

Needham, Matter, Form, and Us

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Abstract: Joseph Needham offered a vision of history that united his understanding of the physical world with his interpretation of social process, in which the material, social, and ideal realms were reciprocally constituted. This essay explores Needham's ideas about matter and form to show how he developed a systematic theory of materialism in his early writings on science and social change. Shifting the ground of discourse in Needham's project from "science" to "materialism," the essay brings him into conversation with new materialists to reflect on the ongoing challenges in theorizing the relationship between social and material phenomena. Calling into question an all-encompassing materiality that sacrifices the role of determinate structures and histories in the production of the world, the essay asks: How can we formulate a framework of material/-ity/-ism that does not dispense with or occlude the already embedded politics of culture, social relations of production, and historical contingency?

The living body is "composed of" myriads and myriads of ultimate particles, electrons, and protons, indeed, but they are arranged and organized in an order far exceeding that of the simple matter of a statue, or even of a complicated and beautiful crystal. And the point is that there is nowhere you can put your finger on and say "Here Form ends and Matter begins."

—Joseph Needham (1941)

Fundamental to Joseph Needham's historical project was the conviction that science was a universal endeavor, in which Chinese civilization played a significant role. Modern science was an ecumenical enterprise rooted in scientific and technological interchanges between East and West—what he described as a "veritable titration." Needham employed this metaphor of volumetric analysis—a method of chemical analysis whereby the concentration of a given chemical solution (the titrand) is determined by the slow addition of another solution of a known concentration and volume (the titrant) until the reaction neutralizes and results in a color change—to describe his approach to "the cultures of East and West." His analytical procedure was thus to "titrate" the great civilizations against one another, to find out and give credit where credit is due," and, in so doing, to "analyse the various constituents, social or intellectual, of the great civ-

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ilizations, to see why one combination could far excel in medieval times while another could catch up later on and bring modern science into existence.”¹ For Needham, the content of historical change was determined by its *constituents* as much as by its *combination*. History, like the scientific approach to the transformations of the material world, rested on the dialectical synthesis of matter and form.

The task of this essay is to situate Needham’s historical materialism in current conversations about materiality and materialism in the history of science and technology. The material things that populate recent scholarship in the two fields are human and nonhuman actors, whose materiality bears consequences for knowledge production and, more broadly, epistemic change. Materially rooted practice and embodied action have likewise been viewed as intrinsic to the history of science. In Needham’s formulation, ideas and material conditions were connected by underlying social forces. The mode of organization—that is, the social relations governing material production—determined how ideas and matter found expression as modern scientific knowledge and technology. If Needham ever invoked materiality of practice, he would have done so to emphasize distinct physical, social, and economic articulations—and not to refer to the thing-like qualities shared by all materials. The materialist approach to which he subscribed has long been supplanted by material culture studies and new materialisms.

While the material turn has spurred a wealth of scholarship that has elucidated the entangled relationship between social process and material environment, materiality has remained a slippery category, resistant to clear definition.² I call into question the concept of an all-encompassing materiality that reduces things, objects, and matter to corporeal substances that gain relevance only as actors, actants, or mediants in human worlds. More specifically, I would argue that embracing materiality as such sacrifices the role of determinate structures in the development of science and technology, leaving us with material/matter all the way down. Here, Needham’s emphasis on matter and form is instructive for a historical framework of materiality that dispenses neither with materials and their properties (matter) nor with the modes of production (form).

Civilization was his unit of analysis, and it supported a historiography that did not rest on the primacy of individual actors. Needham conceived of civilizations as organic structures, constituted by myriad components that were linked systematically and, depending on their configurations, yielded different consequences for science and technology. He expounded on his materialist approach in an intellectual autobiography from 1941 titled “Metamorphoses of Scepticism”:

We cannot consider nature otherwise than a series of levels of organisation, a series of dialectical syntheses. From ultimate particle to atom, from atom to molecule, from molecule to colloidal aggregate, from aggregate to living cell, from organ to body, from animal body to social association the series of organisational levels is complete. Nothing but energy (as we now call matter and motion) and the levels of organisation (or the stabilized dialectical syntheses) at different levels have been required for the building of our world.³

¹ Joseph Needham, *The Grand Titration: Science and Society in East and West* (London: Allen & Unwin, 1969), pp. 11, 12. For the epigraph see Needham, “Matter, Form, Evolution, and Us,” *World Review*, 1941, 15; rpt. in *Their Changing World*, ed. J. R. M. Brumwell (London: Routledge, 1944), pp. 27–37, on p. 29 (subsequent references will be to this reprint).

² As Tim Ingold put it, “What academic perversion leads us to speak not of *materials and their properties* but of the *materiality of objects*? It seemed to me that the concept of materiality, whatever it might mean, has become a real obstacle to sensible enquiry into materials, their transformations and affordances.” Tim Ingold, “Materials against Materiality,” *Archaeological Dialogues*, 2007, 14:1–16, on p. 3.

³ Joseph Needham, “Metamorphoses of Scepticism,” in *Time, the Refreshing River* (London: Allen & Unwin, 1943), pp. 1–27, on p. 15.

The relationship between matter (energy) and form (organization) was a reciprocal one, in which matter, possessing a logic of its own, sought an appropriate form or “level of organization.” The levels of organization, in turn, corresponded to the scale of matter. An organism, for example, was nested: a set of systems, rather than a collection of particles, existing in a larger system of organization.⁴ Such a formulation of matter and form was an inversion of what Needham described as “the old ideas”: the Aristotelian view that form was an imposition on matter. As he had argued in “Matter, Form, Evolution, and Us,” something had happened to matter that made it inconceivable to separate it from form. Extending his method to social evolution, Needham claimed that “still further up there were the conjoint realm of human mind, and of human society, with all its complex associations, reaching up from the family to the whole unity of mankind.”⁵ Levels of organization were the “stabilized dialectical syntheses” that produced living beings through a coordinated and dynamic process in biological and social terms alike.

Needham’s dialectical materialist way was indebted to both his organicism and his Marxism. His insistence on the dialectical nature of matter/form—and, alternatively, organization/energy—as a model for biological evolution and social evolution betrayed his conviction that out of synthesis would emerge higher levels of complexity and organization. Science played a pivotal part in Needham’s vision of evolutionary progress. In “On Science and Social Change,” written in 1944 during his stay in China, he summarized his take on the role of science in social evolution: “Science is a function of the socially acting human mind. Science reveals to us the levels of organisation in the universe.”⁶ By identifying science as a social phenomenon continuous with the physical world, Needham expressed the central postulate of historical materialism: that man is a biological organism that undertakes constant material exchange with nature and that the logic of history is to be found in the shifting relations of production in which he is engaged.⁷ In sum, the biological, the social, and the ideal are all locked into a dialectical synthesis. Earlier in the essay, he likened the principle of dialectical thinking to muscle contraction:

We thus approach the conception of a “contractile enzyme.” The substrate once present, the enzyme protein has no choice but to act upon it, yet in doing so its own physical configuration is fundamentally changed. With the disappearance of the substrate, the configuration change reverses. Probably this conception can be extended to explain many things in embryonic differentiation, but here the configuration change would have to be irreversible or nearly so. This set of ideas is reminiscent of the dialectical principle embodied in the line: “Man is changed by his living, but not fast enough”; and links up with the effect of material techniques upon human thought and human society.⁸

⁴ On Needham’s organicism see Donna Haraway, *Crystals, Fabrics, and Fields: Metaphors of Organicism in Twentieth-Century Developmental Biology* (New Haven, Conn.: Yale Univ. Press, 1976); and Erik Peterson, *The Life Organic: The Theoretical Biology Club and the Roots of Epigenetics* (Pittsburgh: Univ. Pittsburgh Press, 2017). The shift to complex systems and organization as the central object of study in the natural sciences also occurs in the social sciences; see Hunter Heyck, *Age of System: Understanding the Development of Modern Social Science* (Baltimore: Johns Hopkins Univ. Press, 2015).

⁵ Needham, “Matter, Form, Evolution, and Us” (cit. n. 1), pp. 30–31, 37.

⁶ Joseph Needham, “On Science and Social Change,” *Science and Society*, 1946, 10:225–261, on p. 225; rpt. in *Grand Titration* (cit. n. 1), pp. 123–153, on p. 135 (subsequent references will be to this reprint).

⁷ This conviction was upheld by Needham into the 1960s. In 1967 he wrote, “Man in the mass, man in social classes, man working in the fields and forges, man appropriating the results of the labor of other men, man evolving institutions to establish and stabilize class relationships—these are the men to be studied and interrogated through the written and other records of the past. Search first the kingdom of material relationships, and all these things shall be added unto you.” Gregory Blue, “Joseph Needham, Heterodox Marxism, and the Social Background,” *Sci. Soc.*, 1998, 62:195–217, on p. 202.

⁸ Needham, “On Science and Social Change” (cit. n. 6), pp. 130–131.

Similar to his use of titration as metaphor (and method), Needham's discussion of the "contractile enzyme" as an analogy of the dialectical principle in historical materialism bespeaks the pluralist, but unitary, tendencies in his work.⁹ Needham discovered the same principles in historical materialism that he saw in the organismic paradigm. He subscribed to an interpretation of civilization and history that followed the organic theory of nature: the universe as composed of organic wholes (living organisms) that are mutually constitutive and "go together in substantial unity" yet are hierarchically ordered.¹⁰ Needham's framework collapsed the distinction between inorganic and organic and emphasized the greater importance of levels and complexity. He thus approached space as nested containers and time as successive stages. The dialectical, or evolutionary, synthesis that satisfied his interpretation of the continuities between the social and biological worlds supported his universalist ideals.¹¹

Just as living organism and environment were inextricably interlaced, so too was the history of science. Concurrently, Needham cautioned against a history of science "written solely in terms of one continuous thread of linked influences." He championed "an oecumenical [*sic*] history of human thought and knowledge of nature, in which every effort can find its place, irrespective of what influences it received or handed on." And further: "Let us take pride enough in the undeniable historical fact that *modern* science was born in Europe and only in Europe, but let us not claim thereby a perpetual patent thereon."¹² Casting aside Needham's faith in universality and his evolutionary optimism, these exhortations are especially relevant here in thinking about what significance his materialist ideas might hold for current historians of science working within a framework of materiality. Indeed, Needham's caution against Eurocentrism, stating plainly that Europe did not have a monopoly on science, must be heeded in regard to materiality too.¹³

Since the 1970s, historians of science and technology in the Euro-American academy have championed the view of science as an embodied practice that entails the manipulation, collection, circulation, and production of things.¹⁴ In the turn to matter and materials, things came to be treated as carriers of knowledge, thus making material artifacts increasingly critical to the study of science as

⁹ Shiv Visvanathan has made a similar assessment of Needham, claiming that in each of his contributions—concerning China, embryology, and Marxism—there existed "a search for plurality struggling within unity": Shiv Visvanathan, "The Strange Quest of Joseph Needham," in *Situating the History of Science: Dialogues with Joseph Needham*, ed. S. Irfan Habib and Dhruv Raina (New Delhi: Oxford Univ. Press, 1999), pp. 198–219, on p. 199. On the connections between Needham's organicism and his synthetic Marxist approach to SCC see Carla Nappi and Ken Wark's essay in this Second Look section, "Reading Needham Now."

¹⁰ He explained the theory as follows: "all the universe is seen to consist of wholes, or organisms, whose parts, as Lloyd Morgan would say, go together in substantial unity, or in other words, are only themselves so long as they remain in their natural places within the whole to which they belong. . . . The universe, in this view, is a vast array of organisms, mounting up from the simplest atomic wholes to the world-organism, that modern translation of 'anima mundi' itself." See Joseph Needham, "Organicism in Biology," *Journal of Philosophical Studies*, 1928, 3(9):29–40, on p. 34. A. N. Whitehead and John Haldane, along with J. D. Bernal and Lloyd Morgan, were important influences on Needham's thought.

¹¹ Edmund Russell has advanced this idea of connecting historical and biological research by calling for the creation of a new field: evolutionary history. See Edmund Russell, *Evolutionary History: Uniting History and Biology to Understand Life on Earth* (New York: Cambridge Univ. Press, 2011).

¹² Joseph Needham, *Science and China's Influence on the World* (Oxford: Oxford Univ. Press, 1970), p. 61; and Needham, "Poverties and Triumphs of the Chinese Scientific Tradition," in *Grand Titration* (cit. n. 1), pp. 14–54, on p. 54.

¹³ On this aspect of Needham's legacy see Sandra Harding, "Is Modern Science an Ethno-Science? Rethinking Epistemological Assumptions," in *Science and Technology in a Developing World*, ed. Terry Shinn, J. B. Spaapen, and V. V. Krishna (Dordrecht: Springer, 1997), pp. 37–64; Harding, *Is Science Multicultural: Postcolonialism, Feminisms, and Epistemologies* (Bloomington: Indiana Univ. Press, 1998); and Aant Elzinga, "Revisiting the Needham Paradox," in *Situating the History of Science*, ed. Habib and Raina (cit. n. 9), pp. 73–113.

¹⁴ For a brief overview of the material turn in the history of science see Simon Werrett, "Matter and Facts: Material Culture in the History of Science," in *Material Evidence: Learning from Archaeological Practice*, ed. Robert Chapman and Alison Wylie (New York: Routledge, 2014), pp. 339–352. One of the representative works in the turn to thinking of science as practice is

social practice and as culture.¹⁵ The proliferation of “things” and “materials,” along with “objects” and “matter,” frequently employed in tandem with materiality in publications, has been critiqued for merely reproducing a linguistic model of the world.¹⁶ The dilemma posed by materiality is a conceptual one.

Whereas organicism provided Needham with a resolution to the mechanism/vitalism debate, materiality and the new materialism have served as a remedy to Cartesian dualism for post-material turn scholars. The most influential framework in history of science aimed at displacing the hegemony of the Cartesian subject has been actor-network theory, a material-semiotic toolbox.¹⁷ Even though materiality is deployed as a universal framework for thinking about the entanglements between the social and material worlds, the undergirding assumption is that there exists a shared legacy of modernity or a single heritage of the subject/object problem. New materialists have pushed against Cartesianism further, calling for an ontological reorientation that is resolutely posthumanist in that it conceives of everything as a material and all matter as indeterminate, but possessing a force or agency.¹⁸ Their rejection of anthropocentrism is thus aligned with a repudiation of humanist binaries. The new materialists propose a materiality that emphasizes the process of materialization, by which all matter is made relational, emergent, and contingent. Networks, flows, and rhizomes have also unseated hierarchical systems and levels of organization as the critical forms.

Matter and form remain at the forefront of new materialist concerns. Matter is not a passive receptacle for form, and words are insufficient to make intelligible the relationship between the two. The challenge for new materialists has been what Karen Barad has identified as the “necessity of adequately theorizing the relationship between discursive practices and the material world.” For Barad, discursive practices are “specific material (re)configurings of the world” rather than linguistic representations.¹⁹ In her contribution to the new materialism, the boundary between material and discursive is dissolved altogether—such that “there is nowhere you can put your finger on and say ‘Here Form ends and Matter begins.’”²⁰ Matter is an actualizing force where materiality (or “mat-

Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton, N.J.: Princeton Univ. Press, 1985). See also Andrew Pickering, ed., *Science as Practice and Culture* (Chicago: Univ. Chicago Press, 1992).

¹⁵ Ken Alder, ed., “Focus: Thick Things,” *Isis*, 2007, 98:80–142; Lorraine Daston, ed., *Things That Talk: Object Lessons from Art and Science* (New York: Zone, 2004); Ursula Klein and E. C. Spary, eds., *Materials and Expertise in Early Modern Europe: Between Market and Laboratory* (Chicago: Univ. Chicago Press, 2010); and Lissa Roberts and Simon Werrett, eds., *Compound Histories: Materials, Governance, and Production, 1760–1840* (Leiden: Brill, 2018). See also Klein and Wolfgang Lefèvre, eds., *Materials in Eighteenth-Century Science: A Historical Ontology* (Cambridge, Mass.: MIT Press, 2007); and David Edgerton, “Creole Technologies and Global Histories: Rethinking How Things Travel in Space and Time,” *Journal of History of Science and Technology*, 2007, 1:75–112.

¹⁶ See Thomas Söderqvist and Adam Bencard’s review of Daston, ed., *Things That Talk*: Thomas Söderqvist and Adam Bencard, “Do Things Talk?” Max Planck Institute for History of Science, Preprint Series, no. 399, 2010, pp. 92–102.

¹⁷ See esp. Bruno Latour, “Where Are the Missing Masses? Sociology of a Few Mundane Artefacts,” in *Shaping Technology, Building Society: Studies in Sociotechnical Change*, ed. Wiebe E. Bijker and John Law (Cambridge, Mass.: MIT Press, 1992), pp. 225–258; Michel Callon, “Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of Saint Briec Bay,” in *Power, Action, and Belief: A New Sociology of Knowledge*, ed. Law (London: Routledge, 1986), pp. 196–233; and Law and Annemarie Mol, “Notes on Materiality and Sociality,” *Sociological Review*, 1995, 43:274–294.

¹⁸ See Diana Coole and Samantha Frost, eds., *New Materialisms: Ontology, Agency, and Politics* (Durham, N.C.: Duke Univ. Press, 2010). Jane Bennett’s work shares important commonalities with the new materialists: Jane Bennett, *Vibrant Matter: A Political Ecology of Things* (Durham, N.C.: Duke Univ. Press, 2010).

¹⁹ Karen Barad, *Meeting the Universe Halfway: Quantum Physics and the Entanglement of Matter and Meaning* (Durham, N.C.: Duke Univ. Press, 2007), pp. 28, 148. Barad has proposed “agential realism” as an “epistemological-ontological-ethical framework that provides an understanding of the role of the human and non-human, material and discursive, and natural and cultural factors in scientific and other social-material practices, thereby moving such considerations beyond the well-worn debates that pit constructivism against realism, agency against structure, and idealism against materialism” (p. 26).

²⁰ Needham, “Matter, Form, Evolution, and Us” (cit. n. 1), p. 29. Sara Ahmed critiqued Barad and the materialists, arguing that “by turning matter into an object or theoretical category, in this way, the new materialism reintroduces the binarism between materiality

tering,” in Barad’s words) is the consequence of a formation process that is enabled, enacted, and delimited by the myriad entanglements and relationalities (intra-activity) of matter. In this way, the new materialists resonate with Needham’s organicist tendencies—perceiving organisms as intertwined with their environments in plural and complex ways. By identifying consciousness, affect, and meaning as emerging out of the substance of the world, new materialist thought further builds on a physico-chemical understanding of social phenomena. In Needham’s synthetic model of the world, as in new materialism, the boundary between social and natural is collapsed.

What is carried forward in these theories of materiality is a distinctly European philosophical tradition in which the reconciliation of matter and form, and the parallel pairing of matter and mind, is of paramount concern. This ongoing ontological debate, perhaps, accounts for why materiality is used most often to stress the “thingliness” of a material or practice as a way of hinting at a nondualist interpretation. Though the efforts to establish approaches to social theory and research untrammelled by humanism are vital, new materialists tend to assume that the problems posed by these binary oppositions are universally shared. Needham would have railed against such a European “perpetual patent” on materiality, as he did against a like claim for Western science—even though he was guilty of similar theoretical conflations. True to his heterodox views, he would have been troubled by an approach that promoted a single lineage of thought—not to mention by posthumanism.

Needham characterized Chinese laws of nature as a worldview that “depended upon an entirely different line of thought” from the Western tradition, in which “the harmonious co-operation of all beings arose, not from the orders of a superior authority external to themselves, but from the fact that they were all parts in a hierarchy of wholes forming a cosmic and organic pattern, and what they obeyed were the internal dictates of their own natures.”²¹ Although this worldview suggested an organic theory homologous to his own organicist views, Needham’s diagnosis of Chinese civilization relied on a more historical materialist interpretation of the key social factors. In the case of China, the material components, such as rainfall and landmass, were related to the specific practices of agriculture that took shape and from which sprouted a centralized state administered by office-holding elites. Informed by the interwar debates on the “Asiatic mode of production” and Karl A. Wittfogel’s writings on the Chinese state, Needham maintained the view that the inhibitory factors affecting science and technology arose from bureaucratic feudalism.²² Mode of production and social organization, as determined by the material environment, came to dominate both the structure and the content of his arguments on Chinese society and science. The challenge for Needham was radical cultural difference, as embodied by China and Europe, that had to be reconciled into a unitary history of modern universal science. His synthesis reified the contradictions between East and West, and, by extension, form triumphed over matter in his analysis of Chinese science.

So where does this leave us? Materiality as a mode of analysis, as opposed to a material reconfiguration of discourse or an ideological project, must allow for historical contingency as well as for an understanding of materials (and their interactions with human worlds) as mutable and contingent. As Donna Haraway put it, “the meaning-making processes and the materiality of the world are dynamic, historical, contingent, specific; that bodies and institutions and machines are made, not made up.”²³ One way to allow for historical contingency is not to assume a single discourse on

and culture that much work in science studies has helped to challenge. Matter becomes a fetish object: as if it can be an ‘it’ that we can be for or against.” Sara Ahmed, “Open Forum Imaginary Prohibitions: Some Preliminary Remarks on the Founding Gestures of the ‘New Materialism,’” *European Journal of Women’s Studies*, 2008, 15:23–39, on p. 35.

²¹ Needham, “Poverties and Triumphs of the Chinese Scientific Tradition” (cit. n. 12), p. 36.

²² On both the “Asiatic mode of production” and “oriental despotism” see Joseph Needham, “Science and Society in East and West” (1964), in *Grand Titration* (cit. n. 1), pp. 190–217.

²³ “Nature, Politics, and Possibilities: A Debate and Discussion with David Harvey and Donna Haraway,” *Environment and Planning D: Society and Space*, 1995, 13:507–527, on p. 509.

things, matter, and materials. In adopting materiality as a conceptual framework, rather than as a lexicon to underscore the corporeal substance of a thing, material, or matter, we must follow the genealogy of things and thought within a specific historical context.²⁴ To grasp the co-constitution of material and discursive production, we must approach the world as historical.

At stake in materiality/materialism, old and new, is a conception that allows us to overcome binary thinking in our formulations of matter/form—that is, an epistemological and ontological framework that enables us to conceive of and describe an interactive, heterogeneous cast of matter (actors, agents, mediants) and forms (modes of production, cultural systems) while maintaining specificity and nondichotomous difference. The conceptual confusion surrounding materiality further demands clarification of agency and causality so as not to propagate materials as synecdoches for historical processes in our linguistic or discursive practices. Historicity is central. To move toward a more coherent concept of materiality, we may need to revisit the fundamental questions without assuming *a priori* that the European philosophical tradition is the only one that matters.

²⁴ Frank Trentmann makes a similar argument about things and modernity: Frank Trentmann, “Materiality in the Future of History: Things, Practices, and Politics,” in “Material Culture,” special issue, *Journal of British Studies*, 2009, 48:283–307. Studies of material culture in premodern China are instructive here. See, e.g., Craig Clunas, *Superfluous Things: Material Culture and Social Status in Early Modern China* (Honolulu: Univ. Hawaii Press, 1990); and Jonathan Hay, *Sensuous Surfaces: The Decorative Object in Early Modern China* (London: Reaktion, 2010).