really work on non-strategic subjects in Dubna, where most of the secret nuclear laboratories of the USSR were concentrated and most of the German specialists recruited by the Soviets had been employed right after the end of the war (Holloway 1996; Kojevnikov 2004)? Did he just work on cosmic rays, high-energy particles, oscillating neutrinos, and decaying muons? If it is the case, why did the Russians prevent him from having any contact with the outside world for almost 30 years? Only in August 1978 he was allowed to leave the USSR and to come back to Italy for two months to attend a symposium in Rome on the occasion of Amaldi's 80th birthday. We know from newspapers and personal memories of the participants that Pontecorvo's visit was a surprise for many people, causing different reactions. Segrè in particular was still upset by Pontecorvo's choice. He had openly criticized his 1955 press conference, claiming that his defection to the USSR had been a serious problem for the "class action" led by Fermi against the US government. Since then, however, Pontecorvo was relatively free to travel to the West, even if for short periods.

Figure 3: *Pontecorvo in Moscow (1955)*

Today we also know from declassified documents of the KGB that in 1950 he was examined by a mixed commission of nuclear physicists and officers of the Red Army at the Institute for Physical Problems in Moscow, before being transferred to Dubna. Maybe he did not know

anything new on atomic bombs, but his expertise in reactor design, anti-radiation shields, and neutron logging applied to geological prospection must be very useful: in a few years the Soviets filled the techno-scientific gap both in the design of reactors moderated with heavy water and in uranium prospection that in 1950 still divided them from the US. Furthermore, we know from other declassified sources of the British intelligence that Pontecorvo was sighted in 1953-54 as member of a Soviet delegation at the western boarder between USSR and China (Goodman 2007). Did he contribute to the development of the Chinese nuclear programme, before the end of the Soviet-Chinese cooperation in 1958? The question still waits for an answer, because everything concerning the Chinese atomic project is top secret.
The Pontecorvo affaire has been object of a harsh political debate in Italy till the end of the Cold War, very close to the Iron Curtain, where the strongest and most "heterodox" communist party in the West was excluded from any role in the national government since 1948 but always maintained its cultural hegemony over the country until 1990. Who was Bruno Pontecorvo, beyond his unquestioned scientific achievements? A model of "socialist science" or a utopian scientist, victim of a totalitarian illusion as many other intellectuals in the 20th century? A man of science who always promoted peaceful applications of atomic energy and never wanted to have anything to do with the military, like Franco Rasetti or Norbert Wiener? A communist spy who contributed to pass strategic information to the East? A physicist who soon realized that the Soviet atomic bomb was the only way to balance the nuclear power of the USA and therefore to preserve global stability, like Oppenheimer? All these things together and/or none of them in particular, to a certain extent?
The perception of Pontecorvo's case changed in the public opinion from 1950 to the early 1990s, as a mirror of the local and global tensions of the Cold War. Anyway, it constantly oscillated across different times and contexts between two main narratives, which are not necessarily incompatible: let us say the "pro-Soviet atomic spy", from one side, and the "pro-socialist nuclear physicist", from the other. In Italy, it also reflected the complicated history of the post-war PCI, from Stalinism to anti-Soviet euro-communism, until the social-democratic turn of the late 1980s. The huge amount of primary sources that such an inquiry would need range from newspaper articles to historical essays and popular books, from interviews and personal records to TV documentaries and related materials recently published on the Web. Pontecorvo's autobiographical notes and statements, starting from those concerning the evolution of his scientific, social, and political views as Jewish-Italian-Soviet physicist, should be confronted with the "revelations" made in the mid-1990s by some former agents of the KGB like Pavel Sudoplatov, which have renewed the public interest for the 1950 affaire and re-opened the Pontecorvo dossier, so to speak.
According to their "indiscretions", which are obscure and contradictory in many points, Pontecorvo was not a formal agent, like Fuchs, but an informal collaborator of the Soviet intelligence since 1940, after he joined the PCI. He would have passed crucial information about the very early stages of the Manhattan Project during his short stay in the USA, something that Fermi would have been suspicious about but unable to prove. His secret activity would have continued in Montreal, spying on the Anglo-Canadian nuclear programme. As member of the AERE project in Harwell, Pontecorvo would have had access to top secret files which were extremely useful for the Soviets. His decision to escape to the East would date back to the conclusion of Fuchs' trial in 1950 (Sudoplatov 1994).

The “real” Pontecorvo finally revealed or just an attempt from former Russian spymasters to sell the most (in)convenient truth to Western press, in order to gain money, credit, and visibility after the collapse of the USSR? An important consequence of Gorbacëv’s *glasnost* or rather the last version of Soviet *disinformacija*? Again, we deal with half-truths and true lies: typical of this kind of people and of their epoch. On the one hand, historians of science are very sceptical about the reliability of such “testimonies”, even if they are important sources for cultural history on their own. On the other hand, we should be cautious with reconstructions biased by some apologetic attitude towards contemporary scientists.
The same might be said for Pontecorvo’s late reflections upon his political commitment. He defended dissident colleagues like Andreij Sacharov and admired Gorbacëv as reforming leader, but he was definitely disillusioned about the Soviet system. This does not imply that he abandoned socialism for capitalism: like in the case of Lev Landau, his frustration came rather from having realized that the USSR was all but a socialist country. This was probably the “error” he referred to, talking about his decision to live in Russia (Mafai 1992).
Anyway, as former Soviet citizen, Pontecorvo was the strongest opponent of early NATO attempts to exploit strategic human and techno-scientific resources by means of a mass immigration of Russian specialists to the West, immediately after the dissolution of USSR and the political chaos that followed. On the contrary, he supported Carlo Rubbia’s international effort to save former Soviet academic institutions and research laboratories with a sort of “Marshall Plan” built by the world scientific community. As a matter of fact, the Pontecorvo affaire is still far from being solved ... as many other secrets of the Cold War.

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SYMPOSIUM 12

History and Historical Epistemology of Science. Conceptual Streams and Mathematical Physical Objects in the Emergency of Newton's Science

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In *Principia* Newton wrote: "Since the ancients (according to Pappas) considered mechanics to be of the greatest importance in the investigation of nature and science and since the modern—rejecting substantial forms and occult qualities—have undertaken to reduce the phenomena of nature to mathematical laws, it has seemed best in this treatise to concentrate on mathematics as it relates to natural philosophy." (Preface. Cambridge Trinity College May 8, 1686).
Newton offered a new approach to science establishing a standard in the treatment of mechanics. The latter is divided in a pure part, essentially mathematical in nature, and an applicative part, where mathematics becomes the tool for account for physical (mainly celestial) phenomena. In studying Newton's science, one may then focus on mathematics and study the way it allow one to treat with physical phenomena. This requires studying the relation between mathematical and physical quantities: how time as occurring in geometrical arguments is related to time understood as a physical magnitude, for example? The evolution of Newton's setting resulted from the middle of 18th and during the 19th c. in new scientific approaches also involving interplay between pure mathematical developments (differential and integral calculus) and the study of physical phenomena (of different sorts). Thus a new relation between mathematical structure and physical quantities emerges.
The debate:
1. Relationship physics and mathematics both in the Newtonian and the posterior settings: physical and mathematical objects.
2. Heritage of Newtonian's science: Newtonian foundations in others sciences in the history.

‘s Gravesande’s not so Newtonian Methodological Views

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Introduction

‘s Gravesande has traditionally been portrayed as a ‘Newtonian’ and even as a ‘Baconian Newtonian’ (Cohen 1956, 234-243; de Pater 1994, 261; Schofield 1970, Chapter 7). He was, we are told, “one of the most influential advocates of Newtonianism on the Continent” (de Pater 1994, 257). During his stay in England in 1715, he was introduced to England’s leading natural philosophers: Isaac Newton, who was president of the Royal Society at the time, the Royal Society’s curator of experiments, John T. Desaguliers, and the Savillian Professor of Astronomy at Oxford, John Keill, who had begun teaching Newton’s natural philosophy “*by* Experiments *in a mathematical Manner*” around 1704 or 1705 (Desaguliers [1734-1744] 1763, viii). In June 1715, ‘s Gravesande was elected Fellow of the Royal Society and during his stay in England he was won over by the Newtonian cause, the story goes. Shortly after his return, in 1717, he became professor of mathematics and astronomy at the University of Leiden, where he taught Newton’s natural philosophy. In 1720/1 the first edition of ‘s Gravesande’s *magnum opus* appeared – a work which carried the telling title *Physices elementa mathematica experimentis confirmata, sive introductio ad philosophiam Newtoniam* (’s Gravesande [1720-1721] 1747). *Physices elementa* went through three editions during ‘s Gravesande’s lifetime. Due to its publication, ‘s Gravesande soon acquired an international reputation as a premier Newtonian. The above and other details have been frequently repeated in the literature and, for the most part, they have been used to highlight the close connexion between ‘s Gravesande and Newton.

Prima facie there are good reasons for portraying ‘s Gravesande as a ‘Newtonian’, for *Physices elementa* contained the basic doctrines of Newton’s natural philosophy. However, ‘s Gravesande occasionally treated Newton’s doctrines in a selective manner: for instance, *Physices elementa* did not contain a discussion of Newton’s fits of easy transmission and reflection and the ether which Newton introduced to explain optical phenomena was left unmentioned. Moreover, ‘s Gravesande did not accept all of Newton’s doctrines without reservation, which is clear from the position he took in the *vis viva* dispute. In view of this, ‘s Gravesande’s oftentimes critical attitude towards Newton’s doctrines has been rightly highlighted. In the wake of the quibble over *vis viva* ‘s Gravesande signalled that being a Newtonian philosopher is not contingent upon whether one accepts Newton’s doctrines *ad literam*; rather, a Newtonian philosopher is he who follows Newton’s method (’s Gravesande [1720-1721] 1747, I, xi). ‘s Gravesande’s ‘Newtonianism’ was therefore essentially *methodological*, or so it has been suggested: although he may have been selective in his endorsement of Newton’s doctrines, his adherence to Newton’s method was unremitting, it is claimed (Schofield 1970, 140).

My main endeavour is to show that ‘s Gravesande developed a relatively autonomous methodological position. It is high time that we free ‘s Gravesande from his ‘Newtonian straight jacket’ and start seeing him in his own terms – i.e. as an fascinating eighteenth-century *dramatis persona* who, although he clearly took inspiration from Newton's natural philosophy, was running his own methodological agenda.

's Gravesande's Methodological Views

It was not until the (mid-)1730s that 's Gravesande developed a detailed account of scientific methodology. He elaborated on his methodological views in his *Introductio ad philosophiam, metaphysicam et logicam continens* (1736), which appeared two years after his appointment as professor *totius philosophia*.

Given 's Gravesande's clear rejection of hypotheses, it may *prima facie* come as a surprise that they occupied such a central place in his discussion of method. Paradoxically, 's Gravesande's preoccupation with hypotheses arose from his deep concern with certainty. He was acutely aware that the use of hypotheses was a significant and ineradicable aspect of natural-philosophical research. Given his concern with certainty, the following question came to occupy him: how can certainty arise from hypotheses? In this context, he set out to show that certainty can emerge from a careful scrutiny of hypotheses and to explicate the conditions under which a hypothesis can be transformed from a probable proposition into one which carries 'moral certainty'. In the preface to the third edition of *Physices elementa* (1742), 's Gravesande wrote: "I don't deny but that Hypotheses may open the way to Truth; but when that is prov'ed to be true, which before was only suppos'd, there is no longer any room for Hypotheses" ('s Gravesande [1720-1721] 1747, I, xii). 's Gravesande was, in other words, highly concerned with methodizing and constraining the use of (causal) hypotheses ('s Gravesande 1736, 292-294). Hypotheses are required in those cases in which we cannot directly arrive at certainty:

> In many given things, when we undertake to examine [them], we do not discover an open road by which we can arrive at certainty directly. Then probability is to be sought after, but oftentimes this is not granted unless by hypotheses, which, however, sometimes lead to such probability that they have to be taken for certainty. ('s Gravesande 1736, 292)

A hypothesis is defined as follows by 's Gravesande:

> By a hypothesis we understand something feigned by which one responds to a proposed question. One should act upon this fictitious response as if it were true; however, [our] reasoning should be directed in such a way that it gives occasion to explore whether the solution is true; moreover, we should never give assent to this [solution] as long as the truth is not established most clearly. This method of reasoning can have great use, but generally men abuse it miserably. ('s Gravesande 1736, 292-293)

When reasoning hypothetically, the following rules are to be followed:

> 1. The subject with which the question is concerned should be accurately examined and an extensive enough cognition of the subject is called for.

2. We should select from the circumstances [i.e. effects] some of the main [circumstances], namely [those] that have something noteworthy with respect to the others.
3. From these [circumstances] one [circumstance] is again separated and some of the ways in which this [circumstance] can take place are investigated.
4. It should be investigated whether among these causes there is a certain [cause], from which the rest of the circumstances, [which were] separated as prescribed by the second rule, follow; if such [cause] is present, then it makes itself the hypothesis to be explored.
5. The hypothesis is explored by applying it to all the other known circumstances so that it may be established whether it satisfies all [those circumstances] here.
6. The hypothesis itself should be examined and consequences are to be deduced from it so that new phenomena may be discovered and it should be investigated whether these [phenomena] really occur. ('s Gravesande 1736, 293-297)

The first to fourth rule pertain to the generation of hypotheses. The purpose of the third rule is to assemble those causes from which the main circumstances selected by the second rule can be derived ('s Gravesande 1736, 294). By the fourth rule one then selects from the list of causes obtained by the third rule the cause from which the rest of the main circumstances follow. This cause is the hypothesis to be investigated. The fifth and sixth rule explicate how hypotheses are to be tested. By the fifth rule we establish whether the hypothesis obtained by the preceding rule satisfies all other known phenomena. If it does not satisfy all the phenomena at hand, the hypothesis under consideration is to be rejected outright. When it truly satisfies all phenomena, our assessment of the hypothesis will depend on the number of phenomena that it successfully satisfies. If the number of phenomena that a hypothesis successfully satisfies is small, one should investigate whether another hypothesis may be found that successfully saves more phenomena. If such hypothesis successfully saves a larger number of phenomena, our doubt will vanish and "what could initially be considered as a mere fiction, will now be taken to be proved most clearly," i.e. the hypothesis is to be considered as certain ('s Gravesande 1736, 297). When no such hypothesis can be found, our suspicion can frequently be removed by taking recourse to the sixth rule. By the sixth rule we investigate whether the hypothesis under consideration is able to predict previously unknown phenomena and whether these predictions are correct. When both conditions, as stipulated in the sixth rule, are fully met, then what was formerly a hypothesis has turned into a morally certain demonstration. If not, the hypothesis is to be considered as probable only. Those who call the proposition, which has successfully passed the conditions stipulated in the fifth or sixth rule a hypothesis, are mistaken:

> We see that certainty can be deduced from a hypothetical account and that those, who refer all such accounts to probability, err. They, who refer to an account which is directly deduced from observed phenomena as a hypothesis so that they only acknowledge to it probability, err all the more. Many fall into this error when they talk about the Newtonian explanation of the celestial phenomena, which they take for a hypothesis; whereas this most high man has laid down nothing which has not been deduced from indubitable phenomena by mathematical reasoning; […].('s Gravesande 1736, 298-299)

It is worthwhile to call attention to some of ‘s Gravesande methodological assumptions. First of all, he considered a hypothesis’ capacity to successfully save the phenomena (cf. the fifth rule) and its capacity to successfully predict new phenomena (cf. the sixth rule) as criteria for a hypothesis’ truthfulness. Secondly, and more specifically, in order to be accepted as truthful on ‘s Gravesande’s terms, a hypothesis should not necessarily have the capacity to successfully save the phenomena and to successfully predict new phenomena at the same time. According to the fifth rule, a hypothesis which successfully saves a large enough number of phenomena achieves a demonstrative status and is therefore to be considered as truthful. Therefore, a hypothesis that meets the conditions as stipulated in the fifth rule does not, it seems, need to pass the conditions as stipulated in the sixth rule in order to be accepted as truthful. Yet, on the other hand, from his discussion of Huygens’ demonstration of Saturn’s ring it seems that ‘s Gravesande entertained the idea that a hypothesis should meet both the fifth and sixth rule in order to be considered as truthful: “The hypothesis of the ring of Saturn not only explained already observed phenomena and agreed to their least circumstances, the phenomena deduced from this very hypothesis also [agreed to] the heavenly [phenomena] that were observed afterwards” (’s Gravesande 1736, 298). In this manner, ‘s Gravesande observed, Huygens proved the hypothesis under consideration beyond any doubt. Nevertheless, in his scientific practice ‘s Gravesande considered hypotheses that successfully save the phenomena as truthful. In other words, ‘s Gravesande accepted the truthfulness of a hypothesis – whatever its origin or status may be – when its deductive consequences are confirmed by experience.
Such framework of theory confirmation is at odds with Newton’s views on the matter. As I have argued elsewhere, in order to avoid arbitrary speculation Newton insisted that the causes to be adduced in natural philosophy should be constrained by imposing the demand on them that they should be shown to be the necessary and sufficient causes of certain effects given the laws of motion, i.e. given a set of non-arbitrary principles which have been shown to be promising in the study of motion and which remain neutral with respect to the *modus operandi* of gravitation (Ducheyne 2012, Chapters 2 and 3). Put differently, according to Newton not just any cause will do in natural philosophy: true causes in natural philosophy are those causes which have been shown to be necessary and sufficient given a set of prioritized theoretical principles, *in casu* the laws of motion. ‘s Gravesande did not take any of these demands into consideration. Like Newton, however, he insisted on the prediction of new phenomena, but, yet again, this was not a methodological precept that was exclusive to Newton’s methodology: ‘s Gravesande could have perfecty been influenced by Huygens’ introduction to *Traité de la Lumière*/*Discours de la cause de la pesanteur* (1690). Moreover, while for Newton the prediction of new phenomena was a test of the universality of a principle, which has previously been ‘deduced from phenomena’ by analysis, for ‘s Gravesande (and Huygens) it was a direct test of the truthfulness of a principle, regardless of its (theoretical) origin.

Conclusion
Although ‘s Gravesande was clearly inspired by Newton’s natural philosophy, he was integrating Newton’s legacy into his own intellectual agenda. ‘s Gravesande’s case shows how Newtonian and non-Newtonian elements were integrated into an eclectic, but nevertheless comprehensive account of *physica* – at least on our eighteenth-century *dramatis persona*’s understanding. That ‘s Gravesande did not follow Newton’s doctrines *ad*

literam has often and correctly been observed in the literature. Yet, despite such mitigation of ‘s Gravesande’s ‘Newtonianism’, it has frequently been maintained that he was an advocate of Newton’s methodology. Here I have argued that, although ‘s Gravesande took over key terms of Newton’s methodological canon, upon close scrutiny, his methodological ideas were quite different from and occasionally even incongruent with Newton’s views on the matter. Correspondingly, in this essay I have tempered ‘s Gravesande’s alleged ‘methodological Newtonianism’.

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Newton as a Cartesian

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Generally speaking we can distinguish four ways of representing mechanical motion The Aristotelian description of local motion can be characterized as a ***geometrical transition***. Thus according to Aristotle each body has a natural place determined by the geometrical structure of the universe, and motion is a transition from one place of this geometrical structure to another. Galilean theory of motion can be seen as a theory of a ***geometrical flow***. Thus Galileo has replaced the Aristotelian concept of motion as a transition from one place to another by the concept of motion as a flow along a trajectory. Nevertheless, the nature of the motion is still given by the geometrical properties of the trajectory, and the global structure of the universe despite the transition from a geocentric to a heliocentric system remains still a geometrical order. The main innovation of Descartes can be interpreted as the replacement of a *geometrical* theory of motion by a *dynamic* one. Motion cannot be understood in terms of geometry because geometry does not allow us to understand interactions among bodies. Descartes described an interaction as a collision, i.e. as a transition from the initial state (the state before the collision) to the terminal state (the state after the collision). Descartes' theory is based on the comparison of two states and so it can be described as a theory of ***dynamic transition***. Being a theory of transition, it resembles in some respects the Aristotelian theory. But there is also a deep difference between the Aristotelian and the Cartesian concepts of motion. Motion according to Descartes is not a transition from an initial position to a terminal position in a geometrically ordered, universe. It is rather a transition from an initial state to the terminal state in a dynamic universe.

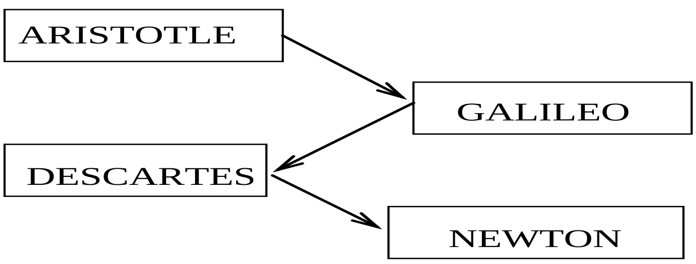

Figure 1

Now we can characterize Newton's theory as a similar transformation of Cartesian physics, as Galilean theory was of Aristotelian physics (see the scheme above). Galileo replaced the Aristotelian idea of motion as a transition from an initial position to a terminal position by a flow along a trajectory connecting the two positions. Similarly Newton's theory of motion replaces the Cartesian idea of transition between states by a ***dynamic flow*** along a vector field. In the following text I will characterize in more detail the Galilean, Cartesian, and Newtonian theories of motion (see also Kvasz 2003, 171).

Galilean science as background of the Cartesian system

The important incentives of Galileo's thoughts for the development of modern science are generally accepted. Galileo's law of free fall is often described as the first scientific law, i.e. regular correlation between empirical quantities expressed in mathematical form. Despite his fundamental contributions, which are well known and so there is no need to deal with them here (see e.g. Drake 1978, Hill 1988, Naylor 1990), Galileo's ideas had also some grave shortcomings, which are the reason why modern science is not a direct continuation of the Galilean. I do not have in mind Galileo's mistakes (his conviction that inertial motions are circular or his ignorance of Kepler's discovery of the elliptical shape of the planetary orbits). Such mistakes can easily be corrected. When speaking about shortcomings of the Galilean system I have in mind the problems of Galilean conceptualization of motion. First of all Galileo's concept of motion is still to a great extent a geometrical concept. Galilean physics ***lacks any idea of interaction***. His description of motion is always a description of the motion of a single, isolated body. The laws discovered by Galileo witness this. The law of the free fall, the law of the isochrony of the pendulum, or the law of the trajectory of projectile motion, these are all laws describing bodies without interaction. Secondly, Galileo has a ***too narrow concept of a natural law***. The laws mentioned above lack the slightest amount of generality. Be it the law of free fall or the law of the pendulum, they are laws describing *particular phenomena*. In Galilean science for each phenomenon there is a special law that describes it. And finally Galilean physics ***lacks any description of states***. Galilean physics deals only with observable quantities and tries to discover regularities in them. Contemporary science, on the other hand, is based on the description of the state of a physical system and its temporal evolution.

It seems that these shortcomings have a common root. They are the consequence of the use of a ***too simple mathematics***. Galileo believed that the book of nature is written in the language of mathematics: "*Philosophy is written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the letters in which it is composed. It is written in the language of mathematics, and its characters are triangles, circles, and other geometric figures without which it is humanly impossible to understand a single word of it; without these, one wanders in a dark labyrinth*." (Galilei [1623] 1957, 237-238). This passage is often quoted, but its strange nature is rarely recognized. Modern science is not based on any triangles, circles, and other geometric figures but on functions and differential equations. The fact that the laws discovered by Galileo are all describing isolated bodies without interaction can be brought into connection with his choice of geometry as the language of science. The language of synthetic geometry is able to represent neither universal laws, nor interaction. Modern science is based on universal laws describing changes of states of physical systems caused by interactions. All these non-Galilean features of modern science can be found already in Descartes, and they are related to Descartes' turn from geometry to algebra.

While nobody would seriously question the great value of Galileo's contributions to the development of modern science, things are not nearly so simple with respect to Descartes (see Garber 1992 or Gaukroger 1980). Descartes is omitted in many expositions of the development of physics and Newton is seen as deriving directly from Galileo. I believe that excluding Descartes from the history of science prevents us from understanding the origins of ontological homogeneity and descriptive universality of modern physics.

Descartes, if he had wanted to, could have worked out the Galilean project much further than Galileo was able to, because he was a much better mathematician. Nevertheless, he was not interested in studying isolated bodies as Galileo, but in the interactions among bodies, a phenomenon Galileo never understood. From Descartes stems the idea that science should search for *universal laws*, that these laws should *describe interaction* and that this description of interaction should have an *ontological foundation* (see Kvasz 2003). If we ask, what language made possible these innovations, it is possible to argue that it was algebra. Thus despite the fact that Cartesian physics is formulated in ordinary language, what seems to have misled many historians of science, ***in a deeper sense Cartesian physics is algebraic***.
First of all, Cartesian physics takes from algebra the universality of its laws. Even though these laws are formulated in ordinary language, they have the *same kind universality as algebraic formulas*. Similarly, the language of algebra enabled Descartes to create the first description of interaction. He did it by introducing the notion of the quantity of motion, and formulating the law of conservation of the quantity of motion. The quantity of motion is *an algebraic quantity* and the law of its conservation is *an algebraic equation* (see Gabbey 1980). Thus Cartesian physics received its universality, its ability to represent interaction, and its ontological grounding from the universality, functionality, and abstractness of algebra.

Cartesian background of the Newtonian system

The Galilean system lacks universal laws as well as description of interaction, and so it is too far away from the Newtonian system. Therefore the Galilean system cannot serve as a background for better understanding of Newton. Only when we put Newtonian science against the backdrop of the Cartesian system will it be possible to understand the creation of Newtonian physics. It can be argued that Newton took the idea of universal laws, the idea of interactions and the idea of ontology in physics from Descartes. Of course, the *particular* universal laws by which Newtonian physics described a physical system were very different from the laws, which Descartes ascribed to it. Similarly the *particular* way how Newtonian science described interactions among bodies was very different from the Cartesian description of interactions. And finally, the *particular* ontology on which the Newtonian system was based, differed substantially from the Cartesian ontology. Thus not the technical details, not the way in which Newton formulated his laws, described interactions, and introduced ontology were Cartesian. Nevertheless, Cartesian was the very idea that science should search for universal laws, that these laws should describe interactions and that this description of interactions should have an ontological foundation.
The law of conservation of the quantity of motion, introduced by Descartes, seems to have been the first universal law in physics. This law was universal because it applied to a falling body, to a pendulum, as well as to a body sliding on an inclined surface. Therefore in using universal laws in the description of nature Newtonian science was rather Cartesian than Galilean. Similarly the first theoretical description of interaction among bodies was in all probability given by Descartes, when he introduced the dynamic state (characterized by extension and motion) and described interaction as a change of this state (by means of a collision). Therefore in describing interactions among bodies Newtonian science was again rather Cartesian than Galilean. And finally the first who realized the necessity to base physics on ontological foundations was Descartes when he introduced extension as the ontological

foundation of the physical description of phenomena. So by building its theories on explicit ontological foundations Newtonian science was rather Cartesian than Galilean. Newton of course categorically rejected the Cartesian laws of nature, the Cartesian description of interaction, as well as the Cartesian ontology. Nevertheless, he owes to Descartes the very idea that the laws of nature must be universal, that they must describe interactions among bodies, and that these bodies must have some ontological status. These ideas are fundamentally Cartesian, and thus Newton was closer to Descartes than to Galileo.

Some influence of Descartes on Newton is visible already in the title of Newton's *Philosophiae Naturalis Principia Mathematica* (Newton [1687] 1999). This title is an allusion to the title of Descartes' *Principia philosophiae* (Descartes [1644] 1983). But there is a deeper sense in which the Cartesian system influenced Newton. The point is that the *main problems solved by Newtonian physics were of Cartesian origin*. To see this we have to concentrate on the main shortcomings of Cartesian physics (just like we concentrated on the main shortcomings of the Galilean system when we wanted to see more clearly the contributions of Descartes). Among the shortcomings of the Cartesian system were: a too loose connection between the phenomenal and the ontological levels; causal openness of the description of motion and an unsatisfactory description of interactions. If we look from this perspective on the Newtonian system, we see that the main achievements of Newtonian science were in a sense answers to, or solutions of, the shortcomings of the Cartesian system.

The first shortcoming of the Cartesian system was that it had only a loose connection between the phenomena and the explanatory models that were used to account for them. Thus for instance Descartes explained the phenomenon of gravity by his vortex model. He postulated a vortex of fine matter, but gave no clue how particular aspects of the vortex (its velocity, structure, orientation, etc.) relate to specific attributes of gravity (its homogeneity, direction, permanence, etc.). This was obviously a main weakness, which gave the whole theory a speculative flavor. In the Newtonian system the ontological level and the phenomenal level are tied together by a mathematical framework, which allows to derive from an attribute of the phenomenon a corresponding aspect of the ontology and vice versa. But even if these close ties between ontology and the phenomena are a non-Cartesian aspect of the Newtonian system, they can be seen as an answer to a deep tension of the Cartesian system—the unreliability of its explanatory models.

Another shortcoming of the Cartesian system was that its description of motion was causally opened, and so for instance the mind could, according to Cartesian physics, have a causal influence on the body. Thus *a physical process*, as for instance the lifting of my arm, *can be caused by a nonphysical event*, in this case by my decision to do so. This means that Descartes' description of motion was not causally closed. This causal gap is closely related to the fact that according to Descartes velocity is a scalar quantity. Therefore a change of direction of motion does not influence the value of the quantity of motion. Consequently the law of conservation of the quantity of motion does not determine the changes of direction of motion and thus in the Cartesian system there is a gap, where the mind can intervene. Newton closed this gap when he introduced the notion of velocity as a vector quantity. Even though the Newtonian notion of velocity as a vector quantity is a non-Cartesian concept, Newton introduced it in order to solve a deep problem of the Cartesian system—its causal openness.

A further shortcoming of the Cartesian system was that the notion of the quantity of motion was introduced for the universe as such and so it included the motions of all bodies in the universe. Therefore, strictly speaking, it was impossible to calculate its value. So even if Descartes introduced this notion in order to describe interactions, it could not be applied to any concrete situation. Only when Newton turned to empty space as the background of the theory of motion, the conservation of the quantity of motion in smaller systems became possible. By eliminating the Cartesian fine matter Newton opened the possibility to *describe restricted mechanical systems*. For the description of such systems he created a new mathematical tool—differential equations (or, more precisely, something what we today call differential equations). The notion of a differential equation is a non-Cartesian notion. But Newton introduced it in order to solve a tension in Cartesian physics—its inability to describe interactions in a restricted mechanical system.

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Acknowledgements

This paper is part of the project VEGA 1/0874/12 Historical and philosophical aspects of the understanding of the language of mathematics.

Newton, Gravity, and the Mechanical Philosophy

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The Dominant Conception of the Mechanical Philosophy

Historiographical conceptions of the mechanical philosophy have long been dominated by the thought of two practitioners, Robert Boyle and René Descartes.[1] It was Boyle who popularized Henry More's term, the *mechanical philosophy,* as a name for a new kind of philosophy of nature,[2] along with the slogan designating its causal principles, *matter and motion*. That philosophy, which Boyle also called the corpuscular philosophy, aimed to explain natural phenomena in terms of the qualities seen in machines, which to his eye were size, shape, local motion, and juxtaposition of parts. These qualities could rightly be called the "Mechanical Affections of Matter", he wrote, "because to Them men willingly Referre the various Operations of Mechanical Engines" (1666, Preface). It was Descartes, meanwhile, a theorist included in Boyle's list of mechanical philosophers,[3] who attempted the most complete mechanical philosophy, setting forth an elaborate system in which the causal principle underlying all physical processes was material contact at bodies' surfaces.

The requirement that effects be produced by material surface contact, a proviso arising naturally for a plenist such as Descartes, is often called the Cartesian sense of 'mechanism'.[4] Boyle sometimes affirms the requirement, but his position is less straightforward. One reason for interpretive caution is that he did not insist upon a material plenum. He tended to withhold judgment on the question, and at one point excluded it as being outside the bounds of natural philosophy; it was one of those questions "rather Metaphysical than Physiological" (in Garber 2013, §2). Another reason for caution concerns Boyle's tactical efforts to unite diverse thinkers. His list of mechanical philosophers included not only Cartesians, but also atomists such as Gassendi (1999, vol. V, 295), and he hoped that emphasis upon commonalities might promote harmony.[5] Still, Boyle sometimes explicitly expects that the motions producing effects should ultimately be explicable by surface contact; although attraction appears to be a motion very different from pulsion (impulse), he writes, he has "not, yet, observ'd any thing which shews attraction cannot be reduc'd to pulsion" (1725, vol. II, 711). Controversies about Boyle's view aside, it not surprising, in light of Descartes' sway, that the requirement of material contact appears in an influential, historiographer's conception of the mechanical philosophy.

According to that contact action conception, the early modern natural philosophies that qualify as mechanical philosophies are those attributing the changes in local motion

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[1] Influential, mid-century accounts of the mechanical philosophy include Boas (1952), who focused primarily upon Boyle, Dijksterhuis (1961), and Westfall (1977).

[2] On the history of the term 'mechanical philosophy', see Sylvia Berryman (2009, 244 n.40), who notes clarifications communicated by Peter Anstey and by Alan Gabbey.

[3] Boyle's list also includes a number of others (see 1991, 10).

[4] On the subtleties of Descartes' use of the term 'mechanical', see Gabbey (2004, 18-19).

[5] For a recent discussion, see Garber (2013 §2).

productive of natural processes to material contact action. Although the slogan *matter and motion* could also refer to the sizes, shapes, and juxtapositions of the particles of a uniform matter, wherever local motion was concerned, the causal principle it denoted was, fundamentally, that of bodies pushing one another. J.E. McGuire once affirmed this conception; although there was considerable disagreement about a mechanical explanation's sufficient conditions, he wrote, mechanical philosophers did agree upon one necessary condition, namely, that "contact action is the only mode of change" (1972, 523, n. 2). More recently, Andrew Janiak reaffirmed the conception, writing that a prohibition against unmediated distant action was "a crucial norm of the mechanical philosophy (in all its guises)" (2008, 53). Nothing could be more at odds with the mechanical philosophy so conceived than Isaac Newton's gravitational force.

A Broader View of Mechanical Philosophies

As I interpret Newton, however, he allowed for a markedly different notion of a mechanical philosophy, and he saw the core of his natural philosophy as such, with his gravitational force its exemplar. This is not to deny his fluency in the prevailing usage of such terms as 'mechanical'; the "mechanical causes" mentioned in his General Scholium are the Cartesian sort, acting in proportion to surface area (*Principia*, 943); and in Query 28 of the *Opticks*, those explaining everything "mechanically" are the hypothesis-feigning philosophers who insist upon "dense matter" ([1730] 1952, 368-69). Yet other senses of these terms were being forged by early modern thinkers, including that which excludes the spiritual, that which represents natural phenomena mathematically, and a good many others (see McGuire, 1972; Gabbey, 2004). In fact, in one draft Newton applied the term 'mechanical philosophy' to his own theory; the general laws to be investigated, he remarks, govern motions produced by "the genuine Principles of the Mechanical Philosophy" (ULC Add. 3970, fols. 255r-256r).[6] Admittedly, he crossed out the passage containing this remark. That he wrote it at all, however, indicates that the term so frequently associated with Cartesian mechanism was not bound to that sense in Newton's mind.

The Author's Preface

In the following well-known passages of his Author's Preface to the *Principia*, Newton repudiates the longstanding belief that rational and practical mechanics properly have distinct goals and domains. More broadly, he indicates that he is both mechanizing natural philosophy, and subsuming mechanics within it.

> *Practical mechanics* is the subject that comprises all the manual arts, from which the subject of *mechanics* as a whole has adopted its name. But since those who practice an art do not generally work with a high degree of exactness, the whole subject of *mechanics* is distinguished from *geometry* by the attribution of exactness to *geometry* and of anything less than exactness to *mechanics*. Yet the errors do not come from the art but from those who practice the art. Anyone who works with less exactness is a more imperfect

[6] The text, written in English, is quoted and discussed in McGuire (1968, 170-71), who identifies it as a draft variant of Query 23 (1706 *Optice*) and thus Query 31 (1717/18 Opticks), and dates it to c. 1705. See also my discussion in Kochiras 2013.

mechanic, and if anyone could work with the greatest exactness, he would be the most perfect mechanic of all.

> ....But since the manual arts are applied especially to making bodies move, *geometry* is commonly used in reference to magnitude, and *mechanics* in reference to motion. In this sense *rational mechanics* will be the science, expressed in exact propositions and demonstrations, of the motions that result from any forces whatever and of the forces that are required for any motions whatever. The ancients studied this part of *mechanics* in terms of the *five powers* that related to the manual arts [i.e. the five mechanical powers] and paid hardly any attention to gravity (since it is not a manual power) except in the moving of weights by these powers. But since we are concerned with natural philosophy rather than manual arts, and are writing about natural rather than manual powers, we concentrate on aspects of gravity, levity, elastic forces, resistance of fluids, and forces of this sort, whether attractive or impulsive. And therefore our present work sets forth mathematical principles of natural philosophy (*Principia*, 382).[7]

Here Newton identifies and contests two related presumptions arising from the same fundamental error. First is the presumption that there is exactness only in mathematics; and that because abstract, mathematical entities are not causally related, rational mechanics – the mathematically expressed science of motion and of Archimedes' idealized machines – cannot tell us about forces as causal principles of change. He counters that there is exactness in the world, and consequently, making material bodies the objects of mathematics does not bring anything extrinsic or foreign to bear upon them. Rather, mathematical methods facilitate the discovery of features intrinsic to a system, notably the geometric proportions of the forces by which component bodies causally interact.
The second presumption is that the part of mechanics investigating real machines – traditionally, practical mechanics – properly includes only the imperfect machines produced by human mechanics. Newton counters that a discipline investigating real machines must also investigate the world, for it too is a machine, with forces such as gravity its natural powers and God its creator. This latter thought is hinted by his observation that anyone able to work with "the greatest exactness" would be "the most perfect mechanic of all" (*Principia*, 381).[8] That it is such a hint, however, is suggested by his later reference to God, in a letter to Richard Bentley, as a ''cause . . . not blind & fortuitous, but very well skilled in Mechanicks & Geometry'' (*Correspondence*, ed. Turnbull, 1959–1971, Vol. III, 235). This is not a world machine in Descartes' sense, clearly enough; for Newton, the world is mechanical in that the forces by which its systems operate manifest geometric proportions. Nor is there any conflict with Newton's voluntarism; for much as a human mechanic might

[7] The Preface has of course invited considerable attention, and one lucid discussion may be found in Stein (2002, esp. 282-83).
[8] Precedents for Newton's thought include a remark by the mathematician and physician Henri de Monantheuil, who called the world a machine and God a geometer; see Hattab (2005; see 113, 114, 115.) Cf. Guicciardini (2009, 300, 315).

interrupt or adjust the functioning of a manmade machine, so might the deity interrupt and adjust processes functioning by secondary causes, notably the planetary orbits.[9]

In casting mathematical features as intrinsic to the world – a point expressed by his choice of the term 'rational mechanics' for the single science of motion he asserts – and mathematical methods as capable of identifying real features of the world, Newton voices ideas expressed earlier by Isaac Barrow, who cited magnitude as "the principal part in the production of every natural effect".[10] Barrow too had his predecessors, of course, and in rejecting traditional disciplinary categories, Newton articulates long-brewing changes in the relationship between mechanics and natural philosophy.

Newton and Natural Philosophy's Traditional Goal

Midway through his Preface, Newton affirms the natural philosophy's traditional goal, though transforming the specifics of its pursuit. In general terms, that traditional goal was the discovery of real causes of natural phenomena. The Peripatetics had specified the goal in terms of their four causes, which looked not to systems but to powers possessed by individual bodies. Descartes in his turn had specified it in terms of his mechanism of contact action, producing a complete explanation of gravity, but within a system that foundered empirically and resisted quantification. Newton now specifies that goal as the discovery of forces, writing these well-known words: "For the basic problem of philosophy seems to be to discover the forces of nature from the phenomena of motions and then to demonstrate the other phenomena from these forces" (*Principia*, 382). These forces are, in particular, impressed forces (interestingly connected, however, to Definition 3's inherent force, the *vis inertiae*), which are defined without restriction to contact action and have various sources, including "percussion, pressure, or centripetal force" (Definition 4, *Principia*, 405). The *Principia*'s centerpiece is of course of that latter kind. As a real cause of phenomena – Newton's language at various points indicating its efficacy – it is, in broad outline, the traditional quarry of natural philosophy. As a cause for which geometric proportions are intrinsic, and one that cannot be localized to any one body, its co-varying quantities of force, mass, and distance arising only within a system, it is not at all the traditional quarry.

This is a mechanical natural philosophy in which the search for real causes of phenomena in the machine of the natural world is pursued with the approach gained from artificial, simple machines – that seeking to express mathematically the co-varying parameters of change within a system of bodies. Several other commentators have understood Newton's theory as a mechanical philosophy, including Richard Westfall, but on quite different grounds.[11] Westfall sees Newton as accepting the tradition of the mechanical philosophy, insofar as he understood nature in terms of moving material particles and treated celestial motions as

[9] Newton's well-known remark about the need to reform the orbits occurs in Query 31 of the *Opticks* ([1730] 1952, 402).

[10] The remark is from the second of Barrow's lectures, *Lectiones mathematicae,* 1683, in Gabbey (1992, 311, citing the 1734 translation).

[11] A.R. Hall and M. Boas Hall also classify Newton as a mechanical philosopher in virtue of his corpuscularianism; see their introduction to the section on matter theory in Newton (1962, 184). Those authors disagree (1995, 76-83), however, with Westfall's interpretation of Newton's post-*Principia* aethereal speculations as a euphemism for God.

problems of mechanics; and as having transformed that philosophy, by making it dynamic[12] and quantitatively precise (1971, 398, also 2001). However, in Westfall's view, Newton jettisons natural philosophy's traditional goal; he orients natural philosophy toward quantifiable expressions of force by turning it away from causal questions, and ultimately locates causal efficacy only in God, a conclusion I have elsewhere opposed (Kochiras, 2009, §3). In my view, by contrast, Newton's theory should be acknowledged as a mechanical philosophy precisely because he retains natural philosophy's traditional goal concerning causes, and puts aspects of the simple machine tradition to work toward that end.

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[12] The term 'dynamic' is convenient but anachronistic, not having been used by Newton. On Leibniz's introduction of the term, see Pierre Costabel (1970).

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Acknowledgements
I would like to express my appreciation to the organizers of the 5th International Conference of the European Society for the History of Science, held in Athens in November 2012, as well as to the National Hellenic Research Foundation and the National and Kapodistrian University of Athens.

On the historical epistemology of the Newtonian principle of inertia and Lazare Carnot's Première Hypothèse

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An outline

Generally speaking physical science makes use of experiments apparatus to observe and measure physical magnitudes: a unit of measurement is effetely a standardised quantity of a physical (and chemical) property, used as a factor to express occurring quantities of that property. Thus any value of a physical quantity is expressed as a comparison to a unit of that quantity. During and after an experiment this apparatus may be illustrated and/or and designed. This procedure lacks in pure mathematical studies. Thus, one can claim that experiments and their illustrations can be strictly characterized by physical magnitudes to be measured. Mathematical–mental modelling of results of the experimental apparatus (experiments, data end errors) permits to enlarge the hypotheses and arrive to claim some theses. From historical standpoint in *physics mathematics* domain such as Newtonian science one generally precedes by means of calculations, therefore the unit of measurements are not a priority in term of solution of an analytical problem. In this sense physical (and chemical) nature of the quantities are not a priority. E.g., space and time are crucial physical magnitudes in Newton's mechanics, but they are also mathematical magnitudes since they involved in derivative operations. Above all, if we should lose their mathematical–objective–sense, e.g., variation–in–time, we may lose the entirely mechanical Newtonian apparatus. In the history and philosophy of science one can see several streams of approaches to conceive and define foundational *mechanical–physical objects* and their *mathematical interpretations* which change both in a physics mathematics domain and a physical one.

On Newton's *Principle of Inertia*

The *Principia* was surely the main scientific theory for more than three centuries. The content appeared such as sophisticated mathematics (derivatives, integral calculus, etc.) in order to interpret each field of phenomena, *Celeste* and *Earthly*. In the *Preface* (and in *Rules of Reasoning in Philosophy*) of *Philosophiae naturalis principia mathematica* Newton (Newton 1803) assumed his idea on relationship between physics and mathematics separating mechanics into two parts: practical and rational.

> Since the ancients (as we are told by *Pappus*) made great account of science of mechanics in the investigation of natural things; and the moderns lying aside substantial form and occult qualities, and endeavoured to subject to phaenomena of nature to the laws of mathematics, I have in this treatise cultivated mathematics so far as it regards philosophy. The ancients considered mechanics in a twofold respect: as rational which proceeds accurately by demonstration; and practical. To practical

mechanics all the manual arts belong, from which mechanics took its name.[1] [...] rational Mechanics will be the science of motions resulting from any forces whatsoever, and of the forces required to produce any motions, accurately proposed and demonstrated [...] And therefore we offer this work as mathematical principles of philosophy. For all the difficulty of philosophy seems to consist in this—from the phenomena of motions to investigate the forces of Nature, and then from these forces to demonstrate the other phenomena [...][2].

Newtonian *Principle of Inertia*[3] (NPI):

> DEFINITION III. *The* vis insita, *or innate force of matter is a power of resisting, by which every body, as much as in it lies, endeavours to preserve in its present state, whether it be of rest, or of moving uniformly forward in a right line*.[4] (Newton 1803, I, 2; *Italic style* and capital letters belong to the author).
> Axioms; or Laws of Motion. Law I. *Every body perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed thereon*.[5]

At present, one can read: *Every body will persist in its state of rest or of uniform motion (constant velocity) in a straight line unless it is compelled to change that state by forces impressed on it*. It has been remarked (Nagel 1961) that all physical laws can be expressed by means of a proposition preceded by two *universal* and *existential* quantifications[6]: ($\forall$) ("for all") and ($\exists$) ("there exists" or "for some"). A possible logical expression of the Newtonian principle of inertia can be:

$$A = \forall x \exists y : P(x, y) \quad (1)$$

A	= the proposition of the principle of inertia.
X	= a body.
y	= a complex system constituted by an inertial system, a closed system, and a clock.
P(x,y)	= a predicate concerning *x* and *y*: if *x* is in *y*, than it is of its state of rest or of uniform motion.

[1] Newton 1803, "IX, line 4. (*Italic style* by the author).
[2] Newton 1803, X, line 3.
[3] In the history of science, after Newtonian principle, others assumptions were proposed. For example, Euler's theorem founding principles of dynamics strictly follow those assumed by Newton in *Mechanica sive motus scientia analytice exposita* (1736) where he reformulated Newtonian mechanics in a more systematic form. See "Theorem [6 and] 7. A body remains in a state of absolute rest, unless it is disturbed to move by some external cause". (Euler 1736, p 21). The laws of motion are presented as theorems. Euler assumed that laws of mechanics can be deduced without any recourse to experiments. And another one: "A body once put in motion by whichever cause, must persevere uniformly and in straight line, unless a new cause, different from that has caused the motion, will act on it". (D'Alembert ([1743] 1758), p. 4).
[4] Newton 1803, I, 2. (*Italic style* and capital letters belong to the author).
[5] Newton 1803, I, 19. (*Italic style* belong to the author).
[6] At beginning of the last century, Thoralf Albert Skolem (1887–1963) suggested a technique to formalize the existential quantification on *y*–variable of a given predicate into a constructive mathematical function (Skolem [1920] 1967).

Nevertheless, the aforementioned discussion belongs to classical mathematical logic which – by nature – is not interested in the *effective calculability* of its functions with respect to, operative–experimental–data. In this sense, the content of the first principle is lacking in experimental and *calculable evidence*. In particular:

- The Newtonian principle of inertia claims that *y exists*, but it does not claim how one can find it.
- The "whether" (or commonly "unless") contained in the proposition is not an *operative situation*. It only explains *a posteriori* the changes of state of motion occurred to the body.
- A precise distinction when $\vec{v} = 0$, and when $\vec{v} \neq 0$, is required by NPI.
- A precise knowledge when for $\vec{v} =$ *constant* in orientation (direction and versus) and in scalar–magnitude for the entire path is required by NPI.
- A precise knowledge of absence–forces or of a non–zero net force is required by NPI.
- The Newtonian principle of inertia is valid subordinately to validation of $\sum F_i = 0$ (for material–point and on the entire path).

Every physical variable should be subjected to its measurement. If the measurement cannot apply, the scientific content generates *uncertainties* in scientific knowledge. For that reason, the content of NPI as mentioned above, can be expressed by a sentences with double negated, «$\neg\neg A$: *It is not true that* $\vec{v} = 0$ *is not equal to* $\vec{v} \neq 0$». Thus, all of the examined experimental–logical–*ambiguities* reported can be found in the Newtonian principle of inertia within a non–classical logic investigation (Pisano 2010; 2011).

From Newton's *First Law* to Carnot's *Première Hypothèse*

If we consider an operative physics, to translate each *x* body in an effective procedure it is necessary to obtain an inertial system: an isolated system and a clock. Two centuries of unprofitable research demonstrate convincingly that with the sole knowledge of the body *x* it is not possible to operatively obtain many bodies. In order to make a physical–mathematical equation like (1) relatively operative, it might be obtained by forcing the predicate, which is by means of one of these three approaches.

1) Substitute the quantifier $\exists$ in (1) with a constant value y_0. This affirmation results in:

$$\forall x\ A(x, y_0) \quad (2)$$

That is, each *x* body at rest or in rectilinear uniform motion if placed in y_0 (that is if its motion is measured, with respect to a given inertial system, in a given closed system provided of a precise clock). Equation (2) corresponds to defining the clock and the reference system in two very different ways:

a. In the way followed by the physicists since the age of Galileo (Pisano 2009) that is with an empirical clock as a reference, with the closed system verified empirically and with the earth reference system; except changing those on a case by case basis in accordance with the following definitions).

b. In the idealistic way suggested by Newton (that is idealising this experimental method to the limit, transcending the same experience: introducing the idealised concepts of absolute space and time, that fix once and for all the clock and the inertial system and then implicitly suggest that we are always capable, as a matter of principle, of verifying if $\vec{F} = 0$ or not and then knowing when a system is isolated or not).

2) To accept the fact that in general we ignore the generic function $\alpha(x)$ but to annul the problem of the existential quantifier saying: in specific circumstances experimental Physics can define: «$\forall x\ A(x, y)$», without further explanation as to what the experimental physicists should do.
3) In order to deny the physical importance of these problems,[7] qualifying them as metaphysical ones. We can only affirm that we can make experimental observations on an «*x*» body: the impossibility for a single body under observation to change on its own its status of motion when at rest or in a rectilinear uniform motion. No quantifiers, nor «$\exists$», nor then «$\forall$». This is what Lazare Carnot did in *Principes fondamentaux de l'équilibre et du mouvement.* (Carnot 1803):

> *Notions préliminaires. Hypothèses admises comme lois générales de Équilibre et du mouvement. Conséquences déduites de ces hypothèses. 1° Hypothèse.* Un corps une fois mis en repos, ne suroît en sortir de lui–même, et une fois mis en mouvement, il ne suroît de lui– même changer ni sa vitesse, ni la direction de cette vitesse.[8]

The hypotheses that can be admitted as general laws of equilibrium and motion. In the first part, Carnot declared his preference toward the analytic approach. In the second part, he declared the two principles assumed in *Essai sur les machines en général* (Carnot 1786) the action and reaction and the conservation of *momenta* in the impact) as empirical laws. Particularly, in the introduction of the *Principes généraux de l'équilibre et du movement* (Carnot 1803) he reasserted his empiric idea

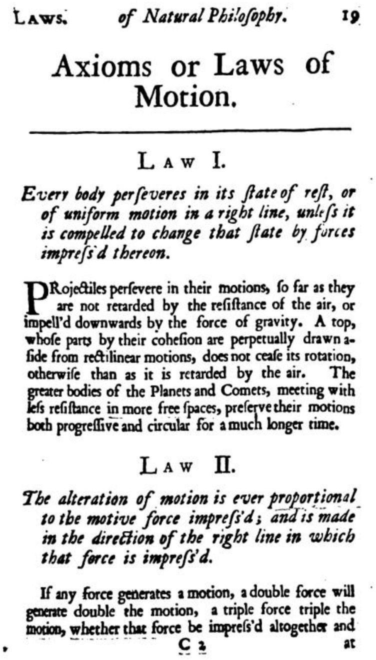
> Ancients established as an axiom that all our ideas comes form senses; and this is no longer object of dispute [....].[9]

He offers his version of the principles by the formulation of seven fundamental hypotheses (Gillispie and Pisano 2013; Pisano 2013).

[7] It has been demonstrated that it is possible to apply this method to the third principle of dynamics «for every action there is an equal and opposite reaction: that is the actions of two bodies are always equal to one another and directed towards opposite directions.
[8] Carnot 1803, 49, line 3. (*Italic style* from the author). First hypotheses: "A body once at rest would not be able to move on its own, and when put in motion could not change its speed or direction by itself" (My synthetic translation).
[9] Carnot 1803, p 2.

On Newton and Carnot's laws

One of the main differences between Lazare Carnot's mechanics (Pisano 2013) and Newton's mechanics lies in the fact that the first speaks of every body in every time and in every place, while L. Carnot speaks of a restricted whole of situations: those where it is possible to affirm that a body is at rest or in motion. These situations are indicated by an intentional generic introduction "[…] once […]". It is thanks to these generic terms that Lazare Carnot's version avoids the problem implicit in Newton's terms, when we talk about rectilinear and uniform motion "[…] until [...]" that is. Lazare Carnot avoids the problem of deciding when it is $\vec{F} \neq 0$ along the course (potentially infinite.)



LAWS. *of Natural Philosophy.* 19

Axioms or Laws of Motion.

LAW I.

Every body perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impress'd thereon.

PRojectiles persevere in their motions, so far as they are not retarded by the resistance of the air, or impell'd downwards by the force of gravity. A top, whose parts by their cohesion are perpetually drawn aside from rectilinear motions, does not cease its rotation, otherwise than as it is retarded by the air. The greater bodies of the Planets and Comets, meeting with less resistance in more free spaces, preserve their motions both progressive and circular for a much longer time.

LAW II.

The alteration of motion is ever proportional to the motive force impress'd; and is made in the direction of the right line in which that force is impress'd.

If any force generates a motion, a double force will generate double the motion, a triple force triple the motion, whether that force be impress'd altogether and

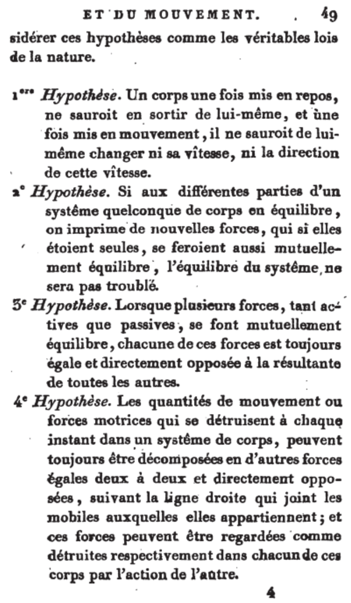
C 2 at

Figure 1:

In any time and in any place on infinite path.

In order to establish rest or motion, also mean to decide if v=0 …non if v < n …or v > n). In Newtonian mechanics first principle (a system and a clock) must be a priori defined.

Special contents are when he uses perseveres. This approach justify the previous unless. (Newton 1803, p 19)



ET DU MOUVEMENT. 49

sidérer ces hypothèses comme les véritables lois de la nature.

1ère *Hypothèse*. Un corps une fois mis en repos, ne sauroit en sortir de lui-même, et une fois mis en mouvement, il ne sauroit de lui-même changer ni sa vîtesse, ni la direction de cette vîtesse.

2e *Hypothèse*. Si aux différentes parties d'un systême quelconque de corps en équilibre, on imprime de nouvelles forces, qui si elles étoient seules, se feroient aussi mutuellement équilibre, l'équilibre du systême ne sera pas troublé.

3e *Hypothèse*. Lorsque plusieurs forces, tant actives que passives, se font mutuellement équilibre, chacune de ces forces est toujours égale et directement opposée à la résultante de toutes les autres.

4e *Hypothèse*. Les quantités de mouvement ou forces motrices qui se détruisent à chaque instant dans un systême de corps, peuvent toujours être décomposées en d'autres forces égales deux à deux et directement opposées, suivant la ligne droite qui joint les mobiles auxquelles elles appartiennent; et ces forces peuvent être regardées comme détruites respectivement dans chacun de ces corps par l'action de l'autre.

4

Figure 2 :

Limited to cases-studies and in particular operative situations where we are able to claim that a body is in rest or in motion.

"[…] un fois mis en mouvement […].

By means of it Carnot avoids to calculate V on a infinite path since it is a case study within inertial.

The Carnot's first hypothesis can be considered an advancement of Newtonian one based on vincula a and collision theory, too

The body cannot change "by itself" its state of motion.

In fact Carnot want to exclude old Impetus theory, according to which a body, whether it is in motion would have previously received a driving force-engine. (Carnot 1803, p 49)

Lazare Carnot correctly does not name the forces and does not ask for a verification of their absence $\sum_i \vec{F}_i = 0$ along the entire course of the body. He says that it is not possible to evaluate in a definite way: *If a motion is absolute, or if there is a motion or a dragging force, […] and it has been very difficult to correct this error.* There is no verification of the absence of forces. Lazare Carnot, then, says deliberately "[…] once it is […]" then, in the condition where we can decide, due to specific circumstances, that a body is static or a rectilinear uniform motion. Therefore for the French scientist it is up to our judgment, empirical and occasional, to decide if a body is static or a rectilinear uniform motion. A problem equivalent to the previous one (establishing if $\vec{F} = 0$ is exact) is the following: Newton would claim to establish exactly when a body is in a resting status as different from the motion status; this means deciding if $\vec{v} = 0$ is exact (but not if $\vec{v} < \varepsilon$).

Lazare Carnot's sentence "[…] once […]" avoids this problem.

The definition of Lazare Carnot's first hypothesis does not claim to provide rules to verify the status of rest or motion. Generally these are impossible since they would be circular by the definition of an inertial reference system.

Final Remarks

In the end, the principle of inertia states that rest and rectilinear uniform motion are equivalent. But what does *equivalent* mean? Newton's statement treats the two cases as if they were the same thing (…"at rest or in motion…"). Carnot's statement, however, is more cautious; it is broken up into two parallel but distinct affirmations: it does not take the passage from statics to dynamics for granted. So after this initial hypothesis, his other hypotheses articulate this equivalency in gradual passages. In fact, while his second hypothesis still concerns static situations, the third and the fourth hypotheses include dynamics. So we conclude that Carnot's hypotheses (after the first) are a precise strategy of passage from statics to dynamics. In addition we note that all of the aforementioned hypotheses are constructive since they are essentially experimental, except for the fourth which is considered by Carnot as a mathematical convention.

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SYMPOSIUM 13

History and Philosophy of Science in EU Secondary Curricula? New Proposals Wanted

Organizers
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It is recognized that science is an important component of the EU cultural heritage and provides the most important explanations of the material world. Recently fewer youths seem to be interested in science and technical subjects. Does the problem lie in wider socio cultural changes, and the ways in which young people in the EU countries now live and wish to shape their lives? Or is it due to failings within science education itself?
Generally speaking current school science curricula was constructed for preparing students for university and college scientific degrees. Such education does not meet the needs of the majority of students who will not pursue tertiary studies in science or even science related fields. These students require knowledge of the main ideas and methodologies of science. What about of cultural process? It seems that the didactics of scientific disciplines across Europe failed to solve the crisis between scientific education and EU social economic development. Reports (e.g., Rocard, et al) suggested new teaching methods, changed new curricula and purposes.
A special debate multi disciplinary dialogue exchanging new ideas proposals between different cultural approaches is auspicated:
a) ESHS Historians in EU Institutions, scientific education and secondary school.
b) Hypotheses and perspectives of history and philosophy of science discipline(s) EU secondary
schools curricula.
c) How history and philosophy of science can assist in solving the crisis in science both education
and foundations in Europe?
d) How new science education produce reliable knowledge and the limits to certainty?
e) A proposal would be presented to charged EU Parliament Commission.

A Proposal to Analyse the Representation of the Nature of Science Conveyed by Science Teaching and to Elaborate New Pedagogical Proposals

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Introduction

In France, these last twenty years, curricula at the secondary school level have undergone many reforms. It is not only a question any more of training scientists but also of allowing all students to acquire a scientific and cultural background that allows them to become responsible citizens, capable of understanding and taking action in a world where science and technology occupy a predominant place. The issue is also to cope with the loss of interest in scientific careers by encouraging vocations. In order to address these issues, curricula developers put not only the accent on contents to be learnt but also on methods and skills to be acquired and attitudes to be interiorized. Emphasize is also put on knowledge about the nature of science (s) and scientific activity (NoS).

The issue of the representation of NoS presented in science education and assimilated by students is a crucial one since the curricula are national and guide strongly the authors of textbooks and teachers. This is why we chose to explore it and started a research program. The other reason is that the NoS issue has been little explored in France. Unlike what exists abroad, especially in English-speaking countries, the studies in this domain are very few and concern the conceptions of teachers (Roletto 1995) and their practices (Pélissier 2011), the introduction of the history of science in physics teaching (Maurines and Beaufils 2011), science education and religion (Maurines 2010).

The study presented here focuses on the science syllabuses and concerns the secondary school level. We first present our research questions and methodology. Then, we give the first results. Finally, we discuss some implications for future research.

Research questions

The studies focused on curricula refer to different fields of research on sciences, in particular philosophy, history, sociology, and psychology of science. They

- analyse the NoS in science education standard documents : this is the case of the comparison at the international scale in English-spoken countries made by Mc Comas and Olson (1998) or of the study of the Portuguese curriculum made by Ferreira and Morais (2011);

- suggest NoS pedagogical goals that emphasize general aspects of science as Lederman (2007), or aspects focused on scientific practices as Irzik and Nola (2011), or both aspects as Maurines and Beaufils (2011);
- propose pedagogical approaches in which moments are devoted to an explicit reflection on NoS (Abd-El-Khalick 2012 ; Höttecke et al 2012 ; Maurines & Beaufils 2011) or based on the implementation of "authentic" experimental situations and the reflection of students on their practices (Duschl and Grandy 2012). Abd-El - Khalick (2012) calls these two types of approach "teaching *about* NoS" and "teaching *with* NoS".
- call for progressive goals (Maurines and Beaufils 2011 ; Abd-El-Khalick 2012) or underline that contents' choices depend on the level of education and on the major (Martinand 1986; Fuchs-Gallezot 2009)

The issue of the image (s) of NoS conveyed by the science syllabuses at the secondary school level leads to several questions:

- Which are the features of science (s) considered by the syllabuses?
- Which representation of NoS is conveyed by these syllabuses?
- Do these features and representation depend on the school discipline, level, and major -scientific or literary[1] ?

Methodology

Corpus and general overview

We chose to explore these questions on the syllabuses of three high school levels (grades 10 to 12), of two school subjects (Physics and Chemistry, noted here PC, and earth and life sciences, noted here SVT), and of two types of general teaching (scientific and literary).
A mixed methodology which combines features associated with both qualitative and quantitative approaches and followed a dialectical process between the theoretical and the empirical was used. We started by elaborating a first NoS matrix that we use to analyse the grade 10 syllabus following a quantitative approach. We then used a qualitative approach in order to categorise the empirical data and elaborate a second NoS matrix. We follow the same procedure for the grade 11 and 12 syllabuses.

The elaboration of the Matrix 1 and the quantitative analysis

The matrix 1, designed in order to account of the complexity and richness of potential discourses on science, includes a high number of dimensions. These dimensions were drawn from an epistemological analysis based on the philosophy, history, sociology and psychology of science since we agree with Mc Comas (1998) that NoS should be a hybrid construct. We also considered the NoS literature, especially the approach of Irzik and Nola (2011), and the French didactic framework of social practices of reference (Martinand 1986).
The approach that we adopted in order to formulate the NoS dimensions of the matrix 1 privileges the individual and his practice. From this perspective, scientific product is considered to be the result of activities performed by individuals, working collectively within a community, in the socio-cultural context of a given historical period. This approach allows

[1] The compulsory teaching ends at the age of 16. They are two scientific school subjects: Biology-Geology and Physics-Chemistry. All students received the same science teaching from grade 6 to grade 10, and then it depends on the major.

considering nine dimensions of the scientific social practices, that we called: aims of the study, object (of study), product (of the study), resource (for the study), elaboration (activities and methods), (scientific) community, society, and history.
The matrix 1 was used in order to identify the dimensions taken into account by each sentence of the syllabuses. It has also to be noted that the syllabuses consist of two type of discourse. One deals explicitly with science, the other focuses on the school subject. We coded all the sentences of the syllabuses by specifying whether the dimensions are considered explicitly as a characteristic of science(s) or implicitly as a characteristic of school science. Our main hypothesis is that implicit statements concerning school science convey information on the NoS.
The table 1 shows an example of how the sentences of the syllabuses were coded. Four researchers made several encodings in order to reach consensus. We then realise a quantitative analysis in counting the number of sentences in which a dimension appears. We finally calculate the percentages of phrases which consider a specific dimension on the total number of sentences.

GRADE 10 PHYSICS- CHEMISTRY												
	Syllabus (BOEN n° 4 - 29/04/10)	Speech about science		Matrix 1 : selection of 9 aspects of sciences' practices								
	Example of syllabus ' sentence	Explicit	Implicit	Aims	Objects	Resources	Products	Elaboration	Attitudes	Community	Society	History
18	Unlike dogmatic thinking, science is not made of inviolable revealed truths, but of questions, research and responses which evolve and enrich over time.	x		x			x	x	x			x

Table 1: *Extract of the encoding table*

The elaboration of the matrix 2 and the qualitative analysis

For each dimension, the comparison of the analysis units extracted from the grade 10 syllabuses led us to distinguish different sub-dimensions within a given dimension, and different categories within a specific sub-dimension. This procedure is illustrated on the table 2 in the case of the dimension "object".

Matrix 1 (a priori)	Matrix 2 (a posteriori)		*Example of units extracted from the PC or SVT syllabuses*
NOS dimensions	**Sub-dimensions**	**Categories**	
Objects	**Types of objects**	**Material objects** **General/ specific**	*World, nature, reality, concrete, universe, plant, animal* *World built by man*
		Phenomena	*Life, health, movement*
		Conceptual (concepts, laws, models, theories,	*Energy*
	Issues	**Descriptive**	*to understand the organisation*
		Functionalist	*to understand how it works*
		Historical	*to understand the evolutive origin of the different living being*

Table 2: *The sub-dimensions and categories of the dimension objects*

The state of progress

The analysis of the grade 10 syllabus is entirely done. The comparison of the different dimensions, sub-dimensions and categories evoked by the PC and SVT grade 10 syllabuses, revealed differences and similarities and allowed us to begin typifying the image of the NoS conveyed by each syllabus.

For grades 11 and 12, we realised the quantitative analysis and have started the qualitative analysis.

Results

1) *The quantitative analysis*

The results presented here concern the PC and SVT syllabuses for the grade 10. Some results will be shown concerning the grade 11.

Two types of results are detailed: one concerning the type of speech about science, implicit or explicit, and the other concerning the most evoked dimensions.

1.1 Results concerning the type of discourse about science in the grade 10 syllabuses

It has to be noticed that the French syllabuses are organised in two very different parts: The first one introduces the general aims of the school subject, the way the teaching should be

done and some justifications about the choices of contents made. The second one specifies in tables the contents (knowledge and competencies) to be taught. We called the first part, the justification part, and the second one, the content part.
Concerning the type of speech about science, the quantitative analysis on the whole syllabuses shows that for the two school subjects the implicit speech is the most frequent whereas the explicit speech is almost missing (figure 1).
Concerning the two parts of the syllabuses, the implicit speech is the most frequent in both cases ; the explicit speech is completely missing in the content-part of the syllabuses (figure 3) and is only present in the justification part of the syllabuses (figure 2).

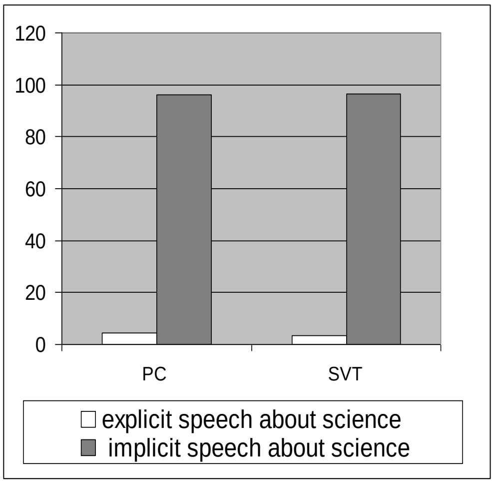

Figure 1: *The whole syllabuses*

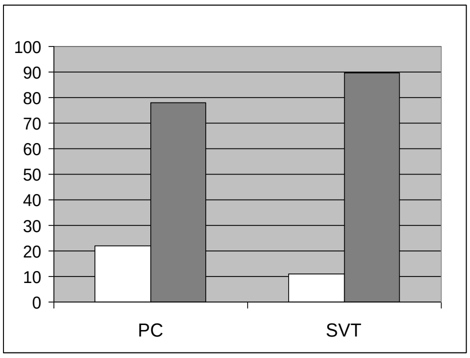

Figure 2: *The justification parts of the syllabuses*

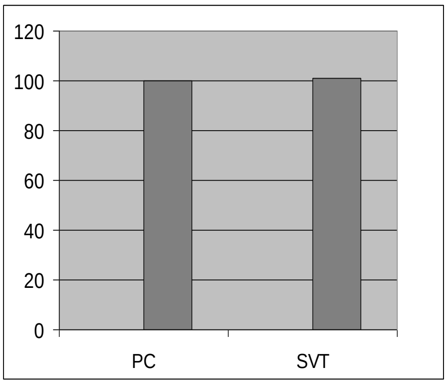

Figure 3: *The content parts of the syllabuses*

1.2. Results concerning the most evoked dimensions in the whole syllabuses of grade 10
The quantitative analysis shows that for the two school subjects “elaboration”, “products” and “objects” are the dimensions the most evoked on the whole syllabuses (figure 4) . A little difference can be noted between the two school subjects, “objects” are more present in SVT and “products” in PC.

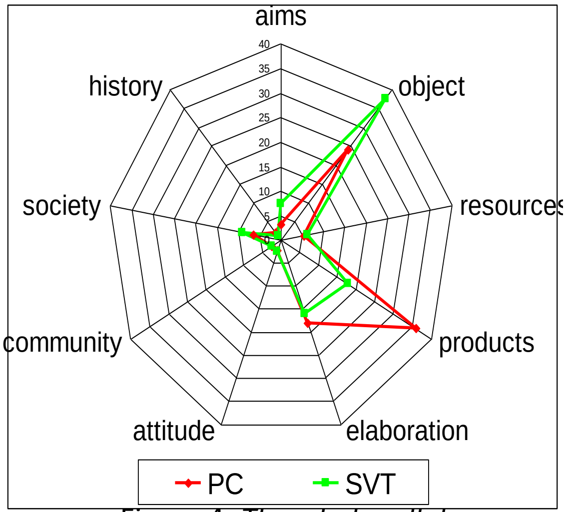

Figure 4: *The whole syllabuses*

If we look at the dimensions which are the most represented in the two parts, we notice that for the justification part of the syllabuses (where an explicit speech is present) all the dimensions are present (figure 5) whereas for the content part of the syllabuses (figure 6), “objects”, “products” and “elaboration” are the majority dimensions for both syllabuses. But differences between SVT and PC can be noticed. In the PC syllabus, the representation of the different dimensions seems to be more balanced (figure 5).

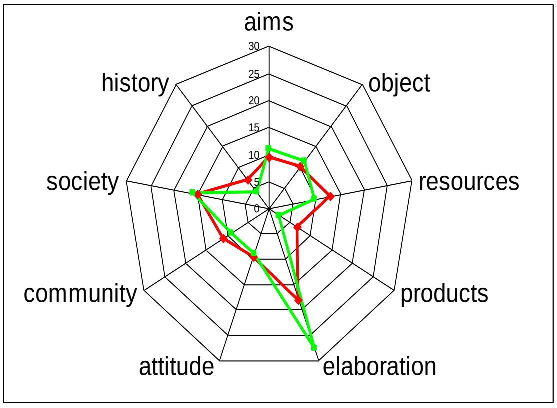

Figure 5: *The justification parts of the syllabuses*

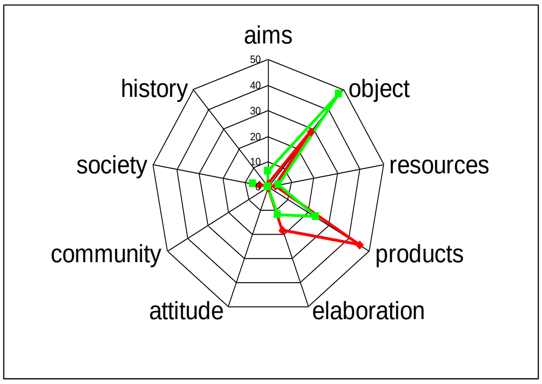

Figure 6: *The content parts of the syllabuses*

1.3. The justification parts of syllabuses of different levels and majors

The figure 7 shows the results obtained for the grade 10 (2nde) compared to the grade 11 (1ère). For this grade, two syllabuses have been analysed: the PC syllabus of the scientific high school diploma field (S PC), and the science syllabus of the literary high school diploma field (ES/L sciences).

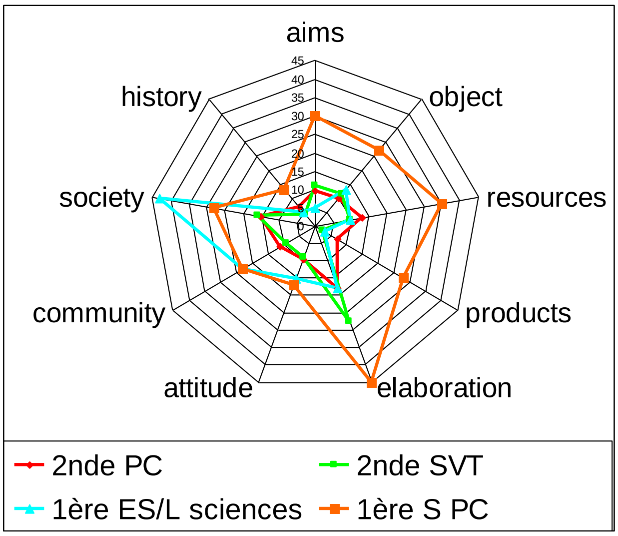

Figure 7: *The justification parts of grade 10 (PC and SVT) and 11 (PC and science)*

The figure 7 shows that all dimensions present for the grade 10 syllabuses are still present for the grade 11 syllabuses at least with the same frequencies and for some of them with higher frequencies. Some differences can be noticed: for the literary high school diploma field syllabus, the dimensions highlighted are “society” “community” and “attitude” whereas for the scientific high school diploma field syllabus, all dimensions are more developed than in grade 10, with a special mention for “aims”, “objects”, “resources”, “products” and “elaboration”.

Thus, it is noteworthy to report that there is a clear variation of the frequencies of evocation of the different dimensions according to the type of high school diploma field. It seems that an implicit progression between grade 10 and 11 leading to a more complete understanding of the NoS exist in the secondary school.

2) *The qualitative analysis of the justification parts of the grade 10 syllabuses*

The analysis of the units extracted from the grade 10 PC and SVT syllabuses leads us to identify different sub-dimensions and categories, and to construct a second matrix The comparison reveals that if some categories are common to both syllabuses, others are specific to one syllabus. But even if the units extracted from the two syllabuses are classified in the same category, they sometimes show difference of meaning.

For reason of brevity, we present only the sub-dimensions (table 3), and the comparison between the two syllabuses only for the dimension ‘elaboration’ (table 4). We invite readers to confer to Maurines et al (2013) for further details.

Dimensions (a priori)	**Subdimensions** (a posteriori)
Aims and general characteristics	Aims
	Presuppositions and values
Objects of study	Types
	Problems explored
Ressources	Intellectual
	Material (instruments, tools, technologies)
Products	Intellectual
Elaboration	General processes
	Activities
	Methods and rules
Attitudes	Cognitive
	Affective and behavioral
Scientific community	Characteristics of the members
	Collective construction
	Relations within the community
Society	Sciences' role within the society
	Relations between sciences and society
History	Scientific knowledge evolves
	The temporal context in which scientists live evolves
	Elaborations' ways throughout time
	Type of history (e.g. succession of special dates)

Table 3: *The sub-dimensions evoked by the grade 10 syllabuses*

The table 4 shows that four categories are common (in orange) and that five categories are specific to the SVT syllabuses (in green). It is also important to notice that there are differences which correspond to different focuses inside the common categories. For example, in the case of the category ‘intellectual activities’ the SVT syllabus mentions only the rational thinking whereas the PC syllabus mentions also the creative thinking.

Matrix 1	Matrix 2		Grade 10 Syllabuses	
NOS dimensions	Subdimensions	Categories	PC	**SVI**
elaboration	General processes	Which stages? Which key points?		
		Constructivist perspective: Knowledge is constructed through scientific activity		
		Different places to make science		
	Types of activities	Practical		
		Intellectual	**Rational thinking**	
			creativity	
	Rules and methods about	Argumentation		
		Security		
		Validity		
		Security		

Table 4: *The categories evoked by the grade 10 syllabuses in the dimension elaboration*

Conclusion and perspectives

The quantitative analysis points out that NoS is a goal for teaching only in the SVT syllabus and that the explicit speech about NoS is rare in both syllabuses and only presents in the justification parts. The number of the dimensions evoked in the justification parts of the syllabuses is higher than in the content parts. The dimensions evoked in the whole syllabuses are limited to objects, products and elaboration.

The different dimensions are more frequently evoked in higher levels of teaching. Their frequencies of evocation depend on the scientific or literary orientation of education and of the school subjects.

Consequently, we assume that

- the images conveyed by the justification parts are richer and less implicit.
- the images conveyed in the grade 11 are richer than in the grade 10 and that the choices made by the curricula developers depend on the issues of the different school subjects and the different education orientation : literary or scientific.

The qualitative analysis for the grade 10 syllabuses points out that each dimension takes into account different aspects which correspond to different categories and that most of the categories are common to the two syllabuses. There are differences which reflect different points of view about NoS between school subjects. We assume that the SVT syllabus conveys a more rationalist and internalist vision of science whereas the PC gives more importance to the human and social dimensions of science. Moreover, the PC syllabus mentions some values of the scientific enterprise. Even if the idea of demarcation is present in the two syllabuses, it seems to us that the PC syllabus explicitly promotes science.

These results raise questions: what do teachers understand about NoS ? how do they take NoS into account in their teaching ?

Concerning the research perspectives, we plan to confront this matrix with other categories issued from NoS literature in order to propose a framework as rich and large as possible which can allow justified curricula content choices.

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The Role of the History and Philosophy of Technology in Secondary Education

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Introduction

If the history and philosophy of science is seen as a useful approach in secondary education, then the history and philosophy of technology has an equal claim. The history of technology has often been seen as the poor relation of the history of science, yet its study can not only support the learning of scientific principles, but also engage students in a debate about contemporary and often contested technological issues – from the 'information revolution' to climate change. From this point of view, technology is much more than applied science. Certainly, scientific principles are involved, but even in its 'purest' form, technology is more about designing artefacts and systems than understanding the natural world. This significant difference is reflected in the sort of models that technologists use for design. Even where the underlying mathematics of a technological model may be identical to a related scientific one (differential equations, Fourier transforms, for example), the way the models are elaborated and used within a technological or engineering culture is usually very different from the comparable scientific context.
In recent years the historiography of technology has been greatly influenced by "science and technology studies" (STS) and "social construction of technology" (SCOT) approaches, both of which can be used – albeit in a fairly elementary manner – to contextualise school studies in this area. As far as the philosophy of technology is concerned, it is certainly less well established as a discipline than the philosophy of science, and its major concerns – design, sustainability, tacit knowledge, and so on – are perhaps less easy to define than those of the philosophy of science – causality, scientific method, scientific revolutions, for example. Clearly, however, the two fields merge when considering a number of theoretical and practical issues, in particular the social context of science / technology.

Science and technology

Few would now treat technology as a linear consequence of fundamental science along the lines of

basic science → applied science → engineering → technology

Nevertheless, within most secondary schools, the science curriculum has very little to say about more complex technological phenomena. When it comes to the very minor presence of history and philosophy of science and technology, the emphasis is almost entirely on science. The history and philosophy of science as an academic discipline tends to concentrate on such issues as scientific method(s), causality, falsification, the mind-body problem, the scientific revolution, and so on. The history and philosophy of technology, on the other hand, is concerned with such matters as technological determinism versus the social construction of technology, issues of design and systems thinking, sustainability, tacit knowledge, practical ethics, and so on.

In recent decades the sociology, history and philosophy of science and technology have become very close, and some would even argue that it makes little sense to distinguish between them as separate disciplines. Major post-Kuhnian movements (Kuhn, 1962) have been Science and Technology Studies (STS), the Social Construction of Technology (SCOT); the Sociology of Scientific Knowledge (SSK); and Actor-Network Theory (ANT). This is not the place to discuss the origin and development of such movements, but major influences were the Edinburgh School from the 1970s onwards (Bloor, 1976); the Paris School (Callon, 1989; Latour, 1984); and academics at Maastricht and Twente (Bijker et al, 1987) and Bath (Collins & Pinch, 1993, 1998).

How can we use such ideas in the secondary classroom? Useful issues to be explored include:

- the complexity and contingency of technology – it is not simply applied science
- technological determinism versus social shaping (Smith & Marx, 1994)
- social, political, economic and legal aspects, as well as technical aspects
- is innovation and invention privileged over use and users? (Edgerton, 2006)

It is also profitable to link such teaching to current issues, for example: the contested history of ideas about climate change; the history of computing, ICT and the Internet (in order to explore the naïve deterministic notions promulgated by many politicians and much of the media); the ethics of social networking; the reasons for large-scale ICT systems failures; and many more.

Case studies can be extremely valuable, for example:

Case study 1: The development of the digital mobile phone

The European digital cell phone was promoted by the EEC (now the European Union) as a socio-technical good (Agar, 2003). It employed military technology for civilian use, and it was not obvious at the start of the GSM project that it would be technically feasible. It required the detailed development of a set of standards, and enormous investment by governments and telecommunications companies. The huge adoption of texting (SMS) was completely unexpected, and an example of users appropriating a new technology in a novel manner. Convergence (3G) with other ICT systems, particularly the Web, raised new challenges. Use in the developing world, particularly in Africa initially, turned the mobile phone into a more general and potentially liberating instrument for information and financial transactions.

Case Study 2: Household technologies

The development of household technologies for cooking, cleaning, food storage, child care, and so on, has much to say about socio-technological systems, gender issues, and market struggles between major manufacturers. A classic work is Cowan (1983), whose publisher's marketing states, with some justification:

> In this classic work of women's history (winner of the 1984 Dexter Prize from the Society for the History of Technology), Ruth Schwartz Cowan shows how and why modern women devote as much time to housework as did their colonial sisters. In lively and provocative prose, Cowan explains how the modern conveniences—washing machines, white flour, vacuums, commercial cotton—seemed at first to

offer working-class women middle-class standards of comfort. Over time, however, it became clear that these gadgets and gizmos mainly replaced work previously conducted by men, children, and servants. Instead of living lives of leisure, middle-class women found themselves struggling to keep up with ever higher standards of cleanliness.

Such case studies offer a wealth of teaching opportunities within a variety of traditional school subjects.

Philosophy of technology in the classroom

In this section I shall give just three examples of questions that might be asked within many existing secondary curricula in order to foreground issues of the philosophy of technology.

Question 1: Is there such a thing as a feminist technology?

This is a fertile question for secondary school investigation and discussion. Let me quote one of the major thinkers in this area, Judy Waijcman:

> Feminist theories of technology have come a long way over the last quarter of a century. The intellectual exploration at the intersections of feminist scholarship and STS has enriched both fields immeasurably. While each has been characterised by diverse lines of argument over the last decades, the underlying continuities are all the more striking. Both fields foreground the way that people and artefacts co-evolve, reminding us that 'things could be otherwise', that technologies are not the inevitable result of the application of scientific and technological knowledge. For me, the distinguishing insight of feminist STS or technofeminism is that gender is integral to this sociotechnical process: that the materiality of technology affords or inhibits the doing of particular gender power relations. Women's identities, needs and priorities are configured together with digital technologies. For all the diversity of feminist voices, feminist scholars share a concern with the hierarchical divisions marking relations between men and women. Key to our analysis is the understanding that, while gender is embedded in technoscience, the relationship is not immutably fixed. While the design process is decisive, sociotechnical configurations exhibit different degrees of determination and contingency at different moments in their relationship. The capacity of women users to produce new, advantageous readings of artefacts is dependent on their broader economic and social circumstances. Such a perspective redefines the problem of the exclusion of groups of people from technological domains and activities. Technofeminism exposes how the concrete practices of design and innovation lead to the absence of specific users, such as women. While it is not always possible to specify in advance the characteristics of artefacts and information systems that would guarantee more inclusiveness, it is imperative that women are involved throughout the processes and practices of technological innovation. STS provides a theory of the constitutive power of tools, techniques and objects to materialise social, political and economics arrangements. Drawing more women into design—the configuration of artefacts—is not only an equal employment opportunity issue, but is also crucially about how the world we live in is shaped, and for whom. We live in a technological culture, a society that is constituted by science and technology, and so the politics of technology is integral to the renegotiation of gender power relations. (Waijcman, 2010)

Question 2: What does the term 'information revolution' mean?
As a starting point for a discussion of this issue I quote from one of my own recent publications:

> The historian and sociologist of science Steven Shapin opened his widely acclaimed book *The Scientific Revolution* with the words: 'There was no such thing as the Scientific Revolution, and this is a book about it'. He went on to write:
>
> > Some time ago […] historians announced the real existence of a coherent, cataclysmic, and climactic event that fundamentally and irrevocably changed what people knew about the natural world and how they secured knowledge of it. It was the moment at which the world was made modern, it was a Good Thing, and it happened sometime during the period from the late sixteenth to the early eighteenth century. It was, of course, the Scientific Revolution. (Shapin, 1996, p.1)
>
> Shapin's tongue-in-cheek opening words prompt a number of questions about the current 'information revolution':
>
> - is it a real, coherent, cataclysmic, and climactic event?
> - has it fundamentally and irrevocably changed our view of the world?
> - has it made the world *post*-modern?
> - when did it happen?
>
> (Bissell, 2012)

Question 3: "Do artefacts have politics?"
This question is the title of a famous paper by Langdon Winner, in which he postulated that the height of bridges on Long Island discriminated against blacks and poor people since buses could not use the route to the beach. The paper aroused heated discussion within the STS community, and a detailed rebuttal by Bernward Joerges ensued. An entertaining additional response was given by Woolgar and Cooper (1999), which includes references to the original papers. The controversy is still a useful starting point, at many academic levels, for a discussion of the complexities and difficulties of analysing socio-technical systems.

Engineering ethics
Most professional engineering bodies have codes of practice of professional ethics. These provide a useful benchmark against which to judge some current and recent technological ethical dilemmas. For example, the IEEE Code of Practise (abridged) exhorts and requires its members

- to accept responsibility in making decisions consistent with the safety, health and welfare of the public, to disclose factors that might endanger the public or the environment;
- to avoid real or perceived conflicts of interest whenever possible, and to disclose them when they do exist;
- to be honest and realistic in stating claims or estimates based on available data;
- to reject bribery in all its forms;
- to improve the understanding of technology;

- to maintain and improve our technical competence and to undertake technological tasks only if qualified;
- to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;
- to treat fairly all persons;
- to avoid injuring others, their property, reputation, or employment;
- to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

The following two case study outlines are based on actual events, and for more senior secondary school students provide an opportunity to explore these contested issues in the light of such codes of practice.

Case Study 3
An engineer becomes aware that a car is unsafe. The management decides it is cheaper to pay compensation to accident victims than to recall and / or redesign the vehicle. Should the engineer remain in the company and try to change the policy? Leave and say nothing? Blow the whistle and suffer the consequences?

Case Study 4
A group of engineering students working with NGOs and a western national organisation build a water clarification system in a developing country. The 'technicality' of the project is promoted both in the western home country and locally. On arrival on site it becomes clear that the design should be adapted for local conditions, and that much of the 'technology' is inappropriate or unnecessary. Nevertheless the system is installed, and an operator employed for it. Sometime later it seems that the system has rarely, if ever, been used. So, is it ethical to stress the advanced technology of a design, when local conditions require something else? Is it ethical to install a subsystem, and continue to pay an operator, when it is rarely, if ever used? How should 'high-tech' western engineers engage with local knowledge?

Philosophy of mathematics and modelling
There are great differences between mathematics as used in science and technology. School (and university) students tend to be taught a scientific / applied maths approach, which emphasises such techniques as solving equations, differential and integral calculus, matrix algebra, and so on. In contrast, technologists and engineers tend to use rules of thumb and diagrams – as well as computer simulation – and are more interested in general, rather than specific results: in particular, in generic approaches that give insight into design or analysis at the systems level. I have discussed this in some detail elsewhere (Bissell, 2012; and forthcoming). In the second of those two publications I remark by way of conclusion:

> This short chapter has aimed to present some of the major special characteristics of the way models are used in information engineering, in contrast to much of the literature on modelling in the natural sciences or economics. These characteristics include:
>
> 1. The primary aim of the modelling is for system synthesis or design, rather than analysis or explanation.

2. Many of the models are based on quite complicated mathematics, such as complex analysis and Fourier and Laplace transforms, and thus were not immediately accepted by practising engineers when they were introduced.
3. Practising engineers had to cope with considerable changes over the period outlined in this chapter, accepting increasingly more sophisticated models of electrical, electronic or control systems than they had been used to, and learning new languages with which to discuss their design processes.
4. The new models were converted into much simpler form for the use of engineers, particularly graphs and charts which, often isomorphic with the mathematical foundations of the techniques, were able to hide the complexities of the underlying models from practitioners.

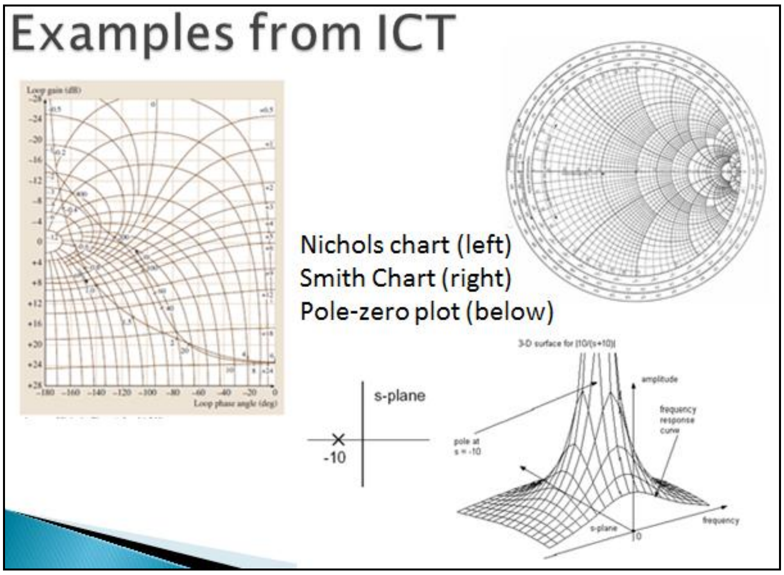

Figure 1: *Some graphical ICT tool*s

Figure 1, taken from the conference presentation, illustrates three of these graphical modelling tools. These are all fairly advanced techniques, normally taught at undergraduate level, but the general principle also applies at secondary school level – namely, the contrast between formal mathematics, and the way engineering and technology practitioners have adopted and exploited such formalities in a way more appropriate to professional practice. The Nichols chart is a way of deriving a closed-loop frequency response from an open-loop model; the Smith chart is a tool for transmission line impedance matching eliminating the need for complex algebraic analysis; while pole-zero plots are a succinct isomorphic representation of a linear differential equation. All three are remarkable, user-friendly, visual representations of the sort of mathematics that many student and professional engineers find very difficult, and all are widely adopted in computer-aided design and simulation.

Constraints and conclusions

Different countries have very different secondary school curricula, some flexible, some highly prescribed. The study of the history and philosophy of technology, however, can fit into most systems, and easily form part of the teaching of, amongst other subjects, science, mathematics, history, social sciences and citizenship. Technology is not simply applied science, so the historical and philosophical aspects of technology can provide: a vehicle for teaching scientific, mathematical and technological principles; an opportunity to discuss a range of philosophical and ethical issues; a way to link social, economic and political problems to the relevant science and technology; and a way to demonstrate the complex, messy and contingent nature of socio-technical systems.

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A teaching proposal on 20th century Physics

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Introduction: Twentieth Century Physics In Italian Secondary School

The reform of the Italian secondary school (which corresponds to the high-school level) involves teaching of the twentieth century physics in the last year of *Licei scientifici* of the new system.

The Decree of the Italian Minister for Education, University and Research, 7 October 2010, n. 211, concerning the draft regulation on "National Indications concerning the specific learning objectives related to the activities and teachings for *Licei*'s courses" includes the following teaching contents.[1]

For the first Biennium:

- Physical Quantities. Scalars and Vectors
- The measurement: uncertainty, significant figures of a number, graphs
- The equilibrium of the bodies and of the fluids
- The motion
- The laws of dynamics
- Work and energy: conservation of mechanical energy
- The temperature and the heat
- The geometrical optics: reflection and refraction of light, the main optical instruments

For the Second Biennium

- The principle of relativity of Galileo. Non-inertial reference frames
- The conservation of mechanical energy and the motion of fluids
- The other principles of conservation (momentum, ...)
- Gravitation
- The kinetic theory of gases. The principles of thermodynamics
- Waves: Interference and Diffraction. Sound. Wave nature of light
- Electric and magnetic phenomena. Electric field, electric potential energy. Magnetic field.

[1] You can find the Decree of the Italian Minister for Education, University and Research, 7 October 2010, n. 211, concerning the draft regulation on "National Indications concerning the specific learning objectives related to the activities and teachings included in the plans of the studies provided for *Licei's* courses referred to in Article 10, paragraph 3 of the Decree of the President of the Republic 15 March 2010, n. 89, in relation to Article 2, paragraphs 1 and 3 of that Regulation, at the following website address:
http://www.indire.it/lucabas/lkmw_file/licei2010///indicazioni_nuovo_impaginato/_decreto_indicazioni_nazionali.pdf

For the Fifth Year

- The magnetic induction and its applications.
- Maxwell's equations.
- The electromagnetic waves and their applications in various frequency bands.
- Relativity: time dilation and length contraction, mass-energy equivalence
- Nuclear phenomena: radioactivity, fission, fusion.
- The quantum of light, the photoelectric effect and interpretation of Einstein, quantization of energy levels in the atom
- Wave-particle duality, uncertainty principle

The learning path proposed in this work is also based in the section of the National Indications for *Licei scientifici* entitled "General outlines and competences" acquired by the student. Here we read

> “At the end of secondary school course, the student will learn the fundamental concepts of physics, the laws and theories that they make explicit, gaining awareness of the cognitive value of the discipline and of the *link between the development of physical knowledge and the historical and philosophical context in which it has developed ”.*[2]

Moreover, in the "Learning outcomes" of The cultural, educational and professional profile of *Licei scientifici* we read that the students are required to

> "be aware of the reasons which have produced the scientific and technological development over time, in relation to the needs and demands of knowledge of different contexts, with critical attention to application-technical and ethical dimensions of scientific achievement, highlighting the most recent"[3]

Einstein’s worldview

The science of Albert Einstein (1879 – 1955) seems to be more a work of art of human rationality that a physical theory. Its beauty manifests the "harmony of the natural laws", arousing, as he affirmed, a “rapturous amazement” to superior “intelligence” that reveals itself in the world of existence (Einstein [1954] 1994, 43).

In 1905, with the publication of three extraordinary papers, Einstein laid the foundations of relativity and quantum theory and gave the definitive proof of the molecular structure of the matter.

The applications of his theories to the modern technology are of an unprecedented scale and they are not only the basis for the creation of the atomic bomb and the production of electricity in nuclear power plants.

Faced with a possible new nuclear war that could endanger the very existence of humanity, Einstein used his fame to call for commitment to peace by scientists, politicians and ordinary citizens.

Learning objectives

Students will be able to:

Know the conceptual deficiencies of classical physics that led to the introduction of quantum theory and the theory of relativity

[2] Ibidem, p. 342.

[3] Ibidem, Enclosure A, http://www.indire.it/lucabas/lkmw_file/licei2010///Profili1.pdf, p. 11.

Understand the dispute between Bohr and Einstein on the causality of events in quantum mechanics
Comprehend scientist's ethics in the vision of Albert Einstein and know the Einstein-Russell Manifesto

Didactic content
The quantum of light
Elements of relativity. Equivalence of mass and energy
Relations between relativity and cosmology
The uncertainty principle
Einstein's dream and the string theory

Teaching methodologies
Lectures and interactive lesson
Use of audiovisual tools:
Superquark, Albert Einstein, broadcast on Rai 1 on 13.09.2005.
Reading of scientific papers and writings of that time:
- Cioci, V. (2006) "La visione del mondo di Albert Einstein: un confronto con Teilhard De Chardin" ("The worldview of Albert Einstein: a comparison with Teilhard De Chardin"), Progresso del Mezzogiorno, Naples: Loffredo Editore 30:113-134.
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J. Robert Oppenheimer: the physicists have known sin
After making significant contributions in several areas of fundamental physics, J. Robert Oppenheimer (1904 – 1967) headed the Manhattan Project; he was, however, deeply troubled by terrible sufferings inflicted by the atomic bombing of Hiroshima and Nagasaki populations. Subsequently Oppenheimer opposed the construction of the H-bomb, but he was tried for having slowed its development with his influence on American scientists.
He developed the belief that the only prospect for humanity to contrast the destructive power of new weapons should be a united world. To him we owe notable publications on the relationship between science, ethics and society.

Learning objectives
Students will be able to:
Know the contribution made by Oppenheimer to astrophysics
Examine the relationship that must exist between science and ethics in the opinion of J. R. Oppenheimer
Understand the conditions that led to the birth of the International Atomic Energy Agency

Didactic content
Oppenheimer and the formation of black holes

Mini blacks holes and extra dimensions
The atomic nucleus
Nuclear Fission and fusion
The atomic bomb

Teaching methodologies
Lectures and interactive lesson
Dramatization of Oppenheimer's trial
Reading of scientific papers and writings of that time:

- Cioci, V. (2005) "Oppenhimer ed i nuovi interrogativi della scienza" ("Oppenhimer and the new questions of science"), Atti del XXV Congresso nazionale di Storia della Fisica e dell'Astronomia (Proceedings of the XXV SISFA Congress), The University of Milan, Institute of General and Applied Physics, Section of the History of Physics, www.brera.unimi.it/sisfa/atti/atti2005/C06-Cioci.pdf
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Franco Rasetti and the "Via Panisperna boys"
Franco Rasetti (1901 - 2001) was perhaps the greatest Italian experimental physicist of the last century. With Enrico Fermi (1901 - 1954), Edoardo Amaldi (1908 - 1989), Emilio Segre (1905 - 1989), Bruno Pontecorvo (1913-1993) and the chemist Oscar D'Agostino (1901 - 1975), he was member of the team of young physicists known throughout the world for their research on radioactivity induced by neutrons as "Via Panisperna boys".
Rasetti refused to participate in the research for the military use of nuclear energy. After Hiroshima he left physics to devote himself to paleontology and botany. He was a promoter of natural consciousness.

Learning objectives
Students will be able to:
Know the contribution of "via Panisperna boys" to nuclear physics
Know the different positions taken by Italian physicists towards the creation of the atomic bomb
Understand the problems concerning the relationship between technology and nature

Didactic contents
Natural and artificial radioactivity
The radioactivity induced by neutrons
The slow neutrons
Nature and technology: the responsibility principle

Teaching methodologies
Lectures and interactive lesson
Use of audiovisual tools:
Eredi di Galileo. *Via Panisperna*, broadcast on Rai Edu2 on 18-09-06
Reading of scientific papers and Rasetti's writings:

- Amaldi, E. (1998) "The case of Physics", in Battimelli G., and Paoloni, G. (eds), 20th Century Physics: Essays and Recollections. A Selection of Historical writings by Edoardo Amaldi, Singapore: World Scientific Publishing, 168-190.
- Cioci, V. (2006) "Storia e confronto di tre diverse posizioni di fisici contro la bomba atomica" ("History and comparison of three different positions of physicists against the atomic bomb") in Leone, M., Preziosi, B., and Robotti, N. (eds) Atti del XXIV Congresso di Storia della Fisica e dell'Astronomia (Proceedings of the XXIV SISFA Congress), Naples: Bibliopolis, 211-215.
- Nason, T. (1966) "A man for all Sciences", The Johns Hopkins Magazine 17:12–17,25–27.

Interdisciplinary lesson with the philosophy teacher about the ethics of responsibility by Hans Jonas

Leo Szilard and the scientist's ethics
Leo Szilard (1898 – 1964) was the first scientist to become interested in nuclear chain reactions for the production of energy. He realized that this mechanism could be used to make powerful means of destruction.
It is well known that the letter written by Szilard and Einstein to U.S. President Roosevelt lead to the development of the Manhattan Project. Before that, however, Szilard tried to persuade the nuclear physicists not to publish the results of their research on neutrons emitted in the fission process in order to prevent that the results of these researches were used against humanity. Frédéric Joliot published the results of his researches, making vain the efforts of Szilard.

Learning objectives
Students will be able to:
Understand the importance of internal confrontation in the scientific community about the possible consequences of scientific researches.
Reflect on the historical conditions that led to the physicists' choices regarding military use of atomic energy

Didactic content
The origins of the concept of atomic energy in the research of Rutherford and Soddy on natural radioactivity (1903)
The chain reaction and the release of nuclear energy
The postponement of the publication of researches by Szilard and Fermi about emission of neutrons in the fission of uranium
The nuclear reactor

Teaching methodologies
Lectures and interactive lesson
Reading of scientific papers and Szilard's writings:

· Cioci, V. (2011) "Frederick Soddy e la scoperta dell'energia atomica" ("Frederick Soddy and the discovery of atomic energy") in Giannetto, E., Giannini, G., and Toscano, M., (eds) Intorno a Galileo. La storia della fisica e il punto di vista galileiano. Atti del XXVIII Congresso nazionale della Società Italiana degli Storici della Fisica e dell'Astronomia (About Galileo. The history of physics and the point of view of Galileo. Proceedings of the XXVIII SISFA Congress), Rimini: Guaraldi, 201-209.
· Cioci, V. (2009) "Szilard e Rasetti: due scienziati a confronto" ("Szilard and Rasetti: two scientists in comparison") in Giannetto, E., Giannini, G. with Capecchi, D., and Pisano, R. (eds) Da Archimede a Majorana: la fisica nel suo divenire. Atti del XXVI Congresso nazionale della Società Italiana degli Storici della Fisica e dell'Astronomia (From Archimedes to Majorana physics as it unfolds. Proceedings of the XXVI SISFA Congress), Rimini: Guaraldi, 303-313.
· Szilard, L. (1978) Leo Szilard: His Version of the Facts: Selected Recollections and Correspondence, Weart, S. R., and Weiss-Szilard, G. (eds), Cambridge, MA: The MIT Press.
· Lanouette, W., and Silard, B. (1992) Genius in the Shadows. A Biography of Leo Szilard: The Man Behind The Bomb, New York: Charles Scribner's Sons.

Conclusions

The Italian National Indications concerning the specific learning objectives of physics for scientific high schools can produce a significant change in teaching with formidable impact on the interest of students in this discipline due to the introduction of the study of the twentieth century physics.

The issues presented in this proposal, i.e. the relationships between science, technology, ethics and society, are fundamental supports to the youth cultural education, especially those youth who are preparing to complete the cycle of secondary education.

This approach promotes interdisciplinary teaching for an integral formation of the students.

Implementation of the History of Mathematics in Catalan Secondary Schools

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Introduction

The history of mathematics in the classroom enables improvements to be made in the learning of mathematics. Through the analysis of significant texts from the historical evolution of mathematical concepts, the History of Mathematics Group of the Barcelona Association for the Study and Learning of Mathematics (ABEAM) have prepared and tested some historical materials to be used in the classroom (Massa *et al.* 2011). The aim of this article is to discuss, by means of analysis of some examples implemented in the mathematics classroom, the criteria for preparing activities with historical texts and the conditions for transforming these historical activities into a powerful tool for learning mathematics.
First we present a survey of the evolution of this implementation over the last few years in Catalonia. In Spain, every autonomous community is in charge of its own secondary and graduate education, so we focus only on the implementation of history in the mathematics classroom in Catalonia.

Background of the implementation of the history of mathematics

In Catalonia, the implementation of the history of mathematics has for twenty years been inspiring some individual actions among teachers. Thus, since the academic year 1990-91, financial aid for research work, granted every year to teachers by the Department of Education of the government of Catalonia, has been devoted to research into the relations between the history of science (including mathematics) and its teaching. This research work has resulted in the drawing up of reports that are now available to other teachers. In addition, workshops, centenary celebrations and conferences by teachers in high schools constitute further examples of activities in which history can be used to achieve a more comprehensive learning experience for students. For example, the workshop devoted to the study of the life and work of René Descartes (1596-1650), held in 1996 at the INS Carles Riba (a Catalan high school), provided students with additional background from a mathematical, philosophical, physical and historical perspective.
As a collective action, we may mention that since 2003 to the present, every two years Pere Grapi and Mª Rosa Massa have coordinated a workshop on the History of Science and Teaching organized by the Catalan Society of History of Science and Technology (SCHCT), and subsequently they have coordinated the publication of the proceedings. The aim of these

workshops is to enable teachers to show their experiences in the classroom as well as to discuss the criteria and conditions for these implementations.

In the academic year 2007-2008, the Department of Education of the Government of Catalonia introduced some contents of the history of science into the curriculum for secondary education, namely, the new Catalan mathematics curriculum for secondary schools, published in June 2007, which contains notions of the historical genesis of relevant subjects in the syllabus.[1]

In the academic year 2009-2010 a Master's degree was introduced for training future teachers of mathematics. The syllabus of this new course launched at the University includes a part on the history of mathematics and its use in the classroom. For example, at the Polytechnic University of Catalonia, the title of the historical part is: "Elements of the history of mathematics for the classroom", while at the Pompeu Fabra University the title is: "The history of mathematics and its use for teaching math". Furthermore, in the academic year 2009-2010, an online pilot course on the history of science for science teacher training was put into practice. This course was drawn up by historians of science belonging to the Catalan Society for the History of Science and Technology (SCHCT) under the name "Science and Technology through History"

The setting up of the Group of History of Mathematics of Barcelona (ABEAM) in 1998[2] was also a significant step. The aim of this group of teachers of Mathematics is to create History of Mathematics materials to be used in the classroom. The list of the texts implemented includes: *On the sizes and distances of the Sun and Moon* by Aristarchus of Samos (ca. 310-230 BC) (Massa Esteve 2005b; Aristarco 2007); Euclid's *Elements* (300 BC) (Romero, Guevara and Massa 2007); Menelaus' *Spheriques* (ca. 100) (Guevara, Massa and Romero 2008a-2008b); *Almagest* by Ptolemy (85-165) (Romero and Massa 2003); *Nine Chapters on the Mathematical Art* (s. I. AC) (Romero *et al.* 2009); *Traité du quadrilatère* by Nassir-al-Tusi (1201-1274) (Romero, Massa and Casals 2006) and *Triangulis Omnimodis* by Regiomontanus (1436-1476) (Guevara and Massa 2005). The essential ideas on the implementation of history in the mathematics classroom of this group are reflected in the following sections.

Teaching mathematics using its history.

The history of mathematics in the mathematics classroom can be used in two ways: as an integral educational resource and as a didactic resource for understanding mathematics (Jahnke *et al.* 1996; Barbin 2000; Massa Esteve 2003).

In the first instance, history in the mathematics classroom can provide students with a conception of mathematics as a useful, dynamic, human, interdisciplinary and heuristic science.

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[1] The list of these historical contexts includes: The origins of the numeration system; the introduction of zero and the systems of positional numeration; geometry in ancient civilizations (Egypt, Babylonia); the first approaches to the number π (Egypt, China and Greece); Pythagoras' theorem in Euclid's *Elements* and in China; the origins of symbolic algebra (Arab world, Renaissance); the relationship between geometry and algebra and the introduction of Cartesian coordinates; the geometric resolution of equations (Greece, India, Arab World); the use of geometry to measure the distance Earth - Sun and Earth - Moon (Greece).

[2] The coordinator of the group is Mª Rosa Massa Esteve and the other members of group are**:** Mª Àngels Casals Puit (INS Joan Corominas), Iolanda Guevara Casanova (INS Badalona VII), Paco Moreno Rigall (INS XXV Olimpíada), Carles Puig Pla (UPC) and Fàtima Romero Vallhonesta (Inspecció d'Educació). The group is subsidized by the *Institute of Science of Education* (ICE) of the University of Barcelona.

- A useful science. Teachers should explain to students that mathematics has always been an essential tool in the development of different civilizations. It has been used since antiquity for solving problems of counting, for understanding the movements of the stars and for establishing a calendar. In this regard, there are many examples right down to the present day in which mathematics has proved to be fundamental in spheres as diverse as computer science, economics, biology, and in the building of models for explaining physical phenomena in the field of applied science, to mention just a few of the applications.

- A dynamic science. It will also be necessary to teach students whenever appropriate about problems that remained open in a particular period, how they have evolved and the situation they are in now, as well as showing that research is still being carried out and that changes are constantly taking place. History shows that societies progress as a result of the scientific activity undertaken by successive generations, and that mathematics is a fundamental part of this process.

- A human science. Teachers should reveal to students that behind the theorems and results there are remarkable people. It is not merely a question of recounting anecdotes, but rather that students should know something about the mathematical community; human beings whose work consisted in providing them with the theorems they use so frequently. Mathematics is a science that arises from human activity, and if students are able to see it in this way they will probably perceive it as something more accessible and closer to themselves.

- An interdisciplinary science. Wherever possible, teachers should show the historical connections of mathematics with other sciences (physics, biology, medicine, architecture, etc.) and other human activities (trade, politics, art, religion, etc.). It is also necessary to remember that a great number of important ideas in the development of science and mathematics itself have grown out of this interactive process.

- A heuristic science. Teachers should analyze with students the historical problems that have been solved by different methods, and thereby show them that the effort involved in solving problems has always been an exciting and enriching activity at a personal level. These methods can be used in teaching to encourage students to take an interest in research and to become budding researchers themselves.

In the second instance, the history of mathematics as a didactic resource can provide tools to enable students to grasp mathematical concepts successfully. The History of mathematics can be employed in the mathematics classroom as an implicit and explicit didactic resource.
The history of mathematics as an implicit resource can be employed in the design phase, by choosing contexts, by preparing activities (problems and auxiliary sources) and also by drawing up the teaching syllabus for a concept or an idea.
Nevertheless, it is necessary to bear in mind that the historical process of building up a body of knowledge is a collective task that depends on social factors. In the past, many mathematicians adopted the solution of particular problems as the aim of their research and were able to devote many years to their objectives. It is worth remembering that our students, while having the ground before them well-prepared, are addressing these notions for the very first time and often lack the motivation for solving mathematical problems.
Indeed, it is not history itself that is relevant for teaching, but rather the genesis of problems, the proofs that favored the development of an idea or a concept. The clarification of this development of ideas and notions can also act as a motivation for solving current problems. The evolution of a mathematical concept can thereby reveal the learning difficulties

encountered by students, as well as pointing the way towards how the concept can be taught (Massa Esteve 2005a).

In addition to its importance as an implicit tool for improving the learning of mathematics, the history of mathematics can also be used explicitly in the classroom for the teaching of mathematics. Although by no means an exhaustive list, we may mention four areas where the history of mathematics can be employed explicitly: 1) for proposing and directing research work at baccalaureate level using historical material[3]; 2) for designing and imparting elective subjects involving the history of mathematics; 3) for holding workshops, centenary celebrations and conferences (Massa Esteve, Comas and Granados1996), and 4) for implementing significant historical texts in order to improve understanding of mathematical concepts (Massa Esteve and Romero 2009). In this article we analyze the last point.

Implementing historical texts in the mathematics classroom

The use of significant historical texts in the classroom to facilitate the understanding of mathematical concepts is an activity that can provide students with more valuable means for learning mathematics.

The main aims for its implementation in the mathematics classroom are to enable students to; a) learn the original source on which the knowledge of mathematics in the past is based; b) recognize the socio-cultural relations of mathematics with the politics, religion, philosophy or culture in a certain period and, last but not least; c) improve mathematical thinking through reflections on the development of mathematical thought and the transformations of natural philosophy.

What historical texts are suitable for use in the mathematics classroom? Not all historical texts are useful for the mathematics classroom. The initial selection could be based on historical texts related to the historical contexts in the new Catalan curriculum. Historical texts (e.g. proof or problems) should in some way be anchored in the mathematical topic to be addressed. Different types of historical texts should be used, depending on the stage in the didactical sequence.

At what stage in the teaching process should we use historical texts in the mathematics classroom? Historical texts could be used to introduce a subject or a concept, to explore it more deeply, to explain the differences between two contexts, to motivate study of a particular type of problem or to clarify a process of reasoning.

How do we use historical texts in the mathematics classroom? It is necessary to bear some points in mind: The relation between the historical text and the mathematical concept under study should be clarified in order for the analysis of the text or significant proof to be integrated into the mathematical ideas one wishes to convey. The mathematical reasoning behind the proofs should be analyzed. Indeed, addressing the same result from different mathematical perspectives enriches students' knowledge of mathematical understanding. The proof should be contextualized within the mathematical syllabus by associating it with the mathematical ideas studied on the course, so that students may see clearly that it forms an integral part of a body of knowledge, and it should also be situated within the history of mathematics to enable students to evaluate the historical development of the concept.

[3] The list of titles of these research works can be very long, for instance: Pythagoras and music, On Fermat's theorem, On Pascal's Arithmetic Triangle, On the beginning of algebraic language, Women and science, On the incommensurability problem, Scientific Revolution,…

In order to use historical texts properly, teachers are required to present some features of the historical period and also to describe historical figures in context, both in terms of their own objectives and the concerns of their period. Situating authors chronologically enables us to enrich the training of students by showing them the different aspects of the science and culture of the period in question in an interdisciplinary way. It is important not to fall into the trap of the amusing anecdote or the biographical detail without any historical relevance. It is also a good idea to have a map available in the classroom to situate the text both geographically and historically.
We have implemented several of these activities in the classroom with satisfactory results. One such activity is about Aristarchus of Samos, which we describe briefly below.
This activity deals with the work *On the Sizes and Distances of the Sun and Moon* (ca. 287 BC) by Aristarchus of Samos (ca. 310-230 BC). In order to implement the activity, we begin with a brief presentation of the context, Greek astronomy, and the person of Aristarchus himself. We then situate his work in the history of trigonometry, analyze the aims of the author as well as the features of the work, and finally encourage students to follow the reasoning of this work, Proposition 7 (Figure 1), in order to arrive at new mathematical ideas and perspectives. This classroom activity was implemented in the last cycle of compulsory education (14-16 year-old students).

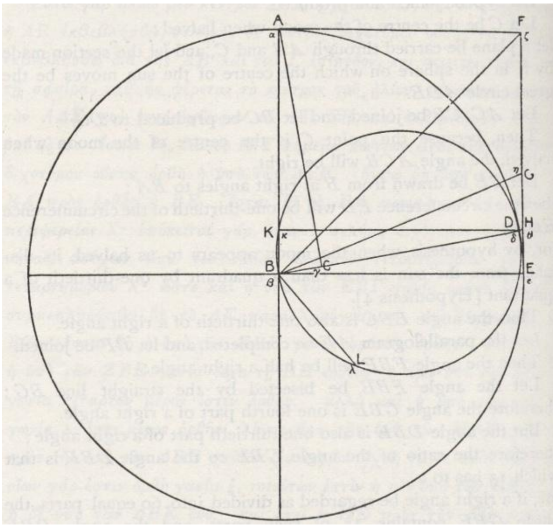

Figure 1: *Aristarchus' Proposition 7*

Another example of an activity implemented in the classroom concerns solving quadratic equations by completing squares in the style of al-Khwarizmi, which we now describe briefly. This activity deals with the work *Hisâb al-jabrwal-muqqabala* by Abu Ja'far Mohamed Ben-Musa al-Khwârizmî (780- 850). In order to implement the activity, we begin with a brief presentation of the context, Arabian mathematics, and the person of al-Khwârizmî himself. We then situate his work in the history of algebra and provide the explanation that al-Khwârizmî gave about solving quadratic equations at the beginning of his work. We present the original text with the drawings of the squares used to develop the geometrical reasoning and invite students to solve some quadratic equations with this procedure, completing squares, without algebraic calculations and using only a visual reasoning connecting algebra with geometry (see figure 2). This classroom activity was implemented in the last cycle of compulsory education.

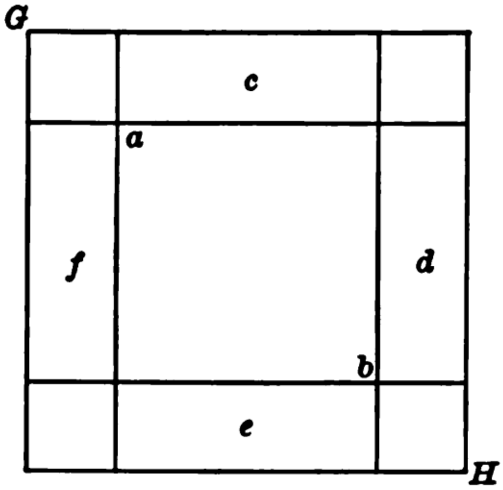

Figure 2: *Al-Khwârizmî's geometrical reasoning*

A third implemented example of an activity in the classroom consists in solving problems about right-angled triangles using the procedure that in Chinese mathematics is called the *base and high* procedure (Pythagorean Theorem).
This activity deals with some problems from the ninth chapter of the book of *Nine chapters on the Mathematical Art,* an anonymous Chinese work dating from the first century. As was the custom in Chinese and Oriental mathematics, this work was commented on by some later mathematicians such as Liu Hui (263) and Li Chunfeng (656). In order to implement this activity, we begin with a brief presentation of the context, Chinese mathematics, and the use of *Nine chapters on the Mathematical Art* in his time. We present the original text and use the later remarks and drawings that the commentators added in order to encourage students to prove Pythagorean Theorem in the same way as Chinese mathematicians, as well as solving some problems from the 9th chapter of *Nine chapters on the Mathematical Art* by using the Chinese procedure (see Figure 3).

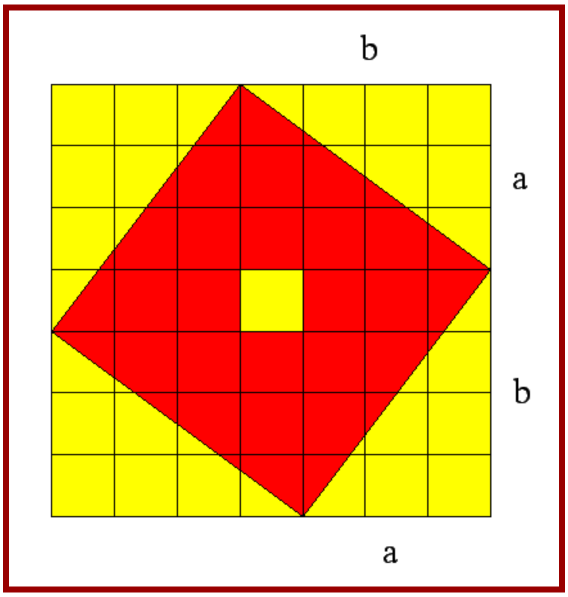

Figure 3: *First main figure*

Some remarks
By designing activities related to topics such as geometry, trigonometry and algebra, we will improve the students' mathematical education.
To this end, we have created a new teaching approach containing explanations introduced via an autonomous learning method. It has been satisfactorily tested with students who build their own reasoning in the same way as that employed by ancient mathematics. The analyses of significant historical texts improve the students' overall education by providing them with additional knowledge about the social and scientific contexts of these periods. The analyses of significant proofs reveal to students the different ways of approaching and addressing problems, thereby enabling them to tackle new problems and to develop their mathematical thinking.
We therefore believe that the history of mathematics should form part of teacher training courses, both in the initial stages and on a permanent basis. With such training, teachers will be able to extend their own knowledge, student learning will be enriched, and the quality of mathematical teaching as a whole considerably improved.

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Pythagoras' Theorem and the Resolution of the Second Degree Equation in the Nine Chapters on the Mathematical Art

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A remarkable identity in the history of the quadratic equation

The subject of this paper is the identity that appears in different historical contexts and also in the ancient Chinese Mathematics. In updated notation the expression is:

This identity appears in $\left(\frac{x+y}{2}\right)^2 = x \cdot y + \left(\frac{x-y}{2}\right)^2$ rhetorical expression, whenever a problem is solved through reasoning that includes the quadratic equation. The first time in the cuneiform tablets of ancient Babylon, the second one in Proposition 5 of Book II of Euclid's Elements and later in Proposition XXVII of Book I of the Arithmetic of Diophantus of Alexandria.

In Mesopotamian mathematics, also known as Babylonian mathematics, rhetorical expression leads to geometrical reasoning: For any two quantities, the area of the square on the semi sum exceeds the area of the rectangle in the area of the semi difference. According to Katz (2007, 187), the scribe doesn't show the reasoning but the reasoning should be in the base of the instructions of calculus given by the scribe to get the resolution of the problem. As an example, in The cuneiform tablet YBC (Yale Babylonian Collection) 4663 (1800 BC) the next problem is posed and solved: *The sum of the length and width of a rectangle is 6 ½ and the area of the rectangle is 7 ½. Find the length and width.*(Neugebauer & Sachs1945, 70). The scribe describes rhetorically the algorithm to solve the problem numerically: *6 ½ is divided by 2, the result is 3 ¼ ; 3 ¼ is squaring, the result is 10 9/16. From this area you must subtract the given area 7 ½, the result is 3 1/16. Now, make the square root of this number and you get*
1 ¾. The length is: 3 ¼ + 1 3/4 = 5 The width is: 3 ¼ − 1 3/4 = 1 ½ (y).
According to Katz (2007, 187) it seems that behind the calculation procedure there is a geometric reasoning about "cutting and pasting" areas. This would be the geometric version of the mentioned identity, because it is as if the scribe knew the geometrical relationship shown in figure 1,

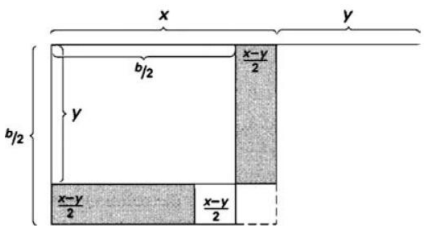


Figure 1: *The geometric relationship between semi addition and semi subtraction (Katz 2007, 187)*

$$\left(\frac{x+y}{2}\right)^2 = x \cdot y + \left(\frac{x-y}{2}\right)^2$$

and that results in the equality

or the equivalent $\left(\frac{x+y}{2}\right)^2 - \left(\frac{x-y}{2}\right)^2 = x \cdot y$ which in turn can be decomposed into

$$\frac{x+y}{2} + \frac{x-y}{2} = x \qquad \frac{x+y}{2} - \frac{x-y}{2} = y$$

The identity is also geometrical in Greek mathematics. Euclid of Alexandria (ca. 300 BC) in the Elements solves the problems through geometric constructions, but unlike the Babylonians, the constructions are justified with clearly established axioms. In Book II, Euclid presents propositions about manipulation of squares and rectangles which can serve to solve algebraic problems with geometric methods. For exemple, proposition 5: *If a straight line is cut in two unequal segments, the rectangle constructed by the unequal segments of the entire line, together with the square of the difference between the two segments, is equal to the square on the half straight line* (Euclid1956).

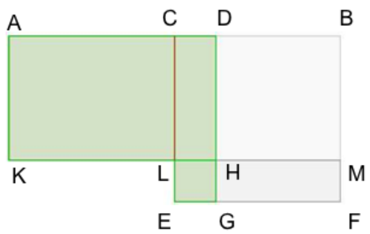


Figure 2: *Illustration of proposition 5*

In the present notation, if x, y are the unequal segments, the statement can be interpreted as:

$$xy + \left(\frac{x-y}{2}\right)^2 = \left(\frac{x+y}{2}\right)^2$$

This result can be used to solve the equation x+y =b; xy = c

$$\left(\frac{x-y}{2}\right)^2 = \left(\frac{b}{2}\right)^2 - c \qquad \frac{x-y}{2} = \sqrt{\left(\left(\frac{b}{2}\right)^2 - c\right)} \qquad x = \frac{x+y}{2} + \frac{x-y}{2} = \frac{b}{2} + \sqrt{\left(\left(\frac{b}{2}\right)^2 - c\right)}$$

The proposition doesn't solve the equation, but the Arabian mathematicians, some centuries later, used this reasoning to justify the algorithm of the quadratic equation.
Regarding the numeric or geometric interpretation of the identity

$$\left(\frac{x+y}{2}\right)^2 = x \cdot y + \left(\frac{x-y}{2}\right)^2$$

In Book I of *Arithmetica*, Diophantus of Alexandria (s. III) uses a rhetorical expression that has a distinctly numeric character. Proposition XXVII says: *Find two numbers the sum and product of which are two know numbers* (In updated notation: x+y = b; xy= c). The suggestions of the author to solve the problem are: *It is necessary that the square of the semi sum of the two numbers exceeds on the square of the difference the product of the two numbers* (Massa 2005, 6).

Rhetorical language and geometric reasoning in Al-Khwarizmi work

From the first algebra text (Chéber) which is still preserved (Katz 2007), al-jabr Hisab w'al-muqabala (813) from Mohamed Ben-Musa al-Khwarizmi, we have designed a geometric reasoning activity, like al-Khwarizmi does. With this model we can solve quadratic equations using only geometric arguments, rather than the actual calculation algorithm.

$$\frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

In the design of the activity, the rethorical original language has been replaced by the symbolic language, although it has been particularly careful not to lose the initial idea, to transfer a way of reasoning, widely used throughout history of mathematics in which the geometry is in the basis of reasoning. Thus, for example, to solve the equation a square and ten roots gives thirty nine dinars (In updated notation*:* $x^2 + 10x = 39$) the author's rhetorical indications, which ressemble those that the Babylonian scribes say:

Divide by two the number of roots, it gives 5 (b/2). Multiply it by itself; the product is 25 $((b/2)^2]$*. Add it to 39; the addition is 64* $((b/2)^2 +)$*. Divide it by the square root, it gives 8,* $((b/2)^2 + c)^{1/2}$*, and subtract half of the roots, which is 5; the result of subtraction is 3* $(-(b/2) + ((b/2)^2 + c)^{1/2})$*. This number is the root and its square is 9* (Massa 2005, 9).

The didactic proposal developed can be summarized in the following sequence of diagrams (Guevara 2009):

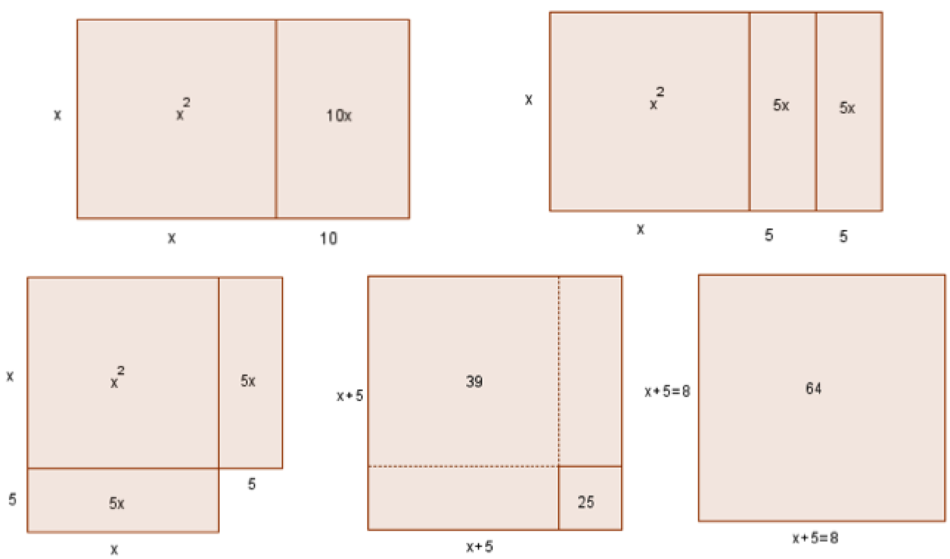


Figure 3: *Sequence of diagrams to solve the quadratic equation*

Rhetorical language and geometric reasoning in Nine Chapters

The nine chapters of mathematical procedures (Jiu zhang Suan Shu) (s. I), from now NC, is a classic text that collected anonymous mathematical knowledge of the time and it was for Chinese mathematicians what Euclid's *Elements* were to Western European mathematicians (Gheverghese 1996,193).

The book is a practical handbook for architects, engineers, surveyors and tradesmen. Candidates for civil service positions studied this text, among others, as a preparation on questions of the imperial examinations (Chemla 2005, 3).

The 246 problems of the *Jiu zhang Suan shu* and their solutions show that the Chinese had access to a variety of formulas for determining areas and volumes of basic shapes, as well as methods to solve linear equations and systems of equations with two and three unknown. They used a decimal system of numeration, including decimal fractions, and they used negative numbers in calculations.

Last chapter, the ninth, consists of 24 problems related to right triangles. The first twelve are solved by the method of the base and height (equivalent to the Pythagorean Theorem) and geometric reasoning consisting on "cutting and pasting" the areas, as we have said in the case of Babylonian mathematics. The last twelve are solved by proportion (lü), similarity between triangles. Special mention should be made to problem 14 because, as a bridge between the two parts of the chapter, Liu Hui solves the problem by geometric reasoning consisting of "cutting and pasting" areas but he also solves it using proportions (Chemla 2005, 727).

In the original classic text (sI), the problems consist of an statement with specific numerical data, some question and the solutions. After that there is a brief description of the calculation algorithm to find the solutions. All in rhetorical language as in the case of the Babylonian scribes (Pla, 2009, 68).

From the translation of the original classic text, the comments Hui and Li Chunfeng Liu, and the presentation and notes to Chapter 9 Chemla (2005, 661-693), Dauben (2007, 283-288)and Cullen (1996, 207-209), the first activities for the high school classroom were designed (Romero2009). Later, these activities were extended with some visual resources (Guevara2012).

In this paper the analysis of the relationship between the Pythagorean Theorem and the resolution of the quadratic equation is made using the classical text of problem 11, Liu Hui's comments and Chemla's interpretation (2005, 689-693).

The quadratic equation in Problem 11

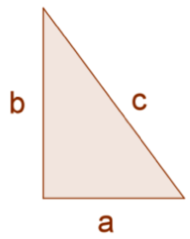
The classical problem:

Suppose we have a single hinged door, where the height exceeds the width in 6 chi 8 cun and where two opposite angles are at a distance of 1 zhang one from the other. The width and height of the door are asked.

The answer: *width 2 chi 8 cun; height 9 chi 6 cun* (Chemla2005, 717).

Liu Hui proposes this interpretation: *the width of the door is the base (gou), the height of the door is the height of the triangle(gu), the distance between the two ends, 1 zhang, the hypotenuse.*

In updated notation and drawing it would be:



$b - a$ = 6 chi 8 cun = 68 c = 1
zhang = 100
a = ?
b = ?

Figure 4: *Right triangle and data of problem 11, in updated notation*

This is the procedure in the classic text:

The multiplication of 1 zhang by itself, makes the dividend. Take half of the excess, multiply it by itself, duplicate it, and subtract it from the dividend.

Take half of the remainder, and divide it by the square root extraction.

Subtract from the obtained half of the exceeding, and it gives the width of the door; add from the obtained half of the exceeding, and it gives the height of the door.

In updated notation:

$100^2 68/2 = 34$;

$34^2 = 1156$

$2 \cdot 1156 = 2312$

$10000 - 2312 = 7688$

½ 7688 = 3844

$\sqrt{3844} = 62$ (a+b)/2

$62 - 34 = 28$ (width)

$62 + 34 = 96$ (height)

Hui Liu raises two explanations for the calculations of the classic text. We will expose only the second one because it is the one that leads to the identity which is the object of this paper: *The multiplication of 1 zhang itself gives 4 red and 1 yellow surfaces. If we multiply the difference by itself and take one half of it, it gives 2/4 of the yellow surface. By subtracting from the dividend this 2/4 of yellow surface and taking the remaining half , we have two red surfaces and ¼ yellow surface* (Chemla 2005, 721).
The surfaces described by Hui Liu have been interpreted by various historians of Chinese mathematics (Chemla2005, 883-885), (Cullen 1996, 207-209), (Dauben 2007, 282-283) as the first fundamental figure of Chapter 9. They refer to the figure that Liu Hui also used to justify the procedure of the base and height.

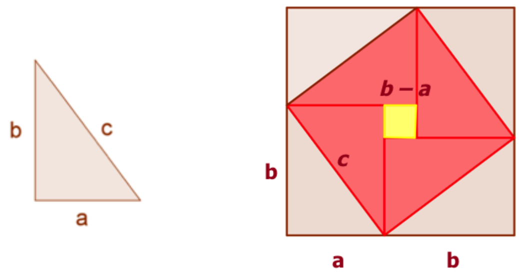
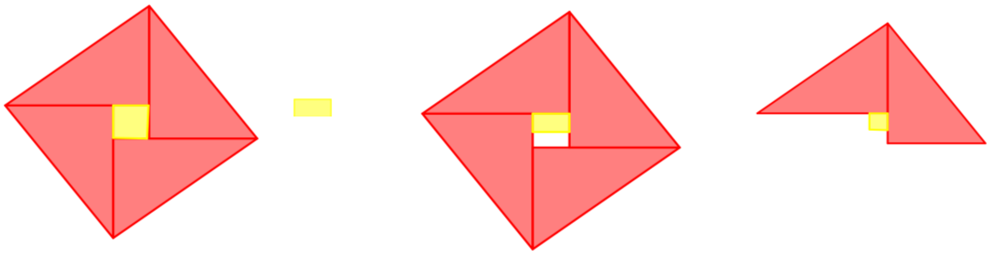


Figure 5: *Triangle and first fundamental figure, with updated notation*

Following the explanations of Liu Hui and calculating areas with the first figure:
b – a = 6 chi 8 cun = 68 *c* = 1 zhang = 100 areas are obtained



100^2 $68^2/2=2312$ 10000-2312=7688 1/2 de 7688=3844

Figure 6: *Calculations based on areas to solve problem 11*

Liu Hui, explains: *This area is a quarter of the area of the large square. So when we divide by extracting the square root we get one half the of the sum of the width and height* (Chemla 2005, 719). These assertions lead to the following diagrams and carry to the expressions:

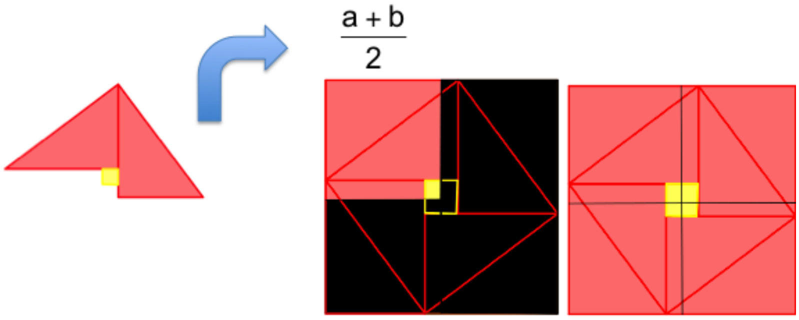


Figure 7: *Gnomon and quadratic equation (Chemla 2005, 691)*

With them, from 1/2 of 7688=3844 and √3844 = 62 which is (a+b)/2 and with b-a = 68 and the identities:

$$\frac{a+b}{2}+\frac{b-a}{2}=b \qquad \frac{a+b}{2}-\frac{b-a}{2}=a$$

we obtain the solutions: 62 + 34 = 96 (b) 62 - 34 = 28 (a)
Again, the relationship underlying this resolution: *For any two quantities, the area of the square built on semi sum exceeds the are of the rectangle in the area of the semi difference* (Chemla 2005, 885).

$$\left(\frac{a+b}{2}\right)^2 = a \cdot b + \left(\frac{b-a}{2}\right)^2$$

In the area of the semi sum, there is a gnomon: The area of the gnomon is a quarter of the exterior square minus the area of the quarter of interior square (yellow). The area of the gnomon A is the equation of the problem: $A = x^2 + (b - a)x$ where x is ***a***, the base of the triangle (Chemla 2005, 691).

Final remarks

Babylon, Greece, Arabia and China pose and solve problems that lead to quadratic equation. Beyond calculation algorithm, the reasoning underlying on all of them is the identity:

$$\left(\frac{x+y}{2}\right)^2 = x \cdot y + \left(\frac{x-y}{2}\right)^2$$

The identity sometimes appears as a numerical property, in others as a geometrical property.

In Chinese mathematics, identity appears in the context of the procedure of the base and height.

It is not only to relate *a+b* and *a·b* with *b – a,* there appears a new element *c* (the hypotenuse of the triangle, the diagonal of the rectangle).

The relationship between the Pythagorean Theorem and quadratic equation, is a topic of interest to introduce in the classroom because it shows the universality of mathematics - appearing in different cultures and periods -, uses an identity that develops with two different procedures - numerical and geometrical- and establishes connections between two different subjects of the curriculum such as solving equations – algebra- and Pythagorean Theorem – geometry-.

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SYMPOSIUM 14

History of Slavic Science – Cultural Interferences, Historical Perspectives and Personal Contributions

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Slavic Science, in spite of its numerous well known scientists and their contributions of crucial significance to the European and global science, was not formerly a subject of frequent historical and cultural analysis. Considering the state of world science without the contributions of Copernicus, Boscovic, Lobachevsky, Mendeleyev, Lomonosov, Tesla, Mohorovicic, Milankovic and others would be an impossible task. Besides them, there are many Slavic scientists who, although having made important scientific contributions, are not well-known outside of their respective countries and cultures.
Strangely enough, even on Wikipedia, the most prominent and non-dogmatic source of knowledge today, there is no entry for "Slavic Science", or "History of Slavic Science". It seems that the concept itself, Slavic Science, is not yet established and widely recognized. There are different concepts such as Slavic cultural studies, Slavic languages, Slavic science fiction, etc, but there is no mention of any generalized approach to Slavic Science. Contrary to that, on the Web there are multiple entries for Islamic Science, Latin American science, and the like...
There are numerous important scientists of Slavic origin and cultural background. It is without doubt that they gave contributions of the utmost magnitude for science in general. But the precedent question still exists - the dilemma of whether their fundamental endowments could be studied also within the framework of Slavic Science, or is there nothing specifically Slavic in their scientific contributions.
Of course, many cultural and scientific essays should be undertaken in order to get an appropriate answer to that query. Slavic Science is subject to many (one could say innumerable) cultural and scientific influences which made its profile as it is known today. In any case, it is not low profile science; contrary to that, it bears a powerful capacity to revolutionize the ruling scientific paradigm. It is not necessary to mention Copernicus, Boskovic, Mendeleyev, Tesla to understand what it means.
Because of all of that, we think that it is worthy of efforts to call European historians of science, as well as scientists from other disciplines, to reconsider the possibility of Slavic Science and to expose various examples and case studies which show interrelations among Slavic and non-Slavic scientists; to research patterns of influences which made a significant

impact on Slavic scientists; and to find historical routes of circulation of scientific ideas which affected Slavic and European science in general.

Friendship between Nikola Tesla & Mark Twain

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"Thunder is good, thunder is impressive;
but it is lightning that does the work."
Mark Twain

Introduction
Nikola Tesla was born in 1856 in Austria (in Lika, today the area of Croatia) in the Serbian priest's family. He moved to the United States at 1884 with the idea that in the "New World" was much easier to achieve and realize inventor's ideas which have already been deeply inspiring. At that time, Mark Twain was already a respected and admired writer, well-known author of short stories and novels.
In the years that followed, Tesla will achieve a number of inventions and discoveries in the field of electric power, lighting techniques, radio technology, wireless management, to a number of high-current applications in industry, medicine, and unusual, but the original inventions in mechanical engineering and aviation. However, the topic of this paper are not his inventions, but Tesla as a person, as a man, who, thanks to his gift of the innovator, comprehensive education and special charisma, was able to meet, collaborate and socialize with the greatest minds of his time - with scientists, politicians, artists and other "lifestyle designers". One of these men was the famous American writer Samuel Langhorne Clemens (1835-1910), at the time, better known under the pseudonym Mark Twain.
Acquaintance and friendship of Nikola Tesla and Mark Twain lasted nearly twenty years since the beginning of the nineties of the 19^{th} century to the writer's death in 1910. Although at that time they both worked hard and created, changed their places of residence and individual long-absents outside New York. That did not stop Mark Twain to invite Tesla to the wedding of his daughter, Clara (Clara Clemens, 1874-1962) in the fall of 1909. That call was a solemn unequivocal evidence of closeness and permanence of their mutual friendship.
In this study, the preserved historical documents of their mutual correspondence, which are stored in Tesla's legacy at the Nikola Tesla Museum in Belgrade are studied. Also, the authors are reconstructing the reasons for the occurrence of stored messages and letters, to clarify the sequence of events that they initiated.

Correspondence between Nikola Tesla and Mark Twain
Exploring of mutual cooperation of Tesla and Twain, the authors reviewed the available archives, met with a number of books, journals, technical and historical articles which enabled them to document the common correspondence, and other certificates of their informal friendly letters, and they systematized and presented them in Table 1.

Date of the letter	By letter	A person in a letter sent	Place of occurrence of letters
15.02.1894.	Mark Twain	Olivia Clemens	New York
04.03.1894.*	Mark Twain	Nikola Tesla	New York
undated*	Mark Twain	Nikola Tesla	New York
17.11.1898.*	Mark Twain	Nikola Tesla	Vienna
06.10.1909.*	Mark Twain	Nikola Tesla	Redding, Connecticut

Table 1

In Nikola Tesla's legacy there are four original documents (* - two messages, letters and formal invitations) which Mark Twain sent to Nikola Tesla. Two short messages, which were hand written by Twain on the original paper of *Player's Club* and probably forwarded by courier to Tesla. Short letter with interesting content, written in the original paper from Viennese hotel *Krantz*,[1] Twain sent at the 1898 during his stay in the Austrian capital. The fourth document was a formal invitation for a wedding ceremony of his daughter Clare, and was sent to Tesla in September 1909. We didn't find any more letters sent to Nikola Tesla by Mark Twain.

Photographing in Tesla's laboratory on South Fifth Avenue

Tesla's laboratory in South Fifth Avenue 33-35 (now West Broadway), was a special place for companionship of a famous scientist and his friends Mark Twain, Thomas Comerford Martin (1856-1924), Joseph Jefferson (1829-1905), Stanford White (1853-1906), Johnson family and others. Visitors to the laboratory were able to learn about the incredible inventions and fascinating experiments and wonderful devices which a scientist demonstrated by explaining his latest research. A visit to Tesla's laboratory was always a kind of event for all of his guests: scientists, engineers, journalists, financiers, partners and dear friends. The presence to one of his exciting experiments, his close friend Robert Underwood Johnson (1853-1937) records in the book of memoirs *Remembered Yesterdays*, published at 1925. Johnson wrote:

> "*When we first met him, his laboratory, in South Fifth Avenue, was a place of absorbing interests. We were frequently invited to witness his experiments, which included the demonstration of the rotating magnetic field, and the production of electrical vibrations of an intensity not before achieved. Lighting-like flashes of electrical fire of the length of fifteen feet were an every-day occurrence, and his tubes of electric light were used to make photographs of many of his friends as souvenir of their visits. He was the first person to make use of phosphorescent light for photographic purposes – not a small item of invention in itself. I was one of a group consisting of Mark Twain, Joseph Jefferson, Marion Crawford, and others who had the unique experience of being thus photographed*." (Johnson, 1925, 400)

[1] Today, the hotel is called *Ambassador*.

First two short messages, which Twain sent to Nikola Tesla at the beginning of 1894, relate to their joint meeting on the occasion of shooting in the laboratory. Photography was initiated by Robert Underwood Johnson, deputy editor of *Century*, wanting to present Tesla's lab and his experiments with new revolutionary cold light. Fosforescentim light photography, which were held on 4th March and 26th April 1894, was attended by Mark Twain, Joseph Jefferson, Francis Marion Crawford (1854-1909), and Robert Underwood Johnson. In a message dated 4th March 1894, Mark Twain addressed these words on the occasion of his dear friend the common presence of photography in the laboratory:

> "*March 4/94*
>
> *Dear Mr. Tesla:*
>
> *If I can possibly*
> *manage it I'll be there*
> *by 4 pm, but I am dreadfully*
> *pushed for time, and you*
> *mustn't depend on me.*
> *In haste*
> *Sincerely Yours*
>
> *S. L. Clemens*"[2]

It seems that the famous writer managed to complete his immediate responsibilities and at the appointed time he came to Tesla's lab. Next taking photoes took place on 26 April of that year, as confirmed by Francis Marion Crawford, in letter to his wife Elizabeth,[3] 27th April 1894.
Another short note, Twain wrote one evening, at midnight, on the premises of *Player's club*. Because of the urgent and unavoidable work he had to cancel his attendance at scheduled social activities, so he has sent Tesla these words of apology:

> "*Friday, Midnight.*
>
> *Dear Mr. Tesla:*
>
> *I am desperately*
> *sorry, but a matter of*
> *unavoidable business*
> *has intruded itself and*
> *bars me from coming*

[2] Tesla's legacy: MNT, LXXXI, K81 - 522A
[3] http://marktwaindaybyday.webs.com/addendavol2.htm (letter is probably in the library of Harvard University: http://oasis.lib.harvard.edu/oasis/deliver/~hou00157)

down tomorrow afternoon.
I am very, very sorry.
Do forgive me.

Sincerely Yours
S. Clemens"[4]

However, Twain in his diary does not mention visit to Tesla's laboratory.
Photos of celebrities, photographed in Tesla's laboratory appear until a year later, in April 1895, in an article titled "Tesla's Oscillator and Other Inventions" that Thomas Commerford Martin published in the *Century Magazine*. The author of one of the photos published with Mark Twain, dated in January of the 1894, which leads us to realize that there may have been more than two, so far known of taking photoes in Tesla's laboratory.

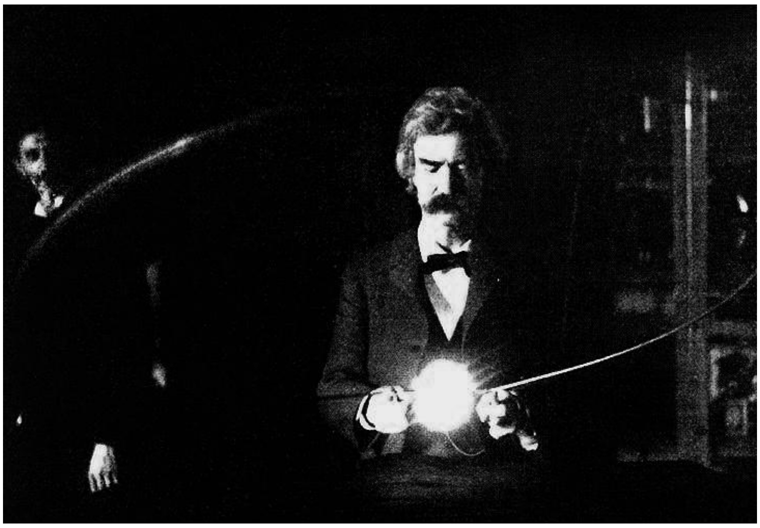

Figure 1: *Mark Twain in Tesla's laboratory in South Fifth Avenue, New York.*

Photos of celebrities recorded a new Tesla phosphorescent light in the laboratory 1894th, will be again the subject of conversation, twenty years later, but that time between the Robert U. Johnson and Nikola Tesla. In preparing his book Memoirs *Remembered Yesterdays*, in which he wanted to represent people and events of his life, Johnson asked his dear friend for help. In his letter dated 5th March 1923 Tesla was asked whether he had saved a group of photographs taken under the cold light in his laboratory, where there were Mark Twain, Crawford, Tesla, Johnson and other friends. He asked Tesla to look for and select one as an illustration in his memoir that should be completed by 1th May, the same year. From the personal archive of Tesla, he chose two of more surviving photos from that period. The presented photo shows Mark Twain and Marion Crawford in Tesla's laboratory. Johnson's letter to the occasion Tesla was kept in Nikola Tesla Museum.

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[4] Tesla's legacy: MNT, LXXXI, K81 - 525A

Twain's letter from Vienna, and wedding invitations

Mark Twain, along with his family traveled to Austria in September 1897. In Austria, he stayed until May 1899 when he had returned to the United States.

During his travels in Austria Twain addressed another interesting letter to Tesla in which he was convinced, that if he had the English and Austrian patents for its products, allowing it to broker their sale in Austria and Germany. In the letter, written on 17th November 1898 in Vienna, Twain said to Tesla:

"*Dear Mr. Tesla -*

Have you Austrian and English patents on that destructive terror which you have been inventing?- and if so, won't you set a price upon them and concession me to sell them? I know cabinet ministers of both countries – and of Germany, too; likewise William II.

I shall be in Europe a year, yet.

Here in the hotel the other night when some interested man discussing means to persuade the nations to join with the Czar and disarm, I advised them to seek something more sure than disarmament by perishable paper-contarct – invite the great inventors to contrive something against which fleets and armies would be helpless, and thus make war thenceforth impossible. I did not suspect that you were already attending to that, and getting ready to introduce into the earth permanent peace and disarmament in a practical and mandatory way.

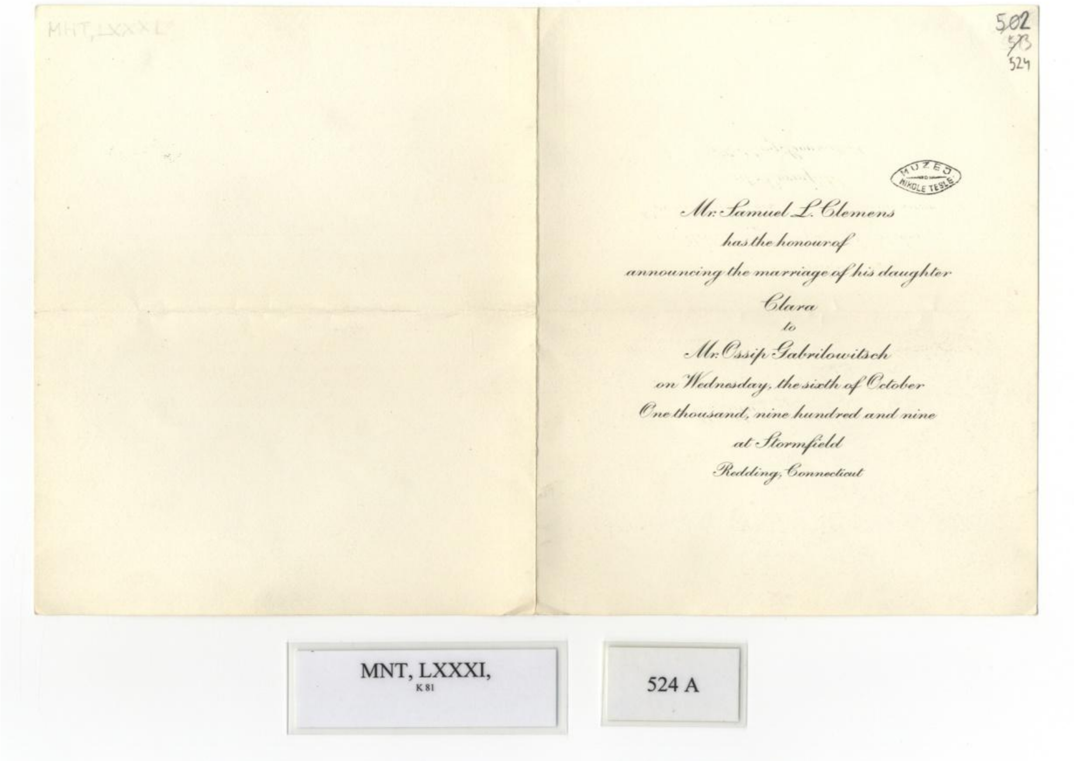
I know you are a very busy man, but will you steal time to drop me a line?

Sincerely Yours,
Mark Twain"[5]

About Tesla's response to Mark Twain, as well as of their mutual cooperation in realization of the writer's suggesetion – there are no stored data.

True friendship and deep mutual respect between two great friends grew in every moment of togetherness and mutual business cooperation. Perhaps this was best evidenced by a formal invitation which Mark Twain sent to Nikola Tesla on the occasion of marriage of his daughter Clare and scheduled wedding ceremony. There are not known facts that Tesla showed honor to his friend Mark Twain and attended the wedding ceremony of his daughter Clara and Osip Gabrilovič in Stormfildu, 6th October 1909.

[5] Tesla's legacy: MNT, LXXXI, K81 - 523A


Mr. Samuel L. Clemens
has the honour of
announcing the marriage of his daughter
Clara
to
Mr. Ossip Gabrilowitsch
on Wednesday, the sixth of October
One thousand, nine hundred and nine
at Stormfield
Redding, Connecticut

MNT, LXXXI,
K 81

524 A

Figure 2

Conclusion

Nikola Tesla and Mark Twain were eminent and respected. It is clear from their sincere mutual acceptance: Tesla's to Twain, expressed in the text of autobiography, and Twain's to Tesla, written in letters and diary. (Twain 1979)

Tesla has kept four original documents of their correspondence, but in Twain's legacy no letters from Nikola Tesla were found. It is believed that Tesla wrote to his friend, but unfortunately there are no surviving documents. Tesla's meticulousness and diligence shown during long correspondence with many correspondents and companies consolidate opinion that he had to reply to Twain's letters and messages. It is also known that the famous writer appeared in the Tesla's laboratory after their messages on 4th March 1894. He managed to complete his responsibilities at that time and, at the appointed time, to come for taking a photograph. Analyzing the text messages and other social dates or days of joint photographing, it can be concluded that the saved document does not refer to these events. The first common shooting was scheduled for Sunday, 4th March 1894, and another one on Thursday, 26th April of that year.

Short undated message posted on Friday, at midnight, with the explanation that the writer can not come to the meeting tomorrow afternoon. It is evident, that the Saturday was a day of the scheduled meeting and that the message refers to an encounter that does not concern this picture.

We didn't find any surviving Tesla's response letter, at Twain's letter sent from Vienna late 1898. It was realistic to expect answer for several reasons: Twain's written text clearly expects the answer, Tesla was always interested in business cooperation, and in this case it was a presentation of his devices to prominent European states, as well as the possibility of their commercialization in these areas. In general, friendship between Nikola Tesla and Mark Twain, two famous and world renowned personalities, reveals the breadth of their interests, mutual respect and sincere appreciation of deep, but overt desire of both of them to work individually in their own creative field, and thus contribute to a new, more beautiful and better world.

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Last Heliocentric Revolution

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The year 1912 is *annus mirabilis* for Earth sciences. In two crucial papers Alfred Wegener and Milutin Milanković independently set up revolutionary theories based on far-reaching visions of continental drift and climate orbital forcing. Their contributions simultaneously did for the Earth sciences what the theory of evolution did for biology and what theory of relativity did for physics. They provided geology with a comprehensive perspective of Earth's dynamics in both astronomical and terrestrial terms, and revolutionized geology by abandoning the ideas of a climatologically self-sufficient Earth and unmovable continents - remnants of the old geocentric picture of an unmoving, centered Earth. In secular sense they finally completed heliocentric theory that was set up by Copernicus. This paper follows the strange synchronicity in their life and work cycles.
The last real scientific revolution occurred almost one century ago in 1912, when two scientists who did not then know of each other changed the principle of Earth sciences. Paradoxically, those two scholars, Alfred Wegener and Milutin Milanković, were not even Earth scientists. The former was an astronomer and meteorologist interested in geophysics, while the latter was a civil engineer interested in climatology.
On the yearly gathering of the German Geological Association in Frankfurt on January 6, 1912, Alfred Wegener lectured on "The Uprising of Large Features of the Earth's Crust (Continents and Oceans) On A Geophysical Basis". Immediately afterward, he sent the lecture to the journal *Petermanns Geographische Mitteilungen*, which gave it the laconic name "The Origin of Continents" and published it in three parts.[1]The lecture astonished all who were present, as it brought into question the reigning views on geology. Taken in continuity with the work of Louis Agassiz, it additionally strengthened the dynamic of the "erratic boulders" by bringing in the concept of "continental drift" and "wandering poles". Leaving the till then inviolable idea of sunken bridges between continents, Wegener postulates that one whole continent existed, Pangaea, which broke apart approximately 200 million years ago, its pieces eventually coming to their current positions. He noticed the congruence of South America and Africa's respective shapes – "Doesn't the east coast of South America exactly fit the west coast of Africa, as if they were once one? That is the idea I wish to follow," he wrote to his future wife in 1910[2]. In this way, he "anticipated sea-floor spreading, the functional

[1] Wegener, A. "Die Entstehung der Kontinente." *Dr. A. Petermanns Mitteilungen aus Justus Perthes' Geographischer Anstalt.* 63 (1912): 185-195, 253-256, 305-309.
[2] Wegener-Köppen, Else. *Wladimir Köppen – Ein Gelehrtenleben*. Stuttgart: 1955. 75.

relationship between bathymetry and age or temperature below the sea floor, perhaps mantle convection, and some aspects of plate tectonics[3]." Sketching the similarities of geological structures, along with the climate of continents in the far past, he cited numerous examples of identical fossils of animals that had lived on both continents hundreds of millions of years ago.

It was all apparently too dynamic for Earth science of that time, as from its static picture it was suddenly thrust into a world that no longer seemed to have a *terra firma*. Wegener was perfectly aware that he had not only deeply disturbed the professional public, whose discomposure could not be quieted for a long time, but he also initiated a true revolution. "If it was shown that harmony and reason came to the history of Earth, why would we hesitate to revert to old beliefs[4]?" he writes to his father-in-law. When the book was translated into English in 1924, it brought up a wave of sharp criticism that kept it from being accepted until 1960. Although Wegener carefully collected geological evidence, American and British geologists standing on the barricades of the old paradigm laughed at him and his ideas. "Complete nonsense," said the president of the American Geological Society, following his colleague's view that "if we believe in this hypothesis, we must forget all that we have learned in the past 70 years and begin again[5]." British geologists were even more scathing, as they claimed that anyone who "values his reputation as a scientist of reason" would not support the theory[6]. At a meeting in New York in 1926, Wegener was received entirely sarcastically. Critics called his theory "geopoetry".

In spite of this great incomprehension, Wegener's theses were the beginning of the *annus mirabilis* in which new Earth science would be born. Only a few months after, Milutin Milanković published paper "On The Mathematical Theory of Climate" in the Serbian Royal Academy's journal *Glas*, in which he looked at then-current theories of astronomic influences that force the mechanism of thermal balance of the Earth, and prepared the mathematical methodology for a fundamentally different vision of climatic cycles[7]. When Milanković began the study of astronomic theory of climate change, it was largely a forgotten relic in science. The leading scientific authorities found it interesting but useless, because Ademar's, Croll's, and other similar lesser-known astronomic theories did not give satisfactory results in keeping with the *in situ* findings. From that consensus among geologists and climatologists, there later grew an opposition to Milanković's theory, the protagonist of which was Austrian geomorphologist Albrecht Penck, who was also strong opponent of Wegener. After attending a lecture given by Wegener to the Berlin Geographical Society on February 21st, 1921, Penck found that his hypothesis had "something seductive" but he remained firm that the shape of continents was the result of contraction and of

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[3] Jacoby, Wolfgang R. *Geology*. 9.1: 25.

[4] Wegener's letter to Köppen.

[5] Hughes, Patrick. "The Meteorologist Who Started a Revolution*". Weatherwise* 47 (April-May 1994): 29-35.

[6] Ibid.

[7] Milanković, Milutin. "On The Mathematical Theory of Climate". *Glas SKA* LXXXVII (1912): 136-160.

vertical crustal movements. He was recognized authority in paleoclimatology because, together with Eduard Brückner, he determined the phases of glaciation in the Alps (accepted in their time, later discarded).
Penck observed essential deficiencies in earlier astronomic theories of climate, not only showing their mistakes, but also going a step further, throwing away the validity of such admissions in their entirety. He postulated that significant climatic deviation can occur due to periodic changes in the Sun's thermal strength, and not because of the orbital dynamic of the Earth. He believed that were only four ice ages, and considered that climate change might be caused by variations of solar heat power, not by the orbital dynamics of the Earth.
With this thinking, he joined one of the most respected European climatologists, Julius von Hann, who, confused by the disaccord of the results of certain astronomic theories, judged that they were useless in principle and that astronomic causes are not powerful enough to enforce the climatic change. It was not unknown to Milanković that "all attempts to explain climatic change in this way were so unsuccessful that in 1908, the great Austrian climatologist von Hann discarded all of them, stating that, from an astronomic standpoint, one would infer the constancy of the Earth's climate before inferring its variability[8].
But Milanković, although not upset, first strongly rejected Penck. "Penck was an excellent observer, a pure empiric, but not a theorist. His world, limited to the Earth's surface, had only two dimensions. He couldn't peek deeply into the cosmos by his spiritual sight…."[9] He was equally decisive in rejecting Julius von Hann. "Thus I replayed 'yes' to Julius Han's 'no', proving that the Earth climate changes, triggered by the astronomical facts, are so strong that they had not passed away without any record. Hence in my first paper I showed how they could be subjected to calculations and by means of the Celestial Mechanics followed unto distant past." [10]
To make the matter even more difficult, the meteorology that was strongly developing at that time did not consider it meaningful that the Sun be placed in the center of climatological questioning. Paraphrasing the belief of that science, Milanković says, "Why take a route that goes through the faraway Sun in order to discover what happens on Earth, when on it, we have thousands of meteorological stations that inform us of all temperature occurrences in the layers of the Earth's atmosphere in which we live, accurately, more accurately than the most perfect theory can". [11]
In that way, Milanković, in the beginning of his work, had an indifferent meteorology and climatology and almost an entire geology against him – the belief in the astronomic theory of climate seemed to vanish and the idea was practically forgotten. But he was so lucid and bold enough to estimate that astronomic theory had not fallen into crisis due to mistakes in principle, but rather that the

[8] Milankovic, Milutin. *Reminiscence, Experiences, and Cognitions.* (in Serbian) Agency for Textbooks, Beograd: 2009. 603.
[9] Ibid. 467.
[10] Milanković, Milutin. *Through Space and Centuries*. Vol. 4. Belgrade: Agency for Textbooks, 2008. 191. Selected Works.
[11] Milanković, Milutin. *Reminiscence, Experiences, and Cognitions*.

fundamental reasons for its failure were a lack of cognition of celestial mechanics, the negligence of particular elements of the Earth's movement, and a weak knowledge of mathematics. In order to save the idea that he found correct, next to the basic critics of existing work he made the next step, cosmically large in its true sense: he thought of the astronomic theory of climate differently than all his predecessors. While they continued to solve the problem of ice ages, he turned to a great vision of modeling the climates of all planets in the solar system with a hard crust where the Earth was only a special case. On that route, he was the first who calculated climatic conditions on the Moon, Mars, Venus and Mercury. In the six works that followed till 1914, he transformed the understanding of climatic change – he brought higher mathematics into climatology, he framed it as an exact science and he commenced the numeric modeling of climate. In this way, he built a great bridge of the linking of climatic change and celestial mechanics.

It is only when, from this interval of exactly one century, we look at Wegener's and Milanković's work and the synergy of their theories that we become aware of the depth of the revolution that they started. Their contributions simultaneously did for the Earth sciences what the theory of evolution did for biology and what Einstein's theory did for physics. They provided geology with a comprehensive perspective of Earth's revolution in both astronomical and terrestrial terms, and revolutionized geology by abandoning the ideas of a climatologically self-sufficient Earth and unmovable continents - remnants of the old geocentric picture of an unmoving, centered Earth.

When Milanković's work appeared in the spring of 1912, directly after Wegener's in February of the same year, the world could no longer remain the same. The defense of the old paradigm was destined to failure, as the same thing had happened as centuries earlier, when Copernicus' revolution destroyed 12 unmoving heavens and when the Earth was expelled from its center location to an unceasing orbit around the Sun. But the old geocentric paradigm of the unmovable *orbis* was not set down and abandoned in 1543 when Copernicus' *De revolutionibus orbis* was published – rather, it was discarded in 1912 when Milanković began to find mathematical proof of the heliocentric origin of the Earth's climate, and when Wegener originated his theory of continental drift. Now even the continents were beginning to move, and Milanković gave Wegener's new Earth a cosmic dimension, as he brought back and reinforced the Sun as the epicenter of Earth processes. This is the true reversal of Milanković's that markedly moved the Earth and its picture from the geocentric and steered it toward the heliocentric horizon, as his *Canon of Insolation* mathematically brought the Earth into canonical accord with the Sun.

In the face of the Earth sciences and their great advancement after 1912, there remains the task of understanding the far-reaching correlation between Wegener's and Milanković's theories. Additionally, one should notice the great similarity in their life paths which enabled the creation of their theories. Wegener and Milanković from the beginning appeared to move in synchronized cycles that intertwined from the beginning of their lives, not ceasing even after the scientists' deaths. Milanković was born the youngest of seven in 1879 in a small town, Dalj, on the shore of the Danube in the Austro-Hungarian Empire, while Wegener was born only a year later, in 1880, into a family of five children in Berlin, the metropolis of the German Empire.

Both graduated at the top of their class; they enrolled in university in the same year – 1897 – and graduated the same year, in 1902. In 1904, both received doctorates – Milanković in civil engineering, Wegener in astronomy. Their scientific careers were somehow opposite, but equally non-specific and non-conformist. Wegener studied astronomy, physics and meteorology at Friedrich Wilhelms University in Berlin, but abandoned his studies in favor of the Earth sciences. Milanković followed a more terrestrial discipline at the Technical University in Vienna, studying civil engineering, but he left in order to study applied mathematics, astronomy, and climatology.
Both scientists began working in 1905. Wegener went to work at the Royal Prussian Astronomical Observatory. He used kites and balloons to study the upper atmosphere. Milanković began as a civil engineer at Adolf Baron Pitel Betonbau corporation in Vienna. In only five years of employment as a civil engineer, he constructed over a hundred buildings, bridges, and dams all over Central Europe. In 1908, Wegener took a position at the University of Marburg. He lectured in meteorology and astronomy. Only one year later, in 1909, Milanković decided to leave his job as a successful civil engineer in Vienna in order to concentrate on celestial mechanics and climatology at the University of Belgrade. Here, he began to teach applied mathematics and gave lectures on three diverse subjects – theoretical physics, spherical astronomy and rational mechanics.
Starting his work on the climate change problem, Milanković was fully aware that "...the question was not answered, and it was left amid a triangle between spherical astronomy, celestial mechanics and theoretical physics. The chair offered to me at Belgrade University included all the three sciences which were separated at other Universities. Therefore, I was able to discern that cosmic problem, to see its importance and to begin with its unraveling." (Milanković 2007: 480)
In 1912, when Wegener and Milanković published their respective milestone papers, both of them found themselves in personal and historical turmoil. Wegener, with his four man expedition to Greenland, escaped death only by a miracle while climbing a glacier that suddenly caved in. In the same year, Milanković joined the Serbian Army to fight successfully in the First Balkan Liberation War against Ottoman Empire. What a dangerous polar expedition was for Wegener is what Milanković experienced in war. Subsequently, both scientists had their own private *annus mirabilis* in 1913: Milanković married Tinka Topuzovic and Wegener married Elsa Köppen, daughter of Vladimir Köppen.
In contrast to the previous year, 1914 was *annus miserabilis*: Wegener joined the Austro-Hungarian army and served at the Eastern front. He was wounded twice. At the same time, and on the opposite side, Milanković, as a Serbian citizen, was arrested in Austria-Hungary while spending his honeymoon in Dalj, and he was imprisoned in the camp of Neszider. He kept a cool head in prison, saying that his "small room, isolated from noise, seemed perfectly adequate for scientific work to me".[12] During convalescent leave in 1915, Wegener set down a more in-depth

[12] "Letter from Vladimir Köppen to Milutin Milanković, August 30, 1921." *Articles, Discourses, Letters*.(in Serbian) Vol. 6. Belgrade: : Agency for Textbooks, 1997, pp. 474. Selected Works. This letter was, in fact, Köppen's reply, as Milanković had sent him a copy of *Mathematical Theories of Thermal Phenomena produced by solar radiation*.

version of *The Origin of Continents* (*Die Entstehung der Kontinente und Ozeane*), where he elaborated on his theory on the pan-continent ("*Urkontinent*") in detail, giving it the Greek name Pangaea – All Earth, All Land. Similarly, Milanković finished his *Theory of Thermal Phenomena Produced by Solar Radiation* during his internment in Budapest in 1917 and published it after the war, in 1920. It was among the most prominent scientific works written during imprisonment of his author.

When Milanković received printed copies of his book from his Paris publisher, he sent one sample to Vladimir Köppen. Köppen was so impressed by Milanković's introduction of advanced mathematics into Earth sciences that he immediately wrote him a postcard, stating, "I am impressed by the abundance of reason and clarity in your interpretation, and I am truly grateful for this precious gift. I am particularly interested in the calculation of secular thermal changes to which you came to a much different conclusion from Spitaler, as he did not take elliptical slope enough into consideration…"[13]

Köppen quickly realized that in Milanković he had found the most powerful ally he could ever find in his defense of Wegener's theory. For almost two decades, since the lecture before the German Geological Society, they had practically been at war with the geological community. Wegener was in an unenviable position; his theory was exposed to criticism and it seemed that, except for his father-in-law, Köppen, he had no other ally. Finding destined support in Milanković, Köppen thought up an inventive step – together with Wegener, he would engage in the writing of the work *Climates of the Earth's Past*. Now, they weren't alone against the world – Köppen's idea was that Milanković write the key chapter in their book. This is not so unusual in scientific practice, but this was a special case having to do with finding the Archimedean point that could move the world. Köppen therefore wrote to Milanković: "I am, unfortunately, one weak mathematician, and I have a difficult time with patterns. But as geologists, in general, are even worse, and these are very important questions, I would ask for your friendly help, which you have already offered. Wegener and I would like it so much", concludes Köppen's letter, "if you would give us one separate chapter about these things, which we would add without changes into our book."[14]

In early 1924, *The Climates of the Geological Past* appeared as "one of the founding texts of paleoclimatology providing crucial support to Milanković's theory on ice ages".[15] Köppen, Wegener and Milanković were finally together, the big picture was assembled – one portion was Earth sciences, the other was celestial mechanics, and no longer could rhetoric, unconnected empirical arguments and manipulations attack. It was the first consequent, comprehensive view on Earth climatic that was based on Wegener's theory on continental drift. In one specific chapter, the scientific public could see the basic paleoclimatic instrument, Milanković's Curve of Insolation, which made mathematical reconstruction and prediction of climate dynamics

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[13] Letter from Vladimir Köppen to Milutin Milanković, September 20, 1922. *Articles, Discourses, Letters*. Vol. 6. Belgrade: Agency for Textbooks, 1997. 478. Print. Selected Works.

[14] Comments on "The Thermal Zones of the Earth" by Vladimir Köppen (1884). Franz Rubel and Markus Kottek.

[15] Milanković, Milutin. *Reminiscence, Experiences, and Cognitions*, 603.

possible. The Curve of Insolation, resulting from mathematical calculation instead of the empirical research with which it agreed, was the crowning bolster and evidence of accuracy of the new Earth science. Milanković's mathematical theory of climate change, from which the Curve originated, was for his collaborators a gift from heaven – the most persuasive proof of the new vision of the Earth sciences. Milanković was the key ally, his Curve of Insolation an exact confirmation of the thesis that Köppen and Wegener advocated, as Milanković's theory made possible the conversion from descriptive to exact Earth sciences.

Wegener now planned to inform the scientific public of the new results and to reconcile it with the new view of the world. In September 1924 in Innsbrouck at the Congress of German Naturalists and Doctors, he gives a lecture describing the just-published *Climate's of the Earth's Past*. Now, Wegener already feels the ground firm beneath his feet, and his appearance gave no doubt to his theory. Introducing the book, he says: "Leaving behind the old theories of the shriveling of the Earth, of the fall into the depths of what were once bridges that connected today's continents, and adopting facts showing the possibility of continental movement, it has becomes us to reconstruct, for every big segment of the geologic past, an internal position of the Earth's continents and with the position of its rotational pull on them…[16]". Then, he triumphantly concludes, exposing Milanković's contribution: "The most important thing is that, in this way, we have come to the absolute chronology of the entire Quaternary Period and achieved that which has, till now… been possible only for the last 10,000 years[17]." Milanković noticed the victory even in Wegener's tone: "In his lecture, Wegener spoke modestly and with reservation about his own theory of continental drift, but when he began to speak about my Curve… he raises his voice and speaks with élan[18]." Now, all three knew that they were victors, and that their alliance was strong enough to result in the great scientific turnover that they were preparing. It was only left to discuss how to proceed.

In January of 1925, Milanković received a letter from Köppen stating that he, along with his son-in-law, Wegener, expected him that summer at his house in Graz. That was the crucial moment when they made the plan for future collaboration in creating the new science. From that collaboration and struggle against the old paradigm, the new Earth science was born. Milanković devoted an entire chapter of his memoirs to that unusual meeting. "'And before you,' Köppen told me, 'other scientists, Adhemar, Croll, Baal, Eckholm and Spitaler, studied the astronomic reasons for climate change. But they did not come to acceptable results in their work. That is why our great, sadly already deceased climatologist von Hann, my dear friend, with whom I published our main meteorological journal, let go of them as useless. But you, not shrinking from his judgment, took that problem into your hands and solved it.' 'Forgive me,' I said, interrupting him, 'I didn't solve it, you did.' 'On the foundation of your calculations!' he replied.… Wegener pondered, then said: 'As soon as I finish my report about Kohov's expedition to Greenland, I'll begin to prepare the fourth edition of my work on the creation of the continents and ocean…'

[16] Milanković, Milutin. *Reminiscence, Experiences, and Cognitions*, 606.
[17] Ibid.
[18] Vasko (Vasiliye) Milanković, Milutin Milanković's son.

'And I will,' I said, 'in the meantime, study all that the exact sciences said regarding the shape of the Earth and the possibility for the movement of poles of rotation… I will study all this, and then when we collaborate, maybe we can move the Earth's poles.' All three of us laughed and were happy as children preparing for some feat… At that, Wegener's little girl and Vasko[19] ran in from the garden. We had great fun playing with balls, our children speaking to us, all flushed. Köppen laughed, looked at us two, and said, 'And we play beautifully with the ball of the Earth'".[20]

After this meeting, Köppen took his last big step – he got to work on the systematic development of the new Earth sciences. With the help of his co-editor, Rudolf Geiger, he began his most ambitious project in 1927 – *Handbook of Climatology* (Handbuch der Klimatologie), which was never completed, but still ran to five volumes. Milanković was again the key contributor, and Köppen asked him for an introduction dealing with solar climate for the work. Milanković titled it *Mathematical Science of Climate and Astronomical Theory of the Variations of Climate* (Mathematische Klimalehre und astronomische Theorie der Klimaschwankungen). Putting Milanković at the beginning, Köppen left nothing to chance. Judging by Milanković's memoirs, all of them were aware that they were not searching for a specific scientific result. They were looking for the new Earth sciences.

Milanković then discarded the main flow of his work and began to solve questions of the movement of poles, which were not of key importance to the astronomic theory of climate change. Wishing to further solidify the stance of Köppen and Wegener, he elaborated on a geophysical and mathematical model of a mechanism that could stand behind the movement of continents. After many years, Milanković set up his model, a type of continental forcing, which suggested something entirely understandable – that the Earth's core slides on a fluidal base. Even if that idea was replaced with the theory of the plate tectonics, it was at that time a strong step toward the understanding of the mechanism of continental shift, the wandering of poles, and above all, toward understanding that these processes could be described mathematically.

Neither Wegener nor Milanković saw acceptance of their theories during their lifetimes. But that stipulated that the cycles of correlation in their daily and scientific lives did not finish even after their deaths. It had taken half a century for Köppen's, Milanković's, and Wegener's theories to be confirmed by independent research and to be fully accepted. Rejection of Wegener's theory lasted until the 1960's, when exploration of the ocean bed confirmed it. Oceanic data convinced scientists that continents do indeed move. Wegener's theory of continental drift became the foundation for the present theory of plate tectonics. The same happened with Milanković. Only ten years later, in the 1970's, Milanković's astronomical theory of climate change was confirmed by the exploration of deep-sea sediment and records

[19] Milanković, Milutin. *Reminiscence, Experiences, and Cognitions*. 619.

[20] Milanković, M (1997) *Reminiscences, Experiences, Cognition*. Agency for Textbooks, Belgrade, pp 693.

from various proxies all around the world. It became the canon of the present understanding of climate dynamics.

After that, it seems that the cycles continue to develop without end. The European Geosciences Union sponsors an Alfred Wegener Medal. The crater “Wegener” on the Moon and on Mars, as well as the asteroid 29227, are named after him. Craters on the Moon and Mars and the asteroid 193GA are named after Milanković. The European Geophysical Union (now European Geosciences Union) established Milanković’s Medal for crucial contributions to paleoclimatic research.

In one century the transition of Earth science which Köppen, Wegener and Milanković began was completed in the deepest scientific way. Milanković’s and Wegener’s theory is among the last heroic scientific attempts of the 20th century. Wegener stated that he had an “obligation to be a hero”. Milanković abandoned an extremely successful and profitable civil engineering career in Austria-Hungary to get a low-paying position as an associate professor at the University of Belgrade. But these romantic lives were full of revolutionary spirit, and therefore potentially dangerous for a pragmatically oriented science with little or no vision. This is why 1912 is the real *annus mirabilis* of the Earth sciences. It has the same significance for Earth science as 1905 has for physics. Cycles of Milanković’s and Wegener’s lives and their joint work left distinctive records in the history of the Earth sciences. The synergistic effort of both scientists changed the ruling paradigm, dethroned a geocentric and static causality and established a heliocentric and dynamic view over Earth history. Therefore, study of Milanković and Wegener and of their *annus mirabilis* is necessary for the preservation of a true perspective of the development of the Earth sciences, and for the understanding of a decisive moment of its past as the basis for its future.

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SYMPOSIUM 15

Humanities, Mathematics and Technics at Renaissance Courts

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The humanist manuscript collectors of the Quattrocento were responsible for assembling in Italy an almost complete corpus of Greek mathematical writings, where the term 'mathematical' has to be intended in the wider Renaissance meaning: the arts of quadrivium - arithmetic, geometry, astronomy and music - as well as optics and mechanics. In this sense, for example, artists and architects, too, were mathematicians inasmuch as they depended on principles of perspective, harmony and proportion; not to mention that astronomy and astrology had a strong influence on such studies as medicine and poetry.
The courts libraries – that generally reflected the patron's intellectual interests – on the one hand provided the “raw material” for a mathematical reawakening, offering access to Latin and Greek texts of Euclid, Archimedes, Apollonius, Diophantus, Proclus, Heron, Pappus and so on. Furthermore, the patrons could see to the financial security of their protégés and thus permit the development of mathematics outside the institutional framework of the universities. Actually, mathematics immensely benefited from the humanists’ eagerness to rediscover, translate and let circulate Greek manuscripts.
Recently, many studies have been oriented to reconstruct the intellectual life of the courts in the fifteenth and sixteenth century. The recovery of classical mathematical tradition went hand in hand with the tendency to apply mathematics to disciplines like architecture, hydraulics, the science of fortification and military engineering, which had matured in the environment of the abacus-schools. Through the encounter of the humanistic culture on the one hand and that of the engineers on the other, the Renaissance courts thus became one of the focal points of different knowledges and techniques which generated a new approach to science and to technics.
The aim of this symposium is to investigate the significance of this culture emerged from the Renaissance courts for the so called "Scientific Revolution".

Mechanics, Mathematics and Architecture: Guidobaldo dal Monte at Urbino and Giovanni Battista Benedetti at Turin

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According to traditional historiography, there are not many parallels between Benedetti's and Guidobaldo's scientific work. The first is said to have had a critical attitude towards ancient scholars such as Aristotle, and to have focused his research on phenomena relating to motion; the latter, on the contrary, showed no interest in such problems and was blinded by a "misplaced homage to the ancients" (Drake-Drabkin, 1969, 46). These are some of the standard *topoi* that one often reads. Apart from the fact that some of these claims are untenable in the light of recent research,[1] here I should like to call attention to a hitherto somewhat neglected aspect that is common to both Benedetti's and Guidobaldo's scientific activity: the strong interaction they had with the court they served and, as I hope this study will show, the notable influence this interaction exerted on their actual scientific work.[2] Both in Turin and in Urbino, it is possible to identify an important condition for their activity: both were in the service of dukes who were intensely interested in mathematics and who had enjoyed a sound formation in this discipline. In Turin, Duke Emanuele Filiberto (1528-1580) and his son and successor, Carlo Emanuele I (1562-1630), were taught mathematics by Benedetti himself; in Urbino, both Guidobaldo II (1514-1574) and Francesco Maria II della Rovere (1549-1631) were taught mathematics by Federico Commandino. The princes' formation in mathematics led to a lifelong interest, which determined the erudite debates at court. In fact, at the Savoyard court, discussions about mathematical were held regularly, as Benedetti describes in the preface of his principle work, *Diversarum speculationum mathematicarum et physicarum liber* (Turin, 1585, fol. 1*):

> Cuius <ducis Emanueli Philiberti> in me benignitas, mea in illum observantia mirum in modum mutuo uso et consuetudine est adaucta, ut idem Dux me secum dum rusticaretur esse vellet, saepe etiam secum pernoctare; quo quidem tempore de mathematicis scientiis mecum agebat, in quibus perdiscendis mea opera utebatur, quaestiones arithmeticam, geometriam, opticen, musicam, aut astrologiam spectantes proponens. (...)
> Illiusque imitatione (ut fere caeteri principum studia imitantur) non pauci aut praesentes, aut per litteras me de his, atque illis mathematicis quaestionibus consuluerunt.

[1] The fallacy of these claims holds particularly in Guidobaldo's case; see (Frank, 2011/2012).
[2] For more detailed arguments about Benedetti and his scholarly environment, see (Frank, 2013b); and, concerning Guidobaldo, see (Frank, 2013a), (Frank, 2011/2012).

These debates with the princes and their erudite courtiers, the so-called *virtuosi*, provided an important stimulus for the mathematicians' works. Benedetti explicitly stresses this important fact in the same passage:

> Cui <duci> ut quod in me esset satisfacerem, acrius quam antea in ea <mathematica> studia (ad quae tamen semper fui propensissimus) incubui.

In fact, as an analysis of Benedetti's principal writing reveals, several problems he had taken on at Emanuele Filiberto's and Carlo Emanuele I's request found their way into his work, including the treatise on the calendar reform, composed in 1578 and published in the form of a letter to Emanuele Filiberto (*Diversarum speculationum liber*, 205-210), the description of an oil lamp he invented for the Duke in 1570 (*ibidem*, 225-227), and the solution of a geometrical problem proposed to him by prince Carlo Emanuele (211-213).[3]
The interest in mathematics of several members of the Savoyard court also left its mark on Benedetti's writing. In fact, the whole second part of the *Diversarum speculationum liber* (205-425) consists of letters on mathematical and physical topics that were proposed to him by his scientific interlocutors, many of whom belonged to the courtly *entourage*. Among these topics, we find considerations on the range of cannonballs (258-259, in a letter to the general of the artillery in the Duchy of Savoy, Giuseppe Cambiano), on the measurement of heights (272-274, in one of the letters to the ducal architect, Gabriello Busca), and on geometrical problems (361-363, in a letter to the Duke's "agrimensor expertissimus" Angelo Ferraio). Most interestingly, Benedetti was approached for the solution of problems even by court members whose professions or roles had nothing to do with mathematics, including the ducal secretary Ludovico Niccolò Caluxio, the Duke's counsellor Ludovico Demoulin de Rochefort, and the president of the Turin senate, Bernardo Trotti. This remarkable fact gives an idea of the important role of mathematics and "physics" in the cultural debates at the Savoyard court.
Yet other stimuli for Benedetti's work arose from the practical tasks he was given by the Duke. For example, Benedetti was responsible for the planning of a fountain in the park of the ducal residence in Turin (1570).[4] Further, as the extant letters between the Duke and his court mathematician document (Bordiga 1925-26; 597-598, 737-738), a major focus of the scholar's activity was on the conception and construction of scientific instruments at Emanuele Filiberto's behest. So, on 22

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[3] Benedetti makes it clear that he took on these problems at the Duke's and the Prince's behest (Benedetti 1585, 205): "Mirum, quam lectione epistolae seu (ut vocant) brevis S.D.N. Gregorii XIII Pont. Max, quod ad me nuper tua Celsitudo misit ex Nicea, ut meam de ea re sententiam proferrem, delectatus sim (...)"; then (Benedetti 1585, 225): "De lucerna spiritali quam Sereniss. Sabaudiae Duce D. meo collendiss. anno 1570 construxi"; and finally (Benedetti 1585, 211): "Problema quod a Celsitudine tua <Carlo Emanuelo> nobis proponitur non solum possibile est, sed facile etiam ad solvendum, hoc est quod circulus talis inveniatur, qui possit circunscribere seu capere quadrilaterum ex quatuor datis rectis lineis terminatum (...)."

[4] See (Maccagni 1967, 353-354) and (Frank 2013b, 148-149).

August 1569, the Duke expressed to Benedetti his satisfaction that "the work on the mathematical instruments proceeds apace", while one year later (12 June 1570), he ordered him to construct

> two water clocks in the <ducal> library, one of which has to work in the "French way" for 12 hours, and the other for the natural 24 hours,[5]

and sent four chests of crystal to make it process. As becomes clear from these letters, Benedetti collaborated with several technicians and craftsmen, such as "mastro Giorgio", "mastro Bartolomeo" and "Giovanni Battista Orefice". This latter fabricated a sundial whose construction the mathematician had to supervise as well (letter dated 21 June 1574). Benedetti was therefore an important element of an ambitious project the Duke drove forward with great determination: the establishment of a kind of ducal *wunderkammer.* Interestingly, Emanuele Filiberto spared no trouble and expense to get particular mathematical instruments, sending his agents even to Poland and Germany.[6]

The echoes of this activity can be seen in the *Diversarum speculationum liber*: there, the author presents instruments he invented himself for drawing sections of ellipses (348-351, in a letter to Girolamo Fenarolo), an armillary sphere and a device to determine the position of the Moon for better navigation (217-224, in letters to Andrea Provana), and a special astrolabe he had conceived, which he instructed the ducal clockmaker, Jacopo Mayeto, to fabricate (423-425), to name but a few.

Apart from the *Diversarum speculationum liber*, the composition of other treatises as well was closely related to his activity in the service of the Dukes of Savoy. In the preface to *De gnomonum umbrarumque solarium usu liber* (Turin, 1574), where he presents his theory on gnomonics, Benedetti relates that the treatise came from the lectures he held for the Duke on this topic; and it was Emanuele Filiberto, underlines the mathematician, who urged him to publish this material (fols. 1r*-2r*):

> Libellus noster de re gnomonica, Dux Serenissime, quem superioribus annis composui iam tandem in lucem emersit. Et id quidem te volente atque iubente. (...) Cum igitur ex nobis inter caetera audire volueris de umbrarum usu (...), a nobis imprimenda committi desiderasti, fecistique ut hoc gnomonicum volumen, veluti implumen volucrem e nido in quo nostros partus fovemus emiserim.

In the main part of the treatise, Benedetti then stresses the close relation of some of the techniques there presented and the design of sundials he had constructed in Turin or cities nearby.[7]

Even the genesis of *Descrittione, uso et ragioni del trigonolometro*[8] is intrinsically linked with Benedetti's ties to the Savoyard court. In the manuscript, dedicated to

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[5] For further examples of scientific instruments constructed by Benedetti for the Duke, see (Frank 2013b, 150-155).

[6] For more detailed information on this topic, see (Frank 2013b, 38-43).

[7] See (Roero 1997, 47).

prince Carlo Emanuele I, the mathematician explained to his disciple the operation of the *trigonolometro* instrument, which was used for solving problems relating to engineering and military architecture. The length of the *Descrittione* (73 folios), as well as the constant references to theorems of Euclid's *Elements,* shows the complexity of such descriptions and the theoretical dimension of the operation of such instruments.

Turning to Guidobaldo, an analysis of his position at the Urbino court reveals interesting parallels to what we have seen concerning Benedetti in Turin. As a recent study reveals, Guidobaldo was closely connected with the della Rovere court. From a list of salaries of the Urbino court, it emerges that he was one of its most influential members, in conformity with the eminent position of the dal Monte family in the duchy.[9] Even more, Guidobaldo's whole life was characterised by his strong ties with the court: as the prince's page he grew up side by side with the duke’s son, Francesco Maria, and was his fellow student at Commandino's lectures. Remarkably, when Francesco Maria became duke in 1574, Guidobaldo was appointed as chief of his guard.
His duties at court also included tasks related to mathematics and its applications. Around 1572, he was consulted about the completion of Pesaro's city walls (Menchetti 2009, 434). Then, after 1575, when Federico Commandino had died, he himself became the leading authority of the problems relating to mathematics (in a wide sense) in the duchy. One of Guidobaldo's areas of responsibility was the supervision of the ducal fabrication of mechanical clocks -- it is known that Pesaro and Urbino were important centres of the construction of such devices, with master clockmakers in the della Roveres' service, including several members of the Barocci family and Pietro Griffi. Apparently, though, even their products required supervision by a mathematician: Guidobaldo was able to verify the (approximate) precision of their clocks thanks to the comparison with the nearly exact sundials he had constructed based on his research into gnomonics. In a letter from a ducal minister, for example, Guidobaldo was instructed that he

> should write a short treatise, as you have just heard the will of His Highness. The other clock destined for Spain has to work at least 26 hours, but 28 hours would be better, because master Pietro is used not to say the truth. So Your Lordship has to make sure that it works as long as it has been decided.[10]

[8] This is a hitherto unedited manuscript, brought to scholarly attention in (Bordiga 1925/26, 613-614). (Roero 1997) published some passages and figures.
[9] See (Frank 2011/12; 20-62, 489-497).
[10] This is a passage of an anonymous, undated letter sent to Guidobaldo, preserved at Biblioteca Oliveriana Pesaro (referred to henceforward as BOP) Ms 430, fol. 217r. Other documents attesting Guidobaldo's task of supervising the clock fabrication are a letter by Giovanni de' Tommasi, dated 1 September 1583 (preserved at BOP, Ms 426, fol. 155r/v), and by Giulio Cesare Mamiani, 1 July 1587 (BOP, Ms 211, fol. 102r/v).

Not only was Guidobaldo engaged with the construction of mechanical clocks, but also with the design and construction of scientific instruments in general. It is plausible that even this area of his activity was conditioned by Francesco Maria II della Rovere's habit of making his mathematicians and engineers "always invent new machines and instruments'', as the Urbino mathematician Giulio da Thiene reports (Lampertico 1890-91, 978). This hypothesis is supported by the fact that a particular kind of sundial that works with refracted rays, invented by Guidobaldo, was displayed in the garden of the ducal residence in Urbino.
The invention of instruments was one of the principal concerns of Guidobaldo's scientific work:[11] devices such as the sundial just mentioned, a proportional compass, instruments for drawing hyperboles and for measuring fractions of degrees along circular arcs, and a device for the measurement of cannonballs are just a few examples of Guidobaldo's intense activity in this field -- an activity that he had in common with Benedetti.
Further, just as his "colleague" in Turin, Guidobaldo too was given tasks as an engineer by his Duke: he was responsible for the construction of a fountain in front of the ducal palace in Pesaro (1587; identical to Benedetti's case), and he was given the tasks of resolving problems with the water supply of the ducal Villa Miralfiore (Pesaro, 1583/87) and of supervising construction work at Pesaro's port (1587).

As I have shown elsewhere,[12] Guidobaldo's scientific work not only preserves the echoes of the experience he had had in similar situations (just as we have seen in Benedetti's writings), but also, along with these engineering problems, the cultural and philosophical environment of the Urbino court conditioned his scientific work. In fact, many of Guidobaldo's scientific interlocutors, such as the philosophers Jacopo Mazzoni, Federico Bonaventura, Cesare Benedetti, as well as Pier Matteo Giordani and Bernardino Baldi, were members of or at least closely connected with the Urbino court. Accordingly, several topics in Guidobaldo's writings can be identified as the reflections on discussions he had held with his interlocutors.[13]
Finally, Guidobaldo's scientific work was also conditioned directly by the court and by the Duke, who asked him to compose a treatise on calendar reform (*De ecclesiastici calendarii restitutione*, Pesaro, 1580) -- identically to Benedetti's case, again -- and had him revise Commanino's translation of Pappus' *Collectio Mathematica* (1586-1588).[14] And, as mentioned above, Francesco Maria II requested that Guidobaldo write a treatise on the workings of a mechanical clock.

There are thus several remarkable parallels between Benedetti's and Guidobaldo's activities in the service of the respective courts in Turin and Urbino. They range from the execution of tasks as engineers or architects to the development and construction of scientific instruments. The dukes did not stop at influencing the mathematicians' actual scientific work, by commissioning treatises on certain topics

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[11] For further information on this topic, see (Gamba-Mantovani 2013).
[12] See (Frank 2011/12, 242-248).
[13] See (Frank 2013a) and (Frank 2013c).
[14] See (Frank 2011/12)

(calendar reform, descriptions of the workings of scientific instruments), and by making them elaborate and publish lecture material (in Benedetti's case) or revise and edit other ducal mathematicians' writings (as Guidobaldo did for Commandino's). Beyond these direct ways of exercising influence on these mathematicians' work, both Benedetti's and Guidobaldo's writings present several topics that can be interpreted as elaborations of problems originating from their courtly milieus.

Because of these parallels between his activity in the service of the Duke of Urbino and Benedetti's as official court mathematician in Turin, Guidobaldo can be considered as his counterpart, a kind of Urbino court mathematician, even though such a title was not officially accorded him.

As I have tried to show, interaction with courtly environments exercised a considerable influence on Benedetti's and Guidobaldo's work, and focusing on this aspect is important for reaching a better understanding of their scientific activity. More generally, it does not seem too daring a hypothesis that the result of the great influence of courtly environments on the work of these mathematicians could be extended to other sixteenth-century mathematicians, such as Federico Commandino, Simon Stevin, and Oronce Finé. The contribution of these milieus to the evolution of Renaissance mathematics seems to have been somewhat underestimated so far, especially if compared with other milieus, such as the Renaissance universities.

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The Euclidean Tradition at the Renaissance Courts: the Case of Federico Commandino

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Federico Commandino (1509-1575), the founder of the so-called Urbino School, lived under patronage of important Renaissance families, such as della Rovere and Farnese. This permitted him access to the most valuable libraries, enabled him to maintain close contact with humanistic circles, and facilited his pursuit of a major program of research in the renaissance of mathematics. He published and commented the works – to mention the most important ones -- of Apollonius (1566), Archimedes (1558), Pappus (posthumous 1588) and Euclid, both in Latin (1572) and in vernacular (1575). Commandino's edition of the Elements, based on Greek sources, combined philological rigour together with mathematical exactness and soon became the reference edition up to the nineteenth century. Furthermore the Urbinate scholar enriched the Euclidean text with comments and additions based on both classical and contemporary sources. This edition epitomizes Commandino's idea of restitutio or the re-appropriation of ancient sources in light of integrated, early modern scientific knowledge.

Paraphrasing the classic essay of Paul Lawrence Rose (Rose 1975), we can recognize in "the Italian renaissance of mathematics" at least two main issues: the restoration of Greek mathematics and the development of rhetorical and syncopated algebra. Usually, the activities of study, translation and edition of Classics were conceived within the most important humanistic circles or the most prestigious Schools – as the Venetian San Marco School or Rialto School – or, again, in the world of the courts (rarely in the Universities). Of course the term 'court' is to be intended in a broad sense: the court was everything and everyone surrounding the public authority, that could be the Prince, the Venetian Doge or even the Pope. On the other side, algebra mainly developed within the abacus environment, inasmuch as it was conceived as a useful tool for solving problems[1].

It is only thanks to his numerous patrons – the Duke Ottavio and the Cardinal Ranuccio Farnese, Marcello Cervini (the future Pope Marcello II), the Duke Guidobaldo of Urbino -- that Federico Commandino, one the most important scholar of the Renaissance Italy, could succeed in his program for the renaissance of mathematics. Following, in some sense, Regiomontanus's *Program*, based on the restoration of the whole Greek mathematical *corpus*, Commandino published the works of Archimedes, Apollonius, Serenus, Ptolemy, Pappus and, of course, Euclid.

[1] Of course these worlds weren't so definitively divided. For examples, Luca Pacioli and Niccolò Tartaglia, teachers in the abacus schools were also editor of Euclidean and Archimedean works. They were interlocutors of both the worlds and, by means of their work, they tried to unify these two cultural environments.

His various patronages secured him not only financial support, but access to the most important humanistic libraries and acquaintance with intellectual circles[2].
After the death of Ranuccio, his last patron of the Farnese family, Commandino returned to his native Urbino, where the patronage of mathematics was a long established tradition and where the Duke's library included a large number of mathematical manuscripts. He established the so-called *Urbino School*, that trained Guidobaldo dal Monte, Bernardino Baldi, and other distinguished mathematicians[3].
Strictly connected to the foundation of the Urbino School, is Commandino's teaching activity in his native town, which probably spanned the years from 1568 to 1574[4].
Commandino's lectures were influenced by the interests of Francesco Maria II della Rovere (1549-1631), who in 1574 succeeded his father Guidobaldo II as Duke of Urbino. Since Francesco Maria was particularly interested in Euclid's *Elements*, the question of getting a satisfactory edition of this text immediately arose.
In the first decades of the sixteenth century the editions of the *Elements* available to the scholars were, essentially 1) the first Latin printed edition (*editio princeps*), which appeared in Venice in 1482 by Erhard Ratdolt and was based on the medieval version of Campanus from Novara; and 2) the Venetian edition of 1505, based instead on the translation of a Greek code, made by the humanist Bartolomeo Zamberti. The medieval *recensio* showed additions, changing of definitions or differences in numbering propositions, whereas the humanist translation, very careful to the linguistic aspect, mercilessly highlighted the very poor geometrical talent of Zamberti. Even if several editions followed, none of them were so correct from a mathematical and linguistic viewpoint to become a shared and trustworthy edition of the *Elements*, the reference point for European scholars. Actually, most of the sixteenth-century *Elements* simply embraced Campanus' or Zamberti's approach with only marginal changes[5].
Commandino's Latin edition of the *Elements,* appeared in 1572 and soon became the reference edition for the scholarly community up until the early nineteenth century[6].
Since he encountered many problems in printing this edition, Commandino set up a press in his household, where, in 1575, the Italian translation was printed by his son-in-law Valerio Spaccioli (because of Commandino's death).[7]

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[2] In this respect, (Rose 1973) publishes two letters illustrating the extent to which Commandino depended on Farnese patronage.
[3] Gamba, Montebelli 1988 and Frank 2013 provide an overview of the cultural and scientific climate in the Duchy of Urbino in the late Renaissance.
[4] I would like to thank Martin Frank for having provided me his draft on Commandino's teaching activity (Frank, forthcoming).
[5] For an overview of the Euclidean tradition in the Renaissance, see Gavagna 2009; 2012, whilst Gavagna 2010 is mainly focused on the Venetian environment.
[6] On Commandino's role in the Renaissance mathematics, see Napolitani 1997; 2000; on Commandino's edition of the *Elements*, see Gamba 2009 and Gavagna, forthcoming.
[7] Among the Commandino's extant drafts, there is the manuscript copy of Book II, whereas Book III finishes at Proposition 10. Remark that in this redaction, very close to the 1572 published text, Commandino's comment are lacking, This and others manuscripts are available in the webpage devoted to *Federico Commandino Manuscript Collection*,

In the Preface to his Latin edition, the Urbinate scholar presented an historical essay of the development of mathematics and clarified the two most common misunderstandings related to the *Elements*[8]. In fact, most humanist mathematicians believed that Euclid, wrongly identified with the philosopher Euclid of Megara, wrote only the statements for the propositions in the *Elements*. They thought that the demonstrations were the work of Theon, who wrote a new edition of the *Elements* several hundred years later. One of the few voices questioning the attribution of the proofs to Theon was the mathematician Jean Borrel, who wrote an appendix to his 1559 work on the quadrature of the circle noting the most common mistakes in interpreting Euclid's *Elements* (*Ioannis Buteonis annotationum liber in errores Campani, Zamberti, Orontii, Peletarii, Ioannis Penae intepretum Euclidis*). Borrel explained that ancient authors, and Proclus in particular, unanimously attributed the *Elements* to Euclid alone and that the misunderstandings arose from an incorrect interpretation of the title found in the Greek codices. Commandino completely agreed with Borrel's interpretation and, furthermore, stated that the author of the *Elements* could not be Euclid of Megara, but rather Euclid of Alexandria. So, when he published his Latin translation of the *Elements*, Commandino eliminated these mistakes, and because of his undisputed authority they disappeared from every following essay on Euclid and his *Elements.*

Even from a design viewpoint, the layout of both 1572 and 1575 editions was completely different from the previous editions. The Urbinate humanist, in fact, decided to visually distinguish the Euclidean text (in roman typeface) from the editor's comments (in italics). Furthermore, the references to previous propositions or definitions or postulates – absent in the Greek codices but usually enclosed in the text of the Renaissance editions – were shifted to the margin of the page. In other words, the Euclidean text had to be clearly separated by further interpolations and comments thereby allowing Commandino to return to the "original purity" (*pristinum nitorem*) of the text, as remarked the Jesuit Christopher Clavius in the Preface of his 1574 edition of the *Elements*. Nevertheless, even if has become commonplace to attribute to Commandino a philological accuracy very close to the modern accuracy, we still don't know which was or were the Euclidean codices used by the scholar to constitute the critical text. He seems to have used the Greek text published in Basel in 1533, but – as far as I know -- we don't have any information about manuscript sources: so we can't determine how rigorous Commandino's philological approach was.

Anyway, comparing the main Renaissance Euclidean editions, we can remark that – at least concerning the case study considered[9] -- Commandino's approach towards the construction of the text aimed to combine mathematical exactness with philological accuracy. To take an example, we could consider the following case

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Contenitore 120, cartella 1, ff.116r-132v, http://echo.mpiwg-berlin.mpg.de/content/mpiwglib/urbino.

[8] For a detailed study about the history of mathematics in the Renaissance, mainly focused on the figures of Pierre de La Ramée and Henry Savile and with some references to Commandino, see Goulding 2010 .

[9] See for example Gavagna, forthcoming.

related to Book VI. According to the Renaissance editions belonging to the Greek tradition, we find, in sequence, the following:

Proposition VI.19 (P19): Similar triangles are to one another in the duplicate ratio of the corresponding sides.

Corollary (Cor19): If three straight lines are proportional, then the first is to the third as the *figure* described on the first is to that which is similar and similarly described on the second (italics mine).

Proposition VI.20 (P20): Similar polygons are divided into similar triangles, and into triangles equal in multitude and in the same ratio as the wholes, and the polygon has to the polygon a ratio duplicate of that which the corresponding side has to the corresponding side

Corollary I (Cor20I): Similar rectilinear figures are to one another in the duplicate ratio of the corresponding sides.

Corollary II (Cor20): […] so it is evident that if three straight lines are proportional, then the first is to the third as the figure described on the first is to that which is similar and similarly described on the second.

First of all, it sounds strange that Cor19 is almost the same as Cor20 and, secondly, the reference to a polygon (*figure*) in Cor19 is not correct, since P19 deals with triangles, not polygons. A problem arose. What was the editors' approach regarding the correction of these anomalies? Let us consider some examples. Bartolomeo Zamberti simply ignored the problems and published the clearly incorrect sequence; Campanus (we include this author even if he does not follow the Greek tradition) remarked that Cor19 should be moved after P20, but left the sequence unchanged; Jacques Peletier expunged Cor19[10]. Niccolò Tartaglia, who used both Zamberti and Campanus for his Italian translation of the *Elements* appeared in 1543, was convinced that Cor19 was in the wrong position and criticized the two editors, but did not make major changes. Finally, Commandino found the most elegant solution. He simply substituted the word *figure* with *triangle* (as some Theonine manuscripts actually read) thus justifying the mathematical meaning of Cor19 and the whole sequence of propositions and corollaries.

Concerning Commandino's comments on Euclidean propositions, even if a complete analysis is still lacking, a quick overview shows that his commentary drew mainly from classical authors and commentators like Archimedes, Apollonius, Pappus, Proclus and Eutocius. The purpose of the Urbinate humanist was to establish a network of relationships and crossed references that made Greek mathematics an organic *corpus*. In the same time, he did not forget to relate the ancient wisdom with the contemporary one and this is the reason why we find some references, for example, to Regiomontanus' works or to Pierre de la Ramée and Jean Borrel's writings and even to Girolamo Cardano's *De regula aliza libellus*, a puzzling algebraic work published only two years before.

Except for some marginal remarks, Campanus' medieval edition of the *Elements* – indeed very far from the humanistic canons – seems to be completely neglected by Commandino. A more careful – but still partial -- study shows that Campanus'

[10] In 1557 Peletier published *In Euclidis Elementa geometrica demonstrationum libri sex.*

influence is probably deeper than it seems. As example we could consider the following case study.

At the end of Book V, devoted to the general theory of proportions, Commandino added eight propositions about inequality between ratios, explaining that they were tools commonly used by ancient mathematicians like Archimedes, Apollonius and Pappus. So, even if they weren't in Euclid's treatise, they belonged to the body of Greek mathematical knowledge and this was a good reason to add the 'lacking' propositions. Commandino says he has drawn the eight propositions from Pappus' *Mathematical Collection*, but commuting their original order and modifying them just a little when necessary. Apparently Commandino totally ignored Campanus, who also added nine propositions on the same issue at the end of his own version of Book V. But comparing the propositions carefully, it is clear that, even if the proofs are actually shaped on the Pappus' ones, they are ordered following Campanus. Furthermore, Commandino considered four propositions not belonging to Pappus' *Collection*, but included in the Campanus' medieval redaction of the *Elements*, as we can check in the correspondence table:

Commandino	Campanus	Pappus
V.26	V.26	VII.7
V.27	V.27	VII.5
V.28	V.28	VII.3
V.29	V.29	
V.30	V.30	VII.6
V.31	V.32	
V.32	V.33	
V.33	V.31	
	V.34	

Table 1

Of course the previous case study does not prove anything, but it offers a clue to the (hidden) influence of Campanus on Commandino.

A very interesting aspect of Commandino's Euclid concerns its diagrams and its relationship to the idea of the restoration of classic mathematics[11]. The Greek-Latin tradition differed from the Arabic-Latin one not only with respect to Euclid's text (number and order of propositions, proofs and so on) but also with respect to the geometrical diagrams, especially those of solid figures, which are very difficult to

[11] This issue is developed in Sorci 2001.

draw. For example, in Campanus' Arabic-Latin redaction, most of the figures of Book XV were omitted, whereas Zamberti, following the Greek-Latin tradition, supplied all the figures[12]. But despite the differences, the drawings of solids were based on the same criterion (a faithful representation of the step-by-step geometrical proof), because the purpose was to illustrate geometrical properties of the figure, not to represent the solid in a realistic way. The resulting diagrams were extremely complex and it was very hard to recognize them as a representation of solid figures.
Commandino broke with this iconographic tradition and provided perspective drawings in his printed editions. At first sight, this could seem surprising, because the Urbinate scholar, as we have said, aimed to restore the 'original purity' of classical texts (and diagrams), while perspective was a discipline re-discovered in the Renaissance. Or maybe it's not so surprising? Actually, in the new Renaissance classification of the sciences we find *scenographica*, a classical discipline whose aim was to represent reality as it appears. Unfortunately the extant fragments (attributed to Geminus of Rhodes) described only the purpose of the *scenographica* but not the technics used, and this is probably the reason that convinced Commandino in using the contemporary perspective technics to represent solid figures according to the Greek science. In other words, even Commandino's perspective drawings are to be interpreted in the light of his program of restoration.
In order to attribute to Commandino the right role in the development of Renaissance mathematics – an essential prerequisite for the Scientific Revolution – it will be useful to deepen or explore several aspects of his life, career and scientific production. On one side a careful and complete reconstruction of the scientific environment where he worked is required; on the other side, scholars should analyze Commandino's published and unpublished writings in order to identify the sources he used (even the hidden ones) and how he used them. This contribution is just a small step in this last direction.

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[12] The Renaissance versions of the *Elements* included the apocryphal Book XIV and XV, that continued Euclid's theory of regular solid.

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Acknowledgements
I would like to warmly thank Arielle Saiber for the careful reading of this paper and for the suggested edits.

Between Germany and Great Britain: Renaissance “Scientists” at Reformed Universities and Courts

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In the second half of the sixteenth century, German universities became increasingly attractive for northern and western European students seeking not only a protestant theological education but also mathematical training. In this context Wittenberg, as the center of Lutheran reformation and Melanchthonian scholarship, played a major role. That *Studium* served as a model for many other German universities. In particular, Melanchthon’s *curriculum studiorum* accorded to mathematics great relevance among the liberal arts. His *curriculum* was adopted by well-established universities (Wittenberg, Tübingen, Leipzig, Frankfurt on Oder, Greifswald, Rostock and Heidelberg) as well as by newly founded ones: Marburg (1527), Königsberg (1544), Jena (1548) and Helmstedt (1576). In the following, I will point out the prestige that German universities had in the eyes of British students. I will especially refer to the biography of the Scottish mathematician and physician Duncan Liddel as an example of scholarly mobility and transfer of knowledge between Great Britain and Germany during the Renaissance.

The prestige of German mathematicians

In 1591, on the occasion of his appointment as a professor of mathematics at the University of Helmstedt, Liddel delivered a public oration in praise of mathematics, which culminated in a celebration of German scholarship in this field. Addressing an audience of local academics and students, he listed, among the most prominent modern mathematicians, Perubach, Regiomontanus, Copernicus, Stöffler and Werner (ff. 48*r-v*, in Omodeo 2013):

> *“Vobis enim a maioribus solida illa et aeterna disciplinarum Mathematicarum gloria relicta est quorum exemplum vos imitari decet nec committere ut Germania quae 300 pene annis toto orbe terrarum fecundissima virorum hoc doctrinae genere praestantium parens habita fuit per vos vestramque ignaviam ita tam praeclara laude spolietur. Hic sedem doctrinae caelestis hic domicilium disciplinarum Mathematicarum hic seminarium quoddam summorum artificum fuisse omnes uno ore gentes exterae confitentur ac non alio quam Regiomontani, Coper<nici>, Purbachii, Stophleri ,Verneri aliorum sine numero Germanorum ad has disciplinas colendas perdiscendasque excitatas et inflammatas fuisse.”*

Like other protestant scholars, Liddel had a tendency to connect the flourishing of mathematical sciences in Germany, in particular astronomy, with the Reformation. His judgment echoed that of the French Calvinist philosopher Pierre de la Ramée, who, in his *Scholae mathematicae* (Basel, 1569), extolled German practitioners as the inventors of ballistics, typography and navigation (p. 65) and Melanchthon as the promoter of mathematical studies among Lutherans (p. 66). In this context, Liddel also praised the generosity of rulers who patronized natural and mathematical research, like the imperators Friedrich I, Maximilian and Karl V, King Friedrich II of Denmark—supporter of Tycho Brahe—, Landgrave Wilhelm IV of Hessen-Kassel, and Duke Julius of Brunswick—the founder of the University of Helmstedt (ff. 47*v*-48*r*). Historians of astronomy are in general agreement with these early-modern assessments concerning the relevance of the international network of scholars linked to German institutions. The Wittenberg network permitted in fact the early reception of Copernicus's work in northern Europe. A geocentric reworking of Copernicus's parameters and models was a notable feature of this circulation. This approach smoothed physical and theological concerns descending from heliocentrism and culminated with the adoption of geoheliocentric systems by Ursus, Brahe and their successors.

British students in Germany
Mobility has always characterized academic careers. During the early-modern period, however, confessional divides reshaped European patterns of mobility. In particular, a northern European network of scholars and institutions was established, connecting German academic centers and courts with institutions in the Baltic area, including most prominently Copenhagen, the Netherlands and the British Islands. Take the Silesian mathematician Paul Wittich of Wrocław, who frequented Leipzig, Wittenberg, Prague, Altdorf, Frankfurt on Oder, Uraniborg, Kassel and Vienna. He never published a book and only his manuscript annotations to Copernicus's *De revolutionibus* are preserved. Nonetheless, his astronomical speculations had a great influence on mathematicians whom he encountered and collaborated with during his life. Brahe and Liddel were among them. The latter met Wittich in Wrocław, around 1582, in the circle of the humanist and diplomat Dudith-Sbardellati and of the physician Crato von Krafftheim. In those years, Dudith gave hospitality to young British scholars who were on their study tours through continental Europe. This included the Englishmen Henry Neville, Henry Savile, and Robert Sidney. The latter was brother of the Elizabethan court poet Philip Sidney and a pupil of Thomas Harriot. These scholars acted as mediators between Germany and England. Savile, in particular, brought back to England a copy of *De revolutionibus*, which he extensively annotated, and a copy of Copernicus's letter to Wapowski on the eighth sphere. He eventually fostered mathematical studies in England founding the "Savilian professorships" of mathematics at Oxford.
Liddel was sent to Wrocław by his fellow countryman John Craig, professor at Frankfurt on Oder. Craig accommodated Liddel in his house from 1579 and taught him logic and mathematics. His biography is one more example of northern European academic mobility. Craig was admitted to the Faculty of Arts of Frankfurt on Oder in 1573. He already held the title of Magister, received from St. Andrews. Back in Scotland in 1584, he became court physician to James I and VI, whom he followed to England. In 1604, he entered the College of Physicians of London and, in 1605, he became part of the University of Oxford. Craig corresponded with Brahe,

from whom he received a copy of his *De mundi aetherei recentioribus phaenomenis* (Uraniborg, 1588) with a handwritten dedication. Later, they started a quarrel over the nature of comets and planetary hypotheses.
Besides, Liddel and Craig, many other Scots received their education in continental Europe. The founder of Marischal College in New Aberdeen, George Keith, 5th Earl Marischal, travelled throughout Europe. During his *Bildungsreise* of seven years, he studied the liberal arts and the three languages of Erasmian education: Latin, Greek and Hebrew. As a nobleman he first visited Paris, to learn French and further the arts, but also horse riding and the use of arms. As a protestant lord, he was then in Geneva, where he studied rhetoric, theology and politics under Theodore Beza. At the same time, he learned geography and history. He also visited Germany and Italy, familiarizing himself with the local languages.
A scholar who had a career more similar to those of Craig and Liddel is John Johnston. Johnston received his first education at King's College, Old Aberdeen. When he enrolled at Helmstedt, in 1585, he possessed already a master's degree. There, he gave private lessons and obtained a doctorate in medicine in 1589. He went to Geneva in 1592 and finally returned to his homeland as professor of the New Testament at St. Andrews. Another Scot, Gilbert Gray, studied at Helmstedt under Liddel and became later *gymnasiarcha* of Marischal College, New Aberdeen.
This phenomenon of northern European mobility of students receiving their education at Lutheran (especially Melanchthonian) universities, included also Flemish protestants. Among them, the mathematician and physician Heinrich Brucaeus welcomed Liddel in Rostock, in 1584. Brucaeus studied in Ghent, Paris and Bologna, where he graduated in medicine. After teaching medicine and mathematics in Rome and Leuven and having been physician to the House of Braganza for some time, he finally arrived in Rostock in 1567. Later, he would become court physician of Mecklenburg. His most famous student in Rostock was Brahe, with whom he maintained a scientific correspondence. On several occasions, he procured books for the "Lord of Uraniborg" and in 1588 was among the first to endorse his geoheliocentric hypotheses. Brucaeus also promoted Liddel's visit to Hven in 1587.
Another reputed Flemish scholar in this web was the anti-Ramist philosopher Cornelius Martini, a pupil of Liddel in Rostock. Martini was born in Flanders and raised near Göttingen. He studied in Rostock and earned his doctorate in Helmstedt, where he became professor of logic. He was among the first lecturers of Aristotle's *Metaphysics* at a Protestant university and he pitted Aristotle's logic against the rhetorical logic of the Ramists.

Liddel's experience

Liddel's biography can be understood against the background of this northern European circulation of scholars. He was of modest origins. His father was an obscure *cives urbis* of Aberdeen; his mother, a midwife. He left Scotland as a teenager and sailed to Gdańsk. At that time, many young men of the popular classes sought to make their fortune in Poland, where they could aspire to work in the trades or pursue a military career. Liddel chose a different path: he wished to study. In 1579, he headed to Frankfurt on Oder, attracted by the teaching there of the Scottish professor Craig.

Craig sent Liddel to Wrocław in 1582, where the he entered Dudith's circle. Liddel furthered there his study of mathematics and of Copernicus's planetary hypotheses under the guidance of Wittich. Once back to Frankfurt on Oder (1583-1584), Liddel devoted himself to the study of medicine and began to give lessons in mathematics and philosophy, relying on Euclid, Ptolemy and Copernicus. An outbreak of plague caused Liddel to move to Rostock (1584-1591) where he was received by Brucaeus and where he met the professor of *humanae litterae* Caselius. This period also included his contacts with Brahe, whom he visited in 1587 at his observatory-castle of Uraniborg. In 1591, he joined Caselius who had moved to Helmstedt. There, Liddel assumed the chair of lower mathematics which he left for that of higher mathematics in 1593.
In 1588, when Liddel was still in Rostock, there appeared almost simultaneously two works proposing a geoheliocentric transposition of the Copernican cosmos: Brahe's famous *De mundi aetherei recentioribus phaenomenis* anticipated by Ursus' *Fundamentum astronomicum.* Liddel acquired both treatises and started lecturing on the geoheliocentric model alongside the Copernican and the Ptolemaic. Brahe was so alarmed that he accused the Scottish professor of plagiarism.
The suspicion Brahe harboured against Liddel might have been inadvertently fuelled by Craig. The latter wrote Brahe that he did not agree with his hypotheses due to the inconvenient intersection of the Sun's orb with that of Mars. He proposed an alternative solution he attributed to Liddel. It envisaged that the center of Mars' orbit be moved to an intermediate point between the Earth and the Sun, or alternatively that there be a double epicycle for this planet, calibrated so that its distance was increased enough to avoid the problematic intersection with the solar circle. This letter (Edinburgh, 9 July 1589), must have aroused Brahe's concern because of the freedom with which Liddel altered and manipulated his hypotheses, but perhaps also because of the disenchantment with which Craig himself argued the plurality of possible geometric solutions without particular regard to the one Brahe had devised. Moreover, Brahe's disaffection with Liddel must have been enhanced by the deterioration of his relations with Craig because of their disagreement on cometary theory.
From the university curricula of Helmstedt we learn that Liddel's mathematics lessons were fairly continuous. He taught the three hypotheses on an ongoing basis and taught calculation of the ephemerides using both Alfonsine tables and Reinhold's Prussian tables. For trigonometry, he used Regiomontanus's *Tabulae directionum* and, for geography, he relied on a canonical text, the *Chorographia* of Pomponius Mela. He lectured on astrology, as well, on the basis of Ptolemy's *Quadripartitum*.
In 1596, Liddel received the title of Doctor of Medicine with a disputation on melancholy. He became professor of medicine a few years later, in 1600, and he held the chair until 1607, when he left Germany to return to his homeland. In his last years in Helmstedt, he also practiced medicine as court physician in Wolfenbüttel. On his return to Scotland, Liddel promoted the study of mathematics and *humanae litterae*. To people imbued with humanistic culture like him, these appeared to be two sides of the same coin. It was to the new college founded by the Earl Marischal that Liddel directed his attention. In his will, he ordered that his Pitmedden

possessions be granted in mortmain to the Marischal College. He also ordered that 6,000 marks of his inheritance be used to fund a chair of mathematics at Marischal College. As a precedent, we can consider the famous *Erasmusstiftung* of Basel, envisaged by Erasmus of Rotterdam and initiated in 1538. At Aberdeen, John Johnston had anticipated Liddel in 1611 with a donation of 1,000 marks for a scholarship for a divinity student at Aberdeen or St. Andrews. A year after Liddel, in 1614, the doctor of medicine James Cargill would leave the same amount, 1,000 marks, for the support of four needy students. However, Liddel's donation is marked by both its generosity and its visionary nature: in addition to the funding of a chair in mathematics, the support of six students required that they teach mathematics for two years. He moreover bequeathed his scientific library to the Marischal College (now University of Aberdeen).

In the 17th century, scholarships and subsidies of this kind were often conceived in a nepotistic light, since family members and descendants of the financiers had to be favored over other applicants. It is not surprising, then, to discover that the first mathematics professors at Marischal College included two of Liddel's descendants. On 3 July 1661, his homonymous nephew Duncan Liddel, son of his brother John Liddel, was appointed. He was replaced on 29 November 1687 by his son and great-nephew of the founder. Hence, the social status acquired by Duncan Liddel extended to the next two generations.

Conclusions

Liddel's biography bears witness to the real possibility of upward mobility for a Scot of modest origins through an academic *cursus honorum* abroad. His long stay on the continent allowed Liddel to gain experience and wealth sufficient to acquire a reputation at home and, once back, to influence the life of the local community, to strengthen the social status he had acquired and to transmit it to future generations of his family. Among the conditions for such *iter*, I have stressed the importance of networks of personal contacts. The intellectuals of the German lands with whom Liddel interacted were united by common cultural and confessional values, since they were linked to a humanism marked by the teaching of Melanchthon. Mathematicians and humanists maintained intense correspondence and supported promising young men. The European movements of many scholars were made possible, beyond temporary disagreements or disputes on specific topics, by a deep sense of camaraderie which found expression in various forms of support and hospitality. Liddel was welcomed in Frankfurt on Oder by his compatriot Craig, with whom he "shared his table"; he and later his student Daniel Cramer were hosted by Brahe at Hven; Brucaeus and Caselius acted as mediators for the appointment of Rostock scholars in Helmstedt. But beyond personal ties it was the existence of more or less formalized institutional spaces that made possible this movement of people and ideas, as well as the consolidation of scientific traditions and 'schools.' Another aspect I wish to emphasize is that of the circulation of knowledge made possible against the background of these institutional spaces. This transfer primarily concerned the acquisition and dissemination of technical knowledge. For instance, Liddel disseminated expertise and knowledge related to post-Copernican astronomy and Galenic medicine, a transfer incorporated into his collection of medical and mathematical books and manuscripts inherited by Marischal College. His donation made possible the establishment of a chair of mathematics at Marischal College. Thus, the transfer carried out by Liddel also involved the transplantation and translation of institutional models.

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Leonardo on hydrostatic force: a research engineering approach towards the idea of hydrostatic pressure?

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Introduction

Leonardo studied problems of fluid mechanics and hydraulic engineering for most of his life (Roberts 1982, 13-22; Di Teodoro 2002, 258-277; Marani 2010, 329-346). His activities and results in these fields, that are often aimed at the solution of actual engineering problems, often present a very original methodology. Leonardo's work on fluid mechanics and hydraulic engineering is based on a research engineering approach, a mix of confrontation with other scholars and technicians, observations of natural phenomena and laboratory experiments, ideal or not (Bellone, 1982; Macagno 1985, 71-96). A chronological examination of notes and illustrations drawn by Leonardo on hydraulics subjects may lead to a better understanding of his attitudes to them, and may give account of how these attitudes change through time. Adopting this point of view, my contribution will focus on a particular theme studied by Leonardo, the hydrostatic force exerted by water on vertical plane surfaces, closely related to the concept of hydrostatic pressure.

Potenzia vs Resistenzia

We will start examining a part of a quite late page of Leonardo's production, the folio 6 recto of Codex Leicester (1506-1508 ca.) which can be considered as a good summary of his mature ideas on the subject. In this page Leonardo defines the problem: *Che potenzia fia quella, che fa l'acqua contro all'argine che la sostiene*, and gives its solution: *L'acqua sostenuta dall'argine sospinge nell'altezza d'essa argine, dalla superfizie al fondo, con varia potenzia; e questa tal varietà è causata dalla disformità, over dalla inequalità della altezza d'ess'acqua, con ciò sia che, quanto più s'appressa al fondo, con maggior forza spinge in essa argine*. After that, he immediately suggest an application for determining the design *resistenzia* of banks: *L'acqua sostenuta dall'argine sospinge nell'altezza d'essa argine, dalla superfizie al fondo, con varia potenzia; e questa tal varietà è causata dalla disformità, over dalla inequalità della altezza d'ess'acqua, con ciò sia che, quanto più s'appressa al fondo, con maggior forza spinge in essa argine*. This page is important for one key point: it demonstrates that at the end of his life Leonardo understands the action exerted by water from both a qualitative and quantitative point of view. From a qualitative point of view, his understanding comes from the observation of jet and ranges: *Come mostra le cannelle, che versano in varie altezze del bottino*; from a quantitative point of view, it comes from considerations and experiments on weights in equilibrium: *Possi misurare la inequalità di tal potenzie [...] col bottino*.

Jets and ranges

Leonardo indeed often uses the range and discharge of a jet that flows out from a container as an indicator of the intensity of the push exerted by the fluid against a face of the container itself. Let's examine a chronological series of notes and drawings on jets that could have influenced Leonardo's ideas on the characteristics of hydrostatic force. One of the first testimonies of this kind in Leonardo's manuscripts belongs to the Codex Atlanticus, folio 303 verso, dated by Pedretti around 1490 (Pedretti, 1978). It is a small drawing (fig. 1), accompanied by a very short note, in which Leonardo represents two containers (*a* e *b*) filled with water, with very different volumes but with the same height. From their bottoms two jets of identical shape and size flow out; Leonardo writes: *Tanto gitta a quanto b*. Although the explicit topic of this drawing is the comparison between the discharges, the note is important because Leonardo recognizes that the ranges of water jets, caused by the "push" of water, don't depend on the volume of the containers, but only on the height of water inside them.

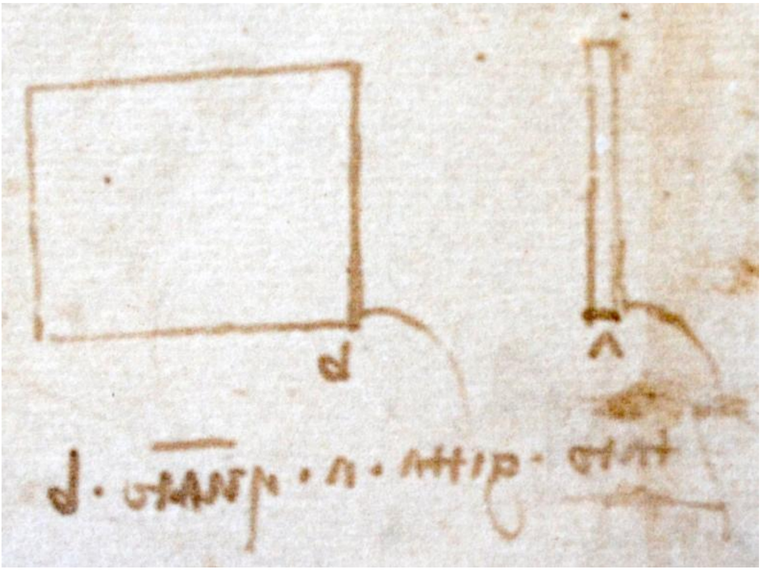

Figure 1: *Codex Atlanticus, folio 303 verso*

On another note, belonging to the folio 5 verso of Manuscript C (ca 1490-91) Leonardo suggests in a more explicit way a direct proportionality between the ranges of the jets and the heights of the fluid in a container (fig. 2).

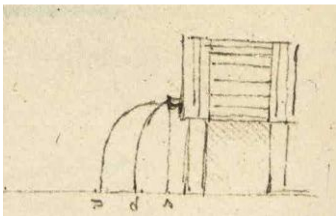

Figure 2: *Manuscript C, folio 5 verso*

In this case the fluid is wine, and it is contained within a small barrel, that lies down on two vertical supports. Leonardo writes: *Quella proporzione che arà b c con a c,*

tale proporzione troverai nelle 2 quantità del vino che si trova in nel vasello, ch'è cagione d'esse mutazione di versare più presso o lontano. In other words, Leonardo says that if double is an observed range (with respect to a shorter one) then double is the corresponding fluid level inside the container and, implicitly, the push exerted by the liquid on the orifice. From the point of view of contemporary hydraulics, Leonardo provides a wrong quantitative interpretation of the phenomenon; two levels which ratio is 2, infact, produce two ranges which ratio is the square root of 2, not 2. Probably the interpretation provided by Leonardo (correct from a qualitative point of view) is the result of a deduction suggested by the observation of the phenomenon itself, not supported by a deeper analysis.
A drawing (fig. 3) on folio 151 recto of Codex Madrid I (1492-97 ca.) depicts what seems to be an apparatus for the 'experimental' verification of the note written by Leonardo on the folio 303 verso of the Codex Atlanticus.

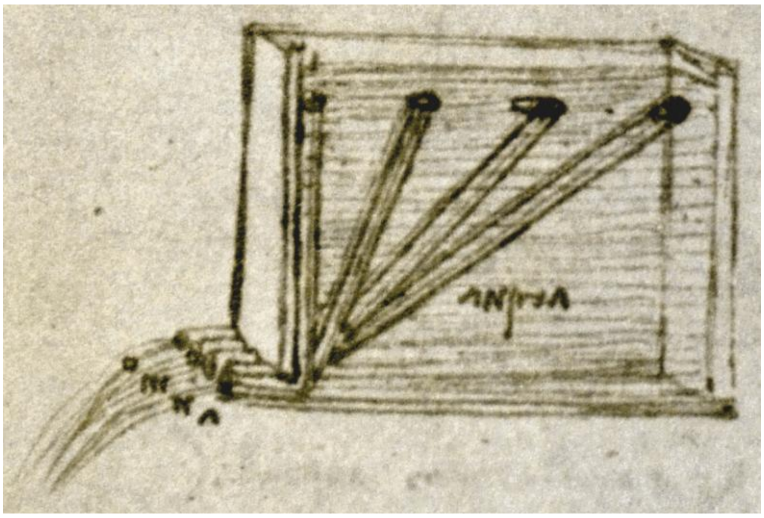

Figure 3: *Codex Madrid I, folio 151 recto*

The drawing represents four pipes protruding from the lowest part of the container; the upper portions of the pipes convey water from different points near the surface of the liquid to the four orifices. The distances of the points from the wall where the outlets are opened increase progressively. Leonardo asks: *Dimando quale di queste 4 canne spignierà più lontan da ssé le sue acque*, so we can infer that this kind of experiment aims precisely to verify that the push in a point near the outlets (in present words the hydrostatic force that generates the jets) depends only on the 'vertical' amount of fluid imposed on the outlet itself, and not on the 'horizontal' one, determined by the other dimensions of the container. Leonardo represents all the four jets flowing out from the pipes with identical ranges, just as if they were produced by pushes of the same magnitude. We don't know if the experiment have been carried out or not, but this detail of the drawing sounds like a confirmation and an experimental justification of Leonardo's belief expressed in Codex Atlanticus, folio 303 verso.
The comparison between the jets produced by a large container and a narrower one characterizes also the folio 117 verso of the Codex Forster IIb (1495 ca.). A drawing (fig. 4) that is very similar to that of the folio 303 verso of the Codex Atlanticus is

here accompanied by a note in form of a question: *Qual gitterà più distante da sé o n o m*?

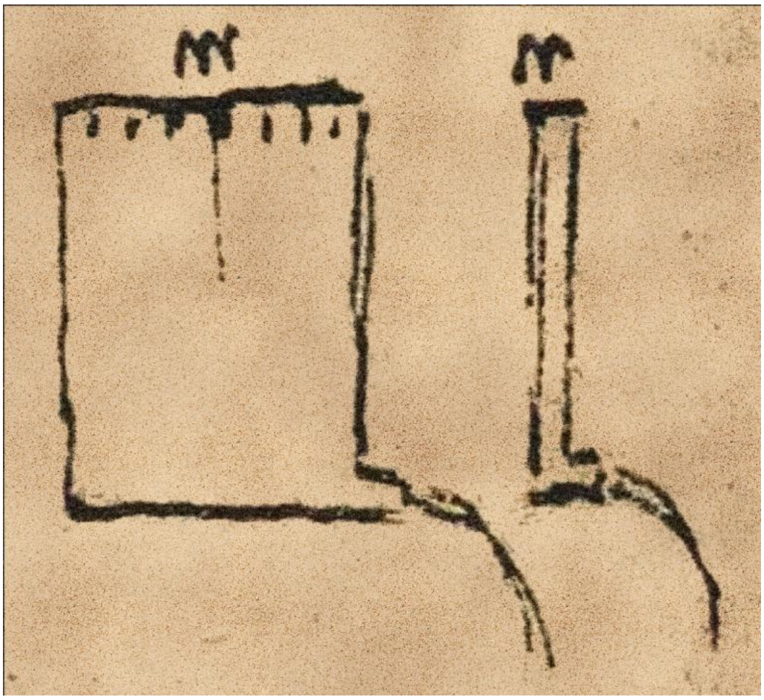

Figure 4: *Codex Forster IIb, folio 117 verso*

The interrogative form can be interpreted here as one of the many questions used by Leonardo to propose different kinds of problems to a fictional interlocutor, with whom he often imagines dialogues aimed at refuting the thesis that he considers false, as well as illustrating the results of his research. The small marks made along the top of the wider container maybe support the hypothesis, because their spacing is equal to the width of the smaller container, which has the shape of a cane.
On the same theme, the folio 114 recto of the Manuscript I (1497-99 ca.) as well contains the drawing of a nozzle supplied by a container that is reduced to the proportions of a "cane" (fig. 5).
This is an element whose transverse dimension is negligible when compared to the vertical one, that univocally defines the height of the water in it. The importance of the vertical dimension is further underlined by Leonardo through the subdivision of the cane in four *gradi di altezza*, which, passing *colla immaginazione* to the description of an ideal experiment, may even become infinite in number: in this case, also the range of the jet flowing out from the nozzle would be infinite. The passage to the infinity, along with the opening sentence of this folio of Manuscript I, reveals a qualitative leap in Leonardo's way of thinking on this subject. He, in fact, asserts that the dependence of the range on water head "is in nature", thus summarizing the data and the intuitions coming from experience and observation in a more general statement, that sounds like a physical law which applies to every similar situation.

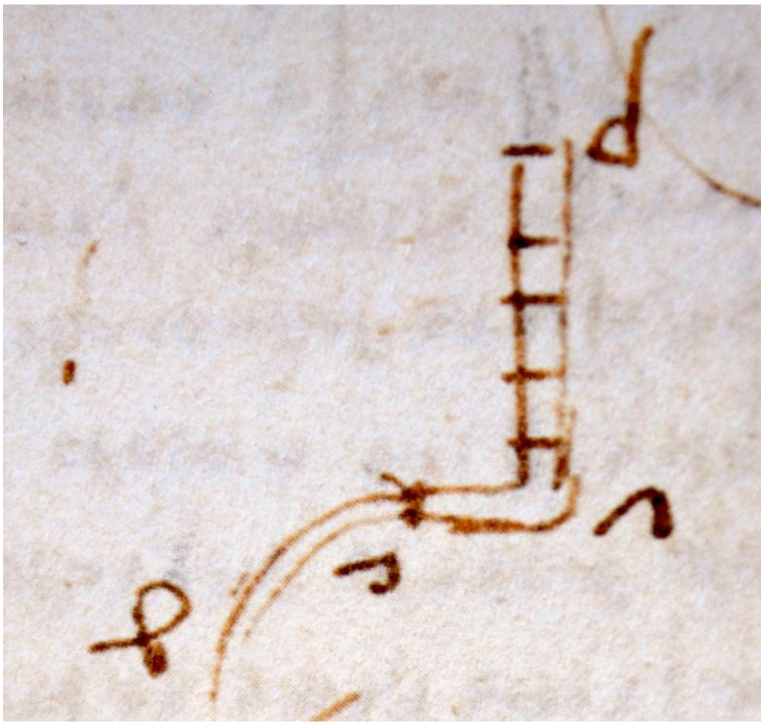

Figure 5: *Manuscript I, folio 14 recto*

This is an element whose transverse dimension is negligible when compared to the vertical one, that univocally defines the height of the water in it. The importance of the vertical dimension is further underlined by Leonardo through the subdivision of the cane in four *gradi di altezza*, which, passing *colla immaginazione* to the description of an ideal experiment, may even become infinite in number: in this case, also the range of the jet flowing out from the nozzle would be infinite. The passage to the infinity, along with the opening sentence of this folio of Manuscript I, reveals a qualitative leap in Leonardo's way of thinking on this subject. He, in fact, asserts that the dependence of the range on water head "is in nature", thus summarizing the data and the intuitions coming from experience and observation in a more general statement, that sounds like a physical law which applies to every similar situation.

Weights in equilibrium

Leonardo tries to describe, characterize and measure the magnitude of the push exerted by water on a vertical surface also in other ways, in particular by studying the equilibrium conditions of systems of hanging weights. A drawing (fig. 6) on the folio 149 verso of the Codex Madrid I (1492-97 ca.) Leonardo represents a quite ingenious instrument.

A container with a square has a mobile vertical face, that is connected to the other faces and to the bottom with a strip of leather. An object (probably an interchangeable body of known weight) is connected to the mobile face with a rope guided by a pulley, in order to counteract the push exerted by the fluid on

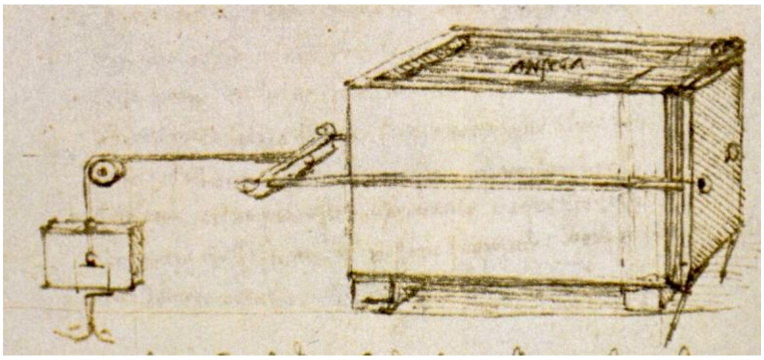

Figure 6: *Codex Madrid I, folio 149 verso*

the face itself. The weight of the object that maintains the mobile wall in contact with the edges of the others gives a direct estimation of the global push acting on the face. The drawing demonstrates Leonardo's intention of studying nature (in this case some properties of the fluids at rest) *ben isperimentando*. The design of some details in this device and the way in which Leonardo intends to use it, however, suggest us that he never conducts any experience with it, not before the draft of the note at least. This experimental apparatus actually contains an error; Leonardo applies the load in the center of the mobile face, while in this case an effective contrasting force must be applied at one third of the height of the face with respect to its bottom. In Leonardo’s arrangement, the mobile face is subjected to a counterclockwise torque, and therefore it is not in a condition of static equilibrium. If Leonardo had really built the device as it is shown and had performed experiments with it, very likely the rotation of the mobile face might have suggested him a shift of the point of application of the counterbalancing weight. Moreover, Leonardo, asserts that the global push acting on one of the faces is identical to those acting on the other three (because all the faces are identical) but he goes wrong when he states that the magnitudes of these four pushes may be subtracted from the global weight of the fluid to compute the magnitude of the push exerted by water on the bottom of the container. If the weight of water and the magnitudes of the four identical pushes had been really determined from a performed experiment, such a computation would have seriously led Leonardo to the paradoxical result of a negative value for the push exerted by water on the bottom, at least in containers with a base side shorter than double the height of the vertical walls.

The research on the action exerted by water on a vertical surface, as well as the development of methods to calculate its magnitude, occupy Leonardo on several occasions, and for quite a long time of his life. The initially mentioned folio 6 recto of the Codex Leicester perhaps illustrates the highest degree of elaboration of Leonardo’s ideas in this field (Fassò, 1987). This is suggested as well by a method for measuring water *potenzia* illustrated in the folio 6 recto itself, whose very original conception directly reminds the drawing on the folio 149 verso of Codex Madrid I. Leonardo proposes an instrument (fig. 7) that consists

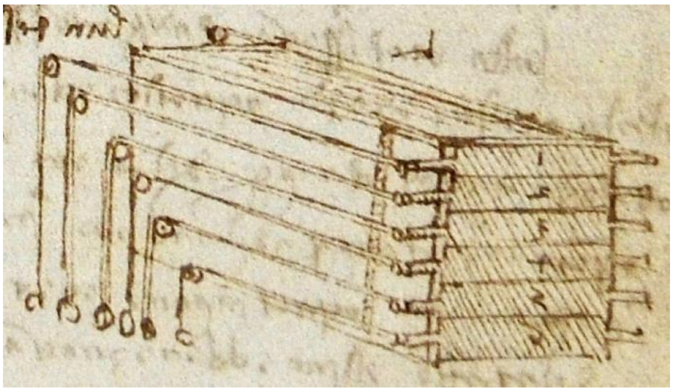

Figure 7: *Codex Leicester, folio 6 recto*

of a parallelepiped container, with a side walls replaced by a flexible parchment. Externally, the parchment is supported by a series of rigid and parallel horizontal bands. Each band is connected to a pair of hanging weights; through a system of pulleys, the loads exert *tanto peso per opposito, che con precisione sostenghino esse righe al contatto della fronte del predetto bottino*. Leonardo does not say anything else about this instrument. Its conception, however, demonstrates that he is aware that the only system of *resistentie* able to keep flat the segmented wall consists of a series of loads whose weights increase with the closeness of the respective bands to the bottom of the container. The values of these *resistentie* indeed are identical to those of the *potentie* that the water exerts on each band. The total *potenzia* acting on the wall is therefore determined by the sum of all those relating to the individual bands.

Even if Leonardo does not develop a calculation technique independent of instrumental measurements to determine the push exerted by water, it is undeniable that with the described instrument Leonardo performs a real mechanical, instead of mathematical, differentiation of the hydrostatic force on the wall of the container, a process that undoubtedly is very advanced at the time. Leonardo actually intends to evaluate the whole action that he calls *potenzia* by summing a finite number of its parts. All these parts are related to an identical portion (the band) of the original wall, but their magnitudes are always different and vary with depth. The design of this instrument, whose conception is even more significant than its incidental construction, moves therefore Leonardo very close to the present representation of the hydrostatic pressure distribution.

It is unclear whether the term *potenzia* uniquely refers to an idea similar to the contemporary concepts of hydrostatic force or pressure. Recalling how easily Leonardo goes wrong when he states that the action exerted on the bottom of a container can be computed by subtracting from the weight of the fluid the sum of the actions that it exerts on the walls of the container itself, it could be argued that in the field of hydrostatics he has some difficulties in understanding the concept of force. Under this point of view, the term *potenzia* probably refers to something analogous to the contemporary idea of pressure. Leonardo, however, often uses the word *potenzia* with different meanings. In the folio 6 recto of Codex Leicester, for example, the measurement of the *potenzia* performed through the weights applied to the segmented face is actually the measurement of a force. At the same time, the *potenzia* of water that increases *in ogni grado della sua profondità* seems again to be more similar to the modern concept of pressure. It is possible, after all, that Leonardo uses this term as common as evocative, with multiple meanings, because he is looking for the right way to call ideas and concepts that maybe are still slightly unclear in his mind, but that he likely feels new (Macagno 1985, 71-96).

Conclusions

This paper presents an overview of the notes and drawings that Leonardo drew up in connection with his studies on the pushes exerted by a fluid at rest on flat vertical surfaces, actions that we now describe through the concepts of hydrostatic pressure and force. According to what can be deduced from the surviving manuscripts and their more likely dating, it seems that Leonardo's ideas on this subject have not undergone radical changes over time, but rather subsequent enrichment brought by different experiences. The observation of jets outflowing from multiple orifices made in the wall of a container may have suggested to Leonardo, since the early Nineties of the XVth century, the idea of a push exerted by the fluid on the wall. The variation of the ranges of these jets, as well as the processes of efflux from containers of different sizes, seem to be the experiences that have led Leonardo to believe, correctly, that the push in one point depends only on the depth of the fluid and not on its volume. Significantly, some of his notes treat the problem by using ideal and 'infinite' dimensional devices, actually a visual translation of the law of variation with depth grasped in its essence. In spite of the often qualitative character of Leonardo's research, he also attempts to quantify water push, probably in order to solve some engineering problems that had stimulated his curiosity. There is no evidence about a resolution of the doubts on the nature of this push that must have accompanied him for a long time, and that drew him more than once in error with regard to the relationship between the weight of the fluid and the actions that it exerts on vertical and horizontal surfaces. It is significant, however, that he considers this action similar to the contemporary concept of hydrostatic force, a quantity whose distribution along the vertical direction may be measured through the balance with a series of increasing weights applied to elements of equal areas. This detail brings Leonardo extremely close to the idea of force per unit area that is nowadays associated with the concept of pressure, whose effects on fluid properties and behaviour seems to be the core of many other notes and drawings by him.

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The Way of the Schlick Family towards Silver Mining in Joachimsthal

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The paper is focused on the prologue of the well-known history of the dollar coins, which were precursors of all the dollar currencies in the World.[1] This history began in Western Bohemia (today's western part of the Czech Republic) in 1516. In that year, the foundation of the mining town of Joachchimsthal[2] took place, after rich silver deposits had been discovered there in the beginning of the 16th century.[3] The oldest preserved silver coins from Joachimsthal come from 1519. The Count Stephen Schlick, founder of the town of Joachimsthal, together with his brothers, began mint these coins at their Freudenstein Castle near the town. Within a few years since the foundation of the town, Joachimsthal became a large mining town, whose population was the third largest in the Czech Kingdom (after the Capital City of Prague and Kutná Hora). The Counts of Schlick built the major economic, cultural, and religious centre on their estates. The German speaking family kept contacts with the Czech Royal Court, but also with the neighbouring Saxon Court. At this point, it is necessary to mention contacts of the Schlick Family with Martin Luther. The town Joachimsthal is also linked to the works of distinguished personalities such as Georg Agricola and Johann Matthesius. However, the glory of Schlick's minting, who created the famous Thaler Coin (dollar), didn't last too long. Ferdinand of Habsburg, the new Czech King and future Emperor of the Holy Roman Empire, strongly restricted the rights of the Schlick family in silver mining and coin minting in 1528, and completely abolished them in 1545. Joachimsthal then became a royal mining town. During the following century, however, the deposits of silver were almost completely depleted and the fame of the mining town was almost forgotten. In the 19th century, Joachimsthal was focused on the production of uranium colours. In the turn of the 20th century, Joachimstal regained its renown, when Marie Sklodowska-Curie isolated metallic radium from the Joachimsthal's pitchblende (more accurately from wastes from a factory producing uranium colours). The so called "Radium Rush", that was supported by the popularity of the local radium spa, brought temporarily back the worldwide fame to the town of Joachimsthal. In the 1950s, Joachimsthal uranium mines were used as the infamous concentration camp for opponents of the communist regime. At present, on the eve of the 500th anniversary of the town's foundation, Joachimsthal is almost a ghost town with dozens of decaying renaissance buildings.

[1] On the history of Dollar currencies see Vorel, P. (2013).
[2] *Joachim's Valley* in English, *Jáchymov* in Czech.
[3] On the issues of the silver mining in Joachimsthal see Majer, J. (1968).

Let's return to a distant past, which preceded the inception of the Joachimsthal phenomenon. The known history of the Schlick family begins in 1394, when this surname appeared on the pages of the account books of the city of Eger.[4] This city formerly belonged to the Holy Roman Empire and, in the 14th century, was joined to the Czech Kingdom as its western part. The first evidenced-based member of the Schlick family was burgher Heinrich Schlick, a merchant with cloth.[5] His life is documented only very sparsely. Some figures on his taxes provide us with the information about the improvement of his economic and social status, caused by clothing and financial businesses, and by his participation in the public administration of the town of Eger. The person, who established the glory of the family, was Kaspar Schlick, son of Heinrich Schlick, who was born in Eger before 1400. Kaspar Schlick[6] achieved his fame and property through his services at the court of the King of Hungary, later Emperor and the Czech King Sigismund of Luxembourg. Politically difficult situation of the King Sigismund in Central Europe in the years 1415–1437 (this mainly concerns the political anarchy in the Czech Kingdom during the Hussite Wars in 1419–1434) brought many opportunities for qualified persons to improve their social and economic status. Kaspar Schlick, the first Chancellor of the Roman Empire of the secular status, was a notable example of this kind of career on the side of the supporters of Sigismund. The efforts to gain the property and estates were characteristic for him. He tried to get for him and his descendants an own estate in Europe and in the Czech Kingdom. The incomes from the services at the court and from the tenure of offices (he started as a secretary and ended as a chancellor) represented the main part of Schlick's profits. Certainly, the official and less official fees for different copies of documents and their certifications, and a number of gifts which diplomats tried to win the Chancellor's favour with, were important parts of Schlick's incomes. Like the father, the son engaged himself in financial business too. It was common in the times of Emperor Sigismund of Luxembourg that the higher administrative stuff served to the King as a certain "financial reserve". Luxembourg stood surety for his numerous debts with the pledges of the royal and emperor properties and often with pledges of the estates. Such estates gave to their holder further gains. The property of Chancellor Schlick was precisely based on such profits. It is possible to see the clear concept in gaining the estates by Kaspar Schlick: he gained records in the profits of small estates lying in the Empire (*e.g.* Alsace) and in the Czech Kingdom, and he turned these estates into the bigger ones through further sales.

The most important issues for the family's future:

a) The gain of the governing in the Royal Estates in the Egerland (including the Castle of Eger) in 1430 was the most important of all.

b) The gift of the Italian estate of Bassano dell Grapa, connected with the promotion/nobilitation to count in 1430. It is necessary to mention here, that this

[4] *Cheb* in Czech, *Egra* in Latin.

[5] On history of the Schlick Family see Tresp, U. (2012). Also see Novotný, M. (2011b).

[6] On newest conclusions about the life and the career of Chancellor Kaspar Schlick, see Elbel, P. and Zajic, A. (2012).

diploma is probably a fake. This estate was important for the future using the title of the Count of Bassano, but the Schlick family had never this castle in real holding.
c) The gain of the Castle of Weisskirchen in Hungary in 1438 had a similar meaning for the Schlick family. The tenure of this castle and estates was particularly important for using the Hungarian title of Lord of Weisskirchen.
d) The gain of the governing in the Royal Estates in the region of the Loket[7] Castle in 1434.
During his career at the Imperial Court of Sigismund, Kaspar Schlick achieved a big fortune and promotion to the Count of the Holy Roman Empire. However, it should be mentioned, that many of the diplomas, issued in favour of Kaspar Schlick, were probably false.
Chancellor Kaspar Schlick got the pledge of two important royal offices: The Burgrave of the Castle of Eger and the Burgrave of the Loket Castle in the Czech Kingdom. His brother Mathes Schlick[8] began to govern this property in the time of the Chancellor's absence in the Czech Kingdom. Kaspar Schlick focused on the estates in Weisskirchen, Kreuzenstein, and Vienna; the latter was located near the court of the Frederick von Habsburg. After his death in 1449, his son Sigismund inherited these estates.
It has already been mentioned that Kaspar Schlick tried to gain the estate Bassano in Italy. His relationship to Italy was probably deeper. In his false diploma, Kaspar Schlick created the legend about his alleged origin in Italy; in addition, he was in contact with Italian nobility. His relationship with the humanist Eneas Silvio Piccolomini is the most important of these contacts. The future Pope Pius II was subordinated to Schlick in the Imperial Office of King Frederick von Habsburg. Piccolomini immortalized his lord in three literary pieces. Schlick's character probably appeared in a love novel Euryalus and Lukretia,[9] and a short curriculum vitae of Schlick is possible to find in Piccolomini's Czech Chronicle.[10] But the most important literary monument of Chancellor Schlick is in Piccolomini's work called Pentalogus,[11] which is an imaginary philosophical and political discussion about the future of the Roman Empire and the church: There are the Emperor and his Chancellor speaking among five prominent representatives of the society. Because Schlick's arguments about the centre of the Holy Roman Empire located in Rome seem to be very sceptical, it is probable, that his relationship to Italy was strictly pragmatic. It is most likely that Kaspar Schlick was not follower of the ideas of humanism.
The success of gaining and holding the estates by Kaspar and Mathes Schlick was enabled by the crisis of the power of the Czech King during and after the Hussite Revolution. Nevertheless, the holding of the estates seemed to be a big problem after the death of Kaspar in 1449.

[7] *Elbogen* in German, *Cubitus* in Latin, *Elbo* in English.
[8] On short biography of Mathes Schlick, see Novotný, M. (2011a).
[9] Piccolomini A. S. [1442] (1929).
[10] Piccolomini A. S. [1458] (2005).
[11] Piccolomini A. S. [1443] (2009).

When Kaspar Schlik suddenly died, his sons Sigismund, Wenceslaus, and daughters Beatrix and Constance were still underage. That is why his younger brother Mathes took over the control over the family's property. He found himself in a difficult situation. His powerful brother left him a large fortune deposited in a number of diplomas and privileges, which, however, were appointed for Kaspar Schlick and his sons and daughters, not for Mathes Schlick and his sons. Knight Mates Schlick defended the majority of these properties.

To simplify, the properties after Kaspar Schlick can be sorted into three groups, ordered according to their significance:

1) The governing of the royal property in the Eger region. The former imperial territory was fully constituted since the early Middle Ages and didn't give any possibility to anybody to gain own estates here. Also, the usurpation of a royal property in the boundaries of this legally consistent territory was impossible. To sum up, there weren't any free estates in the Eger region. Nevertheless, among the other towns of the Holy Roman Empire, the political power of the town of Eger was very important. Mathes Schlick (born in Eger), governor of the Royal Estates in this territory, proved to do his best from his contacts. After his nephew Wenceslaus grew up, Mathes Schlick let him govern over this politically important royal property.

2) The governing in the Royal Estates in the Loket Castle region, where a settlement of Konradsgrün (future Joachimsthal) was located; this was a better starting point for the building of own estates. Here, in the region of the royal Loket Castle, the legal situation was quite different. Almost all of the estates were under the authority of the royal castle, and the number of autonomous estates was marginal. The Royal Governor of the Loket Castle was more powerful here than in the Eger region. On the other hand, the efforts of Mathes Schlick and his sons for the subjugation of their subjects caused bloody wars. However, it can be concluded that Schlicks' governing over the Loket region was comparable to their ruling over their own domain.

3) The tenure of the estates outside the Kingdom of Bohemia – in Saxony, Hungary (which is the Slovak Republic today), and Austria. It has been mentioned that these estates gained Sigismund. After his death, his brother Wenceslaus gained the estates in Austria. He sold them towards the end of the 15th century.

4) The possession of the Bassano estate in northern Italy has been mentioned above. The titular estate of Bassano dell Grapa is connected with the efforts Kaspar Schlick for gaining the title of the Imperial Count. The Schlick family never really held this estate, but they didn't stop to claim it until the beginning of the 16th century. From 1503, the entire family was using the title of the Count of Passaun.[12]

The strengthening of the political position of Mathes Schlick was supported by his strong relationship to the Saxon Court and his great diplomatic skills. Period of the second half of the 15th century in the Czech Kingdom was similarly dramatic as the Hussite Wars of the early 15th century. The reason for that were several years of interregnum, and then the subsequent ruling of King George of Poděbrady, who – due of his Hussite faith – was not recognized the legitimate ruler by neighbouring sovereigns. In this difficult political constellation, Mathes Schlick became an important political element on the border between the Czech Kingdom and the Holy

[12] On the strategies of the Schlick Family, see Tresp, U. (2009).

Roman Empire; he kept this position for almost 40 years, till his death in 1487. He became a true mediator between the Saxon Court and Bohemia. In spite of his speaking German and gaining an important position at the Saxon Court, his allegiance to the Czech Kingdom is undoubted. Mathes Schlick used his strong political position to subjugate the Royal Estates of the Loket Castle region. These efforts caused tensions between him and his subjects, which resulted several times in armed conflicts. It is worth to mention, that the during the unrests in the Loket Castle region – during the war between George of Poděbrady and Matthias Corvinus – it occurred to Mates Schlick to sell his rights to Loket to the Saxon Dukes. Mates Schlick was considering leaving the Loket region and moving to an estate in Saxony. The fact, that the sale was finally cancelled, resulted in remaining the Schlick family within the borders of the Czech Kingdom. That was a crucial moment for the future of Joachimsthal. In 1471, after the failure of the idea of the sale, Mates Schlick and his sons focused more on the subjugation of the Loket region. These efforts can be interpreted as an attempt for a greater degree of independence from the Saxon and Czech states, and as an attempt for actual direct subordination of the Loket region to the Roman Empire. These efforts of the Schlick family resulted in a military intervention of the Czech army in 1506, which defended the integrity of the Czech Kingdom. Nevertheless, the question remains if the Schlick family considered separatist activities, or it was only a consolidation of their own position on the Czech-Saxon border, and a new definition of their relationship to the Czech King and the Czech nobility.[13]

The main business activities of Mathes Schlick concerned the profits of his estates; small local wars and diplomatic negotiations could also be a certain source of his profits. The first information about the mining and metallurgical activities of the Schlick family come from Mathes Schlick's time, namely 30 years before the foundation of Joachimsthal.
Mathes Schlick died in 1487 and was buried in the church of Loket. In 1489, his sons divided their properties into three main family branches: the Loket branch (Jerome), the Falkenau branch (Nicholas) and the Schlackenwerth branch (Kaspar); the last branch gave Joachimsthal to the world.
The consolidation trends for the positions in the Loket region continued long time after the death of Mates Schlick. Jerome Schlick and his sons continued by further oppression of the inhabitants in the Loket region; they tried to turn the people into their subjects. As mentioned above, the highlight of Schlick's revolt against the legal order occurred during a military expedition against him in 1506; the Schlicks were forced to rethink their approach and they began to find the possibilities of the coexistence in the structures of the Czech Kingdom. Nevertheless, the rest of these trends for independence might be possible to find in their entering the royal right of the silver mining and minting after the establishment of Joachimsthal in 1516, as well as in their business with silver, independent of the Czech King. Both of these facts could be understood as a continuation of an old emancipatory trend. The hard clash with the Habsburg superiority after the ascension of Ferdinand I to the Czech

[13] Tresp, 2009, 200–201.

throne in 1526 stroke at the heart of the similar ambitions of the Schlick family. The defeat in 1506, the foundation of Joachimsthal, and its final loss in 1525/1545, are the milestones of a closer association between the Schlick family and Czech nobility. Changing of Schlicks' relationship to the King and nobility was evidenced by their positions in anti-Habsburg uprisings. As early as 1547, a part of the family opposed Ferdinand I, and in the early 17th century, Joachim Andrew Schlick was in the lead of the anti-Habsburg revolt in the Czech Kingdom.[14]

The way of the Schlick family to their founding the renaissance mining town (technological, cultural, a religious centre) led through four generations. The ordinary burgher of the town of Eger, a merchant with the clothes, stood at the beginning of this path. His son Kaspar Schlick, who became the Chancellor to three Emperors, was a very qualified man with many skills and contacts. His career resulted in his economic and social promotion. The career of his brother Mathes was not that great, but he was successful as well. He preserved the gains of his brother Kaspar for Mathes's family and continued in the efforts of Kaspar Schlick to find an own estate for the family. Unlike his brother, he began to concentrate his interest on the Loket region. That was important for his grandsons, who found silver and started the coin-minting there, with the support of mining specialists, mainly from Saxony.

(English translation: Igor Janovský)

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Mathematical Courses in Engineering Education in the 17th and 18th c. in the Iberian Peninsula

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The idea of combining theory and practice in mathematics was forged in the seventeenth and eighteenth century as a result of different influences. Several mathematical courses published through the seventeenth century offered extensive material for teaching pure and “mixed” mathematics, such as pure geometry, practical geometry, optics, statics, mechanics, artillery, and fortification. In the eighteenth century, these textbooks were the fundamental source for engineering courses. In particular, we would like to focus our analysis on relevant mathematical courses developed in the Iberian Peninsula by authors such as Luis Serra□o Pimentel (1613-1679) and Manuel de Azevedo Fortes (1660-1749) in Portugal, and Sebastián Fernández de Medrano (1646-1705), Jorge Próspero Verboom (1667-1744), Pedro de Lucuce (1692-1779), Tomàs Cerdà (1715-1791), and Pedro Padilla y Arcos (f.1753) in Spain. Most of these courses were designed for the training of military officers. References to them appeared in several treatises produced in Spain, France, or Germany. At the beginning of the eighteenth century, the works of Bernard Forest Bélidor (1698-1761) were particularly influential. We aim to determine the central subjects for engineering education. Two parts are recognized as essential for the training of an engineer: practical geometry and fortification. Practical geometry consists of trigonometry, logarithms, trigonometric and logarithm tables, instruments and their application in the field. Fortification consists in describing the building of defence lines, fortresses, and bastions. However, analysis of the contents of these treatises raises other questions for discussion related, for example, with the role of pure mathematics. What was the interpretation or the version of Euclid’s Elements used in these textbooks? Does the use of the geometry of Port Royal have any significance? One could also consider other aspects such as to what extent these mathematical courses spread or appropriated the new knowledge in that time, like algebra or infinitesimal calculus. In addition, an international network of mathematical works was assembled to provide a better education for engineers. The communications on these aspects of mathematical courses will offer new insights into the kind of knowledge available to engineers in the eighteenth century and in consequence its influence on the society. The education of engineers gives us an outstanding example of how international –cosmopolitan- knowledge becomes a local culture, the engineering culture, purportedly “national” in many cases, as explicitly suggested by the title of the notable textbook by Manuel de Azevedo Fortes (“The Portuguese Engineer”).

The Art of Fortifying and the Mathematical Instruments: Tradition and Innovation in the Training of Military Engineers in the 17th c. in Portugal

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Introduction

Innovations in military engineering are contextualized with the questions about knowledge and the emergence of new languages in the modern period. For explanation of reality and theoretical discourse the image and illustrations became more important and sophisticated. Here also fit the recommendations of the Jesuits in the use of mathematical concepts and scientific instruments and the appeal to use and practice of instruments, given the fallibility of the senses: the Euclidean postulates should be the paradigm of scientific evidence, gaining primacy in face of natural philosophy of Aristotle. The beginning of the modern period, confronted by new discoveries and interrogations regarding scientific knowledge, marks the emergence of new languages. The question of images and scientific illustrations as copies of reality, the representation of instruments as complements of the written discourse, had been gaining strength since the sixteenth century. The alert given by the Jesuits in relation to the deceit created by the senses appears within this context, appealing therefore to the use of mathematical concepts and scientific instruments (such as the telescope) and wagering in the practical dimension of these same instruments (beyond the symbolic dimension they already had). It was the Jesuit order that gave Mathematics the responsibility to explain/demonstrate the physical world, countering the Aristotelic primacy of Natural Philosophy; for them, the principle of all sciences should be as evident and universal as the Euclidian postulates. One of the strongest examples of the application of mathematical knowledge is situated at the level of military engineering, which reveals, in its engineers, excellent mathematicians, some of them with a Jesuit education.
The military engineering has proven to be the field par excellence of the application of mathematical knowledge: many engineers are excellent mathematicians, with a Jesuit education.
On the other side, fortresses and fortifications represent a huge effort and technological progress for its time. During the modern period, fortresses and strongholds reflect synchronous scientific and technological advances, also denoting the deepening of specific knowledge that would derive into the appearance of schools and of an immense corpus of treatises. Indeed, the scientific character of these fortifications and the works of military engineering allow us to demonstrate and strengthen the relationship between science and technology from the 16th to the 19th centuries. Fortifications, during this period, expressed, beyond their military content, an ideological testimonial, offering an example of harmony between military techniques and the historical moments.

The appearance of pyroballistic and its widespread usage in the battlefields led to alterations in the fortified spaces, in order not only to improve the fortified structures themselves, so as to enable them to resist attacks, but also to respond to the need of installing artillery pieces and cannons for defence. The bulwarked fortification was conceived not only to protect the surrounding terrain, but also the territory behind it, in a time that the circulation of masters and ideas, in the most diverse domains, characterizes the modern period in a European level. Architecture and engineering were determining fields in this panorama and, in respect to Portugal, the presence of architects and engineers from Italy, Netherlands, France and others, would end up influencing creation in these matters.

The advent of *"engineers and architects of war*" in Portugal in modern period
Portugal, in the early modern period, witnessed several initiatives due to the confirmation of the frontier lines, work made by Duarte d'Armas in 1509, by mandate of king D. Manuel. In Europe, architects and engineers wagered on the adaptation of fortified constructions to the use of artillery, appearing a new polygonal bastion that would revolutionize the conception of fortresses during the second quarter of the 16th century. The geometric organization of space with angular bulwarks and regular layouts had several foreign interpreters in Portugal from the 1500s on, who were instrumental, both in the education of national masters and in the Portuguese military architecture itself. They stayed in Portugal after the dominance of the "Philip kings", and later participated to the reinforcement of the terrestrial frontier during the Restoration War [*Guerra da Restauração*] (1640-1668). In this context, we find, in Alentejo in the XVII century, among many others, João Pascácio Ciermans (Dutch), a Jesuit priest, known as Cosmander (in charge of observing all strongholds along the border, suggesting the reinforcement or the creation of fortifications according to the "Dutch method"), Nicolau de Langres (French engineer), Jean Gillot (Dutch), P. Santa Colomba, the author of treatises Manesson-Mallet, all under the orientation of chief-engineer Charles Lassart. Sure enough, the fortresses from this period were mainly conceived by European engineers, originating from regions that had been war zones for many years, and whose work reflected the abandonment of the Italian model in favour of Nordic models. The ascension to the throne of king D. João IV, in December 1640 marked a new attitude towards the importance of a defensive reinforcement: appearance of a permanent army and auxiliary bodies; creation of the Council of War and the Border "Junta" [Assembly] especially to inspect and deal with all matters relating to fortifications; creation of military provinces, being Alentejo one of them, the most extensive and with topographic characteristics that made it vulnerable, hence the strong concentration of military posts between Moura and Castelo de Vide (responding roughly to the location of the Spanish ones, opposing them from the other side of the border), and the priority given, also during this period, to the defensive reinforcement of inland cities such as Évora and Beja. To this concentration also corresponds a diverse typology, with distinct interventions, from the wholly bulwarked enclosure (Elvas), to the building of defensive points of lesser dimension (isolated bastions, forts) that varied according to the priority of enemy attacks. Within this context we find the character of Luís Serrão Pimentel, author of

the *Methodo Lusitano* (published posthumously by his son, Francisco Pimentel). He was responsible, since 1647, for the Lecture on Fortification and Military Architecture for the education of Portuguese military engineers[1]. Luís Serrão Pimentel basically inspired himself, from a theoretical point of view, in Adam Freitag, Mathias Dogen, Goldman, Marolois, Coheorn and Stevin, while at the practical level he coexisted with some foreign engineers active in Portugal at the time. With him, we see the achievement of the ambition to educate national masters in the area of military engineering, which would continue in the following century and that Azevedo Fortes's book *O Engenheiro Português [The Portuguese Engineer],* implements. This author acknowledges as indispensable to the formation of good engineers' the knowledge in the areas of Arithmetic, Elements of Euclid, Practical Geometry, Trigonometry, Fortification, Attack and Defence of strongholds, the usage of the Mathematical instruments pertaining to its profession.
Luís Serrão Pimentel in *Methodo Lvsitanico* criticises some European theorizers, such as Blaise François, Count of Pagan, from the so-called second French school of fortification, before Vauban's advent. Pimentel inspired himself in the example from Holland, praising the ability to resist proven by their fortifications before the Spanish. The practical application of these treaties as far as construction is concerned can be found in several fortresses in the Southern part of Portugal, particularly Elvas. In this case, the application to the terrain of the most important geometric features of the so-called *first Dutch method* of fortification (that started in Leiden, 1575) resulted from the designs of Dutch Jesuit Jan Ciermans (known in Portugal also as João Pascácio Ciermans, or João Cosmander) in 1643[2]. Cosmander worked in the inspection of military posts at the border with artillery Lieutenant-General Rui Correia Lucas and with the French engineer João Gilot; apart from Elvas, he also worked in the fortifications of Évora, Estremoz, Olivença, Campo Maior and Castelo de Vide.

João Pascácio Ciermans (Cosmander) and his work in South of Portugal

João Pascácio Ciermans, S.J., teached in Lisbon at "Aula da Esfera", in 1641/1642, and received from the Portuguese king, John IV, the rank of colonel superintendent of Engineers; he was also engineer in the province of Alentejo. Flemish, from Leuven, mathematician, and with the exercise of fortifications in Iberia a consummate engineer, renovating, expanding or rebuilding the fortifications in the region of the South of Portugal: fortification of Vila Nova del Fresno, Olivenza (works suspended because of spending), Santa Luzia, in Elvas and in 1642, with João Gilot, inspected all the squares border.
In his formation, mathematics were very important, because since the late sixteenth century was an integral part of Jesuit pedagogy, as demonstrates the *Ratio Studiorum* of 1586, thinking that mathematics was the base of medicine, navigation,

[1] During this period, it was especially important the application of mathematics to science of fortification and military architecture, establishing the monarch in *Ribeira das Naus* a Class, which had as its first master Luis Serrão Pimentel.
[2] Cf. Edwin Paar, "Fortificações urbanas de Elvas: o melhor exemplo actual da Primeira Escola de Fortificação Holandesa" in Clio: revista do centro de História da Universidade de Lisboa, 2006.

agriculture and services to the State. Student of Christophe Clavius, priest at the Roman College, Cosmander, as Clavius, also integrates mathematics with natural philosophy. In Jesuit colleges instruments supported classes, such as the use of the compass of proportion, and the mathematics courses show an alert to new theories, producing also many works in the field of trigonometry and arithmetic. In Portugal, he was tutor to the heir of the portuguese throne, the Prince D. Theodosius, especially in the field of Geometry, and when the master retired to Alentejo, the Prince explained to his associates the 6 books of Euclid according with the exposure of Clavius. Beyond Geography, the Prince applied to the Marine, the Hydrostatic and particularly to Astronomy, which he greatly appreciated, and he was provided with all mathematical instruments. About D. Theodosius, Cosmander said that he *«(…) he appreciated us so much we can say that for regular company only lacked clothing (…) ».*

We underline that this concern for the education of princes was much older, and Pedro Nunes, the most known Portuguese mathematician, was preceptor of Cardinal Henry, in 16th century, Prince much given to the mathematical sciences, as well as his brother D. Louis, learning Arithmetic, Geometry.

Following these principles, and the division between *mathematicae purae* (mathematical disciplines, dealing with quantity, continuous and discrete as in geometry and arithmetic) and *mathematicae mixtae* (mathematizable disciplines, or mediae, dealing with quantity but also with quality, as astronomy, architecture, geography, optics), Cosmander in the book *Disciplinae Mathematicae traditae anno institutae societatis Iesu secularie* (Louvain, 1640), written in Latin, speaks about the last ones: Optics, Static, Hydrostatic, Nautical, Architecture, Art of war, Geography, Astronomy and Chronology. He produced this work and published it, like many other authors, following the Jubilee 1639/1640 of the centenary of the Company, demonstrating that mathematical sciences were in various fields of knowledge, and, as the images in the book demonstrates, with a practical application; only the Enlightenment and the scientific revolution[3] (late 17th to early 19th) assured the appearance of different, and independent, scientific disciplines.

The work is divided according to the months of the year, each one with three weeks; in the book there are no page numbers. The month of October is dedicated to Geometry, where the Author cites Clavius, Euclid, Jacques Peletier du Mans (1517-1582), one of the most important French algebraists before François Viète (1540-1603). Cosmander talks about *Pantometria*, term created by Leonard Digges , that wrote, in 1571, *A Geometrical Practise, named Pantometria*, containing standards for measuring lines (longimetry) surfaces (planimetry) and solids (stereometry). The month of November is dedicated to Arithmetic, citing fractions, prime perfect numbers logarithms, rabdological method (Method of calculation using chopsticks that are marked in the simple numbers simple) and the prostaferesys (difference between the actual movement and the mean motion of a planet). December to

[3] Volker R. Remmert «What Do You Need a Mathematician For? Martinus Hortensius's "Speech on the Dignity and Utility of the Mathematical Sciences" (Amsterdam 1634)», http://oz.nthu.edu.tw/~g9662561/IT2010/1208-4.pdf

Optics, January to Statics, February to Hydro, March to Marine, Architecture, Fortification, War Machines, Geography, Astronomy and Chronology.
The month of April treats the architecture, particularly the military architecture, with many words referring it (revelins, curtains, *cornuta* work, crowned work, fortification). May, dedicated to Fortification, with military contents, and particularly the castramentation and propugnation as well as the movement of troops. Juinto war machines, July is dedicated to Geography, especially to the question of the diameter of the world, the making of map-mundi and the determination of longitude; August refers to Astronomy, citing the meridians and azimuths, the tropics or the use of the astrolabe. Finally, September refers to the measurement of time, Chronology, with particular focus on the calculation of the Gregorian calendar.

Figure 1: *Month of April, Architectonicae.*
Source: J.P.Ciermans (J. Cosmander), Disciplinae Mathematicae traditae anno institutae societatis Iesu secularie. Louvain, 1640.

In the book we don't find diagrams, calculation, or mathematical calculi; the instruments immerge like an ornament in the discourse, not very scientific, to a public not very specialized, with a pedagogical intention.
Another interesting iconographic evidence of military architecture and engineering from the modern period in Southern Portugal is offered by the superb glazed tile panels from a Jesuit College, the actual main building of Évora's University. The ensemble of glazed tiles, called "*azulejos*", dating mostly from the early 1740s; some designs of instruments are very similar to those of Cosmander work, with Jesuit

content too. Particular attention is given to the scientific context and to the technological advances from that period. We can observe not only the instruments' representation – a quadrant, compasses with straight and curved points – but also their usage and practical demonstration.

Final Considerations

1. Bulwarked fortifications or fortresses "in the modern way" imposed themselves in Europe through different schools and models, and for a long period of time;
2. Portugal, and in particular the Alentejo region, have been the stage, from the 16th to the 18th centuries, for the presence of technicians from the fields of military architecture and engineering, originating from different European countries;
3. Among these foreigner engineers, was Jan Pascácio Ciermans, or João Cosmander, a Jesuit priest, teacher of mathematic in Portugal, especially in Court; as Jesuit, accomplishing their principles in its learning, he devoted a large importance to the practice of Mathematic (putting together theory and practice) and to the mathematical instruments, as proof the work *Disciplinae Mathematicae* (Leuven, 1640);
4. Not only should the fortifications themselves must be preserved: their theoretical support, like the treaties in different fields, or their remaining images and representations, must be also safeguarded as part of a vast heritage.

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Contents and Sources of Practical Geometry in Pedro Lucuce's Course at the Barcelona Royal Military Academy of Mathematics

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Introduction

Established in 1720, the Royal Military Academy of Mathematics of Barcelona seems particularly interesting as an example of organizing training for engineering, insofar as its main goal was to provide knowledge in mathematics to both young and experienced officers in military fields.
There are many historical studies of the Academy that describe the running of the institution, the type of education and the books most frequently employed there, etc..[1] However, there has yet to appear an in-depth study of the content of the texts used in teaching at the Academy, and its comparison with other institutions in Europe during that period. Our studies have therefore focused on the contents of this education,[2] and in this communication we analyse the treatment of pure geometry in a Mathematical Course used at this Academy for 40 years. In fact, pure geometry is a version of Euclid's *Elements*. We study what the contents of this geometry were, and also the significance of the treatment of Euclid's *Elements* when this course is compared with other contemporary textbooks.

Teaching mathematics at the Royal Military Academy of Mathematics (1720-1803)

In 1712, the General Engineer Jorge Próspero de Verboom presented the project for a military academy that was modeled on the Royal Military Academy in Brussels, set up by his teacher, Sebastián Fernandez Medrano (Navarro Loidi 2004). The lack of centers for military education gave rise to a number of debates on how to develop the training of Military Officers. On the basis of his experience at the Brussels Academy, Verboom was convinced that Officers should be educated in pure and mixed Mathematics and, after some negotiation, the Barcelona Academy opened in October 1720.

[1] See Riera1975, Capel1988 and Muñoz Corbalán 2004.There are also many documents in the AGS (Archivo General de Simancas) and in the Archive of Military Region in Barcelona containing copies of exams, lists of students, letters, etc.
[2] In fact, we have recently published an article in which we show how training of the military was centred on the teaching of several subjects (multidisciplinary) under the single heading of Mathematics, presented as a Mathematical Course in accordance with the tradition of the mathematical courses initiated in the seventeenth century (Massa et al. 2011).

The first directors of the Barcelona Royal Military were Mateo Calabro (1720-1738) and Pedro Lucuce y Ponce (1738-1779).[3] We focus our research on the time when Lucuce was the director, which corresponds to the period regarded as the most brilliant at this Academy. In 1739, a Royal Ordinance set out the contents of the course in mathematics that was to be taught in the academies. The Ordinance followed the reports made by Verboom in 1730 and also by Lucuce in 1737. The director was required to prepare a course of mathematics according to the guidelines of this Ordinance, Article 9 of which states that: "In order to achieve education according to this idea, the Director General should select the most useful mathematical Treatises, arranging them methodically so as to be of greatest benefit to the Academics, writing the subjects that must be taught as his own doctrine, which should include everything to be imparted in the Academy, extending explanation as far as should be deemed necessary."

What were these Mathematical Treatises referred to in the Ordinance? We have no direct information about this in the Ordinance, although some Mathematical Courses are mentioned in the previous reports by Verboom and Lucuce. It should be remembered that the tradition of Mathematical Courses as textbooks began in seventeenth century, and the courses by Dechales, Ozanam, Tosca and Belidor constitute those most relevant for our research. The three volumes on pure and mixed mathematics by Claude François Milliet Dechales (Chambéry, 1621-Turín, 1678), which form the *Cursus seu mundus mathematicus* (1674), included the first eight books of Euclid, Arithmetic, the Spheres of Theodosius, Trigonometry, Practical Geometry, Mechanics, Statics, Universal Geography, Civil Architecture, etc. This course was widely read and exerted much influence in Europe; for example, it influenced Mathematical Courses such as Tosca's *Compendio* and possibly Lucuce's *Course*. It is also noteworthy that in the XVII century Jacques Ozanam (1640-1717) wrote a *Cours de Mathematique qui comprend toutes les parties de Cette Science les plus utiles et les plus necessaires à un homme de Guerre et à tous ceux qui se veulent perfectionner dans les Mathematiques* (Paris, Jombert, 1693), dedicated to men of War. It consists of five volumes:1) Introduction to Mathematics and to Euclid's Elements; 2) Arithmetic and Trigonometry; 3) Geometry and Fortifications; 4) Mechanics and Perspectives; 5) Geography and Gnomics. In the eighteenth century, and following the tradition of these courses, Tomàs Vicent Tosca (1651-1723) wrote a *Compendio Mathematico* (1707-1715) consisting of 28 treatises in 9 volumes (Navarro Brotons 1985). The first volume deals with Elementary Geometry, lower Arithmetic and Practical Geometry; the second addresses high Arithmetic, Algebra and Music; the third, Trigonometry, Conic Sections and Machinery; the fourth, Statics, Hydrostatics, Hydrotechnics and Hydrometry; the fifth, Civil Architecture, Military Architecture, Pyrotechnics and Artillery; the sixth, Optics, Perspective, Catoptrics, Dioptrics and Meteors; the seventh, Astronomy; the eighth, Practical

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[3]Pedro Lucuce studied Canon Law at the University of Oviedo, but he left this career to join the Army in 1711, during the War of Spanish Succession (1705-1714). After the War he joined a regiment in Madrid where he had the opportunity to study Mathematics on his own initiative. In 1730, he was elected simultaneously member of the Corps of Military Engineers and of the Corps of Artillery. He chose the engineering corps and in 1736 joined the Academy of Mathematics of Barcelona.

Astronomy, Geography and Seamanship; the ninth, Gnomics, the Ordering of Time and Astrology. Tosca's work went into a further three editions during the 18th century, and some volumes were published separately. This is a clear indication of the reception and influence enjoyed by this work. Also in the 18th century, and as an antecedent to Lucuce's course, we may mention the work of Bernard Forest de Bélidor (1698-1761), a French military engineer born in Catalonia, entitled *Nouveau Cours de Mathematique, a l'usage de l'artillerie et dugenie ou l'on applique les Parties les plus utiles de cette science à la Théorie & à la Pratiques des diffèrents sujets qui peuvent avoir rapport à la Guerre* (Paris, Chez Nyon, 1725) consisting of ten parts with many chapters including geometry, trigonometry, geodesy, mechanics and hydraulics. As the title indicates, it was an eminently practical course to be used as part of military training, in which Bélidor was involved. This book was used in the new schools of artillery established by royal decree in France (Hahn 1986). Bélidor is considered to be the modern creator of engineering science, and his works were enormously influential during the eighteenth century in France as well as in many other countries.

In fact, in 1730 Verboom quotes Tosca and Belidor as examples to follow in some parts of course. In this sense, the promoters of the Royal Military Academy of Mathematics of Barcelona shared the general approach adopted by these authors, and emphasized that engineering training should be conducted through a Mathematical Course of this kind.

We therefore present the Mathematical Course drawn up by Lucuce according to a broad and modern vision of mathematics, which consists of eight treatises dealing with the main fields of mathematics, including "pure" mathematics (arithmetic and geometry), and "mixed" mathematics (the rest): 1) On Arithmetic**;** 2) On Elementary Geometry; 3) On Practical Geometry; 4) On Fortifications; 5). On Artillery; **6)** On Cosmography**;** 7) On Statics and 8) On Civil Architecture (Massa et al. 2011, 243-244). Although this course was never published, it has been preserved in several manuscripts written by different students from the Barcelona Academy, and also from two other centres in Oran and Ceuta.[4] We wish to point out that all the manuscripts describing the course were virtually identical, in spite of being imparted by different professors, in different locations, and in different years.

Euclid's *Elements* in Lucuce's Course

Here we focus our research on the treatment of Euclid's *Elements* in Lucuce's course, of which it forms an original part. In 1730, in his "Proyecto", Verboom had already signaled the sources on which this course should be based (Verboom 1730, 44). For the first six books of Euclid, Verboom suggested the "Elements" of Port Royal (by Antoine Arnaud (1612-1694) in 1670) and also the course prepared by Jean-Pierre de Crousaz (1663-1750), professor at the Academy of Lausanne. In fact, after the publication and diffusion of Descartes' *Géométrie* (1637), the relations between algebra and geometry changed and geometry was presented from another

[4]For the purposes of our analysis, we use the copy made by Antonio Remon Zarco Torralbo, which includes all the figures, and is conserved in the Central Military Library of Madrid.

perspective. So the *Nouveaux éléments de Géométrie* (1667) by Arnauld constitute a new order and present new ideas.[5]
Nevertheless, later, in 1739, the only reference in the Ordinance of the Royal Academy is that Euclid's *Elements* should be part of the syllabus.
So, in his introduction to Treatise II entitled "On Elementary Geometry", which deals with Euclid's Elements and Conic sections, Lucuce clarifies which books of the *Elements* he wishes to work with and which in part are explained:
"Since the work is extensive and diffuse, in this treatise we explain Books 1, 2, 3, 6, 11 and 12, with respect to which Book 4 is addressed to Practical Geometry and Book 5 to Arithmetic, while the others, being of little use, are omitted. The order I follow in the propositions is the same as that given by Euclid, so that they may be cited whenever necessary, the most useful being demonstrated with all possible brevity and clarity in order to save time for the explanation of other subjects that are of concern for the instruction of military personnel." (Lucuce 1739-1744, introduction).
The choice of explaining only Books 1 to 6 and 11 and 12 was usual at that time, because these books were considered to be the most useful. In fact, Tosca in his *Compendio* and Dechales in his *Cursus* explain eight books, specifying that Books seven and eight correspond to 11 and 12, respectively. Unlike Bélidor in his *Nouveau Cours*, for example, Lucuce did not base his geometry directly on the "Nouvelle Géométrie de Port Royal" but rather explained some books of Euclid's *Elements* in an original way.
Lucuce explains the books of the *Elements* making proofs by figures, by letters and by numbers. Thus, in the introduction to Book II in Treatise II, he emphasizes: "In this book we consider the rectangles and squares which are formed by dividing a rectilinear line into parts; its comprehension is of great usefulness in Mathematics and specially for Algebra; and although its theorems are obscure, its proofs will be facilitated by lines as well as by literal calculus and also by numbers." (Lucuce 1739-1744, 42).
Ozanam made the proofs in a similar way, but without referring to it, and using a rhetorical style.
Let us now consider the treatment of Book V on the theory of proportions.[6] In an original and modern way, Lucuce moves the book on proportions from the second treatise dealing with geometry to the first treatise dealing with arithmetic. In Dechales' and Ozanam's courses, all the books in Euclid's *Elements* remain together, while Tosca's course, like Lucuce's, only moves Book IV to Practical Geometry.
In a certain sense, Lucuce performs an arithmetization of the theory of proportions. We wish to characterize the arithmetization of theory of proportions that began in

[5] In relation to the 11th and 12th Books of Euclid's *Elements*, "the Course will follow the method of Father Tosca, avoiding [detailed demonstrations of] the curious and the abstract". (He refers to *Compendio Mathematico* by Tosca). For Practical Geometry, the practical instructions for Engineers and Artillery Officers, Bélidor, in the *Nouveau Cours de Mathematique,* was identified by Verboom as being taught at "one of the five academies established in France".
[6] On the treatment of the theory of proportions in the treatises of the late seventeenth century, see Lamandé 2013.

the sixteenth century. In the simplest stage, authors illustrate Euclid's definitions with numbers or/and algebraic symbols, while in a second stage proportions apply to all kinds of quantities, both discrete and continuous. The third stage can be represented by the identification of a ratio with a numerical value, and finally the proof of propositions on theory of proportions is performed by arithmetical lemmas. Lucuce argued that the theory of proportions can be applied to numerical ratios as well as to magnitudes, and that this is necessary for comprehending mathematics as a whole: both pure and mixed. So, at the beginning of Book III in Treatise I Lucuce explains as follows: "Book 3. On ratio and proportion in common. This book, which is the 5th in Euclid and deals with the ratio and proportion in common, whose doctrine is suitable for *all kinds of quantities* both discrete and continuous, that is, it serves for numbers, lines, surfaces and solids; being the universal key for acquiring the knowledge of as many parts as of which the mathematics are composed. Its propositions preserve Euclid's order, so they may be cited where appropriate, the least important being omitted and only the most helpful remaining, to be demonstrated by *letters* and explained by numbers to facilitate their understanding." (Lucuce 1739-1744, 58). At the end of the seventeenth century and at the beginning of the eighteenth century, the arithmetization of Euclid's Elements gave rise to considerable debate; several authors attempted to move the foundation of mathematical proportions from geometrical magnitudes to numerical ratios, thereby avoiding incomprehensible definitions and adapting it to modern ideas in algebra. It is noteworthy that this process is linked to the contemporary process of the algebrization of mathematics from the diffusion of works by Viète and Descartes.
As regards the contents of the book, Lucuce tries to adapt it for a modern readership, although he preserves Euclid's order, which makes this a pioneering choice that did not clash with the conservative approach. Indeed, Dechales in the definitions also tries to deal with all kinds of quantities, but remains Euclidian in his procedure for the demonstration of the propositions. Tosca in his *Compendio* presents a conservative edition of Euclid's *Elements*, only illustrated with numbers, while in the definitions Ozanam also deals with quantities. In fact, Ozanam's course is the most similar in terms of ideas, although in his presentation of the demonstrations he follows the rhetorical approach.
Definition 5 presented by Lucuce is also original: "Definition 5. The exponent of the ratio is the quotient obtained by dividing the antecedent by the consequent. For example, if in the ratio of 6 to 2, 6 is divided by 2, the quotient 3 is the exponent which states the number of times that 6 contains 2 and type 6/2." (Lucuce 1739-1744, 59-60). Lucuce uses this definition to show the relationship between ratios through the exponent of the ratio, that is to say, the numerical value of the ratio. After the definitions and before the propositions, Lucuce presents two arithmetical lemmas that facilitate the demonstrations. "Lemma 1. If four quantities be proportional, the product of the two extremes is equal to the product of the two means; and if the product of the extremes is equal to the means, the quantities are proportional." (Lucuce 1739-1744, 66). Then he gives the demonstrations of the propositions used as well as the idea of the exponent or the arithmetical lemmas. Ozanam also proves some propositions according to Euclid, and from the proposition

XV he enunciates the same arithmetical lemmas and demonstrates the rest of the propositions by these arithmetical lemmas.

Some concluding remarks

After a preliminary analysis of this Treatise II, we surmise the first answers to the questions. We put forward the hypothesis that, although Lucuce knows Tosca's *Compendio Matematico*, Belidor's *Nouveau Cours Mathématique* and Ozanam's *Course*, to a great extent he designed his own course. Now we provide new evidence to justify this hypothesis. Lucuce made no copies, nor did he rewrite a course that had already been published; rather he chose the appropriate subjects according to didactical criteria, without omitting the latest inventions and always mindful of the most suitable and comprehensible mathematics to provide good theoretical and technical training.

This analysis shows Lucuce to be an original mathematician with his own ideas about teaching mathematics for engineering education. Its didactic function makes it a set of choices for subjects designed to be useful in the training of building engineers and artillery personnel.

Lucuce's version of Euclid's Elements consciously sought to adapt the Elements for a contemporary readership (military and engineers) in order to facilitate their comprehension and usefulness.

Finally, it should be remembered that the readership for mathematics in the 18th century began to spread beyond the universities, while the newly-created academies instilled a mathematical worldview that emphasized the usefulness of results, maintaining the reference to classical authorities. In fact, to most 18th century practitioners, results mattered more than classical authority, and Lucuce's early attempt provides an example of multidisciplinary engineering education that contributed in some way to defining engineering as a scientific profession in Spain.

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Pedro Padilla and his Mathematical Course (1753-1756): Views on Mixed Mathematics in eighteenth-century Spain

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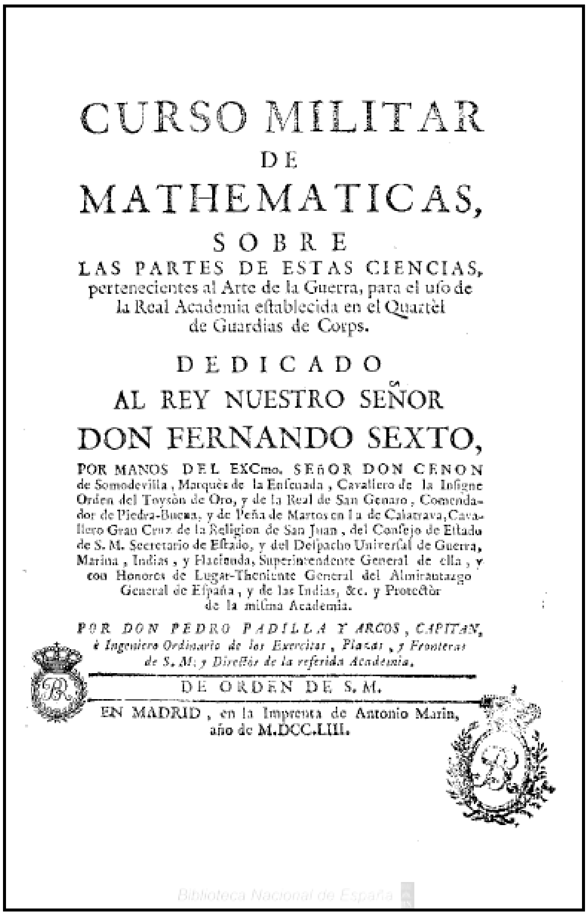
Introduction

In 1717 the King Philip V established the Royal Guards Headquarters (*Cuartel de Guardias de Corps*), mirroring the French *garde du corps du roi*. Intended mainly for noblemen, it was an elitist institution, all its members having the rank of officers and benefitting from huge privileges. Towards the end of 1750 an Academy of Mathematics (*Academia de Matemáticas*) was created within the Royal Guards Headquarters, under the direction of Captain Pedro Padilla (1724-1807?). This academy was ruled by the same regulations as the Military Academy of Mathematics of Barcelona (1720-1803).[1] Attendance was not mandatory; it was only devised for those interested in getting a deeper mathematical knowledge. In fact, rather than its real practical use for the Royal Guards, mathematics was studied as a mark of prestige as Hidalgo (1991) pointed out.[2]

Padilla held the position of Headmaster up to the closure of the Academy of Mathematics in 1760. In 1753 Padilla started publishing his *Curso Militar de Mathematicas, sobre partes de esta ciencia, para uso de la Real Academia establecida en el Cuartel de Guardias de Corps* (1753-1756) [*Military Course of Mathematics, about some parts of this science, for the use of the Royal Academy established in the Military Academy of the Royal Guards*] (Fig. 1). Of the twenty mathematical treatises that Padilla originally intended to develop, only five were finally published: (1) Ordinary arithmetic; (2) Elementary, or Euclidean, geometry; (3) Elementary algebra; (4) Higher geometry, or geometry of curves, and (5) Differential and integral calculus, or the method of fluxions.[3]

[1] For a thorough and recent analysis of the Military Academy of Mathematics of Barcelona see Massa-Esteve *et al.* (2011).
[2] On the creation and organization of the Military Academy of the Royal Guards Ordenanzas of December 21, 1750, September 22, 1751 and November 11, 1755, respectively (Portugues 1765, V, 180–184, 187, 196–199). See also Lafuente and Peset (1982) and Blanco (2013).
[3] Padilla's fifth treatise turned out to be the first Spanish educational book on calculus. See Cuesta Dutari (1985), Ausejo and Medrano-Sánchez (2010) and Blanco (2013).


CURSO MILITAR
DE
MATHEMATICAS,
SOBRE
LAS PARTES DE ESTAS CIENCIAS,
pertenecientes al Arte de la Guerra, para el uſo de
la Real Academia eſtablecida en el Quartèl
de Guardias de Corps.

DEDICADO
AL REY NUESTRO SEÑOR
DON FERNANDO SEXTO,
POR MANOS DEL EXCmo. SEñOR DON CENON
de Somodevilla, Marquès de la Enſenada, Cavallero de la Inſigne
Orden del Toysòn de Oro, y de la Real de San Genaro, Comenda-
dor de Piedra-Buena, y de Peña de Martos en la de Calatrava, Cava-
llero Gran Cruz de la Religion de San Juan, del Conſejo de Eſtado
de S. M. Secretario de Eſtado, y del Deſpacho Univerſal de Guerra,
Marina, Indias, y Hacienda, Superintendente General de ella, y
con Honores de Lugar-Theniente General del Almirantazgo
General de Eſpaña, y de las Indias, &c. y Protectòr
de la miſma Academia.

*POR DON PEDRO PADILLA Y ARCOS, CAPITAN,
è Ingeniero Ordinario de los Exercitos, Plazas, y Fronteras
de S. M; y Director de la referida Academia.*

DE ORDEN DE S. M.

EN MADRID, en la Imprenta de Antonio Marin,
año de M.DCC.LIII.

Figure 1: *Title page of the Military Course of Mathematics (Padilla 1753-1756)*

From the preface of his first volume it is evident that Padilla aimed to show the basic principles of each branch of mathematics, useful enough not only for infantry and cavalry, but also for engineers, artillery and navy (Padilla 1753-1756, preface). Padilla's work introduced a significant change in the pedagogical methods used so far (Blanco 2013, 772). Following the royal regulations (*ordenanzas*), the courses taught at the Military Academy of Mathematics of Barcelona were usually dictated by teachers and assistants. This actually was the rule in most teaching institutions in Europe at the time. Students had to copy down the courses and later make a fair copy of their notes that had to be presented to the teacher once a fortnight (Portugues 1765, VI, 867; De Mora and Massa-Esteve 2008). In his dedication to the King, Padilla stated the reason why he undertook his *Curso*:

> … I have composed the current Course, or Compendium of the subjects taught at the mentioned Academy, so that, being printed, the students, relieved from the annoyance of writing, incompatible with their daily duties, can make greater progress in the study (Padilla 1753-1756, dedication to the King).

By getting his *Curso* printed, Padilla seems to have somehow disregarded the *ordenanzas* of 1739 and 1751.

Besides, Padilla's approach to the general division of mathematics, elaborated in the preface, is similar to that of D'Alembert's tree of knowledge in the *Discours préliminaire* of the *Encyclopédie* (1751), including of course the division of

Mathematics into pure and mixed.[4] Therefore Padilla's classification illustrates the reception and circulation of the ideas of the *Encyclopédie* in Spain (Sánchez-Blanco Parody 1991; Puig-Pla 2002; Blanco 2013).
The aim of this contribution is to explore the connection between theory and practice in Padilla's mathematical course and to examine this course to understand what Padilla regarded as useful mathematics for engineers. This is a preliminary study which provides an overview of the volume on geometry and Padilla's views on practical geometry.

On Elementary and Practical Geometry

The abovementioned royal regulations (*ordenanzas*) established for each academic year the topics to be taught at the Military Academy of Mathematics of Barcelona, how to teach them and the staff in charge. Stationed in spots far from Barcelona, not all the officers had the chance to attend the classes at the Academy. To overcome this obstacle, the academies in Oran and Ceuta were founded in 1732 and 1739, respectively, following the regulations established by the one in Barcelona, as the head academy.[5] In 1738, Pedro de Lucuce (1692–1779) was appointed headmaster of the Military Academy of Mathematics of Barcelona. From 1739 he was in charge of the elaboration of a course of mathematics, the orientation of which was stated in the *ordenanza* of 1739 (De Mora and Massa-Esteve 2008). This course (*Curso Mathematico para la Instrucción de los Militares*), completed in 1744, consisted of eight treatises on the main fields of Mathematics, including pure mathematics (arithmetic and geometry) and mixed mathematics (cosmography, statics, hydraulics, architecture, artillery, and fortification) (Massa-Esteve *et al.* 2011).
Given the relevance of the Military Academy of Mathematics of Barcelona, it is only natural to wonder to what extent Lucuce's course could have influenced Padilla's course. In particular, this paper aims to provide an overview of the volumes that deal with geometry (elementary and practical). In the Treatise II (*On Elementary Geometry*), Lucuce provided an eminently practical view, geometrically constructed in the field for students of artillery and fortifications (De Mora and Massa-Esteve 2008). According to Massa-Esteve *et al.* (2011), the topics of this treatise were: Euclid's *Elements*; rectangles formed over a straight line divided into parts; properties of the circle and straight lines both touching it and inside it; ratio and properties of plane figures; the prism and the parallelepiped, the pyramid, the prism, the cylinder and the sphere; conic sections. At the beginning of this treatise Lucuce stated:

> Since the work is extensive and diffuse, we explain in this treatise books 2, 3, 6, 11 and 12, with respect to which book 4 is addressed in Practical Geometry and book 5 in Arithmetic, while the others, being of little use, are omitted. The order I follow in the propositions is the same as that given by Euclid, so that

[4] It is worth mentioning here that in D'Alembert's classification, the branch of elementary geometry (in pure mathematics) included architecture and tactics, whereas in Padilla's course these branches belonged to mixed mathematics.
[5] See Ordenanzas of July 22, 1739, and December 29, 1751 (Portugues 1765, VI, 858–883, 889–925).

they may be cited whenever necessary, the most useful being demonstrated with all possible brevity and clarity in order to save time for the explanation of other subjects that are of concern for the instruction of military personnel (from Lucuce's course, as quoted in De Mora and Massa-Esteve 2008, 874).

Padilla based his Treatise I (*On Ordinary Arithmetic*) on Euclid's book V, as Lucuce did. Likewise, he acknowledged that his Treatise II (*On Elementary, or Euclidean, Geometry*) was mainly based on Euclid's *Elements* books I–VI and XI–XII (Padilla, 1753-1756, II, 8-9). However, from Table 1 it is evident that he did not use exactly the same books as Lucuce did.

Treatise II (Padilla 1753-1756)		Euclid's *Elements*
Section 1	General Principles of Geometry	
Section 2	Straight lines, angles, triangles and parallelograms	Book I
Section 3	Circle and regular figures	Books III and IV
Section 4	Ratio and proportion of plane figures	Book VI
Section 5	Planes (sections and positions)	Book XI
Section 6	Solids	

Table 1: *Content comparison of Treatise II (Padilla 1753-1756) and Euclid's Elements*

It is important to remark that, while Lucuce maintained Euclid's original order, Padilla regarded it as absolutely damaging for the study of the applications of geometry (Padilla 1753-1756, II, 9).
Padilla, as well as Lucuce, favoured algebraic approaches in his use of Euclid's *Elements*. Hence, for instance, in Treatise I Padilla used fractional notation to express proportional quantities and regarded ratios as fractions:

$$\frac{66}{33} = \frac{10}{5}$$

If four numbers 66, 33, 10, 5 would be proportional [that is, if], the product of the extremes 66 · 5 is equal to the product of the means 33·10 (Padilla 1753-1756, I, §131).

Moreover, in Treatise II Padilla used the mathematical symbol *:* when dealing with proportional magnitudes, instead of defining them verbally:[6]

> If *CD* : *DE* = *FD* : *DB* the parallelograms will be equal… (Padilla 1753-1756, II, §2).

Finally, Lucuce addressed the study of practical geometry in his Treatise III, which was based on Euclid’s book IV (De Mora and Massa-Esteve 2008, 874). This treatise was divided into eight books.[7] When it comes to Padilla’s course, it is true that there was no single treatise devoted explicitly to practical geometry. Yet, the contents of some its treatises could be somehow connected with the contents of Lucuce’s Treatise III, as Table 2 shows.

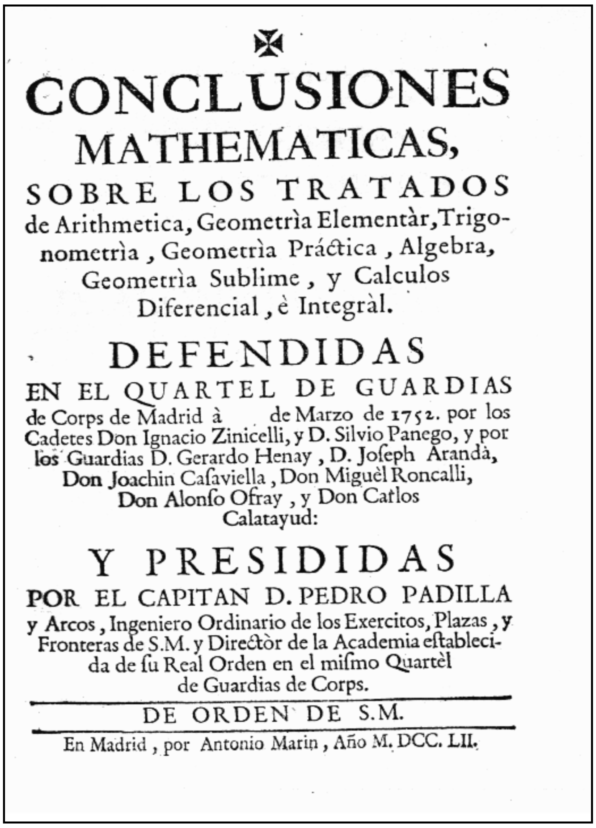
<table>
<tr><td>Lucuce (Treatise III)</td><td>Padilla (1753-1756)</td></tr>
<tr><td>On plane trigonometry (including a chapter on the nature and use of logarithms)</td><td>Treatises VI and VII</td></tr>
<tr><td>On the construction of plane figures</td><td rowspan="3">Treatise II</td></tr>
<tr><td>On the inscription and circumscription of plane figures in the circle</td></tr>
<tr><td>On the proportion, enlargement, reduction and transformation of plane figures</td></tr>
<tr><td>On the use of some instruments</td><td>Not known</td></tr>
<tr><td>On planimetry or euthimetry</td><td rowspan="2">Treatise II</td></tr>
<tr><td>On stereometry or the dimension of solids</td></tr>
<tr><td>On levelling</td><td>Treatise XX</td></tr>
</table>

Table 2: *Content comparison of Lucuce’s Treatise III and Padilla’s course*

Table 2 indicates that Padilla’s Treatise II shared a number of topics with five of the books of Lucuce’s Treatise III. Unfortunately, most of the treatises in Padilla’s course

[6] On the algebraic ways to manipulate proportions in Euclid’s book V see Goldstein (2000).
[7] For a thorough study of practical geometry in the context of engineering education in Spain see Massa-Esteve *et al*. (2011). In De Mora and Massa-Esteve (2008, 875) there is a full description of the contents of Lucuce’s treatise on practical geometry.

that were connected with practical geometry remained unpublished, except Treatise II. Therefore, a thorough analysis of Padilla's views on practical geometry cannot be led. But the fact that practical geometry played an important role in the public examinations held in 1752 at the Military Academy of the Royal Guards proves the importance granted to this subject in this context (Fig. 2).[8] In these examinations, students were asked to measure distances, using the plane table and the protractor, to draw land or city plans, by means of the plane table, or how to pump water from a river up to the highest part of the city for street cleaning.



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CONCLUSIONES
MATHEMATICAS,
SOBRE LOS TRATADOS
de Arithmetica, Geometrìa Elementàr, Trigonometrìa, Geometrìa Práctica, Algebra, Geometrìa Sublime, y Calculos Diferencial, è Integràl.

DEFENDIDAS
EN EL QUARTEL DE GUARDIAS
de Corps de Madrid à de Marzo de 1752. por los Cadetes Don Ignacio Zinicelli, y D. Silvio Panego, y por los Guardias D. Gerardo Henay, D. Joſeph Arandà, Don Joachin Caſaviella, Don Miguèl Roncalli, Don Alonſo Ofray, y Don Carlos Calatayud:

Y PRESIDIDAS
POR EL CAPITAN D. PEDRO PADILLA
y Arcos, Ingeniero Ordinario de los Exercitos, Plazas, y Fronteras de S.M. y Directòr de la Academia eſtablecida de ſu Real Orden en el miſmo Quartèl de Guardias de Corps.

DE ORDEN DE S.M.

En Madrid, por Antonio Marin, Año M. DCC. LII.

Figure 2: *Title page of the public examinations held in the Academy of Mathematics of the Royal Guards (1752)*

Final remarks

From this preliminary study, it is very likely that Padilla's volume on geometry was influenced by Lucuce's course. Yet, it is still necessary to carry out a more detailed comparative analysis of the mathematical courses of Padilla and Lucuce on this subject. In particular, it would be worth analysing and comparing not only the process of arithmetization, but also which editions of Euclid's *Elements* they used.

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8 *Conclusiones Mathematicas, sobre los tratados de Arithmetica, Geometrìa Elementàr, Trigonometrìa, Geometrìa Práctica, Algebra, Geometrìa Sublime, y Calculos Diferencial, è Integràl. Defendidas en el Quartel de Guardias de Corps de Madrid*. Madrid: Antonio Marín, 1752 (AGS Guerra Moderna, 3778).

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Acknowledgments
We are grateful to M. Rosa Massa-Esteve for her helpful suggestions. We also thank the Spanish Ministry of Science and Innovation for financial support ((HP2008-012 and HAR2010-17461).

The Mathematical Courses of Tomàs Cerdà in eighteenth-century Spain

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Tomàs Cerdà was a Jesuit, mathematician, and teacher who lived and worked in Barcelona and Madrid in the late eighteenth century. Our project is focused on Cerdà's contribution to the introduction of Differential and Integral Calculus in Spain. What was the Cerdà's mathematical contribution to scientific development in Barcelona? What was the influence of Cerdà, the mathematician, on various social sectors in Barcelona?

Previous historical studies about Tomàs Cerdà
Several historical studies on Cerdà and the institutions where he practised professionally exist, such as those by Norberto Cuesta Dutari, Manuel García Doncel, Lluís Gassiot Matas, Víctor Navarro Brotóns, Elena Ausejo and Juan Navarro Loidi. Furthermore there are also very interesting works on the development of Differential and Integral Calculus in eighteenth century Europe such as those by Niccolò Guicciardini or Henk J.M. Bos, among many others.
It is thanks to all these sources that we are able to present this work on Cerdà and his contribution to Calculus, which is part of our previous research.

The Army and The Jesuits: transmitting knowledge in 18th Century Spanish
In early 18th century Spain, commercial class able to finance and stimulate sciences hardly existed.
A stable body receiving modern knowledge and able to transmit it to educational institutions and integrate it into the factory production was required.
Basically, it was the Army that would be responsible for this task; cosmopolitism and common well-being would be the pillars of a project started by the new Bourbon dynasty. However, another establishment able to channel new science existed: the Jesuits. At that time, another new social class from the lower nobility was emerging which concerned itself with city affairs such as the prevention of illness, popular education, communications and new sources of wealth.
Complicity between this emergent class and the new royal dynasty resulted in the setting up of several institutions – such as La Academia de Guardiamarinas in Cádiz (1717), El Real Seminario de Nobles in Madrid (1725), La Real Academia de Bellas Artes de San Fernando in Madrid (1752), El Real Jardín Botánico in Madrid (1755). This new impetus also involved the renewal of old institutions such as the Imperial College of Madrid and the Royal Seminar of Noblemen of Cordelles in Barcelona. With the advent of the Bourbon dynasty, the Jesuits' influence decreased, although by the mid- Century, just before their expulsion, they controlled some main

educational institutions like the Imperial College and the Royal Seminar of Noblemen in Madrid and the College of Cordelles in Barcelona.
Some of the most important mathematicians of the time (1750-1767) were associated with these Jesuit institutions: Gaspar Álvarez, Johanes Wendlingen, Esteban Terreros y Pando, Tomàs Cerdà, Christian Rieger, Miguel Benavente, Antonio Eximeno, and José Carnicer. In 1764, Tomàs Cerdà acceded the highest position: the first chair of Mathematics at the Imperial College, in Madrid, and the associated post of Cosmographer of the Indies.

Cerdà: active agent toward modernity

Throughout the 18th Century, the Society of Jesus continued to evolve, while the thoughts of some philosophers, which the Society did not necessarily agree with, had been accepted in their teaching classes. In the "Conclusiones" of several Jesuit's colleges we can read names such as Descartes, Gassendi, Malebranche, Newton and Leibniz.
At the same time the Spanish Monarchy was sending Army officers abroad to learn about new techniques regarding manufacture or military infrastructure, while the Society was sending its own members abroad for the acquisition of new scientific knowledge.
Indeed, Cerdà, who had been born in Tarragona and he was a professor of Philosophy at the University of Cervera, was interested in Experimental Physics and was sent to Marseille in 1754. His mentor there was Esprit Pézenas (1692-1776). Cerdà lived in this city for three years, during which time he learned about the most important scientific works of the time, among which, Newton's works and those of his followers are of particular relevance.
After his time in Marseille, Cerdà's first aim, which was also the aim of the Society itself, was to introduce this new knowledge at the College of Cordelles in Barcelona, where from 1756 to 1764 he taught mathematics. During this time he published a treatise on arithmetic and algebra and another on geometry.
He also prepared many other treatises for publication: the Calculus of Fluxions or Differential and Integral Calculus; Algebra applied to Geometry; Mechanics, Astronomy, Optics, etc. In fact, his aim was to publish a complete course.
In his introduction to *Liciones de Mathemática o Elementos Generales de Arithmética y Algebra para el uso de la clase*, Cerdà writes:

> **"**Having finished the second volume on Equations, the most important in Algebra, which at this time is being printing, the printing of the other three will start, which I have ready for that purpose; namely *Geometry*, and *Trigonometry, Algebra applied to Geometry and Curves, the Direct and Inverse Method of Fluxions,* which others call *Differential and Integral Calculus."*

The text book was for him a basic tool for the educational improvement of a readership that not only included nobles but also children of new artisan classes of Barcelona. We can see from these texts that the contents of his classes included the spirit of the new science, in which experimental sciences constituted the fundamental core.

Cerdà-Simpson: an example of appropriation of Newtonian science

One of the most usual strategies for improving scientific development was promoting travels abroad for study which required short-term, practical results.
It was due to this that the development of science and technology in eighteenth-century Spain became a great experiment in the transfer of knowledge.
Cerdà's contribution forms part of this process; like many other educators or Army officers involved on science, Cerdà read French and English authors and translated or adapted their works for use in Spain.
As regards differential and integral calculus – the paradigm of new mathematical techniques – the main source for Cerdà's *Tratado de Fluxiones*, was the work by Thomas Simpson, who was Mathematics professor at the Royal Military Academy in Woolwich.
Simpson's book, *The Doctrine and Application of Fluxions*, published in 1750 and which is a revision of a first treatise published in 1737, sets out the method of fluxions, started by Newton, in a pedagogical manner.
Cerdà took this book as a model and wrote a text which would be saved in manuscript.
Like many other "transmitters of knowledge", Cerdà believed that the country was in urgent need of renewal as regard its economical and social activities and the role of educators was transmitting the new science that was emerging in Europe, and this in the quickest and most understandable way possible.
The main topic of our project is to conduct a comparative study between Cerdà's manuscripts on Fluxions written between 1757 and 1759 and Thomas Simpson's book, *The Doctrine and Application of Fluxions*, which Cerdà adopted as his main guide.
Transmission becomes adaptation, and therefore appropriation; Simpson's work, who himself was a "populizer-transmitter" of Newton, arrived in Spain through Cerdà, with many nuances and different remodelled contents.
We focus only on two features concerning Cerdà's adaptation of Simpson's book.

Definition of fluxion

The first feature concerns the core of the Newtonian approach to the calculus of fluxions, and thus with the definition of fluxion. Although his aim was pedagogical and practical, Cerdà does not avoid the definition of fluxion with every nuance added by Simpson and Maclaurin.
Fluxion is a concept stemming from the cinematic-geometrical conception, built by Newton since its early beginning and which was to become the kernel of the new calculus.
However, it is with Simpson and Maclaurin that the definition of fluxion would become the "Magnitude" by which "any flowing Quantity" (variable) would be increased in a time interval, if the velocity continued to be invariable at any given position or instant.

Cerdà does not opt for a simplification of this definition as he might have done by identifying fluxion with velocity or, vice versa, with an infinitesimal increment, but rather he keeps the same definition:

> "*That part of line, surface or solid which would be described by the point, line or generating figure in a given time, if the velocity, that it has at a given point or position continued to be constant and invariable, is what we call fluxion at the point of that quantity which is generated in this way, named fluent*."

Cerdà does not identify fluxion with Leibniz's differential. The fluxion is not a real increment but an increment "if the velocity were constant".

The notation

The second feature concerns the notation.
Cerdà substitutes the dot over the variable by the Leibniz's "d" before this one.
We believe that this substitution not only has a practical justification but also reflects a very deep understanding about the concepts with which Cerdà is working as well a desire for appropriating the best of every scientific tendency.
As we have noted in our previous research, Cerdà tends to increase algebrization in his works.

The physical and mathematical world emerging in a Jesuit context

What contents?
Before Cerdà's arrival in Barcelona, pure mathematics scarcely existed at all in the Cordelles.
A glance at the college brochure, which refers several subjects – Religion, Rhetorics, Armory, Geography and Astronomy, Cosmography, Fencing, Language and Music – is enough to see that mathematics did not appear at all in a curriculum designed for young noble men, who did not consider that mathematics could be useful to them.
A reading of some "Actos académicos" (end-of-course proceedings of academic lectures), reflects the contents of the classes given at the Cordelles, or, at least, the way they were presented to the public. In December 1755, before Cerdà's arrival, the courses imparted were Armory, Globes, Poetry, Cosmography, Fables, Fencing, Languages, and Dance.
However, in December 1757, among several other courses we find "Geometry and Globes" (geometry and cosmography) and "Experimental Physics". The exercises explained in the brochure are very elementary and are unlikely to reflect what was actually happening in Cerdà's classes on mathematics, but the picture they provide is very different to that of a college uninterested in sciences, as it did some years before.
The introductory text to geometry reads as follows:

> "*Everyone knows how necessary and useful Geometry is for the good of the State and for political use by the Republic; because the principles of navigation are based on it, as well the principles about distributing rivers for*

commerce, leading the Army, fortifying places, increasing force in machines and making the Elements increasingly useful to mankind."

The introduction to "Experimental Physics" in the "Acto académico" (December 1757) reads:

> "*If the study of Mathematics is very useful, then the study of Experimental Physics is not less so, because with its machines and discoveries many troubles have disappeared, that the wisest men have never solved with simple speculation*."

At that time, science was useful to the State, the Army, Commerce and Industry and the new science had proved capable of overcoming obstacles to the material progress of mankind that the old speculative philosophy could not.
If we recall that these words were uttered in the context of a Jesuit college, labelled by many historians as elitist and antiquated, we may deduce that something was changing during the years Cerdà was teaching mathematics there.
But the change extended beyond the Jesuit College; there was also a change in the sensibilities of the emergent public opinion about the new scientific trends. In 1762, we can read in a Barcelona magazine, "Caxon de Sastre cathalán":

> "*The Aristotelian forms prevailed in Europe for many centuries; Gassendi's Principles and Descartes' Elements replaced these forms throughout almost all of Europe. So, the literate world was divided into several camps. Gassendi held the advantage for a long time, but Newton and his contemporaries, pretenders to the universal Philosophical Throne, did not allow him to enjoy it to the full, and went on to make up the greater part of the Newtonian world...*"

The comment is especially interesting because it appears in the press of Barcelona which, even were it a minority, probably expressed the opinion of influential social spheres in Barcelona. We also believe it likely that it was Cerdà who was the cause of comment. Indeed, in 1762, Cerdà was teaching mathematics in Barcelona and he came out publicly in support of the Newtonian thought.

What mathematics?

In Cerdà's *Tratado de Fluxiones*, which is one of his more theoretical works, for any subject the practical exercises form the main part.
Nevertheless, the practical approach did in no way diminish theoretical accuracy. This treatise is not a recipe book and the Cerdà's objective is to clarify concepts and to explain every proposition and theorem step by step.
On the other hand, when he wrote on some strictly non-mathematical subject, he took a new theoretical view which had not adopted before. A good example of this is his book *Lección de Artilleria* (Artillery Lesson), which was the first Spanish book on the subject in which many applications of calculus of fluxions appear.

What public?
In the mid-eighteenth century, the College of Cordelles was a school for noblemen and the Seminary only admitted people from this class. However, the rules ("Constituciones"), published in 1763, provided for open attendance for external students to public classes.
When Cerdà arrived in Barcelona, a change was occurring not only in the syllabuses of colleges like the Cordelles, but also in the type of students who went there to learn. It was important for noblemen to learn about the new sciences, because they will still responsible for leading the nation; it was also important for the military to improve their scientific and technological training, because they were the ones who built military fortifications, bridges and the roads. Furthermore it was vital for the new classes of skilled craftsmen and sectors of the liberal professions to be included in the network of the new public scientific education; not only because the actors directly involved were demanding it, but also because many State sectors understood that it needed new qualified technicians.
Thus, the condition imposed by the Council of Castilla for authorizing the chair of mathematics at the College of Cordelles was that in its classes "*it was necessary to teach mathematical sciences to all kinds of people, collegiate gentlemen or others...*"

From receiver public to active social agents
Cerdà and the Barcelona Academy of Sciences
In fact, Cerdà had many different pupils, some of them nobles, others from craftsmen's families, as well ecclesiastics and from trading or manufacturing families. What is the most important is that several pupils would appear in Barcelona society pursuing professional careers in which the Cerdà's influence was evident.
Firstly it is necessary to mention the foundation of the *Conferencia Físico-matemática* of Barcelona in 1764. In 1787, Juan Antonio Desvalls, Cerdà's ex-student and for many years secretary of the Barcelona Academy of Sciences, wrote about how the Conference came into existence:

> "*Some people in the city of Barcelona wished to learn about Experimental Physics and their interest on these studies came from Mathematical principles acquired in the course given by Tomàs Cerdà (...) and for making the training stronger it was necessary that theoretical explanations went hand in hand with the practice of experiments, for which several machines were necessary, the cost to be shared between many people. Thus, they met other colleagues with the same claim for joining and creating a private Conference*."

The "Acadèmia de Ciències i Arts de Barcelona" was a new institution born thanks to Cerdà and it would be, for many years, a reference point for the scientific community in this city.

Cerdà and master builders

Secondly it is also necessary to mention another sector of the public that was learning from Cerdà: craftsmen, especially master builders, because architecture has always been linked with mathematics.

A foremost witness of Cerdà's classes was Josep Renart, a master builder who lived in Barcelona during the second half of 18th Century, who, as a younger man, attended Cerdà's classes. In his memoirs ("Quincenarios") we find many references to Cerdà, praising the innovative approach of his teacher.

Furthermore, Cerdà's books have been found in private libraries of other master builders such Andreu Bosch i Riba and Joan Soler i Faneca. In fact, teaching mathematics meant teaching the foundations of the basic geometrical forms, which in 18th Century also meant teaching the foundations of architecture.

Concluding statements

1. The development of Differential and Integral Calculus in the eighteenth century in Europe as a scientific discipline is not a new topic. But it has often used to focus the view of this topic from the "centre" and from the well known scientists as Isaac Newton or Gottfried Wilhelm Leibniz. Our hope would be that our project, as many others have still done, would overcome this view. Cerdà is very far from remaining a simple translator and, with his practice, he is, in fact, introducing the new Calculus in Spain, carrying out a special orientation of this new discipline to his pupils with a very clear purpose which it is that they include the new theoretical mathematical knowledges in their future professional practice.
2. A new scientific institution (the Barcelona Academy of Sciences) was born in Barcelona thanks to Cerdà's influence which would become a new "scientific authority" guided by the prestige of new scientific trends, and whose goal would always be science, social usefulness and the social and economical progress of the nation.
3. The mathematical classes imparted by Cerdà in Barcelona were of great importance to many master builders. With his chair in mathematics running parallel to mathematics classes at the Royal Military Academy of Mathematics, Cerdà introduced many master builders into the world of mathematics.
4. In general, the new approach to the teaching of sciences, as exemplified by Cerdà, owed much too emerging new social demands for new scientific knowledge identified with the social and economical progress of the nation. And, vice versa, this approach had a direct influence on some sectors of society which went on to become active and useful social forces for both the State and the Monarchy.

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Mathematical Course for the Education of the Gentlemen Cadets of the Royal Military College of Artillery of Segovia

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Artillery, along with other techniques, has tended to have a convoluted relationship with mathematics. Elementary mathematics has always been necessary in order to answer many practical questions in gunnery, but mathematics was also studied to improve armaments, or simply for the prestige it gave. The degree of knowledge of mathematics required of a good officer changed over time and in fact was quite basic until the end of the 18th century. The reason for this was due to the lack of precise experimentation and good theories in pyrotechnics. The evolution of this relationship between mathematics and theoretical artillery in Spain from 16th to 18th is studied in this text.

Its origins

Artillery became a common branch of the King's Army in Spain during the Granada War (1482-1492). In its origins, the gunners formed a kind of guild, with their own entrance exam, patron saint, and different names for ranks of infantry and cavalry (Vigón 1947, v. 1 21-111). However, masters training apprentices such as those in a guild did not meet the army's requirements for gunners and consequently, Practical Schools were opened to speed up the training of new artillerymen. In these schools the training was mostly practical and included the study of the composition of gunpowder, the use of cannons, the organization of the artillery, and also some questions of elementary mathematics, such as distances, diameters, and inclinations (Collado 1592, folio 103 verso- f. 104 v.).

Tartaglia and the theory of impetus

Tartaglia's application of the theory of impetus to artillery, explained in *Nova Scientia* (1537) and *Questi et invenzioni diverse* (1546), was a first step towards a scientific formalization of pyrotechnics and had an important influence on Spanish artillery. This theory was based on Aristotelian dynamics, but was improved by the avoidance of a permanent force to maintain the motion. According to this theory, the trajectory of a cannon ball had three parts: violent, mixed and natural. The motion for the violent and natural parts followed a straight line, while for the mixed part, a curved one. Different hypotheses were put forward regarding the form of this curved line and also regarding the straightness of the violent part of the motion, to allow for the calculation of ranges. This theory was also used to give theoretical justification to some experimental results by mentioning light or heavy bodies and other questions of Aristotelian physics. Unfortunately, this theory was inexact and did not explain many questions of dynamics or chemistry.

Tartaglia's influence was important in Spanish artillery and several good treatises were published around 1600, accepting his theories albeit with some criticism. The most important ones are D. Alava's *El Perfecto capitán* (1590), L. Collado's *Plática manual de artillería* (1592) and D. Ufano's *Tratado de la artilleria y uso della* (1613), and put forward a variety of opinions about the importance of mathematics.

Diego Alava praised the admirable effects of arithmetics and geometry on artillery and explained plane geometry, trigonometry, the use of some geometrical instruments, and the rudiments of arithmetic (Alava 1590, 189-258).

Luis Collado pointed out that knowledge of geometry was necessary for a general of artillery (Collado 1592, f. 95 r.), whereas, for a simple gunner it was sufficient to know ordinary units of measure along with the use of some geometrical instruments. However, he assumed that every gunman also knew the rudiments of arithmetic and geometry because he had to apply them in order to explain practical questions[1]. He also criticised Tartaglia and other authors on artillery saying that they were mathematicians and not gunners.[2]

For Diego Ufano, an artilleryman had to be literate and know the four arithmetic operations and the use of some geometrical instruments. In his opinion, geometry was necessary for military engineers but not for gunners (Ufano 1612, 131-146).

Later, during the 17th century, the principal treatises came out of the institutions which opened to formally train the officers of Spanish artillery. The *Chair of Mathematics for the Artillery* of Madrid was opened in 1605 and its first Chairman was Julio Cesar Firrufino, who was in charge from 1605 to 1650. His duties were to teach artillery to orphan children and to a group of expert artillerymen, to examine new guns and gunners, and to assess new inventions. He published *El Perfecto Artillero* (1648), which included a significant part on mathematics, explaining plane geometry following Euclid's *Elements*, plane trigonometry, geometrical instruments and sundials. The final part of "Proposiciones geométricas" (Firrufino 1648, f. 177-211) is concerned with mathematics. In general, Firrufino was a stricter follower of Tartaglia than Alava, Collado or Ufano and agreed with Tartaglia on many questions, such as trajectories (Firrufino 1648, f. 59 r, 122 r.).

For the second half of the 17th century, the most important training institution of the Spanish Army was the *Royal Military Academy of the Netherlands,* operating in Brussels from 1675 to 1705. Its professor was Sebastián Fernández de Medrano and its pupils were officers and cadets of the Spanish Army of the Low Countries. Medrano's treatise *El Ingeniero* (1687) was used as a handbook in the Academy. This manual is principally about fortification, but geometry, trigonometry, and the use of geometrical instruments are also explained. The "use of the proportional rule', and Euclid's' *Elements*" were also studied in the Academy wherever possible.

Artillery was not a major subject in this academy, nevertheless, Medrano was interested in it and he published three books on the subject, namely, *El Práctico*

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[1] For units of measure (Collado 1592, f 7 v), rudiments of arithmetic (Collado 1592, f. 60 r) and geometrical instruments (Collado 1592, f. 68 r-70 r; f. 91 r.-v.).

[2] "Nicolao Tartalla, Gerónimo Rucelli, y el Cataneo, cuyas obras mas dan testimonio de hombres mathematicos, y en otras artes instruidos, que no de prácticos del ejercicio del Artillería" (Collado 1592, f. 5 v.)

Artillero (1680), *El Perfecto Bombardero* (1691) and *El Perfecto Artificial, Bombardero y Artillero* (1699). All three were practical books, using only some rudiments of geometry. Medrano justified the absence of mathematics saying that: “To avoid the confusion of curious persons with the mathematical terms used in Pyrotechnics [...] I have taken care in leaving them out” (F. de Medrano 1691, prologue).
As can be deduced from the above comments, in spite of a general abstract acceptance of the importance of mathematics, and especially geometry, these authors had quite different opinions about the parts of mathematics that had to be taught. There is a noticeable difference between Firrufino and Alava, who included geometry, trigonometry and arithmetic, and Medrano or Ufano who explained only the use of geometrical instruments applied to artillery and assumed some knowledge of arithmetic and geometry. In fact, with existing theories, the practical application of mathematics to the artillery was limited.

Galileo’s influence
In other parts of Europe significant improvements were made in theoretical artillery after Galileo’s *Discorsi e dimostrazioni matematiche intorno à due nuoue scienze* (1638) and the application of his theories to ballistics by F. Blondel’s *L'art de jetter bombes* (1683).
In Spain, however, only a few books accepted Galileo’s parabolic trajectories at that time, for instance, the anonymous *Escuela de Palas* (1693) or Mut’s *Arquitectura Militar* (1664). Even at the beginning of the 18th century, Galileo’s kinematics was not accepted without criticism. For example, Cassani’s *Escuela militar de fortificacion* (1705) admitted the predominance of Galileo’s theories in Europe, but found it difficult to accept them as correct (Cassani 1705, 213). Tosca, in his famous *Curso Matemático* (1712) criticises Galileo and his followers, but he accepts parabolic trajectories for applications because, “as Blondel noticed […] these assumptions cannot lead to a notable error” (Tosca 1757, v. 5, 539).
Practical treatises of artillery generally made no mention of theory during this period, giving only experimental rules. However, their terminology, which was a little old- fashioned, shows that new theories were in fact unknown to the gunners. Also, at this time
Military academies were being promoted by the new Bourbon dynasty in a more successful way than before. In 1722 four "schools of mathematics and teaching of the artillery" were created in Barcelona, Pamplona, Badajoz and Cádiz. Of these four, only Barcelona was successful. Mateo Calabro was appointed its Professor in 1722, but he changed from the arm of artillery to military engineering in 1724, backed by the head of Spanish military engineering, Verboom. With him the school changed and depended on the engineers, a situation the artillery did not accept and subsequently appointed Guillermo Corall for the school of Barcelona. This academy for artillerymen only had a few students and was closed in around 1732.
Calabro led a successful academy with more than 100 students, a syllabus including arithmetic, theoretical and practical geometry, trigonometry, perspective, statics, civil and military architecture, hydraulics and drawing, and only “a general idea of artillery”. Pedro Lucuce (1692-1779) took over from Calabro in 1738, and a new Ordinance for the Academy of Barcelona was published in 1739. Its syllabus was

more practical than Calabro's, but was not very different. It included arithmetic, geometry, conics, practical geometry, trigonometry, statics and motion of heavy bodies, hydraulics, cosmography, civil and military architecture, and "the artillery with all its parts and knowledge of gunpowder" (Massa et al. 2011).
Two new academies for the officers of artillery were opened in Cádiz and Barcelona in 1752. The professors were artillerymen and they taught many practical aspects of artillery and a programme of mathematics similar to the one followed in the Academy of Barcelona of military engineers (Navarro 2013, 85-95).
The head engineer Zermeño criticised these academies for artillery saying: "For the Artillery [...] only practical school are needed (very useful for the instruction of sergeants, corporal and soldiers) [...] since officers and cadets do not need any school, having the Academy" (Navarro 2013, 92). In their answer the artillerymen stressed the importance of mathematics in their training, but did not propose a different syllabus, and merely asked for more information about practical and experimental physics, metallurgy and gunpowder.

Newton's theories

Around the middle of the 18th century, Newton's theories were applied to pyrotechnics. Benjamin Robins published *New Principles in Gunnery* (1742), where the force of the gunpowder when exploding, the speed of a bullet when it leaves the barrel, or the trajectories of balls and bullets, were analyzed using Newton's physics, fluxions and fluents. He had many followers, for instance, in France, Patrik D'Arcy, in Italy, Papacino D'Antony, or in Prussia, Leonhard Euler and Georg Friedrich von Tempelhof. (Heine 2009; Steele 2005).
This Newtonian approach to artillery demanded a deeper knowledge of mathematics than that needed for teaching fortification. The Academy of Barcelona, aimed mostly at military architecture, or the Academies of Artillery of Cádiz and Barcelona, which followed it, did not offer an adequate syllabus for Newton's dynamics.
Spanish artillery overcame this problem with the opening of the *Real Colegio Militar de Caballeros Cadetes de Segovia* in 1764. This College had two structures: an academy for theoretical education, directed by a First Professor, and a company of cadets, with one captain and two lieutenants in charge of the military part of the education. The director was the head of the Spanish artillery and the first professor a mathematician, at the beginning the Italian count Gazzola and the Jesuit Antonio Eximeno respectively (Navarro 2013, 105-131).
The Regulations only said the programme would include: "Calculation, Geometry, Mechanics, Hydraulics, Hydrostatics, Fortification and Artillery" (*Ordenanzas* 1768, 50-51). It was the task of the First Professor to develop these subjects. Eximeno gave the inaugural speech, expressing his support of Newton's ballistics and philosophy (Eximeno 1764, 4, 20). However it seems that he did not develop a modern syllabus and in April 1767 Eximeno was expelled from Spain, as were all the Jesuits.
After some years of confusion, the lieutenant of artillery, Vimercati, was appointed First Professor of the College in 1772 and developed a programme for mathematics which continued until 1804. It was an unofficial preliminary year on arithmetic for cadets without previous mathematical preparation. In the first year they studied Euclid's *Elements*, trigonometry and conics; in the second, algebra and its application

to geometry, and in the last year, differential and integral calculus and mechanics. Finally, the cadets were appointed second lieutenant and they studied one year of theoretical artillery. (Navarro, 2013, 146-163)

In 1777, Vimercati was chosen as director of the Academy of Midshipmen of Ferrol and left Segovia. His successor was a civilian, Pedro Giannini, an Italian disciple of Vincenzo Riccati. As he was a good mathematician and diligent director of studies, the College was run without the doubts and hesitation of the first years. He published *Curso Matemático* (1779-1803, 4 v.) and *Practicas de Geometría y Trigonometría con las tablas de Logaritmos* in order for them to be used as handbooks in the College. Their content gives an idea of the subjects studied in the Spanish College of Artillery during the last quarter of the 18th century.

Curso Volume I (Madrid, Ibarra, 1779) has three parts, namely geometry, trigonometry and conics, and in the prologue he states that he follows "Leibniz, Newton and other famous mathematicians". Volume II (1782) has three parts: the first about operations with numbers or letters; the second on equations and curves; and the third on elementary problems of algebra and geometry. In the prologue he recommends many contemporary authors such as Barrow, Maseres, Castiglione, Newton, de Martino, Clairaut, Mac Laurin, Saunderson, Reineau, Wolf, Agnesi, Vicenzo Ricati, Saladini, Simpson, Bezout, Bossut, Euler, Sauri, and Caravelli. Volume III (1795) is divided into four parts. The first one is on the bases of the differential calculus and the calculation of differentials and integrals. The second is on the integration of rational and irrational expressions, while the third and fourth parts are on differential equations. In the text he follows Newton, Bernoulli, or V. Riccati and the prologue also mentions L'Hopital, Le Seur and Jacquier, Bougainville, and Cousin. Volume IV (1803) has three parts on statics, hydrostatics and dynamics. Giannini frequently uses Bernoilli's "Principle of virtual work", giving a very mathematical development to mechanics. Only when he studies air, are experiments taken into account.

Giannini knew the applications of Calculus to artillery proposed in "the works of the gentlemen Tempelhof, Robins and his commentator L. Euler, Papacino d'Antoni and others", but he did not include them because it would have meant omitting mathematical explanations "with digressions typical of other subjects" (Giannini 1795, prologue). In 1782 the College Council discussed that idea and all the military members, that is all except Giannini, said that it would be better "If the course was less abstract and compact, if the part on practical applications is augmented". The director Lacy defended Giannini, but he asked him for the inclusion of a course about practical geometry in his teaching. Giannini then published *Practicas de Geometría y Trigonometría* (1784) with five parts on geometrical instruments, measurement, calculating areas and drawing plans, calculating volumes, levelling, and included several tables (Navarro 2013, 557-585).

At the same time Lacy, the head of the Spanish artillery, promoted a Practical School in Segovia, including: "1 a laboratory of fireworks, [...]; 2 a practical school of mining; 3 attacks and defences of fortifications [...]; 4 several experiences on the different kinds of pieces of artillery and projectiles" (Morla 1816, v. 2 346-347). In 1788, a laboratory of Chemistry was also opened, led by the French chemist Proust. These institutions were related to the artillery and separate from mathematics, but

Newton’s theories were also accepted in the teaching of artillery. For this subject Tomás Morla published *Tratado de artilleria* (1784-1803, 4 v.). The book is principally on practical artillery, but important theoretical questions such as the force of exploding gunpowder, the speed of a bullet when it leaves the barrel, the trajectories of balls and bullets, or the air’s resistance to motion, are also studied. For those questions Morla follows “Sirs Benjamin Robins and Papacino D’Antoni, to whom the artillery is in debt for the new distinction, and brightness that its scientific part has taken” (Morla 1785, 414). For trajectories he criticises the theories of Galileo and Belidor and defends Newton. However, he concludes that “the only rule and measure we have to throw bombs skilfully is practice” (Morla 1785, 343). In general, Morla mentions and defends up-to-date authors; but he does not develop, explain or mathematically justify those theories.

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SYMPOSIUM 18

Physical Sciences between Europe and the USA before WWII

Organizers
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This symposium re-visits the question of the existence and extent of differences between American and European approaches to physical sciences by comparing research of the same fields in the two continents, the production of knowledge in both places, the transfer of knowledge and travel of scientists. We concentrate on the first half of the 20th century, marked by the growth in size and importance of American science, but when Europe was still the centre. Consequently, we often look at the transfer of knowledge, theoretical as experimental, problems and people from Europe to the US. Still, the circulation of knowledge was by no means unidirectional, as shown in a few of the talks.

We examine how American scientists employed techniques that originated in Europe and integrated them into their own agendas. These include theoretical techniques as with celestial and statistical mechanics, electromagnetism and quantum physics, and experimental methods as in piezoelectricity, X-ray crystallography, and spectroscopic analysis. We pay special attention to differences in the use and development of these techniques and in their further reception in Europe. At the same time the transmission of knowledge and problems was often coupled with other factors that contributed to the differences between American and European research , e.g. the relationship of the field to technology or the disciplinary identity of specific research techniques. Another way to explore the relationships between European and American physical sciences is by looking at the transfer of embodied skills. These moves include visits of well-known European scientists to the US, whose analysis here is used to highlight differences between the scientific communities. The American custom of higher studies in Europe as well as the emigration of European scientists to the US are further encounters that provide us a glimpse on the differences, as well as the similarities, between the physical sciences in the two locations and the mechanisms of transmission, and often integration of methods across the Atlantic.

The Revival of the Larmor-Lorentz ether Theories: Herbert E. Ives' Opposition to Relativity between 1937 and 1953

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Introduction

The highly respected American industrial physicist Herbert E. Ives (1882-1953) is mentioned in the scholarly literature concerning relativity for two different and conflicting aspects of his work. On the one hand, Ives conceived and realized, with the help of his technical assistant G. R. Stilwell at the Bell Telephone Laboratories (hereafter called Bell Labs), the Ives-Stilwell experiment—which was the first confirmation of the validity of the relativistic Doppler effect. As such, some textbooks stressed the relevance of the experiment by emphasizing that it was the earlier direct proof of the temporal transformation in special relativity (hereafter called SRT), and, consequently, that it gave a strong empirical support to Einstein's theory (Robertson and Noonan 1968; Schwartz 1968; Synge 1956; Ridler 1991). On the other hand, Ives is quoted as one of the most authoritative opponents of relativity in the Unites States between the 1930s and the early 1950s (Goldberg 1984, Miller 1991). Ives, indeed, never accepted the implications of both the special and general relativity theories, and he spent the last part of his career challenging the favourable reception of Einstein's theories (Hazelett and Turner 1979).

Ives tried to pursue his anti-relativistic agenda in two ways. First, he directly criticized the foundations of relativity theories by seeking to demonstrate the alleged logical flaws of the second principle of special relativity—namely, the principle of the constancy of the velocity of light—as well as by stressing what he considered as the paradoxical implications of this principle for the concepts of space and time. The second strategy was to build a theory alternative to SRT—namely, a theory that explained the same experimental results that were usually interpreted as a confirmation of SRT. The alternative theory Ives strived to build was based on the existence of the ether and relied on the theories formulated by Sir Joseph Larmor (1857-1942) and Hendrik A. Lorentz (1853-1928) between the end of the 19th and the early 20th century.

While in a longer paper I have made a detailed analysis of Ives's anti-relativistic activity from 1937 till his death in 1953 (Lalli 2013), in the present paper I limit myself to exploring Ives's use and interpretation of the ether theories of Larmor and Lorentz. In his explanation of the results of the Ives-Stilwell experiment, Ives avoided mentioning the SRT and claimed that his observations had confirmed what he called the "Larmor-Lorentz theory", based on the existence of the electromagnetic stationary ether and absolute simultaneity (Ives and Stilwell 1938; 1941). Although Ives later developed his own ether theory and did not refer to the Larmor-Lorentz theory any longer, he continued to ground his research on the fundamental concepts of this theory. Since Ives was one of the few scientists who continued to explicitly rely on the ether concept in the 1930s and 1940s, the analysis of Ives's interpretations and employments of the ether theories of Larmor and Lorentz might help us in understanding the way in which these influential theories of the ether transferred from Europe to the United States, and how this transmission of knowledge made the ether concept to survive till the middle of the 20th century.

Ives as the heir of the American tradition of physical optics

To fully comprehend Ives's appropriation of the ether theoretic views of Larmor and Lorentz it is necessary a brief overview of Ives's backgrounds. Ives's father Frederic Eugene Ives (1856-1937) and the American expert of optics Robert Williams Wood (1867-1955) had a deep influence on Ives's approach to scientific problems. Ives's father was an inventor who pioneered the applications of color photography. The first interaction Hebert Ives had with science was just in his father's home laboratory and concerned both the subject of investigation—namely, optics and its technological applications—and the procedure—a strong pragmatic approach that saw the production of artifacts as the main target of scientific research (Buckley and Darrow 1956). Later, Ives earned his PhD at the John Hopkins University in Baltimore under the supervision of Robert Wood. Like Ives's father, Wood preferred the experimental study of natural phenomena to the paper-and-pencil job of theorists and showed a deep interest in photography confirmed by the fact that Wood registered several US patents in this field (Dieke 1956).

The influence that these two mentors had on Ives is evident in the continuation of Ives's scientific career. Soon after the end of the First World War, Ives was hired as an electro-optical researcher by the Engineering Department of the Western Electric Company of the Bell System, and in 1925 he became the director of the electro-optical research department of the just-established Bell Labs. In this position Ives leaded the research of the firm on the developments of fax and television. Ives's expertise was soon recognized by the American scientific community, which offered him several important roles in various scientific societies, including the membership in the prestigious National Academy of Sciences in 1933. Ives's important positions in a number of American scientific societies show that in 1937, when Ives began publishing his heterodox views on relativity, he was an American scientific authority, at least in the field of applied electro-optics.

The fact that Ives based his theory on the existence of a stationary ether as the substratum of the electromagnetic radiation, shows that the evident continuity between the research of Ives's mentors and his own did not involve only the subjects of inquiries and the methodology, but also the underlying ontological commitments. The 19th century optics was indissolubly tied to the concept of wave motions of a mechanical ether. Several American experts of optics of the same generation as elder Ives and Wood never gave the ether concept up. Two important examples of this tradition were Dayton C. Miller (1866-1941) and Abraham A. Michelson (1852-1931). In 1925 the former sparked a long-lasting controversy on the validity of SRT because he began claiming to have observed a non-null result corresponding to an ether-drift of about 10km/s in his own repetitions of the Michelson-Morley experiment (Swenson 1972, Lalli 2012).The latter continued to believe in the existence of the ether well after the SRT had been accepted in the United States and considered Einstein's theory to be "a monster" (Shankland 1963, 56). The position of Wood with respect to the ether remained ambiguous, but there are some expressions in the 3rd edition of his influential textbook *Physical Optics* that might be interpreted as relying on the ether concepts. In particular, Wood gave credit to the result of Miller's experiments as a proof of the absolute motion of the Earth (Wood 1934, 822-23).

Ives's ether theory and the "English school of physical thought"

In the previous section I have shown that Ives's professional life was rooted in the 19th century American tradition of optics and that his devotion to the ether seems to be a product of this tradition, whose components continued to refer to the existence of the ether in the first decades of the 20th century. However, in his scientific papers and in his correspondence Ives did never refer to this tradition, but to a quite different one. In private communications, Ives made evident that he thought to be the heir of "the classical English school of physical thought, which [he] would like to think [he was] championing, against the paradox of the Semitic school" (Ives 1951b). Elsewhere, I discuss the implicit anti-Semitism that this sentence seems to imply and the intellectual connections with the group of experimental physicists who vehemently opposed relativity in Germany from the early 1920s onward (Lalli 2013). Here, I would like to focus on the first part of the sentence. What does Ives exactly mean with the expression "English school of physical thought"?

By listing the scientists Ives quoted in his published writings, one can draw a very clear genealogical line of the above mentioned English school. The first ancestor is Isaac Newton (1642-1727). Soon after one finds James C. Maxwell (1831-1879); then George F. Fitzgerald (1851-1901), who is, in turn, followed by Larmor and Lorentz, often quoted together to emphasize that they had the same position in the evolution of knowledge. The genealogical tree Ives rhetorically built in his publications ends with Ives himself as the last defender of this tradition.

When Ives tried to make it explicit the epistemological difference between the two schools of physical thought he mentioned in his letter, Ives, of course, did not call them English and Semitic schools. He marked, instead, very clear distinctions between an approach to science that he called "natural philosophy" and the attitude according to which "the sole object of physical theory is to predict the results of experiment [sic]" (Ives 1940, 83). Ives stated that the aim of the former was the deep understating of the way in which nature works and he believed that this approach was the one followed by experimental physicists, while the second approach only aimed at a description of the physical phenomena in mathematical terms—an attitude that was embodied by Einstein's style of reasoning.

Ives's operational interpretation of the "Larmor-Lorentz theory"

According to Ives, from a theoretical perspective the advancement of knowledge pursued by the English tradition had found its culmination in the theories of Larmor and Lorentz. Ives did not make any distinction between these two theories and refer to them simply as the "Larmor-Lorentz theory". With this name, Ives meant an interpretation of the Lorentz transformations as a description of the real contraction

of the longitudinal lengths and the real contraction of the frequencies, due respectively to the motion of bodies and clocks through the ether. Ives called the set of these two contractions the “Fitzgerald-Larmor-Lorentz contractions”, and continued to employ this name even after he stopped mentioning the “Larmor-Lorentz theory” in his later writings (Ives 1937b).
The theories of Larmor and Lorentz, however, were not completely identical and both evolved with time. For this reason, to clarify what Ives had in mind with the name “Larmor-Lorentz theory” it is necessary to compare Ives’s own interpretation with those theories of Larmor and Lorentz that Ives quoted in his publications. In the bibliography, Ives referred to these theories as exposed respectively in Larmor’s *Aether and Matter* and Lorentz’s *The Theory of Electrons* (Larmor 1900; Lorentz [1909] 1916). Ives’s own quotations justify a comparison between the conceptions of ether found in these essays, with those exposed in Ives’s papers. As a first step, one can compare the definitions of the ether proposed by the three scientists. In the *Theory of Electrons*, Lorentz defended his views with respect to Einstein’s in the well-known sentence: “I cannot but regard the ether, which can be the seat of electromagnetic energy and its vibrations, as endowed with a certain degree of substantiality, however different it may be from all ordinary matter” (Lorentz [1909] 1916, 230). Almost thirty years later, Ives did not change much by describing the ether as “the seat of the pattern of radiant energy received by the fixed stars” (Ives 1937a, 263). In Larmor’s treatise, instead, there is no similar definition, and scholars agree that the position of the ether concept in Larmor’s world picture was extremely complex by being related to Larmor’s deference to the dynamical principles (Warwick 1991, Darrigol 1994, Warwick 2007).
The difficulties in drawing the distinctions between Larmor’s and Lorentz’s views of the ether become even more acute when one tries to compare the physical meanings of the coordinate transformations in their theories, as it is shown by the disagreement between various commentators (Warwick 1991, Darrigol 1994, Janssen 1995). However, it is possible to state with a certain degree of confidence that in the two accounts quoted by Ives, both Lorentz and Larmor derived the exact version of the Lorentz transformations of the space-time coordinates, and that both Lorentz and Larmor interpreted the Lorentz-Fitzgerald contraction as a physical contraction of the body in the direction of its motion through the ether, as Ives did. The relationships between the physical meanings of the time transformation and of the electromagnetic field transformations in the two theories, instead, were by far more complex, as it was the relationship between ether and matter. Ives was able to overcome the interpretative difficulties and unify the two theories, only because he took into account a simplified version of the ether theory that focused only on the explanation of the optical phenomena. Ives left aside all the analyses concerning the behaviour of the electron, as well as the interconnection between ether and matter. In other words, Ives had in mind something similar to the simplified description of the Lorentz theory that philosopher of science Adolf Grünbaum later christened the “doubly amended ether theory” (Grünbaum 1973, 723). This could be defined as the core of the Lorentz theory plus the two hypotheses of contraction of lengths and clocks retardation. If we limit ourselves to the optical experiments, the doubly amended ether theory and the SRT are empirically equivalent (for an in-depth

analysis of the empirical distinctions between Lorentz's theories and Einstein's SRT, see Janssen 2002).
The simplification of the ether theories proposed by Ives was rooted in a very specific American tradition, as it is showed by his focus on the behaviour of measuring rods and clocks, as well as by his explicit reference, in his later writings, to the operational principle of Percy W. Bridgman (1882-1961). Ives claimed, indeed, that he was putting forward a truly operational methodology against what he defined as the "pseudo operational procedure" proposed by Einstein (Ives 1951a, 126). Bridgman was really interested in, and sympathetic with, Ives's efforts to build an operational theory of relativity. Bridgman, indeed, utilized some of the arguments Ives had developed in his posthumous *A Sophisticate's Primer of Relativity* (Bridgman 1962). In spite of his appreciation of Ives's attempts and thanks to his careful study of Ives's papers, Bridgman was also able to formulate the clearest objection to the foundations of Ives's approach. Bridgman had long been rejecting a realistic view of nature since it was irreconcilable with operationalism, and recognized that Ives's real ether and true absolute time were poles apart from his epistemological credo. In unpublished notes, Bridgman wrote that Ives's view according to which the absolute simultaneity was real but indeterminable was "a complete negation of the operational attitude which [Ives] correctly adopt[ed] in most other situations" (Bridgman 1959, 4). In this way, Bridgman recognized that some of Ives's arguments were logically flawed, because their very starting point was to handle some concepts, as the one-way velocity of light and distant time, "in exactly the old uncritical absolute Newtonian fashion" (Bridgman 1959, 5).

Conclusion

In conclusion, Ives's efforts to re-propose the luminiferous ether is interesting because it makes clear that some physicists still referred to this concept to make sense of the world in the 1930s and 1940s. Although Ives's commitment to the ether was rooted in the American tradition of optics, Ives did not refer to the luminiferous ether of his fellow countrymen—an ether whose mechanical vibrations allowed the transmission of light waves—but used the more subtle and impalpable ether of Lorentz and Larmor in order to explain the same experimental results of SRT. By doing so, Ives believed to follow the tradition of physical thought on which experimental physicists based their work. Quite contradictorily, Ives used the works of two theoretical physicists as Larmor and Lorentz, to pursue his own agenda. This way to employ the ether theory created some contradictions within Ives's reasoning due to the attempts at transferring a concept developed in a well determined theoretical research framework to a completely different and simplified setting with a specific reference to Bridgman's operationalism. These contradictions were eventually recognized by Bridgman himself who was sympathetically attracted by Ives's approach. In closing, it seems relevant to notice that Bridgman's deep interest toward Ives's theory was the fundamental factor that led him to uncover the logical flaws that were internal to Ives's overall project.

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SYMPOSIUM 21

Scientific archives, unpublished manuscripts in private or public corpuses: historiographical and methodological approaches

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Many historians of science develop detailed studies of inedited documents (or sets of documents): letters, unpublished manuscripts (public or private archives), drafts, communications addressed to academies and learned societies that have just been mentioned in a note of a report, documents published in full in the internal reports or journals of these societies but never communicated outside the restricted circle of its members, notebooks of laboratories or notes taken by students, etc.
The contents of those works enrich or transform our historical knowledge of the disciplines involved and often modify the historiography itself.
In this symposium it seems interesting to encourage the exchange of experiences between researchers working individually or in teams on such corpuses.
Will be welcome:
First: the contributions which show how the study of such documents can supplement (or understand better or even correct) studies based solely on published literature, and can also complete the biographies and bibliographies of the authors of the original documents, or the scientists quoted in those papers.
Secondly: the original studies of these texts (contents analysis in scientific and historical perspectives).Third: the contributions dealing with research programs (individual or collective) focused on some corpuses of archives or unpublished

scientific papers: circumstances of their rediscovery, purposes of the researchers, forms of communication of the results of those studies (theses, analysis and editing of texts, online websites dedicated to them, etc.).
Fourth: the description or inventory of such corpuses of archives and all kinds of related information. For example: what has been preserved, by whom, where and why? These archives are they from a single source or have they been established through national or international exchanges? Etc.
And finally, of course, all contributions that will show how such researches have contributed to enrich the historiography and to support the work of historians of science. It will also be interesting to compare the methodologies used by researchers or research teams. Conferences on these methodologies will therefore also be welcome.

Manuscript 2294 from the Library of Salamanca University

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Introduction

The study of unpublished manuscripts can help us to acquire a different perspective on the development of science. Although many manuscripts about mathematics have been disseminated, not many have been studied from a historiographical point of view.

One of these manuscripts is the 2294 from the library of Salamanca University, which I intend to analyze. Its author is Diego Pérez de Mesa (1563-ca.1633), who was born in Ronda (Málaga) and studied Arts and Theology in the aforementioned University. Manuscript 2294 consists of 100 double-sided pages and it is titled Libro y tratado del arismetica y arte mayor y algunas partes de astrologia y matematicas compuestas por el eroyco y sapentisimo maestro El Licenciado Diego perez de mesa catedratico desta Real ciudad de Sevilla del año de 1598[1]. The first part is devoted to arithmetic and the second to algebra.

In my analysis I will focus on the algebraic part of this manuscript[2] and I will also make reference to other works from the Iberian Peninsula that are of relevance in the second half of the 16th century. The purpose of this research is to contribute to the knowledge about the status of algebra, and also to provide new clues that will increase understanding of the process of global algebraization of mathematics in Western Europe.

Diego Pérez de Mesa

Diego Pérez de Mesa was born in Ronda (Málaga) in 1563 and studied Arts[3] and Theology at the University of Salamanca, where he followed the courses taught by Jerónimo Muñoz (València 1520 - Salamanca 1592) who occupied the chair of astronomy and mathematics[4]. Pérez de Mesa occupied the chair of mathematics and astronomy in Alcalá de Henares University and later the chair of mathematics in

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[1] Book and treatise of arithmetic and great art and some parts of astrology and mathematics written by the heroic and very wise master, the graduated Diego perez de mesa, professor of this real city of Sevilla in the year 1598.

[2] A more extensive study of the manuscript can be read in (Romero 2007)

[3] The studies of Arts were a preparatory training to enter into the superior faculties of Theology and Medicine. The Art faculties were considered to be minors. They derive from the *trivium* (grammar, rhetoric and dialectics) and *quadrivium* (arithmetic, geometry, music and astronomy) but in fact, they were faculties of Philosophy.

[4] Jerónimo Muñoz was born in València where he studied Arts. After travelling in different countries to complete his education and training, he held the chair of Hebrew at the University of Ancona. He returned to València where he served as professor of Hebrew and mathematics between 1563 and 1578. From 1579 he held the chair of astronomy and mathematics in Salamanca.

Sevilla, between 1595 and 1600, probably by invitation from King Felipe II. He wrote interesting works about navigation, astrology, astronomy and mathematics, some of which may not have been published. He lived some years in Naples and Rome.
The reasons why he didn't publish the manuscript we are dealing with and most of the works he did, are not known. One of the reasons may be the fear of the censure[5]. Although the most controlled discipline by the Inquisition[6] was Theology, most of the teachers of astronomy in Spain during this period, Jerónimo Muñoz among them, didn't publish their manuals. Pérez de Mesa defended the competence of Jeronimo Muñoz to deal with cosmology and also taught similar ideas to the ones of Muñoz (Navarro 1992, 203), that it could be one of the reasons for the author not to publish his works related to mathematics.

The manuscript

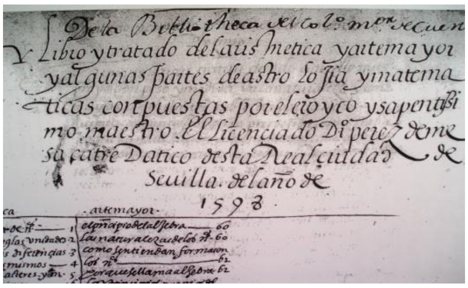

Figure 1

Manuscript 2294 of the Salamanca University Library is one of the unpublished works by Pérez de Mesa. It is a double-faced treatise consisting of 100 pages and dated 1598. Its title is: Libro y tratado del arismetica y arte mayor y algunas partes de astrología y matematicas compuestas por el eroyco y sapentisimo maestro El Licenciado Diego perez de mesa catredatico desta Real ciudad de Sevilla del año de 1598[7]. The first part deals with arithmetic, while the second, named by the author Tratado y Libro de arte mayor o algebra[8], deals with algebra and begins on page 60 and is composed of an introduction and 23 chapters.
It is written in Castilian language as was usual in practical arithmetical texts published in the Iberian Peninsula in the 16th century. Practical arithmetical texts focuse on the tools used to solve mercantile problems and a number of them also

[5] A deep study on the Spanish Inquisition and the censure of cientific literature can be read in (Pardo 1991).
[6] It is necessary to take into account the fact that Spain's communication with the rest of Europe virtually ceased from 1557, when groups of protesters were arrested in Seville and Valladolid. One year later, King Philip II presided over the first of a series of autos-da-fe that culminated in the burning of the Spanish Protestants. This ideological repression constituted a strict control of intellectual activity by both the monarchy and the Inquisition, which at first was confined to theology but soon spread to other fields.
[7] Book and treatise of arithmetics and great art and some parts of astrology and mathematics written by the heroic and very wise master, the graduated Diego Pérez de Mesa, professor of this real city of Sevilla in the year 1598.
[8] Treatise and book of greater art or algebra

included a part dealing with the Arte Mayor[9] or algebra. Arte Mayor (Greater Art) is the expression commonly used in these texts to refer to algebra, in contrast with Arte Menor (Lesser Art), the expression with which arithmetic was sometimes known.

The content of the algebra part

The first chapter of the algebraic part of the Ms 2294 deals about numbers that Pérez de Mesa divides in five categories: the integers, the "vulgar[10] fractional numbers", the "astronomical fractions" and proportional numbers. In the second chapter he claims that the proportional numbers are the foundation of the algebra. In the third chapter the author talks about the possible shapes of the numbers that correspond to the dimension in geometry. According to Pérez de Mesa, the shape of the numbers means the way that their units can be arranged. For example, the units of number 3, can be disposed in this way:

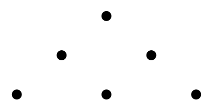

Figure 2

Being 3 a triangular number. In this chapter, Pérez de Mesa quotes "Jordano" and "maestro Ciruelo " referring to Jordanus Nemorarius[11] and Pedro Ciruelo[12] whose works were influenced by the Boethius[13] Institutio Arithmetica, in which the author devotes several chapters to the shapes of the numbers.
Pérez de Mesa often describes parallelisms between the numbers, which belong to arithmetic, and continuous quantities, which belong to geometry.
The author develops his idea of algebra in the fourth, fifth and sixth chapters. The author dedicates the next four chapters to the addition, subtraction, multiplication and division of what he called dimensions or figures, which nowadays we refer to as polynomials. From the eleventh to the sixteenth chapter Pérez de Mesa deals with

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[9] An extensive study about Spanish Arte Mayor can be read in (Massa 2012)
[10] In the third book of arithmetic, Pérez de Mesa talks about "astronomical fractions". He says that the mathematicians, mainly the astrologers, don't divide things in halves, thirds, quarters, etc. as usual, but that the first division they do is in 60 parts. When Pérez de Mesa speaks about "vulgar fractions" he refers to fractions commonly used and when speaking about "astronomical fractions" he referes to a sexagesimal division of the unit.
[11] Jordanus Nemorarius (1225-1260), was a German philosopher and mathematician. He wrote six mathematics treatises, being probably the work of reference for Pérez de Mesa: *The elementis arithmeticae artis.*
[12] Pedro Sánchez Ciruelo was born in Daroca in 1470 and was tutor of King Philip II and professor of theology at the University of Alcalá de Henares. He wrote in 1529 *Cursus quattuor mathematicarum artium liberalium* that is, probably, the work of reference for Pérez de Mesa.
[13] Boethius (ca 480-524) was a Roman mathematician and philosopher who wrote texts on geometry and arithmetic which were used for many centuries as a reference in European countries.

the nature of the fractional numbers, to reduce them, and also with the addition, subtraction, multiplication and the division of fractional expressions. The seventeenth chapter talks about rational and irrational numbers[14] and the last six chapters are about the resolution of equations and systems of equations.
The topics he deals with are similar to those of the works by Marco Aurel[15] (fl. 1552), Juan Pérez de Moya[16] (ca.1513-ca.1597) and Antic Roca[17] (ca.1530-1580), that are reference books of the Iberian Peninsula in the second half of the 16th century, and seem to be written for the author to support his teaching. In some aspects the manuscript goes further than the other mentioned works, although it is not clear that it was the intention of the author.

The idea of algebra

According to Pérez de Mesa, mathematics is a set of disciplines that deal with proportion, weight and measure. Among these disciplines there are music, geometry, perspective, cosmography, geography, astronomy, navigation, mechanics, and also arithmetic. In the introduction of the algebra part of the manuscript the author considers three main parts in the arithmetic: the logistics that deals with commercial issues, another part that takes into account the nature of numbers according to their properties and a third part which is the algebra. Therefore, Pérez de Mesa considers algebra as a part of arithmetic like Aurel and Pérez de Moya, and also like them, the same as Greater Art as the author states in the title. The conception of Roca is different since he considers the algebra as a procedure belonging to the Greater Art.
In the words of Pérez de Mesa, the purpose of algebra, called rule of the thing by several authors, is to find a number or numbers when you know some of its properties. In this research, it has an important role what the author calls proportional numbers, which are numbers in geometric progression.

[14] In most of the first algebra treatises that appeared during the Renaissance, we find a chapter about the classification of binomials and apotomes, which are the expressions consisting of an addition (in the case of binomials) or a subtraction (in the case of apotomes) of a rational number and a square root or of two square roots.
[15] Marco Aurel is the author of the first book printed in the Iberian peninsula which can be considered a treatise of algebra: *Libro primero de Arithmetica Algebratica* (1552), published in Valencia. Very little is known about this author, apart from that it was German, who had settled in Valencia in order to teach practical mathematics and that he is also the author of a mercantile arithmetic. Algebra, however, was not unknown in Spain before the publication of the work of Aurel as it shows (Docampo, 2006: 43-62).
[16] Juan Pérez de Moya (Santisteban del Puerto, ca. 1513 - Granada, ca. 1597) is the author of the most popular algebraic work written in the Iberian Peninsula in 16th century, the *Arithmetica practica y speculativa* (Salamanca, 1562) that went into 30 editions.
[17] Antic Roca, native of Girona, was a physician, doctor of arts, professor of philosophy at the University of Barcelona, mathematician, lexicographer, and the author of an Arithmetic and philosophical treatises. In his work *Arithmetica* explains that he has used the works of 49 authors to write his own work.

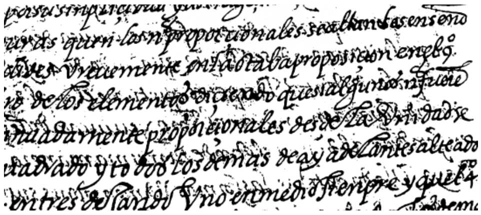

Figure 3

The author says that the foundation of algebra could be found in Euclid Elements, book IX, 8th proposition: “If as many numbers as we please beginning from an unit be in continued proportion, the third from the unit will be square, as will also those which successively leave out one; the fourth will be cube, as will also those which leave out two; and the seventh will be at once cube and square, as will also those which leave out five” (Heath 1956, 390).
We can express this proposition using current notation, as follows:

1, a, a2, a3, a4, a5, a6, a7, a8, a9, a10,…

That is to say, the author places the unknown in the second place of a geometric progression whose first term is the unit and, consequently, the reason has the same value of the unknown. With this approach, Pérez de Mesa highlights the unknown and its powers. For him, the algebra is the art to find out the value of the unknown, although sometimes some power of the unknown is found instead. In this case, knowing in what place this power is located, we can find the second term of the progression, that is, the unknown, by calculating the appropriate root.
Pérez de Mesa calls side, line or root, the second number of this progression and adds that it is the universal means to find the truth looked for. He keeps in mind this sequence along all his work.

The notation

Pérez de Mesa does not define clearly the notation that will be used in his algebra. He introduces the symbols when he needs them and usually he writes them down in the margin.
After establishing that the proportional numbers are the basis of the algebra, the author writes in the margin the following table

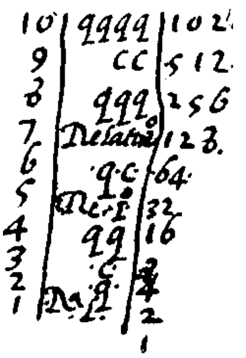

Figure 4

without giving any explanation. In the central column there are represented the symbols that correspond to the successive powers of the unknown. In the case of the first power there are two symbols, that is, the first letters of the words lado (side) and raíz (root) and represent, therefore, the unknown. In the third column there is the value of each power when the value of the unknown is 2.

In the 8th chapter, the author explains the sum and the rest of what he calls the compound figures which, for us, would be the addition and subtraction of polynomials. We are going to discuss one of these operations:

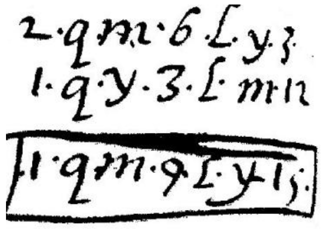

Figure 5

Each term is preceded by its sign “plus” or “minus” and there are points to separate the different symbols. The first terms have no sign and the author always considers them to be positive. He introduces the nomenclature character to refer to the signs “plus” and “minus”.

An example of a multiplication of polynomials:

that in current notation we would write:

(3x3+2x2)·(2x2+3x)=6x5+13x4+6x3

The equations

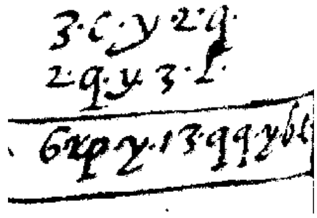

Figure 6

Pérez de Mesa devotes the last chapters to equations, which he usually refers to as equalities, as well as other authors of the time. He begins to treat them in the eighteenth chapter, in which the author explains that the resolution of equations, which he calls regla de la igualación (rule of equality), is the ultimate goal of algebra and consists in knowing in what proportion are geometric figures or dimensions or, more specifically, in a true knowledge of the value of any figure or dimension of the progression. It comes to finding a term any of a geometric progression, the reason of which, will give us the value of the unknown.

Pérez de Mesa classifies the equations depending on the number of terms they have. The simple equalities have two terms and compound equalities, have three terms.

In the simple equalities, the author distinguishes the case in which there are no missing intermediate dimensions from the cases in which one or more dimensions are missing, that is, he distinguishes the case where, in our language, the powers are consecutives from the case where they are not. In the first case it is enough to do a simple division to solve the equation and in the second it is necessary to extract a root after the division.

In the twentieth chapter Pérez de Mesa studies the compound equalities, that is, the equalities that "after having removed the superfluous quantities, which are what has the character plus, and added the tiny quantities, even three dimensions remain"[18]. He says that it doesn't matter which dimensions are, although the "writers" use the dimensions: nº, £ and q, which can be placed in three ways.

Pérez de Mesa considers three cases depending on which term is alone in the second member of the equality. In the first one, the number is in the second member of the equality. In the second, the quadratic term is in the second term of the equality and in the last case it is the lineal term which is in the second member of the equality.

Not all mentioned authors consider the same number of cases for the equations solving and Roca, for example, emphasizes the importance of finding a way to reduce the number of cases as much as possible. However, all of them state similar rethorical rules to find the unknown. The title of the last chapter on algebra in Ms 2294 by Pérez de Mesa is de la Regla de la quantidad and concerns the systems of quations[19]. The way of solving the systems of equations is different from the approach adopted by other Spanish authors. Unlike them, Pérez de Mesa does not take an auxiliary unknown, but rather puts « a » for the first unknown, « b » for the second, and so on. Although in his last work, Tratado de Matematicas, Pérez de Moya used different names for different unknowns, he retains a special name for the first one. Nevertheless, Pérez de Mesa considers all the unknowns at the same level. This method can be taken from Buteo[20] since on the first page of his manuscript

[18] *Igualaciones compuestas se dicen quando despues de haver quitado lo superfluo ques lo que viene con el caracter mas y añadido lo diminuto quedan 3 dimensiones* (Pérez de Mesa 1598, 92)

[19] More information about the equalities in Pérez de Mesa, in (Romero 2008), the system of equations solving in Spanish algebras in (Romero 2011) and about the algebraic symbolism evolution, focused in the second unknown, in (Heeffer 2010).

[20] Joannes Buteo is the Latinized name of Jean Borrel, a French mathematician (ca. 1492-ca. 1570).

devoted to algebra he quotes this author, first calling him “Triputeon” (Pérez de Mesa 1598, 61) and later “Puteon” (Pérez de Mesa 1598, 65).

One of the exercises he proposes is:

Two numbers are given, so half of the lower with the higher is 15 and the lower with a third of the higher is 10 (Pérez de Mesa 1598, 99).

Pérez de Mesa calls “a” the larger number and ”b” the smaller. He says that first the fractions should be reduced to whole numbers and then obtains the system that he sets out as follows:

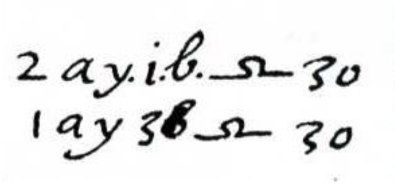

Figure 7

He solves the system by using the method that nowadays is called “elimination method” and by multiplying the second equation by 2 and subtracting it from the first equation, thereby obtaining 5b=30, and thus the value 6 for “b”. He replaces this value in the first equation and finds 12 for the value of “a”.

It is important to point out that the symbol for the “equality” is not introduced until the moment when he has to operate with equations, giving to these equations the status of new algebraic identities.

Although Pérez de Mesa solves this problem in a rhetorical way, I would like to point out the symbols he employs. He uses the letter “y” for the “plus sign”, as he did when operating with polynomial expressions, and puts Ω for the equality. This is the first time in his manuscript that he uses a symbol to indicate the equality. We would do well to remember that neither Bombelli (1572) nor Stevin (1585) nor Viète (1590) used any symbol[21] to indicate the equality.

Final remarks

The algebra part of Ms 2294 is theoretical and basically follows the same guidelines that of the algebras by Aurel, Pιrez de Moya and Roca. The examples are of the same kind that the numerical exercises of the Arithmetica of Diophantus whom Pιrez de Mesa quotes in the last chapter of the manuscript, considering the author the most practical issues as a part of the logistics. The methods he explains to solve equations are presented in a rhetorical way and the author uses symbols in order to make the explanations simpler, but they don’t have an operating meaning. However, when he explains the way to operate with polynomials, the symbols have an operative meaning. It is through the solution of systems of equations, at the end of the manuscript, when he reaches the most mature phase of his algebra, which treats the unknowns as equals in importance, in contrast to other authors of the time and he operates on the equations. The author writes the system of simultaneous equations explicitly, treated the unknowns with equal weight and operated with equations, solving the system by the method that is nowadays called elimination. The use of a

[21] For further information about the evolution of algebraic symbolism, see (Cajori 1993)

special symbol, Ω, by Pιrez de Mesa to indicate equality, allowed him to consider equations as algebraic objects that can be added or subtracted.
It does not seem that Pérez de Mesa is aware of the qualitative step forward he does in the last chapter, because he does not put too much emphasis on explanations nor in the examples he solves. As well as the method used to solve quadratic equations is in the line of those who used Aurel, Pérez de Moya and Roca, in the solving of systems of equations follows a different methodology. It is not clear in what sources was based with regard to the resolution of the systems but the study of the Logistics of Buteo, to whom Pérez de Mesa refers in the third chapter of his algebra, could shed light in it.
Although most of the works in the 16th century Spain have Italian or German influence, Pérez de Mesa seems to be also influenced by a French author. The possible circulation of mathematical knowledge between France and the Iberian Peninsula could be a research line for further studies.

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The Correspondance of Emile Clapeyron to Gabriel Lamé (1833-1835), to Analyze of Social Networks

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Before to engage their correspondence in 1833, Émile Clapeyron and Gabriel Lamé had a long common past. The first one was born on February 1799 in Paris and was a student of the École Polytechnique from 1816 to 1818, the second one was born on July 1795 in Tours and was a student of the same school from 1814 to 1817. The same year 1818, they entered in the engineer's school École des Mines. From this moment, their lives were near one of the other. Indeed, in 1820, they went together and stayed eleven years in Russia. In Saint Petersburg, they were employed to teach applied mathematics and to build various engineering projects. They lived in two flats at the same floor. Between 1823 and 1831, they published eleven papers together on engineering, mathematics and mathematical physics. It is important to note that, whatever the subject, the authors of the paper were always named Lamé then Clapeyron (Barbin 2009).
When they came back in France, they frequented the saint-simonians (Barbin 2009) and they wrote books together, on railways and civil engineers' works (1832), on professional schools (1833). But the professional life separated the two friends: Lamé became professor of the École Polytechnique in 1832, while Clapeyron became professor of the École des Mines of Saint-Étienne in 1833. Saint-Étienne was a town in the centre of France, surrounded by many mines of coal. When Clapeyron left Paris for Saint-Étienne, Lamé and him promised to write one letter to the other by week. In the beginning, Clapeyron did, but Lamé did not, and the frequency of the correspondence decreased.

Themes, Actors and Nets in the Correspondence
The correspondence of Clapeyron to Lamé is composed of 38 letters. Until January 2012, it was in the family of Gabriel Lamé, now it is in the École Polytechnique. In the first letter of 1832, Clapeyron wrote about his professional future. The second letter was written in 1833 from England, where he visited mines and railways, 26 letters were written in Saint-Étienne or in Rive-de-Gier (a mine near Saint-Étienne) from 27th January 1833 to 7th July 1834, one letter is written in Zurich where Clapeyron came to give an advice on a bridge, 9 letters were written in Arras (a town in a mining area in the North of France) from 3th December 1834 until 31th May 1835. The correspondence interests many and various subjects because Clapeyron, unhappy in province, always asked news from Paris. This explains why the correspondence permits to learn about people and their business. It is also a valuable tool to understand the life of an engineer of mines in this period.

We defined four principal themes: railways (53 letters mentioned this theme), scientific life (28 letters), professional life (28 letters) and the French society (6 letters). The letters also contain private news. In this paper we will retain only the two first themes.
There are 80 names quoted in the Correspondence, and 33 main actors – that means that they appear two times or more in the letters. Among them there are 20 polytechnicians (8 are engineers of the École des Mines and 6 of the École des Ponts et Chaussées), there are also 3 civil engineers, a politician and a banker. The most quoted persons are the banker Émile Péreire and the engineer Stéphane Flachat, who play a part in railways, and the polytechnician Louis-Antoine Beaunier, who was the director of the École des Mines of Saint-Étienne and became a politician in 1830. A complete study of the net constituted by all the names linked to all the themes of the letters shows that there is a strong connexion between them.

Emile Péreire	22	Louis Thénard	5	Antoine-Louis Cerclet	2
Louis-Antoine Beaunier	17	Adolphe Thiers	5	Antoine Delsériès	2
Eugène Flachat	15	Paul Dubourg	4	Pierre-Louis Dulong	2
Charles Combes	10	Pierre-Dominique Bazaine	3	Jean-Philibert Fénéon	2
Marc Seguin	10	Elie de Beaumont	3	Les Flachat	2
Baptiste Legrand	9	Gustave Coriolis	3	Pierre Hachette	2
Camille Picard	8	Armand Dufrénoy	3	Jean-Firmin Malinvaud	2
François Arago	7	François-Noël Mellet	3	Jean Perdonnet	2
Stéphane Flachat	5	Jacques Noblet	3	Siméon-Denis Poisson	2
Louis Navier	5	Jean-Victor Poncelet	3	Gaspard de Prony	2
Les Seguin	5	Pierre Arnollet	2	Camille Séguin	2

Table 1: *Main actors with the number of times where are mentioned*

Railways in the Correspondence

The main subject discussed is the project of the line Paris Saint-Germain (27 letters), where Clapeyron wrote about the research for financial supports, about the conditions for delivering the project and on his job in the future railway enterprise. The actors about railways in the correspondence are engineers or scientists (13 actors) and politics or bankers (8 actors), and a scientist who was also a politician, François Arago.
In his “Notice sur les travaux” (*Note on the works*) Clapeyron explained the circumstances in which he began to be interested by railways (Clapeyron 1858, 5):

Coming back in France after the Revolution of 1830, my occupations took a more pratical nature [...]. In this period, I was surprised by the future of the railways inaugurated by the success of the great experience on these new ways between Manchester and Liverpool, I conceived the idea, and wrote projects on railways from Paris to St Germain; but in waiting that financial circumstances permitted the realization of this thought, I was called in St Etienne as professor of the École des Mines, where I was in charge of a teaching on building.

Indeed, after his return in France, he was kept on a retainer with half a salary until October 1832. In 1832, the two friends met again polytechnicians in saint-simonian meetings and in the « Association Polytechnique », founded by Auguste Comte to promote popular education. With Auguste Perdonnet, a saint-simonian engineer of the Ponts et Chaussées, they wrote a plan on railways (Perdonnet 1832). Next year, they wrote a book on *Vues politiques et pratiques sur les travaux publics de France* (Political and practical views on civil works in France) with the brothers Eugène and Stéphane Flachat, two saint-simonian civil engineers, (Lamé 1833a). In 1833, they also wrote a book entitled *Plan d'écoles générale et spéciales pour l'agriculture, l'industrie manufacturière, le commerce et l'administration* (Plan of general and special schools for agriculture, manufacture and administration) (Lamé 1833b). The subjects of these three books are inspired by the philosophy of the saint-simonians. The philosopher Saint-Simon considered that the engineers occupy an upper place in the society: “engineers are among ‘the producers’, those who give the most important products, those who manage the more useful works for the Nation, they are the real flower of the French Society” (Saint-Simon 1819). One of the most important realization of his disciples will be the railways (Wallon 1908). In 1825, the first paper in favour of railways appeared in the saint-simonian journal *Le producteur*. The saint-simonian Michel Chevalier wrote an important paper on railways in the journal *Le globe* in 1831 and his book *Système de la Méditerranée* in 1832. In this period, the saint-simonians distributed a great lot of “popular sheets” in favour of railways in the streets of Paris. In January 1833, the saint-simonian banker Émile Pereire published papers on the necessity of new laws for railways in the journal *Le National*. Laws in favour of railways were voted in June and July: funds were voted for projects and railways were considered as civil engineering.

The « Affair of Saint-Germain » in the Correspondence

The scientist Henri Navier proposed a project of a railway for goods, from Paris to Rouen in 1825, and Stéphane Flachat wrote a report to compare advantages between such a railway and a canal in 1828. But all the projects on this line failed at this period, and new projects on shorter distances emerged. The saint-simonian banker Émile Péreire submitted a project of a line for passengers from Paris to Saint-Germain on 7th September 1832 (around 20 km). Propaganda in favour of this line was done by Émile Péreire in *Le national*, by Stéphane Flachat in the *Journal du Commerce*, and by Michel Chevalier in the *Journal des débats* (Wallon 1908, 51-63). Most of the letters of Clapeyron mentioned this project, called “our affair of Saint-Germain”, “our affair of railways” or simply “our affair”. In his letter of the 3th February 1833, he wrote: “I am very pleased to see that the railway from Paris to

Rouen is not very much advanced, that gives to you time to write the little work about the question of railways lines as we agreed". Some letters mentioned three rival projects around Paris, like the line from Paris to Pontoise.

The preparation of the project Paris-Saint-Germain needed to find funds and guarantees. In five letters we learn that Péreire researched finances, then the saint-simonian banker Adolphe d'Eichtal and then James de Rotschild accepted. Clapeyron was worry against Lamé because his friend was not busy of the affair sufficiently, especially towards "the capitalists", like on 3th February 1833:

> *I ask to you to see Péreire sufficiently and to look after the affair of St Germain. I think that it is time now to consult the capitalists about the question to know if he will obtain funds, we must also think to the guarantee, if the affair is now to the Ponts et Chaussées, it is time to act with energy*.

Indeed, the project submitted by Péreire was approved by the prefects in February 1833 and by the General Council of Ponts et Chaussées in March 1833. But Clapeyron was always anxious, he wrote on 20th March 1833:

> *My advice is that you does not care of our affair of railways sufficiently, for me it is essential that you keeps the strings otherwise than in the strength of things. Being not any well informed, you will be gently eliminated. You can also have the opportunity to make useful acquaintances among the capitalists. Think to that.*

The technical preparations concerned the drawing of the line Paris Saint-Germain (letter of 3th March 1833) and the expenses for maintenance (three letters from February and June 1833). For calculating the costs for maintenance, Clapeyron obtained results by spying on the line Lyon Saint-Étienne of the brothers Seguin, we learn in his letter of 22th May:

> *I would like to give you some inquiries about the expenses of maintenance. I asked to the director of the railway [Paris St Étienne] Marc Seguin [...]. I have no answer and it is probable that Mr will not give them. [...] In anyway these expenses of maintenance must be huge, all was done with an extreme negligence, it is clear that they must pay all that in repairs. The number of workers counted by me to repair the line St Étienne Rive de Giers was yesterday 40, [...] that is 100 F by day, 3000 F by month, the distance is 22000 m [...] there are important expenses caused to the deterioration of the road [...]. These are the precise data:*

maintenance for railway	*maintenance of material*	*various expenses*	*special expenses1832*	*general expenses*	*rental expenses*
10000, 63	18562,65	2438,65	8407,71	*17901,55*	*5687*

Table 2

In seven letters, from April 1833 to August 1834, Clapeyron mentioned his scientific experiments on resistance of rails and on inclined planes and curves, and in six letters, from February 1834 to December 1834, on steam-driven machines. He hoped to write two papers on these experiences. These works are motivated by his hopes to become the director of the works of the future line Paris Saint-Germain. We know that he was unhappy to be in Saint-Étienne, and that he tried many possibilities to leave it. He wrote on 22th May 1835:

> *Did this Conference with Arago take place? Say many things from me to Péreire and to Stéphane. How the affairs of interest among us will be settled definitively? Let me know about all that. It is also good that I would know when the Company will be definitively constituted and when it will judge useful to officially make to Mr Legrand the request of my responsibility of the direction of the works.*

Finally, the project was accepted on 9th July 1835. The Company of railways Paris Saint-Germain was constituted officially on 4th November 1835 with Émile Péreire as director, Clapeyron, Stéphane Flachat and Lamé as engineers (Leclercq 1987, 81). Clapeyron invented new railway engines because Stephenson was unable to furnish engines able to climb the great declivity of the line (École polytechnique 1897, 194-198). Now, we know that this work were prepared in Saint-Étienne.

Scientific Life in Correspondence

The main subtheme about the scientific life is a paper of Clapeyron entitled "Mémoire sur la puissance motrice de la chaleur" (*Paper on the motive power of heat*) (15 letters). Other letters concern scientific subjects (11 letters), on elasticity and on a paper of Lamé about aether, and the scientific community in Paris (2 letters).

In the end of 1832, Clapeyron sent his paper on heat at the French Academy of Sciences, but it was not accepted by François Arago, Siméon-Denis Poisson, Pierre-Louis Dulong. Then he researched a journal to publish it, as we learn in his letter of 24th March 1833:

> *Did you bring my paper on the theory of gases to the committee of the journal des Mines? The rather bad opinion of Mr Dulong increases my will to address the paper to other judges. Independently of the distance of Mr Dulong from purely theoretical research, it is possible that he does not know the principle of the* vis viva*, not enough to understand how it is at the foundation of my research. This rejection by Dulong is a true misfortune really, and you could realize how decisive it is for me if you could know his objections.*

During one year, the publication of the "my paper" made him anxious. He explained to Lamé the reason of the reject on 8th April 1833:

> *I warn you that Arago does not understand the principle of the* vis viva*, and so*

stress on this principle behind him. I am very sorry to get not a better understanding. […] Let bring my paper to Combes, and to urge him to print it in the Annales of Mines.

On 10th June 1833, the paper was presented by Dufrénoy to the Commission of *Annales des Mines*, but it was not accepted. Finally, it appeared in the *Journal de l'École Polytechnique* (Clapeyron 1834). Clapeyron asked to Lamé to distribute it in his letter of 13th August 1834:

I thank you very much, my dear Lamé, of the care you take with my paper. […] Please distribute copies to our acquaintances like Poisson, Navier, Poinsot, Libri, Coriolis – in short at almost all the persons to whom you send papers, what do you think? Also you could give copies to Dufrénoy, Brochant, Élie de Beaumont, Combes.

The scientific references given by Clapeyron in his paper are the Mariotte and Gay-Lussac's laws, confirmed by new experiments of Arago and Dulong, the works of the chemists Bérard and Laroche on the specific heat of different gases (1813), a paper of Dulong on the specific heat of elastic fluids (1828) and the Sadi Carnot's book (Carnot 1824) *Réflexions sur la puissance motrice du feu* (Reflections on the motive power of heat), with a « verification » by Dulong. There is also made a suspicious observation on the hypothesis of Laplace and Poisson (1828). In his letter of 1st April 1833, Clapeyron wrote: "I hope that I would be better understood by the engineers than the scholars, who don't attend as we do to the principle of *vis viva*".

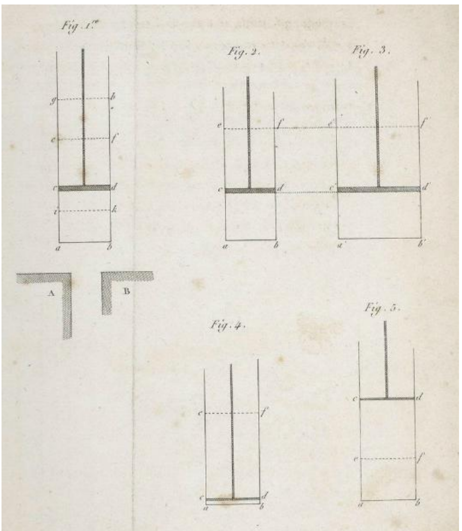

Figure 1

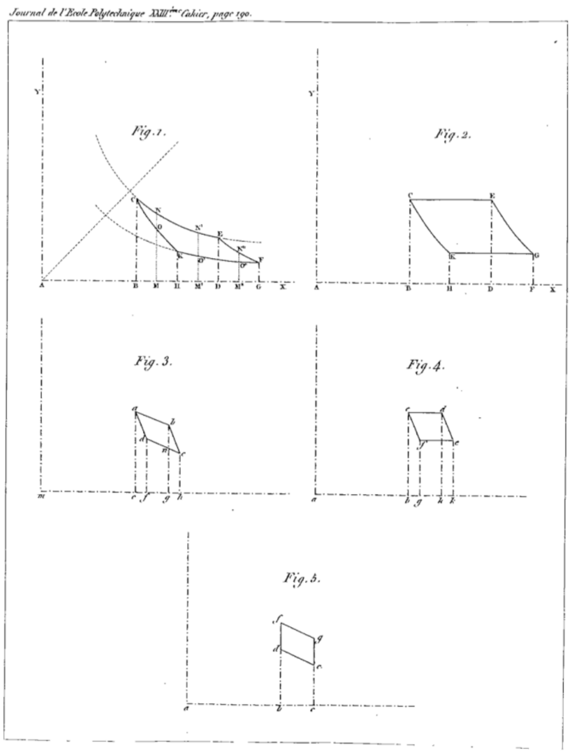

Figure 2

This quotation can be enlighten, if we compare the “Carnot’s cycle” in Carnot (Carnot 1824, 119) and in Clapeyron (Clapeyron 1834, 191). To understand how to pass from one figure to the other, it is possible to use an engineer’s instrument: the Watt’s indicator, which produces a pressure-volume diagram. This diagram was developed by James Watt and by John Southern to improve the efficiency of engines. In 1796, Southern developed a simple technique to generate it by fixing a board, which moves with the piston and traces the “volume” axis, while a pencil, attached to a pressure gauge, moves at right angles to the piston and traces “pressure”. Watt calculated the work done by the steam from the area between the “volume” axis and the traced line. The indicator was unknown by the scientists in this period, but Clapeyron could know it from his stay in Russia or by a paper in the journal *L’industriel* appeared in 1828 (Redondi, 1980, 104).

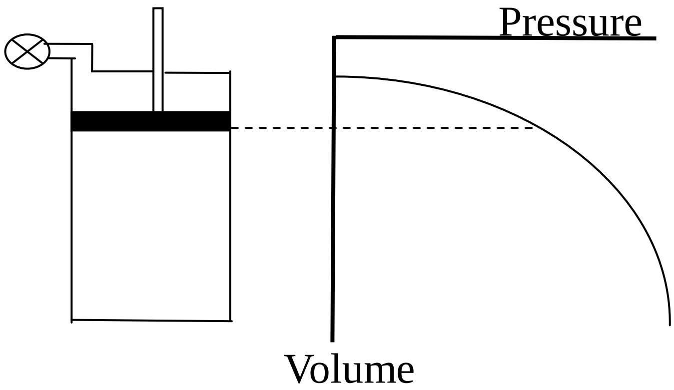

Figure 3

Conclusion

The Correspondence permits to know new things on the preparation of the railway Paris Saint-Germain: on the relations between the different kinds of actors and on the net of the saint-simonians, but also on “the spying” and the experiences of Clapeyron. It permits also to complete the historical information [Birembaut 1976, 191-193] about the Clapeyron’s paper on heat: the relations between the actors in the examination, the refusal and the final acceptance of the paper, and also his reactions about the rejects. At last, we learn about the life of an engineer in the province in the years 1830, about the feeling of isolation and about the more and more difficult relations between the two friends.

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W.H.F. Talbot (1800-1877) Mathematician: the Handwritten Notebooks, the Drafts and the Correspondence with the French Mathematician J.D. Gergonne (1771-1859)

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The national library owns unpublished handwritten notebooks by the scientist William Henri Fox Talbot (1800-1877). They are contained in two boxes – that we shall note (I) and (II) - referenced 7419 and DEC07MB.
Two other boxes contain pages and other scattered notes written by Talbot, but they would require a detailed study and many researches to try to insert them in the chronology of the scientific work of their author because references are very often missing (dates, object, etc.).
We did an inventory of the contains of those notebooks at the request of the Department of Arts of the Cambridge University, which team was working on the Talbot's contribution to the invention of photography and on his photographic production. But they needed a specialist in history of mathematics of the beginning of the 19th Century to get an overview of the scientific pages of the notebooks. And they knew we studied some years ago the seven articles Talbot sent during the years 1822-1824 to the French mathematician Gergonne who directed the *Annals of Pure and Applied Mathematics* he created in 1810.[1]
Pr Larry Schaaf[2] (Montfort University) also asked us to translate some letters from Gergonne to Talbot for the The Correspondence of William Henry Fox Talbot Project he directed during the last years[3].
For that reasons, we also had to specifically study the mathematical contained of the notebooks of the two boxes and to give an overview of his correspondence with Gergonne and of his works published in the *Annals* of Mathematics in order to precise how important or essential was the place of mathematics in the works of Talbot.

A brief description

These notebooks appear in different sizes (small or large notebooks, most of them in a rough book form).
Some of them are noted by capital letters (A to O). The series stops at Q, but notebooks P and Q (published by Larry Schaaf, Cambridge University Press)[4] are

[1] See: 1/ Gergonne, 1823-1824; 2/ Gerini, 2010 & 2002.
[2] See: Schaaf, 2000
[3] See : http://foxtalbot.dmu.ac.uk/talbot/biography.html
[4] See: Schaaf, 1996

located in the National Media Museum in Bradford. Others books are only referenced by numbers.
The first challenge was to try to date those documents. Some of them are dated (like the M one dated “Lacock, 4th December 1834”). Unfortunately, a lot of them are not. An attentive reading of their contents allowed us to correct this gap for some of them, because indications in the text allow knowing approximately the time when they were drafted. For example:

Notebook n° 24096. No date but a note in Astronomy: “April 18th 1817, conjunction of Mars and Saturn at 6 h 9 min afternoon”
Notebook n° 24109 No date but after 1842 because Talbot mentions the “*Manchester meeting (1842) of the British Association (see proceedings of the section p.15)”*
Notebook n° 29088 Sept 12th 1836 It seems to be the continuation of the notebook n° 37145 (not dated)
Notebook n° 35303 No date. Perhaps 1822 because here one can find the same subject Talbot sent to Gergonne in 1822 for his *Annales de Mathématiques Pures et Appliqués*.
Notebook n° 35678 No date but after 1857 because of a reference to the *Quaterly Journal of Pure and Applied Mathematics*, 1857

Table 1

The result of this first work can be read in an annex at the end of this paper.
But in those boxes one can also find some extracts from Talbot's publications in reports of learned societies, and more particularly in the ***Transactions*** of the ***Royal Society*** of Edinburgh.

A precocious education and a precocious interest in sciences
A big exercise book dated 1809 (Box II) shows us how good W.H.F. Talbot’s scientific learning was, even when he was very young. There are 23 large drawings painted with ink by the young child he was then: they show mathematical bodies, and maps in astronomy:

- *Surfaces and solids, regular bodies, circles and trigonometry (Geometry).*
- *Solar system with such indication as: “If the distance from the Sun to the Earth be supposed to be 10, Mercury will be 4, Venus 7, March 15, Jupiter 52, Saturn 95, and the Herschel 190”.*
- *Tellurian system*
- *Fixed stars*
- *The parallax in the difference of aspect of a planet seen from the centre of the earth and from its surface.*

Etc.

Later, he published as we wrote before seven articles in the first French Journal of Mathematics: the *Annales* of Gergonne. He was 22-24 years old when he did it[5]. If one considers his scientific publications during his lifetime, one can see that his first papers dealt with mathematics from 1822 to 1836, and he came back to them after 1865. It's a reasonable hypothesis to say that this science has been his first passion since he was a child. Reading his notebooks confirms that mathematics were a passion for him, a kind of entertainment too, even among other sciences when he was interested for example in optics and chemistry for his invention in photography (he announced in 1841 his discovery of the calotype - or *talbotype*, process). Let us try to explain that impression.

Mathematics as an entertainment

One can note it in most of his notebooks, and more especially from the A one (1823), to the "K" one (1833). Most of his drafts show him working on the properties of the conic sections (the theme of his articles in the *Annals* of Gergonne) and trying to calculate by different ways the integrals needed for those properties.

In the book "L", where mathematics is still dominating, W.H. F. Talbot works alternatively on mathematics, optics, chemistry:

- Mathematics: oblique coordinates, problem of Malfatti, one problem on the ellipse with a citation of Gergonne, non symmetrical equations, integration of the formula $dx\sqrt{1-x^4}$, "cubic parabola", "discontinuous curves", etc.
- chemistry and thermodynamics: report of the *Poggendorf Annalen* of 1833, liquidity, sulphate of silver, acetate of ammonia, electro chemistry, heat and pressure.
- Astronomy: triple or multiple stars.
- Optics: achromatic object glass, "polarished"[6] light, revolving prism.

Here and in the book "M" one can see the interest of Talbot for the properties that will be essential in the invention and progress of photography.[7]

But in most of the notebooks after the M one, even in the years when Talbot devoted his work mainly to chemistry, we can see him here and there solving an equation, giving references to books of mathematics, copying extracts from Euclid 's Elements, etc. His interest in mathematics did not weakened, and he always seemed to give himself some pleasure when he was giving up chemistry for mathematics or astronomy.

But doing mathematics was for him…

[5] The first of them was "*On the Properties of a Certain Curve Derived from the Equilateral Hyperbola*" [*Annals* of Gergonne, XIII, 1822, pp. 242-7].

[6] We should have wrote« polarised » today.

[7] Notebook M (1834) contains less mathematics than the previous one, but however one finds there 74 pages (among 178) devoted to them. The other pages are devoted to optics, astronomy, but primarily to chemistry, and more especially to the iodide of silver and its optical properties under the effect of heat (Talbot writes: "when awarmed").

More than entertainment: a scientific work

His scientific publications in journals or transactions first allow us to give a chronology of his centres of interest, even if he never gave up mathematics.

He began in 1822-23 with mathematics, with his seven articles in the *Annales de Mathématiques Pures et Appliquées* (AMPA) of the French mathematician Joseph-Diez Gergonne (1771-1859)[8]:

- *On the properties of certain curves derived from the equilateral hyperbola*, AMPA, XIII, 1822, 242-7.
- *Demonstration of a property of the equilateral hyperbola*, AMPA, XIII, 1822, 319-20.
- *Solution of the problem: "To find the point in a given plan, the sum of whose distances to three given points external to the plane is a minimum"*, AMPA, XIII, 1822, 329-30.
- *On the sum of certain trigonometrical series*, AMPA, XIV, 1823, pp. 88-95, pp. 187-90.
- *On a curve, the arcs of which represent Legendre's elliptic functions of the first kind*, AMPA, XIV, 1823, 380-1.
- *Theorems concerning a right cone, and the projections of a conic section upon the base of the cone,* AMPA, XIV, 1823, 123-8.

So he liked to work on analytic geometry, and his other papers after 1860 confirm that hypothesis. It is also interesting to note that he read French journals when he was 22-23 years old: most of his articles in the Annlas were answers to some problems published previously (in French) in the journal. After that, for 30 years, he dealt with chemistry and optics (and photography), with some exceptions (three articles in the mathematical field in 1834, 1836-1837[9]: see H.J.P. Arnold, 1977, 335-337.

He officially returned to mathematics in 1857, with an article on Fermat's theorem[10], and then produced after 1860 the texts we give the list here:

- *On the theory of numbers*, 1862, vol. XXII, 45-52 (with the mention: "read 21th April 1862")
- *On Fagnani's theorem*, 1863, vol. XXIII, 285-98 (with the mention: "read 20th April 1863").
- *Note on confocal conic sections*, 1865, vol. XXIV, 53-138 (with the mention: "read 17th April 1865").
- *Essay towards a general solution of numerical equations of all degree having integer roots*, 1875, vol. XXVII, 303-12 (with the mention: "read 17th May 1875").

The topics he was interested in were the same 30 years later: conic sections, analytical geometry, Malfatti's problem[11].

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[8] The complete corpus of those texts with an analysis of each of them can be found in: Gerini, 2012.

[9] For example: *Researches in the integral calculus, Part. I. & Part. II,* London: Philosophical Transactions, 1836-1837.

[10] *On Fermat's theorem*, Transactions of the Royal Society of Edinburgh, XXI, 1857, 403-406

[11] In 1803, Gian Francesco Malfatti (1731-1807)posed the problem of determining the three circular columns of marble of possibly different sizes which, when carved out of a right triangular prism, would have the largest possible total cross section. This is equivalent to

But his Notebooks were more precise, because they show him during his whole life doing every kind of mathematics. There is an important difference between his official publications and his personal notes, and it would be interesting to study and to publish the mathematics of his Notebooks.
For example, he often worked on the equations of degree 3 and 5 (the non dated Notebook No 35313 is devoted to this subject, but also a lot of pages in other Notebooks like No 35669, etc.). We can see here the work of a researcher in mathematics: all his researches on the equations will bring him to write in the Notebook No 35 672 (not dated) the draft of his article "*Essay towards a general solution of numerical equations of all degrees*" edited in 1875 in the Edinburgh Royal Society Transactions.
He also often worked on non rational functions, series, geometry (he tried to prove the axioms of the Euclidian geometry, for example in notebooks No 35 311 and No 35 312, not dated). Here one can see him succeeding in solving problems, or here giving up some directions of research.

A temporary conclusion

We cannot develop here a more detailed study of the contributions of Talbot in the *Annals* of Gergonne or in his notebooks and drafts. One can think that it would be very interesting to work in a more precise way on the contents of those boxes, and perhaps to publish some of them in their original presentation (in a digitized version) with historical and scientific commentaries. If William Fox Talbot didn't stand out in the history of mathematics, we can affirm that his articles in the *Annals* of Gergonne and a lot of his works in his notebooks have a real and misjudged importance. It's apparently the same thing for his works in other sciences.
But such a study of his notebooks needs a team with researchers coming from many fields of knowledge: history of sciences, mathematics, physics and optics, chemistry, technology, arts...

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finding the maximum total area of three circles which can be packed inside a right triangle of any shape without overlapping.

Box N° 7419		Box N° DCE07MB			
Notebooks	Dates	Notebooks	Dates	Notebooks	Dates
Notebook "1"	No date	1 great notebook	March 29th 1809	Notebook n° 35674	4 pages dated march 1866
Notebook "A"	1823	Notebook n° 24096	No date	Notebook n° 35675	No date
Notebook "B"	1824	Notebook n° 24109	No date But > 1842	Notebook n° 35676	No date
Notebook "C"	March 1825	Notebook n° 29088	Sept 12th 1836	Notebook n° 35677	No date
Notebook "D"	9 Oct 1825	Notebook n° 29094	Dec 19th 1837	Notebook n° 35678	No date but > 1857
Notebook "E"	10 Dec 1825	Notebook n° 35297	Nov. 1827 - Nov.1828	Notebook n° 35679	No date
Notebook "F"	18th June1828	Notebook n° 35303	No date Perhaps 1822	Notebook n° 35817	No date
Notebook "H"	11 Oct 1830	Notebook n° 35313	No date	Notebook n° 37145	1836 Aug. 26
Notebook "I"	1831	Notebook n° 35669	No date		
Notebook "J"	1832	Notebook n° 35670	No date		
Notebook "K"	1833	Notebook n° 35671	No date		
Notebook "L"	London 8th January 1834	Notebook n° 35672	No date		
Notebook "M"	Lacock 48th Dec 1834	Notebook n° 35673	No date		

Table 2

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SYMPOSIUM 22

Scientific Cosmopolitanism

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We wish to propose a session on what we call scientific cosmopolitanism. The proposal grows from a group of papers that were presented at the Barcelona congress on the movement of scientists and of scientific knowledge and practices within Europe since the sixteenth century. In Barcelona, the papers focussed on travels between countries and relatively brief stays abroad. The Athens congress provides the opportunity for developing a rather different perspective, focussing on scientists who have chosen to settle away from their own countries, either permanently or for extended periods. The cases of Tycho Brahe and Kepler, both of whom resided in Prague, are well known. So too are those of Herschel in England and Burkhardt de Gotha in Paris. And there are many other instances. The motives that led to such decisions to work abroad might include, among others, congenial living and working conditions or difficulties of a religious or ideological kind. The purpose of the papers in this session will be to discuss key examples, with a view to determining the similarities and differences between them and whether or not the decisions reflected a free choice or pressures that made expatriation a necessity.

Athanasius Kircher S.I.: A German Jesuit's Almost Involuntary Expatriation to Rome

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Preliminaries

It may be somewhat surprising to discuss the German-born Jesuit and 17^{th}-century polyhistor Athanasius Kircher (1602-1680) (Ill. 1) within the framework of "Scientific Cosmopolitanism", a topic devoted to the lives and work of scientists who chose to settle away from their own countries. Indeed examples like the extended sojourns at Prague of Tycho Brahe or Johannes Kepler or that of Friedrich Wilhelm Herschel in England can certainly be seen along with Kircher's almost fifty-year-long stay in Rome from 1633 to his death. Yet there may well be a major difference between their lives abroad and Kircher's residence in the Holy City. The following analysis will therefore attempt to highlight the fundamental difference between those scholars' motivations to spend extended periods, indeed the rest of their lives abroad, and Kircher's years in Rome. For this reason it will be necessary to first summarize the Jesuit's own account of his hoped-for transfer to Vienna and then contrast it with reports on his departure from the south of France, where he had arrived in 1632 and spent more than a year before moving on—but to Rome instead of Vienna.
The Prague expatriates, for instance, responded to invitations by the Habsburg emperors Rudolph II, Matthias, and Ferdinand II, whose interests in astronomy, astrology and esoteric matters created an atmosphere that attracted these scholars. On the surface the case of Athanasius Kircher may appear quite similar—as long as we rely on his own autobiographic account, the *Vita* (Kircher 1684; 2011; Totaro, 175-327) that he probably penned in the late 1660s, in other words, when he was in his sixties—but may have amended at a later date (Totaro, 159; Fletcher, 181). It was found after his death in 1680 and published four years later.

Kircher's Own Account of His Departure from Southern France for Germany and/or Rome

In this *Vita* the young Jesuit narrates that he "made by happy chance the acquaintance of Nicolas-Claude Fabri de Peiresc" (1580-1637) (Kircher 2011, 486-487), councilor at the Parliament de Provence in Aix-en-Provence, a *mycaenas* of numerous young scholars and a learned man in his own right, whose correspondence was as extensive as Kircher's own would later be. The young Jesuit clearly presented himself in the best possible light when he stated that during an extended visit in Aix he "gave [Peiresc] the opportunity of confirming for himself the knowledge [he] had of oriental languages, of Hebrew, Chaldaic, Arabic and Samaritan." Yet even in Kircher's own account we can detect a note of caution on the part of the experienced Peiresc when the older Frenchman asked Kircher to show him "a sample of [his] deciphering of the hieroglyphs"—Kircher's avowed, lifelong goal ever since during a stay in the German city of Speyer in 1628 he had been attracted by a splendid volume illustrating the obelisks of Rome, highly probably Herwart von Hohenburg's *Thesaurus Hieroglyphicorum* (Ill. 2) (Totaro, 87). To test his qualifications Peiresc thus suggested that he interpret an inscription copied out from an Egyptian statue in his possession. The young Jesuit "spent the greater part of the night on it and on the following morning presented him with the results." According to Kircher, Peiresc was so taken by his interpretation that the Jesuit, "for the sake of modesty, [would] not like to repeat [Peiresc's commendatory feelings]," as he coyly put it in his autobiography. And indeed Peiresc even sent him "whole chests of relevant books" to Avignon, where he lived at that time.

This is the extent of Kircher's account of his personal interaction with Peiresc. We now read in the *Vita* that he had been called to Vienna, appointed by the General of the Society of Jesus "as mathematician to the imperial court." And Kircher continues that upon hearing of this new assignment "Peiresc […] used all the means at his disposal to prevent [Kircher's] journey to Vienna." The Frenchman indeed feared that Kircher's new position would not allow the Jesuit to devote his full attention "to re-establish our knowledge of the hieroglyphs." On these grounds "he wrote immediately to Pope Urban VIII and to the pope's brother, Cardinal Francesco Barberini, imploring them to call [Kircher] to Rome while [he] was en route for Vienna." Truthfully Kircher also accounts that Peiresc wanted him to leave for Vienna via Aix and "put [him] up for several days in his house showing [him] extravagant proof of his affection" (Kircher 2011, 488). He continued to state that he still did not have any idea that his host "was negotiating with Cardinal Barberini for [Kircher's] journey to take the opposite direction, [… namely] to be called to Rome." And he then narrates in great detail the perilous journey, how he ended up in Genoa (Kircher 2011, 490-491), hired another ship with his fellow Jesuits to continue on to Leghorn and from there overland to Germany via Venice. Yet fate dictated otherwise: The small boat was driven off course to the island of Corsica, and he and his friends finally ended up in Civitavecchia, the port of Rome. Needless to say that the exhausted Kircher made his way onward by foot not to Germany but to the Holy City—where he was already expected as Peiresc's letters had had the desired effect and had convinced the General of the Society of Jesus to reassign the young priest to Rome.

Kircher's Transfer to Rome (Instead of Vienna) as Reflected in Peiresc's Correspondence and in Other Sources

As smooth as Kircher's account of his honorable assignment to the imperial court in Vienna may sound, it turns out to have been rather self-serving or—to quote from the title of Giunia Totaro's expanded dissertation—to have been "entre vérité et invention" (Totaro 2009). It is certainly true that Peiresc—himself involved in the study of Coptic—greatly anticipated the arrival of Kircher in Provence as early as May 1632. He wrote to Pietro della Valle (1586-1652) (Ill. 3)—who also held numerous valuable manuscripts—that "a new person, most skilled in all the oriental languages, of the German nation, named Rev. Father Athanasius Kircser [*sic*], Jesuit" had made great progress in Coptic. Kircher was of particular interest as he "possessed an 'ancient manuscript by a Babylonian rabbi, who wrote a treatise in Arabic on the rules and manner of reading the hieroglyphic characters on Egyptian obelisks'."[1] Soon Peiresc's entire group of learned correspondents was interested in this "Barachias manuscript." Yet Kircher—residing in Avignon—apparently was in no hurry to introduce himself to the elder scholar in Aix. Not until later in 1632 did he travel there and stayed for a few days—but only on his last visit in early September of 1633 did he bring the Barachias with him.

This is when Kircher's own account and the versions that Peiresc reported in several letters differ rather dramatically. We recall how the Jesuit almost embarrassedly mentioned the praise that Peiresc heaped on him when he managed to decipher hieroglyphs overnight that his host had copied out from an Egyptian statue (Fletcher, 486). The French scholar presents a totally different picture: In a personal memoir of the September 3rd meeting (Miller, 135) he recorded that he became suspicious when Kircher—clearly in a hurry—refused to let him copy anything from the Barachias manuscript "but a page from the last part." In addition Peiresc thought he recognized material that had been published in 1610 in a standard work on hieroglyphs along with other well-known sources. He confronted Kircher, who finally conceded and "was greatly ashamed at the end."

According to Kircher he left Peiresc "after several days [and after having been shown] extravagant proof of his affection (Kircher 2011, 488), allegedly because the Jesuits traveling with him were anxious to depart from Marseille. This is not borne out in Peiresc's account, which claims that Kircher ran out on him and fled Provence for Rome. He did not inform his patron of this hasty departure, which meant that Peiresc could not hand him the letters of recommendation that he had prepared on Kircher's behalf for Roman dignitaries and scholars. Peiresc's correspondence with Pierre Gassendi, the famed French philosopher and scientist whom Peiresc acquainted with Kircher, reveals a different scenario: Contrary to his own account, the Jesuit had received the information of a reassignment to Vienna by the General of the Society of Jesus as early as May 10, 1633 (Kircher 1635, [unpaginated] fol. 4 v°; Siebert, 38-40) and had at least planned an extended "stop-over" in Rome, where he knew that the first-hand inspection of Egyptian obelisks could greatly promote his interpretation of hieroglyphs. When he visited Peiresc over Whitsuntide a week later he did not inform his host of this new assignment—quite to the contrary Peiresc had just entered negotiations to have Kircher transferred to the Jesuit College in Aix as a professor of mathematics. In the back of Peiresc's mind was the hope that he could thus "encourage" the young man in his efforts to edit the Barachias manuscript. None of this transpires in Kircher's *Vita*. At this point we should have a closer look at his allegation that his new assignment to Vienna would fill the post of "Caesaris Mathematicus designatus" (Kircher 1684, 43; Siebert, 43-50) as the designated imperial mathematician. This was—lo and behold—Johannes Kepler's position, vacant since his death in 1630. Such an imperial assignment would have suddenly propelled the thirty-one-year-old Kircher into the same league as Tycho Brahe or Kepler and would have put the young Jesuit in the prestigious group of "scientific cosmopolitans" at the Prague court. However, Kircher is once again embellishing his biography: He might well have felt he belonged in this prestigious category when he

[1] Letter dated May 19, 1632, quoted in Miller, 134-135.

penned his *Vita* some thirty years later, at the height of his fame as a universal scholar and renowned interpreter of hieroglyphs, but the transfer to Vienna in 1633 simply was to put him there to pursue studies at the imperial academy—as Kircher admitted in the dedicatory letter to his 1635 *Primitiae* (Kircher 1635). In fact, earlier in 1633 the high-status post of court mathematician had been assigned to none other but Christoph Scheiner, the experienced Jesuit astronomer and mathematician who had become Galilei's adversary. For Kircher Vienna would indeed have provided an escape from the doldrums of teaching at the Avignon College, which had led to "melancholia" according to the confidential evaluation by his local superiors (Siebert, 42). Scheiner's appointment to this prestigious position, however, made it more likely for Kircher to obtain a reassignment to Rome—which is where he preferred to go in the first place—and which is exactly how Peiresc interpreted this piece of news when Kircher forwarded parts of Scheiner's letter informing him of his imminent departure for Vienna.[2]

When Kircher stated in his *Vita* that he intended to travel from Avignon via Marseille and Genoa "in the direction of Germany" ("in *Germaniam*") (Kircher 1684, 46), he was not totally insincere—except that he neglected to mention that he had planned a detour via Rome. For this purpose he requested the letters of introduction to Peiresc's influential contacts there. Yet Kircher's hasty departure from Aix meant that his patron could not give him these letters in person—he had to forward them to Italy via Marseille, where the group of Jesuits with whom Kircher was traveling also had just left. All these logistical problems—reported by a rather annoyed Peiresc—indicate that Kircher (very intentionally, it seems) had not informed Peiresc in advance of his imminent departure for Rome and Vienna, and that the letters had to be prepared in a hurry.

When Kircher finally arrived at the Holy City in late October of 1633, Peiresc's letters of introduction or recommendation to his contacts there had arrived, and Kircher was well received. We know for certain that Peiresc had written to Pietro della Valle and Cardinal Francesco Barberini, who apparently had to limit his interaction with an over-eager Kircher after a while; beyond that we cannot ascertain who the other "messieurs" were to whom Peiresc wrote upon Kircher's behalf. And there was the Frenchman's request directed to Muzio Vitelleschi, the General of the Society of Jesus, which lauded Kircher's accomplishments, praised his linguistic prowess and his firm intent to decipher the ancient hieroglyphs—all of which may have brought about the official permission for Kircher to spend a more extended period of time in Rome, but not yet a cancellation of his assignment to Vienna.[3]

[2] Peiresc's letter to Kircher, Aix, Aug. 17, 1633—see Totaro, 92-93.

[3] On August 17, 1633, Peiresc informed Kircher (who had not yet left Avignon) that he expected orders from Rome within a couple of weeks for the young priest to leave for Rome right away. He suggested that Kircher immediately betake himself to Aix so that he would not be held up by his Avignon superiors.

Peiresc's Letters of Introduction—Sincere Recommendations or Self-Serving Pieces?

Even this brief overview of Peiresc's interaction with Kircher—both during his visits to Aix and as documented in his patron's correspondence—has shown that the Frenchman became somewhat wary of Kircher's promises and his problematic self-presentation. Peiresc's overweening interest clearly lay in the analysis of the Coptic language, and for the longest time he saw in the German Jesuit a promising candidate for this task. This is why he wrote to Cardinal Barberini and to Muzio Vitelleschi after Kircher's arrival in Rome and even then pleaded with them to facilitate the young man' access to the treasures relevant to his work. He also asked them to afford him adequate free time to carry out his interpretation of the hieroglyphs (Ill. 4) in the shortest amount of time possible.[4]

Why would Peiresc continue his strong support for Kircher even though he harbored severe doubts about the German Jesuit's qualifications? It seems that for once Peiresc—ever in pursuit of an elucidation of the Coptic language and, beyond that, an interpretation of the secrets of the hieroglyphs—considered Kircher's possession of the elusive Barachias manuscript an important piece in this puzzle. After all, the French scholar hoped that this document—as flawed as it might be as a key to hieroglyphics—could yet provide a clue to Coptic (Miller, 138-139). And when early in 1634 Pietro della Valle decided to hand over his own Coptic manuscripts, which Peiresc had coveted for a long time, to none other but Kircher, he knew that he could not give up on the young man. At least Kircher's sojourn in Rome had the tremendous advantage for Peiresc that he could literally keep an eye on him through all his Roman contacts—which was part of his calculated effort to have him reassigned to the Holy City. The French scholar knew absolutely no one in Vienna and had no influential acquaintances at the Habsburg court, which was the main reason for his pleading for Kircher's transfer to Rome.

Kircher's First Years in Rome

Peiresc's letters had clearly paved the way for Kircher's arrival in the Eternal City. And while the young German still did not have any idea how long he would be allowed to remain there he made certain that his presence became known. As he had in the past Kircher tried to gain fame by mounting mechanical spectacles in front of erudite audiences, which garnered him effusive praise. Raffaello Magiotti, an Italian scientist, characterized the new arrival as a "scholar who had spent quite a bit of time in the Orient (from where he brought back a great number of Arabic and Chaldaic manuscripts with whose help he promises to provide an interpretation of the hieroglyphs), who masters a dozen languages, knows his geometry, and owns a collection of curiosities."[5] This may well summarize the high reputation that Kircher seems to have gained after only a few months in Rome, but it also highlights the danger of his not living up to these expectations—which were not even based on facts as far as his sojourn abroad or his mastery of twelve languages are concerned.

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[4] Peiresc's intercessions on Kircher's behalf are reported by Pierre Gassendi. For further details s. Siebert, 54.

[5] Letter of Raffaello Magiotto to Galilei from Rome, quoted in Totaro, 101-102.

And the grace period that Kircher enjoyed upon his arrival at Rome was running out. In 1634 he was finally working on an edition of the elusive Barachias material, now lost, which Kircher claims to have "seen" in the library of the Prince-Elector at Mayence—which makes it seem plausible that he copied out portions of the material, possibly a small treatise on certain Egyptian obelisks (Totaro, 103 ff.). At the same time he also ventured into an elucidation of the famous "Bembine Table of Isis" or "Mensa Isiaca/Isiac Tablet" (Ill. 5) that was discovered in 1527. Its pseudo-hieroglyphs were considered of Egyptian origin although the illustrations on an engraved metal plate were in all probability a Roman falsification. Work on the Barachias seems to have assured Kircher an extension of his stay in Rome although it—and the interpretation of the Isiac Tablet—were not published until 1636 in the *Prodromus coptus* (Kircher 1636) (Ill. 6). Should we mention that Peiresc was not at all excited when he received a partial manuscript of this book in early 1635? He cautioned Kircher that his approach—which the Jesuit consistently used in his later publications, too—of "presenting theories as certainties would put his credibility at risk." […] "The reader," Peter N. Miller continues in his translation, "should not have to take one scholar's word on faith."[6] In addition, della Valle's Coptic-Arabic manuscript known as the *Scala Magna* entrusted to Kircher in early 1634 also occupied him well beyond the end of that year, and only one portion of it featured in the *Prodromus* while the remainder—much to the chagrin of Peiresc, who died in 1637—had to await the publication of the *Lingua Aegyptiaca restituta* of 1643 (Kircher 1643) (Ill. 7).
While Kircher's linguistic theories, especially in regard to Coptic, were on the whole acceptable by the time his *Prodromus* appeared in 1636, the apparent lack of solid analyses in his early—and even more later—work in the field of hieroglyphics fully alienated his patron. When the Jesuit sent him a short essay on an inscription found on Mount Sinai Peiresc complained to fellow scholars "that Kircher 'had imagined to himself' the whole interpretation, as if it had 'come to him through the spirit'."[7] And although this assessment on the part of an elder statesman in the world of letters would prove correct for much of Kircher's later work in the field of hieroglyphics, Peiresc still remained the benevolent protector of the young Jesuit when he asked his correspondents not to divulge this opinion for fear it might detract from the young Jesuit's reputation.

Conclusion

When we now try to locate Athanasius Kircher under the rubric of scientific cosmopolitanism we can see how this junior scholar, greatly aided by an influential and kind patron—and certainly also by a goodly amount of determinism and self-promotion—has begun to make inroads in the group of well-known learned men in the Holy City. Upon arrival his initial appeal to the *intelligentsia* assembled at this cross-roads of erudition and research seems to have been almost overwhelming, and he owed it to his protectors in the Church that he could survive the subsequent years when he did not live up to expectations and had to make all sorts of excuses for

[6] Peiresc to Kircher, March 30, 1635, quoted in Miller, 139-140.
[7] Peiresc to the brothers Dupuy, April 26, 1636, quoted in Miller, 141.

publications that kept being deferred. 1636 marked a certain turning point; Kircher was assured of his permanent assignment in the Holy City and could continue a much more detailed account of the years to come in his *Vita*, where the years from 1634 to 1636 were more or less glossed over.

Figure 1: *Kicher's famous "Fiddle" Portrait in the former Jesuit College of Ingolstadt (Bavaria)*

Figure 2: *Obelisks in Kircher's Famous "Museum" Which He Put Together Once Firmly Established in Rome*

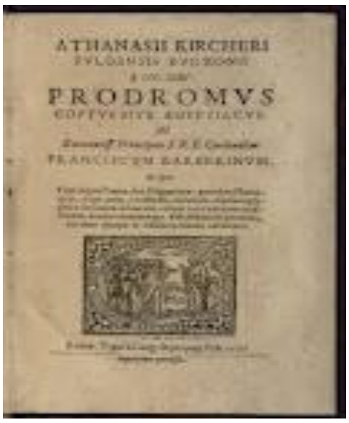

Figure 3: *Title Page of Kircher's 1636 "Prodromus Coptus"*

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Scientific Cosmopolitanism from a Swiss Perspective: Migration from and to Switzerland before and after World War II

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During the seventeenth and eighteenth centuries there were very few university positions in Switzerland. Swiss scientists were forced to emigrate if the sparse chairs were occupied. Famous examples include Johann Bernoulli, who had to go to Groningen before he could, after the death of his brother Jakob, take over the only chair in mathematics at the university in Basel. The same is true for Leonhard Euler, who went to Saint Petersburg and Berlin. Saint Petersburg attracted in these years many other Swiss scientists, for example Jakob Hermann, Daniel Bernoulli, Eduard Regel, Heinrich Wild, etc. (Mumenthaler 1996; Lüthi et al. 2003). Other famous Swiss emigrants were Jost Bürgi, Jakob Steiner and from the French speaking part of Switzerland Jean-André Deluc, Louis Agassiz, and Charles-Édouard Guillaume. The reasons for emigration were in most cases better career possibilities.
After the mediation period and the creation of the federal state in 1848 the employment opportunities for scientists started to improve significantly. The former local academies were successively transformed into the universities of Zurich (1833), Bern (1834), Geneva (1873), Fribourg (1889), Lausanne (1890) and Neuchâtel (1909). With the foundation of the Swiss Polytechnic Institute (later ETH Zurich) in 1855 ca. 35 new chairs were created immediately. Several of them served as a springboard for leading young scientists on their way to top positions in Germany. The first chair in higher mathematics was initially occupied for three years by the Austrian-Swiss mathematician Joseph Ludwig Raabe. Later followed in short intervals such famous mathematicians as Richard Dedekind (1858-1862), Elwin Bruno Christoffel (1862-1869), Hermann Amandus Schwarz (1869-1875), Georg Ferdinand Frobenius (1875-1892), Hermann Minkowski (1896-1902) and the German-Swiss Arthur Hirsch (1903-1936) from Königsberg, who remained in Zurich (Grob 1980, 650). At the newly created chair of theoretical physics at the University of Zurich one finds a series of four young future Nobel Prize Winners following each other shortly: Albert Einstein (1909-1911), Peter Debye (1911-1912), Max von Laue (1912-1914), Erwin Schrödinger (1921-1927). They all used Zurich as a springboard for a first-rate position in Germany (Rasche and Staub 1979).
After World War I and World War II the situation changed radically. With the breakdown of the Austro-Hungarian empire and Nazism many well-known scientists fled from Eastern Europe and Germany to America and some of them also came to Switzerland, for example Leopold Ruzicka, Tadeusz Reichstein, Vladimir Prelog; Paul Bernays, Hermann Weyl, Heinz Hopf; Walter Heitler, Wolfgang Pauli, etc. In postwar years it became common practice that Swiss post-docs had to complete a USA-stay before getting a university position in Switzerland. Several of them remained in the

USA, for example Fritz Zwicky, Felix Bloch and Armand Borel, a fact that has quite often been discussed under the catch phrase "brain drain". The paper tried to give an overview of scientist migration to and from Switzerland (see Appendix). However, in reality many of these scientists were cosmopolites as Einstein and are difficult to be attributed to a specific country.

Appendix: Migration of Renown Scientists from and to Switzerland (based on the "List of Swiss people" in mathematics and science from Wikipedia)

Mathematics

- Jakob Bernoulli (1654–1705), Swiss mathematician
- Johann Bernoulli (1667–1748), Swiss mathematician [[CH→NL→CH]]
- Daniel Bernoulli (1700–1782), mathematician and physicist [[CH→RU→CH]]
- Leonhard Euler (1707–1783), mathematician and geometer [[CH→RU→D→RU]]
- Jakob Steiner (1796–1863), mathematician and physicist [[CH→D]]
- Ludwig Schläfli (1814–1895), mathematician
- Michel Plancherel (1885–1967), mathematician
- Paul Bernays 1888–1977), made significant contributions to mathematical logic, axiomatic set theory, and the philosophy of mathematics [[D→CH]
- Hopf, Heinz (1894–1971), mathematician [[D→CH]]
- Georges de Rham (1903–1990), mathematician
- Edward Kofler (1911–2007), mathematician [[PL→CH]]
- Armand Borel (1923–2003), mathematician [[CH→USA]]
- Konrad Osterwalder (born 1942), mathematician and physicist, rector of ETH [[CH→USA→CH]]

Natural Sciences

- Conrad Gessner (1516–1565), Swiss naturalist
- Theodor Zwinger (1533–1588), physician and humanist scholar
- Jost Bürgi (1552–1632), mathematician and watchmaker [[CH→D]]
- Johann Jakob Scheuchzer (1672–1733), Swiss savant
- Firmin Abauzit (1679–1767), scientist [[F→CH]]
- Albrecht von Haller (1708–1777) [[CH→D→CH]]
- Charles Bonnet (1720–1793), botanist
- Jean-André Deluc (1727–1817), geologist [[CH→D/GB]]
- Horace-Bénédict de Saussure (1740–1799), botanist
- Louis Secretan (1758–1839), mycologist
- Louis Agassiz (1807–1873), work on ice ages, glaciers [[CH→USA]]
- Jean Charles Galissard de Marignac (1817–1894), chemist [[CH→F→CH]]
- Eugene Renevier (1831–1906), geologist
- Alexander Emanuel Agassiz (1835–1910), American man of science [[CH→USA]]
- François-Alphonse Forel (1841–1912), pioneer in the study of lakes [[CH→D→CH]]
- Emil Theodor Kocher (1841–1917), 1909 Nobel Prize in Physiology or

Medicine

- Friedrich Miescher (1844–1895), physician and biologist, discovered DNA
- Raoul Pictet (1846–1929), physicist [[CH→F\D]]
- Johann Büttikofer (1850–1929), zoologist [[CH→NL]]
- Charles Edouard Guillaume (1861–1938), 1920 Nobel Prize in Physics [[CH→F]]
- Alfred Werner (1866–1919), 1913 Nobel Prize in Chemistry [[F/D→CH]]
- Albert Einstein (1879–1955), 1921 Nobel Prize in Physics [[D→CH→D→USA]]
- Walter Hess (1881–1973), 1949 Nobel Prize in Physiology or Medicine
- Auguste Piccard (1884–1962), physicist and balloonist [[CH→B/CH]]
- Jean Piccard (1884–1963) balloonist [[CH→USA]]
- Leopold Ruzicka (1887–1976), 1939 Nobel Prize in Chemistry [[A/H→CH]]
- Paul Karrer (1889–1971), 1937 Nobel Prize in Chemistry
- Alexandre Émile Jean Yersin (1894–1943), physician, isolates the *Yersinia pestis* [[CH→F]]
- Adolf Portmann (1897–1982), zoologist
- Tadeus Reichstein (1897–1996), chemist, 1950 Nobel Prize in Physiology or Medicine [[RU\PL→ CH]]
- Fritz Zwicky (1898–1974), astronomer [[CH→USA]]
- Paul Müller (1899–1965), 1948 Nobel Prize in Physiology or Medicine
- Wolfgang Pauli (1900–1958), 1945 Nobel Prize in Physics [[A→CH/USA]]
- Felix Bloch (1905–1983), 1952 Nobel Prize in Physics [[CH→D→USA→CH]]
- Albert Hofmann (1906–2008), chemist, discoverer of d-lysergic acid diethylamide (LSD)
- Vladimir Prelog (1906–1998), 1975 Nobel Prize in Chemistry [[A-H→CH]]
- Daniel Bovet (1907–1992), 1957 Nobel Prize in Physiology or Medicine [[CH→I]]
- Heinz Rutishauser (1918–1970), mathematician, computer software pioneer
- Edmond H. Fischer (born 1920), 1992 Nobel Prize Physiology or Medicine [[CN/CH→USA]]
- Jack Steinberger (born 1921), 1988 Nobel Prize in Physics [[D→USA→CH]]
- Jacques Piccard (1922–2008), engineer and underwater explorer
- K. Alex Müller (born 1927), 1987 Nobel Prize in Physics
- Werner Arber (born 1929), 1978 Nobel Prize in Physiology or Medicine [[CH→USA→CH]]
- Richard R. Ernst (born 1933), 1991 Nobel Prize in Chemistry
- Heinrich Rohrer (born 1933), 1986 Nobel Prize in Physics
- Niklaus Wirth (born 1934), computer scientist, ACM Turing Award winner, inventor of the Pascal programming language [[CH→USA→CH]]
- Kurt Wüthrich (born 1938), 2002 Nobel Prize in Chemistry [[CH→USA]]
- Michel Mayor (born 1942), astronomer
- Rolf M. Zinkernagel (born 1944), 1996 Nobel Prize in Physiology or Medicine [[CH→AU→USA→CH]]

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Scientific Expeditions: Local Practices and Cosmopolitan Discourses

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The term "scientific expeditions" commonly refers to group travel aiming at the controlled acquisition and widening of specific knowledges. The expedition is also characterized by a clear division of work. This way of organizing scientific work has been popular since the 18th century and has been part of an increased competition among European states in the fields of progress and knowledge. Furthermore, this expedition form encourages co-operation between different social and cultural forces. Typical for scientific expeditions is that they serve and inscribe both cosmopolitan discourses of science and local cultural and ideological practices simultaneously. They aspire to global-cosmopolitan utopias, in other words, claims to civilisation, while being located within specific cultural contexts and -- this being the case in the 19th century in particular -- within discourses of national scientific achievement. We will ask how these mixings manifest themselves in the expectations, management, legitimation strategies and reception of expeditions. The session will open up different fields of knowledge with a focus on scientific expeditions as a means of acquiring insight, but it will also inquire into the intersecting mechanisms and patterns of local and cosmopolitan constitutions of meaning and their realisations.

The Triangular Relationship between Science, Politics and Culture Expressed by the Idea of Progress and Implemented through the Expedition to Egypt

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When we want to touch on the Expedition to Egypt the bibliography is so vast and rich that the risks are first of all, repetition and secondly a bad description of what has already been well related. I am not sure that I can avoid either of them as the topic of the relationship between science and politics at the end of the 18th century, and especially during the expedition has already been well documented (BRET (ed.) 1999[1]; DHOMBRES 1989; LAURENS 1989). Since their relationship has been shown, I would like not only to point out its issue but also to investigate how and why culture steps into their relationship. I want to test the results of my study of the main lines of the scientific practice and the public action of the geometer Gaspard MONGE (1746-1818) on the specific moment of the Expedition to Egypt.
During the second part of the French revolution, Monge is a teacher and a promoter of new scientific institutions and domains, and at the same time he accomplishes his republican service out of France, in Italy and Egypt, as commissioner of sciences and arts. The frame of my research on Monge is the study and the edition of his correspondence from 1795 to 1799. This period is characterized as the political turn in Monge's preoccupation and activities. According to Monge's biographers (De Launay 1933 ; Aubry 1954), this change is determined by the political and social Revolution, his meeting with Bonaparte in 1796 and their collaboration during the first campaign in Italy and later in Egypt. This study is meant to contribute to a better understanding of the scientific issues of the public action of the geometer. I want to underline the specificity of the mathematician's perspective on social and political facts as it appears in October 1797, in Monge's address to the Directoire. When Monge transmitted the peace treaty of Campo Formio that ended the war with the Austrian emperor, he insisted on the difference between the two remaining enemies of the French republic: the papal government and England.

> "Destroy a government that corrupted the moral of the world; but keep a nation to which the whole of Europe is beholden for a large part of its enlightenment; don't oppress a nation that gave Newton to the Universe" (Cheynet and Debidour (eds.) 2002, 108; De Launay 1933, 178).[2]

[1] Especially the first part of the conference proceedings. This congress aimed the inquiry and the evaluation of the historical work done on the expedition to Egypt.
[2] "Détruisez un gouvernement qui a corrompu la morale du monde entier ; mais conservez une nation à laquelle l'Europe est redevable d'une grande partie de ses lumières ; n'opprimez pas une nation qui a donné Newton à l'Univers ! "

In Monge's correspondence, the decisive fight in and out of France, is on the cultural field: Enlightenment versus ignorance and superstition.

A mathematical elaboration through transmission, collaboration and mathematical applications

Monge is well known to be one of the founders of a revolutionary scientific and pedagogical institution, l'École polytechnique, and is also acclaimed for a specific mathematical elaboration aimed not only at engineer training but also at elementary instruction (Monge [1795] 1799, 1-2). During his forty years of teaching and research, Monge develops and describes strong and close links between mathematical branches and between mathematics and technical arts. These links are obvious and expressed in the exposition of his results condensed and systematized in a triptych of treatises and theirs successive editions: the *Descriptive geometry* (1795), and in a sense, its correspondent, the *Application of analysis on geometry* (1795), and the last one his *Application of the algebra on geometry* (1805). These treatises gain a pedagogical and elementary value and play a crucial role in the progress and the foundation of mathematical domains. The last treatise, a short book of 56 pages, constitutes a decisive outcome of his constant effort of reducing, clarifying and reorganizing mathematical principles and methods through his use of methods of Analytic geometry.

A practitioner of progress

This long elaboration began in 1765 from a problem of concrete inspiration. Its principles and methods were advanced not only during Monge's teaching, but also during his research connected to the preoccupations of the mathematicians of the second half of the 18th century. In the Academy of sciences, his geometric perspective and focus feeds the discussions on the relationships between mathematical branches, between mathematics and other scientific fields. Monge's elaboration underlines the fruitfulness of a mathematical practice that coordinates elaboration and transmission and is structured by the links between mathematics and sciences, sciences and technical arts and also integrated to a communal scientific practice aimed at the progress of sciences. In 1772, when Monge became the correspondent of Bossut at the Academy, he presents the specific features of the new scientific practice that d'Alembert and Condorcet wanted to institutionalize from 1769 (Mc Clellan 1977, 243).

Connection between scientific practice and public action through the idea of progress

The idea of progress gathering sciences and arts coordinates their progress with the improvement of the human mind and the happiness of the human kind. The progress is induced and guaranteed by the perfectible nature of the human mind. This idea shapes the triangular relationship between science, culture and politics and determines a specific practice that extends the domains of the scientific investigation and action.

Being a mathematician drives to a scientific activity and elaboration with pedagogical aim for a large audience. The improvement of the human mind is the reason why the scientist cares about the human kind. It becomes a strategy to methodically accomplish progress. The links between happiness of the human kind and progress of sciences and arts are established by the theoretical fruitfulness of the complexity of problems from concrete inspiration. Then, being a mathematician is also to adopt a determined scientific attitude in front of human reality and the material world creating a link of correspondence between issues of physics, practical and technical questions and scientific elaborations and procedures.

The idea of progress: the goal and cause of the collective dimension of scientific practice and of the action in the public domain

The history of the idea of progress described by the mathematicians of the second half of the 18th century, and intensively diffused from 1771 by Condorcet (Schandeler and Crépel (eds) 2004, 176-221), shows that this idea constitutes the goal and cause of the collective dimension of their scientific practice and their action in the public domain. It also indicates that scientists wait neither for politicians, nor for military and diplomatic events to determine the issues and the aims of their practice. The reciprocal impacts and the powerful interactions between political events and sciences, theirs uses and their progress must not cloak the gap between political and social time and that of scientific development. This gap leads scientists to think out strategies to ensure the fulfilment of scientific progress, the perennity of scientific research and its freedom from political powers, establishing solidarity links between science and politics. The revolution constitutes an opportunity for the mathematicians of this period to take care of the institutionalization of their practice within the public area determining precisely the scientist's function.

The projects of an expedition to Egypt: from cultural diplomacy to colonial conquest

I will not trace the origins and the different projects of an expedition to Egypt, I will just mention that, within the question of the relationships with the Ottoman Empire, the idea of an expedition to Egypt is not new and is quite widespread as an enterprise of prestige (Fourier 1821, ii) and also as a strategy of commercial and territorial balance between the leading European countries since the 17th century. The diplomatic policies are associated with two kinds of position: "interventionist" and "non-interventionist". During the 1780s, the interventionist project, the colonial one, cost too much and thus was given up for a diplomatic policy through a technical and scientific cooperation ensured by army officials and engineers (Hitzel 1999, 9-10).

In august 1797, in his correspondence to the members of the government, Bonaparte expressed the benefits of the taking of the Ionian Islands Corfu and Zakinthos in the perspective of an expedition to Egypt and points out its issue within their fight with England (Bonaparte [1797] 2004, letters n°1908 and 1910). On the contrary, at the same period the geometer, very pessimistic, wondered in his letters to his wife what is the utility of the conquest of the "Ulysses' huts" [3] (Monge 1797b). A month later, having shared two weeks with Bonaparte at the headquarters of

[3] "Les cabanes d'Ulysse".

Passseriano, Monge cannot refrain to express his renewed enthusiasm to his wife telling her that the French republic will shine again with the most bright light (Monge 1797a). With the Treaty of Campo Formio in October 1797, the French nation shows the appetite of a conqueror.

On 5th March 1798,[4] the same day of the adoption of the project of the expedition by the Directoire, Bonaparte asked Monge not only to contribute to the preparation of the Expedition but also to participate in it (Monge 1798d). In June, Monge indicated links between his action in Italy as commissioner of sciences and arts and his planned action in Egypt.

> "God knows if after having taken the Madonna of Loretta, I wouldn't have for task to also take the grave of Mahomet in Mecca? But it is a joke on a subject that I think it's not useful and that I refer just to portray our gigantic ideas" (Monge 1798b).[5]

The gigantism of Bonaparte and Monge's ideas seems concerned with the cultural monument they look at. It is not the first time that Monge compares the two cultures. Already in august 1796, Monge writes to his wife that all the monuments of the Roman republic "are foreign to the stupid people of Roma as the pyramids of Egypt are to the poor Mohammedans who do not even know who built them" (Monge 1796a).[6] In Egypt as in Italy, the French policies of conquest are legitimate by the idea of a superior degree of Enlightenment.

Egypt, the field of full-scale mathematical and technical applications through policies of public works

In May 1798, few days before his departure from Civitavecchia, expressing his excitement to Bonaparte, Monge describes their Egyptian project: " to bring the flame of reason in a country where for a long time its light does not go through anymore, to extend the domain of the philosophy and to bring further the national glory " (Monge 1798c).[7]

Even if the Enlightenment of the Egyptians is reported to be the goal; this scientific expedition is more concerned with the progress of science and arts and the French glory rather than the Egyptian people. In the end of October 1798, three months after the taking of Cairo, in a speech draft intended at the Egyptian delegates at the

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[4] 15 ventôse an VI. The letter is not mentioned in the edition of Napoleon's correspondence but we know it through Monge's answer of the 25 ventôse an VI.

[5] "Dieu sait si après avoir enlevé la madone de Lorette, je ne serai pas chargé d'enlever aussi le tombeau de Mahomet à la Mecque ? Mais c'est une plaisanterie sur un objet que je ne crois pas utile et dont je ne fais mention que pour te peindre nos idées gigantesques."

[6] " […] tout cela est aussi étranger au peuple imbécile qui l'habite que les pyramides d'Égypte le sont aux pauvres mahométans qui ne savent pas même quelle est la nation qui les a bâties."

[7] "[C'est un des miracles de notre nouveau Jason, […] qui va] porter le flambeau de la raison dans un pays où, depuis bien longtemps, sa lumière ne parvient plus, qui va étendre le domaine de la philosophie et porter plus loin la gloire nationale."

Divan assembly, Monge described the French intervention in Egypt as the inescapable accomplishment of progress:

> "The arts and sciences will come back in shoals in the country that gave birth to them. The irrigations will be multiplied: the desert will move back in front of you […]. People of Egypt be worthy of so beautiful destinies and don't try to suspend an event ordered by the nature of things and that nothing can stop" (Monge 1798a).[8]

The element that allows the coordination of the progress of sciences and arts and the happiness of Egyptian people is the question of the canals of irrigation and communication. This question constitutes a crucial issue not only in regard to political and financial interests but also in regard to the foundation and the extension of the analytical mechanics. This point appears already in Monge's Italian correspondence in 1796: first, when he constructed and sent a problem for the pupils of the École polytechnique inspired by the irrigation system of Lombardy; and also when he developed a net of Italian and French mathematicians around the research on the principle of the virtual velocities (Monge 1796b). This topic concerns directly Monge and the community of the mathematicians opening new roads of extension of the mathematical applications to physics and reviewing the procedure of linking mathematic domains and studies of physics. The happiness of the Egyptian people seems more a consequence of the progress of science than the original goal.

Egypt: a testing ground of cultural policies

I will neither comment on the creation of the Institute of Egypt modelled on the National institute, nor on the results of the astonishing scientific investigation gathered and published in the *Description of Egypt*. The observation of Monge's activities indicates that he tried to realise the program that he drew on the idea of progress in his correspondence to a political figure and family member, in 1795 and 1796 (Monge 1796c, 1796d, 1795a). Because it is through education that we can accomplish political and social revolution, Monge advocates the creation of new scientific and pedagogical institutions. He devotes one letter to a specific institution: the national celebration (Monge 1796c). The object of this celebration would be a scientific show that would expose the progress of sciences and arts accomplished by the French nation. It would excite both the national enthusiasm and the admiration abroad. He gave as an example Charles and Robert's aerostatic balloon ascent that occurred on 1st December 1783 at the Tuilleries garden and strongly impressed the Parisians. In his letter, Monge chooses especially this balloon because it functions with hydrogen and thus allows the scientists to give a remarkable dimension to the research on water analysis and to strengthen the foundation of the theoretical system of Lavoisier's chemistry. Already in 1783 Lavoisier and his team to which

[8] "Les arts et les sciences vont revenir en foule dans le pays qui leur donna naissance. Les irrigations vont se multiplier ; le désert va reculer devant vous […]. Peuples de l'Égypte rendez-vous dignes de si belles destinées ; et n'essayez pas de suspendre un événement commandé par la nature des choses et que rien ne peut arrêter."

Monge belongs, understands the strategic benefit of convincing a large audience. In 1798, when the Institute of Egypt has just been established, Monge wants to use this strategy "to strike the imagination of the natives" with "a whole new show for their eyes" (JOMARD 1853,36).[9]

The failure of Monge's cultural policies

Jomard's relation marks the double nature of the ascents in Egypt. They are both a technical and scientific success but a cultural failure. According to Jomard, Conté succeeded in building the balloon and raising it without trouble, but not in astonishing the Africans: "two times he launches balloons without producing any surprise; we have seen people crossing the Ezbékeh square during the fly of the balloon and not deigning to raise their head" (JOMARD 1853,36).[10] Even if the French wanted to disguise this failure as a success in the newspaper attended to French people, (Le courrier de l'Égypte), the testimonies underline the unconcern of the Egyptians (VILLIERS DU TERRAGE 1901, 14-15). In 1793, in his "Fragments sur l'Atlantide", Condorcet condemns precisely this kind of use of the aerostat. He underlines that the aerostatic balloons ascent would be useful if an enlightened and durable enthusiasm for the progress of science leads those who use it, and not the desire to take advantage of the infatuation of the ignorance for their own interest or celebrity (Condorcet [1794] 1988, 312-313).
The French cultural strategy fails because it is more a will of demonstration of the superiority of technical and scientific power than a will of spreading knowledge (Ortega 1999). Even if the guided visits to the laboratory of the Institute, the public experiences of physics and chemistry and the sessions at the Institute of Egypt triggered the curiosity of members of the Egyptian elite, they also expressed the feeling of strangeness, and also the difficulty to understand and to be convinced by the French enlightenment (RAYMOND 1999, 109). Monge was very disappointed by the Egyptian reaction (VILLIERS DU TERRAGE 1901, 14-15) and according to him, the major evidence of the failure of his cultural policies is the Revolt of Cairo, on 21st October 1798.

The power of culture the question that makes the differences between the general and the geometer

The implementation of the triangular relationship between science, politics and culture in Monge's action in Egypt requests to distinguish two different cultural targets a French one and an Egyptian one. Whereas Monge aims to the Egyptian people and elite; Bonaparte has no illusion of the role of culture in military conquest. It is his conclusion on the first campaign in Italy. Bonaparte insists on the necessity of the respect of the tradition of the population, for Monge this is exactly the reason of the French failure. The military and the scientist share the same vision but they imagine different ways to reach it. Bonaparte wrote to the Directory at the end of

[9] " frapper l'imagination des indigènes […] par un spectacle tout nouveau pour les yeux […]."
[10] " […] deux fois il lança des montgolfières, sans produire plus de surprise ; on a vu des gens traverser la grande place Ezbékeh, pendant que le ballon marchait, et ne pas même daigner lever la tête."

the first campaign asserting the minor value of the revolutionary idea of freedom as a tool of conquest.

> “Since I have been in Italy, I have not had as help the love for the freedom of the people and for equality, or at least it was a very weak help. Instead, the good discipline of our army; the great respect that we all had for the religion, which even became cajolery for its ministers; justice; and mainly a great activity and velocity to repress the malicious and to punish those who declared against us; that was the real assistance of our army. That is the historic, all that is good to be told in declarations, in printed speeches, is all fantasy” (Bonaparte [1797] 2004, letter n°2149).[11]

It appears that Bonaparte was not so right, when Raymond estimates the reception of the French enlightenment by the Egyptians and its real impact on the local population, he concludes on a weak influence but he underlines that in the long term the policies of cultural diplomacy through military, technical and scientific cooperation before the French expedition are quite efficient (RAYMOND 1999, 103). It also appears that the scientists’ participation in the expedition to Egypt and the weak results of their cultural strategies on the local population lead the geometer to redefine the boundaries of the science in public domain. After his return to France, Monge focuses on scientific education and on industrial and technical development, the two major lines of his scientific path before and during the Revolution. That was Monge’s statement before the expedition to Egypt. When in 1797, Bonaparte asked him for a few lessons on Descriptive Geometry at the headquarter of Macerata, Monge wrote to his son in law

> “[…] I wouldn’t want my descriptive geometry to rise so high; to be useful and reach its real purpose, it must go low brow. It is the fertilizer of fields that we don’t have to spread on the trees; it is the geometry of the worker and the craftsman; it is the base of the national industry and not a meditation object for philosophers” (Monge 1797c).[12]

[11] “Je n’ai point eu depuis que je suis en Italie, pour auxiliaire l’amour de la liberté des peuples et de l’égalité, ou du moins cela a été un auxiliaire très faible. Mais la bonne discipline de noter armée; le grand respect que nous avons tous eu pour la religion, que nous avons porté jusqu’à la cajolerie pour ses ministres ; de la justice ; surtout une grande activité et promptitude à réprimer les malintentionnés et à punir ceux qui se déclareraient contre nous ; tel a été le veritable auxiliaire de l’armée d’Italie. Voilà l’historique ; tout ce qui est bon à dire dans des proclamations, des discours imprimés, sont des romans.“

[12] “Je ne voudrais pas que ma géométrie descriptive montât si haut ; pour qu'elle soit utile et qu'elle remplisse son véritable but, il faut qu'elle aille terre à terre. C'est l'engrais des champs qu'il ne faut pas jeter sur les arbres; c'est la géométrie des ouvriers et des artistes ; c'est le fondement de l'industrie nationale et non l'objet des méditations des philosophes. ”

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The Exact Sciences in the Eastern Mediterranean in the Modern and Contemporary Ages

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The eastern part of the Mediterranean, for centuries a highly contended borderland area between the Ottoman Empire and the Christian powers, was home to emigration and exchanges. From the XVI to XIX centuries important cultural exchanges, which involved the exact sciences and their teaching, took place here with Italy, the German speaking countries and Russia on one side, and, on the other, Greece, the Dalmatian cities (Ragusa etc.), the Ionian islands, Crete and the European countries under the Ottoman Empire.
The cultural exchanges between the East and the West followed in the footsteps of commercial exchanges at whose centre were to be found the marine republics of Genoa and Venice. The old universities and academies of Venice and Padua constituted the meeting points for scholars from Greece, the islands in the Aegean and Adriatic Seas as well as from the Balkans. The Adriatic was host to many important cultural exchanges drawing, to Padua, such men as Francesco Patrizi of Cherso, Giuseppe Tartini from Istria and Simone Stratico from Zara. The free city of Ragusa was the birthplace of Marino Ghetaldi and Ruggero Giuseppe Boscovich. In the first half of the nineteenth century, the Ionian islands (Corfu) housed an important Academy, first French (Charles Dupin was its Secretary), and successively English. It became a meeting point for scientists who had been forced to leave Italy during the years of the Restoration period: Francesco Orioli, Giovanni Battista Moratelli, and Ottaviano Fabrizio Mossotti.
The interest in the Balkans on the part of the great European powers like Russia, Austria, France and England, brought about new relations with these countries after the Napoleonic period. After obtaining its independence, Greece created a polytechnic school whose scholars looked to France and Germany for guidance.
The aim of the symposium is to reconstruct this complex network of relations through the emerging scientific figures in the mathematical and physical sciences.

Francesco Patrizi, Humanist and Scientist in the Late Renaissance

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Francesco Patrizi is one of the great figures of scholars of the XVI Century. The broad range of interests of Patrizi reflects both the continuous development of humanism in the scholarly circles during the sixteenth century, and the attention to practical, scientific and engineering issues carried on by many philosophers of his time.
Patrizi focused his attention on philosophical, scientific, artistic and literary issues, providing in his *Nova de uniuersis philosophia in qua Aristotelica methodo non per motum, sed per lucem, & lumina, ad primam causam ascenditur*, printed in Ferrara in 1591, a sort of "New Philosophy on the whole ". In this work, which influenced the next generation of thinkers, can be found an alternative to earlier schools of thought and some of the defining characteristics of the new scientific mentality (Vasoli 1989a).
One of the most interesting aspects of Patrizi's heritage as a forebear of early modern science and philosophy, is his attempt to incorporate within a methodological context a systematic account of the Natural world. This aspect is more clearly displayed in his later writings, especially in the *Pancosmia, the* section of the *Nova de universis philosophia,* concerning the natural world, and in his work on mathematical and physical spaces (entitled *Franc. Patricii philosophiae De rerum natura libri duo priores. Aliter de spacio physico, aliter de spacio mathematico*) published in Ferrara in 1587 but, as we will see, even more in his technical reports.
Patrizi also made research into the history of ancient and medieval philosophical sources, with the aim of establishing the legitimacy of his own philosophical views. He used his linguistic, historical and humanistic skills to rediscover, to study and to make those ancient texts available to his contemporaries, serving as a model for the future generations of scholars. He also emphasized the centrality of the history of philosophy as a part in undertaking philosophical investigations.
During his life he published 35 works (19 original, 16 translations or works which he annotated).
In 1997 the University of Ferrara organized a meeting dedicated to "Francesco Patrizi Platonic Philosopher in the late Renaissance" (Castelli 2002). Nineteen contributions, divided in sections, were dedicated to Patrizi's utopian work *La città felice* (The Happy city): Patrizi's conceptions on aesthetics and poetics and his classical sources, Patrizi's critic on the peripatetic doctrine concerning the eternity and immutability of the heavens , and finally, Patrizi's world and technical aspects of his work.
Here, after having briefly recalled his life, I will focus on the technical aspects of Patrizi's activity, a part of his intellectual work which is less known.

Birth and first studies

Francesco Patrizi was born in 1529 on the island of Cherso, or Cres, off the coast of Dalmatia, at that time under the jurisdiction of the Republic of Venice. First he attented the School in his home-town, than he studied in Venice and in Ingolstadt. In 1547 he entered at the University of Padua, enrolled in the Faculty of Medicine and Arts, which enclosed philosophical, mathematical and humanistic studies. Padua was an outstanding place for the study of the Aristotelian philosophy, but Patrizi preferred the study of Plato and of other alternative philosophical sources.

As a product of his philosophical studies, he published in Venice the “La città felice” (1553) and some years later he published in Florence the *Dieci dialoghi della historia* (1560) and the *Dieci dialoghi della retorica* (1562) (Ten dialogs on history and Ten dialogs on rethoric).

The mission to Cyprus (1561-1568)

After having traveled to several other Italian cities, in 1561 Patrizi moved to Cyprus. Here, as administrator of the properties of Giorgio II Contarini, Count of Zaffo, he was personally involved in the reclamation of the lands surrounding the village of Kalopsida, near Famagosta, digging channels and building banks so that cotton could be grown.

Patrizi remained in Cyprus for seven years, during which he also acquired an in-depht knowledge of Turkish war tactics and gained his expertise in warfare thanks to his friendship with Girolamo Maggi, a militar engineer and co-author with Castriotto of the three-volume *Delle fortificazioni delle città* (1564) (On the fortification of cities). Beside his administrative tasks, he found the time to cultivate his cultural interests, to strengthen his knowledge of Greek and to assemble an important collection of ancient Greek codices on philosophy, theology and science.

Return to Venice and two excursions to Spain (1568- 1577)

In 1568 Patrizi returned to Venice. Here he resumed his preferred studies, and three years later he published his most important philosophical work the *Discussiones Peripateticae* (Peripatetic Discussions). This work, which provides an analysis and a critique of Aristotle’s thought, laid the foundations for the development of his own anti-Aristotelian philosophy in the following years. A new expanded version of the *Discussiones* was printed in Basel in 1581.

The Spanish Diego Hurtado de Mendoza, Viceroy of Catalonia, asked Patrizi to become his personal “philosopher” and to accompany him to Barcelona. Don Diego, who translated the pseudo-Aristotelian mechanical questions into Spanish, was one of the interlocutors for Nicolò Tartaglia in his work *Quesiti et inventioni diverse*. He was also one of the persons who King Philip II charged to establish his library. Patrizi remained in Spain for six months, occupying himself, among other things, in the trade of codices and manuscripts. Then he was back to Venice, but few months later he returned to Spain, where he concluded the sale to King Philip of the Greek manuscripts of his own Cyprian library. The catalogue of this sale contains a patrimony of encyclopedic erudition. Patrizi’s library was worthy not only for the many rare, sometime unique, books it contained, but also for its vastness in terms of

time and topics, reflecting his project of bringing to light the encyclopedia of Platonic sciences, placing music and mathematics as its core.
In those years Philip the second was waging war against the Turks. Patrizi, who gleaned an experience in warfare wanted to propose his own plan for the rearmament of 600 galleys. This project came to naught, but, as we will see, it allowed Patrizi to publish a work on the military art.
During his stay in Venice and in Padua, Patrizi collected a new library of Greek manuscripts, some of them have been purchased in 1601 by the Ambrosiana Library in Milan and some are now in the Barberini collection at the Vatican Library.

In Ferrara (1577-1592)
From 1577 to 1592 Patrizi was in Ferrara at the Court of the Dukes of Este, appointed to teach Platonic philosophy at the local University (Vasoli 1989b). He was one of the very few philosophers teaching Platonism in an Italian university setting in the late sixteenth-century.
This was the most prolific intellectual period of his life. He developed and completed his project to renew philosophy by rediscovering Platonic, neo-Platonic and Hermetic traditions.
At that time he published several works, most of which were edited by Mamarelli of Ferrara.

1. *Discussionum Peripateticarum tomi quattuor, quibus Aristotelicae philosophiae universa historia atque dogmata nunc veterum placitis collata, eleganter et erudite declarantur, Basel 1581 (*Peripatetic Discussions, in which the universal history and dogmas of Aristotle's philosophy are explained)
2. *La milizia romana di Polibio, di Tito Livio e di Dionigi Alicarnasseo*, **1583** (The roman Army by Polybius, Titus Livius and Dionysius of Halicarnassus). This is a major study on the ancient Roman Army, based on his reading of Polybius, Livy and Dionysius of Halicarnassus .
3. *Della poetica (*On the poetics*)* 1586
4. *Della nuova geometria, libri XV, ne quali con mirabile ordine, e con dimostrazioni a maraviglia più facili e più forti delle usate, si vede che le Matematiche per via Regia e più piana che da gli antichi fatto non si è, si possono trattare,* 1587 (On the new geometry fifteen books, in which, with great order and with easier and stronger demonstrations, it is shown that the Mathematics can be treated by a "via Regia"). This was an attempt to develop the work by Euclid by elaborating a new, more satisfactory geometrical method according to his conception of science. The work was dedicated to Carlo Emanuele Duke of Savoy, patron of the Venetian mathematician Giambattista Benedetti. Benedetti, who corresponded with Patrizi, formulated a theory of the free fall of bodies in complete contradiction to Aristotle, in his work *Demonstratio proportionum motuum localium contra Aristotelem et omnes philosop*hos Venice, 1554. (using Archimedes'results on bodies in a fluid, Benedetti stated that speed of the falling weight would depend on its surface area because of friction with the air; only in the vacuum would bodies of different sizes fall at the same speed).

5. *Philosphiae de rerum natura libri duo priores. Aliter de spacio physico, aliter de spacio mathematico* 1587 (Two books on natural philosophy: one on the physical space, the other on the mathematical space)

6. *Nova de universis philosophia* 1591**.** Patrizi disclaimed the possibility of any motion of the sphere of the fixed stars and so he accepted the theory of the diurnal rotation of the earth.

Technical aspects of Patrizi's activity

In 1975 Danilo Aguzzi Barbagli published some writings, reports and letters of Patrizi, bringing to light, for the first time, Patrizi's technical profile (Aguzzi Barbagli 1975). Recently, other writings and letters of Patrizi have been added to those published by Aguzzi Barbagli and published by myself in the above mentioned volume on "Francesco Patrizi Platonic Philosopher in the late Renaissance" printed in 2002 (Fiocca 2002). All these writings concern the hydraulic problems of the town of Ferrara and show a great interest in practical, scientific and engineering issues by Patrizi.

The Late Renaissance saw a profound change in the overlapping of competencies among various professional categories: philosophers, engineers and architects, mathematics and astronomy teachers at the Academies, Universities and Religious Colleges. There are numerous examples of mathematics teachers and philosophers engaged in technical fields and, vice-versa, technicians with a scientific and mathematical background deeply rooted in classical antiquity.

The circulation of ideas and the exchange of knowledge among various members of any society is considered essential to the development of new approaches to the study of the physical world. An exemplary case of such transmission is found in the management of the small torrential Reno River in Italy during the first half of the 16st Century and on into the following centuries (Fiocca 2001).

For a better understanding of this problem let me recall some facts about the river Po.

The hydrography of the lower Valley of the river Po, prior to the 16th century was quite different from how it appears today. Originally the Po, flowing down from the Lombard Plain, ran south of Ferrara (for this reason it was called Po of Ferrara) and, beyond the city, it divided into two branches: the Volano branch, to the north-east, and the Primaro branch, to the south-east. The Po was important for two main reasons: the prosperity brought by trade, largely depending on the navigability of the river, and the military defence of Ferrara.

In the middle of the 12th century the Po burst its banks 15 miles north-west of Ferrara, and a new branch, north of the older one, was created. In 1522 the Reno stream, which run down from the Apennines, flowed into the Po of Ferrara. This canalization of the Reno transformed the lands affected by its floods and reduced the level and the extension of the marshes as desidered, but, on the other hand, the water of the Reno depositing great quantities of sediments in the Po of Ferrara, quickly almost filled in its bed. This branch became un-navigable, while the new branch to the north become the great one and was called Po of Venice or Great Po. If the reducing of the marches was mostly in favour of Bologna, the impossibility to navigate along the Po caused great damage for Ferrara. In an attempt to solve the

problem and recuperate the drainage of the lands, while re-establishing military defence, Duke Ercole II and his son, Alfonso II, both tried to negotiate a new agreement regarding the Reno with their neighbouring cities, particularly Bologna. Technical consultations with the supervisor of the Papal delegate and specialists from the cities involved continued for centuries to come.
Patrizi was involved in these questions from 1579 to 1581. In these three years he produced a great amount of writings, reports and letters addressed mostly to Duke Alfonso II. In particular, Patrizi replied to the Papal technician, Scipio of Castro who was aligned with the thesis of Bologna. According to Scipio, the theory of the silting up caused by the Reno stream, was wrong. In fact, according to him, all the substances carried by the river, whether heavy or light, remained on the surface of the water and could not rise the bed of the river.
To disprove this opinion, Patrizi claimed that nature did not allow a single cause to produce the same effect on contrary objects. Patrizi did, however, admit that this argument was so subtle that he suggested performing three experiments because, he claimed, experience was the best proof of reason. When intellect was in agreement with natural experience, intellectual understanding was valid, otherwise it was meaningless. Patrizi's appeal to the experiments as the way of knowing the physical world at this pre-Galilean time is worth emphasizing.
It is clear that, in Patrizi's mind, all practical works had to be subordinate to science. In hydraulics this meant subordinating the works to knowledge of the nature of water. In the letter to Alfonso II dated November 28, 1580, Patrizi claimed he was the first to have established a general, orderly, real science of water, resulting from natural and mathematical principles. He based his hydraulic proposals on a scientific basis which took several elements into account: quantity, level and velocity of the water, gradient, breadth and shape of the bed. In fact, in the aforementioned letter, Patrizi formed seven questions on which to base his proposals, namely: "can the bed of the river be made deeper when it has a small or great quantity of water? when the water level is deep or low? when the velocity is fast or slow? When the gradient is high or low? When the bed is wide or narrow? When the river has only one bed or more? When the bed is straight or curved?" Patrizi, eager to discuss all these questions with the Duke and his technicians, was sure he would convince them of the validity of his proposal.
In the aforementioned letter Patrizi explained, also, his proposal which consists in halving the river bed, and so creating two independent channels, one for the water of the Reno river and the other for the water of the Po of Ferrara. Patrizi gave all the technical details in order to realize his project so it can be seen as a model of hydraulic engineering. Patrizi was aware of the boldness of his proposal and so he used his knowledge in the ancient history to compare its own with others bolder enterprises of the past on much impetuous rivers.

The last years in Rome (1592-1597)

In 1592 Cardinal Ippolito Aldobrandini invited Patrizi to teach Platonic philosophy at the University of Rome, the "Sapienza". Patrizi spent in Rome the last five years of his life.

In 1594-95 he published a two-volume work, in which he compared ancient Roman military tactics and strategies with those of his own day, most likely in an attempt to encourage an improvement in art of war in Italy. The work, dedicated to Giacomo Boncompagni, commander-in- chief of Philip II of Spain in the Dukedom of Milan, followed the study of the ancient Roman army published in Ferrara in 1583.
Paralleli militari Ne' quali si fa paragone delle Milizie antiche in tutte le parti loro con le moderne all'ecc. et ill.mo Giacomo Boncompagno Duca di Sora … e Capitano Generale de gl'huomini d'arme del Re Catolico nello Stato di Milano, Roma, 1594 (Military parallels in which the old Army is compared with the modern one, dedicated to Giacomo Boncompagno, commander-in- chief of the Catholic King in the State of Milan) (Philip II of Spain)
Patrizi passed away in 1597 while still engaged in defending his controversial work *Nova de universis philosophia* (The New Philosophy on the universe) from the theological criticisms that had caused it to be condemned by the Congregation of the Index shortly after it had appeared in print in 1591.

Conclusions
Humanist, scientist, mathematician, literary critic and poet, historian, engineer and utopian theorist, Patrizi was all this. As it happens with many other thinkers of his day, it is impossible to locate well him in one of these categories, but this is not a problem: he was after all, a "Renaissance man" who helped to usher in a new era (Stanford Encyclopedia of Philosophy).

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Boscovich as Mathematician and his Italian Pupils

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Ruggiero Giuseppe Boscovich (Ragusa 1711-Milano 1787) was admitted as a novice to the Jesuits in Rome on 31st October 1725. In the year 1727-28 he attended the first year of rhetoric in the Roman College, and in the triennium 1729-1732 he completed the philosophical course. Then for two years he taught grammar at the College and for other two years "humanae litterae" in Fermo. In 1736-37 he returned to the College where he, once again, taught grammar, followed by "humanae litterae" the next year. In the years of his return to Rome Boscovich met Vincenzo Riccati (1707-1775) who introduced him to the use of infinitesimal methods and differential and integral calculus. Riccati was a pupil of Orazio Borgondio at the College (Bursill-Hall 1993).

In the 1740s Boscovich was one of the major contributors to the *Giornale de' Letterati di Roma* with the papers: *Dimostrazione facile d'una principale proprietà delle sezioni coniche* (1746), *Metodo di alzare un infinitimonio* (1747), *Metodo di alzare un infinitimonio. Parte prima delle riflessioni* (1748), *Metodo di alzare un infinitimonio*. *Parte seconda delle riflessioni* (1748), *Dimostrazione di un metodo dato da Eulero* (1749) (Pepe 2010_a).

In 1750, when Boscovich, together with his ecclesiastical brother, Christopher Maire (1697-1767), set off on his journey to the Papal States to embark on his astronomical and geographical enquiries, Cardinal Prospero Lambertini was Pope under the name of Benedict XIV. The Church was opening up to modern culture. Cardinal Lambertini took an interest in the works of d'Alembert and Voltaire. His librarian, Cardinal Domenico Passionei, was in correspondence with the leading European intellectuals. Cardinal Silvio Valenti Gonzaga, Secretary of State and a graduate "in utroque iure" at the University of Ferrara, spoke several languages and was a refined and cultured man as well as collector. In this climate the changes to the *Index Librorum Prohibitorum* were about to be made. When it came out in 1758, although the *De Revolutionibus* by Copernicus, the *Dialogo* by Galileo and the *Epitome* by Kepler were still prohibited, there was no longer the sentence of condemnation of every work concerning the Earth's motion. This change implied an authorization to deal with Newtonian attraction and its cosmological consequences in scientific works. The Copernican system had already been accepted by the progressive part of the Catholic hierarchy. Two clergymen, François Jacquier and Thomas Le Seur, active in Rome, had supervised an edition of Newton's *Principia* in Geneva from 1739 to 1742, that contained the demonstration of Kepler's laws and the Earth's motion around the Sun, but since the *Principia* was a work specialists it had never been censured by the Catholic Church and so could be presented as a purely mathematical treatise on the Copernican question. More than a century before, Cardinal Bellarmino, had also declared that dealing with the Earth's motion as a mathematical hypothesis was admissible, but at that time a mathematical hypothesis was hierarchically lower than philosophy and theology and only provided the possibility to improve calculations and better explain phenomena like eclipses, the positions of the planets in the zodiac, etc. (Pepe 2011).

It is in the preface of the third volume of his *Elementa Universae Matheseos* we can found a detailed description of the genesis of the *Elementa universae matheseos*. In 1737, Boscovich had written a short compendium of plane geometry in Latin for his pupils, then, again for his pupils, he wrote a short arithmetical treatise in Italian that also contained progressions and logarithms. Finally, in an appendix of one of Tacquet's works, he published a compendium of spherical trigonometry (Rome 1745). Later, from 1750 to 1753, he was obliged to leave his teaching activity since he was involved in measuring the meridian between Rome and Rimini, work that took him to some rather isolated places. It was during this period that a publisher, and friend of his, asked him to publish some texts on solid geometry, plane trigonometry and finite algebra, to which Boscovich added the elements of solid geometry and spherical trigonometry which he had compiled during his travelling for the geodetic measures (Pepe 2010_b).

The *Elementa Universae Matheseos* begin the approval of the Catholic censors: Domenico Franchini for the Jesuit Roman Province, F. M. Rossi (Rome, December 11th 1751) and Benedetto Stay (December 20th, 1751) for the Dominican, Giuseppe Agostino Orsi, Master of the Holy Palace.

The mathematical treatise of the *Tomus I* (Rome, Salomoni, 1754; in 8vo, 324 pages, 8 tables) is divided into five parts, each one generally laid out into numbered paragraphs. The first part includes plane geometry and ends with a table of correspondences between the work and the first two books of the *Elements* by Euclid. The *Elementa arithmeticae* are to be found on pages 67-136 and include the four operations between integers and between decimal fractions, the irrationals ("numeri surdi"), and three tables that exemplify the operations; then there are the properties of proportions (pp. 97-110, one table), progressions and logarithms (pp. 111-133). First geometric and arithmetic progressions are studied, followed by logarithms: if the numbers are in geometric progression, their logarithms are in arithmetic progression. The last chapter deals with the harmonic proportion (pp. 133-136). The *Elementa solidorum* represents the third part of the volume (pp. 137-175 with a table). Also this part, like the one on plane elements, ends with a table of correspondences with Euclid's *Elements* (books XI and XII). It ranges from the reciprocal positions of lines and planes in space, to the volume and the area of a sphere. Cavalieri's method of indivisibles is used determine the volumes of solids. After solid geometry, *Trigonometria*, i.e. "ars resolvendi triangula", is dealt with. An *Appendix* closes the volume (pp. 268-324); on page 324 there is also an *Errata corrige*. The appendix contains an afterword to the volume explaining its composition as well as a substantial series of teaching considerations for teachers. As usually occurs in elementary teaching works, references to authors and other works are almost completely lacking. Besides general references to Pythagoras, Euclid and Archimedes, there is a reference to Euler's *Introductio in Analysin Infinitorum* on page 308.

The *Tomus II* (Rome, Salomoni, 1754, in 8vo, 324 pages) contains the *Algebra finita*: different ways to transform the equations (signs of coefficients and solutions), reductions of fractions to the same denominator, divisions between polynomials, integer power of a binomial, third degree equations, real and imaginary solutions, general resolution of third degree equations, fourth degree equations.

The *Tomus III Elementorum universae matheseos* (Rome, Salomoni, 1754, in 8vo, pp. XXVI, (2), 468 pages, 7 folded plates) is the major novelty of this edition. It contains a new presentation of the elementary theory of conics and a dissertation, *De transformatione locorum geometricorum*.
Boscovich's definitions of conics are not based on the properties obtained by the sections of a cone in space, but on the properties referred to a plane. The ellipse, the parabola and the hyperbole are, therefore, defined as loci of points, whose distances from a point named "focus" and from a straight line, that does not pass through it, and named "directrix", are minor, major or equal respectively. This characterization of the conics, without using the sections of a cone, can already be found in Pappus: *Collectiones mathematicae* (book VII, pp. 235-238). The term "eccentricity" that is used to indicate the ratio between the distance from the focus and the directrix, was introduced by Kepler in the *Astronomia nova* (1609).
The *De Transformatione locorum geometricorum* occupies pages 297-468 of this dense third volume.

The *Elementa Universae Matheseos* enjoyed immediate success. The edition printed in Rome of the work was authorized by the church censorship in the month of December 1751. The volumes dated 1752 are very rare: a copy can be found in the library of the Department of Mathematics 'Guido Castelnuovo' of the La Sapienza University in Rome. Thus we may suppose that it was printed in 1752 in the typography of Generoso Salomoni, who often worked for the Roman College and, the year before, had printed the Italian translation of the *Elementi di geometria* by Clairaut edited by Carlo Benvenuti (1716-1789), one of Boscovich's pupils.
Benvenuti, born in Livorno, where he completed his first studies, had begun his novitiate with the Jesuits in Rome, he then taught in Fermo and later returned to Rome. He was a highly regarded lecturer but exposed himself to church censorship with two Latin papers on Newtonian physics (1754) that were clearly influenced by Boscovich's works. Benvenuti was strongly censored within the order, but was saved by the intervention of Benedict XIV and was assigned to a liturgy chair. Benvenuti confirmed his fidelity to the vows in 1772 when he came to the Society's defence against slanderer issuing from the Borbonic courts. After the suppression of the order he took refuge in Poland, where he kept on defending the Society and claiming the non-validity of the Papal Bull of suppression in the lands of the Russian Empire. He died in Warsaw.
Francesco Puccinelli (1741-1807) was born into a noble family from Pescia in Tuscany. After he had completed his studies at the Roman College, he moved to Brera to work with Boscovich. On his return to Tuscany after the suppression of the Society, Puccinelli entered the service of the Grand Duke Pietro Leopoldo and, as an assistant to Leonardo Ximenes, worked on the reclamation of the Maremma. In 1803 he was appointed education superintendent of the University of Pisa by Maria Theresa of Bourbon.

In the first known letter to Puccinelli dated Rome 1763, Boscovich recommended that the young scholar should master analytical methods in mathematics by studying the works of Euler, Hospital, Bougainville and the announced treatise by Vincenzo Riccati, the *Institutiones analyticae*. Regarding the analytical methods Boscovich complained: "Così ne avessi avuta idea nella sua età: ma allora non solo mancavo di guida, ma non avevo né libri, né notizia di essi, ed ora non sono più in stato di farmene padrone." Far be it from an ideological rejection of the analytical methods!

It would, however, be a mistake to place too much emphasis on Boscovich's ignorance, which only concerns the analytical developments of the mid 17th century (partial differential equations, calculus of variations, etc.). Not only his algebra lessons, but also many references in his works written in the two central decades of the century, prove that Boscovich had mastered the methods of Cartesian geometry (see the letter to Giambattista Suardi of March 16th 1748), the way to use power series (Giornale de' letterati di Roma, 1747), and differential calculus (*Epistola*, in *Theoria philosophiae naturalis*, Venice, 1763).

The Roman edition of the *Elementa universae matheseos* (1754) concluded Boscovich's dedication to pure mathematics. He was not involved in the remarkable progress of the analytical methods in the study of ordinary and partial differential equations and calculus of variations that d'Alembert, Euler, Daniel Bernoulli and the young Giuseppe Luigi Lagrange (1736-1813) had been developing between 1740 and 1760. Boscovich confided in his pupil, Francesco Puccinelli, that his interest in the latest developments in mathematics had begun late, and it was to be interrupted by a series of tasks that he was given by different states.

Boscovich was permanently employed in the repair of the Tiber river harbour at Fiumicino (1752), the measure of the meridian north of Rome (1751-55), the problem of Lucca waters (1756), and a mission to Vienna, where he had the lessons on optics by the astronomer Lacaille printed (1757) as well as publishing his most famous work, *Philosophiae naturalis theoria* (1758). When he left for Vienna, his mathematical chair at the Roman College was given as a supply teaching post to his brother Bartolomeo, who considered himself unsuited. Boscovich returned to Rome for about an year between 1758 and 1759, and then in September 1759 he left for Paris; during his journey he met Francesco Algarotti in Bologna and Esprit Pezenas in Marseilles. In the middle of November he arrived in Paris, at that time the centre of mathematical studies. He became friendly with Clairaut and met other academics, like d'Alembert with whom he became friends. Boscovich also met Buffon and Madame du Boccage, remaining in Paris until March 1760. He later moved to London where he stayed for the rest of the year. There he met the mathematicians Thomas Simpson and Edward Waring, as well as the American scientist, Benjamin Franklin, and the painter, Joshua Reynolds. He visited Cambridge, Oxford and Greenwich, where he met the astronomer James Bradley. At the end of the year he left for the Austrian Netherlands, after which Lorraine and Germany. In the two-year period, 1761-63, he made a journey to Constantinople and Eastern Europe, initially planned to observe the Venus transit. In December 1762 Boscovich was in Cracow and between January and May 1763 he was in Vienna. By now Boscovich did not want to go back to Rome and so he willingly accepted the mathematical chair at the university of Pavia, which was offered to him by the Austrian government. The transfer to this university (1764) excluded him from taking up mathematical studies again since the scientific faculties of that university were extraordinarily behind at the time. Boscovich, instead, preferred to move to Milan, where he played a fundamental role in the foundation of the astronomical observatory of Brera.

Francesco Luino (1740-1792) had an eventful life. Born in Luino on Lake Maggiore, he entered the Jesuit College of Brera where he was a pupil of Giovanni Antonio Lecchi for mathematics, and there he met Boscovich, who was a teacher in Pavia at that time (1764). In the appendix of Luino's mathematical work, *Delle progressioni e serie libri due* (Milan, 1767) there are two memories by Boscovich, one about the way to avoid negative logarithms and one about raising to powers of a polynomial series. The relationship between Boscovich and Luino came to an end when Luino, temporary of Louis Lagrange at Brera, did not want to adopt a clear position in the quarrel between the latter and Boscovich. After the suppression of the order and Boscovich's departure, Luino taught elementary geometry and physics at the University of Pavia. Luino's *Meditazione filosofica* came out anonymously in Pavia in 1778 and was condemned by the Church and placed on the Index. Luino lost the chair, and was substituted by Carlo Barletti, (whose place was then taken by Alessandro Volta). In 1783 Luino began a journey in Europe which was described in a volume of *Lettere a diversi amici* (Pavia, 1785). On his return to Italy, Luino taught in the "ginnasio" school of Mantua, as a colleague of Giuseppe Mari.

Luigi Panizzoni played an important role in the reconstruction of the Society of Jesus. After the canonical suppression of the order he moved to Byelorussia where Catherine II refused to enforce the papal brief of suppression of the Society (1773). Panizzoni was sent to Parma in 1793, with the aim of re-establishing the order in the dukedom. In 1800 Panizzoni sent to Pio VII, the newly-elected Pope, a *Supplica per ottenere l'estensione e la dilatazione della Compagnia di Gesù fuori dei confini della Russia*. On November 15th 1811 Giuseppe Pignatelli, on his deathbed, appointed Luigi Panizzoni as Provincial of the still-to-be constituted Order in Rome, in accordance with the laws in force in Russia.

The *Elementi di geometria piana e de' solidi e di trigonometria piana e sferica con una introduzione alla trigonometria, dove de' logaritmi si tratta e del loro uso, e colle tavole de' logaritmi, de' seni, delle tangenti e delle seganti* were published by the ex-Jesuit Luigi Panizzoni in Florence, printed by Gaetano Gambiagi in 1774 as an octavo. Panizzoni went on to say that he had not limited himself to a pure and simple translation, but had completed some demonstrations and had cut some topics. The most remarkable cut concerned arithmetic, about which there were at that time several texts published in Italian. Only the presentation of the logarithms was taken from Boscovich and inserted at the beginning of the trigonometry. This volume does not include any reference to either the measurement of the meridian contained in the first tome of the *Elementa* by Boscovich (pages 17-18) or the theoretical study on indivisibles and infinitesimal methods (pages 158-164). The long critical appendix, which concludes the first volume of the *Elementa*, is omitted. For the disposition of the subjects of plane and solid geometry and plane and spherical trigonometry Panizzoni follows the order given by Boscovich, which is extremely different from that of Euclid's Elements.

Unlike Italy, the *Elementa universae matheseos* enjoyed lasting success in the German-speaking Catholic states, from Austria to Silesia. In fact, there are many educational works which draw inspiration more or less directly from Boscovich's work and resume his publishing program. Joseph Stepling (1716-1778), Professor of mathematics and astronomy in Prague from 1747 to 1759, wrote a *Miscellanea Philosophica* (Prague, 1759), and, after the suppression of the Jesuits, stayed on to direct the astronomical observatory of the town and became professor at the university of Prague. In this context many of Boscovich's pupils are renowned, among whom we may remember: Karl Scherffer (1716-1783), Paulus Makò (1723-1793), Leopold Biwald (1731-1805), Johann Baptist Horvath (1732-1799).

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Applied Mathematics in Boscovich's Papers

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In 1750 the Jesuit Ruggiero Giuseppe Boscovich (Ragusa, 1711 - Milan, 1787) was asked for his first works on the science of waters: the examination of the "passonate" of the Fiumicino harbour, the regulation of the course of the Tiber at Porto Felice, and the access to the Valleys of Comacchio (Lugaresi 2011).
As a consultant on problems relating to the science of waters, Boscovich wrote reports about the regulation of some rivers and streams (Tiber, Po, Adige), some faulty harbours (Fiumicino, Magnavacca, Rimini, Savona) and the reclamation of wide marshlands (the Pontine Marshes, the lake of Bientina in Tuscany).
His main contributions deal with the settlement of harbours placed at the mouth of a river. During the journey he made in the Papal State, Boscovich visited some important harbours of the Adriatic coast, that were placed near the mouth of torrential streams. These rivers carry a great quantity of stones, sand and gravel. Near the mouth, the slope decreases and the river stream slows down causing stones and gravel settle on the bottom and obstruct the entry to the harbour. Such was the condition of the harbours of Fiumicino, Magnavacca, Rimini and Savona. Since it was impossible to completely remove the causes of the problem, Boscovich was obliged to find as best a solution as he could each time the situation arose.
As regards the harbour of Fiumicino, the Tiber was so fast-flowing and winding that it accumulated a great quantity of stones near its mouth, which, given the opposition of the sea at this point, obstructed the navigation of the ships. To prevent the silting up of the harbour the proposed remedy was the construction of "passonate", which consisted of wooden stakes being placed in the ground to regulate the path of the river (Mariani 2002).
In the second half of 18th century a similar problem was to be found at the harbour of Magnavacca, which had become narrow and lacking in waters. It was important to restore this harbour because it represented the link between the Adriatic Sea and the Valleys of Comacchio.
In the 18th century the harbour of Rimini, that stood on a delta branch of the Marecchia river, was in a bad condition. During the floods of the river the forecast shelters were insufficient. According to Boscovich the only way to make the harbour safe and efficient was to divert the river away from it.[1]
As his reputation grew, more and more Italian courts approached Boscovich for consultations. In 1756, the Republic of Lucca asked Boscovich to solve an on-going dispute with the Grand Duchy of Tuscany, part of the Habsburg Empire, over some problems involving hydraulics. It was his first mission outside the Papal State. Boscovich was already famous in this town owing to his works on applied

[1] Boscovich's solution was successful, but it was not until the first half of 20th century that a project to divert the river Marecchia was carried out.

mathematics. In Lucca Boscovich had some friends like Giovanni Stefano Conti and Giovanni Attilio Arnolfini, with whom he was in correspondence.[2] The correspondence with Conti was mainly about optics: Conti in fact was the first producer in Italy of optical lead glass. With Arnolfini Boscovich discussed about hydraulics because Arnolfini was involved for a long time in the direction and in the consultancy of some hydraulic problems on behalf of the Republic of Lucca.
Lucca complained that Tuscany had built some defenses and carried out hydraulics works aimed at preserving the Serezze channel which caused flooding in the republic. Lucca wanted the Grand Duchy to destroy these works but this request was not approved. For this reason Lucca asked Pope Benedict 14th to find a mathematician who was an expert in hydraulics. The Pope commissioned Boscovich with this work. The mathematician of the Grand Duke was the Jesuit, Leonardo Ximenes (1716-1786) (Barsanti, Rombai 1987). When Boscovich arrived in Lucca he understood that the situation was not merely a question of solving a mathematical problem but that a political issue was at stake. In order to defend Lucca's interests, Boscovich decided to have talks with the Habsburg Emperor, so in March 1757 he moved to Vienna, where he stayed for a year.
Boscovich travelled a lot in his life, especially in France. During his first stay in Paris (1759-1760), Boscovich met famous scientists like the astronomers Lalande and Clairaut (Pappas 1991). Joseph Jerome Lalande (1732-1807) was a friend and a great admirer of Boscovich. He said that Boscovich was the greatest mathematician he had met in Rome and that there was no better geometer and expert of such international reputation as Boscovich.[3]
While he was in Paris, Boscovich became acquainted with the French scientist Alexis Claude Clairaut (1713-1765), with whom he was in correspondence, especially in the period 1760-1764 (Taton 1996). An extract of a Boscovich's letter to Clairaut was published in the Journal des Savants in June 1761. It dealt with the study of the flux and reflux of the sea. This subject was related to the study of the Earth's shape.[4]
From the end of 1760, Clairaut's research works focussed on the construction of achromatic lenses and he published some treatises on the composition of achromatic objective lenses. Boscovich, too, worked on theory and calculations for the design of objective lenses and his theory was later explained in the *Opera pertinentia ad opticam et astronomiam*, published in five volumes in Bassano in 1785.

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[2] G. S. Conti (1720-1791) was a noble of the Republic of Lucca, who was interested in the study of exact sciences. G. A. Arnolfini (1733-1791) was a Tuscan mathematician and hydraulic engineer (Proverbio 1998).
[3] In August 1765 Lalande made a journey to Italy that lasted one year. Lalande visited many important Italian cities such as Genoa, Turin, Milan, Rome, Naples, Florence and Venice. Boscovich accompanied him until November. When he went back to France, Lalande published a report, in eight volumes, of his long journey: *Voyage d'un Français en Italie fait dans les années 1765 et 1766*, Paris, 1769.
[4] Clairaut made important contributions to geodesy, both theoretical and practical. In 1736 he was involved in a journey to Lapland with Pierre Louis Moreau de Maupertuis. Their results confirmed the Newtonian theory of the crushing of the earth globe.

Boscovich's works on practical hydraulics were carried out later in his life, particularly in the period he spent in Lombardy, firstly in Pavia from 1764 to 1768, as a professor at the university, then in Milan from 1769 to 1773, as a teacher in the Palatine Schools. The years Boscovich spent in Lombardy are very important in his life because his limited theoretical study on hydraulics was mostly carried out in this period.

At the end of 1763, Boscovich was appointed teacher of mathematics at Pavia University. While he was in Pavia, he was in correspondence with the Jesuit Giovanni Antonio Lecchi (1702-1776).[5] Boscovich and Lecchi share some interests, not only owing to their experience in hydraulics but also their adhesion to the Newtonian tradition.[6]

Some letters, preserved in the Bancroft Library of California University, are proof of the friendship between Boscovich and Lecchi. The letters were written by Lecchi from the end of 1763 until 1770 and they contain frequent references to Lecchi and Boscovich's activity as hydraulic engineers, especially those from 1763 to 1765. Lecchi admired the works Boscovich carried out in that period which contributed to improving the science of waters.[7]

In the same period Lecchi was finishing one of his most famous works, the *Idrostatica*, with whom he intended to provide a good theoretical grounding in the science of waters. In this book he studied the rudiments of hydrometrics and its applications to the flow of rivers. Lecchi complained that hydrometrics and hydraulics were lacking in practical experience. Even though he recognized the soundness of the experiments made until that time, no universal hydrostatic law had yet been established. Lecchi, who looked upon Boscovich as a good hydraulic teacher, asked him to contribute to the *Idrostatica*, that was about to be printed: "I should like you to provide, at your convenience, a set of similar problems, in a letter to be published as an appendix to my work, which will be greatly enhanced by the inclusion of your illustrous name". Lecchi hoped that Boscovich could improve the practical aspects of the science of waters with a set of experiments, taking cue from the works by Jacob Hermann and Bernard Forest de Belidor.[8]

[5] Lecchi studied at Brera College, then he became a professor at the same College: he taught maths (1738-1760), then maths and hydraulics (1760-1773). Since 1757 he also worked as a hydraulic engineer. In 1759 the title of "matematico e idraulico regio" was conferred on him by the Austrian empress, Maria Teresa.

[6] Lecchi was interested in Newtonian analysis, and in 1752 published the *Arithmetica universalis Isaaci Newtoni sive De compositione et resolutione arithmetica, perpetuis commentariis illustrata et aucta*. Boscovich was strongly influenced by the English geometrical tradition and often referred to Newton's works.

[7] Lecchi refers to Boscovich's surveys about the banks of the River Po near Piacenza on behalf of a noble family of the land of Piacenza (Lugaresi to appear).

[8] J. Hermann, *Phoronomia*, Amsterdam, 1716; B. F. de Belidor, *Architecture Hydraulique*, Paris, 1737-39.

Boscovich accepted the proposal and wrote a paper that was put in the third part of the work. Boscovich moreover revised the *Idrostatica* and suggested Lecchi to consult the works by D'Alembert and Bernoulli.[9]
The *Idrostatica* was printed in 1765 and was dedicated to Empress Maria Teresa.[10] With this work, Lecchi contributed to the development of the hydrodynamics in Italy. He tried to apply geometric theories to the experimental observations in order to establish the laws that describe the movement of waters. Lecchi demonstrated how to measure the speed and quantity of water flowing out from vessels of different shapes through holes at different heights. The *Idrostatica* is divided into three parts with an appendix. The first part contains the law to estimate the efflux speed of water flowing from a chink and this speed turns out to be proportional to the square root of the height of the pipe, from which water comes out. The second part deals with water motion in the rivers from a theoretical point of view, and with its consequent practical applications for hydraulics. In the third part, besides the letter of Boscovich on water measure, Lecchi describes how to construct navigable channels and river divisions with some examples taken from the experiments he had performed in Lombardy. The appendix contains five chapters, dedicated to the solution of different hydraulic problems.
In the letter to Lecchi, Boscovich explained principles and rules for the measure of waters, both flowing out of vessels and running in rivers. For the waters that come out of vessels, speed is proportional to the square root of the height and the speed curve is a parabola. This law had already been proved by Lecchi and, before him, by Evangelista Torricelli in the *Opera geometrica* (1644).
For the waters that run in the rivers a general rule to describe the speed did not exist, so it was necessary to adopt actual measures taken from practical observations applied to single cases and taken by means of the quadrant.[11]
In the first part of his paper, Boscovich demonstrated how to obtain the mean speed and quantity of water passing through an opening at a given moment, when height and width are known. He used geometrical constructions and hypothesised that speed is the same at each point of every horizontal line. The method consisted in computing the volume of a solid of water equal to a parallelepiped whose base area is the area of the opening and whose height is the mean speed.[12]
After explaining how to find the mean speed and the quantity of water, Boscovich investigated what happens to the waters flowing out from the vessels. The shape of

[9] He was probably referring to the *Hydrodynamica* (Basel, 1738) by Daniel Bernoulli and the *Traité de l'équilibre et du mouvement des fluids* (Paris, 1744) by D'Alembert.
[10] G. A. Lecchi, *Idrostatica esaminata ne' suoi principj e stabilita nelle sue regole della misura dell'acque correnti*, Milan, 1765.
[11] This instrument was used to measure the river speed; hanging from a wire, it measures the deviation angle of the wire compared to the perpendicular. It was difficult to fix the angle because of the oscillation of the wire.
[12] This method is valid for the openings of the vessels, where speeds and heights are equal in every point of the same horizontal line, and for the openings made sideways in the channels so that water goes out only as a result of the action of the pressure. The method does not work for the waters flowing in the rivers because, in this case, the speeds are different at different points of the same horizontal line.

the opening, other conditions being equal (same area and height), affects the quantity of water going out of it. Boscovich enunciated and demonstrated some theorems, using formulas of the integral calculus.[13]

In the last part of the work Boscovich added some explanations. The rules for calculating the quantity of water can be modified by friction or other causes, most of all by the channel structure. If the channel has a slight slope or if it runs into some obstacles, it can create an overflow that interferes with the speed. So it is better, after making the opening, to observe the current speed with floats and with the deviation of the pendulum and then to obtain the corresponding quantity of water to see if it agrees with the previous calculus. Otherwise the opening has to be widened or opened so that the results are near enough to those expected.

Like many other contemporary experts, Boscovich thought that the science of waters was mostly theory as no reliable laws existed. He also said that as far as waters were concerned little could be said for certain and that it was more a question of common sense and judgement. Although Boscovich wanted to give a general theoretical foundation to the science of waters, he still used practical measurements. His work should have given useful instruments for the measure of the river waters, but it was mainly centred around the study of close pipes rather than open channels and was limited to the calculus of the quantity of water.

Boscovich used quite specific vocabulary of practical hydraulics, that probably came from his reading of works by Belidor and Charles Bossut, that were quoted as reliable sources.[14]

After his contribution to the *Idrostatica*, Boscovich no longer followed the development of theoretical hydraulics nor the analysis contained in the works by Euler, Lagrange and d'Alembert (Blay 2007; Calero 2008; Darrigol and Frisch 2008). However, he did advise his pupil, Francesco Puccinelli, to turn the focus of his studies in that direction as he understood the value of these new theories.

After putting theoretical studies aside, Boscovich's interest lay only in practical hydraulics. He carried out important consulting works not only on behalf of the Reverenda Camera Apostolica, but also of the leading Italian courts, namely, the Republics of Lucca, Genoa and Venice, as well as for the Duke of Modena, Francesco III. In 1766, at the request of the Reverenda Camera Apostolica, Boscovich went to Umbria to examine the irregular flow of some of the Tiber's tributaries and he wrote a report on the floods in the Perugia area. In 1771, at the behest of the Republic of Genoa, Boscovich went to Savona to find a solution for the problem of the silting up of the harbour.

In June 1773, the Venice Republic sought his help for a problem concerning the mouth of the river Adige. In this case he was chosen as an expert in order to settle a controversy between two mathematicians: one was Anton Maria Lorgna and the other one is anonymous. Boscovich did not approve the project by Lorgna and he explained his reasons in the work *Sullo sbocco dell'Adige in mare*.

[13] He observed that the shape of the opening affected the quantity of water going out and on this subject he demonstrated some theorems.

[14] Belidor, *cit.*; C. Bossut, *Traite élémentaire d'hydrodynamique*, Paris, 1771-75.

When the Jesuits were suppressed in 1773, Boscovich decided to leave Italy and accept the invitation of King Louis XV of France who had created for him the post of director of optics for the French navy. In October 1773 Boscovich left for Paris where he remained until July 1782. As director of optics his main task was to carry out studies on the achromatic telescopes in an attempt to improve them since they had a great importance for the French navy.

In 1781 Boscovich was once again called by the Republic of Lucca to examine a reclamation project for the Lake of Bientina proposed by Leonardo Ximenes. This paper was a comment on Ximenes's project for the New Ozzeri drainage channel in Lucca and represented Boscovich's last hydraulic work.

Boscovich was important for both his theoretical and practical studies, making a synthesis between mathematical knowledge and specific problems in the territory. He made the best use of the mathematical knowledge at his disposal, even if he had not studied the recent discoveries by Euler on the motion of fluids.

Boscovich intended to collect together all his papers on hydraulics, but he died before this project could be put into effect. Boscovich's works on hydraulics, edited by Prof. Luigi Pepe and myself, will be enclosed in the project of the *National Edition*, coordinated by Prof. Edoardo Proverbio and promoted by the Astronomical Observatory of Brera, the National Academy of XL, the Croatian Academy of Sciences and Arts and the Pontifical Gregorian University (Lugaresi, to appear).

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River Hydraulics in the Napoleonic Period: the Role of Simone Stratico

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Simone Stratico (1733-1824) is one of the most interesting figures of the late eighteenth and early nineteenth centuries in the Veneto region: he is symbolic of the versatile scientist in applied sciences, with organisational and technical skills, which were greatly appreciated and put to use, firstly, by the Republic of Venice, and then by the Napoleonic government.

Simone Filippo Stratico (or Stratigo) was born in Zara to a Venetian family of Crete, in 1733. His academic career began in 1757 with a post in the theory of medicine at the University of Padua. Between 1761 and 1764 he was commissioned by the Republic of Venice to go to London and other European countries to gather information on shipyards and naval colleges. On his return, he took up the chair in mathematics and naval theory at the University of Padua, previously held by Giovanni Poleni, making contributions that were decisive in re-launching naval construction studies in Venice, by promoting, in 1765, the introduction of a new school for naval construction at the Arsenal. Models and designs of ships dating back to the period of Stratico's teaching are still preserved at the University of Padua.

Stratico's name is linked to the re-foundation of the Padua Academy in 1779, which was soon to become the technical and scientific reference point for the Republic. Stratico was called on, as consultant, to take part in many commissions appointed to examine issues concerning waterways, health, artillery, roads, and the Arsenal. In particular, he was charged to examine the controversial project of the reconstruction of the Brenta River. His extensive scientific production, whether in printed or manuscript form, reflects the diversity of his interests and charges, covering such areas as ship and civil engineering, mechanics, hydrostatics, hydraulics, optics, and the history of architecture.

Stratico was Rector of the University of Padua four times in 1765, 1770, 1789 and 1795, a position that was reconfirmed in 1798, but the change to the Austrian government deprived him of the chair.

During the democratic period (28th August 1797-16th January 1798) Stratico, who had already shown sympathy for the Jacobin cause in the later years of the Venetian government, for which he had been admonished by the authorities, was one of the first members of the new municipality of Padua, presiding over the organisation committee of central government. Together with Toaldo, as part of the Municipal University Commission he was put in charge of drawing up a general reform study plan. The short-lived democratic period brought an end to the innovative proposals which were not carried out until the following French administration of the Kingdom of Italy.

Austria then took over after the Campoformio Treaty, and the teachers who had collaborated with the previous regime were banned not only from their chairs but also from the city. Stratico went to Vicenza but returned to Padua to take up his chair again during the short interim period of 1801, when the city was once again occupied by the Napoleonic army. Banned for a second time from Padua on the return of the Austrian government, he was called to Milan, the seat of central government of the Cisalpine Republic to teach nautical science at the University of Pavia and take part in the Hydraulics Commission. However, the chair of nautical science was never actually activated so Stratico took over the teaching of physics from Alessandro Volta in the years 1802-1804.
In 1805, he was nominated national expert in hydraulics for the Italian Republic and presided over the Hydraulics Commission based in Modena. At this point Stratico's university career came to an end as he subsequently devoted his entire energies to the important public appointments he was given for the administration of waterways. In 1806, after a mission to Paris to present a new project for the canalization of the Reno, Napoleon rewarded him with the *Légion d'Honneur,* and nominated him General Inspector of Roads and Waters. He remained in this post until 1809 when he was pensioned off, nominated Senator and decorated with the Iron Crown. In spite of his advancing age, he continued with his scientific activity by systematically recording, in memoirs and works, the knowledge accumulated through lifelong studies and experience.
In 1813, he published a technical dictionary of naval terms in three languages; Italian, French and English which still holds an important place in the history of naval terminology. In 1819, he edited the Italian translation of the mechanical treatises, written by the Spaniard, Jorge Juan y Santacilla, applied to the construction and manoeuvring of vessels, and 1823, when he was in his nineties, he wrote a Naval Bibliography, rich in notes, on the works published in Europe between 1484 and 1822. In 1825, one year after his death, a famous edition of the Architecture of Vitruvius, already planned by Poleni, was published posthumously.
He was a member of many scientific Academies and Societies, both in Italy and abroad, among which the Italian Society of Sciences (founded by Lorgna) and the Royal Society of London. In 1803 he joined the National Institute, became President of the Academy of Fine Arts in Milan, and before he died he was President of the Lombardo-Veneto Institute.

It was the Napoleonic period that afforded Stratico the opportunity to intervene in the serious problems afflicting the entire Italian territory, particularly those linked to the Po River, the Adige and their tributaries (Borgato 2003; 2001).
It must be underlined that the main impediment was not due to negligence or lack of technical skills, since there existed schools in many states, like Piedmont, Mantua, Ferrara, and Verona, specifically designed for the formation of experts in river control, conservation of riverbanks, regulation of irrigation, and so forth, as well as specific institutions to carry out this work, and consortiums of landowners. The problem lay more in the divisions of territory in the various states whose vision, often limited by their regional concerns, prevented them from coming to agreements concerning the works to be carried out. At the end of the eighteenth

century many longstanding hydraulic problems affecting the territory across the Po and its tributaries had got worse as a result of conflicts of war: besides the disastrous flooding of the Po, an enormous extension of marshland had formed in the upper area of the Polesine, into which the water from the Adige flowed: the Great Veronese Valleys; the draining system of the lower Polesine was unchecked; the Reno, diverted into the Po so many times in one direction or the other the previous centuries depending on the power exerted by either Bologna or Ferrara, flowed into an artificial channel whose banks were subsiding. The area between the Secchia and Panaro tributaries were unable to drain their waters, and the Veneto hinterland of Padua and Vicenza was struck more and more frequently by devastating floods as a result of the network of rivers and channels artificially diverted to protect the Lagoon of Venice.

Napoleon, however, provided considerable expertise by bringing in engineers from the Ecole Polithecnique and the Corps des Ponts et Chaussées.

Stratico was involved in several important issues. Under the Republic of Venice he was engaged in resolving the main hydraulic problems of the Veneto hinterland: control of the system formed by the Brenta and Bacchiglione rivers, which constituted a constant conflict of interests between the towns of Venice and Padua. The policy adopted by the Serenissima had always been that of keeping the river mouths flowing into the Lagoon at a distance in order to protect it from silting up. Various interventions over the centuries had seen rivers like the Piave and the Sile being deviated northwards, the Brenta more and more southwards, as far as the Chioggia Lagoon. The Brenta, in particular, which together with the Bacchiglione and the network of interlinking canals, involving the province and city of Padua, had been distributed over a very long line, hence losing much of its gradient. Frequent and heavy flooding resulted, making it more and more difficult to drain the land into the rivers. Even now in the last few years, the province of Padua has been stricken by a disastrous flow due to the same problem, for which no definitive solution has been found.

The first plan to regulate the Brenta River was drawn up by Antonio Maria Lorgna in 1777, and proposed the joining of the two rivers, Brenta and Bacchiglione below Padua. The plan was examined by three Venetian mathematicians: Paolo Frisi, Simone Stratico and Leonardo Ximenes. While Stratico and Ximenes approved of the plan, Frisi strongly opposed it, so the plan was delayed until it could be examined by another commission, which looked into various projects in the Napoleonic period when the Veneto region became part of the Kingdom of Italy (1806) (Borgato 1998, Borgato-Fiocca 1994).

The political unification of the North of Italy, firstly under the Cisalpine Republic and then the Republic and Kingdom of Italy, provided the opportunity for important changes in regulating the territory.

Between May and July of 1787, the Cisalpine Republic, had extended its territory into the regions of Milan, Mantua, the ex-Dukedom of Modena, and the Papal state cities of Ferrara, Bologna and Ravenna. With the Treaty of Campoformio (17th October 1797) the eastern part of Veneto as far as west of the Adige also became part of the Republic, whereas Austria got all the Venetian territory to the east of the Adige, Istria and Dalmatia. The lower Polesine of Rovigo, initially part of the Austrian

Empire, would later be rejoined to the upper part to include the Po, Canalbianco and Tartaro basins after the peace of Lunéville (9th February, 1801).
Central government in Milan tried to take stock of the different autonomous districts, consortia and boards that managed the waterways of the Republic's territories in order to co-ordinate them and draw up plans of hydraulic intervention. The consequent need to create a body of highly qualified technicians was included in the education plans, prepared by Lorenzo Mascheroni and put into force in the July of 1798, which provided for the formation, at university level, of architects, engineers, and experts in hydraulics and land surveyors (Pepe 1994).
With the law of 12 'frimale' (2nd December, 1798) a commission of five experts in hydrostatics was later set up to: inspect the urgent hydraulic problems over the whole territory of the Republic, collect all the documentation on the plans of the various departments and present a future management plan of the waterways. The tasks of the Milan Commission were, therefore, not only of a technical nature, but also involved organisation and administration, since they were required to provide centralised financial management of hydraulic works: in other words, they had to carry out the preliminary drawing up of a national law for the administration of waterways. Stratico joined the Commission in 1801, when it was restored after the year of the Austrian occupation of Milan.
In the meantime, the Cisalpine Republic became the Republic of Italy (26th January 1802) with Bonaparte as its President and Melzi d'Eril as Vicepresident: new legislation proceeded to bring about order in the country, so on 31st October the Milan Commission was dissolved, and its duties were shared out among the local communities and regulated by the law passed on 24th July 1802, and a section of the Ministry of Home Affairs. At this time, (4th September, 1802) a law on state education was passed approving the university formation for architects, engineers, experts in hydraulics and in surveying.
The general law that governed the administration of the waterways of the Italian Republic was passed on 20th April 1804 providing for a Board of waterways in every Department, composed of 5 to 9 members and a consultant. Central government was represented by two national experts whose job was to inspect and supervise the works: Giovanni Antonio Tadini and Simone Stratico were nominated.
After the creation of the Kingdom of Italy in 1805, a governmental Department for Bridges, Riverbanks and Roads (headed by Giovanni Paradisi, 6th May, 1806), and an Engineering Corps of Waterways and Roads, similar to French Corps des Ponts et Caussées were set up. Initially there were 114 members, and then, when the departments of the Kingdom went up to twenty, the number increased to 214, six general inspectors who formed the general management council, 24 chief engineers, 48 I and II level engineers, and 36 aspiring engineers. The general inspectors nominated were Giovanni Antonio Tadini, Simone Stratico, Vincenzo Brunacci, Domenico Cocoli, Angelo Artico, and Gaetano Canova.
Plans were made to set up a school in Milan (similar to the Ecole des Ponts et Chaussées) for the formation of these engineers but it was never opened.
A short time later, on 20th May, 1806 five regulations were promulgated: for the building and preservation of roads; for the custody and maintenance of riverbanks;

for the navigation, custody and preservation of seaports; for the irrigation and use of waterways for works; for the societies involved in drainage and reclamation.
On 25th July 1806, following the annexation of the Veneto departments, the Central Board of Venice was set up for the protection of the Lagoon.

Given the complexity of the problems, which had to take into consideration the needs of navigation, irrigation, the protection of the population from flooding, and the reclamation of land for agriculture, the overall planning of works for the nation was entrusted to commissions of hydraulics made up of experts who pooled their technical and mathematical skills. Besides the aforementioned Milan Commission, the Republic and then the Kingdom of Italy nominated two other commissions. Since conflicting local and general interests were often on the agenda, heated and, at times, bitter disputes arose within them.
Stratico presided over the Modena Commission which was active between 1803 and 1806 and was composed of two national engineers: Leonardo Salimbeni (president, then substituted by Simone Stratico) and Luigi Assalini (secretary), and one expert for every department involved: Giambattista Guglielmini, for the Department of the Reno (Bologna), Teodoro Bonati for the Department of the Lower Po (Ferrara), Paolo Cassiani for the Department of the Panaro (Modena), Agostino Masetti for the Department of the Mincio (Mantova), Luigi Brandolini for the Department of the Rubicone (Ravenna).
The issues under debate may be divided into four separate matters: the reclamation of the Great Veronese Valleys and the management of the Tartaro-Canalbianco, reclamation of Burana and the barrel under the Panaro, diversion of the Reno into the Po and the works on the Apennine streams and channels to the right of the Reno, and works on the Goro port at the mouth of the Po.
Stratico therefore held top governmental positions in matters of hydraulics for both the Italian Republic (1804) and the Kingdom of Italy (1806). His writings on the matters of waterways as well as the important posts he held are to be found mainly in the Marciana Library in Venice, classified under different codes It. IV (Granuzzo 2010):
322-323 (=5330-5331) On the Adige. On the Adigetto (1758-1774, 1805)
324 (=5332) On the reclamation of the Veronese Valleys to the left of the Adige (1781, 1783, 1804,1811)
325 (=5333) On the management of the Brenta (1777-1789)
326 (=5334) On the Po, cadence, embankments. On the works and port of Goro, sections of the Po and the Po di Volano, on the Cento canal, on the Burana canal and its flowing into the Po
327 (=5335) On the flowing of the Reno into the Po of Lombardy, on the 'Drizzagno' (straightening) of Marmorta, on the silting up of the Reno and its tributaries, on the Apennine streams to the right of the Reno to be carried into the Primaro river (an old branch of the Po) or through a separate mouth to the sea (1804, 1805, 1806)
328 (=5336) Various studies among which: on the Pavia canal, on the repairs to the Bacchiglione, study on the town of Savona
329 (=5291-5292) Correspondence with various boards on questions of waterways

330 (=5293) Positions of importance, correspondence, Commissions on issues concerning hydraulics. Visit to the Departments of the Veneto 1806-1808. Plan for a school of waterways and roads to be set up in Milan, and a study prospectus.

Stratico was not part of the Padua Commission (1806) set up to solve the problems of the Veneto territories annexed to the Kingdom of Italy after the Peace of Pressburg (26th December, 1805), since he was engaged in Milan in the setting up of the school of waterways and roads designed for the formation of applicants to the Waterways and Roads Corp. Although Stratico had already compiled a study plan for the lessons, the school was never opened. Stratico, however, supported the opening of a school of hydrostatics in Ferrara, entrusting its direction to Teodoro Bonati. Some of Stratico's works are related to his university teaching, in particular on hydrodynamics and the relation between velocity and pressure in tubes or channels. One essay is dealing with the outflow velocity of water from openings (vents or lights) in the sides or bottom of a vessel ('foronomia'), a question which has applications also to river hydraulics. Other memoires of applied hydraulics, are related to his expertise in the regulation of rivers and waterways. In particular, they deal with mouths of rivers, diversions, embankments and different types of river dams.

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Simone Stratico and Naval Science in Padua and Venice

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One of the most interesting figures in terms of the vast fields of interest, and of cultural and intellectual involvement, still to investigate and analyze, is undoubtedly Simone Stratico, born in Zara in 1733 and deceased in Milan in 1824.[1]

In a difficult historical period for the Republic of Venice, when the Turks occupied Crete depriving it of one of the richest and most fertile regions, the noble family of Stratico was forced to abandon its possessions and leave the island to seek refuge on the mainland, in Bari, and then move to Dalmatia, where they settled permanently.

At the age of twelve, Stratico proved his brilliance by studying letters and also drawing, geometry, French and treatises on the art of war.

Five years later he enrolled at the Paleocapa College in Venice (reserved for Greek students), where he devoted himself to philosophy and medicine, showing the first proof of his value and expertise in such matters.

In December 1756 he obtained his first degree. He began his academic career in 1757 by lecturing in theoretical medicine at Padua University.

In those years, the University of Padua was a vital center of culture, thanks to the important names who were part of his faculty, particularly in science. One need only recall the names of Morgagni, Pontedera, Vallisneri, Giannella, Suzzi, Colombo, Rinaldi and, above all, the famous Giovanni Poleni.

Stratico couldn’t take advantage of this favourable climate to advance science, earning the reputation as a learned man, so much so that he was called "omniscio" by his contemporaries.

The lack of publication of many works of Stratico is due to his modest nature and somewhat distrustful attitude towards his personal value. This was a suspicion that even the passage of time and the acquisition of a vast culture couldn’t enable him to overcome, and so he ended up depriving the world of a large number of scientific publications.

The Academy of Copenhagen, for example, proposed a prize for the solution to a problem on the curve of the hull of the ship; Stratico prepared the solution of the problem written in Latin, but then he didn’t send it, not trusting the results. This was an example of extreme care and meticulousness by him.

Further evidence comes from the fact that almost all the manuscripts as we have them are repeated several times, and that the copies contain numerous variations or corrections. We can see for example the preface to the “Exam maritime” of George

[1] On Stratico see Cavallari Murat 1978, 453-463; 1982, 176-182; 256-278; Del Negro 1980, 77-114; 1984, 191-229; 1989, 97-128; Puppi 2006, 121-170; Granuzzo 2010; 2012, 143-159.

Ivan, copied in a different way more than ten times, or we can see the '"Index of Italian and foreign authors of works of marine," where Stratico states:
“This bibliography is taken from the bibliography Rodiny placed in the first *Volume of his German* in Vol 4, from *Naval papers of England*, the volumes of the *Journal des savants,* and some other newspaper. It is known that in these works of literature as in dictionaries we must start them in order, to refine them: neither can be published before.”
In the meantime, his interests were turning also to naval architecture, a subject that so much worried the Venetian government, which had a glorious nautical tradition but at the time was in the saddest decline.
Already in the 1707 the Venetian Senate was looking for a person skilled in Naval Architecture from the Republic of Venice or England, or who had studied there and had experience in the rules of ship construction.
Even two years later, in the 1709, the Senate emphasized this need because of a slow and gradual decline of naval art, due to the fact that the shipbuilders have practical knowledge but not theoretical.
Only in 1744 the Senate decreed the establishment of a chair of naval architecture at the University of Padua, that had been held for six years by the Count Rinaldo de Carli and that then hired Poleni, joining the teaching of mathematics.
The Venetian Senate, however, was of the opinion that young people, destined to become excellent naval officers, wouldn’t get sufficient nautical education in the University, but that it was necessary for the Arsenal to resume his glorious tradition of shipbuilding.
In 1752 it established that in the Arsenal a "chair of naval architecture for instruction of the people who have to direct factory ships" was instituted and at the same time gave the order to the Regiment Arsenal and Reformers of the University of Padua to seek "with all the effort or the country or between expert Nations a learned man, experienced and well educated in mathematics, and particularly in naval architecture to teach this science to the workers. "
Long and difficult were the earlier studies conducted by the ambassadors in The Hague and London to find a suitable person to fill such positions.
The Senate continued to show more and more concern about the deplorable state in which the Venetian warships were, of which only a dozen were in good condition, while the other lay abandoned in shipyards, so that in 1760 the Senate returned to urge the Reformers with the purpose of "finding suggests people who in ship Architecture (become a science in the foreign countries), were able to serve the makers, since the success of the vessels for a maritime power as the Republic, may depend on the system of its states."
But in the meantime the story cooperated to create new situations that would place greater emphasis on his responsibilities.
In fact, in 1761 George II King of England died, and he was succeeded by George III of Hanover. As usual, the Venetian Senate decided to send two extraordinary ambassadors to express their congratulations and "get to the fact of all the knowledge acquired from that country for the construction of ships, of progress, of its degrees in the navy, and the means used to achieve: to provide also an exact drawing of the ships of the first rank with the cutaway model and with specification

of the latest proportions. "
Then it was pointed to the ambassadors: "One learns the methods observed for the compliance of the factories to the laws and proportions established, and to the discipline of workers and shipbuilders."
As extraordinary ambassadors, Tommaso Querini and Francesco Morosini II, were chosen (he was the lover of Stratico's sister, and very close to the same Stratico, so much so as to enable him to join the embassy as an expert in naval architecture, boating as well as the English language, while maintaining his salary as professor at Padua University.)
Reasons of ceremony persuaded them to postpone the solemn entry and the hearing until April 18, 1763. The procession was magnificent, so that it deserves to be published.[2]
After signing the last dispatch common, the ambassadors made the journey of return on June 17, and on August 7 they returned to Venice. The report was concluded on September 10, and it was read in the Senate on December 15. The Querini-Morosini relationship of September 10, 1763 was strongly influenced by the acuity of the surveys conducted by Stratico in the marine and shipbuilding field, as stated by recent scholars.
England at that time was at the height of its naval power, with large and fully stocked yards in businesses that allowed them to have on the sea more than 400 warship and nautical colleges opened in London, Portsmouth and Woolwich.
Stratico lost no time: he visited the sites, went to the colleges, he mixed with members of the Royal Society, collecting as much as he could news that could be useful for the Republic of Venice.
Among his manuscripts we have found the draft of a letter dated September 5, 1762 addressed to Morosini and another undated, both focused on topics of naval architecture.
The two ambassadors used these letters in their dispatch sent to the Doge in November 22, 1762.
Stratico then returned to Padua in 1764, bringing with him a rich and useful cultural knowledge, and his efforts for the progressive establishment of schools of naval architecture were fundamental.
In fact in 1775, thanks to Stratico's suggestion, a school of naval architecture was introduced in the Arsenal of Venice, which allowed the training and recruitment of young and competent officers, and a better quality in the construction of ships, which had to regain Arsenal part of the ancient greatness.
As we can see from Stratico manuscripts stored at the Biblioteca Marciana of Venice, on his return he pointed out immediately the need to open a School of Naval Architecture, which was the object of admiration and an example for Foreign Nations.
Young people educated in this school would comply with the experience of the Venetian Masters and Ancient Traditions, respect them and guide them; recognize incompetence when it occurred; familiarizing manufacturers with the notions of

[2] Firpo 1965; 1977, XXX, 117-157.

science, demonstrating that the language of art and science is only one. So they would be expert in complicated calculations and reasoning, mechanisms and movements with balance, weight distribution and forces driving and pressing, laws and connection strength.
For this Stratico prepared a detailed curriculum for young people who wanted to follow his lessons, as well as the topics of the exams, it included research and insights that young people should carry out.
For example, studying his manuscripts, we see that the issues that most interested him were:
1. The properties of a merchant ship and a warship
2. Length of vessels and methods for deleting
3. Principles for reasoning regarding funding cuts
4. know the immersion of the vessel and its scope
5. find the center of gravity of the vessel
6. Methods to measure the strength of the hull
7. Methods for measuring the specific gravity of sea water
8. Methods for defining the boundary of the hull
9. Method of determining the “metacentro” and the maximum height for center of gravity of the vessel.

In a general plan of study designed just for the School of Naval Architecture Stratico emphasizes exactly the materials with which young people need to be educated. The first two years were to be dedicated to the study of Arithmetic and Geometry, Trigonometry in the third year, the fourth to the dynamics of fluids and solids, and the fifth to the study of marine science.
Stratico stressed that an ordered course was missing which passed from pure mathematics, and switched to dynamics and hydrodynamics with method, and where it was possibly to study the "theory of the construction of ships, the formation of anchors, the strength of the wood, their connection, and the machinery related to ships."
Stratico compares this situation to what happens in the military academies where they set up courses in abstract mathematics, because young people more and more come prepared.
For Stratico it was necessary that young people knew well (they are his own words) the shapes, positions, the union of the various parts of the ships, the ways to prevent harmful movements, the appropriate maneuvers to have the devices for which you have show through experiments, theoremic experiences above hydrostatic, hydraulic and mechanical subjects. As far as the instruments of control our concerned, Stratico suggests having them built by craftsmen in France or England, with regard to the ship models he suggests having them built in Livorno.
The focus of Stratico also addressed the widespread books of that period, that were either too far away from practice and therefore too out of the reach of the shipbuilders, or too full of practice, and without any notion of the general theory. Also the two famous treatises of Bouger and of Eulero, are incomplete in some parts. In fact we must add to these, the chapters covering each part of the ship, notions on wood, on strings, on the construction of anchors and on different machines invented for use of ships. The english treatise of Surtherland and Hurray are also too short,

adopted in the Deptford Arsenal School in England. Stratico did not consider it appropriate to make even a nod to the works of Hosto, Witsen, the author of *L'Art de les batir Vaisseux*, to Bernulli, to Pittot, Saverien and Vilehouette, useful but not enough to be the official books of a nautical School.
And here Stratico announces his upcoming effort, his *Naval Dictionary*, designed to make up for all these shortcomings, and to get in Italian an orderly compilation of these principles, modeled on what was being published in Europe.
Stratico, in addition to the practice and to the scientific questions, is very careful about the discipline that must be taken in this school, which is necessary to the good scholars and for the proper functioning of the school.
First, students will be chosen from families in service at the Arsenal: the children's age should not be too young, and they must be able to read and write well. Lessons must be daily and private lessons according to opinion of the professor. At the end of each year an examination must be made, and at the end of the third and fifth year an examination by a visiting professor shall be established, not from the usual master, who could help his students psychologically and morally.
For each test a prize for the most skilled student could be established, and at the end of the five years the boys could do two years of work experience in those departments that were more suitable for the young people themselves. Then the young could be used for those offices inside or outside the Arsenale, where the acquired knowledge would be useful, and where they could receive a salary.
But Stratico professor career was destined to be long and glorious.
In 1761 his teacher Giovanni Poleni dead, and for three years the mathematics and nautical chair remained vacant since it was impossible to find a worthy successor. Leaving the chair of medical institutions in 1761, in 1764 Stratico was called to teach mathematics and sailing theory, which at the time included within itself the teaching of hydrometry. Also in 1764 he was elected Fellow of the Royal Society.
On December 5 1764 he inaugurated his teaching with a lesson titled *Cum mathesim to theoriam Nauticam tradere aggrederetur* in which he demonstrated the usefulness of mathematics and the need for it to be studied especially by those who are devoted to the mechanical arts.
From this moment Stratico acquired greater awareness of its value and of its credit, and he managed to put aside a bit of that reluctance that distinguished him:
The years 1772-1773 proved fruitful for his publications: in 1772 he published a book written entirely in Latin, containing 227 propositions concerning mechanical and static, with interesting applications of civil and naval architecture.
In 1775 he was also appointed by the Venetian Senate as head of the Naval School of Venice, which he presided over and of which he regulated the examination sessions. During this assignment, he translated and published the work of Eulero entitled *Teoria compita della costruzione e del maneggio dei bastiment*, making many notes and commenting on it with a rich critical apparatus.
As evidence of competence and esteem enjoyed by Stratico, especially in such matters, it is interesting to note that in the transition to Padua by Pope Pius VI (returned from Vienna for talks with the Austrian Emperor Joseph II) it was Stratico to receive and entertain him for over an hour, showing him the cabinet of experimental physics in all his members. As soon as the brief occupation of Padua by

the French Republican army, Stratico was called to Milan as an added member to the Commission and professor of marine hydraulic at the University of Pavia.
In the years 1802-1803 he held the chair of physics at the place of Alessandro Volta, also at the University of Pavia among his manuscripts there are in fact lessons on magnetism, that he just held in Pavia in these years.
One of the most important writings of Stratico is about naval science in its historical, mechanical, mathematical, and hydrodynamic aspects.
Stratico as a young man was convinced that Italy would continue the great tradition that has always prided itself and that has always distinguished itself in the course of its history, rediscovering the ancient glory that science had provided an update with the latest skills. Driven by this knowledge, he thought a dictionary might be of great use that includes the different terms in Italian, French and English, so as to create a common ground of comparison without altering the language peculiar to each country. In this way he gave life to a real technological dictionary, following the example of what already existed in England, France and Germany for the Italian language, called *Vocabolario di Marina nelle tre lingue italiana, francese ed inglese*, published in Milan in 1813 , that is, when he had reached the remarkable age of eighty.
In fact, this dictionary is the result of a long and complex work of many years, when he again occupied the chair of boating at the University of Padua and in Venice he presided over the examinations of naval architecture.
These years, more precisely in 1812, Stratico read at the Lombardo Institute two dissertations of naval topic, showing once again vast erudition. In the first, *Dei bastimenti a remi da guerra degli antichi Greci e Romani,* he speaks of ships with several rows of oars used by the ancient Greeks and Romans and of the Venetian galleys. Also he shows that the arrangement of the oars in a limited number of orders proves very suitable to obtain a great speed, and that the ships to many orders of oars were used exclusively for reasons of performance, proving to be slow and difficult to maneuver. In the second essay, *Sul fluctus decumanus o decimus dei poeti latini, e sulla trichimia o terza ondata degli scrittori greci*, Stratico shows that for "fluctus decumanus" means the stronger wave back after a number of smaller waves. It is in fact known as the tenth decumanus after the Latin word meaning "main".
Another important element of Stratico was a major effort to the development of a Treaty of applied mechanics in the construction and operation of ships and other vessels (*Trattato di meccanica applicata alla costruzione ed alla manovra di vascelli ed altri bastimenti*), published for the first time since George Ivan, republished by Stratico in Milan in 1819 with additions and revisions own.
All the works that fall within a large and complex program of study and appreciation of the Italian navy and, in particular, the long and glorious maritime tradition which could boast of our country.
Not content with this, on his ninetieth birthday Stratico published the Bibliography of marine *(Bibliografia di marina)* lying in the principal languages of Europe proving once again (he was now considered the "Nestor Italy's literature") to possess great acumen and historical, philological, as well as technique competence. This bibliography begins in 1484 and ends in 1822. The books of Italian, French and Latin

have been given the original titles, the other is added to the Italian version of the title. But the author not only provides a simple collection of titles of texts dealing with marine science, but also provides the most adequate, however brief, critical comment. We can consider this work as the last scientific-cultural testament of Stratico.

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Ottaviano Fabrizio Mossotti from Corfu to Pisa

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Ottaviano Fabrizio Mossotti (Novara 1791 – Pisa 1863) was one of the most famous Italian physicist, astronomer and mathematician of the 19th century.
He is well known for his scientific works, but also for his contribution to the unification of Italy as Major of the Tuscan University Battalion in 1848, Senator of the Grand Duchy of Tuscany and the Kingdom of Italy[1].
He lived and worked for some years in the Ionian Academy in Corfu; very few was known about the period of Mossotti in Corfu and his coming back in Italy. Some new documents about this period are presented in this paper, with particular attention to his role in the reform of the University that took place in that period, bringing Pisa to a leading role in Italian mathematical research after the unification. He was also a leading figure of this mathematical school with his student and colleague Enrico Betti.

After graduating at Pavia University in 1811 under the supervision of the mathematician Vincenzo Brunacci, he worked in the Brera Observatory in Milan. Here he published in 1813 his first *Note* to explain some phenomena observed by Brunacci, and established a new method to study orbits of comets, cited by C. F. Gauss.
Inquired by the Austrian police for his politically liberal attitude, he was forced to leave the country, going first to London in 1823. In 1827 he received an invitation of the University of Buenos Aires to teach astronomy and physics; he held the chair of *Experimental Physics*, and was appointed Director of the practical school of topography, making an important contribution to the development of scientific structures.
In 1835 he tried to come back to Italy, to guide the Observatory of Bologna, but his nomination was impeded by the Austrian authorities. He lived in Rome, and after in Turin, near to the astronomer Giovanni Plana. In 1836 he published one of his major scientific contributions, *Sur les forces qui régissent la constitution intérieur des corps, aperçu pour servir à la détermination de la cause et des lois de l'action moléculaire*, with a dedication to Plana; this paper was translated in German and English, and presented by Faraday to the Royal Society.
In the same year he prepared an applications request for the Ionian Academy in Corfu[2]. It was the first Greek academic institution established in modern times, inaugurated in 1824, during the British Protectorate, under the supervision of Lord Guilford, the *Lord of Education* of the Ionian State. It should have been formed by four Schools, Theology, Law, Medicine and Philosophy, not always running in the

[1] Pepe 2002.
[2] Phili 1996.

forty years of its life. The Ionian Academy was ultimately closed down with the unification of the Ionian State with the Greek State in 1864.
Corfu became an important scientific centre, where exiled scientist could live and work, with students coming from different countries. On the other side, there was a significant presence of Ionian students in Pisa: among the 840 Greek students in Pisa in the period 1806-1861, they were 2,89% in 1806-1810, and 16,57% in the years 1855-1859.
He began teaching mathematics in 1837, with another Italian physicist persecuted by the Austrians, Francesco Orioli (1783-1856) as professor of physics.
An important role in his nomination was played by Vittorio Fossombroni (1754-1844), Prime Minister of the Grand Duchy of Tuscany and mathematician himself, who supported his application in some letters to Lord Abercrombie, British Minister in Florence.
In Corfu the majority of teachers of different faculties were Italian and the courses were taught in Italian since 1833. While in Corfu he wrote some other interesting papers, including *Sulla costituzione del sistema stellare di cui fa parte il Sole* (On the Constitution of the Sidereal System, of which the Sun forms a part) in 1839, a lecture inaugurating the course of the academic year, translated and published in Great Britain and in Germany.
His lessons of mathematical physics were collected and published in Florence some years later. In the introduction he explained that, following Orioli's suggestions, the government divided the course in two parts, one experimental and one theoretical (he was charged of the last one), so to leave the teachers add all the new advancements in the subject.
He maintained relationships with the Italian scientific community, also through regular journey in Italy, and he was the University representative at the second "Congress of Italian scientists", held in Turin in 1840 after the first one in Pisa the year before.
In the State Archives of Siena[3] there are some manuscripts, probably addressed to the Senate (after Guilford's death the University administration was assigned to a three-member committee, but the Senate had an important role), where Mossotti reconstructs some of the facts that carried him to the research of a new position in Italy.
In the text he underlines the zeal he put in his work to prepare the students, with the charge of more courses than his proper ones. But he complains about the uncertainty of his condition, starting from the language, he is aware that everything could change suddenly, since there is no stable authority and the public establishments are subject to modifications in their organization. He adds that the "smallness" of his earnings can only be compensated by the certainty of their continuation, but the lack of these certainties, and the idea that no law even provides for his subsistence in old age could excite in him a "sense of apprehension." So, in June of 1838, before his departure for a travel towards Italy, he asked again for a document, assuring him about his position, and after receiving a negative response he was even advised to look for a position in his country. Also Orioli received the

[3] Filza 8bis Particolari, Carte Mossotti.

same suggestions. As a result of these words, he asked his friends to help him in the researches of a new job. In the same period the reform of the university of Pisa took place and he was offered a chair in it.

> … il zelo che ho posto nel formare degli allievi nelle scienze il cui insegnamento mi fu affidato, l'incarico assunto spontaneamente di corsi pei quali non era stato chiamato, spero che saranno un testimonio della mia attiva volontà che mi spingeva a cooperare. In mezzo però a tante favorevoli circostanze che animavano il mio agire, non potei a meno, gettando lo sguardo attorno di me, di scoprirne una contraria, capace pur se sola di costernarmi. In questo paese nessuna autorità è stabile; gli impieghi civili al par dei politici sono avvolti dalla Costituzione nella medesima sfera di volubilità, gli stabilimenti pubblici sono soggetti nella loro organizzazione a delle modificazioni notabili col cambio delle persone che reggono a seconda delle loro viste particolari, altre difficoltà non mancano, l'uso della lingua nazionale può essere esclusivamente richiesto. Nella carriera che io seguo dove la modicità degli onorarii può solo essere compensata dalla certezza della loro continuazione, la mancanza di queste certezze, l'idea che nessuna legge ancor provvede per la nostra sussistenza nell'età più avanzata dovevano eccitare in uno come me, sprovvisto d'altri mezzi, un senso di giusta apprensione.
>
> Fu in vista di queste considerazioni che nel giugno del 1838 pochi giorni prima di partire per l'Italia, feci presente a V.E che tanto io che i miei colleghi, ch'erano stati chiamati dall'estero a queste isole, eravamo privi di alcun documento che ci facesse conoscere con quali condizioni il Governo ci teneva in questi posti; che ignorava se doversi considerare come inamovibili, che se ciò fosse non avrei più pensato a un altro posto, ma che in caso contrario il bisogno di una sicura sussistenza m'avrebbe obbligato a cercarmi altrove una collocazione stabile. V.E. diede da prima in particolare un accoglimento lusinghiero alla mia proposizione, ma il giorno della mia partenza avendola io richiesta su di ciò l'opinione del governo, mi replicò che l'ordine delle cose qui non permetteva che mi si assicurasse l'impiego come permanente, e che se mai me ne si presentasse uno che lo fosse, e convenevole ben potrei approfittarne.
>
> Che tale fosse l'opinione del governo me lo confermarono anche le dichiarazioni che il mio Collega il prof. Orioli ebbe circa a quell'epoca dal Presidente del Senato.
>
> Dopo questi precedenti era ben naturale che supponessi che non erano più nelle mani del Governo altri mezzi per assecondare i miei desideri. Passato quindi in Italia feci sapere a miei amici che mi avrebbero fatto cosa grata qualora sortisse l'occasione di procurarmi un collocamento stabile. Conseguenza di ciò fu che nel principio del corrente anno ricevetti una lettera del Provveditore dell'Università di Pisa nella quale m'interpellava qual cattedra avrei desiderato in quella università, e quali erano i miei termini …
>
> Dopo verso la fine di settembre mi fu noto che S.A.I.R. il suo sovrano era disposto a favorirmi con una generosità oltre la mia aspirazione. Infatti all'arrivo dell'ultima corriera d'Otranto (?) mi fu trasmesso da quel signor console di

Toscana il sig. cav. Marge… una lettera contenente l'avviso ufficiale del Motu proprio che S.A.I e R. il Granduca aveva dato a mio favore.
Ecco i fatti. Io dissi dunque al governo ionio la profferenza nell'offerta dei miei servigi, la mia offerta non avendo potuto essere accettata, mi rivolsi ad alcuni amici ed ebbi la proposizione del Granduca di Toscana. Doveva io valermi della proposizione che candidamente mi faceva un Governo per compulsarne un altro. Questo sì che lo avrei considerato disdicevole alla lealtà e alla delicatezza, … che lo accettasi direttamente e l'accettai.
Nell'ammettere però questo nuovo impiego non obbliai i riguardi che devo al Governo Jonio. Non l'accettai che colla condizione che rimarrei in questa Università durante il presente anno scolastico, onde questo Stabilimento non ristesse imperfetto, e s'avesse il tempo di provvedere al posto vacante.
Spero che questa breve apposizione varrà a convincere V.E. della rettitudine dei miei passi, del resto non posso interpretare le espressioni del dispiacere che V.E. mi dimostrò alla notizia del mio distacco che come un movimento della benevolenza che ella ha per me e della quale mi sarà comunque grato il conservare una viva riconoscenza.

In the cited documents held in Siena there is a group of letters[4] written by Gaetano Giorgini to Mossotti in the years 1840-42, strictly related to Mossotti's reconstruction. Giorgini (1795-1874) studied mathematics and mechanics in Paris, and wrote some interesting papers in this field, but he also undertook an administrative career; then he became "Professor Emeritus" in the University of Pisa, of which was appointed Superintendent in 1838. Finally, in 1840 he became Superintendent of Education in the whole Grand Duchy.
In this role he was engaged in the cited important reform of the University of Pisa. It was divided in five Faculties, with new chairs. New teachings of applied mathematics, higher analysis and geometry were established in the Faculty of Sciences to replace the old "Collegio degli artisti" ("College of the artists") where physics and mathematics were taught following the medieval pattern; the Faculty of *Mathematical Sciences* (5 years) was composed of the following courses: Geometry and Trigonometry, Algebra, Analytical Geometry and Geodesy, Descriptive Geometry and Civil and Hydraulical Architecture, Technological Physics and Experimental Mechanics, Differential and Integral Calculus, Mathematics applied to Mechanics and Hydraulics, Mathematical Physics and Celestial Mechanics.
The need of high level new teachers allowed Mossotti to fulfil his desire to come back to his country.
Giorgini addressed to Mossotti a first letter to explain the situation:

"… le cattedre le quali potrebbero divenire prima disponibili sarebbero forse quelle di Fisica tecnologica o Meccanica sperimentale che si avrebbe in animo d'istituire e sarebbe nuova in Italia, di Calcolo Differenziale ed Integrale il di cui titolare è da qualche tempo impedito per motivi di salute, e

[4] Nagliati 2012

di Meccanica celeste ed astronomia, cui peraltro manca in Pisa un osservatorio." (01.06.1840)
(… the chairs which might become available would be perhaps of Technological physics or Experimental mechanics that we have in mind to set up and that would be new in Italy, Differential and Integral Calculus of which the teacher is prevented for some time due to health reasons, and Celestial mechanics and astronomy, which, however, lacks an observatory in Pisa.)

Also Fossombroni was involved, in two ways: Giorgini suggested Mossotti to send through him an official request, and at the same time Orioli wrote him to support Mossotti's request to obtain two of the possible chairs (to increase his salary near to the one he had in Corfu).
Mossotti was named for *Mathematical physics and celestial mechanics* (*Motuproprio* 10.21.1840), and Giorgini wrote to Mossotti to describe the contents of the course he was proposed for:

"*Il Gerbi non insegnava la Fisica Matematica ma una Fisica elementare che non differiva dalla sperimentale se non in quanto mancava delle attenzioni riservate dal regolamento a un altro professore, che avrebbe dovuto tenere l'ordine stesso seguito dal primo e limitarsi a mostrare gli esperimenti. Per togliere questo vizioso e forse impraticabile spartimento d'incombenze, è probabile che le due cattedre saranno ridotte ad una, e che per dare agli Studj un avviamento più vicino alla pratica, verrà aggiunta una cattedra di Fisica tecnologica, o Meccanica sperimentale che abbracci sotto un punto di vista teorico e pratico lo studio dei materiali, delle forze, dei motori e delle macchine. Per le più elevate applicazioni del Calcolo rimarranno le cattedre di Matematiche applicate adesso coperta dal maggior figlio dell'Amici, e quella di Fisica celeste. Sarà poi anche probabilmente da conferirsi la cattedra di Analisi infinitesimale. Ma già mi sembra averle indicato altra volta queste probabilità."*
(Gerbi [former professor] taught an elementary Physics not very different from the one of the other course, so probably the two would put together, and a higher one would be created, to study materials, forces, machines)

Following Mossotti desire to fulfil his duties, Giorgini assured to Mossotti:

"*Dalla comunicazione ufficiale che godo poterle fare in questo stesso giorno ed in replica alle sue da Corfù del 30 caduto, ella vedrà che S. A. ha voluto trattarla in modo corrispondente ai suoi meriti ed alla propria munificenza. Me ne congratulo tanto più, che ciò l'impegnerà a sollecitare la sua venuta tra noi, tosto che i suoi impegni glielo permettano*." (01.21.1841)
("From the official announcement … and in reply to your letter of 30th December from Corfu, you will see that H.R.H. wanted to treat you in a manner corresponding to your merits and his own munificence. I

congratulate, and I hope that this will urge your coming among us, as soon as your commitments allow")

And on January, 25th, 1841 Giorgini wrote to Mossotti that the Grand Duke allows him to stay in Corfu as long as he needs to complete his work ("abbisogna per terminare le sue obbligazioni al Governo Jonio") but with the whole salary and exemption from customs duties in the transport of books and effects.
In his letters Giorgini, who regrets not being able to find a similar position for Orioli, also invited Mossotti to send his research for a new scientific journal, *Giornale toscano di scienze mediche, fisiche e naturali*, published in Pisa from 1840 to 1843, edited by a group of teachers (between them Giorgini and Giovan Battista Amici, for Mathematics and Physics). Mossotti published in it an article on reflection and refraction of light, and the text presented at the third meeting of Italian scientists in Florence in 1841, on a problem of Optics, (course held in his last year in Corfu)
At the end of his period in Corfu, in March 1841, he married Anna Sutter, who followed him in Italy but died two years later with her baby, during childbirth.
Once in Tuscany, Mossotti was engaged in different ways: his scientific interest went on concerning Hydraulics, Mechanics, Optics, Astronomy; he was Professor of *Mathematical physics and celestial mechanics* from 1845, and from 1849 also substitute for *Mechanics and hydraulics* and he wrote other textbooks, for example *New theory of optics instruments* in 1857.
He contributed to scientific journals and was involved as editor in *Il Cimento*, from 1843, and the *Annali delle università toscane* from 1846.
He had also a relevant engagement in political life: he took part to the battle of Curtatone e Montanara in 1848 as Major of the Tuscan University Battalion, and participate to the construction of a scientific community in unified Italy, through his proposal for organization of studies, above all for the training of engineers and the teaching of Mathematics in universities.
His political engagement led him also to be appointed member of the Senate, first in Tuscany (1848-49, appointment by Grand Duke) than in the unified Italy.
He died in Pisa in 1863 and is buried in the Monumental cemetery.

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Meteorology and Climatology in 19th century Greece

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In the eve of this promising spring day, Nick the Breeder, opened his eyes thanking God that he could see for one more day the sun, but…suddenly he realized that he woke up because of the bray of his donkey.
“Oh God” he thought “we’ll have another spring thunderstorm soon after midday” and he walked out to protect his flock.
Passing from the coffee shop for his morning Greek coffee he looked at the weather forecast which had recently started to be regularly appearing in the daily newspaper. A bright sunny day was announced by the Director of the Athens Observatory.
“Do not believe all this nonsense,” he said smiling. “I bet my best sheep that by noon it will be raining cats and dogs”.
This short story, in its few lines, encapsulates the views of ordinary people on the science of meteorology, not only during the early period she took her first steps, but in some extends even today.
As Greece was until recently an agricultural country people needed a good knowledge of the weather for their everyday life activities. Imagine a fisherman on one of the Aegean islets having a boat as small as a nutshell without knowing the prevailing weather in the open sea, or a grain grower in the plain of Thessaly who feared that the ice during the night could destroy completely the crops.
Since the antiquity the knowledge of the weather was based on traditional observations and signs transmitted orally from generation to generation.
As the local climate conditions had remained stable and unaffected by the human activities for centuries, people felt quite confident with this kind of knowledge.
They trusted what they could see around them, what they could understand with their own senses, in a direct dialogue with Mother Nature.
In addition they had a strong respect to nature; they did not even think to act against it, as they knew that the consequences could be disastrous or even fatal.
Furthermore, the Church, as a very powerful component of the social life during this period had also a word to say on this matter.
The Greek Orthodox Church and especially the low rank priests in the villages, where pagan superstitions had been subtly incorporated in the official religious dogmas, illiterate and ignorant themselves, argued that the weather forecasting was probably a sin, as according to the Scriptures only God knows the future.
But after the establishment of the new independent Greek state in 1830 and especially after the move of the capital to Athens in 1834 we could claim that a movement of internal migration from the villages to the cities formed the first stage of what we call now urbanization, the first factories were built and new institutions like the Athens University and the Athens Observatory were founded.

In the urban environment of Athens people could find with increasing difficulty the signs they used to see around them in the countryside but still they were governed by the esoteric need for the knowledge of the weather.
In fact, since the period of the so-called "Modern Greek Enlightenment" Greek scholars had tried to introduce meteorological knowledge in the curricula of their lessons.
For example, in his *Florilegium of Physics*, Vienna, 1790, a book based heavily on the *Encyclopedie* of Diderot and D' Alambert, Rigas Velestinlis, a welknown Greek intellectual discusses several meteorological phenomena. In the chapter "About rain" he discusses the causes of the rain and how one can predict a rainy weather using the barometer. He discusses also the use of anemometer in the chapter "About the winds".
Meteorological observations for educational purposes performed during that period and a number of relevant instruments from those days are still preserved in the Library of Milies, a small village in the area of Thessaly, but great educational center for the Greeks during that period, among them a rain-meter.
A number of popular beliefs concerning the weather and thunder prediction were also presented in manuscripts circulated among the people called "βροντολόγια" (Books concerning the thunders) and "σεληνοδρόμια" (Books concerning the Moon). Some sporadic articles on the subject were also presented in the most readable Greek "scientific" journal of the period, *Hermes the Scholar* (1811-1821). [1]
The connection between climate, weather and everyday life is reflected also in the publication of two books which had a relation with climatology and meteorology.
In 1840 Emmanouil Psychas, a civil engineer and physicist who had studied in Paris published the first significant textbook of Physics in the Independent State. There was an important chapter on meteorology. In 1841, a physician, and for a short period Professor at the University of Athens, Konstantinos Mavrogiannis had published the book *Remarks on the climate of Athens and its influence on the animals.*
He was the first in Greece who discussed from the scientific point of view the connection between the weather and the climate with the health of the humans and he presented some ideas on the way certain climatic conditions could affect human organism.
The interest of the society for the prevailing meteorological conditions was therefore among others one reason for the establishment of the Athens Observatory relatively early compared with other research institutions which appeared much later, most of them after the turn of the 20th century.
Very briefly we note that it was designed by the famous Danish architect Theophilus Hansen and built on the Hill of Nymphs facing Acropolis with a generous donation of

[1] For a critical presentation of the "scientific" articles in *Hermes the Scholar* see The enlightenment in sciences. The Scholarly Hermes and its contribution to the popularization and the development of science in Greece in early 19th century, *History of science,* xxxxvii (1999), pp. 319-345.

500.000 Drachmas by the Ambassador in Vienna and wealthy member of the Greek diaspora Baron George Sinas.
The first director of the Observatory (1846-1855) was George Vouris (1802-1860), professor of Physics at the University of Athens who installed the first set of meteorological instruments. With these instruments Vouris performed systematic meteorological observations in Athens, published in 1843 under the title *Meteorological Observations performed in Athens from November 1st 1835 until June 30th 1842*.
Some years later his successor, Julius Schmidt (1825-1884) extended significantly the network of the meteorological stations and tried to cover as better as possible the Greek territory which was limited by the borders with Turkey, north of Thessaly.
In Dimitrios Eginitis words, the most important meteorologist in Greece until World War II, "Schmidt's meteorological observations from December 1858 until 1884 contributed extensively to the awareness of the climatic conditions of our country. Similarly the observations on various meteorological phenomena, such as storms, hurricanes, etc. performed by him are characterized by their fineness, their descriptive accuracy, the richness of their details and their perfection in general."
While these were happening in Athens, in the Ionian Islands, still under English political administration, a distinctive tradition for the study of weather and climate has been gradually formed.
Since the beginning of the century we have rather complete series of rainfall and air temperature measurements in Corfu.
The general characteristics of the prevailing weather were presented for some years in booklets like Emmanouel Theotokis's (1777-1837, an influential member of the local aristochracy, *Observations meteorologiques faites a Corfou par E.T. corcyree*. (Description de l'annees precedentes publiees dans les cayers de l 'ouvrage periodique imprime a Corfou sous le titre de Mercure litteraire de Filergus Pheacien).
Relevant information was also published in the official newspaper of Corfu. Relevant measurements were taken also on the isle of Zakynthos from 1825 to 1861 by Dionysios Varvianis (1788-1866) who was a teacher of physics and mathematics. These data remained unpublished and in manuscript form. Varvianis published also a booklet on the statistical analysis of the Greek earthquakes. Keeping our interest in the western part of Greece we have found that in Patras an English pastor, Reverend Herbert A. Boys (1844-1926), who was settled there during the 1870s' as chaplain of the English Church of St. Andrews, which took its final form in 1878, started to collect meteorological data.
His observations were published in a series of papers published in the *Quarterly Journal of the Meteorological Society* communicated by G.J. Symons (1856-1900), Fellow of the Royal Meteorological Society and a pioneering figure for the study of rainfall in England.
In the first of these papers titled "The climate of Patras", he gives a short description of the condition of meteorological observations in Greece according to his knowledge.

We quote:

> "There is, I think, no country in Europe combining so many varieties of climate in so small a space, and so provided with observers and means of observations, as Greece, the country of which I write. I believe that at the present time Athens is the only place in Greece where a meteorological register is regularly kept. What was done by the English in the Ionian Islands during the occupation I cannot ascertain ; and though there may be amateur observers like myself at work in other parts of the country, yet my impression is that, beyond those at Athens, very little is to be learnt from observations in other parts of Greece. And Athens is by no means a representative station for the country, being distinguished by a very exceptional climate, much more bracing and dry, much colder in minter and hotter in summer, than any other place at the same elevation in the whole kingdom.
> Patras, the place in which I have been making observations for the last two years, is in many respects a complete contrast to Athens. I have had much difficulty in procuring proper positions for my instruments, which are not very numerous nor of the first quality."[2]

In the second paper Boys described the setup of his meteorological station and gives the information that he had put a rain-gauge " in charge of Mr. James Saunders at Argostoli in Cephalonia".
James Saunders was an astute business man and became very wealthy exporter of currants from Greece to England and the Netherlands. He was the British and Dutch Consul in Argostoli, and was knighted by the Queen of the Netherlands: Ridder in de Orde van Oranje Nassau. He also made a fabulous fortune and became a philanthropist; he gave generously to the Greek community in Cephalonia.
The results of the rainfall measurements in Argostoli were shown in the third and last paper of the series.
As for English people Mediterranean coast was considered somehow the Garden of Edem, it is interesting to cite that discussing the paper a Dr. Tripe mentioned that " If a patient sent to Patras had been there during the severe winter mentioned in the paper, he would have suffered more than if had stayed at home, owing to the sudden changes of temperature, and to the extreme dryness of the atmosphere, which would almost certainly have aggravated his disease. And Mr. Symons added that "he would advise invalids going to the Mediterranean to be very careful, as the climate is very treacherous. He thought a voyage to the drier parts of Australia much better. The humidity at Patras appeared to be very small, but, as the paper showed, there was liability to biting winds".
It is interesting that on one hand Rev. Boys kept his activities on the meteorological observations within the English community of Patras and on the other hand that even today his papers were unknown to the Greek community of meteorologists and

[2] Herbert A. Boys, Results of Meteorological Observations made at Patras, Greece, during 1874 and 1875, *Quarterly of the Meteorological Society,* vol.III, no.23, 373-383.

climatologists. This could be an indication that foreign communities, especially those formed by citizens of the so-called European centre, did not trust the local inhabitants and in a great extent they remained isolated.
Back to the capital the interest of the society for meteorology, at least of the so-called upper class, is reflected on the invitation of Peter Beron from Bulgaria to give a series of lectures on the subject in the winter of 1850.
Beron was invited by the prestigious Physiographical Society of Athens (Natural history Society). This invitation was probably the result of the fact that just three years earlier the astronomer John Lee (1783-1866), one of the founding fathers of the Royal Meteorological Society (est. 1850) presented Beron's work in the Royal Society of London. The Physiographical Society was established in 1837 and founding members were some of the most important scientists of this period in Greece like the German professors of the University of Athens, Karl Nicolaus Fraas and Xavier Landerer.
During the period Beron was invited, the society was at its peak and played a significant cultural role amongst the emerging middle class in Greece.
The lecture delivered by Beron was entitled "Earth before the Deluge".
Beron impressed his audience so much that his lecture was published almost immediately as a small pamphlet and later it was included as annex in his book of *General Climatology.* The other two books published by Beron were *Atmospherology* and *Magnetology* . All these three books were written probably directly by Beron in Greek, as he had a very good knowledge of the language.
Meanwhile Dimitrios Aiginitis as Director of the Observatory, was trying to sell his products.
Aiginitis was not someone upstart. He had come to Greece from Paris after a special invitation of the Prime Minister and reformer of the Greek State Charilaos Trikoupis to become Director of the Athens Observatory.
Furthermore in a very rare occasion in the Greek political scene, the Parliament voted unanimously for his appointment as Director of the Observatory.
In 1891 he ordered a series of meteorological instruments in Paris which arrived in 1893, and finally 17 new meteorological stations established in several cities. For the best operation of the stations Aiginitis wrote a book titled "Practical Meteorology or manual for the operation of the Meteorological Stations in Greece" (Athens, 1892) and through an act of the government it became obligatory that responsible for the stations would be teachers of primary and secondary education.
Through this action we argue that Aiginitis could involve a significant and educated part of the society in his long term project for the scientific development of meteorology in Greece.
Furthermore he arranged to receive daily weather reports from 56 foreign stations and reconstructed the old time series of the meteorological observations which were more than half a million, working with just three collaborators, in a period of four years (1891-1895).
What makes the work of Aiginitis for the development of climatology and meteorology much more impressive is that he worked in a period when Greece was facing severe financial problems as in December 1893 when the prime minister Trikoupis declaired in the Parliament the unfortunate event of the national

bankruptcy and a lost war with the Ottoman Empire in 1897. So that in a situation, which resembles with the current political, financial and social status of Greece, Aiginitis insisted that the knowledge of the environmental conditions was one of the cornerstones for the development of the country and the exit of the crisis. Consequently he argued that the development of agricultural meteorology should be *sine qua non* as well as the reliable weather forecast, which according to Aiginitis should be proved true in a 75-80% for the agricultural purposes and 95-98% for the marine environment.

An interest point arose by Aiginitis is the publication of the description of the Greek climate and the daily weather in the European press for what he calls the "industry of tourism". He mentions that even the executive directors of the big hotels in Athens and especially of the famous *Grand Bretagne* had pressed the authorities for this reason.

To achieve this scoped he needed telegraph services but the Government could not pay so that he succeeded through personal connections to get these services for free from the English Company "Eastern Telegraph".

Despite the several difficulties and the low financing Aiginitis finally achieved to establish a reliable meteorological network in Greece. The timeseries of air temperature and rain from this period are shown indicatively. But Aiginitis was not just a scientist. He was also a prominent member of the uprising Greek intelligentsia, which was characterized by a certain ideology that was trying to connect the ancient Greek civilization with the Christian faith in a peculiar but strong amalgam. In this respect Aiginitis argued that the climate is responsible for the most representative natural feature of each country as well as the idiosyncrasy of its people. In this framework he argues that the properties of the climate act greatly not only on the material characteristics of the humans but also on their intellectual and moral behaviour. They impose the style of living, they develop the spirit and finally form the national identity of the people. Aiginitis claims that the scientifically measured climatological time series assist towards the refutation of several common beliefs which had been prevailed through popular traditions and myths based on ideas transferred from generation to generation for centuries. According to Aiginitis the climate of Greece and Athens, has a specific significance from a scientific point of view compared to the study of the climate of other climate and cities.

Aiginitis writes among others:

> "In the study of the climate of Athens the philosopher will find the sources of his theories, the archaeologist several information concerning the nature, the historian further assistance and the philologist the scientific light he needs to learn about the causes, the history, the development and the nature of the course, the rise and the fall of this great centre of the human civilization."

What he wanted to secure was the belief that the Greek climate had remained stable over the centuries and therefore the inhabitants of the region could not be but Greeks, strengthening the issue of the Greek national identity which at that time was questioned by scholars like the Germans Fallmerayer and Fraas.

The main point of Fraas was that:

> "It is absolutely impossible for this country (Greece) to be considered as one of the civilized nations and moreover it would be a vane trouble Greece to be vaccinated with semen from the North or the West. The high wave of the civilization, which travels from the East to the West, has left behind it a desert, where nothing can reach maturity."

For Aiginitis both Fallmerayer and Fraas were nothing but pseudoscientists and he used extracts from the works of other famous geographers and naturalists like Unger, Neumann, Partsch, Hann, Fischer, Philippson and Heldreich to support his biter and severe attack against his German rivals.
Coming to the conclusion of his work Aiginitis follows again the views expressed by Humboldt that the fears about the climate change are like fallacies of fantasy and they are based on dogmatic misconceptions. As he claims the history of the atmosphere and its annual changes is ancient enough to protect us from the fear of a general and everlasting change of the European climate. In general it is possible that there will be some fluctuations around a certain mean but this mean does not change significantly throughout the ages.

Concluding remarks
Though it seems a trivial conclusion we mat repeat that during the 19th century Greeks seemed to be interested for the climate and the weather of their country. This interest, which comes from the antiquity when they had invented Gods to express the meteorological conditions like Aelus, the God of the winds, Yades, the nymphs of the rain, and naturally Zeus the God who controlled all the weather.
In nineteenth century, through the transformation of Greece from a nation under the Ottoman political umbrella to an Independent nation, the society changed rather rapidly and thus the characteristics of the weather prediction and climate description.
Though traditional forms of weather prediction remained active, especially in the villages, serious efforts took place for the scientific development of meteorology and climatology. These efforts seemed to be started from the Ionian Islands under the influence of the English officials who were settled there at that time.
In Athens, the key point was the establishment of the National Observatory, where despite the expected difficulties, caused by the financial and political status of Greece, a meteorological department was established. Meteorology was further developed at the time where Aigintis was Director of the Observatory and resulted in the publication of a series of observations, the daily forecast of the weather in the capital and its publication in the press and the understanding of the crucial role the knowledge of the climatic and weather conditions has for the development of a country, in almost every aspect of the life, in industry, tourism, navigation, agriculture and why not for its very existence as an independent country.

The Origins of Experimental Philosophy: Experimental Procedures and Empirical Methods in early modern Europe

Organizers
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The origin of experimental philosophy has long been a central problem in the history of early modern science. In the past decade quite a substantial amount of work has been done in the exploration of various cognitive, psychological and social aspects of experimentation. Meanwhile, comparatively little has been done towards a more detailed, contextual and specific study of what might be described, a bit anachronistically, as the methodology of early modern experimentation, i.e. the ways in which naturalists, promoters of mixed mathematics, natural philosophers or artisans put experiments together and reflected (and sometimes discussed) on the capacity of experiments to extend, refine or test hypotheses, on the limits of experiments and, even more, on the heuristic power of experimentation. So far, the sustained interest in the role played by experiments in early modern science has usually centered on ‘evidence’- related problems. This line of investigation favored examination of the experimental results, but neglected the “methodology” that brought about the results in the first place. It has also neglected the more creative and exploratory roles that experiments could and did play in the works of sixteenth and seventeenth century explorers of nature.
The purpose of our panel is to bring together scholars interested in specific early modern instances of experimental methodology. We are especially interested in whether one can find specific methodological considerations on the exploratory and heuristic aspects of experimentation in early modern period. Our aim is to illustrate and further explore in detail particular instances of the so far neglected aspects of early modern experimentation. The individual papers will focus on specific instances of early modern experiments and methodological considerations present in the works of sixteenth and seventeenth century explorers of the natural world. In this way, we hope to enrich the current understanding of the ways in which the methodology of experimental practice contributed to the growth of knowledge.

Exploring Galileo's Method: the Day Earth Stopped Standing Still

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In this paper, I examine the complex argument put forward by Galileo Galilei, in favor of the Copernican paradigm in his work *Dialogue concerning the Two chief World Systems* (1632). I argue that the examples of motion which are described by Galileo in the chapter "Second Day", are not simply explained via the new theory, but re-constituted in a new conceptual system, articulated at the same time. This dialectical relation between theory and experience is concealed in Galileo's dialogue beneath the platonic idea of 'recollection', enabling Galileo to make a compelling case out of Earth's movement..
In particular, I intend to show how the technique of 'recollection' conceals new information into these experiments of motion. Although the phenomena appear the same, there is an additional influence, circular inertia. As Feyerabend claims, and I attempt to show circular inertia, although a vital part of the new theory of dynamics, is in fact an ad hoc premise non reducible to any known theory (Feyerabend, 1993 [1975]) So, Galileo's endeavour can neither rest on empirical data nor on set theoretical grounds. 'Recollection' is an effective rhetorical device that combined with an elaborate exposition guarantee the transition to the new interpretation.
Galileo's treatise is written in Italian as a dialogue between three interlocutors: Sagredo, Simplicio and Salviati. Sagredo is an unbiased and lettered individual, Simplicio embodies the layman follower of the Aristotelian cosmology, while Salviati stands implicitly for Galileo. From the start, Salviati recognizes that knowledge is a sort of recollection, according to the Platonic model:

> «Salv. The unraveling depends upon some data well known and believed by you just as much as me, but because they do not strike you, you do not see the solution. Without teaching them to you then, since you already know them, I shall cause you to resolve the objection by merely recalling them.» (Galileo 1632, 190-191)

The doctrine of recollection, according to Galileo, purports that the empirical data or facts are known to anyone, but since they're forgotten, the solution is not apparent. A definition of the Platonic doctrine of 'recollection' or 'anamnesis' would state that all learning is a re-collection of ideas innate to the human soul which are drawn to the surface. Truth is not teachable since acquiring knowledge is becoming aware, by means of our senses, of what is already in our possession. So, Galileo's description would more or less conform to what is generally accepted by modern scholars as a

proper definition.[1] 'Recollection' thus posits an epistemically broad claim: *all* knowledge is the retrieval of once known but forgotten ideas.
As Salviati mentions about Simplicio, «as usual, he has the solutions at his fingertips though he does not notice them»(Galileo 1632, 168). And Sagredo underlines:

> «[...] But the showing depends upon you;{sic} I say to you that if one does not know the truth by himself, it is impossible for anyone to make him know it. I can indeed point out things to you, things being neither true nor false; but as for the true-that is, the necessary; that which cannot possibly be otherwise-every man of ordinary intelligence either know this by himself or it is impossible for him ever to know it. And I am sure that Salviati holds this opinion too. Therefore I tell you that the causes in the present problem are known to you, but are perhaps not recognised as such.»(Galileo 1632, 157-158)

So, just reminding Simplicio the truth is not enough, he must also figure it out by himself. Only this act can lead Simplicio from the state of simply "knowing" something, to a state of "knowing" beyond doubt, as understanding it. Galileo's use of the platonic doctrine could also refer to a stronger epistemic claim where true knowledge means the ability to causally account for what happens by employing concepts. 'Recollection' can signify a form of philosophical reasoning, very close to what we now call scientific As I intend to show, although both versions of the doctrine find ample support in the text, when put against Galileo's line of inquiry they provide us with a problematic view of his argument.
Just before it is first mentioned that truth is not teachable Salviati urges Simplicio not to trust the empirical arguments that ancients writers have bequeathed them, arguing that they too probably passed them on, without examining them (Galileo 1632, 144). While Galileo does not attack directly the ancient writers, he undermines the empirical basis of traditional knowledge, by casting the shadow of a doubt. Salviati asserts his certainty that these adverse examples executed in thought, actually support his case and that Simplicio will eventually agree (Galileo 1632, 145). The example in question is but the famous tower argument disguised.[2] A rock is left to fall from the top of a mast, while the ship is at rest and while in movement. Salviati contends that the rock would fall, in both cases, on the same spot by the mast, given the insignificance of the air. This is due to the fact that even when the ship is moving, the rock participates in this same movement, before its fall. Since the two movements are not incompatible, the rock conserves them both, following a slanting trajectory, while falling, that again appears as perpendicular to the ship.

[1] For the possible definitions as well as for the vibrant debate on the doctrine, Thomas Williams (2002), "Two Aspects of Platonic Recollection", Apeiron 35, 131-152
[2] The tower argument, widely used at the time by the champions of the aristotelian cosmology as decisive proof against the Copernican view states that if a rock was left to fall from the top of a tower and Earth rotated, Earth should have covered such a distance during the fall that the rock should land away from the feet of the tower. This does not happen, ergo Earth is in a state of rest.

Seeking the logical indeterminacy between the two rival theories, Galileo invites us to apply these conclusions in the the tower argument:

> «But keeping to our purpose, I believe that Simplicio is convinced that from seeing the rock always fall in the same place, nothing can be guessed about the motion or stability of the ship. [...] Now if in this example no difference whatever appears, what is it that you claim to see in the stone falling from the top of the tower, where the rotational movement is not adventitious and accidental to the stone, but natural and eternal, and where the air as punctiliously follows the motion of the earth as the tower does that of the terrestrial globe?» (Galileo 1632, 154).

However, this analogy between sea and land conceals an inductive generalization which is invalid and problematic. Unlike the ship's movement, where its motion is observable in various ways, both intuitive and experimental knowledge of Earth's diurnal rotation seems impossible at the time. Thus, the analogy does not consolidate the new interpretation of the tower argument, it only introduces the idea as a possible explanation**.** The decision between the two possible explanations, lies par excellence beyond investigation by means of the senses so that the case for 'recollection' does not hold any ground, at least according to the first definition. However, we are still left with the objection raised by the second definition. When Galileo speaks of 'recollection', he is clearly refering to an intriguing re-interpretation of certain phenomena. However, the adoption of the new interpretation does not spring from known facts just by dissolving the errancy. On the contrary new information is latently introduced to the empirical evidence and the theory-choice is set up.

To this purpose, one must return to where these empirical examples are first presented. These examples are namely a) the experiment with a rock left to fall from the top of a tower, b) the experiment repeated from the mast of a ship, c) cannon shots to opposite directions and d) a cannon shot toward the sky (Galileo 1632, 126). These empirical arguments, traditionally used in defense of the Aristotelian framework, are followed by a set of epistemic assumptions, which are presented as three indispensable conditions for the attainment of knowledge. Once agreed upon, they form a new frame of judgment favourable for the new interpretation, despite the logical indeterminacy between the two possible states of Earth.

In a beautiful passage, Sagredo mentions the example of Copernicus' followers who although, born and raised in the Aristotelian tenet, they finally switched sides «[...]moved, not to say compelled, by the most effective arguments» (Galileo 1632, 129). With this brilliant example, Galileo compares the rival theories as if they were on a par and predisposes us in favor of the Copernican. So, when Simplicio admitts confusion, Sagredo replies:

> «Sagr. This is *a sign* that those arguments which have until now seemed conclusive to you, and which seemed to give you assurance of the correctness of your opinion, are beginning to *change* their aspect in your

> mind; by degrees they are allowing you *to incline, if not pass over*, to the contrary one» (Galileo 1632, ibid).

Sagredo admonishes Simplicio how to interpret logical doubt between the two views: i.e. not as a sign of confusion, but as a first step towards the new view. Let us call this first condition *principle of doubtful conversion.* In itself this condition does not guarantee a decision. The assistance of the second condition, however, renders a decision inevitable. For Sagredo immediately asks about the two rival views:

> «Are not these two conclusions such that one must needs be true, and the other false?» (Galileo 1632, 129-130)

Thus, the question is set up in a such a way that the two views are not only mutually exclusive but they form a dillemma as well: if only one is true and one must necessarily be true, the other has to be false *and* vice versa. Thus, the Copernican case for Earth's movement need not be deemed true in itself. It suffices to prove the Aristotelian tenet false and by elimination to show the truth of the Copernican view. Let us call this second condition *principle of inconsistency*. Consequently, it is necessary to highlight a criterion, a common ground on basis of which the two views are going to be examined.
So when Sagredo asks Simplicio if false conclusions can claim the same support as true ones in powerful arguments, Simplicio responds:

> «[...] I believe on the other hand that to make a false proposition appear true and convincing, nothing can be adduced but fallacies, sophisms, paralogisms, quibbles, and silly inconsistent arguments full of pitfalls and contradictions.» (Galileo 1632, 130).

So while, the two first conditions for the decision appear inconclusive by themselves, in combination with the *principle of logical comparison* they play a decisive role. All three conditions are introduced by Sagredo and Simplicio concedes in all three, while Salviati, Galileo's strawman, does not intervene at all, so that we are left with the impression that these assumptions are common sense of the time.
Thus, the choice appears to be an open and shut case between two equal theories and the same body of evidence. However, 'recollection' might well bring all these empirical examples in mind, but under a crucial new condition: circular inertia.[3] The latter is at first submitted by Salviati as a reasonable conjecture: if Earth rotated around its axis, all bodies on it would share this movement:

> «[...] Just so, it ought to be that if the natural tendency of the earth were to go around its center in twenty-four hours, each of its particles would also have an inherent and natural inclination not to stand still but to follow that same course.[...]» (Galileo 1632, 142).

[3] Paradoxical for the thought at the time, circular inertia encompasses a contradictory state of affairs: the inertial movement of a body that is at rest.

This hypothesis is introduced to the ship example and by analogy to that of the tower, *without independent arguments.* As Salviati tricks Simplicio into acknowledging: «[…] what happens on the ship must likewise happen on the land [...]», so that circular inertia alters the structure of all examples recollected forward (Galileo 1632, 144).[4] Galileo's critical stance against authority, suggests to reinterpret all examples, under the light of this new influence. Thus, the mixed movement of the falling rock that follows from the new interpretation of the tower example is analyzed in two distinct movements: an observable downward one and a circular one that remains «imperceptible and as if non-existent» (Galileo 1632, 162-163). Again, no argument is offered to consolidate this conjectural influence. Circular inertia is "legitimized" simultaneously with the hypothesis of Earth's movement. The two conjectures support each other logically as parts of the same theoretical web, so that they appear self-evident. Salviati can then guide Simplicio to explain the cannon shots, *given* the principle of circular inertia.(Galileo 1632, 170-171). Undermining the significance of empirical data, he sets both theories on a par:

> Salv. *With respect to the earth, the tower, and ourselves*, all of which all keep moving with the diurnal motion along with the stone, the diurnal movement *is as if it didn't exist*; it remains *insensible*, *inpereceptible*, and *without any effect whatever*» (Galileo 1632, 171).

Salviati concludes that the solution lies in getting rid of "the fixed and inveterate impression" that Earth is at rest. As already agreed, if the Aristotelian treatment of the experiments is false, then the Copernican must be true and Galileo has already pointed out how to decide: by assessing their logical consistency.

> «[...] The solution is the same as that of the stone falling from the tower, and the whole fallacy and equivocation consists in constantly assuming as true that which is in question. For the adversary has it always fixed in his mind that the ball starts from rest on being shot from the piece; but it cannot leave from a state of rest unless rest is assumed for the terrestrial globe, which is the very conclusion in question» (Galileo 1632, 174).

Thus, the Aristotelian arguments are fallacious insofar as they beg the question (petitio principii) and the geocentric view need to be rejected as false. (Galileo 1632, 183; 140).[5]

To conclude, circular inertia is a new ad hoc influence in all examples retrieved by 'recollection', and is mainly accepted thanks to its mutual support to the hypothesis of Earth's movement. Therefore, it is a key ingredient to the *reformulation* of the

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[4] Salviati ingeniously doubts the inferential force of the ship-tower analogy, only for the obviously wrong reasons. Salviati loses the argument on purpose to win the case.

[5] Paradoxically circular inertia would beg the question as well, had it been couched as an argument

issue. 'Recollection' and the three conditions of agreement are crucial in shaping a fake dilemma between the two views, given that there is no common experience on which the new theory can profess excellence of explanation.[6]

Naturally, I do not imply that the new interpretation is founded solely on rhetorical techniques or that it disregards experience. On the contrary, there is a fine relation, between the theoretical arguments presented and the empirical data examined.[7] Feyerabend accurately remarks that inside the Aristotelian framework of motion reside two different concepts of real movement: limited linear motion with observable effects and relative uniform motion that is non operative (Feyerabend 1993 [1975], 67). Feyerabend contends that Galileo pursues the complete inclusion of the first class of movements in the second. In other words, Galileo attempts to generalize the idea of relative motion and to this aim «[t]he idea of *anamnesis* functions here as a phychological crutch, as a lever which smooths the process of subsumption by concealing its existence.» (Feyerabend 1993 [1975] , 67).

From a psychological *and* a logical point of view this process cannot but rest on the success of 'recollection', since it conceals this leap from one conceptual apparatus to another, by providing a sort of conceptual continuity. As the stronger claim of 'recollection' purports: philosophical reasoning and that alone can lead to true knowledge, by accounting for the causal relation, based not only on the senses but on concepts too. Since experience is rendered 'fluid' as Feyerabend puts it, 'recollection' might be possible on grounds of a single concept or a known theory (Feyerabend 1993 [1975] 72).

In fact, impetus theory, the most prominent and widespread candidate was actually known to Galileo and used to explain for shots of projectiles, while it accounted also for relative motions (Galileo 1632, 150-155; 162). However, due to serious theoretical discrepancies circular inertia can be neither reduced to nor explained by the impetus theory.

Firstly, we could infer circular inertia from the impetus theory if and only if only the premises were known and true. Ironically, deducing a necessary principle for the case of Earth's movement (i.e. circular inertia), while presupposing Earth's movement begs the question. Furthermore, inertial movement is explicitly attributed by Galileo to their *natural* and *eternal* tendency, unlike the impetus theory which presupposes an *external* mover that *forcibly* impresses the body with an impetus that grants motion to it for *as long as* external impediments allow. As Feyerabend claims:

> «[...] accepting relativity of motions for inertial paths means giving up the impetus theory, which provides an (inner) cause for motions and therefore

[6] This also answers briefly to Achinstein's objection that we simply witness Galileo "saving the phenomena", in which case counter-induction amounts to nothing. P. Achinstein, «Proliferation is it a good thing? », 40-41

[7] This fine relation that involves «senses accompanied by reasoning»is no mere personal opinion. It is highlighted by Feyerabend (1993 [1975] 58), remarked in the 1967 edition prologue by Albert Einstein (*Dialogue,* xvii) and explicitly mentioned by Galileo himself (1632, 255).

assumes an absolute space in which this cause becomes manifest» (P.K. Feyerabend, 1993 [1975], 63 footnote n· 10).

For all its success, impetus theory only *appears* to explain circular inertia which is a unique concept that signifies a unique state of affairs. Thus, it cannot be subsumed or organized under a higher and more abstract idea, in order to be deductively applied in each case, as 'recollection' would require. Circular inertia only resembles the relative motion of moving parts inside moving frames of reference and that is why the ship thought-experiment is an ingenious one with great illustrative force. But, is based on a limited analogy with little logical consistency and does not provide us with a solid argument. The transition to the new theory of motion does not rest exclusively on experience, or on a theoretical framework. What is pointed out by Galileo, is the possibility to decide, by reason. Though, invoking reason seems to have a twofold meaning: the logical assessment of the opponents argument and the adoption of the specific logic of the new arrangement between theory and experience.

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The Scientific Cosmopolitanism as Traced by Astronomical Instruments

Organizers
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The symposium will explore the extent to which astronomical instrumentation was used to establish a planet-wide community of practitioners who shared the same goals and tools. The international nature of this initially informal group was not always strong enough to fight nationalistic views. The symposium aims at establishing which tools were used, across time and space, to promote international cooperation, in contrast with other techniques or instruments which remained within closed groups of astronomers. To what extent international cooperation fostered the feeling of a truly cosmopolitan community before the establishment of formal trans-national entities is the central question that this symposium aims to address.

Stone Age People Controlling Time and Space: Evidences for Measuring Instruments and Methods in Earlier Prehistory and the Roots of Mathematics, Astronomy, and Metrology

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Introduction

Starting with the Developed Oldowan and Acheulean, ca 1.7 Ma BP, early man (homo and probably Australopithecines, too) more and more shaped materials according to abstract mathematical concepts, which are inherent in the neurophysiological structure of the human brain (Rappenglück 1999, 2009). The reproduction of normalised tools required the perception, aesthetical evaluation, and technical implementation of the proportion, similarity, and symmetry, cognitive modelling, a certain repertoire of logical-mathematical transformations, manual skills, road-tests, and optimisation techniques. Thereby the evolution of metrology was launched (Bednarik 2003, 92-94, 96, 2008, 88; Rappenglück 1999, 2009).

Globular and discoid artefacts probably left over as nuclei during manufacturing lithic flakes (Rappenglück 2009), but sometimes reflecting the idea of producing perfectly round objects are well known since the Late Acheulean (350-250 ka BP). During the Middle Palaeolithic (200 ka-40 ka) artefacts, mostly bifaces, had been shaped triangular or in some rare cases produced as exact isosceles triangles. There however exist a quadratic object and a perfect sphere, too (Rappenglück 2009).

With high craftsmanship Palaeolithic people tried to produce flat surfaces (fig. 1, D). The abstract concept of a plane comes along with that procedure. Hitherto the oldest example, a wooden board, smoothed out and polished on one side, was found at the open air site of Gesher Benot Ya aqov (Israel), ca 780 ka BP (Goren-Inbar, Werker, and Fiebel 2002).

Sketches of two into each other engraved rectangles, showing up the concept of the right angle and of parallelism, comes from the Homo erectus, ca 350 ka BP (Bednarik 1995: 608-609). Neanderthals had been aware of the orthogonal cross ca 100 ka BP and the double arrow, 120 ka BP (Rappenglück 2009). Ochre pieces found in the Blombos cave (South Africa), ca 69-84 ka BP, show tessellation. Early Homo sapiens smoothed the surfaces for engraving rough grids of triangles, by applying the operations of iteration, parallelism, and rotation. Upper Palaeolithic man (40-12 ka) was acquainted with geometrical objects (fig. 1, E, fig. 3, A, C, D, E)like the point, the line segment, the sinusoidal line, the rectangular cross, the diagonal cross, the Latin cross, the isosceles, equilateral, and right-angled triangle, different kinds of quadrangle (rectangle, square, trapezium, rhombus), the pentagon and the hexagon, the arc, the circle sector, the semicircle, the circle, the ellipse, the spiral and the Greek fret (Rappenglück 1999, 2009). They knew tessellation (Rappenglück 1999, 2009), using triangles, lozenges, and hexagons. Mammoth tusks fragments (fig. 3, B) from Maisières-Canal (Belgium), ca 28 ka BP, show fine engraved tessellations made of lozenges (ratio 5:8; mean distance of parallel lines 2 mm ± 0.13 mm). A very similar tessellation with lozenges (ratio 5:10; mean distance of parallel lines 2 mm) object comes from Yudinovo (Russia), ca 15-14 ka BP. With high technical effort the engraving was done completely around a cylindrical shaped middle piece of a Mammoth tusk.

Moreover 3D figures like cuboids, the sphere, the cylinder, the cone, the square-based pyramid or the screw had been depicted or manufactured (Keller 2004; Rappenglück 1999, 2009). Bone tools threaded (fig. 4, A, B) coming from Forneau du Diable (France), 29-22 ka BP and Combe Capelle (France), Aurignacian, 38-29 ka BP, could have been served practically as a kind of screw tap holding soil bolts for anchoring tents (Müller-Karpe 1977). The object of Forneau du Diable (fig. 4, A) shows a groove running across the thread: Like in modern screw taps this design helps to carry out the chipping of the threaded hole.

Upper Palaeolithic people were familiar with parallel lines and array of curves, translation, axial and point symmetry, the right angle, the angle bisector, the perpendicular bisectors of the sides, the division of the circle, the construction of geometrical 2D and 3D objects (Rappenglück 1999, 2009). They used certain scalings, including the Golden Ratio (3:5), in mobile and cave art.

Upper Palaeolithic hunter-gatherers had a sense for dynamical processes: In their artwork they dissolved continuous movements into a superposition of succeeding images, producing a kind of *photo kinetic* sequence (Rappenglück 1999, 2012: 95; Azéma and Rivère 2012). The 3D arrangement of rock pictures in caves was experienced by motion. Spatial impression in cave art was obtained by rotation and folding of picture elements out of the basic plane by 45°, 75°, and 90°, generating a pseudo perspective (Rappenglück 1999). Beside the in profile presentation the biangular perspective or the multi-angle perspective in counterpose exist. All the operations are often not mutually exclusive, but intended together. The rock picture panel in "The Shaft", Lascaux (France), integrates all viewpoints (front, side and plan view) into one plane. Superpositions provide a meaningful interrelationship of the elements, keeping their spatial and substantial entities (Rappenglück 1999, 2009). The artists intentional distorted perspective with the purpose of regaining the real dimensions from a special viewpoint or by a peculiar movement (anamorphis). They conceptually and technically modelled and mapped objects. They produced sketches or traces on mobile objects or rock faces for preparing cave art. They also engraved site maps of landscapes on bones, using the turned down lateral view (Rappenglück 1999, 2009). There is evidence for methods of transferring the plan onto the rock face, e.g. by templates and certain measurement tools.

The notation of countable patterns arranged as sets and rows starts in the Acheulean, 0.8-1.1 Ma (Rappenglóck 2009). During the Upper Palaeolithic (40-12 ka BP) counting methods improved (Keller 2004, Rappenglück 1999, 2008), combinations of counting sets and abstract counting aids (e.g., series of dots, notches, certain geometric figures etc.) were used (fig. 5, D). There are evidences for the concept and representations of numbers (Rappenglück 1999, 2009, 2010). The bone of Ishango (Democratic Republic Congo), 20-25 ka BP, working with the basis 6, 10 and probably 3 and 4 as well as prime numbers 11, 13, 17, 19, documents high degree of knowledge (fig. 5, C). Often (Rappenglück 2008) counting series show a distinct temporal meaning associated to chronobiological (faun, flora, human life) and astronomical processes (lunar, lunisolar, sidereal). There exist observation-based time-reckoning, *palaeo-almanacs* (fig. 5, A) and probably a kind of calendar (Rappenglück 1999, 2008; Utrilla et al. 2012). People surely counted other quantities, too, e.g. components of dwellings, animals, tools, mixing ratios of dye stuff etc. In the Azilian, 12-10 ka BP, a system of tokens (fig. 5, B) for counting probably was invented (Rappenglóck 2009).

Measuring tools, ruler-and-compass constructions, and mapping technics

The building of complex dwellings, the fitting of scaffoldings for the purpose of painting and engraving rock faces in caves, the drawings of geometrical forms, but also the optimised cutting of clothes require natural or artificial measuring tools plus certain kinds of ruler-and-compass constructions and mapping technics (Rappenglück 1999, 2008, 2009).

The artificial levelling of a floor and certain dwelling structures, perhaps equipped with a centre post, can be traced back to the Homo erectus' settlement of Bilzingsleben II (Germany), 350 ka BP (Mania 1990, 76-87; Rappenglück 2009). During the Middle Palaeolithic (200-40 ka BP) Neanderthals realised sophisticated static constructions, e.g. built-in fitments in the entrance of caves (Müller-Karpe 1977, 134, 336, no. 350; Rappenglück 1999). Excellent visual thinking, capabilities of project planning, concepts and tools of measurement (e.g. fixing of spatial dimensions, number and size of frame parts, determination of perpendicular), division in equivalence classes by typecast of components according to form and function, and the ability of counting can be attested. The same, but much more improved (fig. 1), applies to Upper Palaeolithic (40-12 ka BP) Homo sapiens sapiens (Rappenglück 1999, 2009). He put up partially very sophisticated buildings (tents, huts) above or deepened in the ground as well as structures built-in rock shelters or caves, having e.g. vertical side walls, horizontal roofs, circular, oval, or quadratic quadratic layout, levelled floors, and equally arranged supporters around a central post. The hitherto most complex constructions are four domed buildings (each up to 20 t of bones and teeth) in Mežyrič (Russia), 19-14 ka BP (Pidoplichko and Allsworth-Jones 1998). Each of them consisted of a solid basis of big Mammoth bones, selected carefully according to the type and interlocked among each other such that a symmetrical pattern occurred. The tusks were combined to form an arched roof. Several cavities had been drilled into the bones probably for bearing a light wooden framework. The Palaeolithic engineers obviously could excellently count objects: The excavators had to number each part of the domed buildings for keeping track of the components and successfully reconstructing the structure. The people's capabilities of planning and mapping of 3D objects is attested by a site map of Mežyrič settlement engraved on a bone.

Upper Palaeolithic people have worn trousers and parkas (Rappenglück 1999, 2009). In order to avoid a difference in the length of pant legs or sleeves it was certainly necessary to use a natural measure, e.g. the cubit.

In parts of the Lascaux cave (France), 17.3-14.6 ka BP, people installed scaffolds and ladders, which allowed them accessing the superior rock faces (up to 3-4 m) for optimised painting and engraving them (Rappenglück 1999). Therefore the artists probably took measurements of the cave galleries to ensure the appropriate cutting of material for platforms, ladders, frameworks, avoiding too much waste. In the Axial Gallery especially the fitting of the girders into the dedicated carved attachment hollows of the rocks verify the use of natural (human body parts) or artificial measurement tools. At the end of the “Chamber of the Felines” and at the entrance to “The Shaft”, people used a 7-8 mm thick rope and climbed down 6 m and 4 m deep crags, for painting there another rocks: Before descending they certainly fathomed the depth for detecting the necessary length of the rope.

Measuring Cord and Stick

In the cave of Lascaux (France), “Chamber of the Felines”, five fragments of a cord (40-70 mm long, diameter 9.8-12.5 mm, 2 twists / cm) had been found, which are dated to ca 18-17 ka BP (Rappenglück 1999, 2009; Soffer 2000). Still older is the fragment (2-3 mm) of a twisted rope from Ohalo II (Sea of Galilee, Israel): 19.47 ka BP (Nadel et al. 1994: 454). Moreover imprints of fabrics in burnt loam found in Dolní Věstonice (Czech Republic), 28-25 ka BP, indicate the existence of basic weaving, rope, and net making technologies (Soffer, Adovasio and Hyland 2000). The exact drawn straight lines in the northern rock picture panel in “The Shaft” of Lascaux (fig. 6, A) illustrate the application of thin cords (Rappenglück 1999: 49, 56-57) used as chalk lines.

Plumb Bob

Technical constructions, e.g. dwellings or frameworks, in caves required fixing the perpendicular. A cord weighted with a natural object simply provided verticality. There however exist peculiar shaped artificial objects serving as exact plummets. From Kostenki I (Russia), 24.5-18 ka BP, come hitherto unexplained objects (Abramova 1995: 188-215, Cat. 42,69, Fig. 66,15), which by detailed analysis are peculiar formed weights of plum bobs. The best-preserved object (12.7 cm x maximal 5.5 cm) has a conical shape ending in a distinct, very well-elaborated tip (fig. 2, E). The object's upper part is cylindrical worked. It is separated from the lower conical part by a horizontal circular groove. Along with it vertical notches are cut in. Another similar object, 8.2 cm long, poorer preserved, likewise was found at Kostenki I. It is easy imaginable that the annular groove and the vertical notches had been incised to hold a vertical mounting consisting of a "cage" made of thin cords. A tiny piece of a very thin twisted cord (0.55 mm; 6 twists / cm) was found imprinted in loam at the same site (Soffer et al. 2000). Both objects could represent plumb bobs doubtless comparable to examples from Graeco-Roman time (fig. 2, E). In the cave of Lascaux the use of a plummet is evident (fig. 6, A) considering the bird-stick depicted in "The Shaft" (Rappenglück 1999: 91).

Measuring Sticks

There are peculiar pieces of bone, which may have served as measuring sticks (fig. 2, B): From La Garenne (France), 22-18 ka BP, comes a quadratic cut bone (10.5 x 1 cm) showing tiny equidistant notches between two margins, indicated in each case by a double line (Chollot-Varagnac, 1980: 108, No. 46.676, 7-9; Rappenglück 1999, 2009). On a symmetrical cut bone (fig. 2, C; 10.5 cm x 1 cm), discovered in the cave of

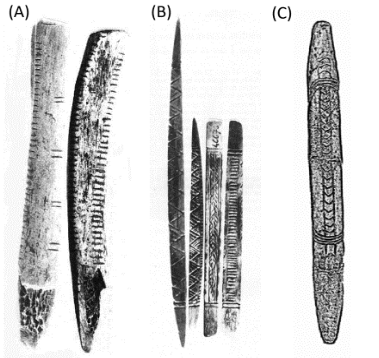
Isturitz (France), ca 28,5-12,5 ka BP, 18 angle shaped notches are incised between two sets of four arcs serving as margins (Leroi-Gourhan 1982: 38-44). From the cave of Brassempouy (France), ca 15 ka BP, comes a rib fragment (11.2 cm x 1.7 cm), which (fig. 2, A) shows parallel cuts - mean distance 2 mm - on both edges along with four sets of always two notches on one side (Chollot-Varagnac 1980: 250-251, No. 48.718; Rappenglück 2009).

Protractor

From the rock shelter Laugerie Basse (France), ca 14 ka BP, comes an object made of reindeer bone, which could have served as a kind of "protractor" (fig. 2, D): A rectangular and isosceles triangle (8,2 x 2,9 cm) with a concave base shows short cuts on all edges, which are of equal length and set in a mean distance of 2 mm (Chollot-Varagnac 1980: 330, 331, No. 53.771; Rappenglück 1999). A broadly similar geometrical sign is depicted in the cave of La Pasiega (Spain), ca 14 ka BP, (Rappenglück 1999: 230, fig. 227, 228; Rappenglück 1999). Bundle of twigs may have best served Palaeolithic man for fixing angles. Such measurement tools had been used by the Aztecs (Rappenglück 1999: 73-74). In the cave of Lascaux (France) some conspicuous "bundle of twigs" (fig. 3, F) can be recognised intentionally dispersed between the depictions of animals. Of course they simple may be abstract representations of certain plants, but it is conceivable that some of them illustrate the equipment used by Palaeolithic man for picking up angles and transferring them easily onto the rock face.

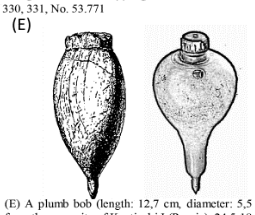
Shadow stick

The rock picture panel in "The Shaft" of Lascaux (France) present a sky panorama at summer solstice midnight local time, about 16.500 years ago. It (fig. 6, A-D) includes a hunter-gatherers cosmological map and a sundial's functionality (Rappenglück 1999). The depiction is anamorphic: The bird-man and the the bird-stick are either vertical or oblique, based upon the viewpoints at the bottom or the entrance to the shaft. In frontal view the bird-stick indicates the plumb line and the meridian (azimuth 0°). Seen from the shaft's top it is inclined (45.3°) with respect to a fictive baseline between the bird-stick's tip and the bird-man's feet. Astronomically the bird-stick points to the northern celestial pole at Lascaux (ϕ: 45.1 ° N I λ: 1.2° E), while the bird-man, standing upright (90.7°), embodies verticality (nadir-zenith). The angle of 68.6° between the arrow and the bird-stick corresponds to the sun's culmination above the horizon at Lascaux at summer-solstice, ca 16.500 years ago: 69.3°. The bird-stick then serves as a gnomon (a sundial). During night it has to be aligned to the northern sky pole using circumpolar asterisms of that time represented by animals or chimeras in the picture panel or δ Cygni in the Milky Way, which was only 3° away and then pole-star. It is identified by the bird-man's right wrist at which the bird-stick points. The arrow targeting the bird-stick shows the ritual of shooting down the sun's bird at summer-solstice, initialising the solar year's decline.



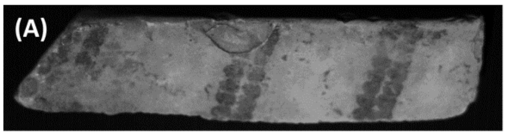
(A) Part of a rib (11,2 x 1,7 cm) with regularly parallel cut notches (2 mm distance on two edges and four additional sets of two parallel notches on one side. Cave of Brassempouy (France), ca 15 ka BP, Chollot-Varagnac 1980: 250 und 251 (Nr. 48.718). (B) Quadrangular rods made from bone (10,5 cm x 1 cm) with scales from La Garenne (Saint-Marcel, France), 22-18 BP. Drawing according to Chollot-Varagnac 1980: 108 (Nr. 46.676) 7-9. (C) A bone, symmetrically shaped, shows 18 angle signs between delimiters (set of 4 arcs), from the cave of Isturitz (France), 28.5-12.5 ka BP. Drawing after Michael A. Rappenglück nach Leroi-Gourhan, A. 1982: 38-44

(D) A isosceles „protractor" made from reindeer bone, (8,2 x 2,9 cm, shows at all edges short notches in the interval of 2 mm. Rock shelter de Laugerie Basse, France, ca 14 ka BP. Collage: Michael A. Rappenglück after Chollot-Varagnac 1980: 330, 331, No. 53.771

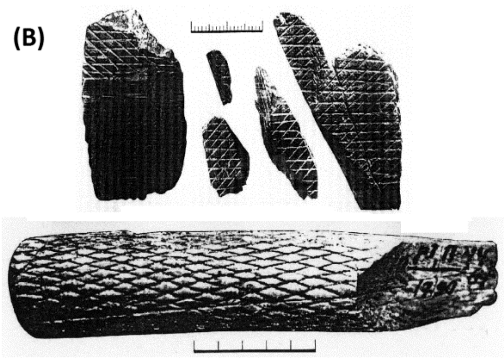


(E) A plumb bob (length: 12,7 cm, diameter: 5,5 cm) coming from the campsite of Kostienki I (Russia), 24.5-18 ka BP upper part of the object has a horizontal, circular notch and in vertical addition to that cuts. This allowed to fix the plumb bob to a cage of strings. By way of comparison: A today's pear-shaped plumb bob. The plumb line is fixed by knot within a screw-top. Collage: Michael A. Rappenglück after Abramova, 1995: 199, fig. 66,15)

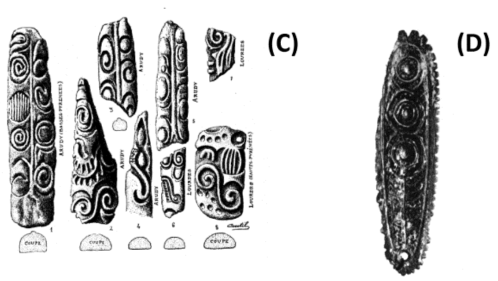
Figure 1



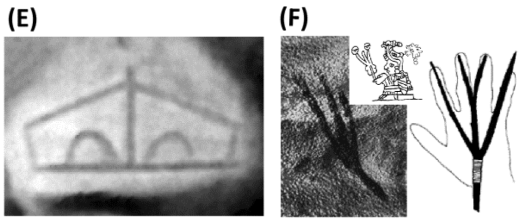
(A) Three parallel double row of points (2 x 7 = 14) painted on a limestone plate from the cave Obere Klause (Germany), ca 12.5 ka BP). Archäologische Staatssammlung München. Image: Rappenglück.



(B) Campsite of Maisières -Canal (Belgium): 5 fragmented objects made of mammoth ivory showing engraved tessalations made from lozanges (5:8; distance on average between parallel lines: 2 mm ± 0.13 mm), ca 28 ka BP) and a similar tessalation (5:10; 2 mm) engraved on an object from the campsite of Yudinovo (Russia), ca. 15-14 ka BP. Images: De Heinzelin 1973: Pl. XLIII a.

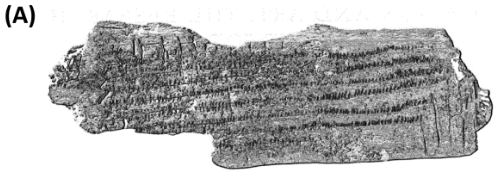


(C) Different pieces of bone engraved with spirals, dated to 22-12 ka BP, from caves of Lourdes (France), Arudy (France), Laugerie-Haute (Franece), and Cambous (France). Drawing: Coutil 1916: 388, Pl. 1. (D) Bone plate from Saint-Marcel (France), 22-18 ka BP, showing carvings of three circles, each consisting of two rings around a center. Image: Chollot-Varagnac, 1980: 218 (Nr. 46.679).

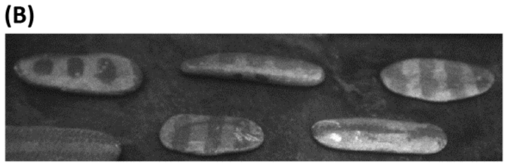


(E) Cave of Font-de-Gaume (France): Pentagon with middle vertical line, ca. 15-13.5 ka BP. Image: Alcalde del Rio, Breuil, and Sierra 1911: 183, fig. 181. (F) Twig-bundle in the „Axial Gallery", cave of Lascaux (France), 18-12 ka BP compared to and an instrument for measuring roughly certain angles used by the Aztecs (Codex Selden). Image: Rappenglück 1999: 73, fig. 51/52.

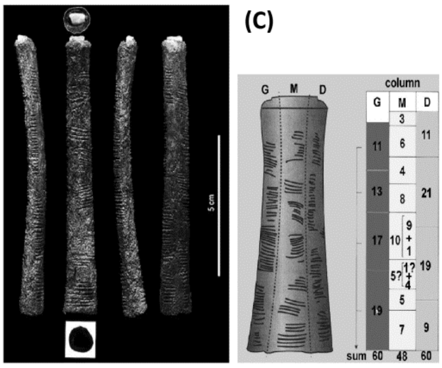
Figure 2



(A) The main face of the Taïs bone: A lunisolar time reckoning of 3 ½ years on a piece of bovine rib (2,7 x 8,7 cm), cave of Thaï (France), ca. 11.6 ka BP, Image after a photo from the original: Michael A. Rappenglück.



(B) At the end of the Upper Palaeolithic, 12-10 ka BP, painted pebbels from the cave of Mas d'Azil (France), and elsewhere suggest that systems of tokens existed. Musée d'Art et d'Archéologie du Périgord. Image: Michael A. Rappenglück).

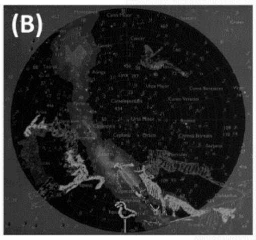


(C) Left: The bone of Ishango bone (Democratic Republic of Congo / Belgium), lenght 10 cm. Right: The numerology of the countable notches arranged on the stick, 20-25 ka BP, Image: Huylebrouck 2006: 10, 13.

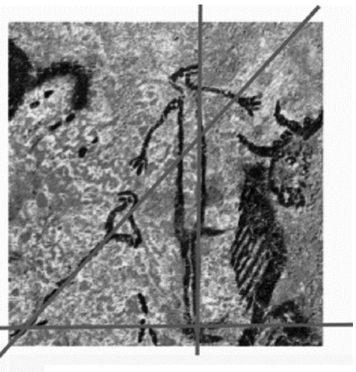
(D) Counting sets of dots, ordered in a 2 x 3 matrix, and of lines associated to depictions of animals (horses) in the cave of Chauvet (France), 32-30 ka B or 27-26 ka BP. Image: Clottes 2001: 69.

Figure 3

(A) The bird-man and the the bird-stick are either vertical or oblique, based upon the viewpoints at the bottom or the entrance to the shaft. In frontal view the bird-stick indicates the plumb line and the meridian (azimuth 0°). Seen from the shaft's top it is inclined (45.3)° with respect to a fictive baseline between the bird-stick's tip and the bird-man's feet. All following images: (Rappenglück 1999, 2004).

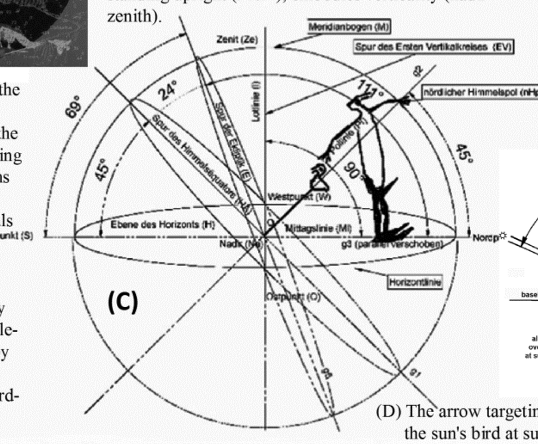


(B) The rock picture panel in "The Shaft"of Lascaux (France) present a sky panorama at summer solstice midnight local time, about 16.500 years ago. It includes a hunter-gatherers cosmological map and a sundial's functionality.

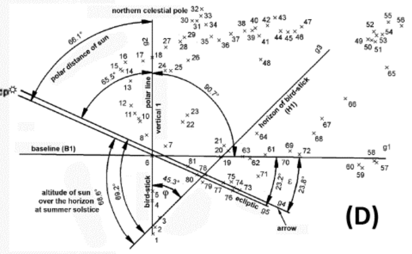


(C) Tthe bird-stick points to the northern celestial pole at Lascaux (φ 45.1 °N I λ 1.2°E), while the bird-man, standing upright (90.7°), embodies verticality (nadir-zenith).

(B, C) During night the gnonom (bird-stick) has to be aligned to the northern sky pole using circumpolar asterisms of that time representedby animals or chimeras in the picture panel or δ Cygni in the Milky Way, which was only 3° away and then pole-star. It is identified by the bird-man's right wrist at which the bird-stick points.

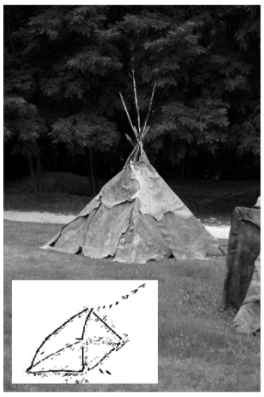


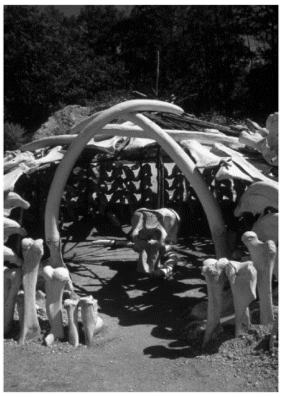
(D) The angle of 68.6° between the arrow and the bird-stick corresponds to the sun's culmination above the horizon at Lascaux at summer-solstice, ca 16.500 years ago: 69.3 ° The bird-stick then serves as a gnomon (a sundial).



(D) The arrow targeting the bird-stick shows the ritual of shooting down the sun's bird at summer-solstice, initialising the solar year's decline.

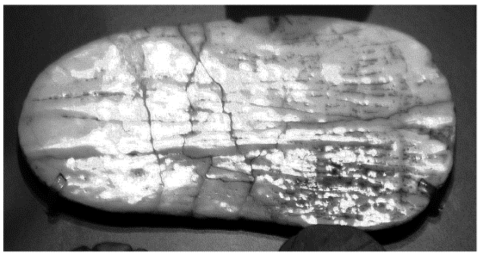
Figure 4





(C) Reconstruction of a complex tent of the campsite Le Cerisier (France), 18-15.5 ka BP, Parc de la Préhistoire de Tarascon-sur-Ariège. Courtesy: Michael A. Rappenglück

(A) Reconstruction of a tent with quadratic layout from the campsite of Plateau Parain (France), 18-15.5 ka, Parc de la Préhistoire de Tarascon-sur-Ariège. Courtesy: Michael A. Rappenglück.(B) Cave of Bédeilhac (France), 13.5-12 ka BP: A quadratic pyramid perspective drawn on the rock face according to Beltran, Gailli, and Robert 1967, fig. XLIV, 38. Photo and Collage by Michael A. Rappenglück (B) Dome-shaped building made from Mammoth bone. Mežyrič (Russia), 19 – 14 ka BP. Museum Le Thot, Montignac. Courtesy: Michael A. Rappenglück.



(D) Neanderthals from Tata (Hungary) smoothed and ochered a Mammoth molar ca. 101-120 ka BP. National Museum, Budapest, Hungary. Image: Michael A. Rappenglück.

(E) Sungir III (Russia), grave of two youngsters: Disk from mammoth ivory showing divisions of circle, ca 29.5-28.4 ka cal BP. Abramova 1995, 179, fig. 51, 1-5

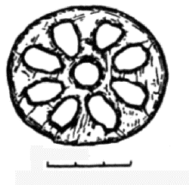
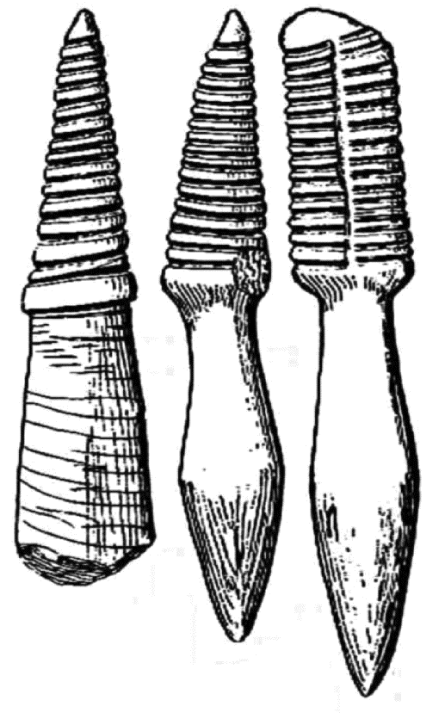


Figure 5

(A) a b c



(C)

(A) a, b, c Three instruments made of bone showing craved threads. One of them has a groove form the rock shelter of Forneau du Diable (France), 29-22 ka BP). Drawing after Müller-Karpe 1977, table 52, 20-2

(B) Very similar object made of Mammoth tusk having a thread in the upper part and a handle in the tower part, from rock shelter Combe Capelle (France), 38-29 ka BP. Museum für Vor- und Frühgeschichte, Berlin, Image: Michael A. Rappenglück.

Figure 6

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New Light on Stonehenge from Ancient Greeks

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Ancient Greek literature sheds new light on a continuing controversy between archaeologists and astronomers over the purpose of Stonehenge's architectural design; not unlike the divergent epistemologies of Laplace and Newton on the role of the Divine in the origin of the solar system:

> "In 1799, the physicist Pierre Laplace presented copies of his *Treatise on Celestial Mechanics* to the new French Emperor, Napoléon Bonaparte. In it, Laplace sought to explain the origin of the solar system not as the product divine design, as Isaac Newton had done, but as the result of purely natural gravitational forces. When Napoléon eventually summoned Laplace to discuss the *Treatise* in 1802, he asked Laplace directly about the role of God in his theory. 'Newton spoke of God in his book,' Napoléon said. 'I have perused yours, but failed to find his name mentioned even once. Why?' Laplace reportedly issued the now famous reply: 'Sire, I have no need of that hypothesis' " (cited in Kaiser 1991, 267 by Meyer 1999, 1).

In the 1960s, two British astro-physicists concluded that Stonehenge was designed as a purpose-built a lunar-solar observatory for predicting eclipses. Professor of Astronomy Gerald S. Hawkins (Boston University and Harvard-Smithsonian Astrophysical Observatory) suggested how Stonehenge could have functioned as a digital Neolithic computer to signal "a danger period when eclipses are possible." (Hawkins 1964, 1258); an interpretation elaborated by the Director of the Cambridge Institute of Theoretical Astronomy, Sir Fred Hoyle, FRS:

> "…I believe beyond reasonable doubt- that the purpose of Stonehenge was to *predict* the occurrence of eclipses. The fact that no serious difficulty is encountered as one delves deeper into the procedures for operating Stonehenge as an eclipse predictor provides, in my view, a very strong argument for thinking that Stonehenge was indeed used for this purpose" (Hoyle 1977, 4 and 157; cf. 1966; 1972).

Nonetheless, many British archaeologists "had no need of that hypothesis." Foremost among these were Professor of Archaeology Richard J. C. Atkinson, CBE (University College, Cardiff) who directed of excavations at Stonehenge for the Inspectorate of Ancient Monuments in the Ministry of Works (1950-1964); and Professor of Archaeoastronomy Clive L. N. Ruggles, FRAS, FSA (University of Leicester):

> "Hawkins second contention is that the fifty-six Aubrey Holes were used as a 'computer' …for predicting movements of the Moon and eclipses, for which he claims to have established a hitherto unrecognized 56-year cycle…. It is questionable whether a barbarous and illiterate community…, which has left us no other evidence of numeracy, could successfully have recorded the data needed to establish a cycle which exceeded contemporary life-span…. (Atkinson 1966, 1302)

> "…[D]etailed reassessments of the ideas of ... Gerald Hawkins... have shown hat there is no convincing evidence that, at any stage, constructions at Stonehenge …served as any sort of computing device to predict eclipses…there is no reason whatsoever to suppose that at any stage the site functioned as an astronomical observatory." (Ruggles 1997, 203)

For his part, Hawkins ultimately concluded that "My function as an astronomer is to do the calculations and to provide what could be called *numerical* artifacts which have to be taken into consideration in studying the structure" (Hawkins 2003). To that end, let us consider six such numerical artifacts from Stonehenge's architecture also found in the astronomical literature of ancient Greece, viz.: 19, 29, 29.5, 30, 56, and 59.

19 & the Bluestone Horseshoe (Phase 3v, c.2550-1600 BC)
Inside the Sarsen Circle of Stonehenge, 19 dolerite bluestones once stood in a horseshoe open to the midsummer sunrise (Figure 1).

> "[They]…are so called from their colour, which in dry weather is a bluish-grey. But when they are wet after rain they acquire a noticeably blue tinge…. There can be no doubt now that it was from this very restricted region [in Wales] that the bluestones were chosen and brought to Stonehenge [in England]. The technological implications of this extraordinary undertaking are discussed below…. The spacing of the surviving stones makes it clear that the horseshoe originally contained nineteen pillars…." (Atkinson 1956, 34, 36, 42).

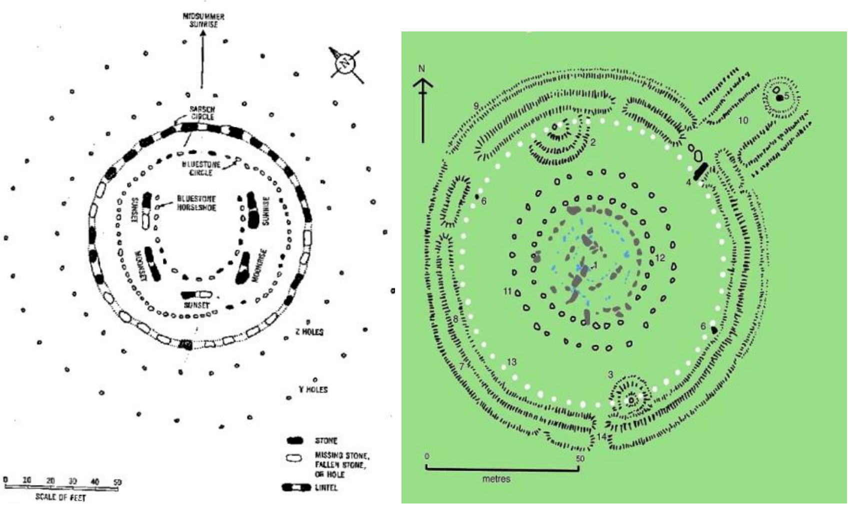


Figure 1: *Reconstructed (left) and Unreconstructed (right) Plans of Stonehenge III(Hawkins 1973, 296; Adamsan. http://en.wikipedia.org/wiki/File:Stonehenge_plan.jpg)*

While a modern archaeologist may have no use for an astronomical hypothesis, both the color and number of the bluestones could well have had ritual significance for, say, an ancient astro-architect. Although the color choice of *bluestones* reflecting a connection to the *blue sky* is as hypothetical as it is self-evident, astronomers have pointed out that the architect's choosing 19 bluestones for the horseshoe constitutes an independent numerical variable reflecting the 19-year cycle of the moon's 235 Synodic months (or lunations); a cycle used by Greek astronomers Meton and Euctemon of Athens to regulate the Attic Calendar c.432 BC. Moreover, British Archaeologist Robert S. Newall, FSA pointed out (Hawkins 1965, 96) that the ancient Greek historian Hecataeus of Miletus (c.550-476 BC) referred to a spherical temple to Apollo on the large island of Hyperborea (Beyond the North Wind) where "...the god [theon or Moon deity Selene – V.T.] visits the island every 19 years, the period in which the return of the stars [astron or luminous bodies – V.T.] to the same place in the heavens is accomplished…." (Diodorus c.50 BC, 47).

DIODORUS OF SICILY

῎Αβαριν εἰς τὴν ῾Ελλάδα καταντήσαντα τὸ παλαιὸν ἀνασῶσαι τὴν πρὸς Δηλίους εὔνοιάν τε καὶ συγγένειαν. φασὶ δὲ καὶ τὴν σελήνην ἐκ ταύτης τῆς νήσου φαίνεσθαι παντελῶς ὀλίγον ἀπέχουσαν τῆς γῆς καί τινας ἐξοχὰς γεώδεις ἔχουσαν ἐν
6 αὐτῇ φανεράς. λέγεται δὲ καὶ τὸν θεὸν δι' ἐτῶν ἐννεακαίδεκα καταντᾶν εἰς τὴν νῆσον, ἐν οἷς αἱ τῶν ἄστρων ἀποκαταστάσεις ἐπὶ τέλος ἄγονται· καὶ διὰ τοῦτο τὸν ἐννεακαιδεκαετῆ χρόνον ὑπὸ τῶν ῾Ελλήνων Μέτωνος ἐνιαυτὸν ὀνομάζεσθαι. κατὰ δὲ τὴν ἐπιφάνειαν ταύτην τὸν θεὸν κιθαρίζειν τε καὶ χορεύειν συνεχῶς τὰς νύκτας ἀπὸ ἰσημερίας ἐαρινῆς ἕως πλειάδος ἀνατολῆς ἐπὶ τοῖς ἰδίοις εὐημερήμασι τερπόμενον. βασιλεύειν δὲ τῆς πόλεως ταύτης καὶ τοῦ τεμένους ἐπάρχειν τοὺς ὀνομαζομένους Βορεάδας, ἀπογόνους ὄντας Βορέου, καὶ κατὰ γένος ἀεὶ διαδέχεσθαι τὰς ἀρχάς.

48. Τούτων δ' ἡμῖν διευκρινημένων μεταβιβά-

BOOK II. 47. 5–48.

to Greece in ancient times and renewed the good-will and kinship of his people to the Delians. They say also that the moon, as viewed from this island, appears to be but a little distance from the earth and to have upon it prominences, like those of the earth, which are visible to the eye. The account is also given that the god visits the island every nineteen years, the period in which the return of the stars to the same place in the heavens is accomplished; and for this reason the nineteen-year period is called by the Greeks the "year of Meton."[1] At the time of this appearance of the god he both plays on the cithara and dances continuously the night through from the vernal equinox until the rising of the Pleiades, expressing in this manner his delight in his successes. And the kings of this city and the supervisors of the sacred precinct are called Boreadae, since they are descendants of Boreas, and the succession to these positions is always kept in their family.

48. But now that we have examined these matters

"Either the 19 year phase cycle or the 18.61 year nodal cycle was represented by the 19 blue stones inside the trilithon 'horseshoe' " (Newham 1972, 47-48)

" It is, of course, the eclipse year…which has the powerful relation to the number 19, since an eclipse occurring at one moment will reoccur almost exactly 19 eclipse years in the future" (Hoyle 1977, 130).

29 Z Holes & 30 Y Holes (Phase 3vi, 1600 BC)

The Y and Z holes (Figure 1) were discovered and excavated by Lieutenant Colonel William Hawley and R. S. Newall, FSA in the early 20th century (Atkinson 1956, 19).

"…[T]he Y and Z Holes…were obviously intended as the sockets for a double circle of bluestones, numbering 60 in all (there are actually only fifty-nine holes, since Z8 is missing)" (Atkinson 1956, 72).

While archaeologists have dated artifacts found in the holes and mapped the holes, they have not offered an interpretation of why the numbers of **29** and **30** or their role in the overall architectural design of Stonehenge. Astronomers, on the other hand, have pointed out that:

"The double circle or spiral of the 'Y' and 'Z' holes represented the 59 days of two solar months." (Newham 1972, 47)

"The 30 Y and 29 Z holes were an improvement in the counting device. Alternate months could use the short 29-day interval, giving a mean month of 29.5 days…. The rings contain numerical information that corroborates the possible connection with the moon. (Hawkins 1973, 301)

29.5 Uprights of the Sarsen Circle (Phase 3ii, 2600 BC to 2400 BC).

The Sarsen Circle contains a total of 29 and one-half uprights and pits (Figure 2). It remains an open question among archaeologists as to when one of the stones was shortened:

"The original number of uprights in the circle was thirty, but of these only sixteen remain in position. One stone in the circle, no. 11, is much smaller than the rest, measuring only 4 ft. wide by 2 ft. thick. It now stands only 8 ft. out of the ground, but presumably at some time the upper part has been broken off and removed from the site. The use of this markedly undersized stone (there can be no question of its width or thickness having been reduced since its erection) suggests that the builders were hard put to it to find sufficient blocks of the requisite size to complete the circle" (Atkinson 1956, 23-24)

"If we move a little around the sarsen ring to stone 11, we find a diminished, stumpy thing, less than 3m high compared to the normal 4m…. It could not have held a lintel connecting to the two adjacent full-size stones…." (Pitts 2001, 265)

Figure 2: *The 29.5-Stone Sarsen Circle and Laser Scan of "Shorty" Stone No. 11 (Atkinson 1956, Plate I; http://www.solvingstonehenge.co.uk/page7.html)*

Atkinson's suggestion that "the builders were hard put to it to find sufficient blocks of the requisite size" for fashioning a full-size 30th upright is belied by the local sarsen stone quarries (http://brian-mountainman.blogspot.com/2011/11/sarsen-speculations.html). On the other hand, the astronomical explanation is simply "…that small stone (no. 11) in the sarsen circle was intentional, and that the circle represented the 29.5 days of the lunar month" (Newham 1972, 47) as was known to Sumerians (c.1800 BC) and Greeks (c.500 BC).

30 & the Station Stones (Phase 3, c.2600 BC)

The Station Stones form a rectangle whose length to width ratio is 12:5, i.e., whose diagonals form twin 5:12:13 Heronian-Pythagorean rational right triangles with a common hypotenuse (Dibble 1976; Atkinson 1978, 50) (Figure 3).

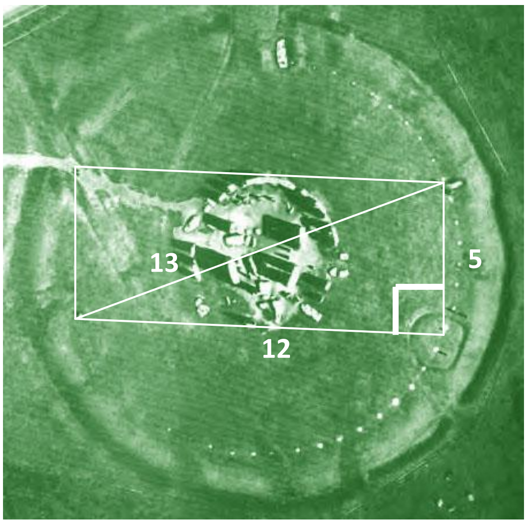


Figure 3: *Aerial Photo of the Station Stone 5:12:15 Triangles*

Three remarkable coincidences deserve notice regarding the 5:12:13 triangle:

1. It is one of three primitive Pythagorean triples (i.e., 3:4:5; 5:12:13; 12:35:37) found at megalithic sites in Britain (Thom 1967, 27),
2. It is *unique* in that its Area (5 x 12/2 = 30 Ratio Units squared [RU^2])) and its Perimeter (5 + 12 +13 = 30 linear RU) equal the same number, and
3. The Ratio Unit number (30) for both its Area and Perimeter is the nearest integer to the moon's *Synodic Period* (29.5306 days).

Not only did the designers of the Station Stone Rectangle incorporate 5:12:13 rational right triangles into their astro-architectural plan anticipating both Pythagoras of Samos (c.570 BC–c.495 BC) and Heron of Alexandria (c. 75 AD) by more than 2,000 years, but they also oriented the sides of the Station Stone Rectangle to the extreme risings and settings of the midwinter and midsummer Moon ($\pm$ 29$^{\circ decl}$) and Sun ($\pm$ 24$^{\circ\ decl}$).

56 & the Aubrey Holes (Phase 1, c.2950-2900 BC)

Thanks to Atkinson's extensive field work at Stonehenge, we know that "[t]here are fifty-six Aubrey Holes, set in an accurate circle 288 ft. in diameter…. Thirty-four of them have been excavated…. The locations of the unexcavated holes have been found by probing and 'bosing' [sub-surface echo-location]" (Atkinson, 1956, 11-12) (Figure 4).

However, Atkinson's contention that Hawkins' 56-year eclipse cycle as "hitherto unrecognized" (Atkinson 1966, 1302) must be rejected in light of the following passage attributed to the Greek astronomer Eudoxus of Cnidus (fl. 370 B.C.) by Plutarch (AD c.46-120) explicitly linking the 56-sided (-angled) polygon to lunar eclipses:

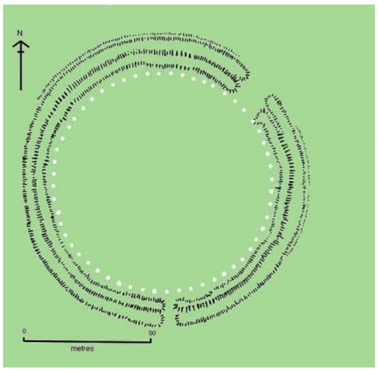
"There are some who give the name Typhon to the shadow of the earth, into which they believe the moon falls and so suffers eclipse…which the sun remedies by instantly shining back upon the moon when it has escaped the shadow of the earth…."The Pythagoreans also clearly believe Typhon to be a demonic power, for they say that he was born on an even measure, the 56th; further, they say that the nature of the triangle belongs to Hades, Dionysus and Ares, that of the quadrilateral to Rhea, Aphrodite and Demeter, Hestia and Hera, and that of the dodecagon to Zeus, while that of the 56-sided (-angled) polygon is said to belong to Typhon, as Eudoxus [of Cnidus, Greek astronomer, fl. 370 B.C.] has reported…. "

δεδεμένον. | ἐν δὲ τῇ τοῦ Ἡλίου θυσίᾳ τοῖς σεβομένοις τὸν θεὸν 363
παρεγγυῶσι μὴ φορεῖν ἐπὶ τῷ σώματι χρυσία μηδ' ὄνῳ τροφὴν
διδόναι. φαίνονται δὲ καὶ οἱ Πυθαγορικοὶ τὸν Τυφῶνα δαιμονικὴν
ἡγούμενοι δύναμιν· λέγουσι γὰρ ἐν ἀρτίῳ μέτρῳ ⟨τῷ⟩ ἕκτῳ καὶ
πεντηκοστῷ γεγονέναι Τυφῶνα· καὶ πάλιν τὴν μὲν τοῦ τριγώνου
⟨φύσιν⟩ Ἅιδου καὶ Διονύσου καὶ Ἄρεος εἶναι· τὴν δὲ τοῦ τετραγώ-
νου Ῥέας καὶ Ἀφροδίτης καὶ Δήμητρος καὶ Ἑστίας καὶ Ἥρας· τὴν
δὲ τοῦ δωδεκαγώνου Διός· τὴν δὲ ⟨τοῦ⟩ ἑκκαιπεντηκονταγωνίου
Τυφῶνος, ὡς Εὔδοξος (fr. 293) ἱστόρηκεν. (31.) Αἰγύπτιοι δὲ πυρ-
ρόχρουν γεγονέναι τὸν Τυφῶνα νομίζοντες καὶ τῶν βοῶν τοὺς
πυρροὺς καθιερεύουσιν, οὕτως ἀκριβῆ ποιούμενοι τὴν παρατήρη- B
σιν, ὥστε, κἂν μίαν ἔχῃ τρίχα μέλαιναν ἢ λευκήν, ἄθυτον ἡγεῖσθαι·
θύσιμον γὰρ οὐ φίλον εἶναι θεοῖς, ἀλλὰ τοὐναντίον, ὅσα ψυχαῖς

Typhon, and when they make round cakes in the festivals of the months of Paÿni and Phaôphi, as an insult they stamp on them an image of a tied ass. In the sacrifice to Helius they instruct those 363
who venerate the god neither to wear golden objects on the body nor to give food to an ass. The Pythagoreans also clearly believe Typhon to be a daemonic power, for they say he was born on an even measure, the 56th; further, they say that the nature of the triangle belongs to Hades, Dionysus and Ares, that of the quadrilateral to Rhea, Aphrodite, Demeter, Hestia and Hera, and that of the dodecagon to Zeus, while that of the 56-sided polygon is said to belong to Typhon, as Eudoxus has reported.

(Griffiths 1970; 165, 189 and 207)

The design choice of a 56-sided (-angled) polygon for the Aubrey Holes is of fundamental importance because it coincides with a remarkable lunar cycle where the moon’s skyline position and phase synchronize enabling eclipse prediction. As Hawkins pointed out, “In favor of this solution - that the Aubrey Holes were used as a computer- are these facts: (1) the number 56 is *the smallest number* that measures the swing of the moon with an over-all accuracy of better than 3 days, and (2) lunar cycles provide the only method of long-range eclipse prediction related to the seasons of the year.” (Hawkins 1965, 144)



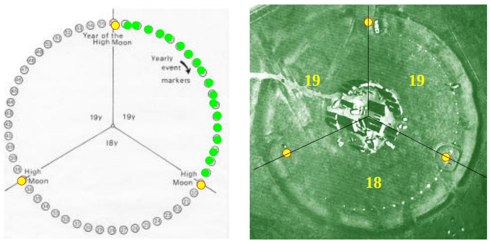


Fig 4. Hawkins’ Neolithic Spatial-Time Computer:
56 Aubrey *Holes* ≈ 19+18+19 *Years*
Records Extreme Moonrise/set on the Horizon
to Track/Predict Eclipse Seasons

Figure 4: *Drawing at left by Adamsan after Cleal et al. 1995 (http://en.wikipedia.org/wiki/File:Stonehenge_phase_one.jpg)*

56/3 & the Area of the Sarsen Circle (Phase 3ii, 2600 BC to 2400 BC)

Atkinson noticed that great labor was expended polishing the interior surface of the Sarsen Circle, while the exterior was left in its original rough state. “This polishing…now survives only on the inner faces of certain stones, such as the lower part of stone 10 (Plate IVA).… [T]he main concern of the builders was to produce a presentable finish on those surfaces which would be seen from the *interior* of the site. The best finish thus occurs on the inner faces of the uprights” (Atkinson 1956, 121).

Investigation as to why the extra effort was made to polish the Sarsen Circle interior led the author to an interesting finding regarding its geometry. Because the outside diameter (OD) of the Sarsen Circle is tangent to the Station Stone Rectangle (5x12 Ratio Units or RU), the Sarsen Circle OD equals 5 RU and outside radius is 2.5 RU (Figure 5).

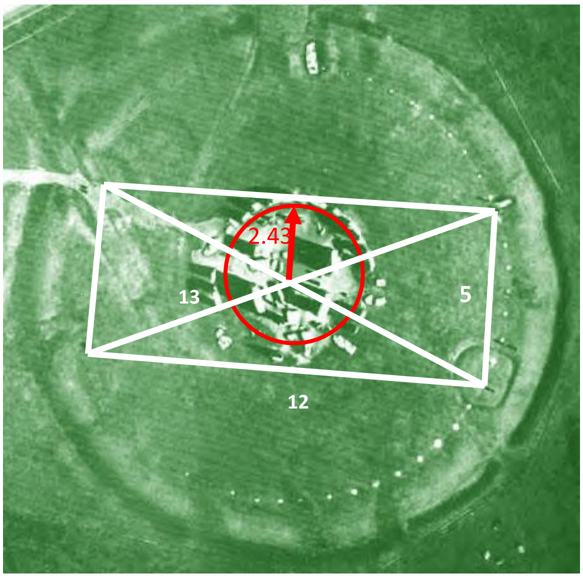


Figure 5: *Aerial Photo of Sarsen Circle, Interior Radius = 2.43 Ratio Units*

Photogrammetric analysis suggests that the average width of the Sarsen lintels is 0.57 Ratio Units and the interior radius is 2.43 RU. Table 1 calculates several Sarsen Circle interior areas for various ancient values of π. The upper bound value for π (22/7) used by Archimedes (c. 250 BC) produces the closest match to the ***Area*** (**18.6 RU^2**) using the modern value of π. While archaeologists may have no need for this numerical artifact, astronomers would point out the coincidence with the 56/3 = (19+18+19)/3 = **18.6 *Years*** of the Stonehenge Eclipse Cycle. It as if the architects of Stonehenge III literally carved their astronomical knowledge in stone.

Given: **Outside Diameter = 5 Ratio Units**

Average width of Sarsen Circle Lintel = 0.57 Ratio Units

Date	Culture	π	Radius (r) (Ratio units)	Radius^2 (r^2) (Ratio units)	Area (Ratio units^2)	http://en.wikipedia.org/wiki/History_of_pi#History Remarks
-1900	Babylonian	3.1250	2.430	5.905	18.5	Tablet c.1900-1680 BC: 25/8
-1650	Egyptian	3.1605	2.430	5.905	18.7	Rhind Papyrus: (8 x Diameter)/9^2
-800	Hebrew	3.0000	2.430	5.905	17.7	I Kings 7, 23; II Chronicles 4, 2.
-250	Greek	3.1429	2.430	5.905	**18.6**	Archimedes of Syracuse: 22/7
+1630	Modern	3.1416	2.430	5.905	**18.6**	To 39 digits

Table 1: *Sarsen Circle Interior Area (= π x r^2)*

59 & the Bluestone Circle (Phase 3iv, c.2550-1600 BC)

To date, British archaeologists have yet to agree on the exact number of stones in the Bluestone Circle (Figure 1). Excavations by Hawley (1924-28) and Atkinson (1954)

"…when plotted on a large-scale plan in combination with surviving stones, enable a new and far more accurate estimate to be made, of 57 stones with a possible error of one stone more or less." (Atkinson 1956, 38) "Atkinson in 1956 thought there had been 56, 57 or 58, but four years later he revised hid estimate upward, to 59, 60 or 61" (Hawkins 1965, 59). "They may have originally numbered 60." (Cleal et al. 1995, 29) "Atkinson, with the advantage of Hawley's excavations, estimated sixty, give or take a stone…. (North 1996, 430)

Pending a definitive Bluestone Circle count, perhaps the best estimate of the number of bluestones is the median (58.5) of the estimated range of 56 to 61. Therefore, one might reasonably estimate that there were either 58 or 59 bluestones in the circle. While neither numeral holds special significance for archaeologists, historians of astronomy recognize the integer 59 as the ancient approximation of paired lunar Synodic Periods (each 29.5306 days) which avoids fractions, viz., two alternating integers, such that 29 days + 30 days = 59 days:

"The strong possibility that there were fifty-nine blue stones inside the Sarsen circle would provide a more suitable means of representing… the 59 days of two lunar months." (Newham 1972, 47) "The numbers associated with the bluestone circle and the rings of Stonehenge II have not been definitely established by archaeologists at the present time. The current estimates for the stones in the bluestone circle are 59, 60 and 61. The first figure, of course, would give the best fit to the lunar month….a counting system that was known to exist in later eras elsewhere in the world." (Hawkins, 1973, 301)

Indeed, the "Double Month" of 59 days was well known in the ancient world, e.g., at the Sumerian city of Mari (modern Tell Hariri, Syria) c.1800 BC, grain allocations "were already reckoned on the basis of alternating 29- and 30-day lunar months." (http://cdn.preterhuman.net/texts/other/crystalinks/calendars2.html)

The Greek astronomer Geminus of Rhodes (c. 10 BC) records that Solon, Archon of Athens (594/3 BC), taught that, "The moon-year has 354 (= 12 x 29.5) days. Consequently they took the lunar month to be 29 ½ days and the double month to be 59 (= 29 + 30) days. Hence it is that they have hollow (29 day) and full (30 day) months alternatively, namely because the two-months period according to the moon is 59 days…." (Aristarchus c.250 BC, 287) The alternating 29- & 30-day month convention is still observed in both the modern Jewish (השנה הלוח *Haluach Hashana*) and Muslim (*Hijri*) calendars. http://stevemorse.org/jcal/mrules.htm.

Given the new light from ancient Greeks on the numerical artifacts encoded in Stonehenge's astro-architecture, one is lead to conclude, as did Professor of Mathematical Astronomy Douglas C. Heggie (University of Edinburgh), that "…the discoveries made in recent years about megalithic science demand a substantial or even radical revision of the archaeologist's standard picture of life and society in the late Stone Age and early Bronze Age" (Heggie 1981, 229). Therefore, archaeologists might well "have need of that hypothesis," as "the numbers have spoken and their message is quite clear" (Hawkins 2003).

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Comparison of Astronomical Instruments through the Ages

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Introduction

The Field of the Astronomical Instrumentation comprises a vast scientific territory for research, and at the same time serves as the Mirror of the Science of Astronomy, since it reflects the advance and the status of this particular branch of Science, and at the same time the rationale of performing Astronomy, in its philosophical and technological basis, as well as its place within the societies of the Great Civilizations, which followed after the Hellenistic and Alexandrian Renaissance. The realm of Observational Astronomy dates since the dawn of scientific thought, with its practices being conducted since the prehistoric times, and in all civilizations. The framework of Observational Astronomy requires specifically built instruments for the measurement of the orbits and apparent angular positions of the celestial objects (Toulmin S., Goodfield J., 1999).

The study of the Heavens serves at the same time many diverse and rich in number purposes, not necessarily restricted to the Astronomical purposes. Within succeeding generations of polymaths, the firm belief of a Universe structured and functioning as a Whole develops, so that the branch of Astronomy, as an exact Science, is always accompanied by her “sister”, Astrology, but also Medicine and Alchemy, and most surprising, with Music and Psychology (Bader, 2010). At the same time, the majority of the Astronomical observational instruments can be used, in their altered or modified forms, for Navigational, Surveying, and Geodetic or Chartographic, but also Geographical purposes, while the Astronomical instruments serving as automated computational devices can also be used for the casting of Horoscopes, for Calendrical purposes, and for the determination of Religious, or Social, festivities (Ben-Menahem, 2009).

Therefore, the study of the History of Astronomical Instruments does not only specify the development of the Science Astronomy, or the realms of the “Social Discourse” we already mentioned, but of most importance, it serves as a guide through a specific World-view, or Mentality towards Man and Nature, Man and God, Man within Society.

Initially, and before the genesis of the scientific mentality, a gift to our Global Cultural Heritage offered by the Ionian Renaissance of the 7th and 6th century BCE, these were marks on the horizon, becoming megalithic constructions (Kelley D. H., Milone E. F., 2005, 157-209).

These primal forms and ways of measuring and observing the celestial phenomena eventually transformed to portable, miniaturized, and complicated scientific instruments, such as the quadrants and the armillary spheres, or even the astrolabes. We remark that the technology used for the astronomical instruments of Observational Astronomy, and Astronomy in general, make this discipline a truly Cosmopolitan Scientific Tradition, but also the research concerning the various "phylogenetic forms" of the astronomical instruments serves both the study of the History of Science in general, and reflects the evolution of the Scientific Mentality, as incorporated in its various forms through the History of the Great Civilizations which were influenced by the Hellenistic and Alexandrian Spirit.

The Major Types of the Astronomical Instruments

We shall refer to the main phylogenetic types of the astronomical instruments, and particularly to the major types of astronomical instruments, as used from the era of the Hellenistic and Alexandrian Civilization, and up to the era of the introduction of the telescope for astrometrical purposes, that is up to the era of Johannes Kepler and Galileo Galilei. Many of these types become obsolete in their pre-telescopic form, and advance towards novel forms, especially equipped with systems of mirrors and telescopic lenses (Grego P., Mannion D., 2010).

These types of instruments can be considered to belong to three major categories, that is to the category of all kinds of the types of the dioptras, but also the various forms of the sextants, quadrants, and mural instruments, as well as the various types of the alidades, to the category of analogical computing devices, such as the astrolabe, the armillary sphere and the torquetum, and to the category of the special, hybrid in their nature, being both analogical and digital, computational devices, such as the Antikythera Mechanism.

The first broad category includes all astronomical, and also surveying, and navigating, chartographic, and geodetic instruments, whose purpose is to measure the spherical angles between two particular points on the sky, or towards their rising or setting above the horizon, that is directed towards specific points on the sky, or belonging in the environment of the observer, such as far away distant buildings for example (Kelley D. H., Milone E. F., 2005, 49-83).

The measurement of the specific angles on the sky, whether these could be the Sun, the Moon, the five planets visible by naked eye, that is Mercury, Venus, Mars, Jupiter and Saturn, as well as the fixed stars, and the various constellations, and their variability with the passage of time, that is the planetary orbits as observed from the system of reference of Earth, or the succession of the visible stars during the passage of the Seasons, offered the only accessible background for the Astronomers of all ages for studying the celestial phenomena, for devising and confirming their Astronomical Models, and for offering a sound foundation for their Astronomical, and Cosmological, Paradigms (Dicati R., 2013).

Here, we can mention all these astrothetical calculations, whose main purpose, along with the other uses, for example the social ones, say for determining the direction towards the Kabaa in Mekka, the so called Qibla, which served for the confirmation and the long inner metamorphosis of the Ptolemaic Astronomical and Cosmological Paradigm, to which slow and continuous development all the great Arabic and Islamic Astronomers contributed by the use of the most accurate astronomical instrumentation of their times (Smith J. A., 2008).

Two such outstanding figures are the famous polymath Al-Biruni (Yanno M., 2007) and Nasir al-Din al-Tusi (van Brummelen, 2007), which together with Ulugh Beg, (van Dalen, 2007) contributed greatly to the use of advanced astronomical instruments, and to the composition of the most accurate astronomical tables and ephemeredes of their age.
One excellent introduction to the various subcategories of the astronomical instruments belonging to the first category, that is the types of the alidades, the dioptras, the parallactic instruments, the sextants, the quadrants, the mural instruments, as well as their status of perfection, their various forms and combinations, together with a survey of their technical details, in the transitory era between the Renaissance and the Baroque, can de readily found in the emblematic work of Tycho Brahe, the European Giant of Observational Astronomy, the so-called "Instruments of the Renewed Astronomy" (Brahe T., 1602). This epitome of Observational Astronomy marks the pre-telescopic era of Astronomy, and expresses in a nutshell all the accumulated and acquired Astronomical Observational Knowledge, from the Hellenistic and Alexandrian era, the Byzantine, the Arabic and Islamic, and the Medieval and Renaissance European epochs.
The second category refers to the astronomical instruments which are used for computing purposes, away from the tedious and enormous calculations based on the values of the chords, or the sines and cosines, of the corresponding angles of the celestial bodies within their daily, monthly or yearly dance along the sky. These instruments, with prominent place given to the various forms of the Astrolabe (Neugebauer, 1949), but also the Torquetum (Lorch R. P. 1976), enables even for the layman to observe, measure and determine various angles, or sides of spherical triangles in a most immediate way, and thus deduce many important astronomical information, that is the easy solution to problems such as finding the time of the day, finding the time of a celestial event, finding the declination of the studied celestial bodies, determining the Qibla, determining the rising and setting times of the stars, the planets, the Moon and the Sun, their meridian passage, and study all these observed and measured quantities using astronomical ephemeredes and tables.
To this category also belongs not only the Torquetum, but also the Armillary Sphere Grego P., Mannion D., 2010), where the geographical position of the observer, as well as all the various spherical angle positions of the celestial bodies on the sky, are immediately interconnected with the various types of astronomical coordinate systems, and in particular for the transition of the horizontal, equatorial and ecliptic coordinate system, as performed analogically by the use of the mechanical parts of these astronomical instruments. All of the instruments belonging to this specific category can also be used for demonstrative and educational purposes, as they offer a means of visualization of the celestial events, as well as the interplay between the various astronomical coordinate systems, and the actual meaning of key astronomical concepts, such as the meaning of the ecliptic, the equinoctial, the ecliptic, the solstitial and equinoctial colure, the tropics, and the immediate reproduction of the celestial dance of astronomical objects.
By the relevant comparison we also remark again the social dimensions of the Science of Astronomy, and especially the usage of the Astrolabe during the acme of the Arabic and Islamic Civilization, for religious purposes, that is for the organization

of the times of the five daily prayers, and the determination of the Qibla (Ilyas M. 2008), where Man bases his efforts on Reason in order to achieve his virtuous approach towards his Maker.

The third category refers to the most surprising aspect of the astronomical instruments, whose major representative is the Antikythera Mechanism (Freeth T. et. al. 2006, Papathanassiou 2010, Moussas et. al. 2012). Here, we observe an analogical – digital computing device specified for reproducing the path of the orbits of the Moon, and the five visible planets by naked eye, while the user of this most complicated instrument can also determine with the greatest accuracy the exact date of the solar and lunar eclipses, while it can also be used for calendrical purposes, for example for the determination of the day of the major athletic and social festivities, including for example the determination of the Olympic Games, or the Nemean Games.

This computing device comprises the heart of the Hellenistic and Alexandrian Civilization, and is the example of the establishment of a primal form of Cybernetics and Automation within the context of this civilization, a mental step towards a novel Self-knowledge of Man within Cosmos, a working and inventing individual whose main purpose is to understand and reproduce according to the Laws of Nature, and also according to their Mathematical Description, by the use of sophisticated Technology and Machinery.

These accomplishments have never been surpassed, with respect to the novel World-view they incorporate and develop, although all the abovementioned Great Civilizations that followed contributed greatly to the improvement of the partial parts of this specific “Noospheric Construction”, especially the Arabic and Islamic Civilization during the Golden Age of the Abbasids.

This third category serves as a new Paradigm in the realm of Scientific Technology, and especially in the Astronomical Technology, or to be more specific, in the history of the Astronomical Instruments. For the first time in the History of Technology, so many Scientific and Technological branches combine their efforts in order to produce an Artifact that places Man as an equal, or at least, “enlightened” Person together with the Gods, or with the God, and along the Heavenly order he firmly believes.

In many cases, we observe the manufacture of combined types of Astronomical instruments, such as Arabic and Islamic, or even European, astrolabes with gear mechanisms placed within their body.

The main “phylogenetic types” of the astronomical instruments already appear during the Hellenistic and Alexandrian era, but also continue to be developed and enriched, both in their functional availability, as well as in the perfection of their form, through their course in History, up to the era of the introduction of the Telescope for astronomical purposes.

Many of them, in particular the instruments belonging to the first category, remain intact, but also altered, with the introduction of telescopic devices and mirrors, as incorporated within their main framework. This advance is always accompanied by the great efforts of the Science of Optics, and paves the way to the Age of Sailing, and the expansion of the Western European Civilization across the Globe.

Reflections on the Use of Astronomical Instruments

The use of Technology in general, and of the various forms of Astronomical Instruments in particular, carries with itself the scientific application, the philosophical considerations of the user of the instrument, as well as his social role. We remark that all the major types of the astronomical instruments introduced and invented within the Hellenistic and Alexandrian period continue their use in the forthcoming Great Civilizations, that is the Byzantine, the Arabic and Islamic, and the European Civilization, without major modifications, but surely undergone many improvements through the historical time of their existence.

We could propose that the Hellenistic and Alexandrian period served as a kind of Noospheric Revolution, within the History of Civilizations, and within the development of Epistemology in its various forms (Holberg J. B., 2007). The branch of Epistemology was considered to be integrated within all the other branches of Philosophy, for example with Metaphysics and Theology, and was not studied exclusively for its own sake, while at the same time, Philosophy, Physics and Mathematics were studied as a Whole, with Technology playing the role of their servant, and at the same time, of their promoter.

Within this period the scientific rationalism acquires its purest form, and seeks methodologically for the invention or improvement of astronomical instruments, for the advance and the development of the particular scientific branch. In the Hellenistic and Alexandrian period all the Sciences flourish, but not only in general, and overall. Each scientific branch begins to grow both in the acquisition of the relevant scientific data, in the novel technological means for the evaluation of the scientific data, in its methodological core, and in its philosophical aspect, that is its concept about Cosmos, Nature, and the place of Man within (Ben-Menahem, 2009, 5081-5986).

This can be readily seen by inspecting the inventors and the users of the most advanced Technology of their epoch, whether these polymaths belong to the scientific tradition of the Hellenistic, the Byzantine, the Arabic and Islamic, or the European Civilization. These great scientists, for example Hipparchus of Rhodes, Ptolemy of Alexandria, Gregory Chioniades, al Farghani, Omar Khayam, and Tycho Brahe, shared a common mentality, and a specific World-view, about the state of affairs between Man and Cosmos, and the use of rarefied technological means in the service of the Science of Astronomy, and for unraveling the secrets of Nature.

Surely, all these succeeding generations of scholars, polymaths, and astronomers belong to diverse Cultural Traditions, and the use of the astronomical instrumentation served for many different needs and purposes, according to the social background and the placement of Astronomy, of each of these Civilizations, but they all share a common rationale.

This common point of reference, so eloquently stated by the great Archimedes, in his famous phrase "give me the firm place to stand, and I shall move the Earth", refers to the mentality of an inquiring mind, whose opinion about the Cosmos follows rationalistic paths towards the understanding of the World, that is the capability of the Human Intellect of understanding a comprehensible Cosmos, perhaps related under the Light of a most Wise Demiourge, armed with his intellect, and especially with the foundation and the methodology of the Scientific Discourse, that is with the

need of the most methodological and most accurate scientific measurements, therefore under the need of the most advanced scientific instrumentation.
This instrumentation is not found within the embracement of Mother Nature, it is not given as a spiritual understanding about Cosmos, and by the hands of the Gods, or God, rather it is absolutely Man-made, and based on his own intellect, on his own power for Rationality, for describing Nature by the appearance of Physical Laws, and their mathematical description, and by the invention of mechanisms which “sharpen the human eye”, and tame the Forces of Nature for Man’s benefit. Nature, Man, and Society begin to co-evolve in a teleological and synergistic way, and this particular framework of Thought and Invention, as offered to Humankind during the Scientific Revolution of the Hellenistic and Alexandrian era, is saved through the Ages by the corresponding Bibliosphere (Netz R., 2011), as well as the contribution of the many scholars and polymaths which could understand, but also accept, its fruits, and even more important, its mentality, and could propagate as a tight system of Memes (Buskes, 2013) through all the Great Civilizations that followed.
Within this sound Memetic structure belongs the mentality of the need and the usage of sophisticated astronomical machinery, the understanding of the reasons for using and developing even further the pre-existing corpus of the Astronomical Instruments, that is to say their “Comparison through the Ages”. We refer to the corpus of the Memetic Structures developed and inherited to the Global Civilization, whose birth took place within the framework of the Hellenistic and Alexandrian epoch.
Of most importance, that is referring to the basis of the whole undertaking for Man to describe, measure and understand the Universe, and his Self-knowledge within Cosmos, is the Scientific Mentality, as being developed by ambitious scholars and polymaths, which combines the forehand knowledge of Physics and Mathematics, as well as a certain Philosophical attitude for explaining the Natural Phenomena (Recchia-Luciani 2012).
Of second importance, as especially regarded for the Science of Astronomy, is the construction and the permanence of a most successful Astronomical and Cosmological Paradigm, the Ptolemaic Geocentric and Geostatic System about the Universe, an emblematic Theory which combines at the same time philosophical beliefs, sound scientific arguments, and a specified Observational Methodology, serving as the “Philosopher’s Stone” for all the generations of Astronomers, and up to the age of Johannes Kepler and Galileo Galilei (Pedersen O., 2011). These succeeding generations of polymaths had as one of their main scientific concerns the justification of the Ptolemaic Paradigm through the use of the most elaborate and accurate astronomical instruments of their times, since only a most profound astronomical instrumentation could provide the most detailed astronomical observational data within the struggle of their purpose.
Of third importance is the whole Scientific Mentality about the systematic use of the astronomical instruments, as well as with their improvement in form and function, and also the innovation of more advanced forms, capable to serve at the same time many practical purposes, and not being restricted to the astronomical ones. This specific Mentality requires an advanced level of Technology, and a specific World-view about the use and the nature of Technology, especially as being incorporated

within the Social structure, and as serving not only Scientific, but also Social needs (Russo L. 2004).

This is the Mentality of the rational Man, who becomes the Demiourge of his own World, can be seen within the History of the appearance and the development of the Astronomical Instruments, and within the passage of time, becomes a driving factor for the arrival of the Age of Enlightenment, the Age of Sailing, as well as an precursor of the Industrial Revolution.

This last remark guides us to the conclusion that the History of the Astronomical Instruments through the Ages can serve as a mirror of ourselves, where we reflect and recognize our Cultural Past, our Global Heritage, but also become aware of the spiritual foundations of our Modern Civilization. These foundations can already be found within the study of the History of Astronomical Instruments, and the results of such a study may shed light on our post-modern perception of Nature, Man and Society, as they develop on their course towards the 21st century.

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The Tools of Research and the Craft of History: On the Interaction between Historians, Their Tools, and the Creators of Those Tools

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This symposium is meant to explore the research culture of historians of science, technology, and medicine (STM), paying close attention to both the open repositories and tools of research that are available, the curators and creators of those repositories and tools, and the differential access to them. The standard model of research throughout most of the twentieth century centres on research libraries and institutional archives as sites for scholarly work, physical locations where researchers must come in order to find the information that they need. With the increasing development and use of digital resources, scholarly work habits are changing radically. One popular model for the distribution of both research tools and repository content is open access, in which both research sources as well as research tools are disseminated in digital form free to all. Another model relies on proprietary, and often costly, subscription-based services that maintain local site-based control over resources as long as the local sites can afford them. In contrast with the traditional place-based model, the digital information revolution has both advantages and disadvantages. The purpose of this symposium is to assess some of the ramifications for scholars in this digital revolution.

Institutionalisation of an Open Access – a New Possibility for Research. A Survey of Perception and Demand

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Context for Open Access

Legal

The idea to open sources for users was common among libraries generally. The solutions were taken either by separate libraries, or by joint consortiums, academic communities. Once at a small but lively meeting convened in Budapest by the Open Society Foundations (OSF) on December 1-2, 2001 the idea of open access was discussed. The purpose of the meeting was to accelerate progress in the international effort to make research articles in all academic fields freely available on the internet, and the initiative become known worlwide as Budapest Open Access Initiative (Budapest Open Access Initiative http://www.budapestopenaccessinitiative.org/background) . The initiative was followed by a Bethesda Statment on Open Acces Statment (http://legacy.earlham.edu/~peters/fos/bethesda.htm) in 2003. Initiative to open access to documents virtually was given an international attention, when a declaration was announced in Berlin, it was written in English language, later translated to other languages. The "Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities" (22 October, 2003), it is one of the milestones of the open access movement.

The documents, mentioned above, goals to disseminate scientific knowledge by the mean of open access. Such acts require active commitment of a producer of scientific knowledge and holder of cultural heritage. Open access contributions include original scientific research results, raw data and metadata, source materials, digital representations of pictorial and graphical materials and scholarly multimedia material.

(Berlin declaration
http://oa.mpg.de/lang/en-uk/berlin-prozess/berliner-erklarung/)

The international legal initiative for open access had impact on local policies of research and academic institutions: the regulations for open access to reseach data became more accepatble withing institutional statutes.

NGO

All around the world libraries joined non-government organisations (NGO) and consortiums to unite forces in acquisition matters, later – in database subscription issues. The practise of "country licence" works very well not only for libraries, but also for other institutions of a country. Electronic Information for Libraries (EIFL, established in 1999) is an international not-for-profit organization dedicated to enable access to knowledge through libraries in more than 60 developing and

transition countries in Africa, Asia, Europe and Latin America. The unit on open access at EIFL strives to remove barriers from commercially published research information, promotes open access for knowledge sharing. (EIFL http://www.eifl.net/openaccess). EIFL supports and provides expertise on open access policies and practices (open access journals, open access repositories, open access books, open data and open educational resources) for libraries and other institutional members.
The eIFL-OA Program is aimed at accomplishing several objectives:

- building a global network of Open Repositories and Open Access journals;
- providing training and advice on Open Access policies and practices;
- motivating library professionals, scientists and scholars, educators and students to become the Open Access advocates and bring these ideas into practice.

Political
The open access initiatives became the object for the European Commission, as a part of several programmes. In the Press release of 17 July, 2012 was stated: „(...) As a first step, the Commission will make open access to scientific publications a general principle of Horizon 2020, the EU's Research & Innovation funding programme for 2014-2020. As of 2014, all articles produced with funding from Horizon 2020 will have to be accessible: articles will either immediately be made accessible online by the publisher ('Gold' open access) - up-front publication costs can be eligible for reimbursement by the European Commission; or researchers will make their articles available through an open access repository no later than six months (12 months for articles in the fields of social sciences and humanities) after publication ('Green' open access). (...) The European Commission will continue to fund projects related to open access. In 2012-2013, the Commission will spend €45 million on data infrastructures and research on digital preservation. Funding will continue under the Horizon 2020 programme“ (Open Access, 2012 ; Open Data, 2012).

Questionnaire for historians of science
Scholarly communication during last decades moved to digital formats and the tradition of scientific contacts faced a great technological challenge, including the archiving practices to document it for the future investigation. One of the most discussed items among librarians and information specialists is open access and institutional repositories, not doubting their role in the future of scholarly communication as a mean to foster dissemination of scholarly information and preserve scientific heritage.
The idea to investigate the research culture of historians of science, paying close attention to both tools of research and access to them was committed in a questionnaire. After presenting the common description of institutional repositories and open access, the channels for scientific communication by preference were listed in the questionnaire also.

We started the questionnaire introducing the open access, and giving the glossary of terms we used for survey (Open Access, 2012):
Institutional repositories – are digital collections of the outputs created within a university or research institution. Whilst the purposes of repositories may vary (for example, some universities have teaching/learning repositories for educational materials), in most cases they are established to provide Open Access to the institution's research output;
Open Access – free access to research output: articles, conference reports, doctoral dissertations and theses, other published or unpublished materials. The development of open access enhances opportunities to disseminate the results of research, ensure their worldwide visibility by providing members of the academic community with extensive access to global scientific resources;

In the contexts of the ways scholars use to retrieve latest scientific information the universal system of search (i. e. Google) were given 86 %, informal meeting with colleagues – 71,4 %, scientific events (conferences, book presentations) – 57 %. Among the ways to retrieve full-text documents open access databases were given 71 % answers, the universal system of search (i. e. Google) was given 100 % answers. The responses from the small community of historians of science gave general only ideas on the perception and demand of open access, though the more exact results require more extensive survey.

Conclusions

- Benefits of OA (vs close access) is determined by information search literacy, also by technical readiness, strategic and political determination at personal, instututional and state level;
- Information management is developing all the time. OA eliminated vasting of time to access, but created information redundancy. OA should be related to relevancy and realibility of information;
- Institutional attitude to OA raise a scientific level, empover dissemination and optimise use of scholarly information.

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New Perspectives on Classification and Methodology in History of Sciences: Theoretical and Technological Bases for the Construction of Adequate Search Instruments

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Funded by the São Paulo Research Foundation (FAPESP 2011/14040-9) and the National Council of Scientific and Technological Development (CNPq 474061/2010-8).

Centre Simão Mathias for Studies in the History of Science (CESIMA) at Pontifical Catholic University of São Paulo (PUC-SP) was founded in 1994 as the first Latin-American research centre specialised in the history of science. However, a major obstacle hindered CESIMA goals, to wit, the primary sources for the history of science are not renewable goods, whereas the lion's share of the sources needed was (and still is) hosted by libraries and research centres in Europe and the United States. Therefore, without travelling to such locations, a Latin American scholar could not expect to develop a promising career except in the history of local science. For this reason, the first task of CESIMA was to establish a Digital Library comprising digitised versions of primary sources.

Our collection currently comprises more than 30,000 titles in all fields of science from antiquity to the present time. The items were acquired as microforms, which were then digitised, or in original digital format. Documents include: books, correspondences, laboratory notebooks, meeting records, memoirs, personal notes, maps, images, journals, dictionaries, and encyclopaedias, among others.

The technical issues related with digitisation, storage, and server access are well advanced. However, a serious problem hinders the completion of this project, namely, the criteria for indexing and cataloguing the collection to allow users locate and retrieve the items they need. The systems available are not well suited to history of science, as they lead to serious distortions and anachronism. In addition, the so-called "digital revolution" made this problem even more acute in the last decade, as access to information increases exponentially, whereas the search engines available lack the specificity needed for scholarly research in history of science.

We addressed these issues at an international seminar CESIMA hosted in 2008, where indexing and cataloguing were a focus of particular attention. Discussions continued the following year at the meeting of Committee of Bibliography and Documentation (CBD) of International Union for the History and Philosophy of Science (IUHPS) at Budapest, and at a two-session special round table conducted at the Annual Meeting of the History of Science Society, in Phoenix. Further discussions with the members of project World History of Science Online (WHSO) led us to submit a proposal to the Brazilian National Council of Scientific and Technological Development (CNPq). Coordinated with WHSO, this project aimed at developing theoretical and methodological tools for search engines adequate to the specific needs of historians of science. It is worth to observe that this call was massive, and ours was one among the only eight projects in the Humanities approved. Analysis of some specific topics, namely the so-called trees of knowledge, is also a relevant part of our latest five-year project funded by the São Paulo Research Foundation (FAPESP).

For the last two years, CESIMA staff, which includes science historians, librarians, bibliographers, postgraduate students, and specialists in information technology (IT) worked very hard. Activities included regular meetings for discussion, and thorough analysis of the literature on indexing and cataloguing. Also workshops and seminars were conducted, with the participation of reputed specialists in information science. Based on some pilot tests, initially our project aimed at the inclusion of history of science in the Universal Decimal Classification (UDC). We were particularly interested in Class 4, which is vacant, and that we believed could be attributed to "Interdisciplinary Areas", history of science among them. However, the conclusion of the specialists who advised us, including a representative of the Brazilian UDC office, was that we should apply for history of science as such to be attributed Class 4.

This option, however, would not solve two major problems: 1) the singularity of the documents with which historians of science deal; and 2) the intrinsically interdisciplinary nature of history of science, which the model developed by CESIMA characterises as comprising three spheres of studies, to wit: 1) a sphere proper to documents themselves, and the analysis of the ideas they contain (epistemological sphere); 2) the sphere corresponding to the specific historical-social contexts in which such documents were produced (socio-historical sphere); and 3) a sphere that links the former two together, as it addresses properly historiographical aspects (historiographical sphere) (Alfonso-Goldfarb 2004).

This threefold approach led us to identify a series of problems. Specialists agree on that one of the major challenges posed by interdisciplinarity is the language common to the members of a research team, or to an interdisciplinary field as a whole (Gnoli 2008; Debus 1991; Kuhn 1997). Then, even were an adequate controlled vocabulary to be elaborated, we do not know whether it would truly solve the problem posed by the documents proper to history of science. For instance, would a controlled vocabulary represent accurately the meaning the words used to designate the various fields of science had along history? Some major libraries prudently elude this issue, and add qualification "before 1800" to such fields.

At this point, we had no choice but to revise the available systems of classification. Among them, the Colon Classification, formulated by Indian mathematician S. R. Ranganathan (1872-1972),[1] seemed the most suitable to our needs. However, we were also aware that it had a problematic history, as it is too cumbersome to be

[1] Ranganathan prepared six editions of the Colon Classification, which describe the proper structure of the system; the seventh edition, edited by M. A. Gopinath, was posthumously published in 1987 (Ranganathan 1987).

applied in traditional libraries, i.e., to define the place of a book on a definite shelf, while the string of words required to represent the main facets is quite long. Both factors contributed to discourage the use of the Colon Classification, except for a few niches (Vickery 1960).

Faceted classification had already been discussed within the field of history of science. More particularly, Magda Whitrow sought to create a cumulated bibliography for journal *Isis* serving the specific needs of historians of science (Weldon 2009). After reviewing past classification schemes, she realised that George Sarton (1884-1956), the founder of *Isis*, had actually elaborated a true faceted system (Whitrow 1964). Facets are the various qualities of a subject, and they allow for standard subdivisions within a scheme. She defined three facets that taken together, would identify the location of any bibliography: 1) subject and civilization; 2) discipline; and 3) aspect or bibliographic form (Whitrow 1971).

However, as Stephen Weldon pointed out, her system could not keep abreast of the fast development of the topics of interest in history of science, in particular, cross-cultural interactions and interdisciplinarity (Weldon 2009).

Those problems notwithstanding, we surrendered to the Colon Classification, due to two main reasons, to wit: the inclusion of interdisciplinarity as a major element of the system, and the notion of interdisciplinarity Ranganathan employed.

Ranganathan acknowledged that since the end of World War II, interdisciplinary subjects had emerged as an antidote to increasing specialisation (Gnoli 2001). *Loose assemblage* and *fusion* are the first and last stages, respectively, of interdisciplinarity subject formation. Loosely assembled subjects are complex subjects, such as “Psychology for nurses”, or “Law for social workers”, in which two subjects from different disciplines are brought together on *ad hoc* basis. When this *ad hoc* relationship solidifies irreversibly into a new subject, the result is fusion (Satija 2001, 202). “Biochemistry”, “geophysics”, and “nuclear medicine” are examples of basic subjects formed by means of fusion.

Later on, Ranganathan isolated three further modes of subject formation: an *agglomeration* is a cluster of neighbouring subjects bearing a generic name, as e.g., “natural science”, “physical science”, “bioscience”, “medical science” (Satija, 2001, 202). They are formed as a function of the affinity of their subject content, or of a common research methodology. *Distilled subjects* are seemingly unitary subjects formed through the distillation of mature feedback and experience among many subjects, as e.g. “management science”. Finally *subject bundles* are *ad hoc* loosely assembled, multidisciplinary, mission-oriented, and highly practical subjects. Some examples are “ocean sciences”, “space science”, and “West Asia studies”.

According to Ranganathan, classification means mapping out the multidimensional universe of objects along a sequence, i.e., a sentence, for which formation he described some rules (Ranganathan 1967, RA1[2]), i.e., the sentence syntax. The problem that remained to be solved concerned the words to be used in this true new

[2] Ranganathan expounded his thought in several writings. To make easier for readers to follow the unfolding of, and changes in his ideas, instead of numbering the pages of his books, he divided them in topics and subtopics (indicated by letters) and paragraphs (numbers). Thus, here RA1 means: Section R (Part), Subsection A (Chapter), paragraph #1.

language, i.e., its semantics, as Ranganathan points out, the number of available isolated ideas and objects is virtually countless, and thus, impossible to manage (Ranganathan 1967, RA2). The solution he proposed was to identify the relationships between individual ideas until reaching the ultimate and irreducible ones, which consequently he named as "fundamental categories", being five: personality [P], matter [M], energy [E}, space [S], and time [T], forming the acrostic PMEST (Ranganathan 1967, RA3, RA81, RB1). While categories space and time do not require further elucidation, energy represents action, matter, material properties, and personality, the distinctive features of an object (Ranganathan 1967, RB71). Let us see some examples (Tables 1 and 2).

Alcohol – *kind* of chemical substance.
Liquid – *state* of that substance.
Volatility – *property.*
Combustion – *reaction*.
Analysis – *operation* performed by man.
Burette – *device* for carrying out an operation.

Table 1: *Alcohol - facets*

This example was provided by Vickery (1958), who explains: "Six italicized terms are characteristics of division by which the terms are derived from the class Chemistry. Each of these characteristics can give rise to its own family tree of terms". How would those characteristics be attributed to the substance known as alcohol in the 1600s?
According to a 17th-century dictionary (Blancard 1684, 9), "Alcohol, is the purer substance of any thing separated from the impurer; it signifies also most subtil and refined dust; and sometimes a most highly rectified Spirit, in so much that if it be set on fire, it shall burn all away without any dregs or phlegm at the bottom". Therefore, at first sight, term "alcohol" was attributed to a set of materials also including a very subtle powder, although the alcohol from wine is also there. Combustion was not understood as a "reaction"- as that notion did not exist at that time, due the different conception of matter then held. But "being combustible" was, indeed, a property of alcohol.

Celestial bodies (star, comet, planet, etc.).
Their parts (axis, tail, surface, etc.).
Systems of bodies (galaxy, constellation, etc.).
Properties of bodies (size, temperature, etc.).
Properties of systems (e.g. distribution of stars).
Motion of bodies (orbit, rotation, etc.).
Interactions between bodies (parallax, eclipse, etc.).
Operations (e.g. spectroscopic observation).
Tools (e.g. telescope).

Table 2: *Astronomy - facets*

To be sure, those terms, listed by Vickers in 1958, associate with the present-day science of astronomy, and thus, are characteristic of the work performed within that field. However, if we were to study “Astronomy before 1800”, we would not find those ideas necessarily reflected in the documents. The first and most visible discrepancy is the presence of astrology side by side with astronomy at some particular periods of time, and eventually merging with it, as they were complementary, i.e., astrology was the study of the stars, and astronomy the study of the stars’ motion.
In turn, astrology is also discussed in medical documents, leading us to consider: 1) diseases, their causes, and cure; 2) physiology; 3) the materia medica; 4) the preparation of remedies; 5) botany, and so forth. In addition, we must bear in mind that each and every of such terms might also have meant something different than they do today.
A second blatant discrepancy relates with the notion of heavenly bodies and systems, which was entirely different in the older astronomy, besides the fact it underwent countless variations at least up to the 18th century.
Currently, there are two solutions to that problem: 1) an excellent thesaurus is available at the website of Isis Current Bibliography (http://www.ou.edu/cas/hsci/isis/website/thesaurus/); that thesaurus was elaborated specifically for the history of science, is flexible, and allows for further additions; 2) requests can be made to specialists in the various fields corresponding to the history of science to characterise documents or sets of documents. This is what Ranganathan’s followers did relative to the classification of science.
To conclude, with the application of the faceted model, the organization of knowledge no longer is a mere taxonomy of disciplines, but incorporates the patterns of thought and behaviour of a definite human society inserted in a particular crossroads in space and time. While the discipline-based system fitted well with the traditional models of knowledge, and distribution of books across material shelves, the faceted approach crosses over disciplinary boundaries, and admits virtual support, thus fitting with our informational society as a glove. It is worth to stress that although history of science is an interdisciplinary field of studies by nature and origin, its organization followed the discipline-based model up to the present time, while material shelves seemed the natural locus for its working materials.
CESIMA staff is currently developing specific software and feeding a database to run the initial pilot tests, the results of which are expected to be available by the first semester of 2014.

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The Culture of Research in History of Science as Seen through the Transformations of the *Isis* Bibliography in the 20th and 21st c.

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I want to call your attention to this photograph that I took the other day from the roof of my hotel. This image of Athens illustrates something that I think is important to keep in mind. We are all historians here, and although we continually spend our time thinking about the way that historical forces change our subjects, we don't always have the same perspective about how historical forces change us. This photograph shows the city of Athens remarkably changed by the twenty-first century. The ancient Acropolis rises above the modern city. In the foreground, a billboard advertising modern apparel. There are dish antennas on the roof that situate us clearly at the beginning of the new millennium.

But this picture is more than simply an image about change over time, it is a snapshot of how the world has come to be populated with the historical remnants of the past. The Parthenon remains dominant in this city, albeit its nature has entirely changed from classical times.

The past remains with us alongside the present, and it continues to inform the present in important ways. The image of a city with its past and present intertwined is the metaphor for this paper. It helps us think about the radical transformation of our scholarly world currently taking place, namely the digital revolution. We tend to focus on the transformational aspects, but the digital revolution is not an entirely new place: it exists as part of a culture with a deep past, transforming it, to be sure, but also deeply affected by it.

The past is continually refurbished in the present, and that keeps that past alive alive in the modern world. This next photograph shows a workman sanding a repaired area on a stone column in the Parthenon. He is standing on metal scaffolding and using an electric grinder, and these allow him to do the work of preservation. Modern equipment makes it possible to keep the past prominent in our world.

As I discuss the development of history of science, keep in mind this metaphor that old ideas and forms are often consciously maintained in order to make them do work for the present. We historians are doing the same thing as the workmen on the Parthenon.

Scholarship as we know it today has its roots in the distant past, in the medieval universities where texts were translated, copied, and maintained primarily in monastic libraries and later universities. Individuals would have some access to books, of course, but not until the advent of printing was there anything like the kind of scholarship that we encounter today. The flood of information that arose with relatively inexpensive book production resulted in a type of anxiety that we find all too familiar: "the information glut."

Though we tend to associate this information glut with the 20th century, historian Ann Blair has shown that the anxiety was prevalent in earlier days when people compared their feeble brains with the totality of accumulated writing and complained of “too much to know”—which is the wonderful title of her book. (Indeed, this feeling seems to go far back in history. Blair documents it in ancient and medieval times across several literate cultures, Greek, Arabic, and Chinese.) (Blair, 2010)

The problem of “too much to know” became particularly acute when publishing made more and more literature accessible to scholars, making it harder and harder for one person to both find and recall the mass of textual material that existed. So various kinds of reference works came into existence, from encyclopedias, to compilations of book excerpts, to indexes and classified listings of books. Thus, was born the reference book as a partial answer to the overabundance of literature arising from the printing revolution.

A creature of demand, these books were produced by scholars who would then send their compilations to publishers. The result was a growing industry of quick reference guides that would help scholars get at the hard-to-find and hard-to-remember material. In these early days, these reference books were, according to Blair, mostly used by scholars, often times surreptitiously.

The early years of reference books contrast markedly with the conditions of modernity in which we find a very different constellation of players and a new set of values governing the rise of scholarship. In the nineteenth century, bibliographies became standard tools, integral to the process of research and documentation. No longer did scholars simply use these books to take short-cuts through major works of literature. Now bibliographies were means of regularized discovery in themselves. (James, 2000; Lowood & Rider, 2000)

Probably the most important aspect of this new outlook was the re-centering of scholarship as part of professionalized disciplines. Professionalization and disciplinary formation created conditions in which different areas of research were divided from one another. Specialization was a central component of this new culture. One way to think about specialization is to consider it as something that can help people deal with the modern information glut. With specialization, professional scholars could focus on a small set of literature so that they could more easily master it.

This newly professionalized environment had several features. First of all, it was institutionally situated primarily in universities. This was a period in which the university and the research institute were coming into their own as the centers of what we might call “scientific culture.” Second, professionalization came with a particular ethos. Max Weber defined this ethos in a widely reprinted work called “Science as a Vocation,” in which he explained that professionals were to be disinterested scholars. In their professional work, they were to be disconnected from the political and social world. (Abbott, 1988; Corfield, 1995; Perkin, 2002; Sullivan, 2005; Weber, 1946)

The study of history of science was consolidated into a real discipline at this time. The Belgian scholar George Sarton was one of the most important men in this movement to make history of science a discipline. He understood that for a

discipline to form, it had to have certain support structures. So he invented these structures. He founded the journal *Isis* and he established one of the first bibliographies of history of science. The development of history of science as a discipline was thus closely connected to a very particular type of reference work, namely the bibliography. (Sarton, 1913a, 1913b, 1913c) It is worth noting that there were at least four major bibliographies arose at about the same time as *Isis*. Indeed, Sarton's work was not even the first. (Kaiserlich Leopoldinisch-Carolinische Deutsche Akademie der Naturforscher & Deutsche Gesellschaft für Geschichte der Medizin, 1902; Josephson, 1911; Sarton, 1913a; Mieli, 1919; Sarton, 1952)
The rise of the discipline took place within the context of social shifts and the production of scholarly tools. The fact that a series of reference tools was available for finding material in the history of science both reflected a desired need to have such a tool, and it helped to unify those people who found this work relevant.
One other thing is important to note. The academic world came to embody a cosmopolitan and internationalist spirit in the first half of the twentieth century. Scholarship since the middle ages had been an international project, with students from all different countries coming to the medieval universities, but in the twentieth century internationalism entered into the profession in a new way. It was perceived as a scientific value, good in itself, and it was believed to be an outgrowth of science. (Crawford, Shinn, & Sörlin, 1992; Greenaway, 1997; Gregory, 1944; "The Members' Vademecum," n.d.)
The idea that science could transcend national divisions brought it into the forefront of international politics. As an example of this, a number of important scientists were appointed to head major international programs like the World Health Organization and UNESCO. There is a wide literature on scientific internationalism. My claim is that this internationalism transcended scientific communities proper and influenced scholarship more generally. One can see this especially clearly in history of science.
As new international scientific organizations sprang up in the middle part of the twentieth century, so too did international history of science organizations. I've mentioned the History of Science Society. In addition, there was an International Academie d'Histoire de Science founded by Aldo Mieli in 1929. (Sarton, 1952, p. 255) In the decade or so before the Second World War, there were four international history of science conferences. And after the war the International Union for the History and Philosophy of Science was formed. IUHPS was and is still a member of the International Council of Science (ICSU). This internationalist spirit must not be forgotten because it is ideologically linked to many historical practices: Sarton's bibliography embraced internationalism from the outset, recording works in nearly all languages.
To summarize, in the age of printed books, bibliographical tools were developed to overcome problems with information glut. Important aspects of scholarship were closely tied to these tools and to the social networks of scholars who formed societies and held conferences. When the people organized themselves into professions, that professional ethos got distributed throughout the entire body of scholarship. The ethos that ultimately emerged included a very strong internationalist ethic.

The point is that bibliographies did much more than find books. They became boundary markers for disciplines. This is especially clear in the case of history of science. The discipline originated at the same time that specialized bibliographies began to be published.

What does this mean for the profession in the digital age? In the rest of this paper, all I can do is to point to a few highlights of the history of the digital revolution and explore how these changes portend the future of our discipline. I reflect in particular on a proposal I have just submitted to create a dramatically new tool out of the bibliographical data that I collect for the *Isis Bibliography*.

In the years before the digital computer, two men, Paul Otlet and Vannevar Bush both proposed an Internet-like system that could be used to find information from the world's knowledge banks and send it to people all over the world. Otlet's Mondaneum and Bush's Memex have frequently been referred to as precursors of the Internet. Otlet's work was particularly interesting in this regard because he was a close friend of George Sarton, and both he and Sarton embraced internationalism with extraordinary enthusiasm. (Otlet & Rayward, 1990; Rayward, 1975)

In the early 2000s the field of digital humanities arose, based on a set of values that have been altering our understanding of how scholarship can be done. Academics in this field are experimenting with a variety of new ideas and techniques for collaboration, research, and teaching. Teachers have begun incorporating cell phones and popular applications such as Twitter in their classes. Researchers in the humanities are learning to write code that deals with newly digitized resources. Academic blogs that communicate ideas faster and to a wider and more diverse audience are now common. The academic world is opening up. (Gold, 2012; Rosenzweig, 2011)

The digital humanities come with their own set of values. The new ethos favors collaboration, openness, and the free access to digital resources. These scholars collaborate widely, and disciplinary boundaries begin to slip away. The digital humanities brings together groups of people with different skills and backgrounds: scholars in the humanities, digital technicians and engineers, and information professionals like librarians and archivists. (Spiro, 2012)

These new values are compatible with the older ones. The scientific internationalism of the pre-digital era of scholarship is found everywhere in the digital humanities ethos. Like the image of Athens that I started with, the digital humanities is a landscape filled with tools that are utterly foreign to the print-age scholar, but one that retains aspects of that print-age culture. Those older scholarly structures rise up prominently in this new landscape. The forms and the values of the past don't disappear. They simply play different roles.

So what does all this mean for reference works in our discipline? The Isis Bibliography has changed substantially since 1974. That was the year that the bibliography began to be produced with a computer database. After about 1990, that database was no longer just an input device, it became the search and retrieval system when the History of Science, Technology, and Medicine database was made available through the new online system. The database changed the way people accessed the information, but the fundamental purpose of bibliography remained intact. The new database was designed as a citation discovery tool. It may have worked differently from the print bibliography, but it served the same fundamental purpose. (Weldon, 2009)

I am interested in expanding that purpose. As editor of the Isis Bibliography, I want to find new uses for it. Along these lines, I have proposed a new tool that I am calling the Isis Document Indexing Platform. It takes bibliography to a new level. It is essentially “bibliography 2.0,” that draws on the networked-information-and-communication structure that some are calling web 2.0. (Rosenzweig, 2011)

When one looks at the sorts of information that exist in the bibliography, one begins to see bibliographical citations in a new way. By combining the interlinked data in the bibliography with the communication and information networks of the open Internet, ideas for new tools emerge. For example, the possibility exists to create a social network of people linked to each other by way of their publications. This interactive bibliography becomes a social tool with the objects of people’s scholarship at its core. One already sees this sort of thing emerging in social bookmarking tools like Mendeley and social networking tools like Academia.edu. The Isis Bibliography has the potential to build on this.

To sum up, I want us to think about the future of our scholarly tools in terms of how the past shapes them. Those of us who manage and develop tools for our discipline need to pay attention. Research tools do not exist in a vacuum. They are made possible by institutions and social networks of people. They come with ideals and ethical principles. We must keep that in mind as we design for the future.

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SYMPOSIUM 32

Women in the Laboratory from the early Modern Times to the 20th c.

Organizers
Annette Lykknes
Board Member of the Women's Commission of the DHST/IUHPS
Brigitte Van Tiggelen
Board Member of the Commission for the History of Modern Chemistry of the DHST/IUHPS

The laboratory is one of the fundamental spaces for teaching and research in science and technology. Being a space of knowledge transfer and development, it is not only modelled by physical settings, materials and the uses of instruments, but also by disciplinary traditions, social hierarchies and divisions of labour. The exclusive presence of men in laboratories compared to other science spaces like the salon, the field or the home shaped the science practiced in that space as well. What happened when women entered the laboratory space?

Gendered practices in e.g. radioactivity and genetics laboratories have already been subject to in-depth analyses, and more studies from these and especially from other fields and other time periods are needed/encouraged in order to shed light on the many facets of women's presence in laboratories. Through comparative and contextual approaches we want to explore the laboratory space from a gender perspective, in the timespan that runs from early modern times to the 20th century. How did women conform to local laboratory cultures and how did their presence in turn reshape these cultures?

We are interested in studying laboratories which attracted a large number of female researchers as well as individual women working in laboratory environments dominated by men. Questions we would like to discuss in the session include: What characterized the laboratories which attracted many women? What roles did the women play in the laboratories? How did these roles affect the credibility of women in exchanges and discussions in the scientific community? To which extent and in what ways were these gendered practices disseminated from one place to another? And what did the presence of women in the laboratory add to the practice of science?

Chemistry at Home: Rosa Sensat and Chemistry Dissemination between Housewives in the early 20th c.

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Introduction

Throughout history, women have spent much of their time taking care of children, preparing food and doing other household chores. Many concepts about chemistry and physics are present in all these activities. Due to the difficulties for women to access scientific knowledge, between the XVII and XIX centuries they used the strategy of writing science books aimed at themselves. Marie Meurdrac and Jane Marcet are some examples.
Marie Meurdrac (?-1687) published in 1666 "*La Chymie Charitable et Facile: En Faveur des Dames*". Her work followed the Paracelsus (1493-1541) medicinal tradition, gave details about the alchemist's operations associated like the relationship between sulphur, mercury, and salt and also gave references to Raymond Lull's (1232-1325) work. She was a Paracelsian chemist and feminist [Tosi 2001]
Jane Marcet (1769-1858) published in 1805 "*Talk of Chemistry*", a fictional converse between a teacher and her two female students. Her book was extremely popular and published in many different languages. Jane Marcet incorporated some experiments into her new editions in spite of her lack of academic studies because she attended Humphry Davy's (1778-1829) lectures in the Royal Society of London. [Rosenfield 2001].
At the beginning of the XX century, a revolution in communication (radio, telegraph, etc.) and also in science (X-rays, quantum theory, theory of relativity, etc.) took place and all of this science knowledge was spread among society. However, in Spain, this science revolution was underestimated by politicians and philosophers of that time. The quotations spoken by Miguel de Unamuno (1864-1936) "Science is a cemetery of dead ideas" and "They invent!" highlighted the Spanish point of view[1].

Women and chemistry

When we are thinking about women and chemistry in the last century, the great figure of Maria Sklodowska comes to our mind immediately. She was also known as Marie Curie (1867-1934) who won two Nobel Prizes[2]. Four women have won the

[1]The phrase reflects that in the early twentieth century, research was not necessary for the Spanish leaders and scientific advances were left for other countries.
[2] Between 1901 and 2012, the Nobel Prizes and the Prize in Economic Sciences were awarded 555 times to 862 people and organizations. The Nobel Prize is an international award administered by the Nobel Foundation in Stockholm, Sweden.

Nobel Prize for their contributions in the field of Chemistry [Robinson 2011]: Marie Curie in 1911 [http://www.nobelprize.org/…/1911] in recognition for discovering the elements radium and polonium, Irène Joliot-Curie (1897-1956, daughter of Marie Curie) in 1935 [http://www.nobelprize.org/…/1935] for the synthesis of new radioactive elements, Dorothy Crowfoot Hodgkin (1910-1994) in 1964 [http://www.nobelprize.org/…/1964] for her research on the structure of vitamin B-12 using X-ray analysis, and finally, Ada E. Yonath (1939-) in 2009 [http://www.nobelprize.org/…/2009] for her studies on the structure and function of the ribosome.
In spite of the recognition to the aforementioned women, the society usually overlooks other women who have contributed significantly to the promotion and teaching of chemistry. This article wants to pay a small tribute to one of these women who marked an era in the field of Chemistry in Barcelona (Catalonia), in the early twentieth century: Rosa Sensat Vilà (1873-1961).
In Catalonia, Spain, in the early twentieth century the relationship between women and science practically did not exist, but Rosa Sensat worked hard to help housewives understand the phenomena that take place at home, in simple activities such as cleaning stains and cooking or explaining the chemical composition of the most important foods. She disseminated scientific theories and chemistry among housewives with no knowledge in science. Furthermore, she visited other countries for getting to know their educational models and observed that female students who studied (often with male teachers) did not see the link and dependence between science and home duties. So she wrote an influential textbook called: "Science at Home” (“*Les Ciències en la Vida de la Llar*" in Catalan), which includes chemistry and physics explanations that any housewife can understand and use. This textbook was adopted as a didactic tool in Catalonian schools. In this article, the authors have only included the chemistry knowledge present in her book.

Rosa sensat vilà or rosa sensat de ferrer[3]
She was born in the town of El Masnou near Barcelona in 1873 and died in Barcelona in 1961 [Ainaud de Lasarte, 2001 and Tort 2006 for a review]. She got a “teaching degree” and started teaching when she was 15 years old and was successful in public competition for kindergarten teacher. Her teaching was influenced by the international trajectory of her professional career. She visited schools in Switzerland, Belgium and Germany and she came back with a new pedagogical insights:
- Dissemination of theories and pedagogical practices aimed at developing the intellect of children, but based on respect and freedom of their personality.
- Promoting the active involvement of children in their own learning.
- The training of teachers, based on experimentation as well as theory, provided through individual and collective reflection.
- The achievement of a public school, with a democratic and secular reality rooted in the country’s traditions, with active participation of all its members (including teachers, parents, pupils and the school management).

[3] In 1902 she married David Ferrer and she took his surname. They settled permanently in Barcelona and, in 1904, their daughter Angeleta Ferrer Sensat was born.

Figure 1: *Portrait of Rosa Sensat*

In 1903 she settled down in Barcelona where she dedicated her life to the dissemination of these educational advances. She was commissioned to design the curriculum of the Institute of Culture and Popular Library for Women, (“*Institut per la Cultura i Biblioteca Popular de la Dona*” in Catalan), where she prepared a comprehensive programme for working women. In 1931 Spain turned into a Republic and she had the opportunity to create a democratic and public school. The first Spanish school with her ideologies was the “*Escola Municipal del Bosc*” in Montjuic, Barcelona and Rosa Sensat was the director. As soon as the Republic was abolished the new political movement also abolished the ideals of that new school.

Science at home, new educational approach

In the prologue of her book Rosa Sensat established a relationship between the observation of nature and the knowledge of events that reveal the laws of life. In her own words, she tried to dignify women’s daily chores by justifying them as a useful basis for scientific research.

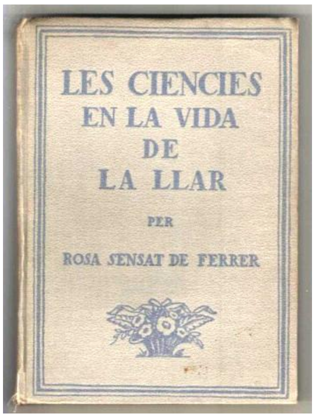

Figure 2: *The cover of “science at home”*

Sometimes she mentioned the relationship to the topics studied in previous chapters for example, in chapter X, "Breathing Animal and Vegetable", she said "We know that there are gases in the air. We saw that only one of them makes things burn. Now we know why and what phenomena maintain our life”.
She was conscious of the readers of the book (that is, housewives), and sometimes she cited phenomena that happen every day. Thus, she introduced chemical concepts with phrases like "all we know...”, “we have seen the thermometer and we know that...”, and so forth. She recurrently employed this language throughout the

book to expose her speech. "Carbon dioxide is another gas in the air. Remember that burning charcoal into oxygen gives off CO_2. You know what CO_2 is and what its composition is (carbon and oxygen)". She also discussed aspects related to knowledge (like when she talks about domestic carbon allotropes, diamond and coal), she employed a language with colloquial expressions that allowed you to talk about feelings. "Diamond is very expensive. It is admired by everyone, excites the greed of men... It's scary to think of the consequences if there were no coal..."
She spared no resources for making scientific concepts more understandable. For example, she makes an analogy to explain the relationship between breathing and combustion[4]. "When a light goes out, it's because it lacks oxygen; were we deprived of this gas, we would cease to exist. Actually, our body is a 'home' for combustion to burn tissues without us noticing. I'm just explaining the chemical change between oxygen, carbon and hydrogen."
According to her knowledge, she said "I do not exactly know the final constitution of the human body, but it seems that it is made of atoms[5]."
Rosa Sensat elaborated this textbook including: (to summarizing some chapters):
The chapters usually have an introduction in which Rosa Sensat stated the phenomena, substance or matter which is the subject of study, from the context of domestic knowledge.

Chapter I. Material descriptions and tool manipulations
Rosa Sensat started her book with the material, glass, plastic, cork, metal, etc., description and manipulation. In figure 3, there are two drawings made by herself, which show the preparation of a cork and how can bend a glass tube. She used exactly the same method as the authors learned in the subject "Chemical Laboratory Technology" in their second year of chemistry degree at the University of Barcelona in 1973, fifty years later.

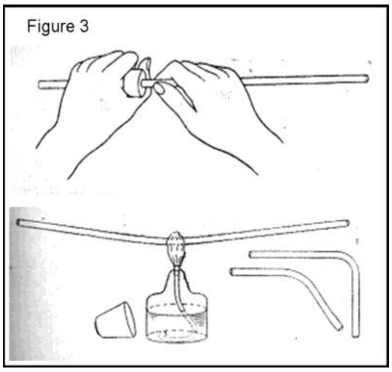

Figure 3: *Preparation of corks and glass tubes*

[4] Rosa Sensat mentions the fact that two different situations like breathing and combustion need the same reactive: oxygen. Without oxygen flames go off and living beings die. The flames go off because oxygen is the element that burns (oxidizes), and living beings die without oxygen because they need it to fulfil the essential metabolic functions.
[5] At that time, the atomic theory began to show its importance in chemistry and physics fields with Rutherford's experiments and Bohr's theory.

She defined the mass as “the amount of matter in a body that is directly related to weight”. Thus she showed that it is necessary to know the amount of mass to restore the composition. In her book, Rosa Sensat linked this concept to the different units of measure that can be found in any kitchen, and likewise in any laboratory.
To understand the chemical phenomena and use them as they serve us, it is necessary to know the materials we can use and have a basic knowledge about the concepts of atoms, simple elements and their symbols, molecules, mixtures and affinities. It is also important to know the different states in which matter can be found, and learn how they change from one state to another.

Chapter II. Study of different substances
The symbols of the most common elements in everyday life were presented to housewives. Rosa Sensat also found some mistakes which were then mentioned in an errata sheet at the end of the book. She explained the science of bread dough kneading and its afterwards cooking. In an oven, the color of bread dough changes gradually and so does its texture and flavour while the dough decreases in weight at the same time. She introduced quantitative chemistry such as a method using precisely determined proportions of oxygen and nitrogen contained in the air. “For every 100 L of air there are 20.93 L of oxygen and 79.07 L of nitrogen. Small amounts of other gases contained in the air, don’t influence this relationship".

Chapter III. Chemical phenomena
Rosa Sensat introduced chemical reactions (breathing and combustion) and in addition she explained the phenomenon of oxidation in relation to inorganic compounds. As an example she mentioned iron nails: “When we expose iron to a harsh environment, it oxidizes. If the humidity of the environment increases, the iron nails rust in their entirety. This newly formed material loses its hardness and toughness, increases its weight and breaks”. She also made a comprehensive study about the gases in the air, oxygen (O_2), nitrogen (N_2) and carbon dioxide (CO_2), their properties and the experiments that can be made with them. Furthermore she indicated the chemical symbols of elements and compounds and chemical equations. In addition, in chapter IX she explained the formation of acids, bases and salts.

Chapters XX – XXII. Clean white clothes
She employed commercial and scientific names simultaneously. She even used some alchemical names like "vitriol oil" (now sulphuric acid). Rosa Sensat explained how detergents work including a study of the characteristics of water and chemical compounds which are involved in bleaching and staining processes. In addition, she studied the characteristics of different kind of chemical compounds which are involved in the laundry and the processes of bleaching, dying and coloring.

Chapters XXIII – XXX. Biochemistry and nutrition
Biochemistry and nutrition were an important part of the book. This is because biochemistry studies food metabolism which allows us to know how food is digested

and how this affects our energy reserves. Biochemistry also investigates the chemical constitution of food and analyzes in what amounts food is healthy.
She described the most significant chemical reactions that can occur during preparation, cooking or digestion (protein denaturizing, hydrolysis, pyrolysis and reactions with sugars). Finally, chemical compounds such as carbohydrates, proteins, lipids, vitamins and minerals, which are basic for the human diet, are studied too. Some of these studies have been validated in our time.

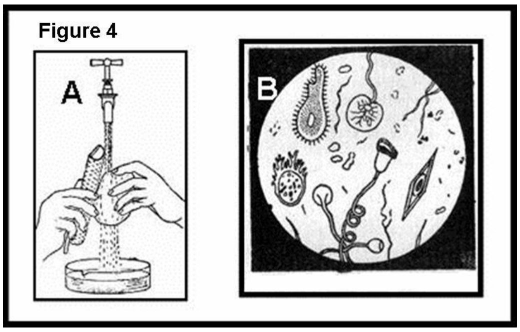

Figure 4: *4A, Obtaining starch from a potato and 4B, Life in a drop of water*[6]

Despite of writing a popular science book, Rosa Sensat did not forget to mention the need for working meticulously in the laboratory, nor did she forget to keep in mind the importance of safety considering the dangers of chemical compounds. Figure 5 shows how to heat a test tube, mouth is directed outwards; in addition, it shows as a solution has to be filtered with a good folded filter paper and with a help of a glass bar, exactly as in the present. Working calmly and in a precise way in a laboratory and in a kitchen, can be safe and efficient.

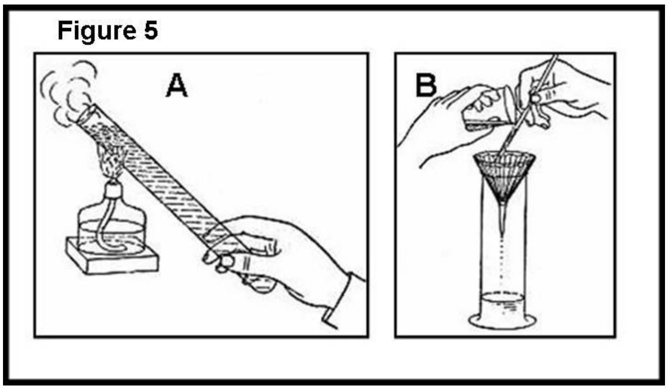

Figure 5: *5A, Safety manipulation of a test tube and 5B, Filtration scheme.*

Conclusions

- From a chemical perspective, this popular book for women contains the description of the material and knowledge necessary to perform simple chemical manipulations with simple element definitions.

[6] She drew the organisms which saw a drop of water with an optical microscope.

- It also offers a comprehensive study about the gases in the air, oxygen, nitrogen and carbon dioxide, their properties and the experiments that can be made with them. The quantitative chemistry was introduced in this book.
- The important role of Rosa Sensat as a proponent of the principles of the 'new school' in favour of domestic scientific education for girls is generally recognized. She launched a modernization of the women's state in society, aiming to increase their knowledge about sciences.
- It is difficult to dissociate the consolidation of science knowledge among women in Catalonia and the role that Rosa Sensat played in this development. She strongly contributed to shaping the importance of chemistry in the chores around the house.
- Her biggest challenge was to get women, who were comfortable in their kitchens, to acquire the necessary chemical knowledge to understand all the steps performed in any process of cooking or food preparation process.

We cannot finish this work on Rosa Sensat without presenting her legacy:
In 1965 the "Rosa Sensat school of teachers, *L'Escola de Mestres Rosa Sensat*" was founded by Angeleta Ferrer, Rosa Sensat's daughter. This school has been working to improve education according to Rosa Sensat's thinking[7].

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[7] The Association of Teachers Rosa Sensat is an educational reform movement, created in 1965 that is still working to improve education. You can visit http://*www.rosasensat.org/* for more information about objectives and activities.

SCIENTIFIC SESSIONS

Color in ancient Philosophy

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Already in the ancient world tried Philosophers to explain the phenomenon of color and combined often the emergence of the colors with the theories of vision. The presocratics as well as their subsequents have connected the phenomenon of seeing with the origin and the declaration of the phenomenon of color, so there are often in their teaching no precise theories of the origin of the colors, but it is presented only in the context of the statement of vision and its function. According to Pythagoras seeing is an activity that occurs when a type of radiation comes from the eyes. Parmenides of Elea argued that many objects and their shape and color, are just an appearance and not a reality[1]. This view of the unrealistic representation of the objects takes later Plato; Aristotle on the other hand denies the illusory nature of the phenomena and takes an empirical and realistic explanation of all phenomena.
Empedocles of Akragas (490-435 BC) coined the four-element theory of fire, earth, air and water. He saw love (Philotes) and hate (Neikos) as the primal forces that bring together the four elements and separate them, and they were responsible for the development of the world and all objects. From the mixture of the four elements develop the forms and colors of the objects of the world[2]. He is probably the same opinion as Pythagoras, that from the eye some rays are addressed on the objects. Just as there are four elements, there are four basic colors: white, black, red, and yellowish green, and four types of pores through which the colors reach the eyes. A strict stratification of colors according to the elements is not possible. The contrasts of the elements are brought in connection with the phenomena of light and darkness, for example the sun to Empedocles is white and warm (Arist. *De generatione et corruptione* 315b10). The main colors are black and white for Empedocles, all others arise from their mixture (Theophrast *De sensu* 59.7–10). Important basis of his teaching is the assumption of outflows from all sensible objects, with the condition as mentioned above, that all bodies have pores (Aristot. *De gen. et corr.* 325b1). The color is fitted by the pores of the visual sense. We see due to the meeting of some of the objective components of outflows and partly of the subjective sense of sight[3]. So seeing is according to Empedocles a fitting of the outflows to the pores (Theophrast *De Sensu* 9)[4]. The colors were transported to the organ of vision by means of the effluents[5], but it is disputed by some scientists that the outflows come out not only of objects but also of the eyes in the form of light[6].

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[1] Crone, 1999, 3-4.
[2] Ierodiakonou, 2005, 19.
[3] Prantl, 1849, 42-46.
[4] Barnes, 1979, 17.
[5] Beare, 1906, 17.
[6] Ierodiakonou, 2005, 26.

Democritus of Abdera (460-370 BC) was a student of Leucippus and followed his atomic theory. Although Democritus didn´t agree with the theory of the four elements by Empedocles, he adopted from him the theory of the four elementary colors. The atoms of the primary colors have for him different forms. For Democritus, as well as for Parmenides, as mentioned above, is the world of the senses an illusion, a metaphor and not a reality. The subjective perception of color with a direct denial of objectivity is often asserted by Democritus (cf. Aristotle, *De Gen. et corr.* 316a1 and Galen, *De elementis ex libri ii Hippocrate*, 417.10). The perception of the colors and seeing at the atomic doctrine is to be understood as outflows (aporroai) of the images of variously shaped atoms in our eyes[7]. For the act of seeing, he combines the watery parts of the eye and the moved and shaped outflows, which produce the impression; among these is the air as a medium (Theophrastus, *De sensu* 50). As for the individual colors, white and black are attributed to the - according to the sense of touch - contraries of the smooth and rough, in such a way that the white is not identified with the glow of the fire (Theophrastus, *De sensu* 73, 74)[8].
Democritus connects the red with fire, claiming that it consists of particles of fire (Theophrastus *De sensu* 75). The fourth color is green, and from the mixture of these four colors arise all other countless colors (Theoph. *De sensu* 76, 78). From these mixtures arise the gold-colored from white and red, purple from white, red and black, blue from green and black etc.[9] (Theophrastus *De sensu* 73-76 :DK 68 A 135). Democritus has referred to the atomic ties as idols (eidwla), images. He has ascribed the color differences on visual impressions to differnces of shape, position and arrangement of the atoms of the thing, that is, of the idols. During the day, we are sensitive only to these powerful idols. At night, when the mind is resting, our body takes up through his pores also idols from a finer structure: thats the reason why we dream.
As colors also tastes are attributed to the atomic shapes and configurations.
Color and flavor, etc. therefore not really exist as the atoms and the void, but they are merely the product of the specific interaction of a composite thing made up of atoms and Empty in a certain configuration on the one hand and on the other in the same way composite body perception organ. Therefore, we can never perceive things as what they are (atoms and
Empty), but only as co-determined objects by our organs of perception[10].
Anaxagoras (499-428 BC) from Clazomenae in Asia Minor had also analyzed next to Empedocles and Democritus in his work the problem of the appearance of colors.. He goes into his teaching of an original mix of, in which an infinite number of small components of different types are included, called Homoiomeres (equal parts formed Material). This mixture is a uniform mixture of all those substances which are also known in the differentiated world. Anaxagoras has taken, albeit in a different

[7] Beare, 1906, 24.
[8] Prantl, 1849, 50.
[9] Taylor, 1999, 116.
[10] Mansfeld, 1996, 240.

sense than Empedocles, Parmenides' concept of the mixture[11]. He has two elementary colors taken, black and white, from their mixture all other colors are created[12]. The opposites, like black and white, are considered by Anaxagoras as elements[13]. He supports the inseparability of the qualities of the substance and thus arose the familiar doubts about the color of snow, which should be black, because it arose out of frozen water and the water is black (Sextus Empiricus, *Pyrrh. Hyp*. I 33: DK 59 A 97, Galen, *De simpl. medic.* II 1). According to his theories can be stated that no color is found pure in nature[14].

For the philosopher Plato (428/427 BC in Athens or Aegina - 348/347 BC in Athens) share black and white the opposites; white is not identical with a color in general, but only one of the two fundemental opposites (*Philebos* 12e, 53a). The main theories about the act of seeing and the colors of Plato can be found in his dialogue *Timaeus*, Plato's only work treating fields of the natural sciences. For seeing therefore, three components are required, the light is the medium, from the eyes is fire emanated and with the light are combined to a combination beam (sunaugeia)[15]; this combines with the rays which emanate from the objects. So Plato believes that seeing is caused by the mixture a) of the radiation that comes from the light of the eyes, b) the rays, the flow out from the objects direction to the eyes and c) the intervening air[16].

At Plato there is not only a physiological but also psychological process in vision, because vision is only complete, when the soul has processed the supplied data[17]. This interaction, which is produced in the *diakritikon* - between the eyes and the object -moves in the elementary contrasts of the eye (fiery and watery parts) and from them the glossy and shimmering of all the possible colors is created. Plato describes the colors as emanations and images of things, but only in the interaction between object and subject, so that the color is neither the Captured/Absorbed nor Accepting/Receiving (*Theaetetus* 153d). Plato accepted the four elementary colors of Empedocles, and he is generally influenced by the theories of emanations of Empedocles, but he believes that everything is created from a Creator (Demiourgos)[18]. Plato describes first the development of four basic colors (white, black, bright and red) and then their mixture to a range of other colors (Timaios 68d). In fact, Plato has some common ideas with Empedocles: a) the idea that the excursions coming from outside interact with the fire of the eye, b) the existance of pores in the eye and c) white and black or light and dark as the fundemental opposites. Plato, however, holds more to Democritus. He ascribes the variety of colors, as well as all the other sense-qualities, to differences in form and storage of the atoms[19]. There are still discrepancies between the democritic and the platonic

[11] Mansfeld, 1996, 157-159.
[12] Prantl, 1849, 58.
[13] Mansfeld, 1996, 166.
[14] Beare, 1906, 40.
[15] Jablonski, 1930, 322.
[16] Beare, 1906, 44-45.
[17] Zeckl, 1992, 206 n. 103.
[18] Beare, 1906, 43.
[19] Gaiser, 1965, 178.

color mixtures[20]. Between Plato and Democritus, it is important to note that Plato in the section about the colors in the Timaeus proceeds to overcome Democritus materialistic world explanation[21]. Plato also brings colors in relation to the basic elements and materials, and especially to the senses-qualities. Black belongs to Denseness and Cold (*Timaeus* 60d). The air participates in the light, also in darkness (*Timaeus* 58d), and from the generation of air bubbles in fluid is notified the white color (*Timaeus* 83d) [22]. Certain colors are attributed to certain natural objects (Timaeus 80e), e.g. the red to the blood, such as other qualities, e.g. bitterness to the black (*Timaeus* 83b).
Aristotle (384 BC Stagira- 322 BC Chalkis) explicitly claimed that the theory of his predecessors, namely the theory of emanations propounded by Empedocles and Plato, is actually inadequate[23]. He has developed not only the psychological and physiological, but also the empirical observation of the colors. Color is a generic term for Aristotle (genos) fall within the individual colors as species (*Topica* 109a36). It is not a substance, but quality (poion, *Topica* 120b38 and *Categoriae* 9a28). Colors move in contrasts between black and white, so they belong to the enantia (opposites, *Cat.* 11b34) namely with intermediate stages that occur as well.
The colors are part of the horaton (which is seen, *De Anima* 418a26). The color is the one which has the power to set in motion the current transparent. (*De Anima* 418a29-418b2): *"the object, then, of sight is the visible: what is visible is colour and something besides which can be described, though is has no name. What we mean will best be made clear as we proceed. The visible, then, is colour. Now colour is that with which what is visible by its essence or form, but what is visible because it contains within itself the cause of visibility, namely colour. But colour is universally capable of exciting change in the actually transparent, that is, in light; this being, in fact, the true nature of colour. Hence colour is not visible without light, but the colour of each object is always seen in light."* There is nothing visible without light (418b2), we see colors through the media of air or water - which are potentially transparent, but only with light really transparent[24]. The transparency is not bound by any particular body or elements. The transparent is colorless (De anima 418b28). The light is defined as the activity (energeia) of the Transparent (418b9). The object seen acts on the eye through a medium, the so called diaphanes (transparent). But this transparent requires arousal, it must first be made clear; this procure the colors of the objects, which are seen; they cause change to the transparent this way that it can act on the eye. What, then, has no color, can not be seen[25].
The presence of fire or aethers in the transparent is the light, the absence of it is the darkness (418b18-20). Like light and darkness, then there are the extremes white and black (*De sensu* 439b16). The black is privation of white, like the darkness of the light (*De sensu* 442a26).
Among white and black, also bright glossy color and dark colors can be understood

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[20] Schultz, 1904, 119-137.
[21] Gaiser, 1965, 179.
[22] Prantl, 1849, 67.
[23] Ierodiakonou, 2001, 219.
[24] Sorabji, 1971, 61 n. 23.
[25] Hoppe, 1926, 8.

as the primaries colors[26]. The limit (peras) of transparent in bodies is their color (De sensu 439b11).
The act of seeing is a movement and transformation (kinesis); the colors move the transparent. De Anima 419a9-15: *"For the very quiddity of colour is, as we saw, just thsi, that it is capable of exciting change in the operantly transparent medium: and the activity of the transparent is light. There is clear evidence of this. If you lay the coloured object upon your eye, you will not see it. On the contrary, what the colour excites is the transparent medium, say, the air, and by this, which is continuous, the sense-organ is stimulated."*
The medium is thus the light or the actual Transparent[27]. According to Aristotle, is the act of seeing coming from the objects to the eyes[28]. The color plays an active role therefore, eyes however, only a passive one.
We have seen that the first simple colors are black and white; the explanation of the origin of the other colors is still present. From both contrasts and under their mutual influence there are transitions, average levels (*Metaphysica*, 1057a23). In some places in Aristotle we find either a scale with gray as a position or negation of light, in other more specified colors as an intermediate level; the transition to the different colors is to be understood as a movement or better conversion. The passage in which the colors and their emergence from Aristotle are analyzed, is the third chapter of *De sensu*. There are three possible methods of color development. The first is the atomic Juxtaposition (e parallela thesis), where, according to numerical relations a quasi harmonic colors are mixed, others but do not (*De sensu* 439b18-22). The second type is a show-through of superimposed colors, wherein this would allow the same conditions (440a13-16 epipoles). And the third reason is a mixture of colors (mixis) at which the numerical ratios of the mixture can not be neglected (440b1-4). The first two species are discarded, the mixture is for Aristotle the exact cause of finite number of colors.
Aristotle takes in seven colors between the opposites, which he uses in conjunction with the seven objects of taste. Black (wherefor gray (faion) is not as a solo species considered), white, light yellow (xanthon) that accompanies white, red (foinikoun), violet (alourgon)
green (prasinon) and blue (kuanoun, *De sensu* 442a19-25). From these colors then are mixed any other colors. The analogies between the colors in the mixture are already connected to the music and with combinations of numbers of mathematics[29]. The colors will come out black and white so that they can be arranged according to certain mathematically-defined conditions (according to different ratios for the more and less). Aristotle goes out in an attempt to make comprehensible the creation and arrangement of the colors, even by the music teaching. The results and problems of acoustic music teaching are now apparently in *De sensu* transferred to the field of color theory. In connection with the music theory is to understand finally that Aristotle sets the number of primary colors to seven. The

[26] Sorabji, 1972, 294.
[27] Beare, 1906, 78.
[28] Beare, 1906, 86.
[29] Sorabji, 1972, 296.

number seven is not empirical, but systematic based[30]. There are at first two primary colors and then the secondary and the tertiary, ultimately, arised from the mixture of the latter[31].
Another formation of color is the reflection. A condition for this is the linearity of the light beam. Aristotle talks in *Meteorologica* III about the reflection and how air, light or water act on it. It is any reflection as weakening, hereby adopted as the negation of light action, and therefore, is what causes the black, which then with the light produces the colors mixed (*Meteorologica* 373b1). Both by mixing the light with the dark background of the mirror, and by weakening of the light itself on reflection, result in color gradations. Also interesting is the rainbow phenomenon (*De sensu* 439b1 and *Meteorologica* 342b1). The rainbow is described as a reflection phenomenon and has three colors red, green and blue; the fourth color, yellow light is one of the subjective colors. Aristotle connects in the fourth book of the Meteorology, the four qualities with the colors. White is attributed to the warm and the black color to the cold. As for the elements and their relation to the colors, we can assume, based on the writings of Aristotle, that the fire is white and the earth is black. Water and air seem to have no color[32]. Remarks about the colors of animals are found in the zoological works. As part of these works, he makes remarks about the colors the hair of humans and their changes in disease or due to of age. About the colors in the plant itself is not a work of Aristotle leave, his pupil Theophrastus, however, describes this phenomena in *De plantis*. Also *De coloribus* is to Theophrastus or to another pupil of Peripatos ascribed; its more about empirical observations of phenomena of the origin of colors in nature and in plants and animals.
In most languages and cultures, there are a few basic colors, about two to six, and white and black are often represented as light and darkness. The ancient Greek philosophers have tried to associate the emergence of the colors with their various theories of the origin of the world, either in terms of four elements or the atoms. In a more thorough consideration of the color theories of ancient philosophers, one finds that in terms the primary colors and the idea of emission of radiation from the objects or the eyes are affected by each other closely; also they had a great reception and influence in the natural sciences on the later centuries and dominated on the various color theories.

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[30] Gaiser, 1965, 187-193.
[31] Sorabji, 1972, 297.
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Mathematics Education for Merchants: the Choice of Contents in Juan de Icíar's Practical Arithmetic (1549)

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Juan de Icíar (b. 1522 or 1523), the most important calligrapher during the Spanish Renaissance, was also the author of a purely mathematical book, *Practical Arithmetic* (Icíar 1549). This rare[1] book is a mercantile arithmetic conceived for educational purposes, an essential book to learn mathematical skills and the teaching thereof in Spain, in the mid-sixteenth century[2]. As a matter of fact, Icíar's *Practical Arithmetic* was the last non-algebraic arithmetic printed in Spain before the first mercantile arithmetic including algebra was published in the Iberian Peninsula by the German Marco Aurel in 1552.

Juan de Icíar was also the author of the first printed work in Spanish devoted to jointly teach writing and reckoning (Icíar 1559). The arithmetic part of this book was Icíar's reworking of Father Gutiérrez's elementary treatise (Gutiérrez 1539). For this reason, Icíar's *Practical Arithmetic* has been repeatedly confused with Gutiérrez's elementary treatise, and consequently overlooked (Ausejo 2012).

This paper presents Icíar's choice of contents, analyses his educational vocation, and discusses his use of fractions in order to operate with any combination of units, the main difficulty of mercantile arithmetic before the adoption of decimal systems of measurement.

Practical Arithmetic: Justification, audience, and contents

The title page of Icíar's Practical Arithmetic is self-explanatory: it presents a book on practical[3] arithmetic addressed to anyone willing to train in learning to reckon; the figures *1234567890* –printed below the author– implicitly suggest reckoning with Arabic numerals.

The dedication refers to classic authors and works –such as Pythagoras, Caelius Rhodiginus' *Antiquarium Lectionu,* Plutarcus, Plato, Jacobus Faber Stapulensis (Lefèvre d´Estaples)– in order to justify mathematics as base and foundation of knowledge. Geometry and, above all, arithmetic, stands out among the disciplines of the quadrivium, since it enables to know the amount, number, weight and measure of anything (Icíar 1549, ij).

The Table of Contents of *Practical Arithmetic* divides de book in two parts. The first one, in nine chapters (Icíar 1549, I-XI), is devoted to Arabic numerals, place values, fundamental operations (addition, subtraction, multiplication, division) and checks by their inverse operation.

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[1] Only one single copy (at the British Library, Shelf mark C.62.h.5.) was known until 2005.
[2] Italian styled *botteghe dell'abaco* are still to be documented in 16th-century Spain.
[3] "Practica" meaning "commercial" (Smith 1908, vol. 2, 492-493).

The second part in the table of contents is actually divided in 5 parts in text, with 15 chapters in total devoted to series –Part II, 3 chapters (Icíar 1549, XI-XV), rule of three –Part III, 2 chapters (Icíar 1549, XVv.-XXI), and rule of fellowship –Part IV, 2 chapters (Icíar 1549, XXI-XXVIII).

At this point, Icíar dismissed the rules of barter, for being elementary; the rules of testaments, for being similar to the rule of fellowship; and the rules of alloying (for gold and silver), for being too specific in a book "intended to teach any merchant and trader" (Icíar 1549, XXVIIIv.)[4]. Instead, he offered a series of fifteen recipes (in spite of announcing 17 in the table of contents) to calculate the profit of loans over various periods of time (Icíar 1549, XXVIII-XXXII).

Icíar went on to Part V in seven chapters on fractions (Icíar 1549, XXXII-XXXVIII), the rule of single false position (Icíar 1549, XXXVIII-XLI), square roots (Icíar 1549, XLIV.-XLIII), *square rules* (exercises with weights, measures, widths and lengths) (Icíar 1549, XLIIII-XLVI), lengths, weights, and coins of several Italian, French, British, and Spanish territories (Icíar 1549, XLVI-XLVII), fundamental operations with square roots (Icíar 1549, XLVIII-L), and a final chapter devoted to *multiplying by minutes* (small change).

Practical Arithmetic was the first one printed in Spain to give a detailed explanation of multiplication by minutes. Besides, it includes most of the basic contents of printed arithmetic, which are: Arabic numerals and place values; fundamental operations (addition, subtraction, multiplication, division and, eventually, square root) and checks; fractions; mercantile arithmetic, that is, rule of three, rule of fellowship, rules of alloying (eventually, rules of barter, rules of testaments), and rules of (at least single) false position; and, eventually, series, financial incomes, and calculation for interest (Malet 1998, 21).

Icíar's educational vocation

Icíar's *Practical Arithmetic* was printed in folio, which suggests a work to be consulted and preserved, maybe a teacher's book but not a handbook for students attending a school. Actually, Icíar warned of the impossibility of self-learning of mathematics: "mathematics can be neither comprehended nor understood without a very good and provident doctor" (Icíar 1549, ij).

As compared with Spanish previous printed mercantile arithmetics, the book is printed in high-quality and really beautifully illustrated[5], but most remarkable is Icíar's educational vocation[6], both in structure and contents. The detailed explanations, the presentation of subjects in order of increasing difficulty, the combination of "theory" and practice (examples), and the choice of contents depending on the audience he intends to reach, together with his precise references to Pellos and Ortega (Icíar 1549, LXIII), show his solid education in mercantile

[4] Note that the book is not addressed to the education of liberal accountants.

[5] As were many Italian arithmetics.

[6] Icíar was a scrivener and teacher in Zaragoza (Spain) at least for 13 years (1546-59): we know of several of his apprenticeship contracts and one contract as private tutor for training in reading and writing, but no mention to mathematics appears therein (Pedraza 2007, 17-25; San Vicente 1969).

arithmetic and the originality of his *Practical Arithmetic* –as far as a practical arithmetic can be original.
To begin with, Icíar devoted three chapters to introduce Arabic numerals and place values. After presenting Castilian reckoning (with Roman numerals) as equivalent to *alguarismo* (with Arabic numerals), he decided to henceforward explain only the rules of *alguarismo*. As he put it, figures in reckoning were like letters in reading and writing (Icíar 1549, Iv.), and he showed how to write any given quantity in Arabic numerals using an upper line of dots to keep trace of place values[7].
The fourth chapter starts to teach addition with examples in Castilian coins, where most reckoning was done in one single unit (*maravedí*), and the fifth introduces addition with coins of Aragon, Navarre and Valencia, that is, with one or two non-decimal submultiples of the currency unit (*ducado*), which implies not only sum and carry, but also units conversion (division with remainder). This shows that the book was actually addressed to an audience already familiar with fundamental operations, just as Mr Jourdain spoke prose without knowing. Nevertheless, in the sixth chapter, the difficulty level is graduated by marking off five types of subtraction, in order to explain carry over, how to deal with zeros, and how to subtract minutes.
As for multiplication, Icíar explained it by our common method of multiplying – named *del ala* (wing multiplication), that he prefers to the *prolix* column method (Icíar 1549, VIIIv.). This is the only method he actually explained in full detail, although he displayed his erudition by giving examples of *multiplicar morisco* (Moresque multiplying)[8], the method of the cup (Smith 1908, vol. 2, 119), the multiplication by places[9], the method of the quadrilateral (Smith 1908, vol. 2, 114), and two examples of the gelosia multiplication method[10]. According to Smith (1908, vol. 2, 115), the gelosia multiplication method might have remained the popular one if it had not been difficult to write and print. In this sense, Icíar commitment to ink was more than rhetoric, as he chose to explicitly explain only our common method of multiplying; however, he duly acknowledged the abacus tradition when mentioning Moresque multiplying and the method of the cup as his preferred alternatives (Smith 1908, vol. 2, 118).
Division is explained with 8 examples of division by units, 4 examples of dividing by powers of ten, and only one example of division by tens, using the galley method without cancel marks. However, a long division (24862662/4378) appears in the last chapter of the first part, devoted to checks, as Icíar warns against the checks of nines and sevens, and considered only the check by the inverse operation. This implies also a choice of contents determined by the audience he addressed, who did not use long division much, except for the real check of multiplication.

[7] This was not trivial at the time, especially in multiplication: see, for instance Ortega's and Ventalloll examples (Ortega 1512, 18v; Ventallol 1521, xxijv-XXIII).
[8] A variant (with two printers' errors) of the cancellation method described in (Smith 1908, vol. 2, 118).
[9] As described in (Smith 1908, vol. 2, 108, footnote 6).
[10] The first one, with the diagonals from the upper left-hand corner to the lower right-hand corner, places the multiplier to the right and writes the result beginning in the upper left-hand corner –as in the method of the quadrilateral, and not at the end of each diagonal.

The second part of the book is devoted to series, an optional subject in mercantile arithmetics that was commonly looked upon as one of the fundamental operations and rarely accorded much attention in the early printed books (Smith 1908, vol. 2, 497). As most medieval and Renaissance authors, Icíar considered always ascending series (Smith 1908, vol. 2, 497). For arithmetic series, he used the ordinary classification –natural, non-natural, continuous, and discontinuous (not intercised) progressions, but not even and odd progressions. He gave one single general procedure for the sum of arithmetic (*intertwined*) series type *(2n+2)*, namely $[(a_1+a_n)/2]n$. For geometric series, he used the terms *dupla, tripla, quadrupla,* and *quintupla*, and gave the general procedure for the sum, namely $[(a_n-a_1)/(r-1)]+a_n$. As for higher series, he gave the general procedure for the sum of the series of squares of arithmetic progressions, that is, $a_n\,(a_n+r)\,(2a_n+r)\,/\,6r$. Finally, he offered two questions (examples) on progressions which are actually not directly related to this subject.
This part is most original as compared to the works on practical arithmetic previously printed in Spain. For instance, Santcliment (Malet 1998) devoted only a short chapter to arithmetic series, Ortega (1512) did not include the general procedure for the sum of the series of squares of arithmetic progressions, Juan Andrés (1515) did not give the general procedure for the sum of geometric series, and Gutiérrez (1539) only gave the general procedure for the sum of geometric series. Moreover, all Icíar's predecessors in Spain –except Gutiérrez– included Boethians proportions. As opposed to Ventalloll (1521) complete, profuse and detailed exposition of the subject, Icíar simplified it by going directly to general rules. However, the unfortunate examples he gives make it difficult to decide whether he was aware of the importance of geometric series in compound interest.
Unlike most practical arithmetics, Icíar chose to deal with fractions in the last part of his book, after the rule of three, the rule of fellowship and the loans, and right before the rules of false positions, square roots, and multiplication by minutes. Nonetheless, in the last chapter of *Practical Arithmetic* he declared that *vocal teachers* should proceed as follows: the four fundamental operations in whole numbers, then in broken numbers; addition, subtraction, and multiplication by minutes; rule of three in whole and broken numbers; other rules (Icíar 1549, Lv.).

Multiplication by minutes

As a matter of fact, Icíar's interest in fractions was related to his detailed explanation of multiplication by minutes at the last chapter of *Practical Arithmetic*: he gave a two folio table of submultiples of all units of currency, weights and measures in Aragon as fractions of the upper unit –for instance from 1 *dinero* to 12 *dineros* as fractions of 1 *sueldo*– to be learnt by heart, so as to be able to directly multiply any combination of units without reducing before and after operating (Icíar 1549, LI-LIIv.).
In order to explain the procedure, Icíar proposed and resolved in full detail two examples, the first one asking to find out the final price of 375 *cargas*, 2 *quintales*, 3

arrouas, and 5 *libras* of wax at 48 *florines*, 6 *sueldos*, 5 *dineros* and ½ each *carga* of wax[11]. He proceeded as follows:
1. In order to multiply 2 *quintales* by the price, he uses the previous table to find out that 2 *quintales* = 2/3 *carga*. He then multiplies (twice) 1/3 by 48 *florines*, 6 *sueldos*, 5 *dineros* and ½.
2. In order to multiply 3 *arrovas* by the price, he uses the table to find out that 3 *arrovas* = ½ + ¼ *quintal*, and then multiplies the previously calculated final row by ½, and the resulting row again by ½ (using that 1 *sueldo* = 12 *dineros*).
3. In order to multiply 5 *libras* by the price, he uses the table to find out that 5 *libras* = 1/6 *arrova,* and then multiplies the previously calculated final row by 1/6 (using that 1 *florín* = 16 *sueldos,* and 1 *sueldo* = 12 *dineros*).
4. Now he has to multiply 375 *cargas* by the price He starts multiplying 375 by 6 *sueldos.* He uses the table to find out that 6 *sueldos* = ¼ + 1/8 *florín*. He first multiplies 375 by ¼ and then the resulting row by ½.
5. He goes on multiplying 375 *cargas* by 5 *dineros.* He uses the table to find out that 5 *dineros* = ¼ + 1/6 *sueldos*. He first multiplies 375 by ¼ and then by 1/6. He also multiplies 375 *cargas* by ½ *dinero*.
6. He finally multiplies 375 *cargas* by 48 *florines* and adds up:

Step	**375 *cargas* 48 *florines***	**2 *quintales* 6 *sueldos***	**3 *arrovas* 5 *dineros***	**5 *libras* ½ *dinero***	**Wax weight Price/carga**
1	16 fl.	2 s.	1 din.	2/3+1/6	
1	16 fl.	2 s.	1 din.	2/3+1/6	
2	8 fl.	1 s.	0 din.	½+1/3+1/12	
2	4 fl.	0 s.	6 din.	1/4+1/6+1/24	
3	0 fl.	10 s.	9 din.	1/24+1/36+1/144	
4	93 fl.	12 s.			
4	46 fl.	14 s.			
5-6	3000 fl.	93 s.	9 din.		
5-6	15000 fl.	62 s.	6 din.		
5			187 din.	1/2	
	18196 florines	***6 sueldos***	***6 dineros***	***89/144***	

Table 1

Icíar's result is wrong at the level of ½ *dineros:* he gives 137/222 instead of 89/144, which shows that the use of fractions was neither current nor easy at the time.

[11] None of the examples seem real, they are exercises that show complex cases of multiplication by minutes for merchants using this method.

Nonetheless, his attempt to avoid long multiplication through fractions shows a deep understanding of place values and distributive property.
According to Icíar, this method was used in Aragon, Valencia and Catalonia (Icíar 1549, Lv.)[12]. It is not clear for how long, but the long multiplications and divisions prevailed in time, as in the following example (Navarro 1843, 65):
24 *varas* 2 *pies* 8 *pulgadas* * 8 *duros* 6 *reales* 8 *maravedises* =
= [896/(3*12)] * [5652/(20*34)] = 5064192 / 24480 = 206 *duros* 17 *reales* 14 *mrs*.
[1 *vara* = 3 *pies*, 1 *pie* = 12 *pulgadas*, 1 *duro* = 20 *reales*, 1 *real* = 34 *mrs.*]

Conclusions
Icíar's detailed explanation of the calculation processes with submultiples, step by step, connects current mercantile practice with modern arithmetic. It shows commercial arithmetic at work, which required the full understanding of new mathematical concepts and properties**.** Moreover, it proves that the assimilation of "modern" arithmetic was not actually a problem due to Arabic numerals and new algorithms, but a problem of units. The adoption of decimal measurement systems proposed by Simon Stevin (1585) had to wait several centuries.

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[12] This assertion is confirmed in (Andrés 1515, xxxiiij; Ventallol 1521, XXVv.-XXVI).

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Notes on the King Alfonso the Tenth's Scientific Translator Team

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Introduction

The present paper examines an astrological book which had a large readership in the Arabic world and medieval Europe, called *Kitāb al-bāri' fī aḥkām al-nujūm, or The book of what stands out in the judgment of stars* (hereafter *Kitāb al-bāri'*). Its author is Abū-l-Ḥasan 'Alī ibn Abī-l-Rijāl (Tiaret, *ca*. 965-1050) who worked as an astrologer in Qayrawān, Tunis, at the court of the Zīrī dynasty.

This study focuses on the chapter titled 'On prorogation'. It was customary for medieval astronomers to include a chapter on this subject in their books and astronomical handbooks.

Prorogation is an astrological technique based on the apparent forward motion of an indicator on the circles of the equator and the ecliptic. The indicator is any celestial body relevant to the subject of the horoscope. The computation of prorogation was used in two ways: (a) to establish the length of a human life, or (b) to determine the celestial bodies that would have an influence on the life of a particular person.

As far as his sources are concerned, Ibn Abī-l-Rijāl quotes Dorotheus of Sidon (fl. in the first century), Ptolemy (*ca*. 100-*ca*. 175), Abū Ma'shar (fl. Baghdad, 787-886) and al-Hamdānī (Yemen, d. *ca*. 951). However, although the author does not mention the pseudoZarādusht (Zoroaster) (fl. Persia, *ca*. 660-583 B.C.) or Ibn Hibintā (fl. Iraq, *ca*. 950), these two authors appear to be his most important sources. Ibn Abī-l-Rijāl included many fragments from these authors in his chapter: in fact, fragments from pseudoZarādusht represent around twenty-five per cent of its contents, and fragments from Ibn Hibintā another forty per cent.

So, Ibn Abī-l-Rijāl used an ancient Persian source with Greek influences (pseudoZarādusht) together with an Eastern source (Ibn Hibintā) closer to his own times.

Most works by Western astronomers and astrologers describe astrological methods that appeared in Ptolemy's *Tetrabiblos*. In this regard, Ibn Abī-l-Rijāl's chapter is quite innovative, because it presents new techniques documented in sources that were unknown in the Islamic West such as pseudoZarādusht and Ibn Hibintā.

The Castilian translation of *Kitāb al-bāri'*

The Castilian translation of *Kitāb al-bāri'* is known by the title of *El Libro conplido en los iudizios de las estrellas*. The chapter 'On prorogation' was translated as 'El septimo capitulo fabla en el atacyr'.

The translation was by Yehuda ben Moshe (fl. Toledo, *ca*. 1205) under the sponsorship of Alfonso X, king of Castile and Leon.

Yehuda ben Moshe took part in a large number of translations, and in the recovery of works made at Alfonso X' court between the 1220s and 1260s. Ben Moshe usually worked with a companion, although not always the same person. In most cases the name of his companion appears in the translation.
Alfonso X's translators applied a variety of approaches to the original Arabic texts. Sometimes, their translations were extremely faithful (for instance, *Azafeha*, and the *Canones de Albateni*). However, most of their works are translations interpolated with explanations by the translator, new chapters not present in the original, and updated versions of the contents (for example, the *Libro de las cruzes*).
In the translation of the *Kitāb al-bāri'*, Yehuda ben Moshe worked together with, at least, two other collaborators: a corrector and another translator. This information is provided in the translation itself, where we find marginal notes in which the corrector and the translator are mentioned as: 'el emendador e los trasladadores'.
The chapter on prorogation in *Kitāb al-bāri'* is a faithful translation of the original text.

Collation

Below is a comparison of the Arabic original and its 13th century translation into Castilian, with an explanation of the most important features.
Seven Arabic manuscripts were studied for the edition: manuscript Landberg 69, Auftragsnummer 158, Staatsbibliothek, Berlin; manuscript Add. 23399, British Library, London; manuscript 2590, Bibliothèque Nationale, Paris; and manuscripts 3503, 4850, 4851, and 4852, al-Khizāna al-Ḥasaniyya, Rabat.
The astrological and technical terms of the chapter 'On prorogation' reflect the faithfulness of the old Castilian translation: six terms are transliterated, twelve are explanatory terms, and the rest of the terms (around 130 in all) are also faithful translations.

Examples of transliterations

Arabic original	الجار بختار *al-jār bukhtār*
Castilian translation	aliernistar

Table 1

In the Old Castilian text, the term *al-jār bukhtār* (الجار بختار) has been transliterated as 'aliernistar'. This transliteration does not correspond to the Arabic original; it may be the result of an illegible script (in Arabic, 'aliernistar' should be اليار نستار) or a misunderstanding.
In his study of the Arabic nouns in *El Libro conplido*, Gerold Hilty mentions the terms 'algebuctar' (or 'agebuctar') and 'aliernistar'.
Examining the Arabic nouns which correspond to the two Castilian transliterations, we find that the Alfonsine translators used two different forms for the same Arabic word:
In *El Libro conplido*, the term 'aliernistar' appears in book IV, chapter 7 (p. 174:a20), and the term 'algebuctar'/'agebuctar' appears in book VI, chapter 2 (p. 10).

However, according to the Arabic manuscripts, both ‘aliernistar’ (book IV, chapter ‘On prorogation’, p. 229) and ‘algebuctar’/‘agebuctar’ (book VI, chapter ‘On the *qisma* and the *al-qasim*’, p. 383) correspond to the same term *al-jār bukhtār* (الجار بختار).

Arabic original	ويجب أن يسيّر درجة زحل فإنّها تدلّ على... الزمانة the prorogation of the degree of Saturn is suitable to know… the chronic illness
Castilian translation	E conuiene que fagan atacir al grado de Saturno: que aquello sera significador… del azemena

Table 2

The Castilian sentence says ‘azemena’. The translator transliterates the Arabic word *al-zamāna* (الزمانة). He does not provide a translation (illness, or chronic suffering). The resulting word, ‘azemena’, is incomprehensible to a modern-day Spanish reader. We find another transliteration in the term used for the astrological indicator called ‘the part of chronic illness’ (سهم الزمانة), which is transliterated as ‘la parte del azemena’.
However, the translation of this term, ‘the part of chronic illness’, does not appear systematically in *El Libro conplido*. The Castilian text presents two more variants, (a) a translation: in book V (224:b15) we read ‘the part of illness’, ‘la parte de la enfermedat’, and (b) an explanation: in the same book V (227:a26) we find ‘the part of azemena, that is, the part of illness’, ‘la parte del azemena, que es la parte de la enfermedat’.
Unlike the term ‘azemena’, the rest of the astrological indicators called ‘parts’ have been translated. For example, (1) سهم السعادة (the part of fortune): ‘la parte fortune’; (2) سهم العبيد (the part of slaves): ‘la parte de los sieruos’; and (3) سهم الغيب (the part of hidden things): ‘la parte de la celada’.
These differences in treatment suggest that ‘azemena’ was one of the Arabic names introduced in the Alfonsine scientific vocabulary. It was transformed into an adjective in *El Libro conplido* (‘azemenado’) and used as a noun in another Alfonsine work, *El Libro de las cruzes* (‘acemena’).

Arabic original	أصابه النار الفارسي والاسكنج الأحمر فمات في محبسته He will suffer from carbuncle and angina, and he will die in his prison cell
Castilian translation	Contecio·l vna enfermedat que es dicha fuego grazesco, e murio en la prision

Table 3

In this example, two terms referring to illness appear: *al-nār al-fārisī* (النار الفارسي) and ‘the red *al-.s.k.n.j* ’ (الاسكنج الأحمر).
The Castilian text translates the first term, *al-nār al-fārisī*, as ‘an illness called Persian rash’, ‘vna enfermedat que es dicha fuego grazesco’. In Spanish medical works of the fifteenth century, *al-nār al-fārisī* or carbuncle was called ‘antras’ or ‘carbunculo fuego de Persia’.
The second term, ‘the red *al-.s.k.n.j* ’, has been omitted in the Castilian text (see below).

Arabic original	خيف عليه الخنق والذبحة It is feared that he suffers from asphyxia and angina
Castilian translation	Acaecera al nacido esquinancia en la garganta e afogamiento

Table 4

In this case, the Castilian text offers the term for angina ('esquinancia' in Alfonsine Castilian).
According to Corominas's etymologic dictionary, the term 'esquinancia' is 'a colloquial alteration from the Greek κυνάγχη… is inflammation of the throat, with fervour of blood… angina'.
This allows us to identify the term 'the red *al-.s.k.n.j* ', which appeared in the example above (no. 3): it is probably an adaptation of the Greek name for this illness (Greek: κυνάγχη; Arabic: *.s.k.n.j*; Alfonsine Castilian: esquinancia).
This example (in sum, there are thirteen astrological examples) also appears in the book *Nativities* by the pseudoZarādusht (manuscript number 939, Biblioteca de El Escorial, Madrid). As mentioned in the introduction, the pseudoZarādusht was clearly one of Ibn Abī-l-Rijāl's sources. The copy is faithful except for the ecliptic longitude of the celestial elements.
The pseudoZarādusht's *Nativities* is partially preserved. It was written in Old Persian (Pahlavi), translated into a more modern Persian (*ca*. 650), and finally translated from this language into Arabic (*ca*. 750). The Arabic version, which Ibn Abī-l-Rijāl probably used, presents additions, topics and vocabulary of the Greek, Hindu, Persian and Arabic astrological cultures.
The term *.s.k.n.j* is evidence of the Greek influence on pseudoZarādusht's *Nativities*.

Examples in which the Castilian text is based on a variant of the Arabic manuscripts

Arabic original	سهم الغيب وجزء الاجتماع إذا شهدا جميعا في أصل المولود أو سعدا في وقت من أوقات العمر The part of hidden things and the degree of the conjunction [of the sun and the moon], if they are witnessed together in the radical horoscope at the moment of birth or if their testimony is auspicious at any moment of the life
Castilian translation	La parte de la celada e el logar de la coniunction quando estos amos fueren fortunados en rayz de nacencia o sse afortunaren en algun tiempo de la uida

Table 5

In this fragment, the Castilian text says 'they were lucky' (سعدا) instead of 'they are witnessed' (شهدا). The Arabic manuscript 4852 in Rabat and the text of pseudoZarādusht coincide with the Castilian text.

Arabic original	قد تركت العلماء وأرجأت الكلام فيه لدقّته وصعوبته The scientists left it and delayed talking about it because of its accuracy and difficulty
Castilian translation	E los mas de los sabios se escusaron de fablar en ello. E quiero alongar e ensanchar la fabla en ello porque es muy sotil e muy fuerte

Table 6

In the Castilian translation, the verb *arja'at* (أرجأت) differs in meaning, time and person. The sentence وأرجأت الكلام فيه ('[The scientists] delayed talking about it') is translated as 'E quiero alongar e ensanchar la fabla en ello'. Instead of 'delayed', the Castilian text says 'extended'.
The seven Arabic manuscripts give four different readings: Rabat 4851 says أرجأت; Berlin, London and Rabat 3503 say أرجت, Paris and Rabat 4850 say أرخت; and Rabat 4852 says أرحب.
The variant of Rabat manuscript 4852, *arḥaba* (أرحب) coincides with the version in the Castilian text, as *arḥaba* is a verb meaning 'enlarge, extend'.

Example of literal translation

Arabic original	والكواكب الثابتة القلوب وما شاكلها The fixed stars 'hearts' (*al-qulūb*) and whatever is similar to them
Castilian translation	E las estrellas fixas, los coraçones e las que las semeian

Table 7

The translator offers a literal translation of the term *al-qulūb* (القلوب) as he says 'hearts': 'coraçones'.
In the Alfonsine book *Libro de las estrellas de la ochaua espera*, two of these stars are also mentioned in a literal translation: 'Coraçon del leon y la real' (that is to say, Regulus) and 'Coraçon de escorpio' (that is, Antares).
In the Alfonsine version of the treatise on the use of the *azafea* by Ibn al-Zarqālluh (fl. Toledo, d. 1100), the stars mentioned above are translated using the Latin term but maintaining a literal translation: 'Cor leonis' and 'Cor scorpionis'.

Example of lack of transmission of errors

Arabic original	وكان مع الشمس في برج غير أنّه لم يدخل [تحت] الشعاع فذلك أشدّ التغريب And he was placed with the sun in the same sign, without entering [below] the ray of the sun, this is the greatest occidentality
Castilian translation	E fuere con el Sol en vn signo, mas non entrando so los rayos, esta es la mayor occidentalidat que puede ser

Table 8

The word 'below' (تحت) is written in brackets because it does not appear in any of the manuscripts studied. However, the word appears in pseudoZarādusht's *Nativities* (f. 30v).
The Castilian text translates the word 'below' ('so'). This suggests that the translator was working with a manuscript without this omission.

Example of universalization of the contents

Arabic original	فأخذه فرّاش ملك اذربيجان The servant of the king of Azerbaijan will catch him
Castilian translation	Priso·l la iusticia del rey

Table 9

In this sentence, the translator omits the reference to the country Azerbaijan.

Examples of explanation

Arabic original	وإن كانت الشمس في وسط السماء أو بيت الرجاء أو الطالع أو التاسع فبالدين والعقل وسنن الأنبياء عليهم الصلاة والسلام If the sun is in the middle heaven, in the house of hope, in the ascendant or in the house IX, it indicates the religion, the reason and the laws of the Prophets, peace and blessings be upon him
Castilian translation	E si fuere en esto el Sol en medio cielo o en la .XI.ª o en el ascendente o en la .IX.ª, sera fortunado por ley e por seer derechero e seguir las carreras e los mandamientos de los prophetas

Table 10

In this case, the translator says ‘in the XI’ (‘en la .XI.ª’) instead of ‘the house of hope’ (بيت الرجاء). Indeed, the celestial house XI is the house of hope in astrology. The translator avoids a literal translation, and makes the text more comprehensible.

Arabic original	فتكون الزهرة تدبّر من أوّل البرج Venus rules from the beginning of the sign
Castilian translation	Pues Venus gouernara en el conpeçamiento d’aquel anno

Table 11

In this case, the Castilian version says ‘year’ (‘anno’) whereas the Arabic text uses the word ‘sign’.
The text is explaining a method which establishes an equality between a zodiac sign and a year: the thirty degrees of a zodiac sign are equal to a year in the life of a man. This shows that the translator understood or acknowledged this equality.

Example of summarizing

Arabic original	فانظر أقرب الكواكب إلى الطالع واحدها نظرا إليه من ربّه أو ربّ شرفه أو ربّ حدّه أو ربّ مثلّثته Observe, from the nearest planets to the ascendant, which one is placed in aspect with the ascendant, from its lord [the lord of the ascendant], the lord of its exaltation, the lord of its term or the lord of its triplicity
Castilian translation	Cata qual de las planetas fuere mas cerca al ascendente e qual d’ellas le cata meior catamiento de las que ouieren en el alguna dignidat

Table 12

In this fragment, the Castilian text presents two differences:
1) The expression ‘which one is placed in aspect’ (واحدها نظرا) is translated by ‘e qual d’ellas le cata meior catamiento’, that is to say ‘which one is the best aspect’. Perhaps the translator used an Arabic manuscript with a different meaning but similar script (Arabic: وأحسنها نظرا.)
2) The last part of the fragment is summarized in the Castilian text: the Arabic original mentions four astrological dignities ‘the lord of the ascendant, the lord of the exaltation, the lord of the term, and the lord of the triplicity’ (من ربّه أو ربّ شرفه أو ربّ حدّه أو ربّ مثلّثته). However, the Castilian text uses ‘dignities’, that is, the generic denomination: ‘alguna dignidat’.

Example of lectio facilior

Arabic original	وعليه المعوّل في الأعمال And the resort of the works
Castilian translation	E d’ello es el iudicio e la obra en las uidas.

Table 13

The translation of the Arabic word *al-mu‘awwal* (المعوّل) which means ‘the resort’, may be a *lectio facilior,* as ‘la obra’ is a translation of the more common word *al-ma‘mūl* (المعمول) (‘the work’).
Another possibility is that he may have worked with a copy containing the variant ‘the work’, as we find in Rabat manuscript 4850.

Conclusions
The translation entitled *El Libro conplido* was a collective work, as reflected by the reference to ‘the corrector and the translators’ (‘el emendador e los trasladadores’). One of the translators was Yehuda ben Moshe but we do not know the names of the others, or how many people were involved.
The collation between the Arabic original of the chapter on prorogation and its Castilian translation provides some insights into the way the translators of the king Alfonso X carried out their work. Probably, the chapters of the Arabic text were distributed among the members of the translation team. But they do not appear to have worked in a coordinated fashion; this may be deduced from the transliteration of a same Arabic term in two different ways (‘aliernistar’ and ‘algebuctar’) and from the fact that the two transliterations appear in different chapters. The inconsistent translation of the astrological indicator ‘the part of chronic illness’ also suggests this possibility.
The translator in charge of the Castilian version was an expert in the fields of astronomy and astrology: the translation reflects his knowledge of astrological foundations as he translates the technical vocabulary correctly, and he understands the workings of the astrological methods.
In the translation of the chapter on prorogation there are examples of explanation, generalization of the contents, and summary. Nevertheless, for the most part the translation is faithful and respects the subjects and the order of the original text.

As the Castilian version lacks the omissions we find in the seven Arabic manuscripts studied, we infer that the Castilian translation does not come directly from any of them. The Alfonsine translator may have been working with an Arabic copy from a family close to Rabat manuscript 4852.

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Berthollet's Revolutionary Course of Chemistry at the Ecole Normale of the year III. Pedagogical Experience and Scientific Innovation

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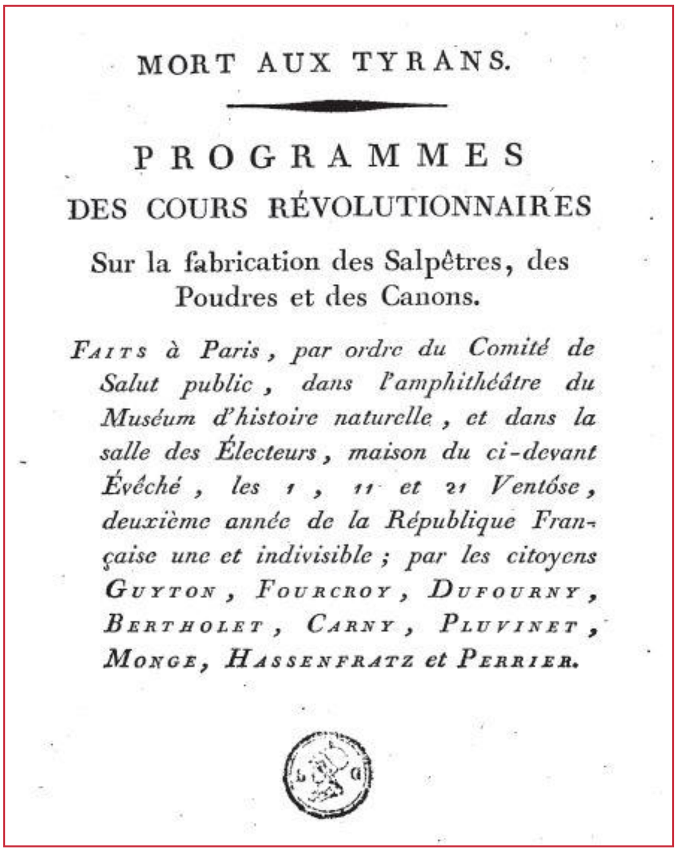
Presentation

Two main points will be tackled in this paper. The first one is the creation of a school for training teachers in France in the late XVIIIth century - historically known as the *École Normale* of the year III - during the revolutionary period. According to the French revolutionary calendar this year III corresponded to the year 1795. The second point to deal with is the relevance of the chemistry course given by the chemist Claude-Louis Berthollet in this school.

A better understanding of the creation of this school demands going back to the year 1793 when the powerful *Comité de Salut Public* (Committee of Public Safety) ruled the government of France and had to cope with the state of national emergency that the country was undergoing after the execution of the king Louis XVIth. One of the first measures taken by the French government concerned with the great demand of nitre[1] for making gunpowder. To this end the government decreed the creation of a revolutionary programme for popular nitre extraction that included the establishment of the revolutionary courses for the manufacture of saltpetre (nitre), gunpowder and cannons (Figure 1).

[1] Crude nitre was a mixture of potassium and sodium nitrates mainly.



MORT AUX TYRANS.

PROGRAMMES
DES COURS RÉVOLUTIONNAIRES
Sur la fabrication des Salpêtres, des Poudres et des Canons.

Faits à Paris, par ordre du Comité de Salut public, dans l'amphithéâtre du Muséum d'histoire naturelle, et dans la salle des Électeurs, maison du ci-devant Évêché, les 1, 11 et 21 Ventôse, deuxième année de la République Française une et indivisible; par les citoyens Guyton, Fourcroy, Dufourny, Bertholet, Carny, Pluvinet, Monge, Hassenfratz et Perrier.

Figure 1*: Font page of the Programmes of the Revolutionary Courses for the Manufacture of Saltpetre, Gunpowder and Cannons (1794)*

Nearly 800 people from all over the country attended these one-month courses (from February to March of 1794) and once instructed, they went back home to instruct others in their own local revolutionary workshops established to provide crude nitre for the refineries. The success of these intensive courses made the *Comité de Salut Publique* decide to apply this same revolutionary method of intensive teaching to other fields in which there was a need for urgent instruction. This was actually the case of the creation of the *École Normale* of the year III to ensure the training of the future teachers.

The plan was to organize courses for instructing people coming to Paris from all the departments of France who would become in turn trainers in their own local *écoles normales* to instruct new schoolteachers. The Paris courses began on 20th January 1795 in the amphitheatre of the *Museum d'Histoire Naturelle* (Figure 2).

Figure 2: *The amphitheatre of the Jardin du Roi (Museum d'Histoire Naturelle) in 1795 from a watercolour by B. Hilair.*

These courses were revolutionary not only for the socio-political context in which they took place or for being an exponent of a "revolutionary" method devised to accelerate the training of future teachers, but also for their pedagogical innovation willingness. The school teaching was divided among the daily lessons of different subjects, lectures and debates. Every day three lessons of different subjects were given. Lectures were intended to further reading and to discuss elementary textbooks. Debate sessions were designed to encourage students to expound in a public forum their thoughts, questions, doubts, objections or clarifications on previously given lessons. The pedagogical experience of the school had a limited success and the courses ended on 19th May of the same year 1795. The lessons of the different courses were published in the *Séances des écoles normales recueillies par les sténographes et revues par les professeurs*[2].
Two main reasons have been pointed out to explain the failure of this short-lived school. The first one was the lack of teaching experience of its teachers and, secondly, the intellectual diversity of its students. The teaching staff of the school included the leading French figures in science: Lagrange, Laplace, Monge, Haüy,

[2] (1795-1797), 8 vols. Paris: Imprimerie du Cercle Social. The *Séances* were published again in 1808 to commemorate the re-foundation of the *École Normale Supérieure* as *Cours des sciences et arts par des professeurs célèbres.* Paris: Testu.

Berthollet, Daubenton and Lacepede. The fact was that they devoted their lectures to explaining the science they practised rather than to teaching the basics of their sciences.
On the other hand, the students of the school constituted a quite heterogeneous group. More than half of them were aged between thirty and sixty, and their intellectual and professional profiles were diverse: retired militaries wishing to come back to the civil life as teachers, teachers of the Old Regime, clergymen and civil servants. Therefore, the syllabus of the courses resulted elementary for only very few students, and highly advanced for the majority.

Berthollet's chemistry course at the *École Normale*
Berthollet was in charge of the chemistry course (Figure 3). He had obtained his medical degree in 1768 in the University of Turin and then moved to Paris, being elected as a member of the section of chemistry in the *Académie des Sciences* in 1780. He was one of the first French chemists to follow Lavoisier's new chemistry and he enjoyed a very close friendship with Laplace and Napoleon Bonaparte. Berthollet gained a great prestige in the field of applied chemistry where his most famous discovery was that of the use of chlorine as a bleaching agent. He was extremely competent as a research supervisor with advanced students although having poor communicative gifts as a teacher for large audiences. As theoretical chemist Berthollet introduced an alternative view of chemical change based in a new conception of the chemical affinities[3]. Nevertheless, he might also be known much more for his famous controversy with the chemist Joseph-Louis Proust regarding the proportions of combination of chemical substances[4].

Figure 3: *Claude-Louis Berthollet, 1748 - 1822*

[3] Berthollet's conception of chemical change was framed within a wide and complex context in which domestic policy – economic, social, and educational – and foreign policy all played a part. For a reassessment of this context, see Grapí and Izquierdo (1997)
[4] The best account of Berthollet's works and life is still the one by Goupil (1977)

Berthollet's chemistry course consisted in twelve lessons and two debates[5]. He reported that the circumstance of having to explain the general principles of chemistry in this course led him to a first although incomplete reflection upon some inconsistences observed in the foundations of chemistry. These anomalies observed by Berthollet concerned with the system of chemical elective affinities which had dominated the interpretation of chemical change for nearly a hundred years.
The second lesson of the course was devoted to deal precisely with the anomalies presented by the elective affinities, therefore giving the first insights of his new system of chemical affinities. The topic of affinities was not the only challenge presented by Berthollet in his course. In the twelfth and last lesson, devoted to acids, he put forward his disagreement with Lavoisier's theory on the nature of acids that considered that the acidity of a substance was due to its oxygen content. On the contrary, according to Berthollet, the presence of oxygen was not at all a necessary condition to explain the acidity of a substance.
Berthollet's chemistry course favoured deep reflection not only on chemical affinities but also on the methodology of the teaching of chemistry. In many lessons he pointed out several teaching guidelines to his students for a better teaching of chemistry. In the first lesson, devoted to the presentation of the course program, he advised future teachers of the importance of making their students aware that the progress of science was unavoidably linked to the use of a rigorous methodology. An early sample of these didactic intentions appears when suggesting the need to view natural phenomena from different perspectives to favour the organization of ideas and to make students training easier. This Berthollet's commitment with chemistry teaching led him to propound a program of the subject with a didactic sequencing of learning contents including practical tasks for a better understanding of the chemical properties of substances. Apparently, chemical experiments were carried out neither in the lessons nor in the debates of the chemistry course. However, the testimony of Raymond Latour – a school student with some chemistry training – demonstrates the opposite (Latour, 1836, 2, 43).
He firmly insisted on the need of teaching not only the theoretical content of chemistry, but also its social involvement. With regard to this issue, he was able to match some chemistry topics with their public usefulness. These three following cases provide precise examples of this commitment: nitric acid and the explosion of gunpowder, the combination of alkalis with oils and the soap manufacturing and, the knowledge of "earths" with the glass manufacturing. Berthollet enlarged this public usefulness of chemistry, encouraging teachers to pay visits to different workshops such as distilleries and dye-works not only to improve students' learning but also to make them aware of the public dimension of chemistry
Especially meaningful were Berthollet's didactic guidelines for the teaching of chemical affinities. In the first lesson, devoted to this topic, he explained to his

[5] The twelve lessons of Berthollet's chemistry course were published jointly with the lessons of the other courses at the *École Normale* in the *Séances*. These lessons along with Haüy's physics lessons and Daubenton's natural history lessons were published again in Guyon (2006). For a pedagogical assessment of Berthollet's chemistry course, see Bensaude-Vincent, Bret and Grapí (2006).

students the best way of using visual resources for teaching the elective affinities. These visual resources were the table of affinities and the diagrams of reaction. For Berthollet was as much unsuitable to use the table of affinities at the beginning as at the end of an elementary course of chemistry. At the beginning, students did not know yet the basic facts that constitute the foundations of the tables and, at the end; students were only able to capture some fleeting ideas. Alternatively, he advocated the drawing up of a table of affinities by means of a wall chart developed trough the course (Figure 4). Likewise, he was in favour of expounding the diagrams of reaction by means of wall charts too (Figure 5).

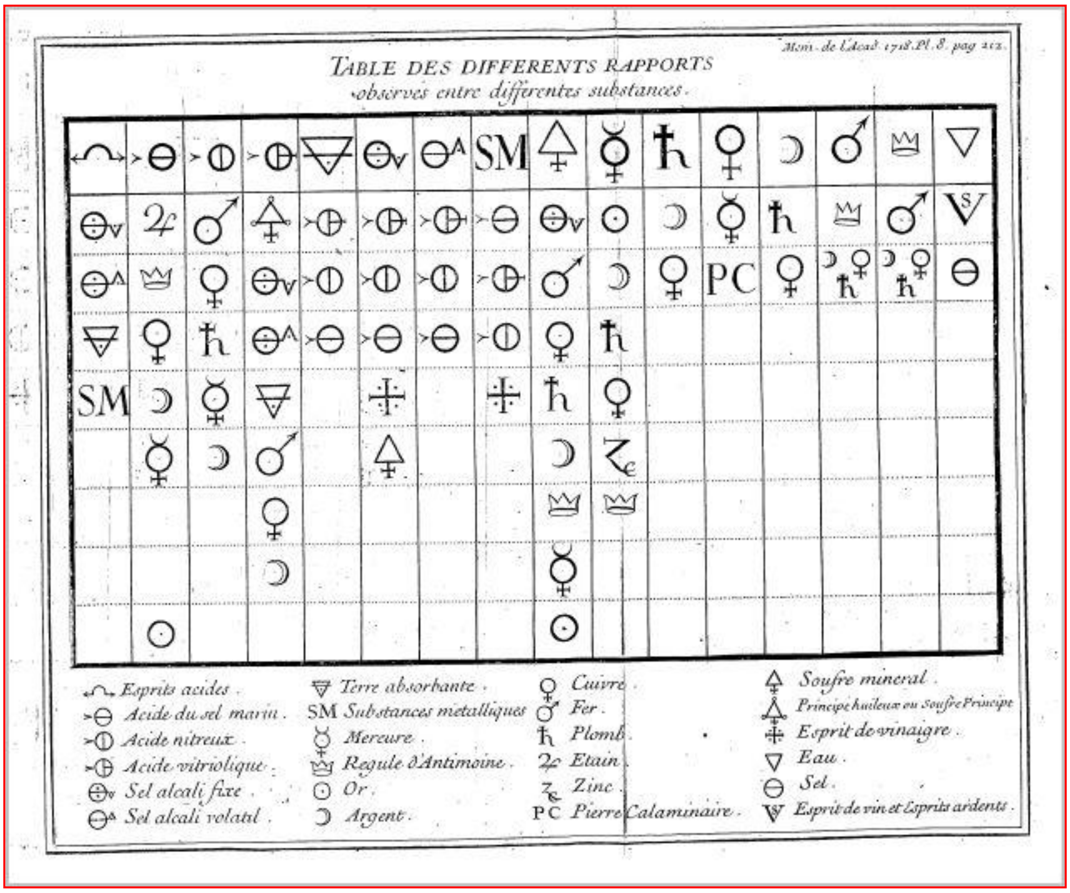
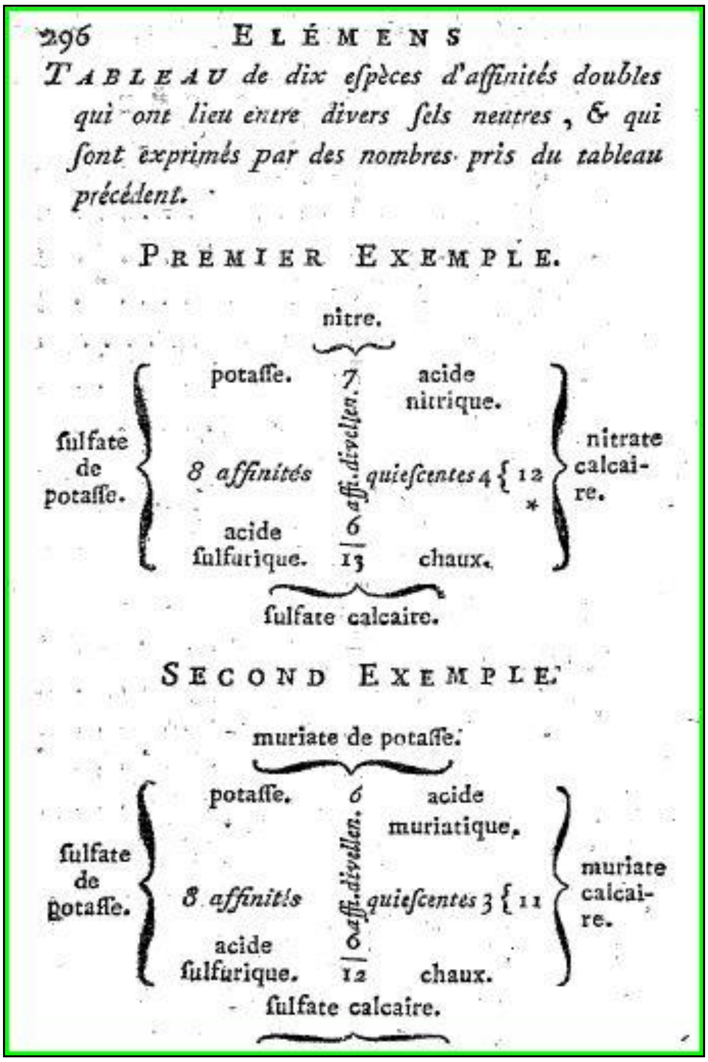


Figure 4: *Geoffroy's table of the different affinities observed in chemistry between different substances (1718)*



296 ELÉMENS

TABLEAU de dix espèces d'affinités doubles qui ont lieu entre divers sels neutres, & qui sont exprimés par des nombres pris du tableau précédent.

PREMIER EXEMPLE.

nitre.

potasse. 7 acide nitrique.

sulfate de potasse.

8 *affinités* 13 *affi. divellen.* *quiescentes* 4 { 12 *

nitrate calcaire.

acide sulfurique. 6 chaux.

sulfate calcaire.

SECOND EXEMPLE.

muriate de potasse.

potasse. 6 acide muriatique.

sulfate de potasse.

8 *affinités* 12 *affi. divellen.* *quiescentes* 3 { 11

muriate calcaire.

acide sulfurique. 6 chaux.

sulfate calcaire.

Figure 5: *Figurative ciphered diagrams of reciprocal decompositions between salts showing the corresponding degrees of attraction (A.F. Fourcroy, 1793, Élémens d'histoire naturelle et de chimie)*

By the way of conclusion

It is hard to believe in the effectiveness of Berthollet's course as a training course for teaching chemistry. There are basically two points underpinning this prospect. The first one refers to the introduction of such a speculative topic as the one of the elective affinities in the first lessons of the course. In this sense Berthollet dismissed Lavoisier's dictum – presented in his *Traité élémentarire de chimie* – of never advancing from what is unknown to what is known and from what is complex to what is simple, in order to render facts and concepts easier for beginners in the study of chemistry.

The other questionable point of his course program was the introduction of a conceptual innovation – such as an outline of his own system of chemical affinities – as well as the introduction of a theoretical controversy - such as Lavoisier's theory of acidity. In principle, these sort of initiatives are more appropriate for being

presented and defended in research memoires than in an elementary chemistry course.
Along with these methodological aspects, it is worth pointing out the absence of any reference to the reform of the chemical nomenclature to which Berthollet had given support. It is striking that the new language that was going to serve to present and diffuse the new chemistry of the late XVIIIth century was not a topic of the course.
In spite of all these weak points of the course, Berthollet's lessons reveal a true interest in the didactics of chemistry that has not been sufficiently appreciated by historians of chemistry. Regarding the *École Normale*, it would have the right to claim of being the first institution in France in looking after the education of teachers and, particularly, the training of science teachers.

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The Importance of the Introduction of L.V. Brugnatelli' s *Pharmacopea Generale* by Dionyssios Pyrros to the Greek-speaking Regions in the beginning of the 19th c.

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"Pharmacopoeia" and "Chymiki" in Greek area in the first half of 19th century

In Greek area the profession of pharmacist, even in the first half of the 19th century, was still practiced freely from whoever wanted to and especially from physicians, since a legal basis was absent. Probable causes were the lack of pharmaceutical schools all over the Ottoman Empire and the lack of interest from the authorities. Pharmaceutical guilds were the precursors of pharmaceutical associations. In order for someone to open a pharmacy he had to have its guild's approval. There were four grades of hierarchy in a pharmacy's guild: first master, master, assistant and apprentice. (Panagiotidou, I. 1994, 167-168)

In the pre-revolutionary Greece the number of the Greek scientists-doctors who studied at the European Universities and appropriated the new scientific medical knowledge was eliminated (Karas, G. 1994, 11-17). In order to cover its medical needs, Greek population sought medical care to practical doctors, who practiced medicine in small villages or travelling from place to place. (Karamperopoulos, D. 2003, 568-569). It was the, financial or geographical, lack of access in medical care which lead Greek people to do their own preparation of medicines. This is affirmed by the great number of manuscripts with medical recipes for several diseases. The so called *"iatrosophia"* (=*medical wisdom*) contained not only recipes with superstitions and alchemical preparations, but also ones from the great ancient doctors Hippokrates, Dioskourides, Galenos, Pavlos of Aigina, Oreivassios, etc.

The process of the constitution of the science of pharmacy in the Greek speaking regions of the Ottoman Empire, as in the rest of Europe, was discursive and social, during which the process of the constitution of the science of chemistry was proved decisive. The reception of Lavoisier's 'new chemistry' in Greek area had as a result the formation of a didactic tradition of lavoisierian-neutonian chemistry (neutonian "Chymiki") mainly from Athanassios Psalidas and his work *Περί φυσικής εν γένει (On Physics in General* 1795). Psalidas was under the influence of the "neutonian dream" for a unified precise science for chemical and natural phenomena and tried to understand the systematization of chemistry based on the model of classification of the naturalists. Even he accepted the notion of element, according to Lavoisier's theory, and recognized the role of oxygen in the combustion, he did not adopt the modern nomenclature of chemistry and he promoted the questioning of chemical affinity. The neutonian tradition maintained and continued as a dominant trend also in the prefaces of translations in Greek of chemical works of Fourcroy's from T.Iliadis, Adet's from K.Koumas, and Brisson's from D. Filippides. **(**Bokaris and Koutalis 2007, 597-607). These naturalistic approaches of Lavoisierian's Chemistry, folmulated in the Greek speaking regions, encountered with the introduction of Brugnatelli's *Pharmacopoeia* by Pyrros' productive work.

Pharmacy in European centers
In Europe up to the middle of the 18th century pharmacopoeia was practiced by *apothicaires* and doctors. The development of the science of chemistry in the end of the same century reconstructs the cognitive discipline of pharmacopoeia and constitutes the science of pharmacy which is academically established while at the same time the social role of the pharmacist is recognized.

Pharmacy in France
The establishment of College de Pharmacy in 1777 in Paris as an administrative and educational institution resulted to the use of the term *pharmacien,* as the official one for the pharmacists since, for the French public, the opinion for *apothicaires* had gradually become underestimated. Afterwards they founded local pharmacists' societies in several scientific centers of French pharmacy. (Sonnedecker, G. 1976, 71-73) After the French Revolution there were six schools of pharmacy of higher education in France which were differentiated from medicine because the legislation of 1803 permitted the graduated pharmacists to practice pharmacy at a national level. Napoleon's legislation established the basis for the modern French pharmaceutical profession. The fundamental shift in the conception of how pharmacy would operate were: the end of guild control of the profession, the increased emphasis on both theoretical and practical education in training and practice of the pharmacist and the separation of the College of Pharmacy as a teaching establishment from the College of Pharmacy as a guild because of pharmacy's connection with the science of chemistry. As Simon points out: *"Chemistry promised to liberate pharmacy from routine artisanal routine, but in order to share fully the benefits that the perfection of science in the 18th century offered, pharmacy now required a formal educational structure" "Lavoisier took the chemistry that was already shifting away from the pharmaceutical tradition and removed it beyond any measure of doubt. It was up to Fourcoy to try and reestablish some sort of filiation, but this time with chemistry as the dominant science and pharmacy as a subservient art."* (Simon, J. 2005, 120-121, 91)

Pharmacy in Britain
In Britain the first regular curriculum of the Society of Apothecaries was issued in 1827 and it was mainly medical. In 1844-45 the society's school of pharmacy became the first institution in London to offer laboratory instruction for pharmacy students under proper guidance. The society consistently fostered and valued the role of education aiming to shape a new profession out of the original heterogeneous group of "chemists" and "druggists". (Sonnedecker, G. 1976, 102-105)

Pharmacy in Germany

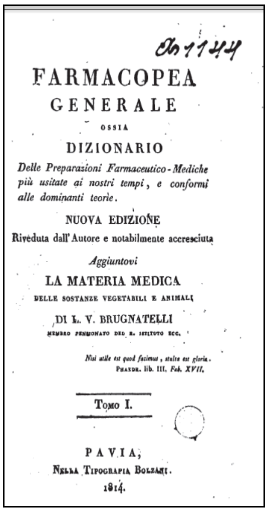
Until after the 17th century the whole of German pharmacy could scarcely rise above the level of technical skill. In 1725 in Prussia German pharmacists began to take place among the representatives of the scientific professions due to the obligatory examinations in which they had to succeed in order to practice pharmacy before the provincial medical board. Bavaria in 1808 was the first German state which made university study obligatory and soon this was followed by other German states. The social status of the pharmacist in Germany was that of a typical representative of the middle class mainly because they were the most available and sometimes the only representatives of natural science within their communities. (Sonnedecker, G. 1976, 92-95)

Pharmacy in Italy

The Austrian legislation of 1778, regulating pharmacy in Northern Italy, required academic study and examination for pharmacists of this area. This requirement was exceeded to the Napoleonic Kingdom of Italy. Thus pharmaceutical education was gradually transferred from the craft-like schooling by the guilds to the Italian Univerisities. The reform of public education on the basis of the law on September 4th in 1802, created two national universities, in Pavia and in Bologna. A university degree was required for those who were to practice pharmacy. The syllabus lasted for three years, during which they studied experimental physics, natural history, botany, *materia medica*, pharmaceutical chemistry and general chemistry in which new anti-phlogistic chemistry was imposed by law. The new chemistry seems to have offered to apothecaries a way to be released from physicians and to be distinguished from grocers, and according to Seligardi, was *"a means for social elevation in terms of cultural prestige and not for career opportunities".* (Seligardi, R. 2007, 31-50)

Brugnatelli and *Pharmacopea Generale*

Luigi Valentino Brugnatelli was born in Pavia on 14th February 1761, where he died on 24th October 1818. He initially worked in the engineering trade and graduated in medicine from Pavia in 1784. His great interest in chemistry led him to continue with his professor of chemistry G. A. Scopoli. Since 1787 Brugnatelli taught chemistry as an assistant to the Chair of Chemistry in Pavia and in1796 he obtained the chair of General Chemistry. (Burns, T.D. et al 2008, 57-87)



FARMACOPEA
GENERALE
OSSIA
DIZIONARIO
Delle Preparazioni Farmaceutico-Mediche più usitate ai nostri tempi, e conformi alle dominanti teorie.
NUOVA EDIZIONE
Riveduta dall'Autore e notabilmente accresciuta
Aggiuntovi
LA MATERIA MEDICA
DELLE SOSTANZE VEGETABILI E ANIMALI
DI L. V. BRUGNATELLI
MEMBRO PENSIONATO DEL R. ISTITUTO ECC.

Nisi utile est quod facimus, stulta est gloria.
PHAEDR. lib. III. *Fab. XVII.*

TOMO I.

PAVIA,
NELLA TIPOGRAFIA BOLZANI.
1814.

Figure 1: *Brugnatelli's Pharmacopea Generale Pavia 1814*

Brugnatelli's *Pharmacopoeia* is a work that appeared in Italian initially in 1802 entitled *Pharmacopea* and then in 1807 with the title *Pharmacopea Generale* (also in French in 1811). Brugnatelli wrote his pharmacopoeia because *"the enlightening advances of every experimental science and especially of chemistry of the time, the official changes which were introduced to its vocabulary and practice, gave an important boost to the work on the perfection of the Art of medicines' preparations… With so many considerable and celebrated acquisitions, it became essential the presence of a pharmacopoeia, which would include with precision the basic improvements concerning the pharmaceutical preparations and being adapted as long as it is possible to the main chemical and medical theories…"* (Brugnatelli, L.1814, 1-2)

In his *Pharmacopea* of 1802 Brugnatelli describes the uses of the remedies, the physical properties of each one and the best doses tested by practice. In a table he explains why he reformed that nomenclature and in another he shows the copperplate engravings of the instruments required for a good chemical laboratory. (Seligardi, R. 2007, 41)

Lavoisierian's Chemistry in Italy

At the end of the 18th century Italy was divided into many states and there was no unity within the scientific community. Pavia's scientific world had stronger links with England and Germany. Until 1790 most Italian naturalists supported phlogiston theory *"more or less as a matter of course".* (Beretta, M. 1993, 309) Italian chemistry was closely linked to other disciplines such as medicine and mineralogy and the first professors of chemistry were doctors or natural philosophers by training. The ''official'' translator and popularizer of Lavoisier in Italy was the Venetian pharmacist Vincenzo Dandolo (1758-1819) who translated the *Traite* (1791) and two dictionaries, which were a partial translation of the *Methode*. (Seligardi, R. 2006, 714-715)

Among the several chemistry textbooks and the different interpretations of the new chemical discoveries, the two best known in Italy was the one of Dandolo who followed Lavoisier and pointed out the importance of oxygen as the reason behind the rejection of phlogiston and the one of Brugnatelli who had his own caloric theory and nomenclature. Dandolo and Brugnatelli, both chemists and physicians who emphasized in experimental practice, represent the main ways in which Lavoisier's new chemistry was approached in Italy: a.as a contrast between phlogiston and oxygen with the resultant opposition between the old and the new chemistry as Dandolo viewed and b.as the starting point to improving chemistry's new approach as Brugnatelli tried by constructing a new theory of combustion and a new nomenclature, which can be framed into the caloric theory interpretation. (Seligardi, R. 2006, 722-723, 713-714)

Brugnatelli's views of chemistry, chemical theory and new nomenclature

In his fundamental work *Elementi di Chimica appoggiati alle più recenti scoperte chimiche e farmaceutiche* (Pavia 1795-1798), Brugnatelli defines chemistry as: "*the science whose object is to discover the nature, and the properties of all bodies, both natural and artificial*". In the edition of 1803 there is a different definition for chemistry: *is the science whose object is to discover the intimate nature and the mutual attraction of the integral and component parts of all the bodies".* According to Seligardi (2006) *"The shift from a more classical view of chemistry as the art of composing and decomposing to a more modern conception of chemistry as the science of the affinities is here even clearer".* (Seligardi, R. 2006, 718)
Brugnatelli's chemical theory was based on Lavoisier's, but was differed from it mainly in combustion and in the nature of caloric and oxygen. For Brugnatelli the main property of oxygen was not that it was the universal principle of acidity, as Lavoisier believed, but the substance with the largest quantity of caloric combined with it. This presence of caloric was therefore taken by the main characteristic of oxygen, and Brugnatelli suggested changing the name to *termossiggeno*. He also proposed the name of *fossigeno* (*photogen* from the Greek *begetter of light*) for nitrogen (*azote* for the Frenchmen) and after 1797 another name, *septone* (from the Greek *putrid*). Since a large part of Lavoisier's new system of nomenclature was oxygen-based Brugnatelli also modified the names of all the combinations of oxygen. He also recommended taking the entire chemical nomenclature from Greek and weeding out all the Latin terms. He started by *acid* (from Latin), to *ossi* (from Greek), so that for instance, sulphuric acid became *ossi-solforico*. Also dissatisfied of some important words of Greek origin in the *Methode,* instead of the term *oxide*, he introduced the also Greek term *encausto* (combusted). These few, but strategic, changes radically modified the substance of the French nomenclature and resulted an entirely new chemical language. (Beretta, M. 1993, 311-313) Thus unlike the others who criticized the new nomenclature without making their own proposals, being more systematic and ambitious, Brugnatelli published the *Vocabolario della Nuova Nomenclatura Chimica Riformata e Accresciuta da Luigi Brugnatelli (*1795 which was added to the first volume of *Elementi di Chimica.*) and the *Sinonimia*, in which he classified the French nomenclature terms among the old names (French translation in 1802). (Seligardi, R. 2006, 717-718) In that way Brugnatelli became one of the chemists who proposed one of the several alternative nomenclatures which mostly published after the death of Lavoisier and their partial success seriously challenged the nomenclature proposed in 1787. (Beretta, M. 1993, 257, 286)

Dionyssios Pyrrhos

Dionyssios Pyrrhos was born in 1774 or 1777 in Kastanea of Trikala. After his elementary education he decided to become himself a monk. After his education in the most important schools of Greek area he decided to go to Europe *"in order to follow experimentally the lessons which he had being taught"*. (Pyrrhos, D. 1848, 5-6, 31) Thus in 1803 he went to Pavia to study medicine. Pavia's University was at that time to a European position of great prestige, respect and consideration. Its professors were among the most important advocates of scientific culture – in particular naturalistic and medical – at the end of the 18th century. (Berzolari,

A.G.2002, 69) After his studies in Italy he returned to Athens where he taught Medicine, Physics, Natural Sciences, Mathematics, Geography, Philosophy and Botanic according to "Linnaeus system" from 1813 until 1815. The same period he contributed to the foundation of the first scientific school, a botanical garden and a museum of mineralogy. Pyrrhos also seems had dealt with the construction of scientific instruments. He also participated in the Greek Revolution for the Greek Nation's Emancipation. (Vlahakis, G.N. 1998, 3-5)
Although there is no evidence referring to Pyrrhos' knowledge about the debate between Brugnatelli and Lavoisier, another Greek scholar of the time, Konstantinos Vardalahos described extensively their debate in his work *Πειραματική Φυσική* (Physics Experimental) published in 1812 at Vienna. (Vlahakis, G.N. 2001, fasc.1)

New Pharmacopoeia (title) - ***Pharmacopoeia General*** (1st page)

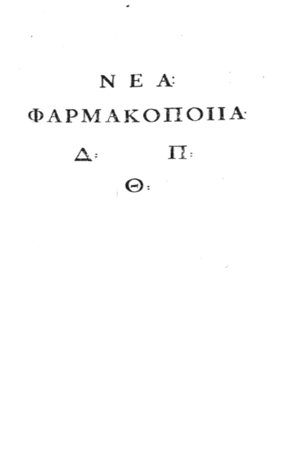

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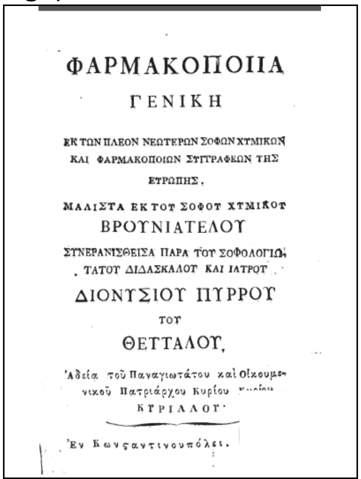
Figure 2: *Pyrros Pharmopoeia New, Constantinople 1818 (cover page)*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ΘΕΤΤΑΛΟΥ,
Ἀδεία τοῦ Παναγιωτάτου καὶ Οἰκουμενικοῦ Πατριάρχου Κυρίου
ΚΥΡΙΛΛΟΥ·
Ἐν Κωνςαντινουπόλει.

Figure 2: *Pyrros Pharmopoeia New, Constantinople 1818 (1st page)*

On February 2nd of 1818, the physician, archimandrite and teacher Dionyssios Pyrrhos translates and prints in Constantinople *New Pharmacopoeia* of the *"great Chymist Vrouniatelliou"* in which he added *"and many others chymical preparations, all collected from the most modern and wise doctors of Europe"… "I translated a newer Pharmacopeia of the eminent Chymist Vrouniatellou, the wise teacher of mine to the Royal Academy of Pavia, which when it came out in the light, the French and other European, they immediately translated it and also printed it for the utility of their gender."* … *"I contemplate this pharamacopoeia to be useful and necessary not onlyto Physicians and Pharmacists* (note that in these words the first letter is capital) *but also to every cognitive man, since with it everyone can also prepare his own medicines, to know their's force and action, their way of use, their dose and their adaption to man's passions."… "I hope to become beneficial and life-useful to all our Christians brothers", "I think this book to be usefull and necessary to our gender*". (Pyrrhos, D. 1818, ζ, θ) This is the first printed pharmacopoeia in Greek language which widely circulated. The tirage of Pyrros's Pharmacopoeia was 1000 (Pyrrhos, D. 1837, 47-48). As he reports: *"Before the recording of the preparations a dictionary of the preparations and actions of this discourse is prefixed and also an interpretation of some instruments of Chymistry and Pharmacy, those two big Sciences. At the end of the book we also add a Dictionnary of some botans and matters and a map of some drawings of those instruments"* (Pyrrhos, D. 1818, ια΄)
According to Pyrros: *"Practical Pharmacopeia teaches the way with which Doctors and Pharmacists can compose and analyze the various substances, that is to say to*

prepare various medicines, which they seem to be more preferable to the Doctor and beneficial to the patient. The Doctors and the Pharmacists should know very well this art, in order not to make mistakes in their actions, as many times happens from their ignorance. That is the reason they should know even the instruments of Chymistry and Pharmacy with which medicines are prepared from them." (Pyrrhos, D. 1818, ιβ΄)
In his chapter "Definitions and actions of Pharmacy" Pyrrhos defines and decribes chemical procedures which were used to medicines's preparation (Table 1).

Table 1. Definitions and Actions of Pharmacy in Pyrrhos's Pharmacopoeia	
1. *evaporation* = *svaporazione* the separation of a liquid from another denser one or a solid by fire	10. analysis through fusion
2.distillation	11. dissolution
3.decoction	12.**oxygenation** = the compound of thermoxygen with P,S, etc, =ossigenazione
4.boil	13.shredding with mortar
5.filtration(through paper or cloth)	14.sieving
6.concentration or inspissation with heat	15. saturation
7.fusion	16. precipitation
8. vitrification	17.cleaning with white of egg
9. crystallisation	18.squeeze

Table 1

The structure of each pharmaceutical preparation is: Greek name, Italian name in Greek, Italian name, Way of preparation, Character, Way of use, Action, Use, Dosage, Observations, Additional preparations.The units of measurement in Pyrrhos work are: drams, grains, beds and handfuls. The quantities are written with entire words and with letters and not with Greek or Arabic characters. Pyrrhos follows the Italian alphabetical order in the text's corpus and the Greek one in contents. Chymistry's and Pharmacy's instruments and apparatuses which are *essential to pharmacists* are described with detail and illustrated in Pyrrhos' s hand drawn table at the end of the book. Those are: retort, still, bain-marie, stove reverberation, filters, mortar, siphon, inhalator, evaporator, flask, fiale, Wolf's apparatus, apparatus hydropneumatic, apparatus pneumatic, sieve and other various instruments. "Pharmacists should also have a lot of bottles, pipes, vessels and containers of various types and matter". (Pyrrhos, D. 1818, ιε΄-κ΄)

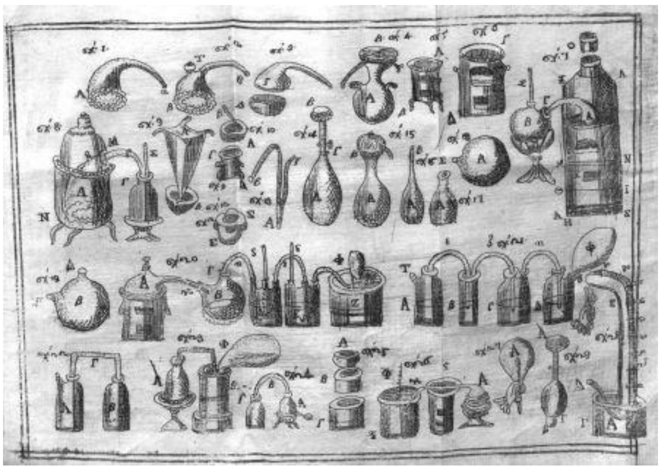

Figure 3: *Chymistry's and Pharmacy's apparatuses described by Pyrros*.

Brugnatelli’s new nomenclature in Pyrrhos Pharmacopoeia

Table 2 shows some representative examples of the hellenisation of Brugnatelli’s nomenclature in Pyrrhos’s Pharmacopoeia.

Table 2. Representative examples of Brugnatelli᾽s new nomenclature in Pyrrhos᾽s Pharmacopoeia		
Brugnatelli’s (in English)	**Brugnatelli’s** (page number)	**Pyrros’s** (page number)
Thermoxigene gas	*Gas Termossigeno*(p.276)	Θερμοξυγονικός αήρ ή ζωτικός (p.92)
Thermoxygenased water	*Aqua termosiggenata*(p.86)	Νερό θερμοξυγενές (p.20)
Gas flogosulphurated water	*Aqua gas flogosolforata*(p.82)	Νερό μικτό με φλογογόνο αέρα (p.19)
Phlogogen gas	*Gas flogogene*(p.269)	Αήρ Φλογογόνος (p.87)
Oxyseptonic ether	Etere di ossiseptonico (p.252)	Αιθήρ οξυσηπτονικός (p.79)
Septon gas	*Gas settono/septonic*(p.274)	Σηπτογονικός αήρ (p.91)
Oxysulphuric *(sulphuric acid)*	*Ossi-solforico retificato*	Θειικόν οξύ (p.168)
Oxyacetate of baryta	*Ossiacetito di Barite* (p.350)	Όξος της Βαρύτητος (p.112)
Oxyacetate of Lead	*Ossiacetito di Piombo* (p.363)	Όξος του Μολύβδου (p.113)
Oxybenzoic *(benzoic acid)*	*Ossibenzoico* (p.379)	Οξυπενζωικόν (p.115)
Oxycitric *(citric acid)*	Ossicitrico (p.393)	Οξυκιτρικόν (p.120)
Oxyphosphoric (*phosphoric acid)*	Ossifosforico (p.399)	Οξυφωσφορικόν (p.123)
Oxysaccharic	Ossizacarico (p.441)	Οξυζακχαρικόν (p.143)
Oxyseptonic *(nitric acid)*	Ossiseptonico/ossisettonico (p.10b)	Οξυσηπτονικόν (p.146)

Table 2

The comparison between Pyrrhos’ and Brugnatelli’s Pharmacopoieas

Although the two works follow the same structure, in Pyrrhos’s Pharmacopoeia are absent procedures from the “Definitions and Actions of Pharmacy” as: esterification, nitrification, gasification, etc. In “instruments and apparatuses” there is no differentiation between baths (in sand, alcohol, oil or water). They are also not mentioned: the thermometer, the medical use of Volta’s battery, the subdivisions and the equivalences of the measurements. Synonyms in Latin, English and French are also absent as well as various tables of the 2nd volume of Brugnatelli’s pharmacopoeia and a list with the newer pharmaceutical works which circulated all over Europe. From the approximately 800 preparations of Brugnatelli, Pyrros has chosen 184, that is to say about the 25%. However Pyrrhos added a chapter entitled Chymistry Economical.

Conclusions

Pyrrhos introduces his Pharmacopoeia in the Greek speaking regions of the Ottoman Empire commited to the values of European Enlightenment according to which Nature *“becomes the new context of ontological reference, replacing the transcendental spirit”* and causing *“automatically an approach to philosophy and to natural sciences”,* recognizing simultaneously the social usefulness of science.(Kondylis 2000, 17)

The introduction of Brugnatelli’s pharmacopoeia, encountered in the greek-speaking regions the scientific evolutions of “chymia”, where the naturalistic approaches of Lavoisierian’s Chemistry predominate under the dominance of the Newtonian questionning of chemical affinities.This questionning does reflect the epistemological values of Brugnatelli’s “chymistry”.

Pyrrhos’s nomenclature is better distinguished for its empirical rather than its theoretical character, in which Brugnatelli’s nomenclature is proven to be very useful, keeping, as he reports, in the case of spirits the old ones: *“Wishing to follow* *the common use of "Chymistry" and to do that in a way with which the names would show the artificial compound of "matters", I keep the old nomenclature of spirits, as we see in the following. In the present Pharmacopoeia from now on with the term 'spirit' we do not wish to mean something else than the compound of atoms, that is to say the very small parts of a matter in the so called spirit of wine or another's fluid."* (Pyrrhos, D. 1818, 29) Pyrrhos uses stoichiometry of "matters" (substances) with the scale's help and simultaneously he attempts the purity of its products to the degree in which the techniques of the Greek-speaking academia and the applied social practices allow him. It is not by accident that from Pyrrhos' Pharmacopoeia physical and chemical operations-which are found in Brugnatelii's textbook (such as esterification, nitrification etc.) - are missing.

The social character of Pyrrhos's Pharmacopoeia is also proven from the "Chymistry Economical" which embodies in his textbook and which will find a more comprehensive approach elsewhere.

Finally, Pyrrhos introduces his Pharmacopoeia reconstructing the empirical practices and preparing the field, not only for its academic establishment, but also for the restoration of pharmacist's new role under the influence of the new scientific evolution. These changes mark the status of the Greek-speaking community, who is aware of the scientific debates which take place in Europe in regard to Chymistry (like Lavoisierian and non, Brugnatelli –Lavoisier, etc.) and attempts guided by the Enlightening values, to productively construct theoretical traditions which reflect the status of the social and economical relations of that era.

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The Mathematical Work of Dimitrios Govdelas and its Influence on the Education of the Greek-speaking Regions in the meta-Byzantine Era

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During the post byzantine years at the Greek-speaking regions-based on the teaching textbooks of that time-the role of Mathematics is limited mostly to the revival of ancient greek Mathematics and to the identification of solutions for everyday's problems. However, in the beginning of the 18th century along with the renaissance of scientific and philosophical thinking, the role of Sciences, especially Mathematics evolves and the basis for the beginning of mathematical education of Hellenism is formed. During the first decades of that century efforts were made to translate and publish manuscripts and other scientific textbooks, which would have been able to cover the educational needs of that time. This process was initiated from scholars mostly members of the church, who studied at universities of Western Europe and tried to introduce their fellow countrymen to the ideas of scientific rationalism and the new natural philosophy using novel scientific and teaching books.
Dimitrios Govdelas is known for his mathematical work and his teaching activity at Iasio of Moldavia. He is an excellent example of the Greek scholars' efforts of that time aiming to further develop and spread the mathematical thinking of the enslaved Hellenism. In particular, two of his mathematical books written in archaic language -here presented and analyzed- intend to further develop the basic mathematical education. In their introduction the ancient Greek mathematicians are mentioned and emphasis is given to the importance of Mathematics in ancient Greece. In addition, the necessity of introducing new Mathematics, such as Algebra and Infinitesimal Calculus is justified. The evolution of the mathematical concept is presented in a didactic fashion from antiquity till that era.

Introduction

The great development of science in the 17th century and the new philosophical inquiry, which resulted from the humanistic reflection of trends and the intellectual movement during the Renaissance, created the Age of the Enlightenment. The dominant idea was that of the independence of the world and of the autonomy of man from any transcendent authority, resulting in both social changes and the structural reform of education in the West. (Dimaras, C. 1998, 1B; Noutsos, P. 1981, 15-16) Specifically the Enlightenment was the intellectual movement in Europe in the 17th and 18th centuries, during which a synthesis of ideas about God, reason, nature and man was accomplished. (Valaes, D. 2005, 241-242) The changes concerned all aspects of human action and manifested in many ways in philosophy, political thought, art, etc. with the ultimate purpose of advances in knowledge, freedom and happiness of man. (Dimaras, C. 1998, 5-6)

The main carrier of the new ideas of the Enlightenment was the rising bourgeoisie, which up to that time remained blocked by the system of absolutism. The influence of the spiritual power of the Enlightenment in Greek thought and culture began in the prosperous Greek communities, such as Vienna, Iasi, Venice, Paris, etc. and through them it propagated, though with some delay due to the special conditions prevailing there and in Greece. The Greek Enlightenment was formed in the Greek-speaking regions as an intellectual movement analogous to the European Enlightenment in the period 1669-1821 and is divided into two periods: the first is the period of preparation (1669-1774) and the second the period of Modern Greek Renaissance (1774 - 1821). (Dimaras, C. 1998, 23) Its most important representatives are mainly scholars, clergy or merchants. The ideology represented by the entities of the Greek Enlightenment is characterized by the strong influence of traditional values and the total acceptance of European ideas and leads, by challenging traditional patterns and creating a new system of values, to the formation of a "Greek style Enlightenment" based on progress in science, philosophy and society, without devaluation and elimination of Greek tradition and knowledge. (Metallinos, G. 1993, 150-153; Matsoukas, N. 1985, 21-23)

The scientific community of the Modern Greek Enlightenment

The 18th century marks the birth of modern science. Central to Enlightenment thought were disciplines such as Cosmology, Physics and Mathematics, since after the introduction of the formalism natural phenomena are described in a more satisfactory way. Science is not shaped from scratch in a hyper-local thinking context about the truth of nature, but in a variety of different local contexts.

In the 19th century the introduction of scientific discourse is no longer a result of long and complex negotiations between different mental operations such as those expressed in a variety of local contexts

Regarding the Greek world, albeit an important part of modern historiography claims that the contribution of Greek scholars in the science of their time was practically insignificant, they however tried to follow the trends of the time, to carry to their compatriots the liberating message of scientific rationality and render the Greeks a part of modern European civilization. (Patiniotis, M. 2006, 3-16)

The Greek scholars of this era through European thought examine the past without an attitude of imitation or rejection but rather to determine their own new knowledge production. They even update and enrich their own tradition trying to capitalize on the creative elements of the past with a continuous review approach. They create a structured scientific discourse, with induction compositions, with criticism and scrutiny that is educational too by forming respective teaching traditions. (Karas, G. 1978, 57-63; Goudas, A. 1870, κδ'-κς’)

The launch of the new scientific knowledge among the wider circles of Greek scholars has resulted in the formation of a scientific community with not only new scientific discourse (according to term ‘transfilling’ by Korais) but primarily with an educational rather than a scientific objective. (Gavroglu, K. and Patiniotis, M. 2008, 154-175) Since the selection of texts to be translated requires knowledge, reflection and special avocation, without excluding the random sample, the criteria for selection vary between individuals and periods, while the aim of translation remains the same for everyone and refers to national benefit. Greek scholars of this era tend to translate contemporary writings which are on display in European bookstores and whose suitability for teaching is confirmed by the large number of reissues in the West. (Karas, G. 2003, 110-122)

Mathematics in the Greek Enlightenment

As early as the late 17th century some clerics study at the Universities of the West to return to Greece and spread Mathematics, which is largely for them the ancient Greek mathematics. (Nicolaides, E. 1993, 131-150)

During the second half of the 18th century there is an impressive editorial production of mathematical works, compared to that of previous centuries .Until the Revolution about 30 titles were released. In the next two decades of the 19th century, another 25 mathematical works are printed, which are texts on arithmetic, geometry or algebra. Some contain both arithmetic and algebra, while others include Calculus. Some 11 of these books belonging to the first category and some 5 of the second category are translations from western manuals while the remainder books are extracts as indicated in their titles or prefaces. Apart from these several others which remained in manuscript form are also the result of compilation or translation work. There are references on the usefulness of the translation of mathematical works by the same scholars, such as in the *'Elements of Arithmetic and Algebra'* by Zissis Kavras, the *'Arithmetic'* by Athanasios Psalidas and *'Histories of Human Acts'* by K.M. Koumas . In the last pre-revolutionary decades the European writings are either translated (and printed or remain in manuscript form) or help towards compilation in Greek belonging belong to French or German scientists. The majority of Greek scholars at that turning to German-speaking universities, such as Vienna, which from the late 18th century was a place of enlightenment ideas propagation and promotion to the East.

From the date of issue of the original writings and those of translation, and based on what we know about the time of translation and publishing, we find that most of the European mathematics textbooks are modern literature.

Main criteria for selection of original mathematical works for the scholars to translate are:

- be a modern proposal
- satisfy as much as possible the personal perception of science,
- can be used as textbooks
- can be directed to the general public and be used as auxiliary to solve everyday business problems, such as numerical manuals. (Karas, G. 2003, 109-122)

The life and the educational activities of Demetrius Govdelas

Demetrius Govdelas was born at Rapsani, Thessaly in 1780. The privileged position of his hometown along with economic prosperity from the mid-18th century generated the opportunities of the region's spiritual growth. Govdelas received his basic education initially in his hometown. In 1798 he went to the Royal Academy of Pest in Hungary and attended courses in Philosophy, World History, Algebra, Geometry, Trigonometry, Physics, Chemistry, and Metaphysics. He was also taught the systems of Ptolemy, Copernicus and Tycho Brahe. He graduated in June 1802, with the

degree of "Doctor of Liberal Arts and Philosophy." The Academy curators ask him to undertake the task of teaching philosophy and law courses.
In 1803 he goes to Vienna, where he meets Anthimos Gazis. In 1807 he is offered a post in St. Petersburg, but is finally unable to travel through Poland because of the war. In September 1808 he works as a professor at the Academy of Iasi and teaches algebra and geometry while at the same time exercising the duties of director. His work within the Greek Gymnasium is recognized and appreciated by the local authorities on account of renovation initiatives. In 1811 his conflict with the school's curator leads him to resign, so he turns to Russia. There he meets with Ypsilantis, most likely to elaborate a plan for declaring the Greek revolution. Letters written at that time indicate that Govdelas belongs to the narrow circle of Anthimos Gazis and co-publishes with him the literary journal *"Hermes the Scholar";* his trip to Moscow is very likely a mission to promote the plan of organizing the liberation struggle.
His second term at the Academy of Iasi begins in March 1816 when he signs a three-year agreement at the school to substitute Stephen Dougka. Classes include Mathematics, Physics, Chemistry, Philosophy, Cosmogony, Theology and Psychology. Govdelas' teaching method is influenced by the German education system. He adds the use textbooks in classes. He collaborates with renowned teachers such as George Asanos, Kallias Sotiropoulos and Georges Jean.
Govdelas is criticised for his teaching methodology and language that he uses and is considered by some as 'committed to the old ways, when these cannot be applied to the present situation since most scholars already uses the spoken language in sciences'. His contemporary Koumas sees him as a "man who has tried a lot but did not complete anything. (Koumas K. in Valaes, D. 1994, 207-226)
He ceases activity in 1821 due to the sudden developments in the Danubian Principalities. Following the closure of the school and the loss of assets and manuscripts, he deposits at St Athanasius Church as many unpublished works in philosophy, mathematics, economics, ethics and literature as he can in order to preserve them and flees to Poland. He spends the next year here but his property perishes along with the manuscripts he had tried to preserve. Testimonies indicate that he was in transit in Munich in 1828. In 1830, faced with serious financial problems, he returns to Iasi asking for compensation on the grounds of having been persecuted by the school. The matter is still unsolved at the time of his death in the same year. (Valaes, D. 1994, 207-226)

The mathematical work of Demetrius Govdelas

The pre-revolution revival of scientific and philosophical thought sees the role of science upgraded and, more particularly, mathematics. Simplified arithmetic textbooks are published in the spoken language specifically designed to be easily and quickly understood by the general readership. The writing of the books by scholars sought to impart knowledge of the basic principles of science leading to a fuller study of other methodical and scientific books. The mathematical knowledge remains largely adherent to ancient Greek mathematical tradition until the last decades of the 18th century, when the first attempts are made to introduce modern mathematics.

The "Elements of Algebra"

Figure 1: *The "Elements of Algebra"*

The *"Elements of Algebra"* by Govdelas is the first stand-alone algebra book published in Modern Greek mathematics education, so it is interesting to study its cognitive contribution to the development of Greek mathematical thinking in the early 19th century. (Karas, G. 2003, 175) The book was published in Halle, Magdeburg in 1806, although the author had completed it in late 1803, when he was in Paris, but not published it for financial reasons. ((Valaes, D. 2005, 243).

As reported in *Hermes the Scholar* (*Λόγιος Ερμής,* 1811, 79), the book was dedicated to Emperor of All Russia Alexander the first. The book consists of 784 pages. It features the author's engraved portrait at the beginning and there is also an overview of the history of algebra from pages XXVI to XCVII while 3 tables are included at the end. The pre-revolution journal "Ερμής ο Λόγιος" (The Scholar Hermes 1811, 79) states that prevailing conditions did not allow for the publication of the second part of the algebra book.

Until then this book is the bulkier mathematical handbook of Greek mathematics education. Of particular interest is the presentation of different aspects of mathematics and mathematical morphology published at the beginning of the book. (Karas, G. 2003, 175)

This work is restricted to the presentation of points indicative of its content.

The first part is an introduction to mathematics comments on basic concepts and definitions on which algebra and general mathematics are based. This chapter contains 35 definitions, 19 conclusions, 23 comments (A, B and C), 10 hypotheses, a theorem and a proof.

It gives details of:

- the definition of Mathematical Science as a Quantitative Science,
- the definition of Amount or Quantity as anything composed of parts and amenable to increase or decrease (measurable in terms of one of its characteristics). The conclusion that follows the definition describes time as an amount and God or the soul as non-amounts. Then there is the comment on the measurement of quantity. He divides Quantity into the "Distinguished" (discrete) category consisting of independent parts (e.g. the army) and the Continuous category which is not composed of independent parts (e.g. time). He also distinguishes into the Concrete category when expressed in relation to a unit (three stars) and the Abstract category resulting from the repetition of an abstract unit (three),
- the "One" which is a thing (being) which, even if it consists of many, cannot be divided many,
- the Unit as an abstract concept of "one",
- the concepts of Multitude, Number, names of numerical symbols from one to nine and their notation (characters),

- the definition of zero and its symbol,
- the definition of Ten, Hundred, Thousand, Myriad other senior classes and their relationships,
- the Psififoria=every mental habit acquired relating to numbers which is carried out with the use of tesserae ,
- symmetrical and asymmetrical quantities, Integer and fractional, rational and irrational,
- Algebra defined as the science of abstract Quantity, discrete and indefinite,
- equality and inequality, greater or smaller than, similar and dissimilar, positive and negative quantity, greater and smaller than zero, monomial, binomial, polynomial, coefficient, exponent, power, algebraic character, homogeneous and heterogeneous amounts.

In his conclusions and comments Govdelas usually refers to the preceding definitions and gives additional details or lists similar definitions from earlier writers. For example, in the comment on page 3, he gives the definition *'Μονάς ἐστι, καθ' ἣν, ὅ ἕκαστον τῶν ὄντων ἕν λέγεται» as formulated by Euclid and the* definition of the number as the multitude composed of units" in a comment on page 5. Further, in the comment on page 8 he refers to Wolff (Elementa Arithmeticae, CI § .10).

In hypotheses he essentially gives the symbols for zero, for the known quantities he uses the alphabet letters *α, β, γ, δ* and for unknown quantities the letters *φ, χ, ψ, ω*. *x* stands for Time, *δ* for difference, *μ* for magnitude. He uses the sign «=» for equality, «>» for the greater (superiority), «<» for smaller (deficit), «⊔».«~» for similarity. He uses the sign the «+» (plus) to express addition or positive quantity (according to Diophantus a point Existence and Redundance) but not for the beginning of a 'quantity'. He uses the sign «-» (minus) to express the difference or a negative amount (according to Diophantus, a point of Defect). He also defines the symbols «$\pm$» ή «$\mp$», $\alpha = 1.\alpha$, $\alpha = \alpha^1$, $1.\alpha = \alpha$, $\alpha^1 = \alpha$ and $\frac{\alpha}{\alpha^2} = \frac{1}{\alpha}$.

Then Govdelas discusses the calculus of integer and fractional "algebraic quantities" as he defines them. He defines the "All" and "Parts", the arithmetic operations such as addition, subtraction, multiplication and division as well as the rules of performing them. The concepts of negative and complex numbers are not completely ignored but were introduced during the development of the calculus of "algebraic quantities'. In operations involving negative quantities there is relevance to subtraction referred to in Metzburg's Algebra, while a new parallel version of multiplication is presented to the classic standard "the product of two differences." Of particular interest is the evidence base of the sign rules, but that seems not to be the brainchild of Govdelas, after they were first used by C.Maclaurin in his book «Treatise of Algebra» in 1746. Similar ideas can be found in Abbe Sauri's, «Cours complet de mathematiques» in 1774. Govdelas also defines powers and roots of "algebraic" expressions. He also discourses upon first degree equations, linear systems and second degree equations with limited presence of negative quantities. (Karas, G. 2003, 175-180).

In the chapter 'on ratios', after having determined the meaning of the ratio, he comments on the definition given by Wolff (Elem. Arithm. C.III. § .117. Vol.I. Elementorum Matheseos Universae) and by Euclid (Book .E "Euclidean Elements"

definition d). In fact he reports this latter definition to be incomplete and claims that Hobbesius had unsuccessfully tried to refine it in his “Tractatu de principiis et ratiocinatione Geometrarum” C.II.p.22. He also makes mention of all Pythagorean ratios and proportions: "*Τεταγμένη*», «*Τεταραγμένη*», «*Ἀνάπαλιν» (αντίστροφη)*, «*Ἐπιμόριος*», «*Ὑπεπιμόριος»*, «*Ἐπιμερής»*, «*Ὑπεπιμερής*» (Taquet in fus Arithmetica, Book. B, Part C), *“Πολλαπλασιεπιμόριος*», «*Ύποπολλαπλασιεπιμόριος”* etc. He even defines proportion as the identity or equality of two or more ratios and in his commentary refers to Euclid (Book. E def. η and Book. Z def. κ). He calls «*Διεχή»* the proportion in which the middle terms are identical and he is the only one who refers to discovering harmonic proportions. (Karas, G. 2003, 136) Commenting on the *Ὑπενάντιον Ἁρμονικόν*» he refers to Stifellius (Lib.IC7.Arithm.), Wolff (Elem. Analyt. § .164) and Klügel (Mathemati harmoni proportion 510).
He studied progressions: Arithmetic, Geometric and Harmonic. He places particular emphasis on polygonal numbers and defines the triangle, quadrilateral, pentagon, hexagon, heptagon, octagon etc. numbers.
Commenting on the definition of harmonic progression he correlates it to Music (Rlugel Mathem. p.610). He then develops the theory of logarithms and Finite and Infinite Series. He defines logarithms as quantities with exponents. Naming their logarithms ‘quantities exponentially. He comments on limits of logarithms $+\infty$ και $-\infty$ when the value tends to $+\infty$ and 0 respectively. He further specifies the symbol of "*Ἀπεραντομεγεθών*” as “∞”.
All these issues are thoroughly developed and are very important from a practical viewpoint. (Karas, G. 2003, 137) Then follow the tables of logarithms by Henry Briggs (1561 -1630). The use of the tables is given in detail along with many examples comprising the problem of finding numbers from their logarithms, when not listed on the tables. Ends with a list of subscribers, the bug fixes and tables of figures
In his work Govdelas used mainly ancient Greek and German literature. Specifically, from mathematics books of antiquity he cites the Euclidian "Elements". He also cites the 18th century work of Christian Wolff on which he relied to write his own books. (Camariano-Cioran, A. 1974, 232) The *Mathematisches Wörterbuch* (vol. 1, Leipzig 1803) by Georg Simon Klügel, which consist of 7 volumes and presents the situation in mathematics in the early 19th century. He also cites the mathematics textbooks *Anfangsgründe* by Abraham Gotthelf Kästner (four-volume work) containing various branches of mathematics, theoretical and applied, which gained him the title "teacher of Mathematics throughout Germany" and the “*Elementa analyseos finitorum”* (Halle 1758) by Johann Andreas von Segner. (Karas, G. 2003, 113, 178)

The "Elements of Arithmetic”
Arithmetic was the most widespread branch of mathematics throughout the Greek world during the Turkish occupation. It is basic knowledge for all other disciplines and is considered to be the cornerstone of Mathematics by 18th century scholars.

Govdelas publishes his "Elements of Arithmetic In 1818. The book, as already stated in page three is dedicated to Voivod Alexander I. Skarlato Kallimachis, majestic ruler of All Moldavia. He proceeds with a 14-page letter to the governor and another 5-page letter to the students. The Introduction (“On the beginning and progress of “Aritmetic”) is 36 pages long and is dedicated to the history of Arithmetic and mathematics in general and citations to the Pythagoreans, Nicomachus, Iamblichus, Plato, Archimedes, Ptolemy and others.

Figure 2: *The "Elements of Arithmetic”*

There are also 4 pages with the contents of Arithmetic and an epigram. The language used is archaic. The syllabus extends to 354 pages and includes: introduction to arithmetic, integers and fractional numbers and their operations, the highest common factor and the least common multiple, units, currencies, underground, fractions and decimals, and relative operations. Then he deals with proportion problems, simple and complex method, company, mixtures and alloys, interest and compound interest.
Govdelas’ *"Elements of Arithmetic"* is the only 1809 numeric manuscript (algebraic manuscripts have not been located) which has been found on record; it does not appear to substantially differ from the 1818 edition. There are only a few changes in the order of chapters and a few additions made. (Karas, G. 2003, 122)
Govdelas’ books are remarkable manuals written for the advancement of basic mathematical literacy and his mathematical work is characterized by "a humanistic treatment of science." (Nicolaides, E. 1993, 141)

Conclusions

The mathematical education during the first centuries following the fall of the Byzantine Empire is reduced to the mere study of mathematical textbooks by Glyzonios and accounting. Mathematical knowledge sticks to ancient mathematical tradition (Karas, G. 2003, 281-2). In the mid-18th century Greek scholars studying in European universities come into contact with modern scientific thought and then promote it at home or in Greek communities of the Diaspora. Though Demetrius Govdelas is one of them he remained abroad.
The magazine *"Hermes the Scholar"* cites him as one of the "hard working" teachers of his time while his contemporary scholar Dionysius Pyrrhus ranks him among the renowned teachers of Thessaly. (Pyrrhos, D. 1837, 49)
Govdelas held a rather conservative attitude toward the excommunication of Christodoulos Efstathios of Acarnania, whose works appear to represent the extremist tendencies of the Greek Enlightenment and express anticlerical and deistic opinions. Govdelas was criticized by some or vindicated by others due to the trenchant satire on ideologically warring groups of scholars at the time. (Papadopoulos-Vretos, A. 1854, A’ 119, 194, B’ 349)

Govdelas makes extensive references to both ancient mathematicians and modern Westerners in relation to calculus and algebra. In both his books ancient Greek, mathematics correlate from the teaching point of view to modern textbooks without any innovation or different teaching approach. Mathematics is presented through its historical evolution, rather than as a closed system and is considered to be a natural evolution of the ancient teaching thus it is treated in a uniform manner. It is studied not only independently but in combination with other sciences (Karas, G. 2003, 282) and philosophy. More specifically Govdelas reports that;

«ἀδελφές οἱονεί δεδεμένες καί ἀναπόσπαστες». «Μηδέ εἶναι, τῶν ἐκ τῆς περί τήν φύσιν πραγματείας, ὅ μή πρός τήν μαθηματικήν ἀκρίβειαν, οἱονεί πρός στάθμην τινα καί γνώμονα, ἀναφέρεται», γράφει ὁ Δημήτριος Π. Γοβδελᾶς

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University as Technological Knowledge Disseminator in Estonia

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In 1802, in the Faculty of Philosophy of the University of Tartu was opened a Chair of Agricultural Technology and Architecture, where Johann Krause held his course on agricultural technology. In the Chair of Theoretical and Experimental Physics were held lectures on physics, initially only for medical students. Professor of physics was rector Georg Friedrich Parrot himself who taught general physics and solid state physics. He was a skillful experimenter and established the first Cabinet of Physics in Tartu. Parrot's articles were based on his own research and tended to be applicable: room lightings, building ship masts, making gunpowder, air purification. In Tartu school statute the natural sciences were connected with mathematics. The teachers had to link theory to practice and in their spare time took students out in the nature, in winter they visited factories, manufactories and artists' studios. Rector Parrot himself undertook the compilation of a textbook binding natural sciences and mathematics. The book consisted of three parts: arithmetic, geometry, and natural science. The latter contained six chapters: general properties of bodies, mechanical forces, heat, light, electricity, magnetism (Parrot 1815). School inspectors were given instructions on how students should use the book during their studies as well as later in life.

Dissemination of technical knowledge and skills

In the1830´s popular-technical lectures were held in the university. These were seen as a great opportunity to disseminate technical knowledge among the general public. The first lecturer was Professor of Agriculture and Technology Johann Friedrich Schmalz, who began his readings in the autumn of 1836, explaining to local merchants and craftsmen the issues of technology (Martinson 1977). Under Schmalz's leadership operated the Institute of Practical Agriculture, which was a joint institute of the university and the Livonian Community and Economic Association. Professor of Construction Art Moritz Hermann Jacobi explained in his lectures the substance of geometry and mechanics and their place in people's lives. His university-level courses were mathematics and the theory of machines. The next winter were started chemistry lectures, the first lecturer was the professor of Pharmacy and Chemistry Carl Friedmann Goebel. Again, this series was meant for craftsmen. They talked about metals, their extraction and use in the industry and crafts; about food chemistry, flour and bread preparation, the salts contained in the earth's crust and their use in industry and household, water, air, electricity, etc.. The series was characterized as "technical chemistry". Lectures were accompanied with experiments, which made them particularly interesting. In the middle of the century, universities accepted technical chemistry in the curriculum of chemistry students.

Under professor Schmalz` undertaking in Tartu was founded a Craftsmen Society, where professors held the majority of their popular lectures. At the exhibitions of crafts, alongside the complicated tools made in workshops of the university could be seen works of regular masters- metal, pottery and glass works. Professor of Physics Friedrich Kämtz was an eager introducer of science his favourite subjects were thermal phenomena, air and thunderstorms. Another outstanding introducer of science was Professor of Agriculture and Technology Georg Alexander Petzholdt. He started a laboratory of agrochemistry and organised study and science journeys abroad. The subjects of his lectures were agrochemistry, chemistry, technology of metals and agricultural tools.

Chemistry gets the dimension of exact science

Goebel activities of spreading knowledge of chemistry among the general public were pursued by his successor Professor Carl Schmidt, whose initiative was to update chemistry room in the university and begin to extensively spread the knowledge in physics and mathematics to students, due to which chemistry acquired the dimensions of exact science in the University of Tartu (Mägi 2008). During his visit to England he noticed a smooth cooperation between local chemistry scholars and practicing chemists through consulting chemists. Back in Tartu, he as well proclaimed his laboratory open to industry, agriculture and trade. University was not prepared for such fundamental intervention in academic life and the idea was put on hold. After some time he presented his project again and finally received the support of university curator. Since then Schmidt's main activity was the chemical analysis of various substances. He researched mud from Haapsalu and Saaremaa bays, Devon clay from Tartu surroundings and lower Silurian clay and bog peat from northern coast of Estonia. He was also interested in oil shale layer exposed on the territory of Kukruse manor. He drew attention to obolus-phosphorite as the potential raw material for phosphorus fertilizer. From there began a scientific research of phosphorite in Estonia. Researches made under Schmidt's leadership were mostly analytical. Schmidt's apprentice, later on a Nobel laureate Wilhelm Ostwald, laid the foundation of a new scientific discipline – physical chemistry (Ostwald 1926). Schmidt's second famous apprentice Gustav Tamman shifted the focus of research of Tartu chemists to physical chemistry and electrochemistry.

First practical results

The vitality of Schmidt's scientific work created good prerequisites for popularizing the pursuit of knowledge. His popular lectures held in the university for more than three decades covered metals acquisition and processing, glass and porcelain manufacture, lighting, heating, dyes and foodstuffs, acid technology, soap making, sulfur and phosphorus acquisition and technical use, newest achievements in chemical technology – hence, almost everything that belonged to technical chemistry at that time and basic knowledge of which was beneficial for everyone - craftsmen, architects, citizens or peasants. Chemical and technical processing of wood was introduced by Professor of Agriculture G. B. Brunner, who was known as a warmhearted peasants' helper in analyzing the soil, fertilizer or feed. Educational lectures were held by Professor Johann Georg Dragendorff, who founded aside the

Institute of Pharmacy a sanitary station to study foodstuffs. Professor Gustav Tamman presented his popular lectures on chemistry with technical content. A total of several thousand people were listening to these lectures for general public as they were a rare opportunity for people of that time to learn more about the changing world.

The first full analysis of the chemical composition of oil shale was carried out in Tartu by G. A. Petzholdt and Alexander Schamarin. In 1864, on annual meeting of the Estonian Agricultural Society its president Bernhard von Uexküll made a presentation on the benefits of cement in construction and came up with the idea to designate an award for the discovery of limestone and marl formations suitable for cement production. An owner of Kunda manor Johann Carl Girard de Soucanton invited to Kunda Schmidt`s student Victor Christoph Lieven, who had written a candidate's work on the use of dolomite from Daugava River as raw material for cement, and had recently launched a cement factory near Riga. After negotiations it was decided to build a cement factory at Kunda as well. The first 3-ton batch of cement was completed here in 1871 and the factory started to produce a continuous supply a year later. Victor Lieven turned out to be one of the first production chemists who acquired his education in Estonia.

School textbooks and technical knowledge

From the middle of the 19th century the Estonians have undergone noticeable changes in self-realization. The importance of language and consequently its planning grew. Instead of the two languages used so far a uniform written Estonian was introduced. New Finnish-like spelling contributed to the spread of written language being easier and more natural than prior German. Vocabulary was supplemented with new modern words describing everyday life. In 1852 in Tartu was published a textbook on reckoning compiled by Friedrich Meyer. In the context of development of technical thinking in Estonia, the most important part in the book is actually its annex – land-surveying instructions. This small publication with separate title is a first sign of birth of the first technical book in Estonian.

School textbooks played an important role in spreading the technical knowledge among the general public. Physics teaching reached parish schools in the middle of the 19th century, leading to a necessity for educational physics literature in Estonian (Lang 1976). Pastor Johann Georg Schwartz in his eight-volume set, published between 1852 and 1861, introduced a physics textbook as the sixth book in the series, which was the first serious attempt to convey knowledge of the physics in Estonian. Alongside the explanations of natural phenomena the book offered examples of their application in technology. Since technical terms did not exist at that point, the author described physical phenomena popularly. In preparing the next physics textbook (1881) the author Jakob Tülk, who studied philosophy, mathematics, mathematical astronomy, and chemistry in Geneva, Paris and Strasbourg, used French and German textbooks as an example. Although reading his book requires prior knowledge of mathematics, the overall work can be considered a success. The first book in Estonian containing chemical wisdom was a George Marburg`s book (1805) which was mostly targeted toward children of peasants and village school teachers. A more detailed overview of chemistry in Estonian dates back to 1887, but it remained in manuscript. By that time russification had reached its peak and Estonian schools and books were prohibited. Estonian language was allowed to return to schools only in 1905.

Beginning of the Engineer School

A shift in professional preferences could be noticed. Interest in the real sciences increased. The closest place to get a diploma of engineer was Riga. In addition to technology one could also learn architecture, land surveying, agriculture and trade. When Riga Polytechnic School received the rights of the University of Technology in 1896, the number of Estonian students rapidly increased. Boys from wealthier Southern Estonia preferred to acquire their education in Riga. Students from Tallinn and Northern Estonia went to St. Petersburg to study technology, but also to Western Europe, primarily Germany and France. There, most preferred places of learning for Estonian technology students were the University of Technology in Darmstadt and Karlsruhe, the University of Nancy and the University of Touluse.
The first technical education institutions that operated for longer period of time in Estonia were schools of navigation, where the necessary knowledge for professionals` exams was obtained. In schools of navigation were taught mathematics, physics, nautical astronomy, ship engineering and basics of steam mechanics. Before the World War I a number of works on machinery, electrical and thermal engineering as well as chemistry and physics dictionaries were published.
The turning point in the development of technical education in Estonia was establishment of the Estonian Technical Society, the most important purpose of which was to disseminate technical knowledge. Tallinn Education Committee advised the Society to open an engineering school. Possible learning directions were: architecture, engineering, electrical engineering, hydro-engineering, mechanical engineering, shipbuilding, land-surveying, technical chemistry. The technical school was given the rights of the university. The school started in 1918 and since 1938 it bears the name of the Tallinn University of Technology.
Estonian Technical Society's efforts in creating Estonian vocabulary of technical terminology and publication of technical literature gave results in the second half of the 1920`s, when a number of academic books based on lectures held in polytechnic school were published. The first volume of illustrated technical dictionary, that comprised machine parts and tools, reached its readers in 1933 and became very popular (Mägi 2013). Dictionary on engineering was compiled under leadership of Professor of Engineering Leo Jürgenson. Derivation of new words was based on the Estonian language, only a few words were taken from Finnish or Swedish languages.
Estonia participated consistently in international conventions of technical journalism. During Paris Congress (1937) under Estonia`s initiative a Baltic section of *Fédération Internationale de la Presse technique et périodique* was formed. One of Federation`s most important goals was to promote the dissemination of technical knowledge, due to which Estonia was relatively well-equipped with the latest technical literature.
However, the journey to status of university has not been easy. The public blamed engineers that they did not participate enough in public life (Leppik 1931). Engineers cannot limit themselves to working only in their chosen speciality, they have to explore other cultural expressions. Spreading of engineers beyond the big cities

would have contributed to spread of technological ideas and faster development of the community.

New technologies

Scientific studies were not conducted in polytechnic school, but were aggregated in the National Testing Centre, which was opened alongside the school. Work directions were: material sampling, thermal and electro-technical engineering measurements and chemical technology research. Primary objects of study were oil shale and phosphorite. The obtained results were presented at fairs in Helsinki and Tallinn. In Tartu, alongside the University, was founded a laboratory of oil stones. National Oil Shale Industry in Kohtla opened its own research laboratory. Oil shale industry became the fastest growing industry in the country due to large investments and strong competition from foreign markets (Kogerman 1935). International competitions for designing furnace suitable for burning shale did not give any results and the problem had to be solved by local engineers. They designed grate furnace which found widespread use in power plants and industrial boilers. Utteretors working in oil factories were also invented by Estonian engineers. Even in distant Australia in Glen Davis was launched an oil industry based on technology created by Estonian engineers.

During close cooperation with the London and Zurich research institutions, technological bases for shale oil and gas production were developed. They learned to obtain from crude oil impregnating varnishes, bitumen, kerosene, asphalt, insecticides. These scientific issues involved generations of known chemistry and engineering scientists (Mägi 2005). In schooling chemical engineers, Estonians took example from the Brits. In addition to chemical technology, scientists practiced the use of shale as an energy resource and issues of disposal of residues. Since oil shale ash was found to have binding properties, scientists were looking for its use in the manufacture of construction materials. The resulting ash binder was introduced in residential construction. Also, they learned to produce autoclaved patent rocks from the ash. Scientists of the National Testing Centre had a prominent role in developing their strength properties.

The general secretary of the International Association of Probing Materials and director of Swiss Testing Centre professor Mirko Roš, during his visit to Estonia gave a high rating to his Estonian colleagues.

Natural Resources Institute

For better use of raw materials, under the initiative of rector of Tallinn University of Technology Paul Kogerman, in Tallinn was founded the Natural Resources Institute. It was founded to organize and coordinate the activities of universities and industrial laboratories. Body structure reminded of the Academy, including Assembly, the Council and the sections. The goal of this Institute was to research natural resources, raw materials and manufacturing and identification of scientific, technical, and economic issues. Professor Kogermann stressed the importance of research: the development of the industry is subject to technical education and research on the use of natural resources. He highlighted the significance of scholars and engineers in adopting the use oil shale, in which Estonia played leading role in the world. Five sections out of ten were led by scientists of the University of Technology. In the Laboratory of Chemical Technology, under the guidance of Professor Jaan Kopvillem were researched superphosphate production possibilities (Kopvillem 1937). Estonian local raw material – phosphorite already attracted the attention of industry since the early days of independence. Basing on the laboratory results, were developed pointers for industrial experiments, which were carried out in German and English chemistry companies. The results confirmed the suitability of Estonian phosphorite for superphosphate manufacture.

In conclusion

The guiding principle „Glory to technology an craftiness" was accepted by Estonian community but the attention to technological achievements and people related to it remained quite modest. Without the upturn of technical thinking industrialisation of the country would not be possible, which in turn would not have lead to economic growth. In the spring of 1939 in his speech during Estonian Day of Engineer, professor Ottomar Maddison asked everyone to contribute to the raise of nations` cultural and intellectual level. Only the strong culture and developed intellect alongside the best solutions of technological ideas ensure the country a worthy place among other countries. Technology signifies spiritual victory over matter and possesses value only to the extent of persuasiveness of victory of intellect over matter. Therefore – each product should contains more spiritual substances.

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Two Hydraulic Machines for Schönbrunn Palace 1780-1782

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In the 18th century, Schönbrunn Palace and the Palace Gardens belonging to it underwent massive changes. During the Turkish siege of 1683, the whole area suffered a great deal of devastation. Soon afterwards, work began on redesigning and reorganising both the existing edifice and the gardens. However, construction work was considerably hampered by the death of Joseph I and the turmoils of a new war. Under Karl VI, the area was used for court banquets and court hunts. Only with Maria Theresia's accession to the throne in 1740 did a new era begin.

In 1742, Maria Theresia and Franz Stephan spent the summer at Schönbrunn. In the following year, Maria Theresia commissioned the architect Nicolaus Pacassi to undertake extensions to the Palace. Franz Stephan himself turned his attention to the garden complex and, in order to implement his plans, had artists and civil servants brought to Vienna from his own country of Lorraine. These included the engineer Jean-Baptiste Brequin de Demange, the architect Jean-Nicolas Jadot, and the garden designer Louis-Ferdinand de Nesle, better known by his pseudonym 'Gervais'.

The design of the whole complex, and in particular the new fountains, consumed a great deal of water. Even in preceding decades, there had repeatedly been difficulties in supplying the necessary amounts of water and obtaining the requisite water pressure. This is mentioned in many of the documents dating from 1563. It was sought to alleviate the problem by erecting various water containers, where rainwater could be collected, or by building new supply pipes, such as the one connected to the hunting grounds of Lainzer Tiergarten. Despite all the measures employed, there were still shortages, so that limitations were imposed and the water fountains were only used on special occasions.

However, according to information that I was able to obtain from the Museum of the District of Hietzing in the course of my researches, I discovered that this magnificent property – which was once owned by Prince Eugene – did have two basins, yet they were not used for supplying the basins in Schönbrunn, nor did they serve a pipeline for Belvedere, as has often been mistakenly supposed. I was further informed that, in the environs of this palace – as well as in adjacent parts of the Vienna Woods – there are several springs which, due to the inclination of the land, may have provided the necessary pressure, and also the requisite amount of water, to fill the basins in Schönbrunn. These springs were brought together and subsequently flowed into the Mühlbach. There are still water springs there today. Furthermore, I learned that, in the vicinity, the remains of an old waterpipe had been discovered during excavation work. The Plans Archive of the Waterworks Department of the the City of Vienna does not include any documents whatsoever about this water pipeline in its Historical Plans Collection. Neither documents nor designs are to be found in the

Haus- Hof- und Staatsarchiv in Vienna. A large part of the plans for the water supply to the palace and the gardens derive from the 19th century.
Information about the fact that a water pipeline existed in St. Veit as early as 1763, and must have led to Schönbrunn, is contained in the Confidential Records of the Chamber Treasury.
If one takes into account the thriftiness of the Imperial household, one may well assume that it was this water pipeline that was developed and improved around 1772 and in subsequent years to provide a comprehensive solution to the constant problem of water shortages. Wolfgang von Kempelen was commissioned to supervise the construction work. From the Confidential Records of the Chamber Treasury it emerges that the estimated costs of 8,000 Gulden for constructing the pipeline were approved. He spent the summer of 1772 in Schönbrunn, preparing and supervising the work.
Several times during the next years, Wolfgang von Kempelen received sums of money (more than 8,000 Guldens) from the Confidential Chamber Treasury for water works.
Besides the extension of the water supply pipe, a new water pump was also constructed in 1772-1773. Connected with this is the confirmation of the receipt of the iron pipes for the water pipeline, which was necessary for the supply line to water pump.
Kempelen was assigned to complete the business concerning the iron pipes without payment. A long correspondence on the matter of payment dragged on for months between the management of the manufacturer's sales office and the Imperial-Royal paymaster's office, although by 20th February 1773 the Regent had made the decision, as a letter testifies.
This water pump must have gone into operation around 20th May 1773, since on that date it is recorded in the Chamber accounts that the Court gardener named Schott received a sum of 238 Gulden and 89 Kreuzer for maintenance of the machine to the end of the year.
Nothing definite can be ascertained about the construction of the machine, or about the person of the actual constructor. Brequin de Demange drew a plan for a water pump in 1750, and then another in 1772. Kempelen as well did so in the early 1770ies.
In a letter to her son Archduke Ferdinand dated 8th October 1772, Maria Theresia herself described the changes that had taken place in Schönbrunn Palace gardens. She wrote that a pond had been moved, an avenue had been laid out in a straight line as far as the hill, and that the flower beds had been redesigned. Moreover, she recorded that Kempelen's machines had proved a success, and that a waterfall would be built upon the hill. She also wrote that there was still a great deal of work to be done.[1]
Designs for water pumps for Schönbrunn were made by various technically capable people, including Nagel in 1752, Joseph Carl Höll at about the same time,

[1] Arneth, A. v. (1881), „Briefe der Kaiserin Maria Theresia an ihre Kinder und Freunde" („Letters of empress Maria Theresia to her children and friends"), Wien: W. Braumüller, vol. 1, 156

Pacassi in 1769 and even by Emperor Franz Stephan I, who occupied himself with constructing a pump and drew a plan for one. The Graphic Collection of the Albertina has in its possession a folder which contains plans for various pumps designed for use in the palace gardens.[2]

A further document, to be found in the Manuscript Collection of the Hungarian Academy of the Sciences in Budapest, shows the plan of a main shaft, complete with detail drawings and an accompanying description of the working steps, drawn and described by Kempelen. The sheet displays neither a year nor any other information or attribution. Kempelen has also recorded some reflections on chemical processes on it.[3]

In the following years, several alterations were made to the Palace Gardens. A large part of the work was carried out by the architect Ferdinand Hetzendorf von Hohenberg. In 1773 a reservoir was constructed on the palace hill, followed by the Gloriette in 1775 and the Neptune Fountains at the foot of the hill. A description of the palace and the gardens gives Johann Elder von Kurzböck in "Latest Descriptions of Remarkable Places in Vienna" which was published in 1779:

> *Everything here reflects the greatness of the monarch who lives here. The building is magnificent, the furnishings imperial and of the finest taste. In the gardens there is everything that great art has to offer. Majestic boulevards, cascades, ruins, basins, dark sacred underbrush, caverns, lively springs, fountains, pyramids, labyrinths, wilderness, statues, pavilions, ponds, menageries, bird houses, and set at the top of a hill a colonnade with the most wonderful view. From the time the monarch allowed her subjects unrestricted access to these Elysian Fields it has been visited by thousands upon thousands. The interior of the palace can be shown to any wishing to see it, unless the monarch directs otherwise. One has only to enquire with the Palace house keeper.* [4]

In 1780/81 the large Neptune basin was built after plans by Hohenberg. The sculptor Wilhelm Beyer was engaged to make the monumental sculptures. Once again there proved to be insufficient water to present the cascade in all its beauty. One could only present it on special occasions, for example when visits were made by high-ranking personalities.

On 16th August 1780, Maria Theresia personally signed a resolution commissioning Wolfgang von Kempelen to construct a water pump for the great cascade in Schönbrunn, and earmarked a sum of 5,000 Gulden for the purpose. Kempelen was allowed to built these machines after his own plans because a year before, on June 1st 1779, at 6 o'clock in the morning the official commissioners from the Royal Office for Minting and Mining met together in the work shack of

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[2] „Wasserhebemaschinen" (Water pumps"), Mappe Nr. 40, Nr. 89-97, Grafische Sammlung Albertina Wien

[3] Manuscript Collection, Sign. 5082/25, Magyar Tudomános Akadémia, Budapest

[4] Iby, E., and Koller, A. (2007), „Schönbrunn", Wien: Christian Brandstätter Verlag, 79

Wolfgang von Kempelen not far from the Mint office in Vienna. They were there to examine the fire and steam machines which he had developed. Unfortunately the presentation of these machines did not run as smoothly as either the commissioners or von Kempelen had hoped for. But Kempelen did not allow this to discourage him and continued to work on further developing the machines. His plans for Schönbrunn were following:
In order to obtain the necessary volume of water for the cascade, Kempelen proposed setting up two steam engines developed by him, working on the reaction principle, at the two already existing supply pipelines. In constructing these two machines, Kempelen was also hoping to build up the required pressure for the water fountains. However, since two waterfalls would have had to be sacrificed for this purpose, Maria Theresia rejected the proposal. This left Kempelen with only one pipeline at his disposal. In order to be able to master the technical difficulties despite this, he suggested constructing a steam engine instead of the second reaction machine, since a pipeline for the smaller water fountains would then remain free. This steam engine was to be set up behind the Neptune Fountain. The proposal was accepted. Kempelen's plan was that the reaction machine on the hill would pump up the water, while the steam engine, located behind the fountains, would be responsible for the cascade. However, difficulties arose in constructing the water pipeline, so that another application had to be made to cover the new additional costs that would arise. The extra 4,000 Gulden were approved by Emperor Joseph II on 28th December 1780.
At any rate, the water pumps must have proved a success when they went into operation, even though there were very probably some 'teething troubles', because on 2nd June 1781 the *Pressburger Zeitung* (*Pressburg Newspaper*) reported on the new technical achievements in the Palace Gardens:

> *Vienna 30th May. The imperial pleasure garden at Schönbrunn has received a new glory in the form of two brand new water machines. These being the invention of the honourable Mr von Kempelen from the Hungarian Royal Advisory Council, who is well versed in his knowledge of mechanics.*
> *The first of these machines is a simplified fire machine without cylinders or pistons which can lift a huge amount of water without using much wood. The second is what is considered to be a new lifting machine without a wheel, which through water, functions in a way never seen before; it consists only of a horizontal lying copper cylinder of 16 shoe lengths . This is connected in the centre to the water pipe running down hill in such a way that with hardly any friction and with even less water loss it can spin on its centre. As soon as the water starts to flow this cylinder starts to turn with an incredible speed and with such an amazing power that it can, with the help of a crank, through its turning, drive four nine-inch pumps more than thirty times a minute.*
> *The whole hill on which the large water container is placed, has a vertical height of 20 fathoms; at its foot the cascade has only 3 fathoms height. Thus the fall of the water from above through iron pipes was being unused. The inventor made use of this fall by allowing the water, before it falls over*

the cascade, to drive the above mentioned cylinder machine which is placed in a completely hidden vault built into the hill. At the same time this machine, through an underground channel, is raising the same amount of water that has already fallen up to the cascade again, as well as the water that is falling from the water container. This results in the doubling of the amount of water and an abundance of it for the cascade. Both these new inventions serve not only their purpose here by this pleasurable attraction, but have their place in various mills and hammer workshops, and particularly with the mining machinery, and thus will be extremely useful in the future.[5]

On 2nd July 1782, Count Kaunitz Rietberg wrote to Joseph II informing him about improvements that had become necessary in the vaults that housed the pump cylinder. The civil servant Franz Klotwig, who was responsible for the building, had drawn his attention to the problems. The cost of the required improvements would amount to 2,794 Gulden and 58 Kreuzer.

In August, the Emperor dismissed the costs estimate that he had been presented to him, because he felt that they were too high. On 17th August 1782, he reprimanded the Court Architect Hohenberg in a letter, in which he made reference to a regulation dating from 23rd May 1777, which stipulated that already existent materials should be used wherever possible and that no new ones should be ordered.

Kempelen was by now already preoccupied with making his final preparations for an imminent two-year tour with his chess automaton and the speech machine. However, not all the bills had been paid from the state coffers, so that the craftsmen were still waiting for their money, and were consequently pressing Kempelen to do something about it. He therefore sent a letter petitioning Count Kaunitz to speed up the matter, so that the outstanding debts could be settled. State Councellor Count Kaunitz, in turn, petitioned the Emperor on the matter on 4th December 1782. From this letter it also emerges that the two engines were still not working perfectly, which is why they had not yet been put into full operation, and that the actual costs had amounted to 11,652 Gulden and 4 Kreuzer.

Kempelen set out for his two years traveling. He must have sent detailed bills to Vienna again from Paris. These were then accepted upon being presented to the Emperor.

Today, nothing more is known about the further deployment of the two water pumps, how they worked, how much material they needed to function, or about the cost of repairs. At the start of June 1793, the Court Architect, Hohenberg, inspected the two water pumps and found them to be no longer in working order. On 10th June 1793, Hohenberg asked the Court construction management what they proposed to do with the two unusable machines, and with the vault behind the Neptune Fountains, which was in need of repairs. From a letter written by the Court Architect, it emerges that the cylinder machine, or reaction

[5] Pressburger Zeitung, 44. Stück, 2. Juni 1781

engine, would be usable, yet due to several mistakes which the builders had made during the construction process, it was not working properly, while the second engine (a fire turbine) was completely unusable. Further, Hohenberg requested strengthening measures for the acqueduct leading to the upper basin.[6] This report by Hohenberg created a sense of uncertainty among the responsible authorities. They were not sure whether the two engines should be scrapped or improvements ordered. Therefore, on 16th June 1793, a letter was written to Kempelen, asking whether these two engines could be put into operation once again, what the costs would be to undertake improvements on them, and what the real situation was with regard to the vault that was in need of repair. As a result of this request, Kempelen inspected the two engines a few days later and came to the conclusion that his engines would have worked just as well as before, if they had not been neglected for so many years and had been properly maintained. He then wrote as much to the Court Building Director, Freyherrn von Struppi. In the case of the reaction machine, all the wooden components had decayed, the brickwork was damaged, all the screws had rusted, the copper tubes were bent, the basin holding the cylinder had to be freshly lined with lime and partly covered with copper, and the cylinder and piston re-covered with leather. The only parts that were still undamaged on the engines were those made of brass and copper. Kempelen estimated that it would cost between 250 and 270 Gulden to repair them.

As far as the steam engine was concerned, Kempelen also found that it was, firstly, no longer operational and therefore, secondly, in need of a complete overhaul, which would be very expensive. Since he was the inventor of this machine, and had intensively studied ways of improving steam engines for many years, he suggested setting up a new one as a water pump. It should be similar to the one that had been employed at the time when the canal was being built in the Kingdom of Hungary. He estimated the costs of scrapping the existing machine as 40 Gulden.

The copper and brass parts should be stored, since they could be re-used in building a new engine at a later point in time. If a new machine was not desired, then one could profit from selling the parts. [7]

It is no longer clear from the files, precisely what the final fate of these two engines was. It is to be assumed that they were transported elsewhere and that the material was used for some other purpose.

(English translation: Tracey Bernhard)

[6] "Hofbaudepartement", Karton 129, 1793, Zl. 751-900, 810 ex 1793, Haus- Hof- und Staatsarchiv Wien

[7] "Hofbaudepartement", Karton 130, 1793, Zl. 901-1050, 947 ex 1793, Haus- Hof- und Staatsarchiv Wien

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19th century Translations of European Mathematical Textbooks into eastern Mediterranean Vernaculars: Cosmopolitanism versus Colonialism

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Introduction

Traditional Arabic mathematical textbooks were first printed in the Eastern Mediterranean early in the nineteenth century. Simultaneously the first translations of European mathematical textbooks into the vernaculars of the Eastern Mediterranean were appearing in printed form. The publication of translations of modern mathematics seems, at first glance, to move toward a more cosmopolitan outlook, at least at the intellectual level. But did the promise of a more cosmopolitan mathematics bear fruit? This paper examines that question and suggests that the introduction of European mathematics into Mediterranean lands grew from contradictory motives and initially made only a limited contribution toward a more cosmopolitan mathematical science. Two English geometry textbooks translated into local vernaculars exemplify these contradictory motivations. Although such translations sometimes contributed indirectly to increasing the cosmopolitan character of late Ottoman society, the opposite was often the intent of the translators.

Traditional Ottoman mathematics education was based on classic Arabic Euclidean texts (Fazlioğlu 2008). During the Ottoman period, the study of geometry began with the *Ashkāl al-Ta'sīs* of Shams al-Dīn al-Samarqandī (died 1236), often using a commentary written by Qāḍīzāda al-Rūmī (died about 1436).[1] An Ottoman treatise, *Kevâkib-i seb'a* (1742), reported that "there is a book titled *Eskâl-i Te'sis* in geometry at the *iktisar* level that they would read. Following that, they would read the book of Euclid with its proofs at the *istiksa* level" (Ihsanoğlu 2004, 14). And the Venetian Abbé, Gaimbattista Toderini, describing a visit to the Vâlide Madrasa, observed students at their geometry lesson using an Arabic translation of Euclid (Abdeljaouad 2012, 487). This translation was probably the redaction of Euclid's *Elements* prepared by Naṣīr al-Dīn al-Ṭūsī (1201-1274).[2]

Example 1: The Turkish translation of John Bonnycastle's *Geometry* (Cairo, 1826)

John Bonnycastle (1751-1821) was largely self-educated in mathematics (O'Connor & Robertson 2010). By the time he was 18, he taught in two different schools in London. He began to contribute to the *London Magazine* mathematical department

[1] Qāḍīzāda's Arabic commentary, together with additional commentary notes by Tāj al-Sa`īdī (fl. 17th century) was printed in Istanbul in 1274 /1858 (De Young 2012, 13-16). A Turkish translation circulated only in manuscript.

[2] Al-Ṭūsī's Arabic treatise was printed in Istanbul in 1216 / 1801 (De Young 2012, 3-6).

in 1774. In 1782, he applied for and was awarded a position in the Royal Military Academy, Woolwich, where he remained for the rest of his career. He authored several successful introductory mathematics textbooks. The first edition of his *Elements of Geometry* (1789) appeared relatively late in his career.
Bonnycastle, like many others of his day, believed Euclidean geometry provided an excellent mental training for students. As he wrote in the preface to his textbook (1789, v-vi):

> Geometry has always been considered an excellent logic, which in forming the mind, and establishing a habit of close thinking and just reasoning, in every enquiry after truth, is far superior to all the dialectical precepts that have yet been invented.

But he went on to state a second and more important motivation for his textbook: the practical usefulness of geometry and the application of its results in other disciplines. He therefore felt at liberty to make various modifications to the text, noting that:

> As the work was rather designed as a regular Institution of the most useful principles of the science, than a strict abridgement of Euclid, some alterations have been made, both in the arrangement of propositions and the mode of demonstration (p. vi). . . . Many propositions in Euclid, which are of little or no use in their application, and were only introduced into the Elements as necessary links in the chain of reasoning, are here omitted; and others substituted in their place, which are equally conducive to that end, and at the same time more useful and concise (p. v).

An Ottoman Turkish translation of Bonnycastle's textbook was made by Hüseyin Rıfkı Tâmânî (died 1817), in collaboration with Selim Aga, an English convert to Islam and an engineer by training. Hüseyin Rıfkı or Hüseyin b. Muḥammad b. Kirîm Gazî was born in Taman, an Ottoman province in the Crimea. In 1795, he was appointed to a teaching post in the Mühandishâne-ı Berrî-ı Hümâyûn (Imperial School of Military Engineering) In Istanbul. He was appointed chief instructor in 1806, a position he held until his death. In addition to Arabic and Persian, he learned French, Italian and Latin. He translated a number of Western treatises, primarily in applied mathematics, into Turkish (Lawrence 2009; Sayılı 1966), most of which circulated only in manuscript.
The translation of Bonnycastle's *Geometry* was printed both in Istanbul and in Cairo.[3] The Cairo Bulaq Press printed a variety of geometry textbooks, traditional geometry as well as translations of European textbooks (Abdeljaouad 2011, 2). The traditional geometry texts were taught in Islamic madrasas, while translations of modern

[3] There is no explicit printing date stated. The most commonly assigned date is 1825 or 1826, but Leiden University Library has given the date as 1212 / 1797, as reported on the WorldCat website (URL: http://www.worldcat.org/usul-i-hendese-john-bonnycastlenin-kitabndan-mutercem-ve-istihrac-olunmustus/oclc/7777091168referer=brief_results).

geometry textbooks were intended for use in the new academies and schools established to provide education for a corps of modern military engineers who, it was hoped, would form the backbone of a new military establishment capable of defending Ottoman domains against foreign forces.

The Turkish translation of Bonnycastle's *Geometry* states (p. 4) that it was based on the 1789 English edition. It was not, however, a totally literal rendition of Bonnycastle's work. The Turkish text contains additional definitions (for example, definitions of curved lines and acute-angled triangles in book I). Moreover, the translated definitions frequently include added explanation or amplification that does not appear in the English edition. The English edition included nearly 30 pages of notes and discussion of selected definitions and propositions. The notes take up nearly 60 pages in the printed Turkish edition. The Turkish notes omit some discussions found in the English while inserting additional material. Furthermore, although references to earlier propositions are inserted parenthetically in both the English and Turkish editions, there are fewer internal references included in the Turkish text.[4]

As is common in some Persian translations from the Arabic, it is primarily the verbs, adverbs and prepositions that are translated into Ottoman forms. The technical geometrical vocabulary is typically derived from the Arabic Euclidean tradition. Some formulaic expressions also differ somewhat from traditional Arabic Euclidean style (De Young 2007). Whether the observed differences are characteristic of the Turkish tradition as a whole or represent only the *ad hoc* decisions of a local translator has not yet been determined.

In terms of its basic "architecture", the Turkish edition has been set using the same typeface throughout. Proposition headings, which state the number of the proposition in alphanumeric (*abjad*) form and whether the proposition is a theorem or a construction problem, are centered in an otherwise blank line, bounded at each side by a seven-pointed asterisk-like symbol. This symbol is also used to separate sections of the proof. If the enunciation statement does not completely fill the lines, the last words will also be centered with the demonstration beginning on a new line. If the last line of a proposition is not completely filled, the words are centered on the line. Any corollary statement also begins on a new line. The printed Turkish edition inserts diagrams to illustrate almost every definition, but the proposition diagrams have been gathered on one or more fold-out pages that follow each Euclidean book.[5] The English edition had placed each diagram immediately following the enunciation of the proposition.

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[4] In one of the two manuscripts consulted for this study these internal references are placed in square brackets, while in the other they are simply inserted into the text without any attempt at demarcation.

[5] This procedure may have been intended to reduce production costs, since setting each page in whole lines is the simplest form of typesetting and placing several diagrams on a sheet using copperplate engraving is one of the cheapest ways to reproduce geometrical diagrams (Rider 1993, 98-99). An identical procedure is followed in the two Turkish manuscripts I have been able to examine (Cairo, Dār al-Kutub, handasa turkiyya 42 and Cairo, Dār al-Kutub, Ṭal`at riyāḍa turkiyya 3), implying that they have been copied from the printed text rather than reflecting an earlier version of the translation..

Although Ottoman madrasas continued to teach traditional mathematics using traditional textbooks and methods, the growing perception that scientific and technological advances in Europe posed a threat to the Ottoman polity prompted educational reforms. In addition to importing European experts as teachers in the new engineering schools in Cairo and Istanbul, European textbooks were also imported and translated. These translations were not made by Europeans but by Ottoman students who had been trained in the older mathematics in traditional schools but who now were studying the new European mathematics in the new government academies (Abdeljaouad 2011; 2012).

Example 2: The Arabic translation of John Playfair's *Geometry* (Beirut, 1857)
John Playfair (1748-1819) was early recognized as a talented mathematician. He became Joint Professor of Mathematics (with Adam Ferguson) in Edinburgh University in 1785. Ten years later he published *Elements of Geometry*, the most frequently printed English geometry textbook of the nineteenth century. It was closely modeled on the earlier textbook of Robert Simson, but made Simson's erudite text more accessible to the average student (Ackerberg-Hastings 2002). Playfair introduced "algebraic" symbols in book V (and in later editions to book II as well). He also adopted an alternative formulation for Euclid's parallel lines postulate, now known as "Playfair's axiom".[6]

Playfair's treatise was translated into Arabic by Cornelius Van Alen Van Dyck (1818-1895), a medical doctor and talented linguist who came to Beirut in Ottoman Syria under the auspices of the American Board of Commissioners for Foreign Missions (Sa`id 1937). He is best known today for his Arabic translation of the *Bible* (1860). Simultaneously, he translated Playfair's *Elements of Geometry* into Arabic. Architecturally, Van Dyck's translation was almost identical to Playfair's textbook and provided a literal rendition of Playfair's textbook into Arabic. Van Dyck corrected a few typographical errors in the English text, but made few other modifications to Playfair's treatise. But he added appendices on plane and spherical trigonometry. The vocabulary used to translate Playfair's technical terminology, however, often differed from that of the Arabic tradition.[7] The system of transliterating English letters used to label geometrical entities also failed to follow the *abjad* (alphanumeric) system used in the Arabic tradition. The diagrams themselves were usually exact replicas of Playfair's diagrams (De Young 2013).[8] In these ways Van Dyck seems intentionally to distance his translation from traditional Arabic Euclidean discourse.

The missionary emphasis on science and mathematics education developed as a response to the disappointingly small number of conversions recorded by the Beirut station. By mid-century, as the ABCFM faced declining support, the missionaries

[6] The axiom reads: "There being two intersecting lines, it is impossible for both of them to be parallel to one and the same given line".

[7] Van Dyck's apparent choice to ignore traditional Arabic discourse traditions appears to be more than an individual idiosyncrasy. Elshakry (2008, 707-710) recounts a similar recasting of the Arabic traditional terminology by his fellow-missionary, Edward Lewis.

[8] Thus the diagrams had to be read from left to right, rather than following the right to left conventions of traditional Arabic geometry texts.

increasingly turned to education as a way to gain influence over youth and indirectly to convert them to Protestantism. They discovered that young men would join their schools if they offered access to modern science and mathematics.[9] Since appropriate textbooks were not available in Arabic, Van Dyck translated what was at the time probably the most widely used mathematics textbook in the United States, Playfair's *Geometry*, into Arabic.

Conclusion

Nineteenth century efforts to translate modern mathematics were inspired by contradictory motives. Those translations produced and printed under the auspices of the Ottoman state, such as Rıfkı's translation of Bonnycastle's *Elements of Geometry*, were intended to strengthen the state (especially technologically and militarily) against the growing encroachments from Europe. These translations were intended to preserve the political and cultural and economic autonomy of the aging Ottoman Empire. These desires influenced the choice of textbooks to be translated – Bonnycastle's treatise, for example, had been composed with a focus on practical applications of geometry in a military context. The primary goal of this translation effort was not to increase the cosmopolitan character of the Ottoman state but rather to preserve that state against the power of the European Other.

Van Dyck's translation of Playfair's *Geometry*, on the other hand, was intended as a tool to bring about both conversion to Protestant Christianity and opening up of the Ottoman State and society to increased influence from Europe (especially Protestant Christianity). The translations and textbooks produced by Protestant missionaries working in Ottoman dominions were intended to weaken the Islamic religious community and move its citizens toward conversion to Christianity as well as to draw Eastern Christians back to the "true faith". By extension, these studies of modern mathematics and science would, it was hoped, undermine the Ottoman state as it existed and bring about political and social reforms that would remove its decadence and corruption making it more like a modern European state.

Several of Van Dyck's students, inspired by his enthusiasm for Western science, began an Arabic journal, *al-Muqtaṭaf*, to introduce modern scientific ideas to Arabic readers. Their journal's support of evolutionary biology was widely perceived as an indirect attack on religion and led the missionary community to withdraw its support for the journal. And when some of those trained by the missionaries attempted to increase cosmopolitanism through modern science, they were criticized and rebuffed by the missionary community. The missionaries, although motivated in part by a form of cultural imperialism, contributed to greater openness to European ideas and culture in Ottoman Syria. But they did so indirectly and in directions not intended by missionary educators. They did not convert Muslims or Eastern Christians to Protestantism nor did they directly reform Ottoman culture.

Hüseyin Rıfkı also contributed to the introduction of European ideas into the Ottoman Empire, but his translations were not intended to produce greater

[9] As one missionary remarked, "We shall bait the hook with arithmetic" (Elshakry 2007, 183). The strategy was successful – by mid-century more than two thousand students had enrolled in missionary schools.

cosmopolitanism in mathematics. The goal of introducing modern European mathematics was to supplant the older mathematics being taught in the madrasas. The introduction of European mathematics was intended to play a significant role in reforming the military establishment, producing a military system capable of defending the Ottoman state against encroachment from European powers. These reforms in mathematics were successful in the sense that they produced a military corps able to compete on a more equal footing with the European military powers. But this military reform ultimately failed to meet its objective of preserving the status quo of the Ottoman state.

Although translations opened a window that promised greater cosmopolitanism in mathematical ideas, the results failed to fulfill this promise. The translations rarely interacted with traditional mathematics. In part this was because their intent was not the introduction of a more cosmopolitan mathematics but rather the opposite – to replace traditional mathematics with modern European mathematics. The reason for wishing to substitute modern European for traditional mathematics – the reform of the Ottoman state – was partially realized, but often in directions other than those the translators or their employers had envisioned.

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Wallace and Darwin on Man: a Limitation of Natural Selection?

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Introduction

In his most famous book, *On the Origin of Species*, Darwin remains practically silent on the subject of man. It is only in the conclusion that the naturalist states that thanks to the theory of descent with modification by means of natural selection "light will be thrown on the origin of man and his history" (Darwin 1859, 488). Numerous authors will complete this blank through diverse interpretations of *The Origin*. For instance, Spencer will develop social Darwinism, while Greg (1868) and Galton (1865) will elaborate their eugenicist theory (Richards 1987, 169-176; Tort 2008, 29-31; 2010a, 67-86; 2010b, 63-152; Paul 2009). Darwin will answer to such excessive applications or limitations of natural selection in *The Descent of Man*, published in 1871. It is particularly interesting to note that Wallace is once again the cause determining the writing of one of Darwin's major works[1]. Indeed, *The Descent of Man* can be considered as the answer to an article on "The Limits of Natural Selection as Applied to Man" written by Wallace in 1869. In the following pages I will argue that, surprisingly, the answer given to Wallace in *The Descent of Man* is not a plebiscite for natural selection. In the contrary, in order to maintain continuity between man and the rest of the animals, Darwin develops an "anthropomorphic zoology" and a "zoomorphic anthropology" (Durant 1985, 302) mostly based on the heredity of acquired habits (i.e. Lamarckism).
In order to explain Darwin's answer to Wallace's limitation of natural selection and its consequences, the lifelong debate between the two naturalists will be briefly discussed, from the agreement on the emergence of different races of man to the disagreements over spiritualism and sexual selection.

An initial agreement: the problem of the origin of human races

In 1864, Wallace publishes in the *Anthropological Review* an article on "The Development of Human Races under the Law of Natural Selection". In this article, Wallace tries to conciliate the monogenist theory of the human races with its polygenist counterpart through a subtle use of natural selection[2]. Indeed, Wallace

[1] It is because Wallace is on the verge to publish his theory of natural selection that Darwin starts working on *The Origin*, abandoning his much more voluminous project that was edited by Stauffer (1975) under the title *Natural Selection*.
[2] This debate is framed by the opposition between the *Ethnological Society of London*, in favour of the monogenist theory of the origins of human races, and the *Anthropological Society of London*, in favour of a polygenist account of the emergence of the different races of man. Darwin, a convinced monogenist, will join the *Ethnological Society of London* (Tort 2008, 56-59; Hoquet 2009, 287-288, Desmond & Moore 2009).

uses natural selection and what can be considered as a premise to its limitation in order to distinguish two approaches of the question of the evolution of humankind and its different realisations represented by the distinct human races:

> " Man may have been, indeed I believe must have been, once a homogeneous race; but it was at a period of which we have as yet discovered no remains, at a period so remote in history, that he had not yet acquired that wonderfully developed brain, the organ of the mind, which now, even in the lowest examples, raises him far above the highest brutes; - at a period when he had the form but hardly the nature of man, when he neither possessed human speech, nor those sympathetic and moral feelings which in a greater or less degree everywhere now distinguish the race. Just in proportion as these truly human faculties became developed in him, would his physical features become fixed and permanent, because the latter would be of less importance to his well being; he would be kept in harmony with the slowly changing universe around him, by an advance in mind, rather than by a change in body. If therefore, we are of opinion that he was not really man till these higher faculties were fully developed, we may fairly assert that there were many originally distinct races of men; while, if we think that a being closely resembling us in form and structure, but with mental faculties scarcely raised above the brute, must still be considered to have been human, we are fully entitled to maintain the common origin of all mankind." (Wallace 1871, 321-322)

Deciding if the different races of man have a common or distinct origin is a question of point of view. The opposition between the monogenist and the polygenist theories can be overcome thanks to a conciliation of their apparently drastically opposed premises through the consideration of the extension of natural selection. According to Wallace (1871, 311-317), natural selection can act on physical and/or mental structures. In the case of man, the different races were developed after a switch of the selective pressure from physical structures to mental structures. Depending on one's definition of man both the monogenist and polygenist theories can be acceptable. The polygenist position is tenable if the higher mental faculties are considered as an essential component of the human species, while the monogenist approach is supported by a less exigent, more physical definition of humankind.

Wallace's article convinces Darwin to give his notes on man to the co-discoverer of natural selection after having abandoned the idea of writing an essay on man (Darwin in Marchant 1916, 155; Kottler 1985, 420; Richards 1987, 186-187). Moreover, Darwin (1874, 127-128) acknowledges Wallace's influence in *The Descent of Man* by emphasising the importance of the shift of the selective pressure from purely physical structures to mental faculties for the evolution of mankind, and more particularly for the emergence of moral faculties. However, despite this apparent agreement between the two naturalists a profound disagreement emerges from the consideration of the origin of the different races of man having its sources on two very different theories of sexual selection and culminating in the question of the limitation of natural selection.

A profound disagreement: the question of the limitation of natural selection
After having read Wallace's article "The Limits of Natural Selection as Applied to Man", Darwin cannot refrain to write to the co-discoverer of natural selection, making reference to his previous article on the origin of the different races of man:

> "But I groan over Man – you write like a metamorphosed (in retrograde direction) naturalist, and you the author of the best paper that ever appeared in the *Anthropological Review!* Eheu! Eheu! Eheu!" (Darwin in Marchant 1916, 251)

The context of the composition of this article has to be studied in order to understand why Wallace writes "like a metamorphosed (in retrograde direction) naturalist". As Richards notes "Wallace's metamorphosis had an unusual precipitating cause. He had undergone a conversion to spiritualism and as a result saw man in a new light" (Richards 1987, 128). Other causes are identifiable, such as Wallace's firm belief in Spencerian progressionism, his will to answer Greg's objections on the limits of natural selection and his experience on the education and on the development of moral sense in savages (Kottler 1974; 1985, 420-421; Richards 1987, 176-184). Briefly summarised, Wallace's 1869 article maintains that natural selection cannot be considered as responsible for the development of certain faculties, particularly in the case of man. Therefore, the naturalist introduces a higher, spiritual law in order to complete the action of natural selection. Two cases are studied: the origins of sensation and consciousness; the development of the human species from a lower animal species (Wallace 1871, 333). Traces of the higher spiritual law, which is necessarily a will-force according to Wallace's metaphysics (1871, 366-368), are numerous in the evolution of man. For instance, the brain of savages, the complexity of their hands, feet and larynx are far too developed for the use they make of them (Wallace 1871, 335-343, 349-351; Gould 1980; Kottler 1985, 421-424). In addition, the fact that human beings are deprived of hair cannot be explained by natural selection, since hair deprivation conveys no immediate advantage, and announces a future destiny of humankind planned by a higher force (Wallace 1871, 344-349). The development of moral faculties that can be partly explained through group selection confirms such a pre-planned human destiny, the sanctity attributed to moral actions being its most evident mark (Wallace 1871, 352-355). However, such characteristics essentially define the human species. The only model of selection relevant with respect to the evolution of human faculties is artificial selection, which implies intelligence and voluntary action or, according to Wallace's metaphysical terminology, will-force (Wallace 1871, 359). Wallace confesses that his account of human evolution "has the disadvantage of requiring the intervention of some distinct individual intelligence" (Wallace 1871, 360). Therefore, he will insist on the last chapter of *Darwinism* that continuity does not need to be unified around natural selection and that the emergence of man can be considered as a continuous rupture (Wallace 1889, 461-464). In short Wallace argues for a dualistic evolutionism.

In *The Descent of Man*, Darwin addresses all the arguments based on the development of human faculties used by Wallace in order to argue for an insufficiency of natural selection. Far from only reiterating the slogan of *The Origin*, i.e. descent with modification by means of natural selection, Darwin emphasises other principles such as sexual selection and the heredity of habits (Darwin 1874, 61). Such principles are evocated in *The Origin* but are subordinated to natural selection. In *The Descent of Man*, and particularly in its second part, Darwin develops what can be considered as the domain of the useless that takes into account both non-adaptive and anti-adaptive structures and behaviour. Although Darwin explains several aspects of Wallace's evidence for the existence, adequation and responsibility[3] of a higher spiritual force by natural selection, his main strategy against Wallace's discontinuous theory is to put an emphasis on the other principles of evolution, i.e. on the domain of the useless. In other words, Darwin answers to Wallace's arguments against natural selection with respect to man by a limitation of natural selection.

Darwin's continuous theory: the example of sexual selection

The antagonism between Wallace and Darwin is particularly obvious with respect to sexual selection (Kottler 1985; Cronin 1991 118-191). The two naturalists give two distinct definitions of this principle that mark a general disagreement over their respective evolutionary theories. According to Darwin, sexual selection concerns "the advantage which certain individuals have over others of the same sex and species solely in respect of reproduction" (Darwin 1874, 208). Contrarily to what can be considered as a post-fisherian sociobiologist approach of sexual selection[4], Darwin distinguishes this principle from natural selection. Mayr recognises that though considering sexual selection as a particular case of natural selection "facilitates the mathematical treatment" of such behaviour, he has "a feeling that something rather important was lost in the process." (Mayr 1972, 88) What is lost by the adoption of a mathematical treatment of sexual selection is Darwin's ethology developed throughout *The Descent of Man* and *The Expression of the Emotions in Man and Animals*. Indeed, as it has already been noted, Darwin develops an "anthropomorphic zoology" and a "zoomorphic anthropology" (Durant 1985, 302): every human faculty is expressed in animal behaviour that is described through anecdotes in anthropomorphic terms. With respect to sexual selection, Darwin states that males voluntarily exhibit their ornaments in order to seduce females that

[3] According to Hodge (1977) these three criteria are necessary in the context of Hershel's *vera causa* and structure *The Origin of species*. See also Ruse (1999, 176-180), Waters (2009) and Hoquet (2009, 51-59) for a discussion of these three criteria.

[4] For an example of such a perspective, see Cronin's *The Ant and the Peacock* (1991). In this book, Cronin tries to conciliate Darwin's theory of sexual selection with Wallace's through Fisher (1930).

consciously choose the ones they consider as the most beautiful males thanks to an acute aesthetic sense[5].

Prefiguring Morgan's canon[6], Wallace refuses both the voluntary character of seductive behaviour and female choice and considers sexual selection as a part of natural selection (Wallace 1889, 296). Indeed, the naturalist defends an ultra-adaptive theory with respect to animal behaviour, which will be greatly criticised by Romanes (Richards 1987, 331-408; Hoquet 2009, 349-382). According to Wallace (1889, 287-300), the most vigorous males are the more ornamented, which is explainable by a physiological law developed by Tylor (1886) (Cronin 1991, 131-146). Males seductive antics and their ornaments are only due to a surplus of energy mark of the vigour, that is an adaptive feature, while female choice is illusionary and only corresponds to the success of the fittest males in the battle for mates. Allied to the theory of the limitations of natural selection with respect to man, such an ultra-adaptive account of animal behaviour confirms the rupture between humankind and the other species.

It is precisely the discontinuity between man and the rest of the animals that is avoided by Darwin through another instance of the limitation of natural selection perfectly illustrated by sexual selection. Indeed both the seductive ornaments and behaviour of the males and the choice exerted by females limit natural selection. In accordance with his anthropomorphic zoology, Darwin states that males have intelligently acquired the habit of displaying their ornaments (Darwin 1874, 402). In addition, female animals, as female humans, make a practically arbitrary choice, following their taste and even making capricious decisions thanks to high mental powers conferring them a well-developed aesthetic sense. In sum, Darwin's anthropomorphic zoology makes the assumptions that animal behaviour can be explained by analogy with human behaviour because animal faculties are not essentially different from human faculties, the distinction between them being only one of degree (Darwin 1874, 420-421). Moreover, the study of seductive behaviour and structures leads Darwin to account for non-adaptive and anti-adaptive features. For instance, males are handicapped by their encumbering and conspicuous ornaments in the struggle for existence. Females are not immune to these difficulties, the most famous example being the acquisition of a too conspicuous plumage threatening a safe hatching. Far from convoking natural selection in order to explain the modifications of behaviour necessary due to such handicapping structures, Darwin contradicts the seventh chapter of the *Origin* dedicated to instinct and confirms the solution privileged in his manuscripts until 1856 by stating that animals intelligently react to their structure and their environment and acquire new habits that can be transmitted to their offspring by an instance of Lamarckism (Darwin 1874, 452-453). Such a solution that directly contradicts Wallace's theory has a transformative power over the definition of natural selection: it is no more a

[5] This theory is developed in the general chapter on sexual selection and in the chapters dedicated to birds. See Darwin (1874, 207-259, 358-499).

[6] "In no case is an animal activity to be interpreted in terms of higher psychological processes if it can be fairly interpreted in terms of processes which stand lower in the scale of psychological evolution and development." (Morgan 1894)

positive and creative principle but a negative and eliminative principle (Hoquet 2009, 193-231). Indeed, in accordance with Baldwin's organic selection (1856), the creative and positive power is conferred to the intelligent actions of animals, natural selection becoming a simple *cleaver* eliminating the ones that are not able to alter their behaviour. In short, Darwin's continuous theory illustrated by the development of an anthropomorphic zoology and a zoomorphic anthropology doubly limits natural selection by recognising phenomena for which it is not responsible and by radically changing its definition.

Conclusion

The controversy between Wallace and Darwin has profound implications. Indeed, it cannot be limited to a sterile debate over spiritualism. On the one hand, the consequences of Wallace's ultra-adaptive theory with respect to man appear thanks to this life-long dialogue between the two naturalists: either man has to be treated as a mere automat or a rupture between humankind and the rest of the animals has to be supposed. Therefore, the limitation of natural selection for Wallace means that this principle is not universal, i.e. does not operate on man. On the other hand, applying descent with modification to the evolutionary history of man as an answer to Wallace's discontinuous hypothesis is the occasion for Darwin to evaluate the importance that has to be attributed to natural selection concerning behaviour in general. Though natural selection seems to be central to account for the evolution of purely physiological structures and for the emergence of mental faculties, the creative and positive power seems to be transmitted to the animal once it is intelligent enough. In other words, Darwin, as Wallace, limits natural selection but such a limitation is drastically different. Indeed, natural selection is still universal for Darwin; it operates both on man and animals since the naturalist refuses any discontinuity. However, natural selection cannot directly account for all phenomena and a growing, ever-expending domain of the useless has to be considered. Moreover, natural selection can be transformed, i.e. redefined as a mostly negative and eliminative principle, which also corresponds to a certain instance of limitation through a reduced responsibility. Darwin's revision of the centrality of natural selection in *The Descent of Man* is not only in line with his manuscripts and his lifelong relations with animals (Townshend 2009) but also historically founds a new approach in ethology opposed to the mainstream realist-Cartesian paradigm (Lestel 2011). Animals are no more considered as mere automats but as hermeneutic creatures capable of innovation that can be transmitted and, by extension, of culture.

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L'Orient Express, vecteur du cosmopolitisme technologique et culturel européen

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What is cosmopolitanism? A concept which combines two notions : the *cosmos*, the universe, and even the arranged universe, and the *polites*, the man of the *polis*, the citizen. It is a state of mind which consists in considering as its native its country of origin as well as any other country. It is, in short, the feeling of being a citizen of the world beyond the nations without being linked to one of them.
As for the Orient Express, this feeling of belonging to the world – especially to the European world - is linked to a long intellectual tradition which aims to bring the West to the East and Georges Nagelmackers, founder of the Compagnie Internationale des Wagons-Lits and of the Orient Express, has for some people partially illustrated it and set it in motion.
Belonging in appearance to the background, technological cosmopolitanism is immediately concrete and practical : it deals with the cooperation between states. And the Orient Express is indeed a very large project, which was to join European technology forces.
These two types of cosmopolitanism are strongly linked : first, the technical collaboration was realised under the sign of the annihilation of the borders and national peculiarities, even when the context was not good at all ; once the company launched, wealthy travelers were invited to meet and mingle to share some exceptional days in the Orient Express.
But these links, have they lasted, have they vanished, or did one take advantage upon the other?

The importance of technical realisations: from the Pullman cars to the Orient Express

The Orient Express is the invention of a Belgian man, Georges Nagelmackers, a young engineer trained in the universities of Liège who, after he discovered the comfort of the Pullman cars during a travel in the United States, wanted to reproduce which was then a model of luxury transportation on the European continent, with the improvements he found necessary [1].

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[1] *Cf.* Georges Nagelmackers, *Projet d'installation de wagons-lits sur les chemins de fer du continent*, Liège, Imprimerie de H. Vaillant-Carmanne & Cie, 1870. See also Roger Commault, *Georges Nagelmackers, un pionnier du confort sur rail,* Uzès, 1966 ; Gérard Coudert, Maurice Knepper et Pierre-Yves Toussirot, *La Compagnie des Wagons-Lits : Histoire des véhicules ferroviaires de luxe*, Paris, La Vie du Rail, 2009 ; Christine Renardy, *Liège et l'Exposition universelle de 1905*, Bruxelles, La Renaissance du Livre, Fonds Mercator, 2005.

Nagelmackers was quite confident and no doubted the success of the enterprise given the popularity of Pullman's car in the United States. But to go further, he would perhaps, according the assumption made by Jean-Paul Caracalla and Jean des Cars, contribute to the union of European states by the railroad, as Pullman had managed to unify the territory of the United States with the success of his cars [2].
Still, the Compagnie Internationale des Wagons-Lits was founded in 1876, after many hazards linked to the Franco-Prussian war and the many technical complications that its creation involved [3].
It is indeed during the early 1870's that were built the essential foundations of a European technology collaboration which was not obvious at all. Clive Lamming, who wrote a book on luxury trains, writes about this : "The international trains are experiencing a difficult start in the nineteenth century which withdraws into its borders, with its particular minorities who jeopardize empires, its armies ready to restart the 1870 war. To these difficulties must be added those inherent in railway carriages : their systems of braking or signaling differ from one country to another, and from one network to another in the same country. Not easy to realise in this context the Europe of business travel, of luxury hotel business and of international gastronomy when the guns and the vengeful hymns still haunt the minds." [4]
Despite this unfavourable context, many contracts between the various European railway authorities and Nagelmackers reflect this close collaboration. From the Belgian company, risky only in appearance since quickly joined the big financial and industrial tycoons [5], we go to the birth of the first international transport.
The departure of the Orient Express ("Train Express d'Orient" at the time), which was given on October 4th 1883 in Strasbourg's station (Gare de l'Est), was preceded by countless negotiations, facilitated by the success of the Compagnie des Wagons-Lits. These necessary and preliminary agreements are listed by Jean-Paul Caracalla and Jean des Cars in their album devoted to the Orient Express [6] and in various railway magazines [7] : agreements with the French Eastern railways in Paris ; with the general and imperial management of the Alsace-Lorraine Railways in Strasbourg ;

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[2] Jean-Paul Caracalla et Jean des Cars, *L'Orient-Express. Un siècle d'aventures ferroviaires*, Paris, Denoël, 1984.
[3] Nagelmackers completes his *Projet* on April 20th and France launches a declaration of war to Germany in July.
[4] Clive Lamming, *Les grands trains de 1830 à nos jours*, Paris, Larousse, 1989, 78 (translation).
[5] Nagelmackers was indeed surrounded by influent members of his family at the beginning (his cousin Octave Neef-Orban, who worked in the railway industry and was a political man and the President of the Company, Ernest Nagelmackers, his oncle, and Jules Nagelmackers, his brother). Then came the personalities : King Leopold II, Charles Delloye-Matthieu, the baron Del Marmol, the banker Frédéric Braconier and many others. To go further, see Roger Commault, *Georges Nagelmackers, un pionnier du confort sur rail,* Uzès, 1966, Christine Renardy, *Liège et l'Exposition universelle de 1905*, Bruxelles, La Renaissance du Livre, Fonds Mercator, 2005, and *Le Recueil financier annuel, revue technique, scientifique et financière*, Bruxelles.
[6] Jean-Paul Caracalla et Jean des Cars, *op. cit*., 19-20.
[7] Les 120 ans de l' « Orient Express » (1ère partie) *in Rail passion*, n° 77, janvier 2004, 68.

with the General Management of Railways of the Grand Duchy of Baden in Karlsruhe, with the General Management of Railways of the state of the Kingdom of Württemberg in Stuttgart; with the General Management of Railways of the kingdom of Bavaria in Munich, with the direction of the Imperial and Royal Railways of the Austro-Hungarian state and with the League of private railways of the Austro-Hungarian government in Vienna and Budapest, and finally with the General and Royal Management of Romanian Railways in Bucharest. A map of European Railway is somewhat created or recreated.

This list of contracts shows us that various agreements were made within the same country (because of German federalism and of the partition of Austria-Hungary), complicating things. These conventions are spread between March 2nd and May 2nd 1883 and it is the Elsass-Lothringen (Alsace-Lorraine) network which was chosen as network manager, responsible for relationships. Because the Ottoman railway was not yet linked to European railways, the railway route, which went through Strasbourg, Munich, Vienna, Bratislava, Timisoara, Bucharest and Giurgiu, first took a large curve by Romania and Bulgaria and ended with a crossing in the night between the Black Sea ports of Varna and of Constantinople (there was also a ferry crossing the Danube between Romania and Bulgaria), which shows a striking contrast between the beginning and the end of the trip, far more epic.

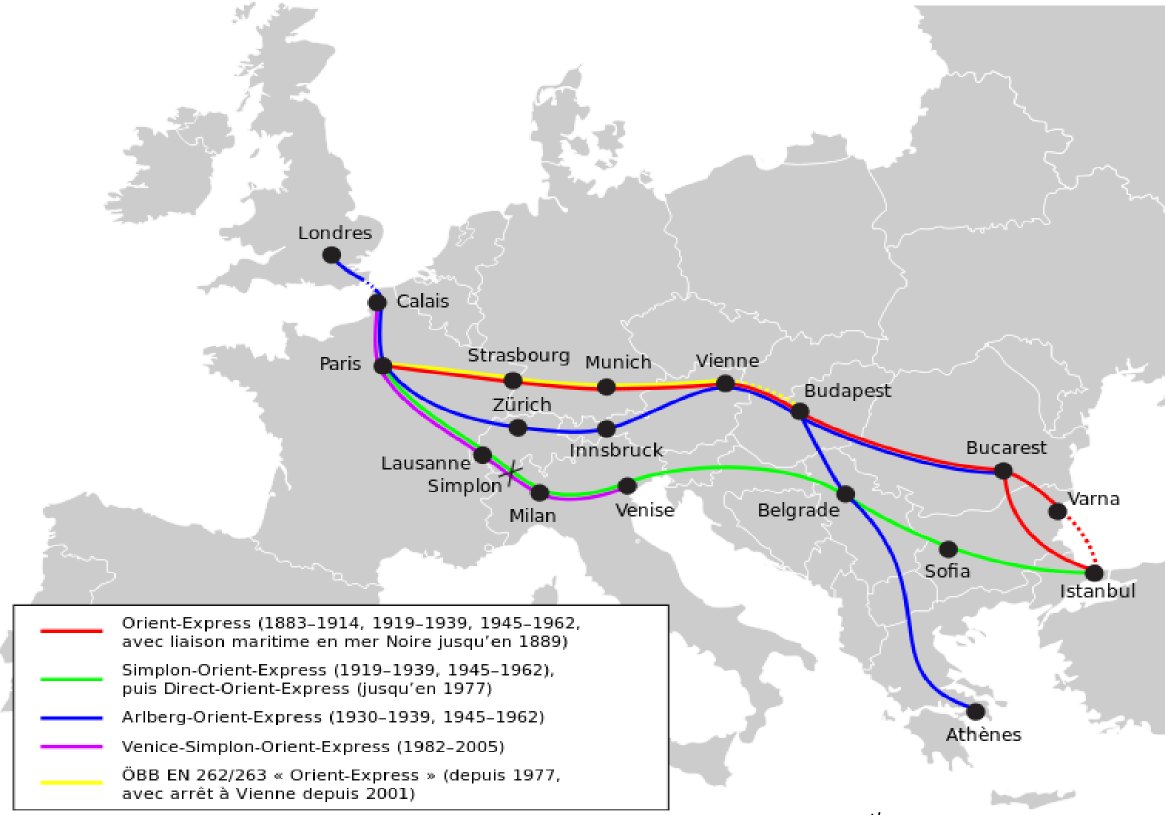

Figure 1: *The Orient Express trips thoughout the 20th century*

Despite this quite uncomfortable arrival, the Orient Express remains the first great international express, because of the destinations it covers, in its design (as far as its name makes the Oriental dream closer) and in its manufacture.

Between luxury and modernity, a transeuropean culture

In the first Orient Express, which evolved since then, there were three sleeping cars with three axles and with fourteen seats in each, a sixteen seats car with bogies (Number 75) and two vans at both ends which were devoted to luggage provisions and staff rooms. The dining car (Number 107) was commissioned to the Rathgeber society in Munich, which made the entire chassis and bodywork, while the splendid decoration was provided by the workshops of the Compagnie Internationale des Wagons-Lits : Gobelins tapestries, morocco leather from Córdoba and velvet of Genoa adorned the walls. Delivered on August 1st 1882, it was the result of hard work in the French workshop of Marly-les-Valenciennes to complete the finish. It had twenty-four seats and two dining rooms with a smoking-library and a boudoir for the ladies; there was also a very small central kitchen.

During this first trip as well as in next ones, the menus were served according to the countries crossed by the train: sterlets from the Danube, fresh caviar from Romania, Turkish pilaf, wines of the Moselle, of the Rhine, of Hungary and Romania, lists the French journalist Georges Boyer[8]. Indeed, Georges Nagelmackers invited personalities from many European countries [9]. There were also local musical interludes during the journey [10]. The success was absolute : travelers were all very enthusiastic [11].

The Orient Express, which went through (and still goes through) so many countries should arouse in those who took it frequently the feeling of belonging to the world, coupled with an illusory disappearance of the borders. Indeed, when a passenger does not have to change trains at border crossings, nations seem less heavily exist, and when coexist in the same place people belonging to various nationalities and of different backgrounds, even if restricted to few groups (diplomats, industrialists, writers, artists, what is called, with or without shade, with or without irony, "the beautiful world"), links are created and very different types join.

This huge success was followed by the creation of a weekly branch towards Belgrade and Nis in 1885, with a new agreement signed with the Royal Railways of Serbia. Extensions were added step by step : on June 1st 1894 was created the Ostend-Orient-Express, the first of many extensions of the Orient Express, passing by Constanza and Trieste ; a service steamer to Alexandria was an option suggested by the Austrian company Lloyd. But it was in 1930, with the creation of the Taurus Express, that East became more and more wider.

The international nature of travels, deliberately emphasized by the juxtaposition of elements of European culture in the early years, became more cosmopolitan with the creation of the Compagnie Internationale des Grands Hôtels, launched in 1894 by Nagelmackers [12]. It is indeed in the famous Pera Palace, creation of the Armenian

[8] Journalist (*Le Figaro*) who wrote his journey in the paper of October 20th 1883.

[9] *Cf*. Edmond About, *L'Orient Express – De Pontoise à Stamboul*, Magellan & Cie, 2007, pp. 19-20 : the French journalist lists the guests and notices there were French, Belgian, Dutch, Turkish, Austro-Hungarian and German people.

[10] *Cf*. Edmond About, *ibid.* , Magellan, 2007, 29.

[11] *Cf*. Edmond About, *ibid.*, Magellan, 2007.

[12] *Cf*. Joanne Vajda, « Les Pereire et Nagelmackers, promoteurs du transport ferroviaire et du réseau hôtelier parisien, 1855-1900, *Revue d'histoire des chemins de fer*, n°38, 2008.

architect Alexandre Vallaury that rich European travelers got together. For the local ones, Pera, its Art Nouveau style and comfort were a European ugly patch combining Western culture and local color ; however, everyone who cared for comfort went there, including some who criticized it, for example Pierre Loti.
Constantinople becomes modern: the Turkish rail network grows and the country also changes in the 1920's because of the reforms of Ataturk. The perception of the city changes, as opposed to the colorful visions and somewhat caricatured that were depicted by De Amicis and Loti, and Turkey becomes European [13]. From now on, everything is somewhat blurred : European travelers wonder about the oriental identity of Turkey and feel at home in this distant country.
The Orient Express also changes a lot. If the decoration, passengers and international menus are the trademark of the train, many details and artistic improvements are added over the years, and the greatest artists contribute to the reputation of the Orient Express, which is based on large advertising campaigns : the poster makers Cassandre, Pierre Fix-Masseau and Roger Broders or the painter Théo Van Rysselberghe, the French cabinetmaker René Prou, the British cabinetmakers Morrison, Dunn and Maple [14] work for the Compagnie Internationale des Wagons-Lits ; note that Maple, at the very end of the nineteenth century, had worked for the Compagnie Internationale des Grands Hôtels : he was indeed responsible for furnishing the Élysée Palace, grand Parisian hotel designed by architect Georges Chedanne in 1899 in Art Deco style. Links between luxury hotel and luxury rail are striking, and Pierre Giffard wrote that the reading room of the Orient Express was "Grand Hotel rolling Lounge"[15].
Travelers appreciate the immutable rites of the dinner, bedtime and sunrise, marks of a fine life while they should be satisfied with simple necessities [16] and still require more dexterity of the multilingual staff members, who remind the grand hotels concierges, discrete and accommodating, perceiving all without seeing anything.
An Orient Express community is born, which collects luggage labels of big hotels and luxury trains, community which is depicted by a character of the play by Abel Hermant, *Trains de luxe*, written in 1910: "It [the foreign colony, that is to say foreign residents in Paris or in seaside resorts] is really at home in the big express which takes it, takes it again, carries and distributes it ... » [17].

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[13] *In Le voyage à Constantinople*, *l'Orient Express*, Emmanuel Collet, Alain Servantie, Sophie Basch, Eddy Stols & Joos Vermeulen, Jean-Paul Caracalla et Jean des Cars - Bruxelles, Snoeck-Ducaju & Zoon – Pandora, 1997, 62 *sq*.
[14] Shirley Sherwood, Venice Simplon Orient-Express, le plus célèbre train du monde reprend du service, Paris, Payot, 1984.
[15] Quoted by Joanne Vajda, « Les Pereire et Nagelmackers, promoteurs du transport ferroviaire et du réseau hôtelier parisien, 1855-1900, *Revue d'histoire des chemins de fer*, n°38, 2008. See also the *Panorama du voyage 1780 – 1920* by Sylvain Venayre, Paris, Les Belles Lettres, 2012, 437-438.
[16] *Cf*. Edmond About, *op. cit.*, Magellan, 2007, 23.
[17] Abel Hermant, *Trains de luxe*, Paris, éditions de France, 1934, 11 (translation).

To the luxury temptation, one must add the adventurous side, widely reflected by the tumultuous chronicles of the train [18], by literature and by arts, which gives the feeling of belonging to a large community with sometimes mysterious and dubious activities.

Permanence, mutations and decline of cosmopolitanism

But for the Orient Express and Europe, things change during the First World War : the train becomes German and is ruled by the Mitropa. In fact, cooperations are stopped for a while, and the changes of the borders that tear Europe apart affect the Orient Express. But in 1919, the Treaty of Versailles requires the creation of a new train, the Simplon-Orient-Express and it is at the end of the Roaring Twenties that the train knows the great artistic and technological improvements mentioned above, with the Pullman cars : these are the most successful years in the history of the train and generally of the Compagnie Internationale des Wagons-Lits, whose workshops create number of prestigious cars, mainly in Aytré, in Charente, and in Birmingham. But this rich society of the blessed ones described above and for a large part fantasmatic [19] is not the society described by Paul Morand in *Ouvert la nuit*. In 1913 already, he spoke of the "tri-weekly public. The same, always. French dressmakers and younger milliners, returned to Constantinople after a trip of restocking "and he also mentions " the women of the Civil Service"(...) with "six blond babies ","officers", French and English who occupy waters for a long time, and "Jewish Spanish families from Salonika" [20].
The misery of the refugees is shown here with force ; in their very different way, John Dos Passos, in *Orient Express* [21] and Graham Greene, in the book of the same name [22], confirm this sense of irreversible decline ; the first one writes a dark account of his staying in Turkey and, remarkably and significantly, doesn't mention the name of the train, and the second describes in his novel heartbreaking stories of lost characters.
However, the fascination remains, as show the publication and success of thrillers and Orient Express adventure novels in the 1930s. But the wealthy travelers seem more worried and dejected, like those of *Murder on the Orient Express* by Agatha Christie, and scoundrels of all kinds are now moving in the luxurious train [23].

[18] Unexspected stops due to bad weather, attacks… *Cf. L'Illustration*, n° 4486, 23 février 1929, 19 : the newspaper deals with the big cold which paralyzed the whole Europe and Constantinople.
[19] The Belle Époque and the Roaring Twenties literature is somewhat responsible for this representations (*cf*. *Les Poésies d'A.O. Barnabooth*, by Valéry Larbaud and *La Madone des Sleepings* by Maurice Dekobra).
[20] Paul Morand, *Ouvert la nuit*, « La nuit turque », Paris, Gallimard, 1922, 73-74 (translation). See also *Le voyage*, Paris, Pocket, 1996, where he depicts different eras in the history of the train.
[21] John Dos Passos, *Orient Express*, 1927.
[22] Graham Greene, *Orient Express*, 1932. Cosmopolitanism is moreover somewhat linked to judaism in this novel (cf. Myatt's character).
[23] See also *The Mask of Dimitrios* by Eric Ambler and *Orient Express* by Louis-Thomas Jurdant.

The Second World War accelerates the decline of the Orient Express, which loses its name of luxury transportation in 1948, and now takes refugee populations in old cars and has no longer dining cars.

A capacity for renewal ?

Should we talk about nostalgia or did the train become obsolete today ? In the late 1970s, the British James Sherwood begins to restore the cars he purchased in the workshops of Ostend ; the Venice Simplon-Orient-Express, however, no longer goes, or very occasionally, to Istanbul [24]. For some, the magnificent restoration of cars is a sign of kitsch. "Resurrecting the prestigious train " [25], not only the train but also its mind, was James Sherwood's motto. Was it a successful or an impossible bet? Indeed, what remains of the cosmopolitanism? The new Orient Express is again a luxury train, with its rituals (evening dress and dinner jacket are required [26], there are Villeroy and Boch crockery which commemorates various artistic inspiration from the Orient Express [27] and brown uniform like in the old days), its passengers, its hotels . But it is probably more a dream for the admirers of the Belle Époque in the time of quick trips. Moreover, the many albums and websites devoted to the Orient Express are full of historical details and commentaries.

What is certain is that we no longer truly deal with the incredible cosmopolitanism of Constantinople-Istanbul [28], the double identity city, which was no doubt more cosmopolitan in the past, when European authors admired this gateway to the East, and thus may be less glamorous and less mysterious (also because it is far easier to go there). The Orient Express has become the symbol of international and somewhat outdated luxury, and no longer carries refugees, diplomats or spies. Literature and cinema, deeply nostalgic, mourn the disappearance of these uncommon travelers [29].

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[24] Simultaneously, Albert Glatt launches the Nostalgie-Istanbul-Orient-Express, also made of Pullman cars, which goes in France and all over the world (China, South Africa, India). In 1987, the Compagnie des Wagons-Lits buys seven Pullman cars bought a few years later by Accor, which planified many exceptional events until 2008 (considering that it was not bankable anymore).

[25] Shirley Sherwood, Venice Simplon Orient-Express, le plus célèbre train du monde reprend du service, Paris, Payot, 1984, 75.

[26] Explicitly mentioned in the Orient Express catalogue, 12. « Étiquette... Avec un cadre aussi prestigieux, l'élégance est de mise à bord. Les messieurs optent pour le smoking au dîner tandis que les dames se parent de leur plus belle robe de soirée, ambiance assurée d'une grande occasion. Dans tous les cas, veste et cravate sont de rigueur pour les messieurs au dîner. Pendant la journée, une tenue -correcte- plus décontractée est admise, à l'exclusion des jeans et chaussures de sport. » *in Orient Express, Voyages en Europe & en Asie du Sud-Est 2012*.

[27] See Villeroy & Boch website : http://www.villeroy-boch.com/fr/ca/home/la-societe/a-propos-de-villeroy-boch/geschichten/villeroy-boch-im-legendaeren-orient-express.html.

[28] *Cf*. Sophie Basch, who associates, following Dos Passos, the cosmopolitanism of the people from Istanbul with the complex architecture of the city, *op. cit.*, 71.

[29] *Cf* . Pierre-Jean Rémy, *Orient Express*, Paris, Albin Michel, 1979. See also *The Orient Express* by Gregor Von Rezzori, New York, A. Knopf, 1992 and *Le Roman de l'Orient Express* by Vladimir Fédorovski, Paris, Éditions du Rocher, 2006. Jean-Pierre Jeunet, *Amélie Poulain*'s

It is also remarkable that we always speak of the old train, not of the new one, which is a confidential phenomenon that concerns only the fans, and certainly does not deal anymore with state cooperation.
The Orient Express was both international and cosmopolitan in its prime days: its aims were the disappearance of the borders and the collaborations of various European forces (industrial, financial, technological, artistic, gastronomic forces). Its success and strength is based on an efficient combination : the access to the oriental dream in Istanbul - and all literary travelers know the descriptions made by Loti, Chateaubriand and Flaubert - and the mixture of European cultures in a closed, moving and luxurious space which raises a strong sense of belonging to the wider world ; hence the cosmopolitanism. When today people are more found of ultra-fast international transport, it seems that we sometimes dream and want to find this slow comfort (regarding today's standards) of retrospectively happy years.

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film director, made a film for Chanel number 5 perfume starring Audrey Tautou who chases a handsome stranger in the Orient Express (*cf*. *Ferrovissime*, September 2009, n°19).

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Global Pressure, Local Opposition. Tendencies toward a Human Academic Environment

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Introduction

5302 Flemish researchers signed by October 2013 the online petition in which they clearly criticize the 'quantitative rather than qualitative evaluation by policy makers, the excessive publication pressure imposed on young researchers, and the creation of a bureaucratic environment based on a culture of mistrust'. (AHHO, 2013) Something is rotten in the Garden of Akademos. I describe what is going on in the Flemish academic world and present solutions to solve the malaise. The content of this article has been updated since the conference.

Dehumanisation of the Academic World

It is common knowledge: Thomson Reuters *Web of Science* dominates the academic world. The comparison with *Credit Rating Agencies* like Moody's hold: they all seem to forget that their arbitrary rankings strongly influence individual lives. The pressure to publish in ISI-ranked journals makes the academic work environment unfriendly, therefore unhealthy and can lead to burnouts. Indeed, most research suggests that work-related features, such as the chronic stressor of workload, are strongly related to burnout. (González-Morales, 2012) During the last five years, in Flanders, burnout and depression numbers grew 10% per year. (Netto 2013) One out of five Flemish employees faces a high risk of having a burnout. (IDEWE 2013)
75% of the American academics are overall satisfied with their job. However, a survey among American faculty (n=23,824) shows that they "[…] continue to experience multiple sources of work-life stress." 71% blame research or publishing demands, 74% point to institutional budget cuts and 75% is upset about unprepared students. More then 17% of faculty feels they did not have a healthy balance between their personal and professional lives; this number raised a third between 2004 and 2010. (HERI, 2011) Consequently, young researchers do consider leaving the University because they feel undervalued, they are longing for a partner, or it is impossible to combine work with family life, in short, because they want a normal life. (Ryan, 2012) At the University of Aberdeen, "Post-doctoral researchers in Medical Sciences […] were told […] that they need to be publishing, on average, 3.25 papers per year in order to have a competitive chance of getting a research fellowship." (Doran, 2012) Indeed, the assistants are expected to publish for the sake of the quota of the institution. Half-time professors teach – having less time to do research – while full-academics spend more and more time on the hunt for research funding. (HERI, 2011) All academic work (teaching, research and other tasks) is regulated by managers: at the university they see their numbers raised twice as fast as academics. (Grove, 2012) Knowledge is today perceived as a mere industrial

product and universities are changed into companies. And this leads to "[…] fears about the changing nature of universities as the market in higher education continues to grow." (Hunt, 2012) Professors cut classes, prepare less and get bad evaluations. Research is done in their spare time. All of this causes frustration and, in the end, depression and burnout. Needless to say "[…] institutions and government must never lose sight of universities' key roles in teaching and challenging students." (Hunt, 2012) But, more importantly, it is time that the overall dehumanisation of the academic world is stopped. 'Dehumanisation', i.e. the act of degrading people with respect to their best qualities. (The Free Dictionary, 2012)

The bibliometrical inquisition

National governments link research funding to scientific output. The academic authorities rank their faculties according to the amount of ISI-papers, weighed by the respective impact factors of the journals in which the papers appear. Individual academics are assessed by h-index: an author has an index h if she has published h articles each cited h times. The impact factor i for a certain year y is the number of citations for that journal during the previous year (y-1) divided by the number of articles during that same year (y-1).

It is all about quantities. Some editors ask authors to cite the journal at least once in their contributions. Authors cite their own articles. Or they co-author articles to which they did not contribute at all. Researchers get more inventive by the day, being shrewd just to cope with the pressure laid upon them to publish. At least one out of three admits to cheat one way or another. (Martinson 2005) To spice the curriculum vitae researchers submit abstracts to go to conferences, without not showing-up; however, in the end, they do get a publication in the book of abstracts (maybe even an article in the proceedings). For the ESHS-conference of 2012 about 500 authors submitted an abstract, the scientific committee selected 450 presentations. All authors enrolled. Eventually 280 participants showed up, 170 stayed at home, of which only 10 apologized for the no-show. Needless to say that the large number of absentees had a bad impact on the conference (smaller audience, empty sessions, etcetera).

The past decade, the number of retraction notices has shot up 10-fold (even as the literature has expanded by only 44%), reports Nature. (Van Noorden 2011) Misconduct is the most important reason for this (44%): fabrication or falsification (11%), self-plagiarism – e.g. salami-slicing – (17%) and straightforward plagiarism (16%). But scientists make more and more honest mistakes too (28%) or are all too fast submitting their results that prove to be irreproducible (28%). "Too many sloppy mistakes are creeping into scientific papers. Lab heads must look more rigorously at the data — and at themselves." (Nature 2012) Half of the neuroscience papers suffer from statistical errors. (Nieuwenhuis 2011)

The administrators counteract the creative, sometimes unethical even criminal behaviour of their subjects with an ad hoc policy. Henceforth the weight of a publication is inversely proportional to the number of co-authors. The eigen-h-index results from dividing the h-factor by the years of professional employment. You will publish until you die. And towards misconduct, the managers are firm: zero-tolerance and legal proceedings. But these measures come to nothing. Scientists know that cheating is exactly the sheer opposite of what science is all about. Science is about finding the truth and its evident that you cannot fraud the process. Then again, at least one third is a scammer. Scientists also know that the golden rule should hold. Let me quote a passage from the CBE Style Manual, as an illustration of comparable ethics that can be found in almost every methodological introduction to the scientific method:

"Scientists build their concepts and theories with individual bricks of scientifically ascertained facts, found by themselves and their predecessors. Scientists can proceed with confidence only if they can assume that the previously reported facts on which their work is based are indeed correct. *Thus all scientists have an unwritten contract with their contemporaries and those whose work will follow to provide observations honestly obtained, recorded, and published*. This ethic is no more than science's application of the ancient Golden Rule: 'Do unto others as you would have them do unto you.' It is an ethic that should govern everyone in the community of scientists when they serve as authors, editors, or manuscript referees." (CBE 1983, my emphasis)

All our great predecessors in one way or another told us that "they were standing on the shoulders of giants", in other words, that science progresses by confidence, mutual respect and collaboration, more and more scientists. Nevertheless, many authors consider defrauding. It is true that the journals are not apt to put the deontology into the limelight: "Only a third of top-ranking peer-reviewed journals had publicly-available definitions of misconduct and less than a half described procedures for handling allegations of misconduct." (Bosch, 2012) However, this cannot be the reason that "instead of publishing for the sake of truth, the truth is now violated to publish", as a distinguished colleague wrote in a Flemish newspaper. (Loobuyck, 2013) Rather, "the modern scientist faces intense competition, and is further burdened by difficult, sometimes unreasonable, regulatory, social, and managerial demands. This mix of pressures creates many possibilities for the compromise of scientific integrity that extend well beyond FFP [:] fabrication, falsification, or plagiarism (FFP) in proposing, performing, or reviewing research, or in reporting research results." (Martinson 2005)

The institutes focus on the quantitative aspects of research: it's about numbers. Of course, all researchers would like to see more attention on the substantive aspects of their work: methodology and content. But that is hard to measure. The peer-review process – core of the academic method – controls method and content. It is a shame peer-reviewing itself is not without problems: referees can be biased, too strict, and/or irresponsible. "Peer review arouses very diverse emotions, beliefs, and ambitions. It angers, it reassures, it intimidates, it tramples egos, and it puffs them up. For some, peer review demonstrates the vacuousness and unreliability of social science; for others, the substance and reliability of social science." (Starbuck 2003) Some peer-reviewers even boycott publications because they or their co-workers want to publish comparable studies. Whatever of it, the peer-review process only tells us whether manuscripts can be published or not. They don't say much about the societal of academic worth, as many papers on absurd scientific topics show. "Leaning to the Left Makes the Eiffel Tower Seem Smaller" (Eerland, 2011), "The effect of acute increase in urge to void on cognitive function in healthy adults"

(Lewis, 2011), “Walking with coffee: Why does it spill?” (Krechetnikov, 2012), “Shape of a Ponytail and the Statistical Physics of Hair Fiber Bundles” (Goldstein, 2012), “Chocolate Consumption, Cognitive Function, and Nobel Laureates” (Messerli, 2013). Absurd science does pay off: the impactfactors of the journals in which the above titles appeared range from 2.3 to 51.7 for the New England Journal of Medicine (ranked first). These are impact factors the majority of authors can only dream of. Come up with something stupid, perform research methodologically unchallengeable and submit the results blindly following the guidelines of the editor – there is a big chance it will be published in an ISI-journal.

Rehumanisation of the academic world

“We’re all in for the money,” so the governments on all levels hold. On the work floor, people think differently. PhD-students hang unambiguous cartoons on their doors, reputable professors oppose openly in the media to the economic hegemony worshipped by their rectors. It is my content that the universities should undergo a process of rehumanisation, instead of being economically driven. (Xianming, 2006) How can we get there?

In Flanders (Belgium), following the Norwegian example, an alternative ranking for research output is already available (Vlaams Academisch Bibliografisch Bestand – Flemish Academic Bibliographical File). It lessens the pressure on the humanities. The Thompson/Reuters ISI-monopoly is broken by the acceptance of local publications and a valuation of monographs. Books, indeed, are weighed four times as much as ISI-papers, given that they hold a GPRC-label (Guaranteed Peer Reviewed Content). To get the label, a book needs to be publicly accessible (in a forum-language), unambiguous identifiable, contributing to the development of science; reviewed in a peer-review process by scientists who are experts in the relevant disciplines. It is a first step to make the academic world more human.

Something is rotten in the Garden of Akademos, but humanism will direct it. (Cornelis, 2013) The situation is largely due to the short-sighted interventions of the gardeners who are standing outside the fence. Our government and the institutional managers truncate the crops with disrespect. The universities should invest in people management, humane regulations, prize work qualitatively well performed, lower student intake, especially less doctoral students, sabbaticals for everyone (one of my universities only grants three sabbaticals per year for 700 professors), psycho-medical assistance in case of burnout ... in short, the university has to achieve a decent, people-friendly work environment.

Science ethics should be taught, students should get clear provisions on assignments and there must be indeed a zero tolerance for plagiarism and data-fraud during training. For the allocation of funds less emphasis should be laid upon the quantitative aspects of the output, giving a secondary role on impact- and h-factors. All peer-reviewed publications should be honoured, but above all, there should be more emphasis on the qualitative aspects of the research output. Editors should welcome negative and zero-results, stimulate slow science, and demand correctly performed double-blind review, discourage co-authorship. Researchers should renounce competition, go for honest and open scientific communication and perform humane interaction. All of us should show respect for authorship (especially younger people), recognize the limitations of the human condition, and have a humanistic worldview. If so, there would not be such a stench in the Garden of Akademos.

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Teaching Biology by Storytelling

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Introduction

Stories are a really important aspect of humans, as it is through stories that humans communicate with each other, exchange images, experiences, conceive the world and construct an opinion about it (Bruner 2003). Perhaps it is storytelling - the ability of referring to the past and the future that takes place while telling a true or a fake story - that distinguishes humans from the animal kingdom (Mayr 2001). Storytelling has been used as a teaching method ever since the beginning of humanity. It can be considered as an ancient, diachronic, educational method. All oral traditions consist of stories and they use stories as a vehicle to transfer knowledge from generation to generation (Egan 1989).

Stories provide a structure in which new experience and knowledge can be organized. Every story falls in to three acts. Act one is the set-up, act two is the confrontation and act three is the resolution. This narrative form itself reinforces the coherence and the long-term memory (Bruner 1985, 2003; Klassen 2006). If knowledge can be encoded and incorporated in the structure of a story, then it is easier to be remembered than with any other way (Egan 1989)

Another reason why stories are such an effective memory technique is because they provoke emotions which have a strong part in memory and learning. Nothing of what we learn gets stored statically in our minds. Our memories, including our knowledge, are bonded with our feelings, and stories incorporate their contents to live events and images that carry strong emotions. When information is associated with feelings it passes more easily to the long-term memory (Egan 1989).

Stories are, also, an effective and a useful educational instrument because they provoke, they activate and they cultivate imagination. «Imagination is essential for effective thought, interpretation and innovation, for symbolic function, abstract thought and the comprehension of abstract scientific concepts, and responsible for all human creations» (Vygotsky 1987,37, as mentioned by Kokkotas *et al*. 2010). Moreover stories provoke, activate and cultivate the formation of mental images (Hadzigeorgiou *et al.* 2011). During storytelling each listener forms his own personal mental images, and through those he connects knew information to the already existing information.

Storytelling refers to the physical action of telling a story, which conveys the concept of oral communication as well. Oral communication is a group process that results in the transmission of information from one brain to another. Using functional Magnetic Resonance Imaging (fMRI) it has been found that while hearing a story or while watching a movie, different people present the same brain function (Wilson, Molnar-Szakacs & Iacoboni 2008). Moreover it has been shown that during

successful communication the brains of the speaker and his listeners present common, temporarily identical response patterns (Stephens *et al.* 2010).
Within a literature research we also came up with the idea that when storytelling is used in class, it reinforces class cohesion, as it helps all pupils of the class to become a bonded community (Wills 1992). That may be due to the fact that it is easier to understand each other through examples that storytelling usually provides (Abrahamson 1998). Moreover while a story is being told there is a feeling of "common creation" in the classroom as there is interaction between the storyteller and the listeners (Peck 1989). During the process of storytelling both the students and the teachers are satisfied and inspired. When information is mixed with inspiration, encouragement, satisfaction and enchantment, meaningful learning can take place (Tigner 1993). After all it is only inspiration that may lead to action, which can be interpreted as further studying, thought, or the development of a special interest about a subject (Kokotas *et al.* 2010).
Storytelling is considered to be a constructivist educational instrument, as when hearing a story each person criticizes the elements of the story according to his own experience and image of the world and decides whether to incorporate the new information to his construction of the world or not. A story simply gives a direction about how the world functions according to what has been examined until now (Postman 1989). The hearing of a story results in making connections with personal previous experience. Knowledge is incorporated into previous knowledge and gets connected with each student's personal values. That way personal understanding is constructed (St. Clair 2008) and conceptual learning is promoted (Klassen 2006).
Storytelling helps to enforce critical thought, to promote understanding facts and detection of valid and invalid generalizations, and it also helps to focus on concepts and consequences in a moral and distant way (Wills 1992).
During storytelling students become involved in several ways. Firstly they are emotionally involved and they participate as they connect to the subject and they get activated, motivated, and inspired. A listener of a story is not a passive receiver. The processes of thought that take place when listening to a scientific story are complicated and they result in meaningful learning. In the beginning as the story folds out, facts are collected, and predictions are formed and as the details of the story get revealed the hypothesis gets examined. (Kokkotas *et al.* 2010)
It has been proposed that listening to a coherent story, may be the best way for one to learn, remember and be able to reproduce scientific ideas. When storytelling is used to teach science many educational objectives are achieved as it can contribute to humanize science teaching, to improve class atmosphere and to develop positive attitudes towards science (Kokkotas *et al.* 2010).
For all the above mentioned reasons we believe storytelling could be a useful educational instrument in biology teaching. A story derived from the History of Science, such as the story about the way that James Watson and Francis Crick discovered the structure of the double helix of the DNA could be a proper one. The use of History of Science in Science Teaching, serves multiple educational goals such as the understanding of Nature of Science and the humanization of Science and scientists, allowing students to connect with them and become motivated and inspired.

When the information to be learned is embedded into a story coming from the History of Science we consider it as essential that the story should be followed by a task that would make students consolidate what they have learnt. Since the story of the Double Helix ends with a big discovery which is validated with the publication of a research paper, the use of the original research paper in the class would be a way to introduce History of Science (Klopfer, 1969). When research papers are used to teach Science, there are opportunities to examine how a scientific theory evolved, and to consider the ideas that led to a discovery. There is also the opportunity to discuss about the variety of research techniques and to see the impact of common ideas and prejudices on scientific ideas (Klopfer, 1969). All these enhance the understanding of the Nature of Science and promote exploratory learning, which is learning about research. In order to use a research paper in class the text should be adapted to students' age and knowledge. Moreover it has been proven that reading is not enough; the paper should come with a set of questions (Falk *et al.* 2008). Considering the above, our research question was if knowledge about DNA structure could be effectively introduced by telling the story about how DNA structure was discovered followed by an activity based on original scientific literature. The research hypotheses were that this teaching intervention a) will be effective in promoting learning about the DNA structure, b) will help students' understanding of the Nature of Science.

Materials- Sample

Our research is a case study of a group of ten postgraduate students who were attending a master's degree in science teaching in the National and Kapodistrian University of Athens. Eight of them were physicists, and two of them were schoolteachers. Their knowledge about biology was elementary since none of them had attended a biology course after high school. This specific group was chosen because all of the students were at about the same level of biological knowledge, all of them were trained to become teachers in primary or secondary education and they were easily accessible by the authors.

For the teaching intervention and its evaluation we used: pictures, evaluation sheets, the original research paper of Watson & Crick (1953) which we translated into Greek and the story. For the "creation" of the story we took under consideration that it had to be amusing, conveying a message and facilitating the teaching and learning of Science and making scientific ideas understandable. Finally, since it is a story coming from the History of Science, it had to be historically accurate and be made in a way that would consider the thinking, morals and beliefs of the time it was referring to (Klassen, 2009).

The story that we used for the purpose of this research was based on James Watson's book "The double helix" and on Francis Crick's book "What Mad Pursuit: A Personal View of Scientific Discovery". In both books the writers describe their discovery of DNA from their personal point of view. Using the information coming from those sources and using storytelling techniques - Narrative Pyramid (Maratou 2011; Ellery & Rosenboom, 2011), Haiku and the rules of oral speech (Ong, 1997) - we created our story.

Method

At first we administered a questionnaire containing closed questions about DNA structure. Next, in order to motivate students we projected a few slides which pictured nucleotides and DNA molecules, the instructor asked a few questions and led a conversation to help students recall relevant knowledge and make connections of that knowledge to what was known back in the ’50s.
New knowledge was introduced by the story. During the storytelling, slides with pictures of the story’s heroes and places were shown, in order to make the story more appealing. The storytelling lasted forty minutes and was followed by the reading of the Watson and Crick’s scientific research paper. Then students were asked to answer two open-ended questions (“What is the DNA structure?” and “Comment on the phrase included in the paper: *It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanism for the genetic material*”) based on the story they heard and the research paper they read. It took students ten minutes to fulfill this task. It was followed by a conversation which lasted thirty minutes and we discussed students’ answers to the two open-ended questions as well as several aspects of the story that had impressed the students. This discussion was recorded and transcribed for further analysis. Last, we handed out another questionnaire consisting of three open ended questions aiming to evaluate students’ understanding of DNA structure, the structure’s importance, and Nature of Science. After three weeks we distributed again the same questionnaire that was given to the students prior to the process in order to make comparisons.
The whole design and analysis of the research followed the principles of qualitative research whereas descriptive statistics were used for the analysis of students’ answers to the questionnaires.

Results & Discussion

Analyzing students’ answers to the pre-post questionnaires, to the open-ended questions and the discussion that took place after the reading of the paper we found that after the intervention:
a. all students described the DNA structure in an acceptable way and more interesting is that 60% of the students mentioned that the phosphodiester bonds are at the outer part of DNA and the nitrogenous bases at the inside. The latter was presented with a high emotional load in the story contributing to students’ understanding (Egan, 1989).
b. all students (100%) mentioned replication referring to the significance of the DNA structure - “*the model will act like a matrix for the creation of the second one*” - and 40% also referred to the transferring of information from one generation to another, whereas before the teaching intervention only 40% of the students answered correctly to that question. This knowledge persisted to 70% of the students 3 weeks after the intervention.
We consider the activity of listening to the story and then reading the article as important for the connection of DNA structure to the replication mechanism and our research hypothesis that this teaching intervention is effective in promoting learning about DNA structure was confirmed.

Students highlighted all that data that had puzzled a lot the heroes of the story (e.g. the place of the nitrogenous bases, which bases make pairs) and they also made comments like "*the story helped me understand the research paper*" and they got into the process of thinking like the scientists about what was known at their time and did not judge the facts presented in the story according to today's data – *"It has two helixes, not three as it has been suggested till today"*.

Science and scientists were humanized - *"even masters make mistakes like all humans" "every night they were drinking at Eagle"* – and students sympathized the heroes - "*the guys didn't steel, all they wanted to do, was a confirmation, people always judge too harsh" "he's being diplomatic*" "*he's reserving the copyrights*". They were also motivated to learn more about the heroes' lives and their scientific accomplishments – *"what did they do afterwards?".*

Furthermore, students made comments about the Nature of Science - *"the story shows that what today is correct, will not necessarily be correct after a few years" "the scientific community is like true society"* – and a discussion about values and ethics of science and scientific research followed – "*one tries to catch up the others and surpass them" "a good collaboration and fruitful discussions may lead to great results" "they got so passionate about it, they just wanted the truth to be revealed".*

Concerning the way that Watson and Crick were led to promote scientific knowledge: before the teaching intervention 80% of the students supported that one cannot produce scientific knowledge unless he/she follows the common scientific method but after the intervention 80% of the students answered that the common scientific method is not the only way. Furthermore, 60% of the students were able to explain or draw conclusions about Watson and Crick's method, and all students made thoughts about aspects of the Nature of Science – *"mistakes can turn out to be very important" "although they did not do an experiment they discovered the structure" "they formed hypotheses, which they changed according to the scientific facts they learned"*. So it seems as storytelling is effective in promoting learning about how knew knowledge can be produced (exploratory learning). And last but not least the students seemed to enjoy the process in the whole.

From students' comments - *"this procedure of knowing the story behind the discovery is very helpful"* – and from the results that revealed that their knowledge was enhanced after the intervention, we can assume that the story, along with the research paper, helped students understand some scientific facts. During the intervention they *did* think like the scientists and judged facts according to the historical era, sympathized with the scientists, got interested in their lives and developed motives for further learning. All these outcomes are consistent with similar studies (Wills 1992; Kokkotas *et al.* 2010). It seems that the method can be effective to introduce aspects of Nature of Science and to achieve cognitive objectives. Our work is still in progress, further study is taking place to find new ways to incorporate storytelling to biology teaching and to validate the contribution of storytelling to biology learning.

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Social Representations of Folk Healers in Mass Media: the Case of Father Gymnasius

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Traditional societies used herbs and empirical healing practices and/ or rituals of magical or religious origin to cope with illness and disease. Folk healers were held in high regard, as the only ones capable of curing bodily and mental ailments and, therefore, to help maintain social stability. Nowadays, in the era of modern medical science, established mainly in western societies, which exhibits a high degree of specialization, what do people think about folk healers and their practices?
In this article we aim to examining social, political and cultural receptions of folk healers studying the case of an illiterate monk, Father Gymnasius, who, supposedly, cured illnesses by using herbs at the end of 19th and the beginning of 20th c. and therefore gained much fame during the 1930s. His remedies were published 36 years after his death (Father Gymnasius, 1975), which can be found in the Internet as well. We initially focus on the representation of social and political implications of his actions, through newspapers of his time. We shall also investigate modern notions concerning folk medicine and its practitioners, through the rejection or acceptance of this specific manual among Internet users.

Social and Cultural Aspects of Greek Folk Medicine

Therapeutic practices in ethnomedicine address themselves to both supernatural and empirical theories of disease causation. Ackerknecht (1942, 503-521) has said that primitive medicine is “magic medicine”; In folk medicine, however, there is more to treatment than magical or religious ritualization, however effective this may be psychosocially in providing emotional catharsis and reassurance (Hughes, 1968). All human groups have a pharmacopoeia and at least rudimentary medical techniques; some groups, in-deed, are exceptional in their exploitation of the environment for medicinal purposes and in the degree of their diagnostic and surgical skills (Ackerknecht, 1942, Sigerist, 1951, Laughlin, 1963).

Folk medical beliefs and practices differ from culture to culture but have in common the process by which they are passed on from person to person and generation to generation by word of mouth and imitation (Graham, 1999).

A recent study (Barlagiannis, 2010) presents an analysis of how medical knowledge was circulated in 19th century Greece and how doctors were organized. Family seems to be the first factor responsible for the transmission of medical counseling from one generation to the other.

Another factor was called *νυχτέρι* (nihteri) [night work], the time and place where women work, entertain themselves, but also initiate the younger ones into the

secrets of health, hygiene and child upbringing (Kyriakides, 1922). These *νυχτέρια* also become of greater importance considering the place of women in medicine.
A third factor concerns groups residing in geographical areas with a high production rate in pharmaceutical herbs. *Βικογιατροί* [Vikogiatri] (doctors from the area of Vicos) was one of those groups: they were practical doctors with a deep knowledge of herbs growing in their area.
At later times we come upon more 'formal' institutions. A *School of Practical Medicine* was founded in Athens by the abbot and empirical doctor Petrakis and another one in Sparta by Panagiotis Giatrakos, also an empirical doctor (Gialas, 1976:11). The Greek Revolution of 1821 presented many opportunities for observation and became a kind of 'school', especially for surgeons[1]. The contribution of many people serving as doctors in the war generated the presuppositions for them to demand a role in the new state later.
The main aspect of folk medicine is its empirical way. In contrast to modern scientific medicine, based on logical deduction and the study of medical texts, folk medicine begins with observation, experience and experimentation. Given that, (taking under consideration the oral character of rural culture), folk medicine appears more 'democratic', as anyone has access to it and can, through his own experiences, contribute to its process (Faure, 1994:23). The term "appears" is used because one shouldn't forget that medical practice is a major source of income and social prestige and that its practitioners usually kept their professional secrets well hidden.
There were also many occupations related to medicine. Apart from the professional doctor, one can find a blacksmith, a midwife, usually a mother herself experienced in childbirth, a trader acting as a pharmacist, even a veterinarian applying his knowledge to the human body. Finally, a barber will be responsible for conducting (every springtime) the bleeding, for protection from oncoming fevers.
In folk medicine the primacy of observation prevents the search for general rules and grouping of the diseases, whereas it exemplifies the specific traits of each one and the special methods to treat it.
Turning our gaze upon folk healers themselves we distinguish two basic traits: First, as far as gender is concerned, there are many, if not more than men, women occupying themselves with folk medicine. This happens for two reasons: women in a community usually 'control' the communication and information network (Ladurie, 1982:384-385), granting them many advantages in practical medical knowledge, in the context of oral culture, and, in a greater anthropological context, women, either in the climacteric age, no more concerned with childbirth or widowed, under no man's rule, hold a primary role in the control of the basic stages of human life; birth (midwives), disease and death (wailers) (Merakles, 2011:64-66).
A second trait is the folk healers' prominent social status. Their medical stature alone offers them a respectable place in society, usually with an equally high income. If medical stature comes with an 'important' family name as well, like the Giatrakoi brothers, we could argue that their actions towards their fellow-townsmen not only

[1] The majority of these (empirical doctors), having almost no knowledge of medicine or surgery, gained, in a matter of speaking, the title of Doctor in the battlefield (Goudas, 1862:9).

lack solidarity for the sick but also exhibit an authoritative attitude. Unfortunately, there are no sociological studies for this kind of doctors in Greece.
If an analogy to other European areas, for example 19th century France (Leonard, 1977:159-164), applies, we see that doctors originate mainly from the classes of clerics (e.g. father Gymnasius), merchants, craftsmen, landowners and cultivators, all of them specialized and often literate. Moreover, their medical art was not only for the poor and humble but for the rich, and prompt at paying, families as well.
Nevertheless, we should not consider the above a group cut off from scientific medicine. Former students in European pharmacies or ones under the tutorship of doctors (e.g. Gymnasius), doctors with a university degree from Italy, unsuccessful doctors from all over Europe, wanderer doctors, like Pouqueville, doctors from various armies passing through the southern territories bring together folk medicine with modern medical theories and practices, sometimes even late and distorted.
According to Barlagiannis (2010:251-264), the year 1833 was the turning point of the transition –which was completed by the banishment of former King Othon– from one medical example to another state-centered one[2].
On the other hand, monks had, we could say, a 'natural' inclination towards folk medicine: they had access to previous, even scientific, knowledge through books, as they usually knew reading and writing; they also could grow herbs and various plants, as they usually lived in rural areas and relied on agriculture for sustenance. These two factors, in contrast to most other people, along with the fact that they lived in secluded areas where proper medical care was often scarce, enabled and forced them to practice this kind of medicine.

Social, political and cultural representations of father Gymnasius' folk medicine in newspapers of his time

Father Gymnasius Lavriotis (his real name was Georgios Tzanetis) was born in Theologos of Thassos in 1858. His father was a miller and a shoemaker; his mother was a practical midwife who knew well of the healing power of herbs. He became a nurse in England and served mostly in Thassos.
He was saved when his plane to Thessaloniki crushed, because of a malfunction, near the skete of Saint Anna in Agio Oros (Holy Mount). He stayed there and was nursed back to healthy by the skete's botanist. In a short time, he was anointed a monk under the name of Gymnasius Lavriotis. In 1930 he initiated his 'official' activity, herb healing. It is estimated that over 1000 people, patients and their escorts, visited him (Michalopoulos, 2010). Their presence caused problems, as it was impossible for Gymnasius to examine them and, more importantly, to personally care for and cure them all. It seems that people from all social classes sought the

[2] The official body of doctors was formed based on the needs of government planning, best served by the social 'gaze' (Foucault, 1963), offered by European clinical medicine; two other factors were the lack of a 'scientist-doctor producing' mechanism and the pressure exercised by folk pursuing to have their contribution to the Greek Revolution of 1821 officially recognized. It was a time of integration, not of prohibition. This prohibition did finally take place at the end of the 1850's, after 1862, when university degrees were given and formerly recognized empirical doctors were of old age; the so-called fight against charlatanism began in the countryside, where the competition was fiercest.

monk's help, a fact that proves the cultural resistance of folk medicine in a large part of Greek people at the beginning of the 20th century[3].

But what were the notions and images of Father Gymnasius' practices in intellectuals, doctors, journalists, superior civil servants and politicians of his time? There are many appreciative testimonies[4], by doctors of Gymnasius' time, about his deep knowledge of the healing power of herbs.

Father Gymnasius was a folk, illiterate person. His first knowledge in botany came from his mother, a practical midwife, who used herbs (mainly in injuries). She had some notes in her possession, from her father, who had copied a manuscript from Mount Athos. It is common knowledge that many monks there practiced the use of herbs for various ailments. We have, therefore, to assume, that Gymnasius must have learned these notes by heart (Michalopoulos, 2010).

Gymnasius could cure only some afflictions, and not of terminal status. He mostly treated skin and stomach illnesses, injuries, tuberculosis, asthma, malaria and dislocations. To cure someone, he had to examine him in person. He did not offer recipes from afar [5].

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[3] A journalist of Κήρυξ (Keryx) [Herald], 15/07/1930, from Kavala wrote, that inside the ship to Thasos "the spectacle was heart-breaking: One could see paralytics on stretches, bound lunatics, constantly shaking neurasthenics, blind and injured people, many little children suffering from many and various disease being brought aboard by boats (…)".

[4] The editor of the newspaper Ταχυδρόμος (Tahydromos) [Postman] of Kavala, 11703.21/10/1980, Ioannis Primikidis, who was well acquainted with Gymnasius wrote, self-possessedly, that "(…) Gymnasius Lavriotis was not a miracle worker, nor a fraud, nor a charlatan, nor a healer. He was a kind man, who studied botany at a great length and with his practical intelligence he mastered it and practiced it with proficiency worthy of a philosopher-doctor" (Primikidis, 1980). Tahydromos began continuously publishing Primikidis' article on the front page from issue n. 11703.21/10/1980 to n. 11731.25/11/1980.)

Pavlos Nirvanas (Apostolidis), member of the Academy of Athens, a doctor and an intellectual, spoke with Gymnasius in Athens and gave a journalist of the newspaper Πατρίς (Patris) [Homeland], 10/10/1930, the following response: "From what I have heard until now, his recipes are very practical and what was done to him was unfair. Why should he be prosecuted, since he has done so many healings? Gymnasius is a wondrous healer and the diseased can benefit a lot from his expertise".

The monk-doctor of the Holy Monastery of Vatopedio, Oikonomou, who was healed by Gymnasius, wrote: "Gymnasius is a well experienced and able botanist. I have many proofs of that. He has a deep knowledge of the healing properties of herbs and of human anatomy as well. He is neither a fraud nor a charlatan, but a very homely person" {Ταχυδρόμος (Tahydromos) [Postman] of Kavala, 11708.26/10/1980}.

[5] "If I don't see the sick person", he told V. Mesologgiti, "I can offer neither advice nor medicine" {Μακεδονικά Νέα (Makedonika Nea) [News of Macedonia], 28/7/1930}. In folk medicine, close observation and examination is of primary essence and deters from the search for general rules and from the grouping of diseases; on the contrary, it emphasizes on the special traits of each one and the specific ways to deal with it, as mentioned above.

That Gymnasius gave his recipes only in person can be proved in a fact recounted to Michalopoulos (2010) by the lawyer Alekos Sotiriadis: When over 1000 patients gathered in Theologos of Thasos, their stay generated health hazards for the locals. There were political implications as well. Along with a representative of Kavala in the Greek Parliament , they

It seems that newspapers of that time, in order to increase their circulation, published their own recipes stating they were of Gymnasius[6]. There was even a response from Gymnasius himself, when he was informed that several people compile their own recipes and sell them as they were his.
Nevertheless, his fame was growing rapidly and many were the patients eagerly waiting to be cured by the monk. In July of 1930 many people gathered around the little chapel of Panagouda in the village of Theologos and set camp. There was great danger for diseases and infections[7].
The Prefect of Kavala, after being informed[8], ordered the arrest of Gymnasius. He was taken to Kavala, Thessaloniki and was in time released to return to Thasos. He

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went to Theologos and asked the crowd to form groups according to their diseases, to receive their recipes from Gymnasius and depart. Naturally, the patients argued. They wanted a personal examination and recipe from Gymnasius.

[6] A pamphlet was published in Kavala with 60 of Gymnasius' recipes, sold for 5 drachmas. Φωνή (Phoni) [Voice] of Kavala stated: "For several days a pamphlet has been sold by the thousands with recipes supposedly of the miracle-worker monk of Thasos, Gymnasius Lavriotis. We have been contacted by Gymnasius himself and asked to state, on his behalf, that he never presented anyone with a recipes catalogue, as, according to him, he needs to examine someone personally in order to give him a cure. (…) We therefore warn our audience against these pamphlets, which are nothing more than a fraud (…)" {Μακεδονικά Νέα (Makedonika Nea) [News of Macedonia], 31/7/1930}.

[7] The surrogate lawyer of Gymnasius and the community sent an epistle to a local newspaper to inform all people eager to meet with Gymnasius not to visit him, as he would receive no one.

A letter in Κήρυξ (Keryx) [Herald], 15/07/1930, by the lawyer Alekos Sotiriadis wrote: "As surrogate lawyer of the community of Theologos of Thasos, I state that the Community Council of Theologos of Thasos converged abruptly on 20/7/1930 and, by its verdict n. 541, unanimously decided: 1) To ask all of the patients to cease seeking any examination or treatment by the monk Gymnasius Lavriotis and 2) to especially advise any patients not of the community to depart, as the monk will not supply any help. As surrogate lawyer of the aforementioned monk Gymnasius, I also state that he refrains from offering any medical services and that tomorrow he will depart for Mount Athos (…)".

[8] Furthermore, around 200 people, devout supporters of Gymnasius, travelled by sailboat to Kavala and, along with other locals, protested strongly about Gymnasius' arrest. Gymnasius was taken to the state attorney and, after trial, was set free, with the verdict saying that "since he does not accept money, he is no law breaker" and returned to Theologos. Patients kept flocking around him, causing sanitary problems. They discovered him even in the farm of Tsakalos, in Palio Tsifliki of Kavala. The authorities tried to stop them, but it was impossible. Medical Officer Chrysanthakis reported to the Port Authority that no boat should sail for Palio, as there were reports of typhus there. On August 2 1930, the Medical Officer along with the Director of the Prefecture and the Commander of the Security Police went to Palio tsifliki and asked Gymnasius to depart for Mount Athos. The case also came to the attention of Kakoulides, General Commander of Thrace, who decided to find a solution by ordering the deportation of Gymnasius to Mount Athos, as there was a corresponding decree forbidding monks from Mount Athos to wander outside the Mount for more than twenty days. There, Gymnasius was badly treated by the monks, probably because of internal competition and rivalry, as his fame had grown and many patients travelled there, eagerly seeking to meet with him. In the end, even the Holy Supervision had to order his

then made his decision: to publish his recipes and examine no more patients (Father Gymnasius, 1975:12). He died at the age of 77 in 1938.

The Handbook *Father Gymnasius. 369 Recipes of the Monk. Herb Healing*

The Handbook *Father Gymnasius. 369 Recipes of the Monk. Herb Healing* was edited by journalist G. I. Koukas and published by Leon Publications in 1975. In the Prologue it is stated that the recipes are published "exactly as Gymnasius Lavriotis told them. They were given to us written in an old account by the nun of the monastery of Chios, Kaponeri, whom we met in Leros. The same person also gave us her own recipes and those of monk Pachomios as well. In this volume one can find the recipes of Gymnasius Lavriotis and the monk Pachomios Tsakonas" (Father Gymnasius, 1975:16).

This book falls in the category of folk healing manuscripts. Professor of Medicine and folklorist Gerasimos Rigatos (2004) argues that in the centuries following the fall of Byzantium, places which are a part of Greece now but were under Ottoman rule at that time could not keep up with the intellectual, scientific or technical progress brought to the West by the Renaissance. The texts of ancient doctors were replaced by knowledge and information cut off from the initial corpus and were complemented, altered to a great extent, by spells, prayers, agricultural notes and astrological speculations (Rigatos, 1998). The result was various concoctions, in whose texts an observant researcher can find the roots of Hippoccrates' medicine, even recipes of Galinos, notes of Dioskouridis, of Aetios, of Oreivasios, of Pavlos Aiginitis and other known doctors of old, argues S. Chaviara-Karachaliou (1993). Perhaps the 'purest' part of those manuscripts was the one referring to healing plants.

In the *Handbook*, the symptoms of many diseases are presented first and various treatments are suggested, including the boiling of herbs and the addition of animal parts (shells, carapaces, noses etc.) or the usage of chemicals (petrol). All recipes result in decoctions, salves or pills. The recipes are presented according to the alphabetical order of the diseases, which vary from usual maladies (headache, anorexia, weakness, constipation, catamenia, burns, wounds, hemorrhoids, alopecia) and symptoms (fever, cough, exanthema, emesis, hemorrhage) to serious diseases (malaria, ulcer, enterocolitis, diabetes, cataractis, hand and foot paralysis, appendix), but also include advices of preventive medicine, body vivification or against obesity.

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removal, on August 29 1930, with the following discharge: "N. 470. The bearer of this document monk Gymnasius, not residing among our brotherhood, departs from our holy monastery. He is thereby given this letter of discharge to use it where he deems appropriate. In Great Lavra, August 28 1930. The Wardens of Holy and Reverend Monastery of Great Lavra. Epiphanios the Old, Christophoros the Old and our brothers in Christ". He was deported to Piraeus and hospitalized in Dromokaetio Mental Hospital, where he was found sane and, with the interference of the Archdiocese of Athens, was sent to the Holy Monastery of Osios Meletios, on Kithaironas mountain, where people started gathering as before. {Ταχυδρόμος (Tahydromos) [Postman] of Kavala, 11707.25/10/1980}

Besides the aforementioned recipes, one can find 'magical' ways to cure diseases[9]. Usually, commercial interests are implicated in the spread of notes of occult and magic. For the past years there is an increase in bookstores and publishers promoting not only relevant bibliography, but also related equipment and tools for the conducting of magical and occult practices, even special seminars for their setting (Mpenekos, 2006:157-158).
Folk medicine stands in the middle, between proper logical observation and magic (Megas, 1942:163-195)[10]. Folklorists and ethnologists divide homeopathic magic in two categories: the first is curing by the same or analogue, "verbally or pragmatically" (Merakles, 2011:115).
The other category is based on the principle "ο τρώσας και ιάσεται [the one who caused the wound will also heal it]". For a scorpion's bite one could apply a salve made of a scorpion burned and trimmed. But in both of these categories the basic principle of similarity applies, of the analogue, that takes us back to the ancient belief of a 'universal sympathy'.
Professor of Folklore Studies M. G. Merakles (2011:116) notes that there is something fascinating in the primeval healer's irrationality: performance. That is, the passion we put into our effort to make something impossible happen, since this external simulation is the only thing we can do. Under this light, man's theatrical moves came before his demystificated, secularized, scientific advances.
The editor also notes, to validate the recipes, that as the monk Gymnasius in Greece, doctor-botanist Droz in Switcherland also published pamphlets with simple advices for herbs and diseases. He bestowed almost magical abilities to the 850 herbs of his country, just like Gymnasius. "Nature is a great doctor", they both said. This richness

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[9] Epileptics, for example, are also called "moonstruck, because they supposedly suffer near the end of the moon's phase, and seldom at other times. Those under the age of 25 are easier to cure than older ones, as the disease is of demonic origin[9], we could say. And so it is believed all over the world. The symptoms of this disease are known. A strict diet is required, without any meat consumption. The patient must only fast on lenten food, milky products and a few fish. (…) Another way is to slay a chicken, cut it in two and, after quickly removing the bowels, to place it on the head, as a hat, and keep it there until it is cold. We do the same thing three times. (This recipe is better suited for children heavily or lightly moonstruck, but can also be of use to adults)" (Father Gymnanius, 1975:33-34).
For a headache caused by the "evil eye" (Veikou, 2004) the monk suggests a form of exorcism: "In the censer, along with the incense, we also pour dust from a deer's horn and cense the patient" (Father Gymnanius, 1975:27).
For dyspnea, along with other methods with herbs, the handbook suggests: "We take a bat, cut off its head and drink the blood flowing from the neck" (Father Gymnanius, 1975:29).
For the sty, the monk suggests to "take a barley seed and make with it the sign of the cross on the sty" [which, in Greek, is called "κριθαράκι" (barley of the eye)] (Father Gymnanius, 1975:40). For the lupus (skin disease) (Father Gymnanius, 1975:42), "we overburn in the oven a dog's head. We take 50 drams of incense, 50 drams of wax and 50 drams of aloe, mix them with a spoon of dust from the dog's head, make a salve and apply it on the wound".
[10] A collection of herbal lore was published by Elpiniki Stamouli-Saranti (1938, 1937). For beliefs and uses of blood see the paper of special hematologist Mike Paidousis (1974) "Blood in superstitions and folk medicine. More data and bibliography concerning folk medicine, meteorology and other relevant topics can be found in Dimitrios Loukatos (1977).

of the Greek countryside in herbs we present in the following table. In the beginning there are the herbs described by Gymnasius and various others, used by him. Next there are the herbs of Pachomios and afterwards over 100 other Greek herbs" (Father Gymnasius, 1975:81).
In the handbook's epilogue it is stated that 117 years have passed since his birth. And people still do talk about Gymnasius. A few months ago a song was composed for him by Giannis Markopoulos, with lyrics by K. Virvos. Old pamphlets containing his initial 100 recipes were sold everywhere. "Many people took advantage of me", he used to say, "I never hurt anyone". He had come to know of 20000 herbs and their healing properties of each one. He knew to apply with precision the recipes of the great doctor Hippocrates, without having read anything about him. He was Nature talking" (Father Gymnanius, 1975:109).

The reception of Gymnasius' folk medicine on the Internet

Our time is one of unparalleled but also uncontrollable speed of communication. Technological advances and globalization have rendered the cultural products of small or large groups accessible but at the same time 'vulnerable' to the influence of external factors. Speaking of folk culture we mean more than just a historical object, destined only for a museum, but a contemporary creation within a living tradition. Folk culture does exhibit historical aspects, but these aspects tend to repeat themselves, to adjust, to evolve. And this adaptability is what keeps folk culture 'alive'.
According to Krawczyk-Wasilewska (2006:248), "ongoing globalization has, however, increased enormously in the last decade or so, thanks to the popularity of the Internet as a global information system. Modern electronic technology has created a new style of communication between people far and near. They use mobile phones and the internet not only for information purposes, but also for entertainment and online contacts as well as exchanges of personal views and opinions. This type of immediate social reaction to new phenomena and problems tends to create a special kind of written, oral and visual folklore of a global character, which could be termed 'e-folklore'". Under this category many 'traditional' aspects of folk culture could fall: advertisements of various products (material or not), astrology, match-making, memorial (web)sites, alternative healing methods etc.
On 9/3/2012, Gymnasius' handbook had 22133 visitors on the web and still remains a topic for discussion. In a blog (http://kopanakinews.wordpress.com/ 2012/04/17) mostly visited by people residing or having an interest in the villages of Aetos Municipality and the whole area of mountainous Trifyllia, in Peloponnese, Greece, a satirical political article was posted on April 2012 under the title of "[Antonis Samaras and Father… Gymnasius]". Its subtitle was "[Easter Liturgy: Mr Samaras and Getafix's Magical Potion. Extra: Mr Samaras will heal Economy with herbs]". The article is accompanied by a picture showing the President on the New Democracy (now Prime Minister of Greece) with his wife and some monks stirring something in a cauldron at the Patriarchate of Chrisovalanto and a highly caustic comment and, below, a sketch with the famous druid Getafix (Panoramix in the Greek format of Asterix magazine, by Goscinny and Underzo) preparing the magical potion for the Gauls.

Figure 1: *The Great Arch Perfumer of the Secret Allocations*

Figure 2

The article goes on with Gymnasius' history, starting with a caustic, allusive remark: "Holy Providence often selects light-minded people to bear Her gifts". It continues with Gymnasius' healings and, concluding, blames doctors of his era who, for religious reasons, advertised him as a proven healer, increasing his popularity and leading to his arrest and abuse by the monks of the Esfigmenos Monastery. At the end it states that "He is described as guileless, kindhearted and far from avaricious, but the well-known lyrics of Kostas Virvos claim otherwise:

"Father Gymnasius
a worthy monk
sold herbs
for every disease
but could also recite
every spell.

'Take your concoctions from me
blessed and cheap
a chicken for each
or fresh today's eggs

but I fast
so I want them Lenten'.

"Father Gymnasius
a worthy monk
also gave medicines
to barren women
but they cost
two yellow pounds".

Virvos' lyrics were melodized by composer G. Markopoulos and the song was recorded in the album "Θεσσαλικός κύκλος [Thessalian cycle]" (1974). It can be found on *YouTube* with 478 "Views" (26/7/2012), 7 "Likes" and 0 "Dislikes".[11]
The lyricist satirizes the monk's supposed venality. We cannot be certain, as presented in Press of that time, whether he accepted money for his services or not. It is possible that some of his followers mediated between him and his numerous patients and received, on his behalf, money and offerings. The song's lyrics depict broader social beliefs concerning folk healers of the clergy. It is worth mentioning, that burlesque of the clergy was not something unusual: folk people always displayed the tendency to satirize and ridicule these so called 'servants of God and people', who for many different reasons were often charged with proverbial aberrances**.** Therefore, the venality of clergymen (usually of high rank) is a motif present in many folk narrative genres, mainly in facetious narrations and proverbs. Traditional agricultural classes have been regarded by social and humanistic sciences as most conservative, in both metaphorical and literal sense; they are the ones that preserve traditionally given cultural schemes. However, behind this phenomenal accession of traditional agricultural classes lies a resistance, even latent, many times ridiculing the representatives of hegemonic discourse (Kakampoura, 2005:121-125). In relevant folk narratives recorded in *The Types of the Folktale* (Aarne & Thompson, 1961), a surprisingly great majority of facetious narrations satirizes clerics and

[11] An indicative comment is given below:
1. Ιδιαίτερο!
Και ως προς τη μουσική και ως προς τους στίχους και -κυρίως- ως προς την ερμηνεία του από τον ίδιο τον συνθέτη…
Γραφικότατος ακόμη και ο τίτλος "Ο πάΤΕΡ Γυμνάσιος"…
[Very special!
Its music, its lyrics and, mostly, its performance from the composer himself… Even its title "Father Gymnasius" is graphic enough…]
Comment από [*by*] *Γιόλα Αργυροπούλου - Παπαδοπούλου | 14/12/2011 | Απάντηση* [Response]
2. Δηκτικότατο το δίδυμο Βίρβου-Μαρκόπουλου.
[The duet Virvos-Marcopoulos is very mordacious]
Comment από Βίκυ Παπαπροδρόμου | 14/12/2011 | Απάντηση
3. Βεβαιότατα!
[Of course!]
Comment από Γιόλα Αργυροπούλου - Παπαδοπούλου | 14/12/2011 | Απάντηση

priesthood in general. There is also a differentiation of folk critique according the transgressor cleric's rank: high ranking clergymen are often depicted as erotomaniac, avaricious and repulsive, whereas simple and folkish priests appear more amiable, with their ignorance. Monks are treated even more sarcastically, perhaps because of the contradistinction between the uncertainty of livelihood and the secure, in many ways, monastic life (Merakles, 1980:53-55; Varvounis, 2006:116-117).

It seems, however, that Gymnasius' handbook is indicated as a valid source for the healing properties of herbs in modern articles about related issues or it is mentioned in the bibliography of environmental projects[12].

Gymnasius' handbook has also been used both as a source and in the bibliography of the Program of Environmental Education "Aromatic plants and herbs of our region" that took place in the Third Grade of the Public Primary School of Paranestio (2005-2006) (http://kpe-kastor.kas.sch.gr/biod_net/schools2/dim-paranesti-programme.html).

On the other hand, the monk's 'magical' recipes constitute a topic for satire and mock in social networks, by modern rationalists.

Concluding Remarks

Folk healers were also called "παθοί [victims]", since they usually began having personally experienced the diseases they tried to cure, but also "doctors of the oke" or "doctors of the heap". Merakles (1999:146), commenting on the second, degrading characterization, notes, that these names represent a dramatic, self-criticizing acknowledgement of traditional society admitting to the limits practitioners of medicine had (including deceptions), to whom, however, members of the community turned to in times of need, as the only option they had. The same folklorist, noting common folk's pragmatism deriving from experience, argues that people in traditional, pre-neoteric societies were never deep down metaphysical. Their struggle was always about real survival. All of his non-scientific approaches are nothing more than failed attempts to reach science (Merakles, 1999:140).

Gymnasius was an illiterate folk healer who knew well of herbs' healing properties. The fact that he was a monk raised him even higher in folk acceptance and social prestige, whereas many educated people of his time acknowledged his abilities. During the decade of 1930, when he mostly acted as a folk healer, Greek countryside was still in a traditional, pre-modern state; magic was still predominant in folk mentality and explanation of physical phenomena, which, in the case of folk

[12] In a more recent blog there is an advertisement for another book, supposedly of the same author, Gymnasius Lavriotis, titled *452 θεραπευτικά βότανα. Ο καλόγερος και οι συνταγές του: Εκατοντάδες θεραπευτικά βότανα* [*452 Healing Herbs. The Monk and his Recipes. Hundreds of Healing Herbs*], published in 1999 by Damianos Publications and has 1046 "Views" (http://books.vres.gr/ book.php?book_id=72106).

For example, in an article in a local blog from Mytilini, a journalist writing about the healing properties of olives and oil refers to ancient writers (Plinius, Herodikos, Silimvrianos, Hippocrates, Plutarch, Demokritos) and monks (Agapios Monachos the Cretan), and to a recipe of the monk Gymnasius: "The monk from Mount Athos father Gymnasius suggests a hot bath and embrocation with a mixture from shaken olive-oil, yolk and ouzo for the bodily comfort of fatigue" (http://www.iama.gr/ethno/mytilini/labraki.html).

medicine, was amplified by insufficient infrastructure in infirmaries, clinics and scientific personnel.
Furthermore, as stated by Marcel Mauss & Henri Hubert (1903), some complex practices, of uncertain outcome and unsafe methods, such as medicine and surgery, would never have made it that far if not supported by magic and if, for their own preservation, magic had not absorbed them.
In the age of postmodernity and the Internet, people of Western societies regard folk healers sometimes with respect (because of their deep practical knowledge of herbs), sometimes mocking their naïve views of folk magical thought and sometimes utilizing the notions of clerics' and folk healers' greed for satirizing modern political and social events and practices.

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Book Review: Lewis Wolpert, *The Unnatural Nature of Science - Thales's Leap: West and East*, Harvard University Press, 1992

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Lewis Wolpert's Book *The Unnatural Nature of Science* contains nine chapters in which he presents how "unnatural" nature of science is.

In the first chapter the author gives some evidence that science involves a special mode of thought which is usually counter-intuitive. The word "unnatural" is intentionally used in order to highlight the fact that the world is not constructed in a common-sense basis. For example the fact that the earth goes round the sun doesn't fit with our everyday experience. In other words, doing science requires a conscious awareness of the pitfalls of "natural" thinking.

The second chapter is devoted in distinguishing technology and science. There are historical reasons for this differentiation but not only such. Agriculture and metalworking exist much before the motions of the bodies were explained by Newton's Laws of Mechanics. Not only technology is very much older than science but it has other purpose than that of science. Science produces ideas whereas technology results in the production of usable objects: for technology success is measured in terms of wants and needs, while in science success depends on explanations correspondent with reality. In our days, much of modern technology is based on modern science, but science started to have an impact on technology not until the nineteenth century.

And after this distinction is well established, in the third chapter, *Thales's Leap: West and East,* Wolpert claims that the peculiar nature of science is related with the fact that science has arisen only once: in Ancient Greece. We are going to present this specific chapter in detail.

In the fourth chapter the author provides a comparison between scientific creativity and creativity in terms of the art. Wolpert supports the idea that, although science and art are both products of the human imagination, they happen in very different sense. Creativity in the arts is intensely personal and reflects the feelings and the ideas of the artist. By contrast, scientific creativity is always constrained by self-consistency, by trying hard to understand nature and by challenging well-established beliefs.

In the fifth chapter science is viewed as a social activity encompassing competition, cooperation and commitments. New ideas are established after they are accepted by the scientific community. Scientists must be ready to insist on their views due to the common reluctance to surrender existing views. Despite its social character, science is usually an anonymous enterprise: as ideas become incorporated into the body of knowledge, the creators of these ideas simply disappear. For example nobody studies Watson and Crick's original paper to know about DNA. Wolpert concludes that science, through its individuality and sociality, approaches closer and closer the truth, but perhaps never attains certainty.

In the next chapter, the author underlines the fact that science is described in different ways by philosophers, sociologists of science and scientists. It is true that defining nature of science with consistency turns out to be extremely difficult. Although scientists themselves have helped to create the illusion that science is highly subject to a specific method, the existence of scientific method is doubtful. Apart from method, scientific process includes imagination, confusion, determination, passion, agreements and disagreements. Additionally, some philosophers and sociologists of science doubt whether science is a special and "privileged" form of knowledge. "Privileged" in that it provides the most reliable means of understanding of how the world works. Fortunately for science, it is finally judged by how adequately it explains the world.

If scientific knowledge is so special, in the sense that it provides our best understanding of the world, how can we distinguish between science and non-science? This topic is discussed in the seventh chapter. The distinction has to do with subjects such as astrology and paranormal events, and also with issues of the compatibility of science with religious beliefs. While religious belief is incompatible with science, many scientists are deeply religious. A possible explanation could be the difference between natural and unnatural thinking.

In the next chapter, it is claimed that the social obligations of science are closely linked to technology and politics. It is claimed that scientists and policy makers are responsible for handling scientific products such as nuclear weapons and genetic engineering. Wolpert concludes that it is scientists' obligation to inform the public for ethical problems such as clinical trials, ecology and research on human embryo, so as to share the responsibilities as fairly as possible.

The last chapter deals with the public understanding of science. Wolpert concludes that although science provides the best way of understanding the world, there are a lot of people who misunderstand its content and purpose. It is assumed that if the public have an improved understanding of science, they will have a more positive attitude towards it. Attempts at "popularization" perhaps failed to emphasize two key features of science: the limits of science, in the sense that science cannot solve all problems, and of course the unnatural nature of science.

The specific chapter we emphasize is the one called *Thales's Leap: West and East*. In this chapter Wolpert relates the peculiar nature of science to the origin of science. The author claims that some of the characteristics that constitute the so-called unnatural nature of science account for the origin of science. Specific features of science made it arise only once in the history of humanity: In Ancient Greece. The intention is not to account for science's single origin but to emphasize how rare scientific thought occured in human cultural history and to use its origin to illuminate some of the special characteristics of scientific inquiry.

Thales of Miletos developed his ideas in Miletos. His contribution to the scientific mode of thought was probably influenced by the intellectual tradition of Miletos, which has provided a rich and varied environment. It was the main harbor and the richest market of Ionia. Ionians were colonists, and may be assumed to have the intellectual vigor and the freedom to question well established ideas that characterize many immigrant communities. Greeks, unlike Jews, had no dogmas like the Old Testament to constrain their thinking, though they had plenty of myths. Thales of Miletos, in particular, tried to explain the world not in terms of myths but in more concrete terms, terms that might be subject to verification. For example he asked himself what might the world be made of? His unexpected answer was water. Water could clearly change its form from solid to liquid to gas and back again. His suggestion was an unnatural thought – contrary to common sense, but such thoughts are often the essence of science.

But more important than his answer to the essence of the world, was his explicit attempt to find a fundamental unity in nature. For the first time there was a conviction that there were laws controlling nature, and that these laws were discoverable. Such ideas were to be crucial to the success of science and its survival later in the West. This was one of the most exciting and important ideas in the entire history of mankind. But, even more important, this idea was open for discussion and debate. It was a wonderful leap that was to free thinking from mythology and relating everything to man. In other words, the possibility of objective and critical thinking about nature had begun.

For the first time with Thales of Miletos, attention was focused on the nature of the world with no immediate relevance to humankind. It is with the Greeks that man and nature are for the first time no longer perceived as inextricably linked. There begins a curiosity about the world itself.

Moreover, it was also Thales who established mathematics as a science, irrespective of how much he might have learned from the Babylonians and Egyptians, who had established arithmetic procedures and the elements of geometry for their practical needs. Thales turned these tools of measurement into a science. For the first time general statements were stated. They were general statements that applied to all, for example, circles and lines. This is a characteristic of science.

Anaximander, a fellow-citizen of Thales in Miletos, came to progress the whole dialogue that had been opened. He did not find Thales's ideas about water persuasive. Anaximander believed that air was a much better candidate for being the primary substance of which all things were made. And so began the sort of claim and counterclaim for the understanding of nature which eventually gave rise to modern science. However science was still lacking experimental method.

Thales and Anaximander were succeeded by Aristotle. Aristotle viewed scientific inquiry as a progression from observations to general principles and back to observations. He maintained that the scientist should induce explanatory principles from the phenomena to be explained, and then deduce statements about the phenomena from premises which include these principles. Aristotle's science, which became dominant, accords with a reasonably common-sense picture of the world.

Up to now Wolpert concludes that the Greeks were the first to begin a change in thought: transition from explanations by means of myths to explanations which were self-consistent and open to critical analysis. Needless to say that most of Greek science turned out to be wrong. It was full of misconceptions about motion and the position of the earth in the universe. That is no disgrace, for being wrong is a constant feature of scientific method.

The years after Thales two great achievements in the cultural history of humanity took place: it was Euclid's geometry and Archimedes's mechanics. They were both fundamental to further scientific advance, and one may speculate, with some concern, how the scientists of the Renaissance would have fared without them. Euclid was not the inventor of geometry, for many propositions had been known for a long time before him. His achievement was to follow through Aristotle's demand for a logically derived science based on a minimum number of postulates, which had to be taken as given; his five postulates are indemonstrable but taken to be true. Archimedes, on the other hand, was the first applied mathematician. He applied mathematics to understand how the world works, laying the foundations not only for statics but also for hydraulics. He achieved for physics what Euclid had done for geometry, beginning with definitions and postulates, he gradually proved certain propositions.

Up to now it is revealed an early science's peculiarity. It is an apparent "uselessness" of science. Particularly, what was the use of Thales's answer that the world is made of water? Or in what way was it necessary for laymen to know that the heart is the first organ developed in the embryo? And in what way was it needed to know the cause of some bodies to float while some others sink.

Wolpert continues supporting the unnatural nature of science in terms of Ancient Greek cosmology. Every civilization and culture has provided its own answer to the question: what is the structure of the universe? Only Western civilizations though, starting with the Greeks, have used studies of the heavens to provide an answer. Other cultures have shaped their cosmologies on terrestrial events, the heavens merely providing an enclosure. Egyptians and Babylonians made a lot of observations of the movements of the sun and the stars, but these did not form part of an explanation. The Egyptians were primarily concerned with establishing a calendar, while the Babylonians were interested in the accurate prediction of events in the heavens, such as the appearance of the new moon. The first who made an attempt to provide an explanation was Anaximander, Thales's contemporary in Miletos. He assigned sizes to some heavenly bodies and likened the moon and its eclipses to the turning of a wheel. It took more than two centuries for Greeks to develop a two-sphere universe. This model had considerable conceptual elegance and provided, for the first time, an economical way of linking observations into a coherent whole.

Even in Greek times there were competitors to the two-sphere model. In the third century BC, Aristarchus proposed that the sun was at the centre of the universe and earth revolves about it. But that clearly contradicted common sense, so Aristotle's ideas prevailed. Aristotle's view of the universe embodied features which had existed for centuries. The concept of circular motion of the heavenly bodies about the earth created great problems when it came to understand the movement of the planets. Because they, like the earth, in fact rotate around the sun. As a result, their motion did not fit in with simple circular motion. Ptolemy provided the most comprehensive explanation of planet's complex motion in terms of epicycles. That is, a planet rotates about a small circle which in turn rotates about the earth. But the problem was that, while accuracy in the predicting planetary motion was achieved, this accuracy was at the price of complexity. More and more epicycles had to be added in order to fit planetary observations.

The author finally raised the question that “given the apparent progress of Greek science, why did progress in astronomy and other sciences stop until the arrival of Copernicus, Kepler and Galileo?”. The Greeks could have reached Copernicus’ heliocentrism, in the sense that they required no new observations. It was a barrier that is hard to explain. It seems that these specific ideas required a major conceptual advance. Part of the answer could be the role of Roman power and the rise of Christianity, and also the contribution of Islam.

In conclusion, the book is interesting and instructive. The most interesting point is the author’s approach to the origin of science. Beginning from the idea that science is a very rare activity in human culture, and it is mostly guided by curiosity, rather than necessity, Wolpert claims that the fact that for thousands of years the mythology and cosmology of almost all cultures entertained neither a critical tradition nor curiosity about nature is persuasive evidence for the unnatural nature of science. As a consequence, the author claims that the conditions needed to be very special for science to have started at all, as it did in Ancient Greece. He presents the evolution of science as a rather chancy affair, likening the progress of science to biological evolution. If dinosaurs had not mysteriously disappeared – due to a cosmic catastrophe perhaps - and been replaced by mammals, we would not be here. And so is with science. There was no inevitability that science should have arisen in Greece. The factors already mentioned by chance happened to work in Ancient Greece. So it is always to Miletos and to Thales that it is necessary to return.

The book adds clearly in the existing literature on public understanding of science. It provides adequate answers to all these students, science teachers and laymen who are looking for an informative, consistent and coherent approach to the features regarding the nature of science.

Lewis Wolpert, the author, is a biologist, a researcher in fact. So this book is a scientist’s view on nature of science (NoS); neither of a philosopher nor of a historian of science. This is rather unusual, considering nature of science to be a mere philosophical subject and the scholars working on that are mostly philosophers, sociologists and historians of science. Although the author’s absence of formal education has raised some criticism, his perspective to nature of science is enlightening.

History of Fuzzy Modeling

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Theoretical model

The creation of a theoretical model for explaining the workings of natural phenomena and for organizing and interpreting the data gathered from experience is a sign that marks the step from empirical knowledge to the scientific process. Theoretical models are shaped around a set of assumptions or hypotheses that are the culmination of a long process of observation. We can find a first theoretical model in some of the texts of the Chaldean astronomers; it is not expressed as such, but in the form of a rule or algorithm with which the learned men of Babylon calculated the movements and positions of the stars (Ephemerides, Goal Year Texts; Neugebauer 1983). Some Hippocratic medical schools also conceived a theoretical model when they conjectured that our organism is made up of four humors that coexist in equilibrium and harmony (On the Nature of Man; Littrè, 1839), they thought that the imbalance of these substances gave rise to illness or provoked death. Other doctors of the same period attributed illness to an excess of heat or cold, humidity or dryness. None of them had irrefutable proof that demonstrated the truth of their assertions; however, they designed a model to which they adjusted their observations. Simultaneously with these medical trends, some learned Greeks rejected the use of hypotheses, considering them to be vestiges of old practices and conceptions tied to magic and religion (On Ancient Medicine; Sachs, 1948). They then proposed that only that which had been perceived by the senses was worthy of science; since there was no empirical proof of the existence of these cosmological or physiological models, these doctors rejected them as useless and fantastical.
In other areas of research, such as geometry, no one opposed the Greek mathematicians' use of hypotheses in their proofs. Plato, admiring the results, introduced these kinds of formulations into philosophical argumentation (Plato, Meno 86b-e).
The mere observation of natural phenomena is not a sufficient condition for the appearance of a science; not even the extraction of a general law applicable to all the events of the same kind is, nor is the knowledge of the causes that trigger these phenomena. All these factors are necessary but not sufficient for creating a science. The learned Greeks, contrary to their eastern predecessors, sought the origin of phenomena in nature itself, not in the whim or will of gods and demons. But nature showed itself to be unstable and changing. The constant flow made it impossible to establish a permanent and lasting knowledge of the beings that make it up. How is it possible to know something that is so today but ceases to be so tomorrow? The first Greek cosmologists sought the substance that endures as opposed to change; the unity of the being as opposed to the plurality of its forms. They formulated so many

hypotheses that, in the end, some philosophers, such Protagoras, concluded that all knowledge is reduced to sensation: “Man is the measure of all things” (Sextus Empiricus, Adversus Mathematicos VII, 60). The difficulty of establishing scientific knowledge led Parmenides of Elea to formulate the principle of non-contradiction: “it is impossible for something to be and not to be at the same time” (On Nature). This basic and unprovable formulation, in Aristotle’s (Metaphysics IV, 4, 1009a-1010a) judgment, together with other axioms with analogous qualities, lays the foundation for western science. This principle rises above the discordances that we notice in nature: it stops time at that instant and captures the immutable being that does not experience change. For Parmenides of Elea, everything in nature is Being, to the point that it is impossible to conceive of Non-Being. From our point of view, this hypothesis is hard to accept because we all see how things transform themselves from what they are not now to what they will be later on. In short, all organisms seem to be and not to be at the same time. Plato gave being to the Non-Being Parmenidean (Teaethetus 257c). How can this be explained? A man is an animal, a mammal, etc., but not a bird or a stone or a fountain. Shortly afterward, Aristotle went farther with this idea and proposed an ontological model that got around these contradictions: natural beings are here and now, updated, but they possess potential qualities that they will develop later on (Metaphysics IV, 5 1010a). Thus, a boy is a potential man and a seed will become a tree in time. Aristotle attempted in this way to achieve a universal and necessary knowledge, from its causes, rising above appearances and sensations. Because of this, just like Parmenides, he needed to capture the event and examine it. In his cognitive model, the principle of non-contradiction acquires the role of a basic, irrefutable axiom: “the same attribute cannot at the same time belong and not belong to the same subject” (Metaphysics IV, 3 1005a). Analytic reasoning, inaugurated by Plato in Philosophy (Proclus, In Euclides, 211, 19-22), is applied here to break down phenomena and discover their primordial elements. Aristotle reduces the formulations of science to propositions in which a predicate is affirmed or denied regarding one or several subjects. But between both extremes of the contradiction – possessing and not-possessing a certain quality - there sometimes exists a range of attributes that are more or less close to these extremes: “there is a more and a less in the nature of things”(Metaphysics IV 4 1009a). Aristotle knows that, in cases such as the move from white to black, from large to small, from slow to fast, there is not one but many intermediate terms located more or less close to both extremes. However, in his theoretical model, he only contemplates those qualities that do not admit the existence of an element that simultaneously denies the extremes of the contradiction (Metaphysics IV 7 1011b), such as when we decide between even and odd numbers.

Non-Classical Logic

The Aristotelian paradigm is clearly insufficient to decide on events involved in human discernment and natural language, but was not questioned until well into the 20th century, when thinkers such as previously (Bertrand Russell, 1923), and finally (Jan Łukasiewicz, 1970), already had enough theoretical tools available to rescue and interpret the notion of vagueness, by inquiring about the irrefutability of those

principles: contradiction and excluded middle. And after these the seminal papers of (Lofti A. Zadeh, 1965, 1975), from which derives many of the more innovative and interesting new Mathematics, with very surprising applications.
Jan Łukasiewicz took the exposed argument by Aristotle in Peri hermeneias - De Interpretatione (Chapter IX), in which the philosopher of Stagira explained how one cannot affirm or deny the existence of a contingent future event. Aristotle intended with this reasoning to refute the Megarian deterministic thesis according to which every event that happens is necessary, now, in the past, and in the future. The opposition between necessity and possibility was studied by Aristotle in this work and gave rise to modal logic; it also inspired to (Łukasiewicz, 1920, 1930) for create the three-valued logic, in which one of the truth values is undefined.
Fuzzy Logic can be conceptualized as a generalization of Classical Logic, dealing mathematically with imprecise information usually employed by humans. As a Multi-Valued Logic, it extends Boolean Logic, usually employed in classical science.
Fuzziness describes event ambiguity. Hence, it measures the degree to which an event occurs, not whether it occurs, whereas Randomness describes the uncertainty of event occurrence. Whether an event occurs is random; to what degree it occurs is fuzzy. It may be applied to generalize the Classical Set Theory of Cantor, giving the Fuzzy Set Theory. A Fuzzy Set is any point in the cube $I^n = [0, 1]^n$. So, given U as the Universe of Discourse, we have that $(U, I^n = [0, 1]^n)$ may be the fundamental measurable space of fuzzy theory.

Fuzzy Logic and Modeling

A linear combination like a fuzzy model is clearly understandable. The fuzzy model proposed by Takagi, Sugeno and Kang (TSK, by acronym) is described through fuzzy IF-THEN rules which represents local input-output relations of nonlinearity. The main feature of a TSK fuzzy model is to express the local dynamics of each fuzzy implication (rule) by a linear system model. The overall fuzzy model is achieved by fuzzy "blending" of the linear system models.
Fuzzy Modeling is many times used to transform the knowledge of an expert into a mathematical model. The emphasis is on constructing a fuzzy expert system that replaces the human expert. A fuzzy model represents the real system in a form that corresponds closely to the way humans perceive it. Thus, the model is easily understandable, and each parameter has a readily perceivable meaning. The model can be easily altered to incorporate new phenomena, and if its behavior is different than expected, it is usually easy to find which rule should be modified, and how. Furthermore, the mathematical procedures used in fuzzy modeling have been tried and tested many times, and their techniques are relatively well documented. So, we describe here the different ways to implement Fuzzy Rules, and by these, to improve tools for Fuzzy Reasoning. For instance, either the Sugeno method, or the Takagi-Sugeno-Kang (TSK, by acronym) method.

Fuzzy Rule-Based Systems

The Rules shows great advantages over Classical Logics (Zadeh, 1975). In Classical Logics, Reasoning is Monotonic, with inferences without contradiction with the pre-existing. Whereas in RBS we can delete facts or assertions from the FB, as the new

inferences prove them wrong. This makes this kind of reasoning Non-Monotonic, because we can modify the conclusion. Then, a question appears: what is to be done with the conclusion of an assertion now invalidated? For this problem, we need to introduce the concept of Type of Dependence of a Rule, which can be Reversible, if we delete the assertions, then we delete automatically the above inferred facts; or Irreversible, if the facts, once inferred, can neither be deleted nor changed.
What happens in case that we have more than one suitable rule at the same time? Which one should be applied first? In each step, we call the Conflict Set the set of applicable rules; it is, obviously, a dynamic set. The subjacent decision problem is called Resolution of Conflicts or Control of Reasoning. There are some different strategies for selecting each time a Rule from the Conflict Set.
The introduction of concepts and methods of Fuzzy Logic is very usefulness covering adequately the indetermination or imprecision of the real world (Klir and Yuan, 1995). We define the "world" as a complete and coherent description of how things are or how they could have been. In the problems related with this “real world”, which is only one of the “possible worlds”, the Monotonic Logic does not work with frequency. Such type of Logic is the classical in formal worlds, such as in Mathematics. But it is necessary to provide our investigations with a mathematical construct that can express all the “grey tones”, not the classical representation of real world as either black or white, all or nothing, but as in the common and natural reasoning, through progressive gradation.
Logic analyzes the notion of consequence. So, it deals with Propositions or Set of Propositions, and their mutual relationships. Formal Logic attempts to represent all this by means of well-defined logical calculi. Some calculi differ in their definitions of sentences and their respective notion of consequence. In Medicine, a fuzzy proposition may be true to some degree, and this degree may be evolving with time. So, the sentence “the patient is old” is true in some degree: the older the age of the patient, the truer the sentence. Standard examples of fuzzy propositions may include linguistic variables, such as the related with age, being possible values: young, medium, old, with intermediate degrees, by fuzzy modifiers, as almost, something, enough, very, etc. (Garrido-Postolica, 2011).
Fuzzy Logic has two different meanings: wide FL, and narrow FL. In this last sense, narrow Fuzzy Logic, FLn by acronym, is a logical system that attempts to formalize the approximate reasoning. So, it will be an extension of Multi-Valued Logic. Therefore, this FLn has a much wider range of applications than traditional logical systems, because the apparition of new concepts. Instead of this, if we consider Fuzzy Logic in its widest sense, FLw by acronym, it will be a synonymous with Fuzzy Set Theory (FST, by acronym). Indeed, it is the theory of classes with unsharp boundaries. Therefore, FST is much broader than FLn, including this latter as one of their branches. So, in the broad sense, everything dealing with fuzziness may be called a Fuzzy Logic. But in the narrow sense, the base of Fuzzy Logic will be the formal calculus of Multi-Valued Logic.

Fuzzy Optimization

The Mamdani method is the most commonly used in many applications, due to its simple structure of “min-max” operations. It proceeds in four steps:

1) evaluate the antecedent of each Rule; 2) obtain each Rule´s conclusion; 3) aggregate conclusions; and 4) defuzzification.
If we only take into account the factors that really matter in the problem, it is enough to write a set of rules that model the problem.
Another advantage of using the fuzzy approach is that, should we want to add more variables to the problem, all we would have to do is write new rules or edit the existing ones. This means a lesser amount of effort than rewriting an algorithm. So, Fuzzy Logic is adaptable, simple and easily applied.
Mamdani´s method is useful when there are a very small number of variables. Otherwise, we will find certain difficulties, as may be: the number of Rules increases exponentially with the number of variables in the antecedent; the more Rules we construct, the harder is to know if they are suitable for our problem; and if is too large the number of variables in the antecedent, it results difficult to understand the causal relationship between them (the antecedent and the consequents); hence, constructing new Rules may be harder.
The second Fuzzy Inference method was introduced by Takagi, Sugeno, and Kang (so TSK method, by acronym) in 1985. It is very similar to Mamdani´s method in many respects. The first two steps are the same. The essential difference between them is that in Sugeno´s the output membership functions are either constant or linear.

Conclusions
Fuzzy Modeling may be used to transform the knowledge of an expert into a mathematical model (Garrido, 2011, 2012). The emphasis is on constructing a fuzzy expert system that replaces the human expert. Also as a tool that can assist human observers in the difficult task of transforming their observations into a model. In many fields of science, human observers have provided linguistic descriptions and explanations of various systems. For this, there is a need to construct a suitable mathematical model, a process that usually requires a very subtle mathematical understanding. This new modeling is a many more direct and natural approach for transforming the linguistic description into such model. It represents the real system in a form that corresponds closely to the way humans perceive it. Thus, the model is easily understandable, and each parameter has a readily perceivable meaning. The model can be altered to incorporate new phenomena, and if its behavior is different than expected, it is easy to find which rule should be modified, and how. The mathematical procedures used have been tried and tested many times. So, there are different ways to implement Fuzzy Rules, and by these, to improve tools for Fuzzy Reasoning. We have showed here a general vision for modeling and optimization problems, by searching the historical foundations of these topics.
ACKNOWLEDGEMENTS: This work was supported by the MYCINN´s Research Project FF 2011-29623 that we belongs to, “El papel de las polémicas en la producción de las prácticas teóricas y en el fortalecimiento de la sociedad civil”. Being their Principal Researcher Cristina De Peretti.

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Confronting the Unexpected: The Treatment of Anomalous Phenomena in Scientific Research

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The paper consists of three instances in which the scientific community has found itself in a situation *vis à vis* anomaly. First, it briefly introduces two of these examples, Gravity-waves-measuring controversy and introduction of conception of Default Mode Network of Brain on the field of neuroscience, and then it proceeds to draw certain lesson on the grounds of Kuhnian idea of Essential tension between tradition and innovation. Finally, after a brief characterization of the third example, the recent controversy of OPERA experiment, it is in short embedded into the framework outlined on the background of the previous two examples.

The first of these examples took place in the late sixties and early seventies. The so-called gravitational waves, is a phenomenon predicted by Einstein's theory of relativity. Main source for this case will be Collins' sociological analyzes of this case. Gravitational waves were considered undetectable using then available technologies and therefore were in point of fact the mere theoretical consequence of the theory of relativity. For if they should reach at least hypothetically measurable values, their source would have to be a release of huge amount of energy, which can only occur during destructive cosmic events as for example explosions of stars (supernovae) or the collisions of black holes.[1]
In 1968 the American physicist Joseph Weber[2] announced that he was able to detect gravitational waves using experimental apparatus of his own design. Thus Weber was the first who began to deal seriously with gravitational waves and whose research in this field brought some results.[3] However, his measurements showed values that significantly exceeded the values predicted by cosmological theories. Assuming they are correct, these anomalous results would have two possible explanations: first, that the current cosmological models based on well proven and functioning theory of relativity are wrong, or second, that the number of events of

[1] Collins 1992, 79. See also Collins 1981, 35; 1982, 98; Collins and Pinch 1998, 91.
[2] Weber 1968.
[3] Collins 2004, 24.

such magnitude that causes gravity waves reaching the measured values is that the universe would in a short time completely "burn up".[4]

Initially, Weber's results did not cause many reactions. But Weber constantly offered new measurements which supported his first results, until in the course of a few years his work began to awaken an interest in the scientific community. The analysis of periodicity of the signal showed the characteristics that seemed to suggest that this signal originates from a remote and constant location in the universe and therefore excluded the possibility that it comes from the sun or a local source of interference.

So, Weber's results began to gain wider serious concern from the community of physicists in 1972, when several research groups independently decided to replicate the measurements or to obtain analogous ones from the devices of slightly different design, so that these results would confirm or question the Weber's results. Within the next three years at least six studies was made which did not prove Weber's results, and not a single one that would confirm them. Moreover several experimental errors were discovered, which Weber made during these measurements.[5] Scientific community's attitude began to turn gradually. Weber's measurements became the object of sharp criticism and whole controversy has come to its conclusion with the fact that these results are invalid.[6]

What seems to be a fairly trivial case of unconfirmed experiment, of an experiment that was not replicated successfully, on the basis of which it was refuted by the scientific community, has, however, some background that puts the whole thing in a different light. Collins argues that available evidence simply did not give the grounds for rejection of the validity of Weber's results. It was possible to interpret this evidence in a multiple manners, and scientists were far from consensus on this. It was even possible to bring a plausible interpretation in Weber's favor.[7]

In principle, there were five main arguments used against Weber: first, in the computer program Weber used for data processing was discovered error responsible for most of the detected signal. However, even after correcting this error, Weber was able to find a signal corresponding to gravitational waves on the same data sets. The second complaint concerned the statistical data processing and the fact, that Weber is capable to find such signal on any data set. Furthermore, it came out that data from two distant detectors, which showed identical signals were due to poor time synchronization mutually shifted by four hours and therefore, no signal should be reported. However, to many scientists, this does not constitute the reason for the rejection of other similar cases, in which the data has been synchronized correctly. The third argument against the credibility of Weber's result was the gradual disappearance of the periodic recurrence of the signal – one of the main reasons why scientists have begun to take the measurements seriously. However, even this difficulty can be explained simply by pointing to the instability of the cosmic source.

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[4] See Collins 1992, 81–83.

[5] See Collins 1981, 39–42.

[6] Ibid., 38–39.

[7] Collins 1992, 91.

The fourth argument was Weber's inability over the years to improve the signal to noise ratio. Thus the intensity of the detected signal fluctuated throughout the whole duration of this controversy only very slightly above the threshold and furthermore, it was gradually dropping.
The fifth and most important reason to doubt was that none of the six teams that tried to replicate the experiment, succeeded. That would be sufficient itself as a reason for rejecting Weber's results, were it not the case that critics of Weber themselves failed to agree on whether or possibly which of these experiments can ever be considered conclusive and actually questioning Weber's measurements.[8]
The inability of the scientific community to agree on the conclusiveness of evidence against Weber's results is, according to Collins, not sufficient to make this scientific dispute decided unequivocally. Scientists have therefore found themselves in a situation where the standard available scientific means failed.[9]
The final result, i.e. the rejection of Weber's measurements, then Collins explains by that certain non-scientific factors came into play. In 1975, Richard Garwin, convinced of that Weber's measurements was incorrect, published the results of his experiment. What was, however, different on his approach, was not its content but its form, particularly the form of presentation. For Garwin had given his results – through the article and lecture and public confrontation at physical conference – not as a neutral statement, but willfully and quite explicitly as a challenge to Weber's results.[10] This became the last nail to the coffin of Weber's experiment. It was precisely by Garwin's coming to scene, why, according to Collins, the mood of scientists and their opinions on this controversy gradually began to change and their reserved attitude was replaced by almost universal consensus on the fact that Weber's results were produced by some intentional or unintentional mistake.[11]

The second example introduced here took place at the turn of the millennium in the field neuroscience: the discovery and theoretical account of the resting state of the brain in the theory of the so-called Default Mode of Brain.
The prevailing theory of neuroscientific research for the vast majority of the twentieth century, the so-called "reflexive" theory was focusing on cerebral localization, that is mapping different parts of the cortex and their correlations with brain functions, and it by large neglected resting states of the brain. In studies of cerebral localization, this theory reflected almost only invoked activity during active cognitive operations. Thus, in principle, the scientific community presupposed that brain activity was closely related to specific behaviors and subsequently, link specific active behavior with active brain regions on the basis of correlations. If some other activity or deactivation of brain regions were discovered during the research, which was not important for this research, it was considered "noise" and was eliminated from observation.[12]

[8] Collins 1981, 39–43.
[9] Collins 1992, 88.
[10] Collins 1981, 43–44. Garwin appears as „Quest“ here.
[11] Collins 1992, 93–94.
[12] See Havlík 2012, 229–237.

Previously neglected resting states of the brain began to be reflected in 2001 by Michael Raichle's theory of the Default Mode of Brain. Raichles motivation was to examine the basic building blocks of brain activity (baseline), of which he assumed that it is central to the invoked activity, manifesting itself in responsive answers to the external environment or in solving cognitive tasks.[13] This theory, however, has brought a whole new perspective on the brain and its functions, and became in Kuhnian sense the new paradigm in neuroscience.

Default Mode of Brain, or Default Mode Network (DMN) is an intrinsic network of the brain, consisting of the nodes – specific brain regions whose coactivity and connections are measured in resting states of the subject. Resting state can be described as a state, which can be achieved in the observed subject when it finds itself in a state of passive perception while lying, and it must not fall asleep, or when the subject passively observes a stimulus without invoking active cognition.[14]

The idea of DMN arose from the observation of identical reductions of the activity of certain brain regions in the moments when the body went into a state of active cognition, which required active attention, such as when the subject was to fulfill the given task. This active cognition corresponded to the activation of other specific brain regions, Attention System. Active cognition is characterized by different neural activity than is the neural activity in DMN. DMN activity is maximal in resting states and during active cognition, which requires attention, or when performing assigned tasks, it is reduced or DMN is completely deactivated and attentional system is activated. Unlike the "reflexive" approach to the brain, which assumed that the brain is active only during active cognition, DMN theory claims that the brain is active all the time, both during active cognition and the resting state.[15]

Deactivation of specific parts of the brain during the transition to a state of active cognition was observed long before there was a theoretical account of DMN. Previous reflexive conception deliberately overlooked this anomalous - and within its scope inexplicable – observations in favor of maintaining accurate statistical data. In fact, these manifestations of DMN were seen by many researchers. Anomalies were characterized both by appearing repeatedly and their mutual consistency when the subject came into the states of active attention and reflective cognition. However, there was no commonly accepted theory that would explain them satisfactorily.[16]

Initially, the DMN theory gained almost no attention. The first submitted paper reporting observed and measured results on this subject was identified by a scientific journal as speculative and controversial and was rejected. At the same time, however, one can also say that the reflexive conception was getting to the threshold of its research capabilities and was not able to offer any promises of further scientific achievements. The first concept of DMN was submitted in 1998 without causing any significant interest. This theory has not received wider attention until several years

[13] Gusnard and Raichle 2001.

[14] Raichle 2001.

[15] Ibid. See also Carthart-Harris and Friston 2010.

[16] Raichle and Snyder 2007.

later when other laboratories managed to replicate the original results.[17] Nowadays the DMN begins to appear more widely even in scientific textbooks.

Despite the fact that these two examples are at first sight very different, it is possible to trace some very similar features on them. For this comparison, let us borrow Thomas Kuhn's thesis presented in The Essential Tension.[18] Here Kuhn argues that scientific work is inseparably accompanied by two opposing modes of thought: on the one hand, scientist must be grounded in tradition, that is to have proper education and to be able to solve scientific problems by use of standard scientific methods; but on the other hand, he must also be open to new ideas and new ways of solving problems, that is "he has to possess certain mental flexibility, and he must be prepared to recognize troubles where they exist".[19] These two contradictory aspects only constitute the essential tension, which is necessary for successful scientific work. Besides the ability to identify new problems and new approaches to problem solving is also necessary to control brilliantly the scientific skills – only a great craftsman can raise his craft to a higher level.

These two modes and different extent to which they are put into effect within the scientific community that finds itself in a situation when facing anomalous results, clearly show in the following two examples. In both cases, the community primarily seems to show conservative skepticism, and it took quite a long time before experimental results even gained some wider attention. It took several years before scientists began to seriously consider these results. It seems that the scientific community begins to deal with an anomaly only when it has such a nature that it can be replicated, generalized and then explained theoretically and explore it in the context of other known phenomena.

In the case of Weber's measurements, the conservative tendencies prevailed after all within the scientific community and – despite the fact, that measurements contradicting Weber's results were themselves problematic – it come to the conclusion that Weber's results cannot be considered valid. But on the other hand, even these results were not so strong or conclusive and did not offer the promise of further development. Such a stalemate situation, where arguments for both options are in much equally strong, was resolved – as Collins shown, by some non-scientific factors, namely by the way in which Garwin interpreted and presented this counterevidence. That was the last straw, which finally outbalanced the discussion against Weber's results.

In the case of DMN theory, the situation was quite different. The scientific community was because of stagnating tendency of reflexive conception in a positive attitude to novelties and the perceived presence of anomalies in the form of measured brain activity when the subject under examination is not in a state of active attention or reflexive cognition, were important factors that have played a crucial role in the adoption of a theoretical framework explaining the anomaly. However even in this case, the process of acceptance of the theory was not do

[17] Raichle 2009.
[18] Kuhn 1977.
[19] Kuhn 1977, 236.

without problems. The initial unwillingness to accept a novelty Kuhn explains that "to assimilate them [new theories, new point of view] the scientist must usually rearrange the intellectual and manipulative equipment he has previously relied upon, discarding some elements of his prior belief and practice while finding new significances in and new relationships between many others".[20] Initially, the idea of constantly active brain did not get any attention at all, which was caused by the fact that the first results obtained on the basis of this approach have been identified as too speculative and unpublishable.
The first study of this kind was not accepted to publication and did not gain any attention until after several years when there were reports of successful replication of these measurements. But then, because of the promises that this new field of brain research brings, it gets relatively rapid adoption.[21]

The last example is very recent and quite different one. Events around the OPERA experiment do seem to fit completely into the framework that I have outlined above. On 22nd September 2011 a scientific team OPERA published an article[22] through preprint server ArXiv.org and a day later they arranged extraordinary press conference, where they announced the results of their measurements that immediately brought huge excitement among the general public around the world. The analysis of data collected in previous years showed that neutrinos sent from CERN to the laboratory Gran Sasso (about 730 km) came 60 ns earlier than the speed of light allows.[23] After a half year of unsuccessful efforts to discover the cause of these results, the team decided to publish the results, arguing that they will welcome help from other scientists in finding potential errors in the experiment. Shortly after the announcement of the results articles began to appear on the same server from various scientists and scientific teams that were in the vast majority trying to give a theoretical explanation for the possibility of superluminal neutrinos.[24] The first serious argument against the validity of the results of the experiment was pointed out by the scientific team of the ICARUS experiment, also situated in laboratories in Gran Sasso. The neutrinos received by OPERA detector did not show appropriate energy spectrum to allow them to be superluminal. However, this objection can be refuted by using neutrino models that work with different energy spectra.
Another objection raised the fact that neutrinos have been sent to OPERA in 10.5 microsecond pulses, and it was not possible to distinguish in what part of the pulse the detected neutrinos were located. OPERA team refuted this complaint by that they had sent neutrinos in pulses with a length of 3 ns, which arrived to Gran Sasso again about 60 ns earlier than would correspond to the speed of light.[25]

[20] Kuhn 1977, 226–227.
[21] Raichle 2009.
[22] Adam et al. 2011a.
[23] Blumfiel 2011. Viz také Reich 2011.
[24] See for example Marfatia et al. 2011; Ling 2011; Henri 2011; Broda 2011; Zhu et al. 2011; Magueijo 2011.
[25] Adam et al. 2011b

At the beginning of 2012 two events occurred shortly after each other, which caused a loss of confidence of the scientific community in these measurements. First, the OPERA team announced the first discovery of two technical errors, and second, the ICARUS team announced new 3ns neutrino pulse velocity measurement, which was in complete accord with the speed of light assumptions.[26]
At the end of March 2012, the OPERA team publicly indicated that the estimated value of the error caused by technical problems was just around the anomalous 60 ns, of which the neutrinos seemed to arrive to Gran Sasso earlier than the speed of light allows, and then on July 11, they reported a new measurements, which were carried out after removing the detected technical flaws, and these measurements were entirely theory-conforming.[27]
Therefore this story has a rather banal ending: after detecting errors in the experiment and their removal neutrinos speed measurements came back into conformity with the theoretical assumptions and the initial results were therefore rightly declared invalid. However, what seems to be much more interesting here in the context of the above examples of measurements of gravitational waves and the discovery of the DMN, is the way and extent to which the scientific community responded to the announcements of these anomalous results. During the following six months since the controversial announcement there was created and published through ArXiv.org more than 200 studies about superluminal neutrinos and OPERA experiment.[28] The vast majority of reactions initially - before the discussion moved towards the technical design of the experiment - did not question the fact that superluminal particles were obtained, but on the contrary the scientists tried to find some theoretical account for the phenomena. At least as for publication activity, considerable part of scientific community initially accepted the results – they were relatively very inclined to accept novelties. This situation is completely different from the two examples above, where distrust to the novelties prevailed within the scientific community, at least in the beginning, and as a criterion for accepting (or refuting) was taken (un)successful replication of experiment. In the case OPERA, this initial skepticism was not so dominant within high-energy particles physics community (its publications). Some interesting explanation of this attitude offers Amelino-Camelia (he himself is theoretical physicist): "in the present (depressingly long) normal-science season many physicists maintain full readiness toward possibly adopting a new paradigm, as soon as experimenal results suggest this might be appropriate."[29]

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[26] Antonello et al. 2012.
[27] Adam et al. 2012.
[28] See Amelino-Camelia 2012, 3.
[29] Amelino-Camelia 2012, 9.

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Anomalies and the Crisis of the Bohr-Sommerfeld Atomic Theory

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Introduction

The crisis in the old quantum theory that in the summer of 1925 led to the new Göttingen quantum mechanics is a classical case in both history and philosophy of science. Why did physicists believe that the existing quantum theory of the atom had come to a dead end and that further progress within the framework of the Bohr-Sommerfeld theory was futile? To appreciate the status of the theory in the spring of 1925 one has to take into consideration not only its difficulties but also its successes. Moreover, one has to extend and differentiate the list of anomalies beyond the classical ones, such as the anomalous Zeeman effect and the helium problem. An anomaly is not just an anomaly. Nor is a confirmation just a confirmation, witness that some of the successes of the old quantum theory turned out to be spurious. From a later point of view, the successes were apparent only. While some anomalies were taken very seriously, others were ignored for all practical purposes and others again were recognized as anomalies only post factum. Why?

At the end of this brief paper, I address the question of how widespread the feeling of crisis was in the physics community. There are reasons to believe that some of the main players in physics around 1925 did not perceive the situation as a real crisis initiating a revolutionary change.

Experiments and the Bohr atom

Although Niels Bohr was of course a theorist, not an experimenter, he was much occupied with problems of an experimental nature and with confronting his atomic theory to experimental tests. Not only did he follow relevant experiments closely, for a period he also engaged in spectroscopic and other experiments himself – although with little success. A most important element in the early phase of his theory was the remarkable agreement between theory and spectroscopic data that he was able to demonstrate in the case of one-electron atoms, meaning the H atom and the He^+ ion. As well known, his theory resulted not only in a complete explanation of the hydrogen spectrum but also in a confirmation of his theory when challenged by apparently unwelcome data, first by the so-called Pickering-Fowler lines and subsequently by deviations in the hydrogen spectrum found by William Fowler in London (Robotti 1983). While he solved the first problem in the first part of his trilogy in *Philosophical Magazine*, in the fall of 1913 he countered Fowler's objection by taking into regard the finite mass of the atomic nucleus, thereby laying the foundation of what later became known as the isotope spectroscopic effect (Bohr 1913; Kragh 2012b). Had it not been for these early successes, his theory would have met with much greater resistance than was actually the case.

However, from the very beginning there were also problems, phenomena within the domain of the theory that it was unable to account for. One example was the heat of formation of molecular hydrogen, which Bohr calculated in 1913 in approximate agreement with experiments made by Irving Langmuir. Unfortunately, as the experiments became more precise it became clear that the agreement was an illusion (Kragh 2012a, 77-79). Generally speaking, as the theory progressed, so did the empirical failures, which accumulated in number and seriousness. As far as empirical tests are concerned, the general picture of Bohr's theory over its whole life time, from 1913 to 1925, is a confusing mixture of successes and failures, or of confirmations and disconfirmations (see the table in Kragh 2012a, 347).

The brief history of Bohr's atomic theory provides a most instructive example of the interplay between theory and experiment, for other reasons because it demonstrates that a confirmation is not just a confirmation, and an anomaly is not just an anomaly. The way experiments are viewed relative to a theory in actual scientific practice is not always rational, and it can sometimes be quite arbitrary and depending on local circumstances, such as was the case with Bohr's old quantum theory of the atom. Anomalies come in different kinds and are often evaluated in different ways by the scientific community – some are regarded as crucially important, while others are hardly noticed and have little effect on how the theory is judged.

For example, among the anomalies two came to be recognized as particularly grave and even catastrophic, namely the anomalous Zeeman effect and the helium anomaly. The theory was unable to explain helium in whatever of its possible configurations, such as Max Born and Werner Heisenberg proved in 1923, causing them to speak of a "catastrophe" and a "misery" (Heisenberg to Pauli, 19 February 1923, in Hermann, Meyenn, and Weisskopf 1979, 80). On the other hand, compare the seriousness of the helium anomaly with other anomalies known in the early 1920s, such as Wolfgang Pauli's calculation of the H_2^+ ion and the so-called Paschen-Back effect in hydrogen (Jensen 1984). To these anomalies might be added Lothar Nordheim's calculations of the H_2 molecule (Kragh 2012a, 248-249). In all three cases the result was that these simple atomic systems were outside the reach of the orbital Bohr-Sommerfeld theory, and yet, whereas the helium anomaly was of great importance in the crisis that about 1924 eroded confidence in the theory, the two other anomalies played almost no role at all. They were largely ignored or assigned very little weight.

We have a similar case in the theory's failure in accounting for the covalent bond that keeps atoms together in molecules, a failure that was evident as early as 1915 but with no serious consequences for the theory. The sustained impotence in the area of molecular constitution was of no importance in the crisis of the old quantum theory. It was of importance in the reputation of the theory in chemical circles, but that was something few physicists cared about. They chose to disregard the problem, leaving it to the chemists.

Confirmation for the wrong reasons

Some of the successes or confirmations were impressive and genuine, such as the series spectra of hydrogen and Bohr's interpretation of the Franck-Hertz experiments in terms of stationary states. But others were “confirmations for the wrong reasons,” so to speak, meaning that although they were explained beautifully by the theory, the explanation was wrong – which was only realized after the demise of the old quantum theory. This kind of apparent confirmation is of obvious interest to philosophers of science because it relates to the epistemic power of verification as relative to the power of falsification.

Let me briefly mention two examples of “confirmations for the wrong reasons,” both of which can anachronistically be seen as a result of physicists’ lack of knowledge of the electron’s spin before 1925. In their experiments with beams of silver atoms in a non-uniform magnetic field, Otto Stern and Walther Gerlach detected a splitting that later physicists would recognize as a result of the two spin states of silver’s valence electron, but at the time it was interpreted as solid confirmation of Sommerfeld’s space quantization in particular and of the Bohr-Sommerfeld quantum theory in general (Friedrich and Herschbach 1998).

We have an even more interesting case in the fine structure of one-electron atoms, which, as well known, was brilliantly explained by Sommerfeld’s relativistic generalization of Bohr’s theory, the fine structure arising from the variation of the electron’s mass in its orbit around the nucleus. To make a long story short, Sommerfeld’s complex calculations resulted in a fine-structure splitting that precisely matched the experiments made by Friedrich Paschen, and the case was consequently interpreted as both a striking verification of the Bohr-Sommerfeld atomic theory and the special theory of relativity. Planck described the theory as a “revelation,” and Einstein, in a letter to Sommerfeld, wrote that “Only now does Bohr’s idea become completely convincing” (Kragh 2012a, 163-164). Of course, with hindsight we know that the true explanation is to be found in Dirac’s relativistic spin quantum mechanics, which magically results in an expression for hydrogen’s energy levels that is *identical* to the one found by Sommerfeld (Vickers 2012).

The point is that Sommerfeld’s theory was right for the wrong reasons, not only qualitatively right but in quantitative details, and that, understandably, it was regarded a great triumph of the old quantum theory. Physicists at the time had no reason to suspect that the agreement between theory and data was fortuitous and the triumph thus illusory. Interestingly, the only one who pointed out the possibility was a philosopher, namely Bertrand Russell. Referring to the fine structure verification, he said: “A theory which explains all the known relevant facts down to the minutest particular may nevertheless be wrong” (Russell [1923] 1927, 88). And right he was.

Bohr’s theory of the chemical elements

Whereas the confirmations or successes mentioned so far were considered to be solid and genuine, others were of a more temporary nature and by 1924 they had disappeared from the list of confirmations. An important example was Bohr’s ambitious attempt to create an atomic theory of all the elements in the periodic table, something he invested a great deal of work in and optimistically thought would in principle reduce chemistry to atomic physics.

I will not go into this fascinating theory except pointing out that in the years 1921-1923 it was generally seen as promising and successful, and that it added to the feeling that the existing atomic theory had not yet run out of power. Bohr's new theory had a great deal of explanatory power and also, apparently, predictive power. The best known example is Bohr's prediction – or "expectation" as he cautiously phrased it – that the unknown element 72 should be a homologue of zirconium and not a rare earth metal, such as most chemists believed. The discovery of hafnium in early 1923 by means of X-ray spectroscopy apparently confirmed the prediction and therefore, again apparently, also the theory. At least, this is what the eminent physical chemist Walther Nernst thought. In a letter to George von Hevesy of 1923 he confided that had it not been for the discovery of hafnium, he would not have believed in Bohr's theory (Kragh 1980, 297).

The case is interesting not only because it is one more example of a theory leading to the right result for the wrong reasons, but also because it invites reflection on what a prediction is and on the difference between "predicting" something from a theory and merely "expecting" it. Whereas Karl Popper considered it a genuine prediction, his view has rightly been questioned by philosophers of chemistry (Scerri 1998; Kragh 2012a, 295-297). At any rate, by early 1924 Bohr's theory of the periodic system no longer held authority but was replaced by the better theories of Edmund Stoner and Pauli. What had looked like a success a few years earlier was not realized to be a mistake, a blind alley.

Other kinds of anomalies

Ordinary anomalies are such discrepancies between theory and empirical data that are known at the time of the theory and therefore may enter in the evaluation of the theory, either in isolation or in competition with rival theories. On the other hand, there are at least two other kinds of anomalies, one which might be called a "post hoc anomaly" and the other a "potential anomaly." There were in the old quantum theory a few consequences of the theory that disagreed with experiments but were recognized only after the crisis had culminated in the summer of 1925 and quantum mechanics had emerged. I have identified two anomalies of this kind, one relating to the dielectric constants and the other to the fine-structure components of one-electron atoms (Kragh 2012a, 350-351). In the latter case, according to the theory of Bohr, Hendrik Kramers and Sommerfeld a certain line called IIIb was expected to appear in the He^+ spectrum. The same kind of reasoning that successfully accounted for other of the fine structure components predicted the IIIb line, but in fact this line did not turn up in the spectrum. The missing line *could* have been recognized as early as 1919, and would then have been considered anomalous, but it went unnoticed until the fall of 1925 and thus did not contribute to the crisis of the old quantum theory.

My final example is superconductivity, a case which rarely appears in the context of the old quantum theory and in fact received scant attention by the core group of physicists engaged in atomic and quantum physics. But one can reasonably argue that it was an anomaly, or that it could or should be counted as such, namely in so far that it was seen as an effect of atomic structure (Kragh 2012a, 195-196, 263-264). Only few superconducting metals were known, and Heike Kamerlingh Onnes, the discoverer of the phenomenon, was eager to know why. He suggested that the electron structure of the metals was responsible and that Bohr's quantum theory of atoms might throw light on the problem. However, nothing came out of his suggestion. Superconductivity was obviously anomalous – it defied theoretical explanation – but at the time it was not clearly considered a quantum anomaly and for this reason the lack of explanation was not seen as a problem for the quantum theory of atoms. Physicists *could* have argued that the phenomenon was part of the domain of atomic physics and therefore constituted a challenge to Bohr's theory. But they did not, and so superconductivity remained a potential anomaly only.

Was there a crisis in atomic theory?

The crisis in the old quantum theory that in the late summer of 1925 led to Heisenberg's quantum mechanics has been much discussed by both historians and philosophers of science. According to Thomas Kuhn, "History of science, to my knowledge, offers no equally clear, detailed, and cogent example of the creative functions of normal science and crisis" (Kuhn 1970, 259). There no doubt was a sense of crisis in parts of the physics community in 1924-1925 when it became clear that the existing quantum theory had come to an end and that further search for substantial progress within the framework of the Bohr-Sommerfeld theory was futile. Specialists in quantum theory expected that the only way out of the crisis was to establish a radically new foundation of atomic physics, probably one where there was no place for electron orbits or similar visualizable models. And this is what happened.

However, although the perception of a serious crisis was real, it was far from shared by all physicists. To speak of a crisis in physics in general is a gross exaggeration. It was restricted to the relatively few who were actively engaged in foundational research related to atomic structure, hardly more than two dozen. Even Sommerfeld did not identify the situation leading up to quantum mechanics as a crisis preceding a revolution. As he wrote in 1929, quantum mechanics "does not signify a revolution, but a joyful advancement of what was already in existence" (Sommerfeld 1929, v). Neither did Einstein consider the turn to quantum mechanics revolutionary.

And Bohr? He seems not to have shared the feeling of crisis to the same extent as, for example, Pauli and Heisenberg. To be sure, in a letter to his Swedish friend Carl Oseen written in January 1926 he said that atomic theory had "passed through a serious crisis in these last years" (Stolzenburg 1984, 238). But although using the term "crisis," he did not see the new quantum mechanics as antithetical to the old theory. His beloved correspondence principle secured a natural transition between the two theories. As he wrote in a slightly earlier manuscript, "the whole formulation of quantum mechanics may well be regarded a sharpening of the content of this principle" (Kragh 2012a, 355). He may have agreed with Sommerfeld's view that the quantum revolution was a "joyful advancement of what was already in existence." Thus, the two founders of the old quantum theory of atomic structure tended to emphasize continuity rather than discontinuity in the process that led to the new physics.

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New Phase in History of the Weber - Fechner Law

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The short foreword

Research of activity of sense organs is of great importance not only for medicine and physiology, but also for philosophy. It is not the big exaggeration to tell, that a line of the most active struggle of idealism and materialism lies exactly here. Throughout two last centuries scientists have strongly moved ahead in this area. There is a set of proofs to that, and Nobel Prize in 2004 there is a bright demonstration to that. From this point of view the history of the Weber-Fechner law is interesting and instructive certainly.

Successes of the 19th century

In 1834 the German anatomist and psychologist E. H. Weber (1795 - 1878) has presented outcomes of his research of the activity of sense organs. He studied a differential threshold of sensation by sense organs, i.e. he was interested, what minimum change of stimulus will be remarked by man-observer. For example, he has found out, that the addition of one candle to sixty burning candles allows to detect increase of intensity of stimulus, and the addition of one candle to 120 burning candles appears poor for fixation of increasing of stimulus brightness. In the presence of 120 burning candles for detection of increase of intensity of stimulus, it was required to add, as minimum, two candles, and in the presence of three hundred candles – five candles. Weber has concluded that two signals can be distinguished from each other, if the difference between them is proportional to their value. So, Weber's rule is such
$\Delta I/I = const$ (1)
where I is stimulus intensity, ΔI is a value of the differential threshold, which being added to stimulus intensity I, will call a hardly discernible difference in sensations and the numerical value of a constant (const) depends on that, which sensory system is investigated. Weber investigated hearing, vision and touch.
The mathematical rule, formulated by Weber, has not broken norms of medical habitualness (has not upset paradigm, which was adopted in medicine and in physiology) and has not become a source of stinging debate. Experiment of Weber was simple and clear, and his outcome became a base for all following researches in sensory physiology.
The situation has been changed, when the physicist, philosopher and physiologist Gustav Theodore Fechner (1801 - 1887), the contemporary of Weber, has published the book under the title «Elemente der Psychophysik» (1860). Essence of the Fechner's making is extremely simple from the mathematical point of view: he has integrated the ratio obtained by Weber and has deduced the following formula
$\Psi = \chi \log (I/I_0)$ (2)

where Ψ is sensation, χ is a constant, I has the same meaning, as in Weber's rule, and I_0 is the intensity of stimulus in conditions of the absolute threshold of sensation (Fechner 1860). Formula (2) is called the Weber-Fechner law. It became the fundamental law of psycho-physics and one of fundamental laws of general sensory physiology. From a stand of world outlook, the formula (2) represents for the physiologists and doctors something so grandiose one, that it remains as a object of debate until the present day.

The hard discussion of this formula began at once after the publication of Fechner’s book. It was started by those who were sure, that the sensations are not a subject for any measurements. The formula (2) has represented the mathematical method for ordinary research of mental process!!! It could not been accepted by all who stood on idealistic stands, thinking that mental processes can not be a subject of measurement at all. But even for those who thought differently, the Fechner formula has appeared unusual because of usage of logarithmic function.

Maybe, it is not so important already, whether Fechner was a fine argumentative person (controversialist, eristikos) naturally or he has been steeled and has been formed by the conditions of boiling of passions around his book, but in the discussion, where he was always a victor, the phrase was born, which was stored by history of science: “The Tower of Babel was never finished because the workers could not reach an understanding on how they should build it; my psychophysical edifice will stand because the workers will never agree on how to tear it down”.

Fechner has not taken into account that the scientific idea appears in one head. The head of his contemporary, French-man M.H. Plateau, was exactly such a head. The objections of Plateau were been essentially addressed to Weber, but not to Fechner. However Fechner has accepted the impact upon himself.

As distinct from Weber, Plateau was sure, that in sensory processes the ratio of sensations is a constant, if ratio of acting stimuli is constant. In this case, sensation is determined by a power function of stimulus (Plateau 1872).

The debate in the 19th century was finished by Fechner’s victory, and the Weber-Fechner law became the basic law for 5 sense organs

Events of the middle of the 20th century

The published article of Plateau has attracted the attention occasionally. In the middle of 20th century Stevens S.S. has attempted to give it an experimental verification.

In September 1960 in Chicago, the centennial symposium honoring Fechner was held. The American Psychological Association and Psychometric Society sponsored it. The main report was made by Stevens S.S., director of Psychological Laboratory of the Harvard University. In 1961, his report in the adapted form was published in the journal “Science” (Stevens 1961) with a tendentious title «To honor Fechner and repeal his law» with the subheading «A power function, not a log function, describes the operating characteristics of a sensory system».

In the beginning of the article, Stevens honored Fechner and unique traits of his character, and then he has presented entity of a problem, which is bound with the formula (2). He has paid attention that any "opponents" of Fechner could not adduce essential experimental arguments against his formula. It was made by himself

Stevens on the basis of his own experiences one hundred years after appearance of the Fechner formula.
Stevens studied 9 stimulus: electric shock (~ 60 Hz), warmth, lifted weights, pressure on palm, cold, white noise, tone (~ 1000 Hz), white light. He used the scale log-log for his experimental outcomes. The intensity of stimuli was given in arbitrary units on the abscissa. The sensation intensity, which was investigated, was given on the ordinate axis. Intensity of sensation as a function of stimulus intensity was a straight line. The fan of straight lines in figure has shown that all these processes are quite satisfactorily described by a power function
$\Psi = m (I – I_0)^n$ (3)
where the above-mentioned symbols are used, m and n are constants.
For electric shock (~ 60 Hz), warmth, lifted weights, pressure on palm and cold, the range of stimulus was equal to one order of magnitude, i.e. the stimulus has changed not more, than 10 times during experiment. For vibration (60~), the range was equal to 1,5 order of magnitude, for white noise and 1000~tone it was two orders. And only for white light this value was equal to 3,5 order. In figure was the broken line, which corresponds to n = 1, i.e. it is a linear function. From figure was evident among nine effects, studied by Stevens, eight have power n < 1, and only for electric shock n > 1.
For the tenfold change of a parameter, desire of the experimenter to present outcomes of experience in linear coordinates would be quite normal. It was made by myself for power functions with n = 0,33; 0,5 and 1,2 (all three values correspond to Stevens experiment. The result was such: at tenfold change of stimulus, the power functions with the exponent 0,33 < n < 1,2, can be quite satisfactorily described by the linear function with different coefficient of proportionality. The problem of legitimacy of linear approximating of outcomes can arise only at the smallest values of stimulus. But such measurements in physiology are specially difficult and are made not often. Usually physiologist works at any average values of stimulus, when it is possible to expect the best repeatability of outcome and to claim large accuracy of outcome.
It is impossible to distinguish between the linear dependence and power function as well, if the exponent is less than 1,2. These functions are quite reliably distinct, if the power n is much higher than unit (2, 3 etc.) So for tenfold changes of parameter, mathematics does not allow to consider Stevens' power functions as a convincing advantage before a linear function for approximation of experimental data.
The range of change of stimulus in Stevens's experiments is too small (an eye works in a range of change of stimulus on 10-16 orders, and an ear works on 6-9 orders) and is insufficient for repeal of the Weber-Fechner law. Stevens did not manage to cancel the logarithmic law.
What was possible? Fechner has been separated from Weber. So the separate Fechner law has appeared, which one was called in the publications a dubious, shady, notorious and so-called law. A word "law" was taken in an inverted commas. It was possible to put at the same level the Weber-Fechner law, power function of Stevens and linear dependence. Formula (3) can be found in any modern textbook on psychophysics and sensory physiology alongside with the Weber-Fechner

formula. Thus this branch of science has appeared a field for voluntarism: each experimenter approximated his outcomes by any function.
I will give 2 examples to show, how the relation to the Weber-Fechner law has changed after the Chicago anniversary.
The first example.
In 30-s' years of 20th century the teachers of Moscow schools told to pupils about Weber-Fechner law at lessons of biology.
The second example.
In the beginning of the 21st century the reviewer of the Russian journal «Successes of physiological sciences» declares, that «the mental act «sensation» is not subject for measurements and gradations».

Rigid dictatorship of thermodynamics
The hundred-and-fifty jubilee of publication of the Fechner book has been celebrated in Moscow Lomonosov University in December 2010. It has been shown, that the Weber-Fechner law is experimental acknowledgement of one of the most general laws of physics and cannot be repealed, because the law of conservation of energy cannot be repealed.
The end to voluntarism and derision of the Weber-Fechner law has come thanks to successes of thermodynamics of irreversible processes in systems under electromagnetic radiation. W. Wien, Lord Rayleigh, Max Planck (1914,1959), A. Einstein, S. Bose (1924) were the forerunners of this theory. The Nobel prize winner, Russian theoretical physicist L. Landau (1946) was initiator (founder) of new branch of thermodynamics of non-equilibrium radiation. Subsequent development of this branch of science has received in activities of M.A. Weinstein (1960), P.T. Landsberg (1980) and Yu.P. Chukova (1988, 2001, 2002, 2004,2010). They have shown, that efficiency of conversion of electromagnetic radiation energy in the Wien region is logarithmic dependence on absorbed energy.

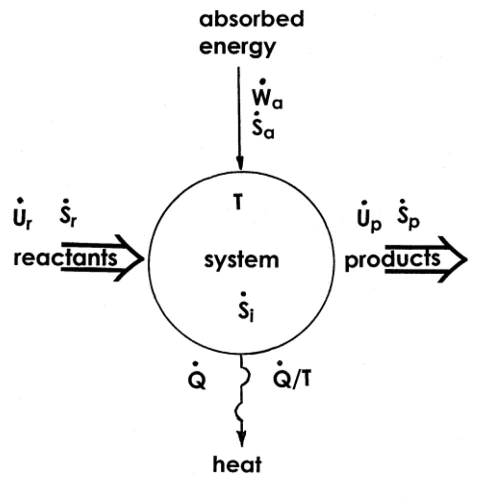

Figure 1

Considered by Chukova (1988, 2001, 2002, 2004, 2010) open thermodynamic system is given in Figure 1, were the following notation is used:

$\dot{W}_a$ is the rate of electromagnetic energy absorption,

$\dot{S}_a$ is the flux of entropy of absorbed energy,

$\dot{U}_r$ is the flux of the internal energy of reactants,

$\dot{S}_r$ is the flux of entropy of internal energy of reactants,

$\dot{U}_p$ is the flux of the internal energy of products,

$\dot{S}$ p is the flux of entropy of internal energy of products,

$\dot{S}_i$ is entropy generation rate due to irreversible processes inside the system,

$\dot{Q}$ is the flux of thermal energy ,

T is temperature of the system,

$\dot{Q}$/T is the rate at which the entropy of thermal flux leaves a system.

Let η be the efficiency of conversion of energy of electromagnetic radiation into other types of energy. On the basis of the law of conservation of energy and the law of increase of entropy for a stationary state of system it is received

$\eta = 1 - T (\dot{S}_a + \dot{S}_i) / \dot{W}_a$ (4)

Thermodynamics has the rule to begin the analysis with the case of reversibility of the process. In the event of thermodynamic reversibility of the process, the entropy generation rate is equal to zero ($\dot{S}_i = 0$). The efficiency of energy conversion in a reversible process is called the thermodynamic-limit efficiency and is denoted as η^*. In nature, reversible processes without losses are unavailable. But they are of great interest to the theorist, because they allow formulation of a upper limit for energy conversion.

These limitations can not be overcome by any way in systems, obeying the energy conservation law. Between all thermodynamic prohibitions, the best known is the limitation for a heat engine (the efficiency can not be more than unit).

For a reversible process, Eq. (4) gives the simple formula

$\eta^* = 1 - T \dot{S}_a / \dot{W}_a$ (5)

From this formula, we see that the thermodynamic-limit efficiency depends on the temperature of the system and the properties of the absorbed power. If they are known, the thermodynamic-limit efficiency can be calculated. The absorbed power is measured experimentally or may be calculated according to the formula

$\dot{W}_a = \int E_\nu d\nu$ (6)

where ν is the frequency and E_ν is the spectral density of the absorbed power. If E_ν is known, then the entropy of the absorbed power is calculated according to the Bose-Einstein formula for bosons

$\dot{S}_a = 2\pi k c^{-2} \int \nu^2 [(1+\rho) \ln(1+\rho) - \rho \ln\rho] d\nu$ (7)

where c is light speed, k is the Boltzman constant, h is the Planck constant and

$\rho = c^2 E_\nu / 2\pi h \nu^3$ (8)

is called the distribution function. It indicates the number of photons in the quantum state. Formula (8) is right for bosons. Bosons are the particles with integer spin and obey the Bose-Einstein statistics.
Formulas (4) ⍰ (8) allow to calculate the ⍰* for any frequency and spectral density of absorbed power. Using Eqs (4) – (8) as the basis, we can deduce the law of energy conversion which holds for electromagnetic radiation in the frequency range (0 < ν > 10^{22} Hz) (Chukova 1988, 2001, 2002 , 2004, 2010). The main result of this calculation is given in Figure 2.

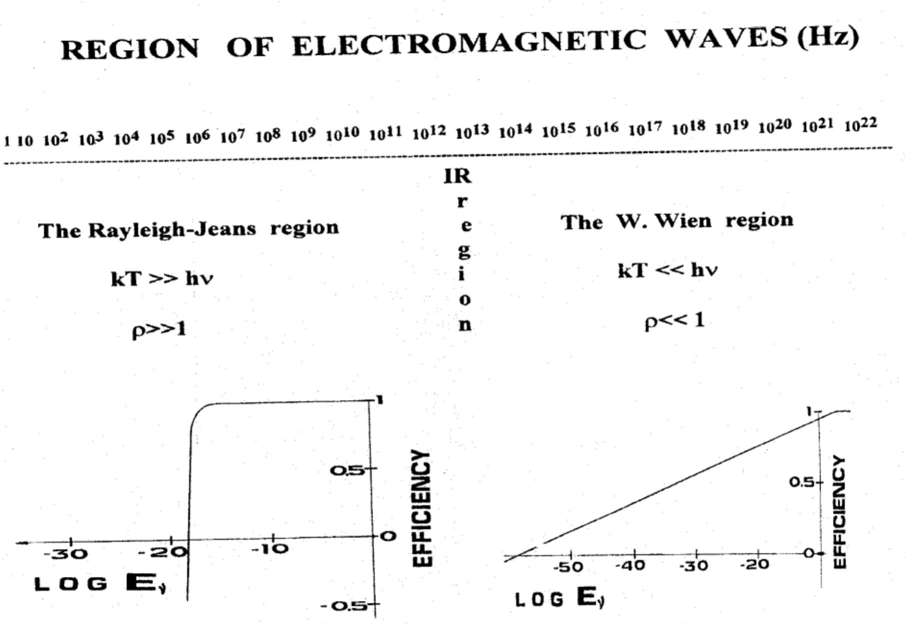

Figure 2

Figure 2 demonstrates, that there are two quite different regions of conversion of electromagnetic radiation energy. Both regions are known to physicists from times of the study of equilibrium thermal radiation (radiation of the absolutely black body). It is the region of the W. Wien laws (visible, ultra-violet, x-ray and gamma-radiation) and the region of the Rayleigh-Jeans law (all RF regions and extremely low frequencies). The IR radiation is boundary between these two regions. The division of the electromagnetic waves into these two regions is well-known to the experimenters by a ratio of a quantum energy of electromagnetic radiation hν and quantum of thermal oscillations kT. In the W. Wien region hν>> kT, and in the Rayleigh-Jeans region hν << kT. In the thermodynamic theory these regions differ by value ρ, which is much higher than unit in the Rayleigh-Jeans region, and is much lower than unit in the Wien region. In the intermediate infrared region ρ is comparable to unit.
The laws of efficiency of energy conversion in these regions are described by quite different functions. We see them in bottom of Fig. 2, where the log of spectral

density of absorbed power (spectral density of absorbed power is measured in J/см^2) is plotted along the abscissa axis, and thermodynamic-limit efficiency of energy conversion η^* is plotted along the ordinate axis. The dependence is given in each region for one arbitrary selected frequency.
In the Wien region, the function determining dependence of thermodynamic-limit efficiency η^* on absorption, is logarithmic function (straight line in semilogarithmic scale). If thermodynamic-limit efficiency has changed from 0 up to 1, the change of spectral density of absorbed power must be many tens of orders of magnitude. It allows an human eye to work over an extremely large range of change of stimulus (external parameter). In the Rayleigh-Jeans region, the dependence of η^* on log E_ν is very sharp and looks like a step (the Devaytkov law).
In the context of this paper, only visible light and near infrared radiation (the Wien region) are of interest. In this region the thermodynamic-limit efficiency of conversion of electromagnetic radiation energy η^* increases with increase of absorption according to the logarithmic law. It is the Weber- Fechner law for vision. In other words, the Weber-Fechner law is the experimental proof of more general thermodynamic law of conversion of electromagnetic radiation energy.

Conclusion

So, scientific debate, which lasts for a century and a half to the present time, applies to the formula, which is needed for quantitative estimation of sensations. Now formula (3) can be found in any modern textbook on psychophysics and sensory physiology alongside with the Weber-Fechner formula.
But the formula (3) has the right to stand near to the Weber-Fechner law only in one case, when an eye at transition from day illumination to the evening replaces the device of cones (day vision) with the device of rods (evening vision). The fundamental thermodynamic law demonstrates an influence of a wavelength on absolute value of energy conversion efficiency. The change of a wavelength of electromagnetic radiation changes a slope of a straight line (in semilogarithmic coordinates) significantly. This problem is considered in details in the book (Chukova 2010).
The Weber-Fechner law (as experimental confirmation of fundamental law of thermodynamics) can not be repealed, as the energy conservation law can not be repealed.

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The Past and the Future of Psychology: Students' Conceptions

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Introduction

Empirical sciences tend to consider history of the science as of minimal importance or in the very least as of lesser importance than the issues with which that science deals. This is understandable in view of the explicit goal of science to increase the amount of available information about that section of reality to which that science is devoted. History is considered as irrelevant to that goal, possibly even as a kind of distraction from the major objectives of the science. Psychology is apparently not different in its approach from the other sciences. Indeed, psychology may even be more extreme in its attitude to history both because it is a relatively young science, and because of its effort to establish its legitimacy in the scientific forum.
The curriculum of psychology in different universities has sometimes included a course about the history of psychology, which however was never obligatory and rarely crowded. In recent years there was been an awakening of interest in the history of psychology, manifested also in the establishment of a journal by the APA devoted to this theme (Pickern 2013).
However, even a cursory examination of the history of the physical or biological sciences reveals that not infrequently it may contain insights that shed light on the present development of the science and the controversies exciting its proponents (e.g., Hagen, 2000; Sherwood, 2011)
The major question that has inspired the present study was whether the history of psychology could be of any value in shedding light on the development of this science in the present. A positive answer to this question could help to provide a basis for considering the history of psychology as an important resource for present-day scientists in psychology.
Some notes about the history of psychology
Psychology as the discipline of studying mental and psychic processes has its early recorded beginnings in ancient Egypt, Greece, China and India (Murphy and Murphy 1969). Its later development occurred in the Western and Eastern cultures in the framework of philosophy. Theoretical models and philosophical reflections were complemented and largely replaced by the modern empirically grounded approach which started at the end of the 19th century. The official date of birth of psychology as a modern science is 1879, the year that the first laboratory of experimental psychology was founded in the university of Leipzig in Germany by Wilhelm Wundt, who is considered as the founding father. If that act by him would not suffice for justifying his title as the founding father, it may additionally be mentioned that he also wrote the first textbook of psychology, and was the first scientist who presented himself as a psychologist (Kimble and Schlesinger 1985; Munger 2003).

From the very beginning of the new science, two major trends became evident. These were the experimental trend representing the "hard" science, and the humanistic trend representing the applied "soft" science.
The "hard" science was based on experiments, and proclaimed empirical research and evidence-based facts as the basis for any conclusions or findings. Four different groups can be identified within this trend. The first is the experimental group that focused on studying the inner world, with an emphasis on perception, memory, cognition and beliefs (e.g., Titchener, Weber, Fechner). The second is the experimental group that focused on studying behavior (e.g., Watson, Pavlov) and generated the approach known as "behaviorism". The third is the experimental group that focused on studying physiology (e.g., Helmholtz, Wernicke, Broca, Charles Bell). The fourth group of empirically-devoted investigators focused on the mathematical approach and developed a rich array of statistical tools for the young science of psychology (e.g., Galton, Thurston, Spearman) (Cowles 2001; Michell 1999).
Somewhat less variegated were the groups of psychologists who devoted themselves to the "soft" humanly relevant approaches. In this camp one can count the functionally oriented psychologists who focused on education, following Dewey and partly also Darwin, and mainly those who focused on the applications in the domains of personality, development and mental disorders. The latter group developed the theories of personality (e.g., Allport, Maslow, Maddi), of human development (e.g., Piaget, Erikson) and mainly dynamic psychology, clinical psychology and counseling (e.g., Freud, Adler, Jung, Carl Rogers) (Hothersall 1995; Nye 1996).

Hypothesis of the study

Thus, the major trends or schools in psychology have been present, side by side, from the beginning of the history of modern psychology. This state of affairs formed the basis for the concept that underlies our study. Studies show that on the individual level , conceptions of the past and the future are coordinated. Both form part of one's life narrative, in a form that manifests the determination of the future by the past as it is shaped by the individual (McAdams, Reynolds, Lewis, Patten and Bowman, 2001**;** Watson & Smith, 2001). Hence, it is possible that the situation is similar in regard to the sciences, so that conceptions about the history of a science may influence the conceptions about the present and the future of that science. Further, on the individual level, goals are the means through which an individual may influence one's future, so that goals constitute also the major process through which conceptions of one's past may affect the future. These considerations have led to the hypothesis of our study that the conceptions of psychology students about the history of psychology would be related to their conceptions about the goals of psychology in the future.

Method of the study

The participants of the study were 180 psychology students, in two academic institutions, studying psychology as a major discipline, in the 3rd-7th year of studies. The sample included 121 women and 99 men, in the age range of 21 to 27 years.

The tools of the study were questionnaires relating to views about the past and to views about the present. Questions about the history (the past, see set I of the questionnaires) focus on characterizing the approaches in terms of the following dimensions in regard to the two approaches: Coexistence; Animosity; Shared methodology; and Shared contents. Questions about goals (the future, see set II of the questionnaires) focus on goals in terms of the following dimensions: Methodology; Objective; Theoretical hegemony; Nature of theory.
The following questionnaires were administered:
I. Contents of the questions: Views about the past
A. Behaviorism and cognitive psychology
RATINGS 1 to 5 of the following
1. Coexisted or followed each other: Coexisted versus followed
2. Extent of animosity bet. proponents of each: Low versus High
3. Degree of shared methodology (empirical, interpretational): shared versus not shared
4. Degree of shared themes: many versus few

B. Psychoanalysis and clinical & medical psychology
RATINGS 1 to 5 of the following
1. Coexisted or followed each other: Coexisted versus followed
2. Extent of animosity bet. proponents of each: Low versus high
3. Degree of shared methodology (empirical, interpretational): shared versus not shared
4. Degree of shared themes: many versus few

II. Contents of the questions: Views about the present:
RATINGS 1 to 5 of the following:
1. Extent of applying only strict empirical methodology or also “softer” methods: exclusive empirical versus both
2. Extent of focusing only on pure science or trying to contribute to the welfare of humanity: pure science versus helping humanity
3. Extent of striving toward one theory or a combination of several: one versus combination
4. Extent of striving toward pure physiological approach or preserving some space for psycholgical processes: physicalism versus both

The procedure of the study consisted in administering the questionnaires anonymously to the subjects. All questions were included in one questionnaire. The order of the questions was random. The respondents did not know the hypotheses or objective of the study.

Results of the study
Correlations were computed between responses in regard to the dimensions of the history of psychology and the responses in regard to the dimensions of the goals. Significant correlations were found between the dimensions in regard to the past and the dimensions in regard to the future. These correlations are presented in Table 1.

Dimensions in regard to the past	Dimensions in regard to the future	Correlation coefficients*
Coexistence of approaches	Combination of theories	.61
Shared methodologies	Also "softer" methodologies	.48
Shared themes	Also psychological processes	.53
Shared themes	Also helping humanity	.49
Low animosity	Combination of theories	.42

*All correlations are p<.01

Table 1: *Significant correlations between the dimensions in regard to the past and the dimensions in regard to the future.*

The relations between the responses concerning the past and the future enable suggesting a binary typology of approaches to psychology. The approaches may be labeled "scientific" versus Liberal/humanistic. The typologies are presented in Table 2.

Typology Type 1: "scientific"	Typology Type 2: Liberal/humanistic
Focus on promoting a strictly empirical and mathematical methodology; Avoiding the qualitative “softer” methodologies; Restricting psychology to scientific goals, avoiding applications for serving humanity; Striving towards one basic theory; Promoting reductionism to physiology.	Focus on combining different methodologies, reserving space for the “softer” interpretative and qualitative methods; Focus on applying psychology to promoting human welfare; Focus on combining different theoretical approaches; Avoiding pure physicalism

Table 2: *Typologies of approaches to the science of psychology*

Discussion and Conclusions

The results of the study show that the approaches and models used in constructing and teaching the history of psychology have implications in regard to the shaping and development of psychology in the present and future. What the students believe about the past contributes to the construction of the goals they see for the future of their science. Hence, it is of importance to teach the history of psychology and to construct the textbooks and syllabuses of the courses about the history of psychology in a form that could contribute to the envisaged development of the science in the future.

Another important conclusion of the study concerns the tendency towards the emergence of two kinds of typologies in psychology. The first, which we called "scientific", is characterized by being strictly empirical, theoretically homogenous, reductionist (physical or physiological) and with restricted applications. The second,

which we called "liberal/humanistic", is characterized by a diversity of theoretical approaches, a tendency to complement the quantitative methodology by the qualitative ones, and by the salience of a rich variety of applications, ranging from education, counseling and coaching to clinical and health psychology.
As noted, the two described trends have originated in the early beginnings of modern psychology and they are further developing at present, rooted in the historical conceptions of the past.
It is however of interest to note that there may be two types of students or investigators who tend to study, research or handle the applications of each of these two trends of psychology. A recent study provided information supporting this conclusion (Kreitler and Weissler Unpublished Manuscipt). Students who expressed their interest in one or the other kind of psychology were administered the Meaning Questionnaire which assesses tendencies in regard to cognitive contents and processes. The results showed that students who prefer the "scientific" approach are characterized by cognitive tendencies focused on quantitative aspects, causality, results and implications, structure and comparisons. In contrast, those who prefer the liberal/humanistic kind of psychology are characterized by cognitive tendencies focused on emotional, cognitive, evaluative and sensory aspects as well as relations of time and space. These preliminary findings complement the findings reported in the present study about the relations between conceptions of the past and goals for the future, by adding the personal perspective to the historical one.

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The History of Ideas "the optical disc as a "unique" carrier of information in the systems management"

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Storage Media – a machine recording medium body, a substance used for recording and storage of information in order to directly enter it in the computer. It is the interface between the machine and the source documents with numerical data, text, diagrams, schedules, etc. A device for recording media are distinguished by the physical structure (magnetic, semiconductor, dielectric), the type of material (paper, plastic, metal, combined), the template (printed, handwritten, magnetic, perforations), the principle of reading the data (mechanical, optical, magnetic, electrical,), type (tape, disk, card).

60-70-ies of the twentieth century marked by the creation of territorial, national and international computing. There was a need for external storage devices. The development of lasers provided the appearance of optical storage media. First digital compact disc – optical information carrier in the form of a disk, which enables reading and writing data using a laser was invented in the 1965 American researcher J. Russell. He was used for storing audio digitally. During 1977-1978 Philips and Sony got permission to develop the digital compact disc, similar to a Russell's CD. During this time the on Tokyo audio output rate was presented a prototype of an audio CD Mitsubishi, Hitachi and Sony. In the first Soviet-American seminar in Washington DC Representative Research Center of IBM R. Landauer in the report "Optical logic and memory with an optical sampling" praised the use of lasers in communication devices, information processing and optical storage [Gibin, 1976, 7].

In the 70-ies of the twentieth century already there are different media (magnetic disks, tapes and cards, punch cards and paper tape, optical media) and a large number of devices with different productivity, working with them. Recording media were inconsistent and a lot of time was spent on sending information from one storage type to another. Therefore, there is a need for information storage media using generic "common" media.

Experience with optical media and data storage devices (starting with the 60-ies of twentieth century) as well as an analysis of the optical data recording methods allow 21-25 June 1977 at the World Electrotechnical Congress in Moscow N. V. Gorshkov (1927-1995) and V. V. Petrov (geb. 1940) put forward the concept of an optical disc as a "unique" media. The report, "An optical disc as a "unique" media management systems", they noted that a goal is paying attention to what's nearby with a significant expansion of the range of computers and external storage devices is rapidly increasing the number of types of non-interacting media, which are used for external storage devices [Gorshkov, 1977]. This creates great difficulties in communication, resulting in a need to have additional equipment for its implementation. All this leads to the idea of the feasibility of establishing a universal, "single" media, was widely s use of which would develop external storage devices and other peripherals of computers that meet the basic requirements of modern requirements and in the near future" [Gorshkov, 1977, 1].

Figure 1: *Academician of the National Academy of Sciences of Ukraine V. V. Petrov*

In the report, they will consider whether the main requirements for "unified" storage medium for use in external mass storage management systems, computer systems in data acquisition and processing of information in electronic computers middle and even low productivity in the training data and for the exchange of data between electronic computers the same and different productivity. Authors determined the cost, size and shape of a "single" media.

V. V. Petrov and N. V. Gorshkov noted that such support should be available to a person in connection with the trend of building large data banks. For this purpose it is necessary that its value was less than the value storage on paper, i.e. not more than 5.2×10^{-8} rubles / bit. This, in turn, is possible in the case where the data recording medium is due to the energy fields or radiation using common to a large number of media address, which is part of the same external storage devices.

The report noted that the capacity of the media must be at least 10^{10} bits of its use in the development of advanced external storage devices. Otherwise - would increase the cost of storage. This meant that it could record the information that is contained in 500 volumes of 500 pages, or all the information that is given in s in all kinds of publications per year, the All-Union Institute of Scientific and Technical Information of the USSR.

Given the established conditions regarding the cost and capacity of a "single" media, N. V. Gorshkov V. V. Petrov determined that to ensure minimum access time - namely, 0.1, this support should take the form of a rotating disk, which moves along a radius of one, several or more of the real estate hub of energy. "To implement the automatic change of media devices in the external mass storage device - they wrote -"single"carrier should consist of no more than one disk, have a Displacement surface, and for ease of Article working with him in the devices collecting and preparing the data it should have a diameter not exceeding 200 mm ... 400" [Gorshkov, 1977, 9]. Data transfer rate in such a carrier should be 2-5 MB/s on one channel, which is significantly greater than the best transmission data at the time of disk drives (1-1.5 MB/s).

The report also addressed the issue of necessary presence of the recording medium overwriting data for a universal, "single" media. They concluded that this support should have a recording medium without overwriting data, because the medium has a rewritable information storage it less reliable, the process for rewriting need more sophisticated equipment, overwriting the value of the carrier is much larger and because the in systems designed to store large amounts of data overwriting of data are rare [Gorshkov, 1977, 10-11].

Also consider additional requirements for such carrier:

1. the average density recording 2–6 10^5 bit/s
2. the use of external storage devices capacity 10^{12}–10^{14}bit
3. high reliability and long time storage 5-10 years
4. the possibility of its use in the simple and complex devices
5. possibility of replication
6. single-stage process of recording information
7. standard location data [Gorshkov, 1977, 11-12].

The report will note that at the time was not created any device using an optical disk as a universal, "single" media and a lot of material in the report than have posed character." "Using the optical disc as a "single" media management systems in large computing systems and networks, electronic computers, and even the average low productivity - they wrote - can lead to substantial progress in the technique of external devices" [Gorshkov, 1977, 21]. That, in turn, will increase more than two orders of the recording density information and several times the data rate on one channel in comparison with the existing time, magnetic disk drives, use as the primary media optical disk which is convenient for computing machinery for a wide range of consumers, reduce and make more flexible range of external devices of computers and simplify the exchange of data within and between electronic computers; introduce optical disk as an official document, expedite and simplify information and management systems.

The use of a "single" in the external media storage devices has increased the amount of stored data, coordinate and significantly increase the reliability of the transmission and reception of data, simplify the structure of the steering system. The discovery of large magnetoresistance in magnetic multilayer (1988 A. Fert in Fe/Cr [Fert, 2008] and the German physicist P. Gruenberg in Fe/Cr/Fe [Gruenberg, 2008]) provided a more dense writing data to disk. This turn, increased the external storage technology consumer electronics.

In the early 1980s. CD-ROMs increased lsya. Most of the composition or digital audio discs CD-A - 52%, while the volume of distribution of video on CD-ROM - 8%, and computer information - 40%. In the late 80's - early 90's. there is a need to increase the amount of memory in the pervasiveness of multimedia applications (educational programs, information and reference materials, etc.) that may be presented by a complication of the software. As a result of increased production growth rate CDs CD-ROM (Table 1).

Types of CD/Years	1992	1994	1999	2002
CD	1280	2200	8900	9000
DVD	–	–	320	1600
CD-R	1	40	1200	5600

Table 1: *Annual sales of CDs of various types million pieces*

Today, the concept of a universal, "single" media a lot in common with than a standard CD, which exist in the twenty-first century. (Table 2) [Petrov, 2004, 9].

Characterization	"single" standard media	CD
The cost of storing information	$(8–20)\cdot 10^{-7}$ cent/bit	$(2–20)\ 10^{-7}$ cent/bit
capacity	10^{10} bit (1250 Mbite)	650 Mbite
The access time	0,1 sek	0,3 sek
The average density recording	$(2–6)\cdot 10^{5}$ bit/мм^{2}	$(5–6)\cdot 10^{5}$ bit/мм^{2}
The speed of data exchange	1–5000 Кbite/s	6000 Кbite/s
The diameter of the disc	200–400 мм	120 мм
Ability to perform in a mass storage system	yes	yes
possibility of replication	yes	yes
High mechanical strength	yes	yes
The possibility of recording information in real time	yes	yes

Table 2: *Comparison of characteristics proposed in 1977 a "single" standard media and CD [Gorshkov, 1977, 10]*

In Ukraine, now working in the field of optical storage are concentrated at the Institute for Information Recording of the National Academy of Sciences of Ukraine. It was created in 1987 to improve work in the field of data storage devices, works on the physical foundations, principles and methods of optical recording media and optical data storage media for electronic computers, information systems store and process large amounts of information.

Optical discs are widely used for storing and transferring data. In September 2011, Sony is developing a system Disc Archive Storage System - a system archiving video on arrays of optical discs. Such a system will consist of a cartridge 12 with the optical disc. Proposition issue for write-once cartridges and toner possibility of multiple rewriting with capacities ranging from 300 GB to 1.5 TB.

Figure 2: *Disc Archive Storage System*

At the beginning of the XXI Director of the Institute for Information Recording of NAS of Ukraine V. V. Petrov, and members of the Institute have pointed out that "despite the increasing use of computer networks for the transmission and receipt of information, the role of the CD as a means of paperless information dissemination in the next decade will increase. Edition on CD-ROM journals, information and reference materials, textbooks have become a reality of our time" [Petrov, 2003, 181-182].

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Sony announces next generation video archive storage system at IBC Disc Archive Storage System set to revolutionize video and data archive storage market: http://www.sony.net/SonyInfo/News/Press/201109/11-108E/index.html

History of Russian Computer Science

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The study of the history of science, familiarity with the life and activities of outstanding individuals – scientists, engineers, inventors, has always been an important part of the cultural and scientific heritage.
In the middle of the 20th century, a new stage began in the development of science, and, as we can say, in the history of human society! That was – the invention of electronic computers, the unprecedented pace of their improvement and dissemination, the creation of global information networks, as well as new means for storage and processing of huge amounts of data.
New information technologies have a strong influence on the society. The Computer Science presents one of the highest achievements of contemporary scientific mind. The widespread use of computers and networks has a major impact in all aspects of human life. The knowledge on formation and development of computer and information sciences in different countries is of great value. Acquaintance with the historical events and distinguished individuals bringing this field to the state-of-the-art progress will provide for better mutual understanding and partnership.
Nevertheless, there exist many blank spaces on the map of historical development of Computer Science. Thus, Professor P. Edwards wrote in his article “Making History: New Directions in Computer Historiography” (“IEEE Annals of the History of Computing”, 2001, N 1):

> Most historiography in English has focused on the United States … But European, Japanese, and Soviet computing have their own independent stories … As computer networks link the entire globe, understanding the spread of computer technology and the contributions of lesser-known participants becomes increasingly crucial to a full grasp of computer history. This is a colossal and difficult task, beyond of reach of any individual. In the future, I hope we will see more team projects and edited volumes comparing, contrasting, and linking the history of computers and networks around the world.

Unfortunately, the history of Russian Computer Science until now was almost unknown in the West. Meanwhile, this history is rich in remarkable scientists and outstanding events.
Of particular interest is the initial period of formation and development of Cybernetics in Russia. This period coincided with the establishing of the Siberian Branch of Russian Academy of Sciences, and building of a new scientific center in

Siberia, near Novosibirsk. We call our new “science city” *Academic Village* (*Academgorodok* in Russian).
The decision on the establishing of Siberian Branch has been taken in May of 1957. The foundation of the town and the building of its first stage (several Institutes, the University, the schools and some residential districts) was realized in the beginning of the 1960s. At that time there have been created here for the scientists and their disciples more favorable conditions than they were then in the center of the country. A number of prominent Soviet scientists, like Aleksey Lyapunov, Leonid Kantorovich, Andrey Ershov, and others, working in the field of mathematics, and cybernetics moved here from Moscow and Leningrad.
Aleksey Lyapunov (1911–1973) called “the father of Russian cybernetics” descended from an old nobel family which made great contribution to the world culture. He was a distinguished mathematician, a specialist in the theory of sets. However, the range of his interests was so widespread that he can be rightfully named a person of enciclopaedic knowledge.
In the history of Russian science, Professor Aleksey Lyapunov occupies a particular place in connection with his activities in defending cybernetics and genetics.
In those hard years, when cybernetics was suppressed in the USSR, Professor Lyapunov, in the 1954/1955 academic year organized at the Moscow University a Seminar on cybernetics. This Seminar attracted, from the very beginning, great attention of different specialists. During ten years (1954–1964) a total of 120 sessions of this famous “Big” Lyapunov's Seminar was held.
In the 1952/1953 academic year Lyapunov presented to the students of the Moscow University a brief course (from just eight lectures) entitled “The principles of programming”. It was the first course on programming in the country which played a fundamental role in the development of this new field of knowledge.
In 1955, Aleksey Lyapunov (together with Sergey Sobolev and Anatoly Kitov) published in the journal “Problems of Philosophy” the first officially permitted positive article on cybernetics in the USSR entitled *“The Main Features of Cybernetics”*. Indeed, this publication marked the beginning of the early period of cybernetics in the USSR.
Beginning from 1961 Professor Lyapunov lived in Novosibirsk and worked at the Siberian Branch. This was one of the most fruitful periods of his life. Aleksey Lyapunov was an outstanding pedagogue, and a propagandist of scientific knowledge. His interests in this field covered the teaching at all the levels of education, from the primary school to the University.
Aleksey Lyapunov obtained international recognition. In 1996 the IEEE Computer Society honored Lyapunov as a *“Computer Pioneer”.*
A brilliant mathematician and economist *Leonid Kantorovich* (1912–1986) was, like Norbert Wiener, a child prodigy. At the age of 14 he enrolled at the Leningrad University and at 18 graduated from this University. At 20 he became a Professor. At 27 Kantorovich published his famous book, which contained the basis of “linear programming”, the mathematical theory that established a new line of mathematical economics. In 1975, he was awarded the *Nobel Prize* in economics.
Andrey Ershov (1931–1988) graduated from Moscow University in 1954. It was the first group of graduates of the new specialty “Programming”. Ershov’s post-graduate

studies was held under the supervision of Professor Lyapunov.Thanks to his brilliant works, Ershov pretty soon became one of the leading Soviet programmers. In 1960, he moved to Novosibirsk Academgorodok.

Eershov's special merit was his constant concern for international cooperation in the field of Computer Science. He took an active part in international conferences and the works of IFIP. He was a frequent guest to the European and American Universities.

In 1974 Ershov's works were marked by awarding him the honorary title of *"Distinguished Member of the British Computer Society".*

The establishing of the Siberian Branch as well as the creative work of scientists of this new scientific center during the following years was of great importance to the history of computer science in Russia (Soviet Union). Looking at these events in detail one can realize a principal contribution of Siberian scientists to the automata theory, theory of computing systems, parallel and distributed computing technique, theoretical and applied programming, etc.

It is well known that in the 60s the Siberian Branch attracted great attention of the world scientific community. In the Siberian Branch, from the very beginning, priority was given to the development of computational mathematics, mathematical modeling, computer technology, programming. The latest models of domestic computers have been working here.

Formation and development of Computer Science in our country has been inseparably linked with the Siberian Branch, with its main goals and objectives. Siberian scientists in the 60s and 70s played the leading part in the development of the most important chapters of Cybernetics (Computer Science), in the promotion of this new science, and the wide use of its achievements.

Here, since 1964, the members of the *Computing Center* of Siberian Branch (renamed later to the *Institute of Computational Mathematics and Mathematical Geophysics*), systematically carried out important research in Computational Mathematics and Computer Science.

Not surprisingly, it was here where an initiative appeared of study and dissemination of knowledge on the history of Computer Science.

Our first monograph *"Essays on the History of Computer Science in Russia"* was prepared and published in 1998. In essence, it was the first serious work on the basic problems of formation and development of domestic Cybernetics and Informatics. The presentation of this book took place in November of 1998 in Moscow, at the State Polytechnic Museum, during the "Wiener Readings" devoted to the 50th anniversary of the publication of Wiener's "Cybernetics". Here, the leading Russian scientists and their foreign guests shared their memories and experiences at the same Large Auditorium of the Museum where in 1960, during the First Congress of IFAC, Norbert Wiener himself spoke.

The book "Essays on the History of Computer Science in Russia" was favorably received by the readers and experts. Professor S.S. Demidov wrote in the journal "Problems of the History of Science and Technology":

> On the one hand, this is a historical work, the first experience of writing the history of domestic research for one of the most important branches of modern knowledge ...
> On the other hand, it is a human document, filled with the breath of history ...

Since then, the work on the study of history of Computer Science in our Institute continued.
In the Siberian Branch, we regularly publish a series of scientific-biographical monographs under the common title “History of Computer Science”. As for today, we have published 11 books, the main content of which is the biographies of Russian and foreign scientists, the famous heroes of the history of Computer Science:
Essays on the History of Computer Science in Russia. – Novosibirsk, 1998. – 662 pp.
Kolmogorov and Cybernetics. – Novosibirsk, 2001. – 159 pp.
Aleksey Andreevich Lyapunov. – Novosibirsk, 2001. – 524 pp.
Leonid Vital’evich Kantorovich: a Man and a Scientist. Vol. 1. – Novosibirsk, 2002. – 544 pp
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Remembering Aksel Ivanovich Berg. . – Novosibirsk, 2010. – 168 pp.
Aleksey Andreevich Lyapunov. 100th Anniversary of the Birth. – Novosibirsk, 2011. – 587 pp.
Naturally, these books are published in Russian. However, an English translation of the *Summary, Foreword and Contents* is included in each volume. In addition, we are printing an annual booklet (in English)[1], which contains these brief details of all published books. Apparently, the reading of these reference material is sufficient to get an idea of the corresponding Russian book.
Our books contain a collection of authentic essays, reminiscences, interviews and other historical documents. A number of materials (including photographs) were obtained from private archives of such famous scientists as Aksel Berg, Aleksey Lyapunov, Andrey Ershov, and others. These materials pertain to the leading Russian scientists who were in the middle of the 20th century in the front line of development of Computer Science and Computer Technology in Russia.
Special attention is paid in our books to the humanistic problems of scientific research. When evaluating our heroes we pay utmost attention not only to their scientific achievements, but also to their human qualities: their behavior, their actions, their respect to other people and events.
New information technologies have a strong influence on the society. They can bring people prosperity, physical and spiritual well-being. They pave the way to unprecedented opportunities for development of all areas of human activity.

[1] *Book Series “History of Computer Science”* / Ya. Fet (ed.) – Novosibirsk, 2013.

Unfortunately, the achievements of information technologies, like some other results of scientific and technical progress, have also their reverse side.
The creator of cybernetics Norbert Wiener was well aware than the new means of communications and the mass media can turn to the people their dangerous consequences. Even at the down of computers, in 1948, in the first edition of his famous book “Cybernetics” Wiener wrote[2]:

> One of the lessons of the present book is that any organism is held together in this action by the possession of means for the acquisition, use, retention, and transmission of information. In a society too large for the direct contact of its members, these means are the press, both as it concerns books, and as it concerns newspapers, the radio, the telephone system, the telegraph, the posts, the theater, the movies, the schools, and the church…
> That system which, тore than all other, should contribute to social homeostasis is thrown directly into the hands of the most concerned in the game of power and money, which we have already seen to be one of the chief anti-homeostatic elements in the community.

Today these dangerous phenomena have become threatening. The uncontrolled use of the media in the interests of commercial structures leads to the fall of morality of the population. These phenomena can be seen as one of the important challenges facing the society.
It is not the first time when history poses to the reasonably minded scientists certain complicated tasks related to the protection of society against various threats. It is appropriate to recollect here Aurelio Peccei (1908–1984), the recognized scientist and humanist who founded in 1968 the “Club of Rome”, one of the most powerful democratic movements of the 20th century. The main objective of the Club was to attract attention of the world community to the global problems threatening the existence and well-being of the mankind. One of the first so-called “Reports of the Rome Club” considered environmental hazards associated with unnecessarily high consumption of natural resources and the pollution of the environment.
Peccei invited a number of prominent scholars and public figures to participate in these studies. They were highly qualified people sincerely interested in developing effective means to address these issues.
The “Reports of the Rome Club” attracted widespread public attention in Europe and America. However, those who were in a position to respond to the vital recommendations of scientists ignored their warnings and precautions. Peccei and his colleagues came to a discouraging conclusion: the human society, in its present state, is not able to respond intelligently to the alarming phenomenon occurring in the environment and in society itself.
In 1977, Peccei published his famous book “The Human Quality”. He wrote[3]:

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[2] *Norbert Wiener.* Cybernetics, or Control and Communication in the Animal and the Machine / The MIT Press, Cambridge, Mass., and Wiley, New York, 1948.
[3] *Aurelio Peccei.* The Human Quality / Oxford: Pergamon Press, 1977.

> In the end, the problems comedown to the human qualities and the way of their improvement…
> Until our so-called technological society also becomes a human society, violence will continue its triumphant march and we will continue to fight special cases of this general phenomenon without understanding the origins of the violence…
> The main problem is – how can we get the spark which will kindle the flame of developing the human qualities…

These conclusions were written by an experienced, wise, and honest man, whose life was dedicated to one purpose: to help people in solving their extremely complex, vital issues. They are also valid with respect to the issues that we are concerned about today. Watching the current negative events, we must unconditionally agree with the conclusions of Aurelio Peccei.
The only remedy that we can offer in order to *kindle the flame* could be the *enlightenment*.
Fortunately, in the History of Computer Science as well as in the History of Russian Computer Science, there are amazing, charismatic personalities having, in addition to their brilliant minds, also deeply human hearts. There is a quite reasonable proposition that the level of morality in scientific community is much higher than in most other sectors of the society. Dissemination of authentic information about our heroes, the Pioneers of Computer Science, and instilling of their human qualities in our contemporaries, seems to be an efficient instrument for *enlightenment.*

Two German Philosophers of Mathematics, two Epistemological Traditions: Frege and Weyl on the Method of Abstraction

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This paper aims to contrast two aspects of the issue of abstraction principles according to the accounts offered by the German philosophers Gottlob Frege and Hermann Weyl respectively. German epistemology of mathematics appears to have developed with relation to two distinct philosophical traditions. On the one hand, Frege is the leader of the analytic tradition in philosophy and epistemology of mathematics particularly. He defended the view that arithmetic is reduced to logic (Logicism) so he insisted on the analytic status of arithmetical truths, although he retained Kant's account of geometrical truths as synthetic a priori. Besides, Logical positivism endorsed basic claims of Fregean Logicism as well as philosophy of language and brought it under its own philosophy of sciences. On the other hand, Weyl follows a different tradition in what concerns mathematical knowledge. He retains strong commitments to transcendental idealism and Husserl's approach to mathematics. The paper focuses its attention on the procedure of abstraction and attempts to detect the main differences between Frege and Weyl's accounts that indicate the relative characteristics of two different philosophical traditions in epistemology.

Abstraction principles have been introduced by Frege in *Grundlagen der Arithmetic* (1884), especially §§64-68. In particular, he introduced the principle: "The direction of the line a is identical to the direction of the line b if and only if a is parallel to b"

(D=) $(\forall a)(\forall b)\ [\ (D(a) = D(b)) \leftrightarrow (\ a//b\ )\ ]$

(Two lines have identical directions if and only if they are parallel)

The abstraction principle (D=) is taken by Frege to define the term 'direction of a line'. This principle introduces the concept of *direction*.

Another abstraction principle introduced by Frege in Grundlagen aimed at the explanation of the concept of natural number on the grounds of the conception of 1-1 correlation:

"the number of the concept F is identical to the number of the concept G if and only if the concept F is 1-1 correlated to the concept G"

(N=) $(\forall F)(\forall G)[(N(F)=N(G))\leftrightarrow(F1\text{-}1G)]$

(Two concepts have the same number if and only if they are 1-1 correlated).

For example, the number of the concept 'wheel of my car' is the same as the number of the concept 'leg of my table' because the two concepts are 1-1 correlated.

Both the examples were introduced by Frege (1884), in order to make the readers of his *Grundlagen* acquainted with the function of a certain form of abstraction method that differs from traditional abstraction. Traditional abstraction aimed to substract certain features of objects (e.g. colour, size, material) in order that an abstract object is derived. Traditional abstraction functions properly in case of the filament of Galileo's pendulum where colour, material and thickness were substracted. What remained from the filament of the pendulum was a straight segment in order that the law of the pendulum was formulated. Frege's own account of the method of abstraction is more complicated. He attempted to treat the above abstraction principles as contextual definitions, that is, he took them to fix the truth conditions of appropriate contexts in which the meanings of certain terms ('direction', 'number', 'shape') are defined.

The characteristics of abstraction principles have been under consideration for a long time. Since the last decade of 20th century, the advocates of the Neo-Fregean program Bob Hale and Crispin Wright studied Fregean abstraction systematically as a kind of analytic definitions that implicitly introduce abstract concepts, e.g. direction, shape, number and their instances i.e. directions of lines, shapes of figures, numbers. According to Hale and Wright (2001) an abstraction principle accomplishes two main tasks. The first is concept formation. The outcome of the stipulation of a universally quantified biconditional is an implicit definition of a concept. This is achieved by establishing a certain pattern of use for new terms e.g. 'the direction of line a', 'the number of concept F'. So anyone who is acquainted with that particular pattern of use will be put in position to grasp an explanation of that very concept.

The specific way by which a concept is introduced by abstraction, is explained by Frege himself as following: he believes that new concepts are obtained by a process of *recarving the content* of the right-hand side of the bi-conditional in question in a new way on the left-hand side. In *Grundlagen*, §64, he holds for example, that the concept of the *direction* of a line is introduced by recarving the content of parallelism in a new way on the left-hand side (as an identity of directions). This is how we obtain epistemic access to directions. According to Frege, parallelism that is expressed by the right-hand side of D= is quite familiar to our cognitive equipment because it is *given in intuition*. However, this is taken to be a characteristic of geometrical notions only, not of arithmetical or logical notions. Frege agrees with Kant that intuition is important in case of geometry but he does not believe that it has anything to do with arithmetic. In case of N=, the right hand side of the principle is quite familiar to our cognitive equipment since it is taken to be *given in logic*. So our acquaintance with the concepts of direction and number is due to familiarity of our cognitive equipment to parallelism and 1-1 correlation respectively.

According to the (analytic) Neo-Fregean account, the process in question is explained in terms of *re-conceptualization* (cf. Hale 2001). Hence, an abstraction principle is taken to re-conceptualize the states of affairs that are described by the right-hand side of the bi-conditional and expose them by means of a new concept. Re-conceptualization of the states of affairs that are described by the right-hand side of the biconditional D= in a new way provides a description of those states of affairs through a new concept: the concept of direction. Analogously, re-conceptualization of the states of affairs that are described by the right-hand side of N= (i.e. 1-1 correlation between the instances of concepts) provides a new concept: the concept of (natural) number. On the Fregean account, the second task that an abstraction principle accomplishes is that it makes us able to recognize certain ontologies of abstract objects, e.g. directions, shapes, numbers, e.t.c. The abstract objects in question are the instances of the new concept that is introduced by means of each abstraction principle. For example, the direction of the line a is an instance of the concept 'direction' that is introduced by means of principle D=. Accordingly, the Fregean view is committed to a certain aspect of Platonism since those abstract objects are taken to be real so long as the states of affairs from which they arise (parallelism, 1-1 correlation, etc) are real too.

A quite different account of the same abstraction principles is offered by Weyl (1926). This account is constructivist, however Weyl's constructivism is bound to certain aspects of transcendental idealism. He makes use of notions such as intuition, intention and the notion of ideal object, which have been developed in the tradition of Husserl's philosophy and he offers an explanation of the method in question within a phenomenological approach. Weyl holds that the functional expression 'the direction of the line a' corresponds to some specific feature of a line: direction. In general, things of the original domain that are correlated by an equivalence relation have a feature in common. Hence, lines that are parallel to each other have a feature in common: direction. Besides, according to the abstraction principle N=, two equivalent (by means of 1-1 correlation) concepts have the same feature in common which is a number. The concept 'wheel of my car' and the concept 'leg of my table' are 1-1 correlated hence they have a feature in common: number 4. Further, on Weyl's approach to abstraction, this common feature has to be transformed into an ideal object in each case. The situation is similar in case of a colour (e.g. red) that is the common feature of two flowers. That feature is transformed into an ideal object. Similarly, the shape that is the common feature of two similar geometrical figures is transformed into an ideal object too. So, in all cases of abstraction principles, ideal objects arise as the outcome of transformation of the common features of things that are involved in the respective abstraction principles as equivalent by an equivalence relation. How is generation of ideal objects achieved? Weyl believed that this question should be answered in the light of transcendental idealism.

In general, Weyl appealed to constructivism in mathematical methodology (Mancosu and Rychman 2002). In fact, for some time (until 1925) he defended intuitionism especially Brouwer's views, for example, that what makes theorems meaningful is the construction carried out in its proof. In particular, Weyl's approach to mathematical definition is constructivistic as well, but he has put constructivism in the context of transcendental idealism.

In his *Philosophy of Mathematics and Physical Sciences* (1926), Weyl regards abstraction principles as a kind of 'creative' definition. His constructivism is associated with a phenomenological point of view. Weyl had been strongly influenced by Husserl, and in the preface of his *Das Kontinuum* (1918) he had expressed his agreement with Husserl's account on epistemology of logic and mathematics. The role of consciousness in the procedure of generation of ideal objects through abstraction is important in Weyl's view. Ideal objects are constituted by certain creative acts of the human mind. According to Weyl, the procedure of abstraction discloses common features of certain items of an original domain of discourse that are correlated by means of equivalence relations.

Firstly, he endorses the notion of intention to describe directedness of certain mental acts like thinking, believing, e.t.c., certain notions coming from the phenomenological tradition. In his description of the procedure by which directions are derived from parallel lines (indicated as principle (D=) above), Weyl remarks that the mathematician has an intention to consider exclusively certain invariant properties and relations among the originally given objects.

Secondly, according to the phenomenological approach, an object is *constituted* in case it is brought into light by a certain process. Constitution of objects is achieved by means of a process that is involved in intuition and enables the objects to disclose themselves. This idea comes from the phenomenological tradition (Tieszen 2005). So we have to follow certain processes that are involved in intuition until ideal objects become present to mind. The role of intuition in case of abstraction is crucial since it is required for intentions of the mind to be fulfilled. The mind is directed towards various objects, states of affairs, properties or relations but in order to obtain knowledge, the intentions need to be fulfilled. Intuition fulfills an intention so that the object towards which the mind is directed comes to become present to mind (Husserl 1900). That is, unless intuition fulfills intention, the object in question is absent, i.e. it is not experienced of. In particular, in case of abstraction principles, the mind is directed towards certain properties and relations of things that remain invariant under an equivalence relation. However, the alleged intentions should be fulfilled by intuition so that those invariant properties and relations are transformed into ideal objects like directions, numbers, shapes etc.

In conclusion, Frege and Weyl deal with the procedure of a certain method, abstraction, through entirely different approaches that are brought under two different philosophical traditions. On the one hand, abstraction is explained by means of an analytic account, as an epistemological procedure that makes us able to obtain epistemic access to abstract entities. On the other hand, the same method is approached by means of a phenomenological account according to which certain intentions of the human mind directed towards invariant relations are fulfilled by intuition. This method brings so into light certain ideal objects. Thereby, the issue of abstraction appears to be an issue where two different epistemological traditions are met.

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D. Pikionis and A. Konstandinidis: the Introduction of Modern Architecture and Modern Building Technology in Greece and the Criterion of "Greekness"

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Architectural modernism has been interwoven with the vast modernization of building technology, as well as of production and the labour process in general, which took place during the last years of the 19th century and the first years of the 20th. In most of the manifests of that period, the new architecture appears as a synonym of concrete, glass and steel. The demand for (or, if you wish, the problem of) standardization and massive production of housing prevails in the field of theory and in the programmatic discourse of architects. The key question is the social role of architecture in a framework of revolutionary developments in technology, technique and science and, simultaneously and even more fundamentally, of revolutions literally speaking. Which means real social revolutions.

The beginning of such a modernization process in Greece, mainly under the governments of Venizelos, was accompanied by the insertion of similar criteria in architectural theory and practice and, of course, by the inauguration of Greek modernism. Based on the new building materials and techniques, Greek architectural modernism achieved some remarkable results, which sometimes gained a certain international recognition.[1] However, the, rather poor, modern architectural theory in Greece maintained an apparent peculiarity in comparison with the climate that prevailed in the rest of the Europe. Architectural modernism in Greece, as also partly happened with art (although we can't examine this further here), always remained in a clearly more conservative rhetoric, which has been largely related to the adoration of tradition and, in particular, to the leading demand of the generation of the Mid-war period: the so-called "greekness". I will argue in favor of this point by a brief examination of the theoretical works of two prominent, even nowadays, figures of Greek architecture: Dimitris Pikionis and Aris Konstantinidis.

The proclamations of European modernism are not homogeneous and unanimous. On the contrary, they are divided by contrasts of different types: the free subjectivity of the artist against the rigid objectivity of pure science,[2] plasticity against structural

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[1] In 1932, in his work *Gli elementi dell' architettura funzionale,* Alberto Sartoris included works of Stamos Papadakis, among which the drafts for the Greek Pavilion in the Venice Biennale of 1931. The culmination of the international interest about Greek modernism coincided with the 4th CIAM in 1933, organized partly in Athens. On this occasion, the 1st Architecture Exposition of works of Greek architects took place in the NTUA (National Technical University of Athens).

[2] The Bauhaus hosted and, to a certain extent, tried to reconcile this controversy, which dated back to the period of the Deutsche Werkbund and of the polemic among Hermann

linearity,[3] the adoration of the eternal against the adoration of the ephemeral. In principle, though, one would be justified to say that the primary division concerns the role that architecture is to play within the framework of the great social, economic, and political mutations: either the catalyst of a capitalist modernization (in a range starting from Le Corbusier's statism and Mies Van der Rohe's liberal rationalism and ending to the fascist evolution of Italian futurists) or, on the contrary, the facilitator of the liberation cause of the working class (in a range starting from the social-democratic projects of workers' housing in Vienna an ending to the revolutionary declarations of Russian constructivists and supremacists and of Hannes Meyer).

However, there is a common element in both cases: architecture is meant to serve a large–scale utopia, a utopia that has the ambition to transform the whole world. That's why architectural theory has, as a rule, the form of manifests (as it also happens with art). Despite their diversity, all these numerous manifests have some more or less constant features:

- Unwavering trust in, enthusiasm about and, sometimes, even fiery adoration of progress, of science and of the future
- Justification of architectural design and theory based primarily on social criteria. Even when this justification is accomplished in the name of impersonal principles like art or "contemporary technology" (which actually happens very often), it still refers to a certain version of justice
- A principally global content, which is equivalent to a certain internationalism, too much different in each different case, but still internationalism[4]

We will see that these features are absent in the modernist discourse about architecture in Greece.

It's time we proceed to our two examples.

Dimitris Pikionis has been one of the main figures of the so–called 30's generation in Greek art and literature. He was connected with De Chirico, Bouzianis, Parthenis, Papaloukas, Hadjikyriakos – Gikas, as well as one of the most well–known nationalist writers of that period, who established the criteria of "greekness", Pericles Giannopoulos. Pikionis taught morphology and rhythmology and later became a professor of Decoration in the National Technical University of Athens. In 1966 he was elected a regular member of the Academy of Athens. Between 1935 and 1937 we was a co–editor, along with other renown artists and writers (Hadjikyriakos –

Muthesius Henry van de Velde - see Schlemmer O. (1970), "*Manifesto for the First Bauhaus Exhibition",* in U. Conrads (ed.), *Programs and Manifestos of Twentieth-Century Architecture*, Cambridge, Mass.: MIT Press, 69.

[3] This is how one could define the two dominant versions of the modernist morphology: the architecture of Le Corbusier and the one of Mies van der Rohe.

[4] It is interesting that not even the initial declarations of the Italian futurists, who eventually turned to fascism following the political trajectory of Marinetti, were founded on a supposed "itality". On the contrary, all references to the Italian architecture, both historical and current, were skeptical or even openly hostile – see, Sant Elia F., Marinetti T., "Futurist Architecture", in U. Conrads (ed.), *Programs and Manifestos of Twentieth-Century Architecture,* Cambridge, Mass.: MIT Press, p. 34

Gikas, Papaloukas, Stratis Doukas, Sokratis Karantinos), of the "Third Eye", one of those vanguard reviews which have entrenched the Greek version of modernism. From this viewpoint, Pikionis constitutes a typical case of a Greek modernist of the Mid-war period, with all the ambiguity of intentions that characterized a generation oscillating between their attraction to the artist vanguard of the early 20th century and the stubborn quest of the Holy Graal of greekness,[5] Pikionis's ambivalence towards what he calls "New Art" or "new movement" is telling: on one hand he recognizes the "vanguard" art as "more competent than any conventional sentimentalism to interpret the unconscious rationalism that we find in the tradition"[6] or he praises the new building materials,[7] on the other he is reluctant towards rationalism and "the doctrines like the one of "modern engineering standards", which we consider unconditional only in order to justify our spiritual deficiencies".[8] It is for this reason that he was skeptical about the 4rth CIAM in Athens.

Pikionis's writing style is romantic and literary,[9] full of emotional exaltation, ethical urges and quotations or lyrics, often ancient Greek. His references to Greeks and the greek nation, orthodoxy and Greek Christianity are amazingly frequent, sometimes even picturesque.[10] Popular tradition, a leitmotiv in his writings, has a transcendental character, as the field where "the secret powers of a land or a race, physical or metaphysical" act.[11] It is clear that Pikionis is one of those intellectuals who strived, above all, to establish a cultural model of the Greek national consciousness, which was still under construction.

In his article "the spirit of tradition" (1951), probably the only writing of him that resembles the form of a manifest, Pikionis sums up briefly and clearly his position about the Greek popular tradition. His article starts with four points:[12]

- Traditions are the survival of ancient forms
- Each tradition is the "expression of the soul of each nation", but they all

[5] See Philippidis D. (1984), *Νεοελληνική Αρχιτεκτονική* (*Modern Greek Architecture*), Athens: Melissa, chapter 6

[6] Pikionis D. (2010), "Η ανοικοδόμηση και το πνεύμα της παράδοσης (Reconstruction and the spirit of tradition)", Journal *Eklogi 2(9), 1946, in D.* Pikionis*, Κείμενα* (*Texts*)*,* Athens: MIET, 64

[7] Pikionis D. (2010), "Το πρόβλημα της μορφής (The question of form)", *Bulletin of the Ministry of reconstruction*, 1946, in D. Pikionis*, Κείμενα (Texts),* Athens: MIET

[8] Pikionis D. (2010), "Γύρω από ένα συνέδριο (Regarding a Congress)", Journal *Technica Chronica,* 4(39), 1933, in D. Pikionis*, Κείμενα (Texts),* Athens: MIET. The ambivalence of Pikionis towards modern architecture and art is long-lasting. It is not about an evolution from the approval to a gradual rejection, as sometimes presented. This is proven also by the chronology of the references above.

[9] Apart from articles about architecture, Pikionis has also written autobiographic texts, prose and poetry.

[10] "[...] always of the same sacred body of Greece" - Pikionis D. (2010), "Το πρόβλημα της μορφής (The question of form)", *Bulletin of the Ministry of reconstruction,* 1946, in D. Pikionis*, Κείμενα (Texts), Athens: MIET*

[11] Pikionis D. (2010), "Η Ελληνική Αρχιτεκτονική (The Greek Architecture), interview in the Journal *Aiksoni,* 1(1-12), 1951, in D. Pikionis, *Κείμενα (Texts),* Athens: MIET

[12] Pikionis D. (2010), "Η Ελληνική Αρχιτεκτονική (The Greek Architecture), interview in the Journal *Aiksoni,* 1(1-12), 1951, in D. Pikionis*, Κείμενα (Texts*), Athens: MIET

belong to a global family

- Some of these national traditions reflect more accurately the spirit of the global tradition and some less
- The Greek tradition belongs "by divine fate" to the ones that reflect this spirit best

In this way he can recognize the popular tradition of all peoples and, at the same time, entrench the Greek superiority. But where is this superiority attributed to? In his articles one can pick the following factors:

a. the geographical position of Greece in a cultural crossroad between East, West, North and South[13]

b. the influence of "eastern spirituality"[14]

c. a double inheritance of ancient Greek art, with all its adoration for the "organic world" and its emphasis on plasticity, on one hand, and, on the other, of byzantine art, with its transcendence and the pursuit of the "non-perceptible essence of the divine"[15]

d. a special temper of Greeks. It seems that the idea of a certain race superiority of the Greek nation is not completely alien to Pikionis. In his text titled "The problem of form" (1946) he straightly speaks about the "difference of the race", although he leaves the question about how important this difference is for the cultural inheritance unanswered.

How is it possible to conciliate this nationalist jargon with the acceptance, even critical, of the modern movement, which was international from the very beginning? It has been already mentioned that Pikionis comments somewhere that the New Art is in a better position to appreciate the inherent rationalism of the popular tradition. But this relation is also established vice versa, by traditional art and architecture themselves. By their own nature, they are open to "the shapes of the vanguard movement of the "New Art".[16] According to Pikionis, what modern architecture seeks for is, in the final analysis, the reconnection with the principles of tradition, renewing forms and materials (by replacing wood by concrete, for example), but keeping the fundamentals. Therefore, a country with a superior popular tradition, as Greece, is even more open to the New art. We find here a bizzare, but nevertheless quite widespread in the 30's generation, idea: thet modern architecture and art, though imported from abroad along with modern technology, have in depth an inherent Greek element. In Pikionis this idea is not as clear as in Konstantinidis.

Aris Konstantinidis (1913-1993) was actually one generation younger than Pikionis and, unlike the latter, he had studied abroad, in the Polytechnic school of Munich. Although his studies and the first steps of his career took place in the Mid-war

[13] Pikionis D. (2010), "Η ανοικοδόμηση και το πνεύμα της παράδοσης (Reconstruction and the spirit of tradition)", Journal *Eklogi* 2(9), 1946, in D. Pikionis*, Κείμενα (Texts),* Athens: MIET

[14] *Pikionis* D. (2010), "Το πρόβλημα της μορφής (The question of form)", *Bulletin of the Ministry of reconstruction*, 1946, in D. Pikionis*, Κείμενα (Texts),* Athens: MIET – in the same article, Pikionis praises the Islamic art

[15] Pikionis D. (2010), "Το πρόβλημα της μορφής (The question of form)", *Bulletin of the Ministry of reconstruction*, 1946, in D. Pikionis*, Κείμενα (Texts),* Athens: MIET

[16] Pikionis D. (2010), "Το πρόβλημα της μορφής (The question of form)", *Bulletin of the Ministry of reconstruction*, 1946, in D. Pikionis*, Κείμενα (Texts),* Athens: MIET

period, Konstantinidis basically belongs to the generation of the after-war reconstruction. He had an active role in this reconstruction as a civil servant of the Ministry of Public Works and as project manager of the Autonomous Workers' Housing Organization (1955-57) and, later, of the National Tourism Organization (1957-67). Nevertheless, the theoretical questions he poses to himself would fit better in the climate of Mid-war modernism,[17] which, besides, still dominates art and architecture after the War.[18] Konstantinidis never taught in the university, apart from a three year period during which he was a guest teacher in the University of Zurich. But he wrote all the time, much more than Pikionis.

Kostandinidis's writing style is less literary, more simple and somewhat unorthodox, with a lot of secondary phrases put autonomously, without any primary sentence, and an excessive use of quotation marks and dots. His writings are less decorated and more modern. Nonetheless, they are also full of quotations of Greek or German writers and philosophers (not ancient ones though), which come again all the same in different texts.

At first glance the theoretical work of Konstantinidis seems quite different from the one of Pikionis. Helenocentric comments are obviously more rare and Christianity is actually absent. His jargon is more rationalist. Standardization and modern techniques are exalted.[19] In a few words, Konstantinidis seems to be a more typical modernist – besides, he has stated about himself from the very beginning: “like a modern architect which I am (really modern)...”.[20]

To juxtapose Konstantinidis and Pikionis is not just my own idea. Konstantinidis himself has preserved this opposition for many years by accusing Pikionis of “scenografic” reproduction of traditional forms (besides, Pikionis was also a painter). In his first book, titled “two "villages" of Mykonos and some more general thoughts allong with them”, he had already attacked “lovers” of the tradition, a characterization behind which we should see Pikionis.[21] In his memoirs, which were published one year before his death, Konstantinidis escalates his polemics into a real tirade.[22]

Despite the first impression, though, Konstantinidis's theoretical project is not so different from the one of Pikionis. Firstly, beneath a more enthusiastic acceptance of

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[17] Philippidis D. (1997), *5 Δοκίμια για τον Άρη Κωνσταντινίδη (5 Essays on Aris Konstantinidis)*, Athens: Libro, 85

[18] In contrast with what happened in literature, where the first post-war generation of writers, recruited from the ranks of the left, has completely renewed the data.

[19] See Konstantinidis A. (1987), “Φτηνά Σπίτια (Cheap Houses)”, Newspaper *Vradini*, 20 and 22/6/1944, in A. Konstantinidis, *Για την Αρχιτεκτονική (About Architecture)*, Iraklion: University editions of Creta, 51

[20] Diary note of 1937, in Konstantinidis A. (1992), *Η αρχιτεκτονική της αρχιτεκτονικής (The architecture of architecture)*, Athens: Agra, 19. It is not insignificant that Pikionis, in contrast with Konstantinidis, uses the terms “New Art” and “vanguard movement” instead of “modern”.

[21] Philippidis D. (1999), “Δημήτρης Πικιώνης – Άρης Πικιώνης (Dimitris Pikionis – Aris Konstantinidis)”, newspaper *Ta Nea*, 25/11/1999

[22] See Konstantinidis A. (1992), *Εμπειρίες και περιστατικά, μια αυτοβιογραφική διήγηση (Experiences and incidences, an autobiographic narration)*, Athens: Estia

the international modernist movement lays also a similar ambivalence. His criticism is launched in the name of the same, more or less, principles: tradition, which can't be neglected in favor of innovations, and emotion, which can't leave the monopoly of design to rationalism. In 1938 he writes: “And this modern architecture often doesn't care about man. It neglects eternal truths because, as it says, it has discovered new ones”.[23] In 1965 he writes that “nobody can work only by their rationality”, but elements like heart, “sentiment”, “soul” and love are also needed.[24] In the same article he even criticizes the totem of modern architecture, Sullivan's moto “form follows function” - twenty years later, though, he would unleash his attack against post-modern architecture right in the name of this very moto.[25]
What's much more interesting is the convergence with Pikionis about the matter of “greekness”. Konstantinidis tries to clearly break with whoever “may dream "Greek" styles and...whatsoever”[26] and, as already mentioned, he refers to the Greek nation more rarely and less obsessively. He doesn't hesitate to question ancient Greek architecture, which he considers to be rather sculpture, and he commits the sacrilege to question even Parthenon: “And how can Le Corbusier...shout that architecture is art, because there is Parthenon, which he presents as the best model for us today...-but what's the connection between Parthenon and what we should make today as architecture?”.[27]
However, neither Konstantinidis omits underlining a supposed superiority of Greece. He tries to attribute this superiority to more rational factors, like the mild climate of Greece and the austere and “mathematic”, as he calls it, Greek landscape. Considering that climate is the key factor in forming human character, Konstantinidis associates the Greek climate with a perennial tradition that has prevailed in Greece for ages, tranfering the “artistic wisdom” of ancient Greeks.[28] Therefore, the climate and the “divine in beauty” Greek landscapes are reflected also in the people who “here are beautiful and brilliant (in soul and in body), full of quality and thrifty ethics”.[29] Konstantinidis rhetoric may be less nationalist and more localist, but his

[23] Konstantinidis A. (1992), *Η αρχιτεκτονική της αρχιτεκτονικής (The architecture of architecture)*, Athens: Agra, 31
[24] Konstantinidis A. (1987), “Σημερινή αρχιτεκτονική και ανώνυμη παράδοση (Current architecture and anonymous tradition)”, Journal Baumeister, 4, 1965, in A. Konstantinidis, *Για την Αρχιτεκτονική (About Architecture)*, Iraklion: University editions of Creta, 168
[25] Konstantinidis A. (1987), *Αμαρτωλοί και κλέφτες ή η απογείωση της αρχιτεκτονικής (Sinners and thieves or the take0off of architecture)*, Athens: Agra, 56
[26] Konstantinidis A. (1992), *Η αρχιτεκτονική της αρχιτεκτονικής (The architecture of architecture)*, Athens: Agra, 19
[27] Konstantinidis A. (1992), *Η αρχιτεκτονική της αρχιτεκτονικής (The architecture of architecture)*, Athens: Agra, 41
[28] Konstantinidis A. (1987), “Σημερινή αρχιτεκτονική και ανώνυμη παράδοση (Current architecture and anonymous tradition)”, Journal *Baumeister,* 4, 1965, in A. Konstantinidis, *Για την Αρχιτεκτονική (About Architecture)*, Iraklion: University editions of Creta, 170-172
[29] Konstantinidis A. (1987), “Αρχιτεκτονική και τουρισμός (Architecture and tourism)”, Journal *Architektonika Themata*, 1, 1967, in A. Konstantinidis, *Για την Αρχιτεκτονική (About Architecture)*, Iraklion: University editions of Creta, 200

primary concern remains the same as the one of Pikionis: to entrench a particularly Greek contemporary architecture.[30]

By the way, let's note that Konstantinidis's comments regarding the Greek nation are not always just a cool-headed recognition of climate and landscape characteristics. In various occasions he quotes nationalist scholars like Ion Dragoumis or, more frequently, Giannopoulos, who is a point of reference also for Pikionis. Although rarely, he also refers to "the valor and force of the Greek race"[31] or to "the moral and biological duty of Greeks in beauty and quality and anthropometric ethics".[32] It seems that neither Konstantinidis is totally hostile to the idea of some features that are intrinsic in the Greek race.

But here we face the same problem as before: how can the omnipotence of the Greek tradition conciliate with the declarations of modern architecture? As for Konstantinidis, popular tradition completely coincides with the fundamentals of modernism. This tradition is depicted in the people's housing, in the refugees' huts and in anonymous architecture, and it is completely alien to neoclassicism and historical morphology. All historic architecture is put into brackets in favor of the eternal forms of anonymous architecture, especially the one in the islands, where one can see the original Greek architecture.

But modern architecture is nothing but the search for the primary and everlasting truth of architecture,[33] which, in the framework of Konstantinidis metaphysics, substitutes the "mysterious content" of the Greek nation in Pikionis' thought. It is an absolute point of reference that can't be proven, because, as a priori true, it is not questionable.[34] Greek traditional architecture,[35] which is intrinsically interwoven with the landscape and nature,[36] (and where else could eternal truths be found if not

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[30] This is outspoken in the article Konstantinidis A. (1987), "Το πρόβλημα για μιαν αληθινή Ελληνική Αρχιτεκτονική (The problem of a real Greek Architecture)", Journal *Architektonika Themata*, 6, 1972, in A. Konstantinidis, *Για την Αρχιτεκτονική (About Architecture)*, Iraklion: University editions of Creta, 245

[31] Konstantinidis A. (1987), "Τα παλιά αθηναϊκά σπίτια (The old Athenian houses)", 1948, in A. Konstantinidis, *Για την Αρχιτεκτονική (About Architecture)*, Iraklion: University editions of Creta, 87

[32] Konstantinidis A. (1987), "Αρχιτεκτονική και τουρισμός (Architecture and tourism)", Journal *Architektonika Themata*, 1, 1967, in A. Konstantinidis, *Για την Αρχιτεκτονική (About Architecture)*, Iraklion: University editions of Creta, 202

[33] The attempt to found modern architecture on archetypes and on the primary past is not at all an invention of Konstantinidis. Giedion, e.g., probably the most well-known theoretician committed to modern architecture, as well as a basic ideological organiser of the CIAMs, presents a similar argumentation. Le Corbusier does more or less the same, not having any problem to combine this with the adoration of machines and contemporary technology – see Le Corbusier (2004), *Για μια αρχιτεκτονική (Vers une architecture)*, Athens: Ekkremes

[34] Philippidis D. (1997), 5 Δοκίμια για τον Άρη Κωνσταντινίδη (5 Essays on Aris Konstantinidis), Athens: Libro, 83

[35] Again, the emphasis on the terms "popular" or "anonymous" architecture insstead of tradition is not coincidental

[36] "yes, madam, this is the miracle here in Greece; when you stand in front of an architectural work...not to be able to tell which work is made by man and which one is made by nature" - Konstantinidis A. (1987), "Το πρόβλημα για μιαν αληθινή Ελληνική

in nature?), is a prominent carrier of this truth – it is therefore modern by its own nature.

Despite all differences, the theoretical positions of both architects are close to each other, much closer that one could expect having in mind Konstantinidis's polemic (because we should note that the polemic between them has always been absolutely unilateral). In the eyes of Konstantinidis, Pikionis is guilty of imitating traditional forms, but, namely, Pikionis also sought that "inner essence" and not the forms of tradition. Similarly, the romantic emotionalism and excessive lyricism that are attributed to Pikionis are nearly equally apparent in Konstantinidis' writings, despite his iconoclastic language.[37] A rather telling coincidence is that they both argue in favor of their position about art's mission using repeatedly the very same lyrics of Dionysios Solomos: "the common and the principal". Although their architectural styles are quite divergent (which we could also discuss about), the widespread idea that Pikionis and Konstantinidis incorporate two opposing poles in the Greek architecture of 20th century can't be confirmed, at least not from a theoretical point of view. This idea fails to detect the fundamentally common element of those two cases, because it fails to put the two architects in their social context.

What that both architects share is a helenocentric point of view, which forces them to invent all the time compromises between national tradition and modern architecture and it deprives their word of the radicalism that modernist manifests had in other countries. Contrary to the modern architects in the rest of the Europe, who looked for a new role of architecture in a different society (as they perceived it in each case), their struggle was meant to establish a Greek type of architecture. As already mentioned, this characteristic is common not only between them, but also between the big majority of Greek modernist architects of the Mid-war and the early after-war period. It is telling that even the introduction that Patroclos Karantinos wrote for the publication of the Ministry of Education about the Mid-war project of building thousands of new schools, which was the biggest modernization project connected with the modern architecture in Greece, refers to the traditional architecture of Santorini. Modernism has been the third consecutive architectural movement in Greece, after neoclassicism and the populist byzantine eclecticism of Aristotle Zahos, which was founded on a certain perception of greekness.[38]

All the three features of modernist manifests, which where presented in the beginning, are absent or only occasionally present in the texts of Greek modernist architects. There must be some reasons behind their reduced radicalism and their heleno-centricity. The usual narration about a vassal and provincial Greek capitalism is not satisfactory. In the Mid-war period Greece was a rapidly modernizing country.

Αρχιτεκτονική (The problem of a real Greek Architecture)", Journal *Architektonika Themata*, 6, 1972, in A. Konstantinidis, *Για την Αρχιτεκτονική (About Architecture)*, Iraklion: University editions of Creta, 245

[37] Le Corbusier's ironic reference to the "dissertations about the soul of the stone" - Le Corbusier (2004), *Για μια αρχιτεκτονική (Vers une architecture)*, Athens: Ekkremes, 8 – could perfectly apply to both Pikionis and Kosntantinidis, as well as many other Greek architects, even much more recent.

[38] *See Philippidis D. (1984),* Νεοελληνική Αρχιτεκτονική (Modern Greek Architecture)*, Athens: Melissa, chapters 5 and 6*

For a while, it has had one of the highest rates of development in the world. On the other hand, the workers' movement was growing quickly, having already given remarkable organizations and important struggles, and, moreover, it unleashed an unsuccessful revolution just after the war. Therefore, the two main preconditions of modernism that were highlighted in the beginning, capitalist modernization and large-scale liberation projects or the working class, were not absent. What has been really different was the social role of architects. Concerning this, it would be worthy to pinpoint three factors:

1. Given that the national question in the Balkan in the first half of the 20th century (and even today to a certain extend) was not yet resolved and that the Greek nation state was still under construction, one of the primary duties of the modernization of Greek capitalism was to establish and impose a national identity
2. For a while, architects had an active role in this modernization process, and that's why they shared its basic goals. However, they were soon superseded by the specific form which the construction sector took in Greece, under the reign of middle-scale contractors, who were not architects and didn't even hire architects in most cases. The ambivalence of Greek modernist architects towards progress and their nostalgia for a mythical harmonic past, that sometimes turns into deep frustration, are connected with the disgust in front of the catastrophic results of a violent modernization which they had served, but they couldn't control.
3. Architects of that period, at least the most famous of them, were basically recruited by the bourgeois class and they formed a stratum of organic intellectuals in the service of the state. Architectural theory was, therefore, much less influenced by the experiences of the workers' struggles, the guerrilla war and the exile than prose or poetry.[39] This fact permits Konstantinidis to write articles about the need for free standardized houses in the middle of the Nazi occupation and Pikionis to be searching for the spirit of the tradition and for the tasks of reconstruction during the civil war.

Pikionis' and Konstantinidis' writings, despite all differences between them, constitute a typical sample of modern architectural theory in Greece, right because their agents are a typical sample of the social stratum of architects in that period.

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Konstantinidis A. (1992), *Εμπειρίες και περιστατικά, μια αυτοβιογραφική διήγηση*

[39] Examples of left Greek architects, who participated in struggles and suffered persecutions, like Ioannis Despotopoulos, were not unknown. Nevertheless, the typical figure of a Greek modern architect would have to wait for Takis Zenetos in order to find a genuine devotee of the modern adoration of the future – in a period that it was already late for that.

(Experiences and incidences, an autobiographic narration), Athens: Hestia
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To Bridge the Gap between the Two Cultures: a Social Pre-History of the Strong Program in the Sociology of Knowledge

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Introduction

The aim of this paper is to analyse the wider social context behind the development of the so-called strong programme in the sociology of knowledge, the very first approach in the discipline of the sociology of scientific knowledge. The reason that led me to this inquiry was twofold: First, the wider social circumstances, in which the strong programme had been developed, have not yet been systematically explored, and thus the pre-history of the strong programme is largely an unexplored area. Second, it is the unfamiliarity with the strong programme's social background, which has had, I believe, misleading consequences with regard to its reception, one of them being the widespread misconception of what the strong programme really represents.

It can be said that the development of the strong programme is commonly interpreted and understood only internally, in terms of the theoretical sources which inspired it. These include various works in philosophy of science (mainly Thomas Kuhn's, but also Michael Polanyi's and others'), sociology of knowledge (the works of Karl Mannheim and Émile Durkheim) and historiography of science (here especially the Marxist tradition represented by John Desmond Bernal). This account is basically correct and I agree with it. However, the omission of the extra-theoretical factors behind its development can lead, and in fact has led, to false judgements about the strong programme. The most notable of these are: that it is just an outcome of social scientists' looking for a new research specialty; that it is postmodernist; that its proponents are "anti-science"; and, most importantly, that they do not understand science at all (e.g. Koertge 1998; Gross et al. 1996; Wolpert 1992).

I will attempt to show that a more complete account of the origins of the strong programme invalidates these and similar accusations and demonstrates that, in fact, their exact opposite is the case.

C. H. Waddington and the "Two Cultures"

In various sources we can read that the foundation of the Science Studies Unit at the University of Edinburgh was partly stimulated by a public debate that took place in Great Britain after Charles Percy Snow's famous 1959 Rede lecture called "The Two Cultures and the Scientific Revolution" (Fuller 2000, 327; Mazzotti 2008, 3; Henry 2008, 224). In this lecture, a scientist-turned-novelist Snow described what he perceived as a growing gap between the natural sciences on the one hand and the humanities on the other. As he perceived the situation, these two cultures were largely ignorant of each other and were not capable of mutual recognition and communication. Snow, himself representing both of the cultures, saw this as a serious problem: scientists were for him of crucial importance for the future of Great Britain (and of the world as such), but they were ignorant of the traditional humanistic values and thus were not able to serve people's real needs; humanists, on the other side, were in his opinion too unappreciative and even critical of science and thus undermined its social status and its importance for the future of mankind. The blame, he argued, belonged by large to the obsolete British educational system, which according to him needed serious modifications (see Snow 1998).

Snow's lecture provoked a heated debate among both scientists and humanists. One of the scientists who participated in the discussion and supported Snow's part of the argument was also his friend Conrad Hal Waddington (see Waddington 1960). At that time, Waddington was known mainly as an embryologist, animal geneticist and as an author of popular books on science. What is more important, however, for our present purposes, is that it was him who later in 1966 founded the Science Studies Unit at the University of Edinburgh, where the strong programme in the sociology of knowledge has been subsequently developed.

As a matter of fact, Waddington had been thinking about the divide between the "two cultures" long before Snow delivered his famous lecture. It was back in the 1930s, during his years in Cambridge, when Waddington was collaborating on a research with the embryologist Joseph Needham, through whom he became acquainted with the group of British scientific socialists led by an X-ray crystallographer and a historian of science John Desmond Bernal (Fuller 2000, 327; Werskey 1979, 168). Bernal, a passionate Marxist, was at that time discussing with his group what he perceived as a "social function" of science. The idea he and his group had been promoting was basically that science should not be pursued only for its own sake; instead, scientists should be "socially responsible", i.e. they should reflect the needs of society and their work should be directed towards social well-being (Bernal 1939; Freeman 1999).

Waddington had largely agreed with these ideas. However, he also pointed out that if science is to fulfil its social function, scientists need to be acquainted with what the people's and society's real needs are, so that they can serve them in a proper way; in other words, scientists must first of all know how they can be socially useful, and they must also be capable of doing it. Therefore, he was warning against excessive specialisation of scientists and their consequent inability to be socially beneficial in any way outside their respective specialties. He was arguing that the opposite should be the case: that scientists should consciously take up their social responsibility and that they should actively pursue the problems that had been traditionally dealt with within the humanities. Thus, in his 1941 work called *The Scientific Attitude* (see Waddington 1941), where he formulated these ideas, he was basically addressing the issue that was pronounced by Snow eighteen years later. As he writes there:

> "Up to the present, the collaboration of scientists in the general cultural activities has been very flimsy. They have mostly been content not to challenge the verdict passed on science many years ago by the encrusted incumbents […] of ancient Professorships: that science is 'stinks' and has nothing to tell the humanities. The general adoption of this valuation by the

cultivated world was the penalty which science paid for being allowed inside the privileged circle of the Universities." (Waddington 1941, 24)

And as he writes in another passage:

> "[…] if civilisation is to continue to advance, and if full use is to be made of the opportunities for a richer life which technical advances present, the scientist and technician must join with the artist and writer in thinking out what these possibilities are and bringing them to the notice of people in general." (Waddington 1941, 24)

Politics and the "Two Cultures" in the 1950s

While the "two cultures" problem had been largely ignored at the time when Waddington had been pointing at it, it became a significant and resonant topic in Great Britain after the war, during the 1950s. At that time there had been a growing talk in Great Britain of an economic decline, which gradually turned into talk of a "national decline". It has been claimed mainly by the British scientific left – John Desmond Bernal, Patrick Blackett and others – that, compared to other countries, Britain's economic performance was faltering and that the cause of the unsettling situation was that science had not been getting proper recognition and support from the state. It has been argued that instead of a meritocracy, a state run by experts, Britain was a "mediocracy", a state run by amateurs. Thus, there had been a growing demand for a greater support of the sciences that would lead to technological and economic advance and that would get Britain back on its feet economically as well as politically on the global political map (Ortolano 2009, 161-166).

In 1956 these ideas were taken up by British Labour Party under the leadership of Hugh Gaitskell, then in political opposition, as their official political programme. They began to cooperate closely with the British scientific left and this cooperation led to the formation of the so-called "Gaitskell Group" consisting of Hugh Gaitskell, Harold Wilson and other members of the Labour Party, and also John Desmond Bernal, Patrick Blackett, and other scientific socialists, who were pushing forward Bernal's technocratic ideas mentioned above. The purpose of this group was to discuss and plan the future scientific state policy based on these ideas and to prepare a corresponding new political programme (Ortolano 2009, 173-174). Two years later in 1958 the group was joined also by Snow who shared Bernal's vision, but very strongly emphasised also the need for a simultaneous modernisation of the educational system, if these aims were to be successfully realized. His attitude to Bernal and the "two cultures" problem was basically the same as that of Waddington – he had claimed that if scientists were to play more and more important role in society, it was essential to ensure that they would be educated not only in their scientific specialty but also in the humanities. Snow heavily supported the Labour Party before the upcoming elections in 1959, and thus it seems appropriate to view his 1959 Rede lecture on the "two cultures" problem not as a statement of an independent intellectual, but rather as a thoroughly political message (Ortolano 2009, 174-175; Snow 1998, 18-21, 33-40).

In spite of the fact that the Labour Party lost the 1959 elections to the Conservatives, its members continued in their cooperation with Snow and the scientific socialists and further pursued their policy of science support and the modernisation of the educational system in the following years. The debate that had been launched by Snow's lecture made these ideas more appealing to the public and it can be said that the uneasy social atmosphere in Great Britain got one of its main expressions in the 1963 special issue of the *Encounter* magazine called "Suicide of a Nation?", which reflected on the idea of the post-war Britain's economic, political, and, as it was called, national decline, and pointed again to the need of appropriate changes in the scientific, educational, and government policy (see Koestler 1963). At roughly the same time Hugh Gaitskell died and was superseded in his leadership of the Labour Party by Harold Wilson, who was even more radical in his views about the scientific-technocratic future of Great Britain when he "promised a 'violent revolution' that would 'explode the system of government into a proper realization of how to deal with life in a scientific world'" (Ortolano 2009, 176-177). Shortly after, in the same year, he delivered his famous speech on the implications of the scientific and technological change, pronouncing his technocratic vision of Great Britain "forged in the white heat of [scientific and technological] revolution" (Ortolano 2009, 169; Fuller 2000, 327), which was apparently highly influenced by Snow's lecture on the "two cultures", and ultimately he led his party to the victory in the next year's elections, in 1964 (Ortolano 2009, 170).

Science Studies Unit at the University of Edinburgh

After securing the office, Wilson began fulfilling the party's programme, part of which was also the proclaimed modernisation of the educational system. Wilson's idea was that, in accordance with Snow's lecture, scientists should not be only narrowly focused specialists, but should be aware of the wider social circumstances of their work, so that they could direct their work towards a greater benefit of the state and its people. Therefore, he started a policy of liberal arts education for undergraduate science students and openly endorsed and called for establishment of such interdisciplinary study programmes at British universities (Ortolano 2009, 170; Fuller 2000, 318).

The Science Studies Unit at the University of Edinburgh was a downright outcome of these educational reforms. Waddington has taken advantage of the political situation and in 1964 made a request for an establishment of an institution where scientists would be taught about the social dimensions of their research, in the hope of tracking them into more socially beneficial directions – which was in accord with the ideas that he propagated as early as in his above-mentioned 1941 work *The Scientific Attitude*. Eventually he succeeded with his request and the Science Studies Unit was established with support from the state two years later, in 1966 (Fuller 2000, 318-319; Henry 2008, 224, 231; Mazzotti 2008, 3).

To the position of the Director of the newly established Unit, Waddington appointed David Owen Edge, who was in tune with Waddington's and Snow's idea of bridging the gap between the two cultures. Edge was a former radio astronomer, who left his scientific career in 1959 to become a director of the Science Unit at the BBC's Third Programme. There he had held popular science radio programmes for the general public, where he had invited various contemporary scientists – Peter Medawar or David Bohm, among others – to give talks on science. He was familiar not only with contemporary scientists however, but also with contemporary philosophers of science: most notably he met Thomas Kuhn and Imre Lakatos, as well as Mary Hesse for example (Bloor 2003, 172-173; MacKenzie 2003).

After being appointed as the director of the Science Studies Unit by Waddington, he was left free to choose the staff that would prepare and teach the "Science and Society" courses for science undergraduates that Waddington had in mind. The people that Edge selected for this task were David Bloor, an experimental psychologist also educated in philosophy and mathematics, Barry Barnes, a chemist with Ph.D. in sociology, and Leonard Schwartz, a political scientist. Schwartz left the Unit after a few months and was replaced by a radical socialist political historian of science Paul Gary Werskey; however, he had also stayed in the Unit only for a few months and was eventually replaced by Steven Shapin, a geneticist with Ph.D. in history of science (Fuller 2000, 331; Henry 2008, 224; Mazzotti 2008, 4). As is well known, it was these three people – Barnes, Bloor and Shapin – who were behind the development of the strong programme in the 1970s.

The question that needs to be answered is how three formerly practising scientists ended up developing a research programme in the sociology of scientific knowledge, when none of them had been interested in sociology of knowledge before. Barnes and Bloor describe their situation after arrival at the Unit in the late 1960s as follows. As I have already mentioned, they were appointed by Waddington with the preparation of the course called "Science and Society" for the undergraduate science students, that would increase their awareness of the wider social impact and significance of science and scientific research. For this purpose, Barnes and Bloor naturally required and were searching for a plausible conception of what science is, what are its intrinsic features and characteristics (if there indeed are any) etc. They eventually came to the conclusion, however, that the various conceptions of science and scientific research that they had found in available philosophical as well as sociological literature were in substantial conflict with their own experience as scientists; in short, these conceptions seemed to them to be too idealistic and inadequate with regard to the actual scientific practice. Therefore, according to what they say themselves, they decided to develop an alternative way to analyse science based on the scientific, naturalistic attitude that they had been trained in. As Barnes said in a recent interview,

> "scientific attitude is one I was trained in […]. So, my thought was that we need to be naturalistic about the natural sciences as they are empirical phenomena like those they themselves study. We should learn from social sciences about how humans in general behave and apply their conclusions to scientists, because scientists are humans". (Hwang et al. 2010, 603)

Very similar views were also held by Bloor (e.g. Briatte 2007). Thus, their idea was to develop a down-to-earth, materialistic approach to (scientific) knowledge based on the model of natural sciences that would analyse it in terms of causal explanation.

And that is, in fact, exactly how the strong programme was formulated by Bloor in 1973 and also later in 1976 (see Bloor 1973; 1976).

Conclusion

We can now summarize what we have learned about the origins of the strong programme. I have tried to sketch out the wider social and political circumstances that had preceded and eventually led to the establishment of the Science Studies Unit, where the strong programme has been shortly after developed as a naturalistic, causal approach to the study of the relationship between science (or, more precisely, scientific knowledge) and society. I hope I have been able to show the links between the development of the strong programme, the "two cultures" problem, the political situation in the post-war Britain, and the scientism associated with the British scientific left going back at least as far as the 1930s. Thus I hope that we can now understand why such a research programme originated right in Britain and right at that particular time, and what were the causes of (or motivations behind) its development.

To conclude, it remains only to consider what we have learnt from this with regard to the strong programme as such. As we can see now, all the accusations that have been mentioned in the introduction are false: First, the accusation that the people behind the development of the strong programme were social scientists with little or no understanding of science; second, that the strong programme is postmodernist; and third, that the strong programme is "anti-science". As I tried to show, the exact opposite of each of these accusations is, in fact, the case. First, all the people behind its development have been actually trained scientists and its development has been governed by the scientific, naturalistic attitude contrary to the speculative philosophical approaches. Second, as such, the strong programme is thoroughly modern, being rooted in the scientism that had been current among British scientific left since the 1930s and that culminated in the 1960s as a result of the debate over the problem of the "two cultures". And therefore third, it is as far from being in any way "anti-science" as possible, since scientific attitude, as I have tried to indicate, lies at the very heart of it.

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Poster

Certissima Signa. Astronomical Illustrated Manuscripts

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Certissima Signa (< http://certissimasigna.sns.it >) is a website created by the Astronomical Illustrated Manuscripts Research Group operating at the Scuola Normale Superiore, Pisa, Italy (< http://www.sns.it/en/ricerca/lettere/manoscrittiastronomici >). The aim of the website is to offer scholars a virtual meeting point, providing information about astronomical illustrated manuscripts (from the 8^{th} to the 15^{th} century) and related subjects, with a special focus on the relations between texts and illustrations. Several institutions are constantly improving the digitization of their collections, offering access through the world wide web to digital reproductions and descriptions of their manuscripts. *Certissima Signa* is meant to offer a general overview of the now accessible materials, providing scholars and students with a large collection of links and a critical orientation guide through the mass of material increasingly published online.

The first stage of the project concerns the manuscripts of the so-called *Aratea,* i.e. Latin translations of the Greek poem *Phaenomena* by Aratus of Soloi (written in the 3^{rd} century BC). Aratus' poem was one of the most famous astronomical texts in antiquity, and by sure the most widespread, due to its beautiful poetic style and its descriptive, non-specialistic attitude. It was widely read in the Graeco-Roman world, and was translated in Latin by many authors: by Cicero in the 1^{st} century BC; by Germanicus in the 1^{st} century AD; by Avienius in the 4^{th} century AD; and again by an anonymous monk in the monastery of Corbie (northern France) in the 8^{th} century AD. This translation, commonly known as *Aratus Latinus*, exists also in a different version, the so-called *recensio interpolata*, revised in Carolingian times. The manuscripts of Cicero, Germanicus, and the *Aratus Latinus* are decorated with several illustrations, whose iconographies can be easily traced back to ancient originals, and whose relations with the corresponding texts still have to be fully examined and explained.

Beside these texts, manuscripts of Hyginus' treatise *De Astronomia* (1^{st} century BC - 1^{st} century AD) have been included in this group. Manuscripts of Hyginus' scientific work contain texts and images of Hellenistic origin, derived from the mythological and astronomical commentaries to Aratus' poem, also found in the Latin commentaries to Germanicus (especially the so-called *Scholia Basileensia*) and in the *Aratus Latinus*: for this reason, manuscripts of Hyginus' work have been included in the database. For the same reason, two anonymous Carolingian texts have also been included: *De signis caeli* (which draws extensively on the *Aratus Latinus*) and *De ordine ac positione stellarum in signis* (with materials from the commentaries to Germanicus).

In its first version, *Certissima Signa* contains a complete list of all existing illustrated manuscripts of the Aratean tradition, with a constantly improving number of analytical descriptions of single manuscripts. Special sections, also under implementation, are devoted to ancient authors and texts, medieval scribes and monasteries, and the development of ancient and medieval astronomy. Already available is the collection of links, which guides the users through the existing websites devoted to the study of ancient science and medieval manuscripts, and through the digitized collections of the most important European and American institutions.

A section devoted to the manuscripts of Arab and Persian astronomical works is also planned, which will be developed in a further stage of the project.

CERTISSIMA SIGNA

Manoscritti astronomici illustrati

SCUOLA NORMALE SUPERIORE

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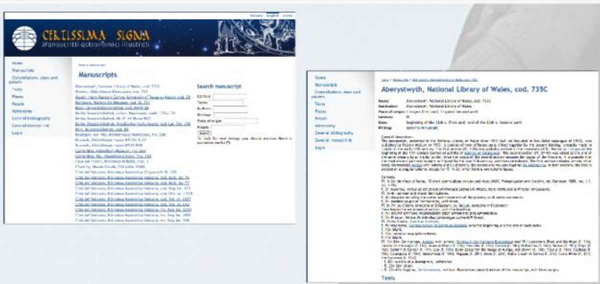
Certissima Signa is a website created at the Scuola Normale Superiore by the research group "Astronomical Illustrated Manuscripts" (`http://www.sns.it/en/ricerca/lettere/manoscrittiastronomici/`). The aim of the website is to offer scholars a virtual meeting point in which to find information about the medieval astronomical illustrated manuscripts and related subjects, with a special focus on the relations between texts and illustrations. The first stage of our project concerns the manuscripts containing *Aratea* (Latin translations of the Greek poem *Phaenomena* by Aratus of Soli, III century BC). Aratus' *Phaenomena* were translated by many authors: Cicero, Ovid, Germanicus (I BC–I AD), Avienius (IV AD) and an anonymous monk in the monastery of Corbie (and of the VIII AD); the last one is commonly known as *Aratus Latinus*. Beside these, manuscripts of Hyginus' *De Astronomia* (I BC–I AD) have been included in this group. Hyginus' work uses the same mythological and astronomical materials of the Greek commentaries to Aratus, of the Latin commentaries to Germanicus and of the *Aratus Latinus*. Because of their relation to the Aratean illustrated tradition, two Carolingian texts have been included: *De signis caeli* and *De ordine ac positione stellarum in signis*. A section devoted to the manuscripts of the Islamic tradition is also planned in a further stage of the project.

Manuscripts



Texts

Illustrations

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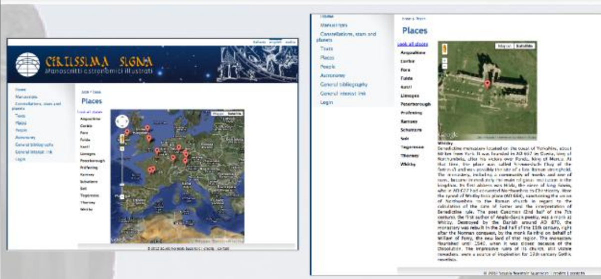
Constellations

Places



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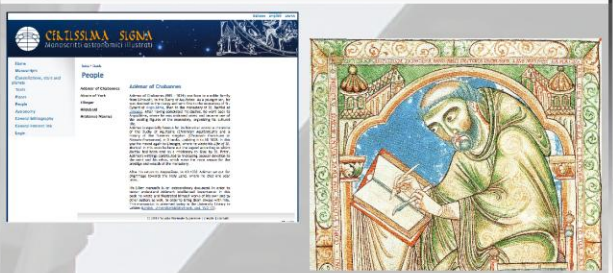

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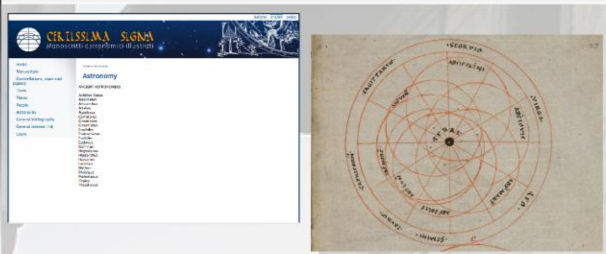

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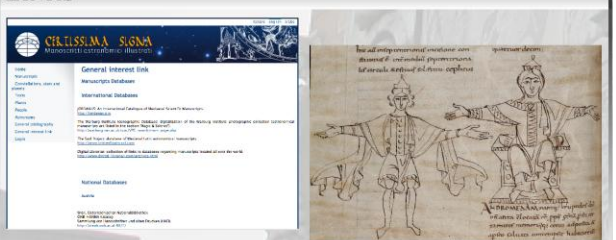

List of Authors - Index

ISBN 978-960-98199-3-0