THE WAY
TO THE "MAX-PLANCK-INSTITUT für Kulturpflanzenzüchtung"

by
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I. PREFACE

At the beginning of scientific studies there are concrete problems as a rule, which have to be solved. 1924 and 1927 I got in touch with the problem of breeding lupins free from alkaloids. I worked out the methodical assumptions for the selection of alkaloid-free lupins, and by means of this method I started the selection. Immediately after this first result I eliminated other negative qualities of the lupins, too, and that first in the way of recognizing qualities. After that the methods were applicated and the aims desired were reached.

Lateron I have developed other methods for recognizing invisible qualities (albumen, oil, total fibre, primary fibre, secondary fibre, saccharin, acid, etc.). Considering the rarity of the individuals with the qualities striven for the chief characteristics of all these methods was the quickness, respectively the "sufficient quickness" as we call it today ("quick-enough-method").

A lot of other problems were dealt with besides. We were stuck in a lot of work and were "looking up" at the problems from below, if expressing it figuratively.

Today, after 30 years of activity in the field of cultivation research, I don't feel only the need but I am under compulsion to "look down" retrospectively upon things and if possible to find out the conformity with natural law, on the basis of which a progress in the cultivation research can be achieved.

In the following I have tried to arrange my studies after these points of view and after conformities with natural law.

II. GENERAL

A. Natural Selection, Natural Active Selection, Artificial Selection, Breeding, Scientific Studies and Progress.

A selection is given if from a bigger heterogenous material of individuals or also of concrete or abstract possibilities and variants those with certain qualities are singled out.

The seperation in the natural selection takes place without the will or the planning of man. The wild grown plants for instance are selected by the "environment Nature". The geographic situation, climate and soil effect that only individuals with certain qualities survive or that they are at least favoured. A natural selection can also take place in the environment culture created by man. Thus, bacteria for instance are subjected to a selection in the "environment Culture" (antibiotica), and certain antibiotica-resistant forms can remain.

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Man, too, is subjected to a continual natural selection in the "environment Culture". Artists, scientists, merchants, people of all professions, who are not up to the vocational competition, are eliminated from their line of profession.

I pointed out that with man (contrary to plant and beast) in addition to the natural passive selection a natural active selection takes place and that the latter is evoked by the intervention of the environment. The natural active selection is an essential leading principle of the cultural progress. It can result in a positive as well as in a negative direction.

The artificial selection is guided in its direction by man, and on account of that it starts from a certain basis of the specific culture or of a period of this culture. Supposing the development of the aeroplane is the cultural situation. According to the development man wants pilots with certain physical, intellectual and character qualities. He develops methods in order to be able to recognize people with these qualities required, and he examines the existing heterogenous material of man by means of these methods.

Consequently the artificial selection consists of the cultural starting position, which has to be judged by man; the aim, which is set by man on the basis of the starting position firstly with regard to the necessity and secondly to the realizability; the development of the method for recognizing the qualities by man; the existence of the heterogenous material of individuals; the application of the method of recognition to the heterogenous material of individuals.

The artificial selection in plant and animal leads up to breeding it; the material of individuals is not regarded to be unchangeable and influence is taken on this material by means of the genetics. One can increase the mutability, one can systematically produce certain combinations, and one can secure the stability of the form desired.

Not only in the breeding of plants and animals one takes influence on the variety respectively the composition of the material, but also in the pharmacy for instance one can by means of the chemistry combine the material to be examined, of which one expects certain qualities.

A publisher of newspapers can do the same by varying the headlines of his newspaper in size, colour and contents and thus, takes up an artificial selection of this variant from these possibilities, which increases the sale of his newspaper. In this case the starting position is: a certain edition; the aim: an increase of the edition; the method: the measuring of the edition; the material: the different variations in respect of the contents and the representation; the artificial selection itself: the application of the method for recognizing the variants. Or a young girl notices that her overcoat is worn out. On this basis the aim "new overcoat" is set. This aim is realizable as she has got the money necessary for the purchase at hand and as there are coats of various styles offered. Her body supports her in finding the method for recognizing the right overcoat (apart from that, questions of taste are important). From the variety of ready-made

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models she choses the coat that fits her by trying on. In this case the industry takes the part of the chemistry or of the genetics by producing a great variety, which is directed by the fashion designer.

B. Wild Grown and Cultivated Plants.

1. Genetic history of the cultivated plants.

The significance of the selection for the creation of cultivated plants.

The wild grown plants in the "environment Nature" are subjected to a natural selection. When man made his appearance he began with the selection of plant varieties on the basis of his cultural situation. The aim was to find species of plants, which could provide for their needs.

The first step was to single out from a variety of species of plants by means of an artificial selection those, which answered a certain purpose. These species were collected first "selected crops varieties". They remained under the influence of selection by nature.

After the invention of the plough and other preregnisites for the agricultural botany (cultivation) he began with the selection of cultivatable profitable species from the selected crops varieties.

At the moment of taking into culture these cultivated selected crops varieties still show the characteristics of the wild grown plants. The culture itself gives a protection against the abolition by the conditions dominating in nature. Mutants can survive, which would have been eliminated by the "environment Nature". Thus, quite naturally those forms are favoured, which are most suitable for cultivation and propagation. The product of this natural selection in the "environment Culture" are our "country-varieties".

From the development of our civilized life (increase of population, wars, technocracy etc.) arose the necessity of cultivation in order to hurry the process, which up to now took place by a natural selection of the plants in the "environment Culture" and apart from that to open completely new possibilities of evolution.

Starting with a certain cultural situation, for instance the lack of sugar caused by war, one can set the aim not only to search for species of sacchariferous plants but also to achieve within the sacchariferous species an increase of saccharin content by artificial selection and isolated propagation of especially saccharin-rich individuals.

This required not only the potentiality (method) of recognizing individuals with certain qualities, but also the possibility to influence the material of plants in this way that the individuals with certain qualities can be expected in the material.

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The products of this evolution "directed by man", as Vavilov says, are the high-bred lines. Already before the discovery of the theory of heredity there was without any doubts a directed breeding, and the change from the natural selection in the "environment Culture" (country-varieties) to the cultivation (high-bred lines) is almost indeterminable.

There are several hundred species of lupins on the earth. From them the Lupinus albus in the Mediterranean area and the Lupinus mutabilis in Southamerica have been selected as "selected crops varieties" and lateron as cultivated species. Without any doubts both species originate from wild forms, which had shattering pods and hard-coated seed. By taking them into culture they were subjected to a natural selection with regard to their suitability for the culture, that is to say: today's cultivated "country-varieties" have got non-shattering pods and soft-coated seed. While the uncultivated wild plants are subjected to a negative selection in respect of shattering and hard-coated seed, they stood under the conditions of the "environment Culture" in a positive selection in respect of non-shattering and soft-coatedness.

All lupin varieties, even these two, have a high alkaloid content. Also the "country-varieties" of these two lupin species which are cultivated nowadays, are bitter and poisonous and can only be used as an article of food for man after it has been artificially freed from the alkaloids. There is no natural selection in respect of alkaloid-free so that this characteristic of the wild grown form can't automatically vanish under the conditions of culture.

2. The "sweet lupin" as example for the directed evolution of cultivated plants from wild plants (1927)

The cultural situation of the lupins, that we had to face in the twentieth of our century, was as follows: there were two useful species of lupins in the Mediterranean area and Southamerica, of which "country-varieties" with non-shattering pods, soft-coated seeds, white seedcoats and a rapid youth development existed. There were also varieties of lupins in Central Europe. These varieties still showed all the characteristics of wild forms: shattering pods, hard-coated and dark coloured seeds, breaking-off pods and the Lupinus luteus for instance an especially slow youth development. All the lupin varieties and species were bitter and poisonous on account of their high alkaloid content.

During the course of the last century light, acid soils, on which practically only rye and potatoes grow, were more and more cultivated in Pomerania and in the March Brandenburg. Consequently the starting basis of the cultural situation was that there were not enough cultivated plants for a normal rotation of crops on these grounds. Therefore one searched for suitable varieties of leguminosae. Lupinus luteus and Lupinus angustifolius were taken into culture.

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The actual selection of the varieties took place sometimes in the middle of the 19th century. Both species were used as lupins for green manuring and for green forage. At the end of the 19th century, after the frequent appearance of lupinosis the feeding with lupins was given up. In the twentieth an association for the promotion of the lupin cultivation (Nötling, Brams and others) was constituted, which especially dealt with the question of the lupin cultivation on light soils and their utilization.

A number of research workers, the first one was von Rümker in 1913, realized the necessity and possibility of cultivating alkaloid-free lupins. Especially Prianischnikow pointed out in 1924 that the selection could only be successful if a great number of individuals was tested. I emphazise this because the "Handbuch der Pflanzenzüchtung" has published irritating descriptions by Hackbarth and Troll in this connection.

The experiments which Roemer (1916), Prianishnikow (1924) and others carried out in this direction have not been successful. The essential reason for the failure was the fact that quick methods for recognizing the qualities required were devised, but that these were not "quick-enough" methods, as we call them nowadays.

Since 1927 I have developed "quick-enough" methods for the selection of following characteristics: freedom from alkaloids, non-shattering pods, non-breaking-off pods, soft-coatedness and rapid youth development.

By means of these methods we found in the "country-varieties" of Lupinus luteus and Lupinus angustifolius individuals which were alkaloidfree, had non-shattering pods, a rapid youth development and showed a white seedcoat colour.

After the discovery of these mutants with certain characteristics a combination of the valuable characteristics was carried out. The problem of the non-shattering pods in the Lupinus angustifolius, and of the non-breaking-off pods in the Lupinus luteus and the Lupinus angustifolius remained unsolved.

Immediately after the discovery of the sweet lupin I have carried out the first experiments on mice and rabbits in respect of the untoxic properties of the sweet lupin. In the twentieth and later a great number of scientists has ascertained the compatibility, the easy digestibility and the high biological value of the lupin and especially of the lupin albumen.

The name "sweet lupin" that we originally introduced as a collective name for all the alkaloid-free forms of all lupin varieties was registered by the "Saatguterzeugergemeinschaft" as a trade-mark. Sweet lupins of other growers may not be called "sweet lupins", even if they comprehend the same gene of alkaloid-freedom, as for instance those of the Dutch colleagues. I mention this because I want to make an appeal to the present patentees of the trade-mark to release the name "sweet lupin" as a definition of all alkaloid-free forms of the different lupin varieties.

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The studies show that it is possible to carry out a planned change of a wild grown form into a cultivated form in a very sho time by means of the modern breeding research.

In 1937 the then director of the institute at Müncheberg mad me leave and with that the work of my life. The break in the continuity of my lupin studies led to a practical loss of my ent material of Lupinus albus, Lupinus mutabilis and Lupinus perenni

The sweet lupin became a playball of personal, economical an political interests, what prejudiced considerably its general development. Everybody thought he could make a deal with such a new bred plant, and everybody neglected the fact that the creati of a new bred plant lays the obligation on the institute, the commercial life and also on the state to take care that it is no imperilled by impertinent interests immediately after its discov

It would have been more significant if all interested person at home and abroad could have taken part in helping with the breeding plan, the growing, the propagation and with the introduction of the new cultivated plant.

In spite of all difficulties it is being well developed toda in those countries in which it could be antochthonous as for instance in Poland, White Russia and Portugal.

In this passage I would like to mention a curiosity which is connected with the discovery of the sweet lupin and this example of mutation from the the wild to the cultivated plant. In a forestry journal the breeding of sweet lupins was described as follows: "The cultivator sat down at the border of a field and observed the behaviour of the rabbits. If rabbits started eating lupin plant which they normally refuse the cultivator retrieved the plant from them and propagated them. It was found out that these plants were alkaloid-free plants."

3. The accomplishment of the change from the wild grown to the cultivated form in our present cultivated plants

Our present cultivated plants have been subjected to an intensive natural and artificial selection in respect of their growth value and their efficiency. But quite a number of them ha still got characteristics of wild grown forms, which depreciate considerably their cultivation value and efficiency. Thus, the tobacco for instance produces blossoms and seed, although we only utilise its leaves.

For a complete change of the tobacco into a cultivated plant it would be necessary to grow it as a foliage plant. The short-d form of the tobacco does not bloom in the summer of our latitude The seed production and the propagation, however, can take place under short-day conditions that have been produced artificially.

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Hemp and spinach are dioecious plants, the efficiency of which is depreciated by the dimorphism of sex. In both plants the accomplishment of becoming a cultivated plant failed, that is to say the breeding of monoecious forms.

Apart from that the fibre content of the hemp was up to now just as low as that of the wild form. Therefore the hemp lacked even in two steps of change: monoecy and fibre-richness.

The unwanted blue-colouring of the asparagus is also to be regarded as a requisite of the wild grown form.

In the two old, cultivated plants Lupinus albus and Lupinus mutabilis it was the high alkaloid content, which had to be overcome in order to carry out a complete change into a cultivated plant.

What we showed by a few examples applies also for a lot of other cultivated plants.

4. Genetic history of cultivated food-plants (1953).

I thoroughly considered, if the primitive human is able to alter the plants he utilizes in every direction he wants to. In regard of food-plants I came to the following conclusion: there are apart from the edible plant varieties plants with an unpleasant flavour, plants with a bad dietetic effect and plants, which contain poison. The alkaloids of the lupins have to be reckoned among the poison. From the fact that during the culture of many a thousand years man did not succeed in producing alkaloid-free lupins and from other examples the conclusion has to be drawn that the primitive human is not able to eliminate the characteristics "dietetically unfavourable" and "poisonous".

On the other hand I suppose that the primitive human was able for instance to carry out a positive selection in respect of pleasant flavour from the vegetatively propagated, non-poisonous but bad tasting fruit varieties; because he could repeatedly test the fruits of the seedling upon flavour and quality and multiply those which appealed to him most.

5. Transmission of valuable qualities of the wild form to the cultivated form (1926).

In 1926 I started transmitting valuable qualities of a wild form to the cultivated form. Secale montanum, a wild grown species of rye, is perennial. We were to try to transmit the perennial character to the cultivated form and to test, if the perennial rye could be of any importance for fodder purposes.

The first crosses of wild grown and cultivated rye were produced in the summer of 1927, the F_1 was grown in 1928. Seeing that I was engaged in the studies of lupins during these years, and that in the new established institute a rye department for cultivation research was established I handed my rye material over to the rye department for being continued in its cultivation. Unfortunately the problem of cultivating a perennial cultivated rye has not been carried out consequently enough so that today we have taken up these studies again.

It is quite possible that a big-kerneled, perennial cultivated rye with a fragile rachis, possibly resistant to mildew and brown rust, has a very fair chance as forage rye.

Parallel experiments I have carried out with tomatoes. In 1929 I took over the crossbreeding progenies of different wild grown and cultivated tomatoes, which Hanna Becker produced. I found out that the wild form Solanum racemigerum had a number of valuable qualities. It is early mature and resistant to Cladosporium fulvum; apart from that it has genes for non-bursting and non-falling-off fruits. I was able to isolate specially early ripening and Cladosporium-fulvum-resistant individuals from the cross-progenies, and other plants, the fruits of which have got an especially pleasant flavour and do neither burst nor fall off.

The difficulty in the combination of valuable qualities of the Solanum racemigerum with those of the cultivated tomato was that the size of the fruits apparently is directed by polygenes, and in the F_2 under the limited number of a few thousand specimen there did not one individual occur with normally sized fruits. The final combination could only be succesful by back-crossing with the cultivated form, as KAPPERT has repeatedly pointed out.

These studies were interrupted, too, by me retiring from the institute at Müncheberg. But they are continued today in Sweden, the U.S.A. and a lot of other countries.

Summarizing it should be stated that there is the possibility of mobilizing valuable qualities of wild forms for the improvement of our cultivated forms.

6. Economical fundamentals of plant improvement breeding work - private and run by state (1937).

The breeding work in Germany is done by private breeders with the various cultivated plants on a differently large scale. An attempt was made to find out the law according to which the process takes place. Utilizing the cultivated products of the individual, cultivated plants economically brings differently high takings, which depends, if there an annual change of seeds and plants takes place, if oneself produces seeds or plants or if it has to be bought, how big the cultivated area is, how the relation between the test weight of thousand grains and the price of the seed per kg is, how quick the gradual abolition takes place.

All these questions are subjected to a systematic examination.

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Already now we can draw a few final conclusions: the expenditure of work and with that the expense of money, which is necessary for a running improvement of a plant species by cultivating, is always in certain limits equally high. The cultivated plants with high takings are intensively bred, whereas those with low takings are only bred very rarely or not at all. Berries, fruit and forestry plants belong to those varieties, which are not bred. From the politically economical point of view an intensive breeding work also with these plants is required.

Another disadvantageous consequence is that an undesired disruption takes place, as many breeders work with cultivated plants with high takings. If only a few would participate in the profit of cultivation possible, these could carry on with an intensive modern plant breeding with the specialists necessary.

The extent of private breeding in the individual cultivated varieties depends furthermore on how far the intellectual property in the cultivations is protected. In Germany there is a legal protection of a few varieties, of others not. For the varieties legally not protected one can obtain a protection by the trademark or in certain cases a protection of patents. There are also plant varieties the protection of which lies in the way of propagation.

It is desirable that the protection of the intellectual property in all cultivated plants was realizable.

The data of the private cultivation indicate the possibility to complement the private breeding by breeding run by state. A private and state breeding combined, however, arise difficulties in respect of the utilization of the cultivation products. The private breeding work has to regard the state breeding work as an unfair rival. On the other hand the intercalation of the state cultivation on the field of forestry plants, fruit varieties and berries as well as of the "lesser" cultivated plants is necessary.

III. Aim on the Basis of the Cultural Conditions.

At the beginning of my expositions we saw that every cultivation is based on the specific cultural standard and that aims arise from this standard, which are required as needed, and which are realizable from the point of experience and knowledge. In the following chapters I am going to try to show in a few examples this establishment of cultivation.

In 1942 the start was made to build up an industry of freezing and refrigeration machines in Germany. But most of the vegetable varieties, berries and especially the strawberries turned out to be unsuitable for this new preserving method. Therefore I suggested to breed a special strawberry species, the fruits of which can be preserved easily, that is to say fruits, which donot lose colour, shape, consistency and flavour after freezing and remiting. In 1947 the first strawberry species were cultivated with the financial support of the refrigeration industry. When the refrigeration industry was shut down because of the hard economical situation, there was no need any more for especially valuable qualities of strawberry varieties. This example shows the dependence of the establishment and work of the breeding on the specific "cultural" conditions.

After that we turned to an intense cultivation of strawberry varieties, which have an expanded growing- and utilization purpose. The result of these studies was the variety "SENGA SENGANA" which has a monopoly as a midseason variety not only in Germany but also in most of the European countries.

It is practically the only strawberry variety which is arable that is to say which can be "agriculturally" cultivated on a large scale, and the fruits of which are preferred today to all other varieties.

A. Production of Crops Independent of the Soil (1937).

Mushrooms.

In the whole world the problem is being discussed whether the increase in the population would cause a shortage of food. One group contends that the production would keep up with the increasing want; the other group is convinced that this would be impossible in the long run. Independent of these theoretical discussions a mobilization of a soil-independent production of victuals of algae apart from those of the agriculture, horticulture and fishing was started in many places (especially in Japan, the U.S.A., but also in Germany).

First we coped with in a preliminary phase with the problem of the mushroom Psalliota bispora Lge., which already was a cultivated plant.

These works start with studying the nutrition and biology of the mushroom and with the question of the practical growing and they end in an organized cultivation. A few results could be achieved: We have developed methods, by means of which we can stimulate the spores to germinate more concentratedly than under normal conditions (Breitenfeld). It was found out that the microorganisms of the covering soil are most likely the reason for the formation of fruit-bodies of the mushroom (Eger).

We have developed a new inoculation method for the actual growing (Active Mycelium), by means of which the vegetation period can be reduced and the crop per cubic meter-volume considerably increased (Huhnke, von Sengbusch). This Active Mycelium Spawning Method in its application results in a complete reform of the entire mushroom cultivation. The explosion-like crop in the first two harvesting weeks makes a considerable reduction of the duration of cropping possible. Thus we are able to about double the turn-over frequency of the cultures.

We are employing this new method now and we have altered all single factores of the culture. Thus the Active Mycelium spawning Method has become the basis for a new cultivation method.

B. The Albumen Problem (1935).

While cultivating the "sweet lupin" I was also coping with the albumen problem. The ratio of albumen to carbohydrates in normal cultivated plants (except in a few leguminosae) is 1:1o up to 1:15. Consequently they are lacking in albumen too much as to produce the necessary ratio of 1:6 for the full nutrition of man. We keep animals in order to get a more concentrated albumen producer, but with that we loose about 8o-9o % of the nutritive material as well as of the albumen.

It would be an essential problem to increase the albumen content of our main forage plants by cultivation especially in times of scarcity, when there cannot be supplied enough animal albumen (for instance in India and China). This concerns especially wheat, maize, rye and other corn varieties as well as the potatoes. On the basis of our experience we have today it should be quite possible to increase the albumen content of our cultivated forage plants considerably.

A method for the isolation of the vegetable albumen, especially in forage plants, would contribute to solve the same problem, the lack in albumen. In 1937 I have pointed out the importance of this very possibility. The problem of isolating albumen, adequate to isolation of saccharin in beetes, seems having been solved in England.

C. The Oxalate Problem (1953).

In the course of the last decades the spinach has become the most important vegetable variety of the freezing industry. We have raised the question, if the oxalate content of the spinach has a bad effect with an increased consumption.

We developed quick determination methods for recognizing the characteristic "Oxalate-poorness" (Brozinski, Niedieck) so that the conditions for the selection of oxalate-poor spinach are given.

Furtheron we have examined of which significance the oxalic acid supplied by food is and that we did seperately with dissolved and undissolved oxalates. We were able to find out that persons tained with oxalate stones (about 7o % of the renal stones are oxalate stones) usually show a higher oxalate excretion than healthy persons, and that this excretion takes place in the form of undissolved microstones and big single crystals, which we were able to inspect quantitatively by means of our sieve-test (vpn Sengbusch, Timmermann). With a supply of oxalic acid by victuals we find

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similar signs of an urine overload of undissolved oxalate in healthy persons as well as in the genotypes, which are inclined to a high endogenous oxalate excretion.

The fact that an exogenous supply of oxalates can be injurious for man nearly made us begin with a cultivation of an oxalate-poor spinach. We have examined the oxalate content (soluble and insoluble) in the fresh plant and in the ready-for-cooking frozen products. We found out (Goldacker) that by boiling the spinach before freezing about 80-90 % of the soluble oxalates, that is to say of the poisonous respectively the injurious oxalates, leave the spinach and merge into the boiling water. In the light of these results we thought the cultivation of oxalate-poor spinach unnecessary. This example shows that the foundations of every breeding work have to be studied thoroughly in order to avoid useless work.

The final conclusions of these discoveries, however, are much more far-reaching and they led to the attacking of a new working-field: development of methods for the reduction of endogenous formation of oxalates, increase of the dissolvability of the urine for oxalates, dissolution of renal calculi in the kidney.

The development of methods for reducing the formation of oxalic acid can be successful only, if we have adequate animals, which show a high endogenous formation of oxalates on account of their genotype. From hundreds of rabbits we have selected those, which showed a high excretion of undissolved oxalates (catheterization of the rabbits and examination of the urine sediment). By an organized cultivation of "oxalate-rich rabbits" a strain homogenous in this character shall be created. These animals we want to use for the selection of the corresponding therapeutica, which reduce the endogenous formation of oxalates.

This example, too, shows that not only in the cultivation but also in the breeding the specific cultural standard is of great significance for the aim. In this case the aim is the breeding of a strain, which is to be used especially for medical purposes.

The problem of dissolving renal calculi in the kidney was up to now coped with by various researchers without any success. It is so interesting, because every surgical operation on the kidney means a danger of life, and after a surgical extraction of renal calculi had been carried out twice another stone formation would mean a removal of the whole kidney.

The team Brozinski, Niedieck, von Sengbusch and Timmermann have developed the prerequisites for the dissolution of renal calculi in the kidney. A solvent compatible for man was found, which dissolves renal calculi in vitro within the time of up to 150 hours. Furthermore suitable catheters as well as a rinsing method for the kidney have been devised. By rinsing the kidney with P.3, P.4 and P.6 a detachment of smaller renal calculi was achieved so that they could leave the kidney on the usual way through the ureter. In

December 1959, January and July 196o for the first time we succeeded in dissolving the beansized renal calculi with P.8 in the kidney of three patients, which most likely consisted partly of oxalates (P.8 → Titriplex III with triethanolamine, buffered with pH 8,6). We can hope that with a further development of the solvent and of the rinsing technique the method of dissolving renal calculi in the kidney can be improved.

IV. Methods of Recognizing Characteristics (1927)

A. "Quick Methods" and "Quick-Enough-Methods".

When the aim is set on the basis of the cultural conditions, we come to the next step of the artificial selection, the method for recognizing the character desired.

If we are able to recognize the characteristics in question by means of our organs of sense, as for instance the colour of flowers or the shape of plants with the eyes or the fragrance of plants or of parts of plants with our olfactory organ, the use of these organs is simultaneously the suitable selecting method.

The selection of fruit and berries in respect of good flavour has been carried out without any doubts also by the primitive human by means of his sense of taste.

If the characteristics in question are only visible under certain circumstances, this condition has to be brought about by means of a method. As for instance with a high temperature and a low athmospheric humidity the pods of the lupin shatter at the time of maturity, we can see the characteristic "non-shattering" respectively "shattering" of the pods. Consequently, if we want to recognize the shattering of the pods, we have to wait for an especially drought and warm weather at the time of maturity.

The characteristic "soft-coatedness" is recognizable only if we dry the seed of the lupin and after that let it soak in water. Because the genotypes with soft-coated seed even swell if the seed was well dried, whereas the hard-coated seed does not resorb water.

The primitive human will be able to influence by cultivation visible characteristics and those, which can be easily made visible.

The invisible characteristics, however, can be recognized only by means of chemical and physical methods. For the determination of the saccharin content we use the specific weight, the refraction index and the rotatory power of the light. The alkaloid content is chemically determined by means of special reagents, the fibre content by methods of the biological and chemical roasting.

In the course of more than 3o years we have coped especially with the development of methods, which make a recognition of invisible characteristics possible (especially the substance in the cultivated plants).

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Plants, which have the characteristics we are looking for, are remarkably rare. This concerns single characteristics as well as combinations of characteristics. Usually we do not know in advance how often a plant with a certain characteristic is held in a material. In the past we called the methods we use for our breeding studies "quick methods". Now, considering the conditions described, we have introduced a new name "quick-enough-method", that is a method by which we are not only able to examine a great number of individuals, but so many that the form desired is really bound to be found. Whether a method is quick or quick enough is settled only by the result.

B. Early Diagnosis (1923).

By early diagnosis we mean a method, by aid of which we can judge a characteristic which is not respectively as fully distinct or which normally is not or only imperfectly recognizable in the state in which the plant to be examined is.

The advantage of the early diagnosis is that by means of it we are able to save time, especially with longlived plant varieties, or to recognize characteristics before the flowering, which are usually not recognizable until flowering. Thus, we are able to carry out a planned and organized fonctification of the cross-pollinating plants.

Experiences gained with the early diagnosis, in short-lived cultivated varieties indicate that the early diagnosis will be of great importance for the cultivation work of long-lived cultivated varieties and that most likely it will be successfully applicated. The advantage of the early diagnosis for the breeding work of the allogamous plants is already proved. It is the only possibility to achieve a progress in cross-pollinated plants. In this connection it is of no interest that in several cases a clear demarcation of the early diagnosis from the normal method of determining characteristics already early marked is not possible.

C. Analysis and Synthesis of Complex Characteristics (1935).

A number of characteristics present themselves as a complex that is a complex consisting of several partial characteristics. In these cases it is not sufficient to inspect the complex methodically as a whole, but we have in order to cultivate plants with certains complex characteristics to examine, what partial characteristics the complex is consisting of. Furthermore we have to develop methods, by means of which we can recognize the partial characteristics. Also this problem shall be exemplified.

Before wer found the mutant with non-shattering pods in the Lupinus luteus, which is conditioned by a rezessive gene, we thought we could reach this aim only on a very complicated way. A theory was enunciated that the non-shattering of the pods was a complex characteristic, which had to be analysed (thickness of the layer of fibres as a cause for the tension of the pods, kind of the fibres, breadth of the pods, length of the pods as a cause for

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the tension of the pod-halves).

On the basis of this analysis we wanted to select the individual qualities independent from each other (thin layer of fibres, certain kind of fibres, broad pods etc.) in order to synthesize them to the total complex "non-shattering pods" after that. We had calculated that this complicated way of analysing and synthesizing is easier realizable than the search for the exceptionally rare form with the total complex "non-shattering pods", particularly as each partial characteristic on its own is not able to cause the non-shattering of the pods.

D. Causes of the Performance (1955).

Many individual characteristics of the cultivated plants are of great interest. Apart from these, however, there are complex characteristics, which depend on the development of the different parts of the plant and on its physiogical reaction: this is the effect of the cultivated plant. Therefore the method for recognizing the total effect of the cultivated plant takes a special position in the methods for recognizing valuable qualities of cultivated plants. For this reason we believe that the problem "causes of the performance of our cultivated plants" has to be put into the centre of the breeding research.

Our cultivated plants are grown only because of an especially valuable quality. We utilize only parts of the plant. These parts can lie overground or underground as bulbs, thickenings of the roots or seeds and fruits, Only that part of the produced organic substance, that is put down in the utilized part, is a criterion for the effect (Börger, Huhnke, Köhler, Schwanitz, v.Sengbusch).

Accordingly, in our opinion the effect of a cultivated plant does not only depend on the net assimilation rate. We distinguish three parts, which are connected with the particular effect of a cultivated plant: the assimilative apparatus, the root apparatus, the storing organ. We cannot seperate the effect of the genes, which influence all the three different parts, from each other in one plant. Still we would like in order to be able to carry out a planned effective breeding to applicate a combination breeding, in which the effective genes of the three different parts of different original plants can be combined. Experiments already showed that these considerations are right. In order to study the particular effect of particular parts of a plant we can employ methods as for instance the reciprocal grafting of different varieties, the artificial reduction of the storing organ in proportion to the assimilative organ and the artificial reduction of the assimilative organ in proportion to the storing organ; similar reduction of the root system.

First results make it presumable that the storing organ is not only passively but even actively engaged in its effect. Thus, the starch content and the size of the bulbs are dependent on the genotype of the storing organ. On the other hand the starch content and the size of the bulbs are independent of the genotype of the foliage of another variety, which has been grafted with a certain potato species. The size of the kernel of the corn is fixed by the genotype so that even with a reduction of the ear by one-half of the size the size of the kernel does not increase by the corresponding rate.

V. Material (Applied Genetics)

A. Gene Mutation and its Importance for the Breeding of Plants.
Heredity and Parallel Variations.

We examined the mutants genetically, which had been found during the mutation of the wild form of the lupin into the cultivated form, as well as the valuable characteristics of the wild grown tomato, which we used for improving the cultivated tomato, the character "sex" in hemp and spinach and a lot of other characters. We ascertained that most of these traits are monogenous and that they have a recessive character. This fact was the prerequisite for an easy carrying out of combinations in those cases, in which a combination of equal characteristics was desired.

Further we found out that one characteristic can be caused by two or more genes. Thus, we found in the Lupinus luteus for instance three different genes, which everyone on its own effect freedom of alkaloids. The same applies to the white colour of the seed. This fact suggests that the alkaloids of the lupin for instance can be blocked in the course of its material formation at different spots, as it has been substantiated already by other research workers.

In the lupin specimen we can also demonstrate the law of parallel variations. In all varieties we had coped with we succeeded in finding alkaloid-free forms, soft-coated forms and forms with a white colour of the seed shells.

First we thought that we had to look for forms for the non-shattering of the pods in the Lupinus luteus and the Lupinus angustifolius, which according to the same mutation would not shatter as the pods of the Lupinus albus and the Lupinus mutabilis. It became obvious that nature apart from the parallel variations still kept ready other possibilities for solving this problem. We found a mutant in which the non-shattering of the pods is caused by the eccration of the sclerenchyma cord of both pod-halves. The breeder when attaining his aim can reckon with a great variety of nature.

B. The Great Number in the Breeding of Plants.

The selection of mutants with certain characteristics comes often upon difficulties as a great number of individuals has to be examined, and we are unaware of what great a number of plants we have to examine until we find an individual with the character desired. I found one alkaloid-free individual in 10.000 plants of the Lupinus luteus, one alkaloid-free mutant in 100.000 individuals of the Lupinus angustifolius and one in 1 million plants of the

Lupinus mutalibis. The mutant with non-shattering pods was found in lo million plants. In order to carry out the selection successfully the method for recognizing the characteristics has to be "quick enough".

Moreover, we can manage such a great number only if the individual work proceedings are mechanized. That does not only apply to the examination on single characteristics but also to the sowing, the cropping, the thershing of single plants etc. Therefore we have developed threshers and winnovers according to plan, which supported us in reaching the aims set.

C. Sequence of Mutations.

While selecting alkaloid-free mutants from the Lupinus albus an interesting problem came to light. We found out that there were apart from the rose-coloured seeds between o,1 % and 1,o % white-coloured seeds. Examining the rose-coloured ones we did not find any alkaloid-free individuals, whereas in the white-coloured seed we came upon them comparatively often, 1:1oo up to 1:5.ooo. From that we concluded that there must be a sequence of mutations in this way that the mutation from rose- to white-coloured seed has to take place first before the mutation to alkaloid-freedom can succeed. This phenomenon might be of importance for the formation of varieties, for which a series of subsequent steps of mutations is necessary and not just an addition of steps of primary mutations.

D. Sex and Effect (1937).

Hemp, spinach and asparagus are dioecious cultivated plants, in which the characteristic dioecism is the reason for a sex dimorphism, which in return is the reason for an inferior effect in economical respects.

1. Hemp (1934).

Neuer (1934) first tried to breed monoecious hemp. The difficulties in fixing the monoecism led to the team-work between Neuer and us.

By means of the trimming method one can make the hemp flowering twice. During the first flowering the selection of the ideal monoecists is carried out and the other plants are annihilated. During the second flowering the reciprocal fertilization of the ideal monoecists takes place. By means of this method we are able to produce purely monoecious hemp.

Studies on the heredity of monoecism showed that the monoecious plants are varied female plants with homogenous gametes. Thus, the monoecists have all the advantages and disadvantages of the female plants.

In 1953 we tried to breed also a monoecious hemp with a male habit. The male monoecious forms would be important as profitable fibre plants and apart from that as an interesting object for studying the heredity of sex.

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We also looked for male plants with a budding for seed. Huhnke found individuals with the characteristic desired in the hemp variety "Dr.Schurig/Markee". After having found these we tried to fix the male monoecists. It appeared that with an isolated fructification and propagation of the male monoecists 5o % of their descendants were always pure females and 5o % males and male monoecists. We explained this phenomenon with the omission of the y-oosphere in the male monoecists. Dierks was able to support this theory by reciprocal crosses between male and female monoecists and females.

We can succeed in breeding male monoecious hemp only if we find male monoecists, which form y-oospheres, and if these y-oospheres together with the y-pollen grains produce male monoecists with homogenous gametes.

Already in 1934 I began coping with the cultivation of hemp with a high fibre content. Corresponding chemical (Schwarze and v.Sengbusch) and microscopical (v.Sengbusch) selection methods for recognizing a high fibre content were developed. By means of this method we tried to alter the dioecious as well as the monoecious hemp (Huhnke, Neuer, Schwarze, v.Sengbusch) in respect of a high fibre content during the years 1935 to 1945. We achieved an increase of the fibre content from 12 to 16 %. The fibre-rich hemp was destroyed in the war.

Independent of us the team Bredemann, Garber coped with trials of the same aim. This team achieved an increase of the fibre content from 12 to 24 %. In 1951 we associated with this team. It appeared that Bredemann's fibre-rich hemp still showed deficiencies for the practical growing (little produce of straw, early maturity).

It was to be tried to combine the high fibre content with late maturity and high produce of straw. By means of a method developed by us we found out during these trials that the primary part of fibre in the total fibre is relatively little in the fibre-rich Bredemann-hemp (4o %). Desired, however, is the highest part possible of the primary fibre (primary fibre = long fibre; secondary fibre = short fibre).

The Italian hemp of high quality is marked by a high content of primary fibre (8o %). By means of corresponding methods for inspecting the content of primary fibre, the quality and the late maturity a primary-fibre-rich, monoecious (Fibrimon) and a primary-fibre-rich dioecious hemp (Fibridia) was bred. Today Fibrimon is used for the production of fibre and paper in France and Poland, whereas Fibridia continuously gains ground in Italy.

It became evident that the cultivation of hemp as a fibre plant considerably decreased. The fact that the whole crops of the hemp as well as of the flax and jute has to be transported and prepared in several working phases seems to be the reason for that. The fibrous bast plants are being outmatched by the cotton, because with cotton only the fibres are harvested and prepared. It is just possible that all bast fibres have to give way to the easily to be harvested cotton on account of the reasons mentioned above.

It is a question of a selection process, which among the fibre plants prefers those, which make the most rational fibre production possible.

2. Spinach (1937).

The male individuals of the spinach spring up earlier than the female ones (sex dimorphism). The breeding of monoecious spinach (female monoecists) rules out the male types. We have bred three different female monoecious spinach varieties, a winter-, spring- und summer-spinach.

It remains to be seen whether in spite of the difficulties in the seed production of monoecious spinach (elimination of the males before flowering) these varieties come true in the cultivation

3. Asparagus (1938).

The problem of sex and performance in the asparagus is a different one than in hemp and spinach. The male asparagus plants seem to be more efficient than the female ones (in the female plants a great part of the assimilates is deposited in the fruits and the seed, whereas in the male plants they are stored as spare substance underground). We as well as a number of researchers have found out the theoretical possibility of cultivating a pure male asparagus. Male monoecists have to be looked for. After the self-pollination of the male monoecists theoretically yy-plants with homogenous gametes, which are purely male, could appear. If crossing pure females with yy-males the descendants are exclusively male individuals.

Colleagues in Wageningen successfully coped with this problem in the same way as pointed out before.

Above all we brought another problem of the asparagus into prominence: the cultivation of an asparagus with white-remaining tips. This white-tipped asparagus makes a retrenchment of work during the cropping possible. While up to now we have to cut the asparagus under the ground so that it remains white-tipped, we can wait until the asparagus with white-remaining tips has pushed through the soil and jutted out of the ground for about 1 cm. The asparagus with white-remaining tips is just being tested.

We tried to alter the expression of sex in hemp, spinach and asparagus. In all three species the fixing of the sex expression and not its recognition played the main part. One can see the sex expression "monoecism"; its fixing, however, requires a systematic application of the genetic knowledge. It was repeatedly tried to produce monoecious varieties of hemp. But all trials failed as the F_1 of the monoecious form always was dioecious. Only the knowledge of the genetics and the assumption that the characteristic "monoecism" was recessive encouraged Neuer to look for monoecists in the next generation. By a systematic isolation of the monoecists found in the next generations an increase of the monoecious part could be gradually achieved.

E. Components (Inbreeding and Heterosis) of Vegetatively Propagated Cross-Pollinated Plants (1922).

The breeding of a number of cultivated plants is carried out empirically. This especially applies to the berries, the stone and pomaceous fruits as well as to a number of forestry plants. Varieties, which have certain characteristics, are crossed with each other. After that individuals are selected from the most efficient descendants in respect of a characteristic or a combination of characteristics. On this occasion it becomes evident that individuals with valuable characters are extremely rare and certain combinations of characters are hardly to be found.

The reason for that is that the starting material, as for instance of the raspberries and strawberries, is heterozygote. Already in 1922 it was considered carrying out a systematic propagation in those cases by inbreeding and recurrent selection with regard to certain extreme characters. Thus, we would get inbred lines, which are homozygote for each valuable characteristic, that is to say components, with which we could systematically carry out a combination breeding. We are of the opinion that thus we can achieve certain combinations of characteristics, as for instance the detachability from the calyx of the strawberry, the large fruitedness and firmness of its fruits and their dark red colour. Today we have not got a line yet which is homozygote for the detachability from the calyx for instance.

It should not be of great difficulties to dissolve the loss of vigor by inbreeding, as with the crossing of two inbred lines an effect of heterosis is to be expected. On account of the octoploidy of the cultivated strawberry, however, a homozygoty can be obtained only very slowly. Therefore those studies have to be carried out in the same way with polyhaploids, that is to say on a tetraploid level (Hondelmann).

Apart from the systematic combination of the characteristics of components we could expect especially efficient gene combinations (heterosis effect).

As in 1927 the entire genetics have been attached to the breeding research as applied science (although already before, the genetics played an important part in the cultivation), the isolation of components of certain plant varieties especially of the long-lived, vegetatively propagated plants should be included in the breeding research and the cultivation today. Thus, a considerable progress of effect in many cultivated varieties could be expected.

F. Genome Mutation and Effect (1938).

In 1938 I have produced a "Gigas-rye" by means of colchicine in the research department of the F.v.Lochow-Petkus Ltd. in Petkus. This rye is the starting material of today's "Tetrarye" of the F.v. Lochow-Petkus Ltd.. The tetraploid rye, however, has still got a number of disadvantages. It is less tilled and shows more sterility. The standing resistance of the tetraploid rye is due to a little tillering, to stable stalks and to the partial sterility and with that to the little weight of the ears. The tetraploid rye shows a much higher weight of 1.000 grains than the diploid rye.

We tried to develop a diploid "Gigas-rye" on the genetic basis. A great tillering and a better fertility can be expected with a great stalk stability in the tetraploid rye. It is very intersting that the weight of thousand grains of the diploid "Gigas-rye", that we have found, is similar to that of the diploid and not of the tetraploid rye.

In order to be able to grow systematically tetraploid as well as diploid rye the "cabin method" was developed. By means of this method the rye is cultivated with a long distance between the single plants. A short time before flowering a judgement of the habit takes place and after that the different rye forms are planted in pots and isolated in groups. Thus we succeeded in cultivating various types of rye and in comparing them with regard to their effect.

The question in this connection is, if a high effect can be achieved only by increasing the assimilation surface. We have to consider the possibility that by a one-sided enlargement of the assimilation apparatus the effective capacity of the storing organ can be even decreased. The effect of a cultivated plant will always be a question of achieving a maximum effect of the storing organ.

The tetraploid rye is an example for the formation of a new rye variety by genome mutation, and with taht the variety of the rye material has been enlarged.

VI. Practical Results.

A. Breeding Results: Plants

1. Lupins.

In the Lupinus luteus we found alkaloid-free mutants (v.Sengbusch), mutants the seeds of which are soft-coated (v.Sengbusch), which have a rapid youth development (v.Sengbusch) non-shattering pods (v.Sengbusch, Zimmermann) and white seeds (v.Sengbusch, Klawitter).

We carried out a combination of these characteristics, which first were found in single plants. The first alkaloid-free form of Lupinus luteus was called "v.Sengbuschs gelbe Müncheberger Grünfutter-Süsslupine".

In the Lupinus angustifolius we found alkaloid-free mutants (v.Sengbusch), mutants with soft-coated seeds (v.Sengbusch) and hardly, shattering pods (v.Sengbusch, Zimmermann). The first alkaloid-free form of Lupinus angustifolius was called "v.Sengbuschs blaue Müncheberger Grünfutter-Süsslupine".

In 1931 the "sweet lupins" Lupinus luteus and Lupinus angustifolius were sold to the "Saatguterzeugergemeinschaft" for DM 5o.ooo and thus withdrawn from our breeding work. Simultaneously the sales contract stipulated that the determination method for alkaloids, which I had devised, was not to be published for 1o years.

The lupins with non-shattering pods were sold again for DM 5o.ooo to the same company, which had bought the sweet lupins.

Lupinus albus: alkaloid-free mutants (v.Sengbusch), mutants with a late maturing time (v.Sengbusch). The forms, which had been developed in Müncheberg, got practically lost after 1937.

Since 1949 late and alkaloid-free forms are bred for the cultivation in Portugal. The breeding of these forms is continued in Portugal (Marques de Almeida), and they are grown under the name "Tremoco doce da Francelha".

Lupinus mutabilis: an alkaloid-free mutant (v.Sengbusch), which got lost in Müncheberg after 1937.

Lupinus perennis: an alkaloid-free mutant (v.Sengbusch), which got lost in Müncheberg after 1937.

2. Tobacco.

In the year 1928 an alkaloid-free mutant was found (v.Sengbusch). The breeding work on the tobacco had to be given up at the order of the institute for tobacco research in Forchheim. The alkaloid-free strains were offered to the U.S.A. There they became the starting material for alkaloid-free respectively alkaloid-poor tobacco varieties.

Together with Melchers we coped with the short day problem of the tobacco, and with a number of tobacco varieties we produced short day forms, which do not flower in summer. The breeding of this material was abandoned, and the material was apportioned to a few tobacco institutes

3. Rye.

In 1938 we bred a tetraploid rye by means of the colchicine-method in the F.v.Lochow-Petkus Ltd. (v.Sengbusch). This tetraploid rye is the stock for the tetraploid rye "Tetra" of the F.v.Lochow-Petkus Ltd. I bred this material from 1938 to 1942.

4. Tomatoes.

We discovered genes for early maturity, non-bursting of the fruits, Cladosporium-fulvum-resistance, non-dropping off of the fruits and for the pleasant flavour of the wild Solanum racemigerum, and we produced strains with more or less large fruits and with these characteristics desired (v.Sengbusch).

For its further development the material was handed over to the private breeders of tomatoes. No strains of the material that had been left in Müncheberg seemed to be efficient for practice. On the other hand there are breeders at home and abroad, who succeeded in breeding varieties, which are early ripening respectively Cladosporium-fulvum-resistant.

5. Hemp.

We developed dioecious and monoecious fibre-rich varieties, the breeding and growing of which is continued in France (Fibrimon) and Italy (Fibridia) - (Huhnke, Neuer, v.Sengbusch).

6. Spinach.

We bred three monoecious spinach varieties (winter-, spring-, summer-spinach) - (v.Sengbusch). From these three varieties the variety "Wisemona" has been licensed by the Bundessortenamt (state department for plant varieties). The firm of Sperling, Lüneburg, traffics in this variety.

7. Asparagus.

We cultivated an asparagus variety, the tips of which remain white. Apart from that this variety has the advantage that it can be harvested with only a little expenditure of hand-labour (v.Sengbusch). This variety is just being in its first phase of propagation and in its first cultivation in practice.

8. Strawberries.

We produced a number of varieties, which all have specially valuable characteristics for the preserving with low temperatures: SENGA 29 (DBP), SENGA 146 (DBP).

SENGA PRECOSA ripens earlier than all the other early maturing varieties.

SENGA SENGANA (DBP) is a very profitable variety that is arable. It is a first quality strawberry and a good shipping variety. It is a universal variety which has become very popular all over northern Europe.

B. Breeding Results: Animals

Rabbit.

For the selection of mediums, which decrease the endogenous oxalate formation in man we bred a rabbit strain that is marked by a high oxalate excretion as persons are tained with stones (v.Sengbusch, Timmermann).

C. Plant Breeding: Machines.

1. Single Plant Thresher.

We constructed a single plant thresher for the overcoming of a numerically vast material of individual plants.

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2. Special Seed Cleaning Machine. (Steigsichter)

We developed a special machine for cleaning seeds (v.Sengbusch, Zimmermann) that proved a success in the practice of breeding.

3. Special Scale for the Starch Determination in the Potato. (Stärkewaage)

We constructed a special scale, by means of which we can determine the starch content in the potatoes of the breeding material (Heimerdinger, v.Sengbusch). The scale is being constructed by the central workshop of the Max-Planck-Gesellschaft.

4. Special Sorting Machine for Peas. (Erbsenlöchtemaschine)

We constructed a special micromachine for sorting peas that makes it possible to sort out entire strains of peas in their green state (Fuchs, v.Sengbusch).

D. Mechanization of the Strawberry Cultivation.

We were able to complete the mechanization of the strawberry cultivation. The strawberry plants are lifted with a remodelled potato digger. They are planted in piece-work with a planting machine, hoed by a mechanical hoe (during the first year with a hoeing machine that can be steered, in the following years with a hoeing machine that is firmly connected to the tractor). Manuring and plant protection are also carried out by machines. The water supply in case of dry climates is guaranteed by means of sprinkler irrigation.

The hand-labour left, is merely the hoeing between the rows and the picking of the fruits (Huhnke, Mellenthin, v.Sengbusch).

In this way the running of a farm-like strawberry planting is pursued in Schleswig-Holstein.

E. Methods for Recognizing Characters.

We first developed methods, by means of which we are able to make invisible characteristics visible as for instance the shattering of the lupin pods (v.Sengbusch), the soft coatedness of the lupin seeds (v.Sengbusch), the splitting of tomatoes (v.Sengbusch), the Cladosporium-fulvum-resistance of the tomatoes (v.Sengbusch), the suitability of the strawberries for freezing (v.Sengbusch).

Furthermore we developed "quick-enough-methods" for recognizing invisible characters, such as the alkaloid content (v.Sengbusch), the albumen content (Schwarze, v.Sengbusch), the oil content (v.Sengbusch), the total fibre content (Bredemann, Garber, Huhnke, Schwarze, v.Sengbusch), the content of primary fibre (Huhnke, v. Sengbusch), the total content of saccharin and the content in special sugars (Jordan, v.Sengbusch), the total content of acid and the content in special acids (Jordan, v.Sengbusch), the oxalates (Brozinski, v.Sengbusch).

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The corresponding methods have been successfully applied in the cultivation of lupins, tobacco, tomatoes, hemp, strawberries and other cultivated plants.

F. Methodical Results: Mushroom.

We developed a new method of spawning mushroom cultures with active mycelium (Active Mycelium Spawning Method). By means of this method we are able to reduce the growing time of the mushroom and to achieve an explosion-like course of the crops in first two picking weeks. Further this method makes it possible to achieve yields which are 5o-1oo % higher in cbm. volume than with the usual cultivation methods (Huhnke, v.Sengbusch).

G. Maintenance of the Germination Capacity by Storing Seed in Low Temperatures.

We were able to show that the seeds of a number of cultivated plants maintain their germination capacity for a considerably long time while being stored at -2o° C. (-4 F.).

This method is especially interesting for controlling the progress of the cultivation work on cross-pollinated plants.

H. Results with Regards to the Urology.

1. Urine sieve.

We constructed a urine sieve (DBGM) for the determination of the crystal and concrement content of the urine. The mesh-gauges of the three sieves was 6o, 12o, 2oo μ (v.Sengbusch, Timmermann).

2. Stone-dissolving medium.

For the dissolution of renal stones in the kidney the solvent Brotisen P.8 was developed. (Titriplex III + triethanolamine) - (Brozinski, Niedieck, v.Sengbusch, Timmermann).

3. Renal catheter with reflux funnel.

For the flux of the solvent into the kidney a special renal catheter (DBGM) with reflux funnel was constructed that makes a rinsing of the renal pelvis possible (v.Sengbusch, Timmermann).

4. Bladder loop (Blasenschlinge).

For the treatment of bladder carcinomae with stalks we developed a nylon apparatus with a loop, which can be inserted by means of a normal cystoscopy.

VII. Cooperation with Foreign Nations.

a) Lupinus albus: In order to make an export of Lupinus albus-sweet lupin seed from Portugal to Germany and other countries possible the Portuguese cultivation of Lupinus albus has to be converted to sweet lupins and to the particular growing conditions of Portugal. In 196o about 6o hectares (148,3 acres) have been cultivated Lupinus albus-sweet lupins. Cooperation with Marques de

Almeida, Estacao Agronómica Nacional, Lisbon.

b) Monoecious hemp: Cooperation with M.Nicot, Fédération Nationale des Producteurs de Chanvre, France. M.Nicot breeds monoecious fibre-rich hemp (Fibrimon) in France. The breeding station is situated near Bayonne, the propagation is carried out at the Loire, whereas the cultivated areas serving the production is situated in the Sarthe-region. The factory producing the cellulose is in Vivoin.

c) Dioecious hemp: Cooperation with Dr.Allavena, Consorzio Nazionale Produttori Canapa, Italy. Near Parma dioecious fibre-rich hemp is being cultivated as a substitute for the fibre-poor Carmagnola-hemp.

Some hundred hectares have been cultivated with Fibrimon in France and with Fibridia in Italy in the year 1960. We hope to make the cultivation profitable again by converting to fibre-rich hemp varieties in these countries.

VIII. Consequence of the Example of Breeding "Sweet Lupin".

The breeding of sweet lupins, that is to say the complete abolition of undesired substances by breeding work led to the dealing with similar problems, which have been successfully solved, too. Thus, in the U.S.A. for instance a cumarine-free and with that a Bokhava clover free from bitterprinciple. In Holland a cucumber was cultivated, the fruits of which as well as its entire stem- and leaf-apparatus are completely free from bitter principle. Furthermore a chicory was bred also practically free from bitter principle This apperently caused the increase in the sale of chicory.

IX. Universality of the Artificial Selection and Influence on the Possibilities as Basis for the Progress.

We are attempting to lay the methodical foundations for the increase of effect. This increase of effect can be achieved the more according to plan the better we know the conformity with natural law, which leads to the increase of effect in the cultivated plant.

With regard to this I have carried out studies, by means of which I found out that firstly the artificial selection and secondly the systematic mutation of the plant material are the prerequisites for the increase of performance. The progress in respect of finding new methods takes place in the same conformity with the natural law of the artificial selection and the influence on the variety.

Let us take the aim to cultivate an alkaloid-free lupin as example. In this case the preliminary aim is to find a method, by means of which we can test a great number of lupins for their alkaloid content. With this the second preliminary aim would be to find a method, by means of which we can in return find the method for the determination of alkaloids; that is to say a method

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for the selection of the determination method for the alkaloid content. For this purpose we chose from the fullness of possibilities and under considerations two plant varieties, both of which had an equally high albumen content. One of the two plants, however, had a high alkaloid content, whereas the other plant had a low one. The lupin and the soja bean meet these requirements.

Thus, the method for the selection of a suitable determination method for the alkaloid content was obtained. From the variety of determination methods for the alkaloid content we chose that, which showed a clear distinction between those two plant varieties. In further steps we selected those conditions, which make it possible to carry out a great number of tests by means of the selected determination method for alkaloid content. The method for the selection of the alkaloid-free lupins was not used until the last step.

The same process is repeated over and over again from step to step: first we look for a method, which leads to the selection of the method or form desired. Not until then we select the objects desired by means of this method.

In all cases we can either use the artificial selection of already existing and well-known possibilities, or we try to influence the combination and the kind of these possibilities.

With the discovery of the fact for instance that the earth is a globe, this is one of the possibilities, man can imagine. In these possibilities an artificial selection has been carried out. The same principle underlies all inventions. Man in his considerations creates possibilities, one of which he picks out. If for instance on the basis of the cultural situation there is the request to join two pieces of cloth not by buttons but continually, there are doubtlessly various possibilities for serving this purpose. The selection of the zip-fastener consists of being selected from a number of realizable and non-realizable possibilities as the one that meets the aim.

The artificial selection in combination with the influence on the material of the individuals respectively variants as well as the artificial selection of the intellectual creation of possibilities are the basis for the progress in many fields of science, technic and economy.

The assumption that the progress takes place after the schema described does not mean that the progress comes up automatically. Man stands behind every step. With the first step he has to realize the cultural situation. With the second step he has to set the aim on the basis of the cultural situation, which in return can come true on the basis of the specific cultural situation. He has to be capable of judging the methods, by means of which he can recognize forms, which meet the aim desired. Furthermore he has to be capable of achieving systematically the variety, if the material to be selected from can be altered, whether by increasing the variety of plants of animals or by creating purely intellectual possibilities.

We are used to regarding these intellectual possibilities as ideas. In many cases the entire progress takes place in the brains of man. The judgement of the starting situation as well as the aim, the selection method, the possibilities, from which one is selected, and the application of the method on the variety proceed intellectually. The human brains act as method for recognizing characteristics and as creator of the variety.

Finally I should like to point out that above all a selection of man takes place, who is capable of contributing to the progress in certain fields, which can take place after a certain schema but not without support of man.

The development of our cultural life is sure to be essentially influenced by the reciprocal effect between the environment created by man, which is a product of the natural active and artificial selection, and men, which are subjected to the selection by the environment culture.

Enumeration of Corresponding Publications

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3 II. GENERAL

A. Natural Selection, Natural Active Selection, Artificial Selection, Breeding, Scientific Research and Progress.

67-1937, 118-1939 117-194o, 112-194o, 118a-1952, 125a-1942, 125b-1942, 193-1959.

5 B. Wild grown and Cultivated Plants.

1. Genetic history of the cultivated plants.

152-1953, 193-1959.

6 2. The "sweet lupin" as example for the directed evolution of cultivated plants from wild grown plants: "sweet lupin" (1927).

7-193o, 8-193o, 9-1931, 11-1932, 15-1933, 23-1934, 26-1934, 27-1934, 29-1934, 31-1935, 32-1935, 34-1935, 37-1935, 39-1935, 41-1935, 42-1935, 43-1935, 44-1935, 45-1935, 47-1935, 48-1936, 5o-1935, 69-1936, 74-1936, 75-1937, 76-1937, 77-1937, 78-1937, 79-1937, 8o-1937, 81-1937, 82-1937, 84-1938, 94-1938, 95-1938, 98-1939, 99-1938, 1oo-1938, 1o2-1938, 1o3-1939, 1o4-194o, 1o5-194o, 111-194o, 125a-1942, 125b-1942, 125c-1942, 129-1943, 138-1947, 139-1948, 171-1956.

8 3. The accomplishment of the change from the wild grown type to the cultivated type in our present cultivated plants.

41-1935, 42-1935, 74-1936, 75-1937, 76-1937, 95-1938, 97-1938, 1o3-1939, 1o5-194o, 116-1942, 125a-1942, 125c-1942, 126-1942, 129-1943, 131-1943, 135-1944, 142-195o, 15o-1952, 152-1952, 177-1957.

9 4. Genetic history of cultivated food-plants (1953).

27-1934, 76-1937, 78-1937, 116-1942, 152-1953, 193-1959.

9 5. Transmission of valuable qualities of the wild type to the cultivated form. (1926)

1o-1931, 12-1932, 16-1933, 17-1933, 18-1933, 19-1933, 2o-1933, 21-1933, 36-1935, 72-1936, 188-1958.

10 6. Economical fundamentals of plant improvement - breeding work, private and run by state (1937).

193-1959.

11 III. Aim on the Basis of the Cultural Conditions.

78-1937, 114-1941, 116-1942, 127-1943, 134-1943, 148-1952, 179-1957, 193-1959.

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