INSTITUT FÜR
PHILOSOPHIE
DARMSTADT

The Age of Technoscience

Alfred Nordmann

In Alfred Nordmann, Hans Radder, and Gregor Schiemann (eds.)
Science Transformed? Debating Claims of an Epochal Break
Pittsburgh: Pittsburgh University Press, 2011, pp. 19-30

Mode-2 research, post-academic science, technoscience, post-normal science, new natural history, entrepreneurial science – all these various labels speak of more or less profound changes in the organization of research. Do these changes amount to an epochal break that transforms scientific knowledge production as a whole? The theories behind each of these designations do not offer straightforward answers to this question. If a new kind of commissioned research enters the scene in the late twentieth century, this might leave most of the sciences unaffected. And if today's research practices defy notions of "pure research" or "basic science" and if they thereby open our eyes to the rich interactions between science, technology, and society, this might lead us to see these rich interactions also in the past. All that has changed, some would argue, is how we appreciate scientific practice, but the business of science is as complex as it has always been.

Instead of reviewing various accounts of past and current research practice, I want to make a case for an epochal break between the scientific and the technoscientific enterprise. However, to make a case is different from settling a matter of fact. Rather than decide whether or not scientific knowledge production has changed as a whole, I want to show in what sense it is adequate, illuminating, even important to consider the various diagnosed changes in terms of an epochal break. Doing so is not a neutral exercise but motivated by concern for the scientific enterprise. From the point of view of science and how it understands itself, hardly anything could be as dramatic as the shift to a technoscientific mode of research. From the point of technoscience, in contrast, the whole history of science and engineering research has always been technoscientific. In a final, apparently dialectical twist to my argument, I therefore argue that those who deny the epochal break have happily settled into the age of technoscience, while those who see an era coming to an end are those who care about science and its deep connection to modernity and the enlightenment project.

I.

What is an epochal break? Surely, it is not a moment in time when, suddenly, everything changes and the world is becoming a different place. Some have argued that World War I or the nuclear destruction of Hiroshima were such moments. Others cast doubt on such ruptures but see them as salient moments that grew out of the past and beyond which much continued as it was. This is true also for the epochal break that matters most and that shaped our very idea of an epochal break, namely the transition from a medieval or pre-modern to the modern world. As Hans Blumenberg, in particular, has pointed out, there would be no modern world without the assumption of an epochal break – to be modern is to distinguish oneself from those who came before, to respond to the seriousness of one's age, to relate oneself to the demands of the day (Blumenberg 1976). And yet, the history of modernity is full of uncertainty and controversy about the precise time and place, the extent and significance of the transition from medieval to modern times. Still, to be modern is to frame one's own place in the world historically, part of a movement from one era to the next, each with its own character and destiny. Even as the moderns remained profoundly unsure how they could and should distinguish themselves, they liberally proclaimed epochal breaks, most prominently in the philosophy of Hegel or in the case of Goethe who declared the beginning of a new era after witnessing an all-but-forgotten battle in one of the countless wars between the Germans and the French.[1] The notion of epoch or era became an instruments of the moderns to reflect upon themselves, their place in history, and the distinctiveness of their times and thus of their calling.

In recent years, one of the preeminent philosophers of technoscience, Bruno Latour (1993), has argued that we have never been modern. His claim does not contradict Blumenberg's but complements it: Modernity presupposes that one can distinguish the modern self from that of the dark ages, that one can distinguish culture from nature, science from technology, this era from another. Since we have never quite succeeded in establishing and fortifying these distinctions, we have never been modern. And yet, it is characteristically modern to engage in such work of purification, that is, to engage in the work of distinguishing oneself, of attributing blame either to nature or to human intervention, etc. And this is Blumenberg's point: There is no compulsion from facts or principle that would force anyone to see an epochal break here or there; but to see an epochal break is tantamount to accepting one's historical destiny or mission, and this is what moderns do.

[1] Not without a sense of irony, Hans Blumenberg (1976) begins his reflections with this reference to Goethe.

This is also how one should understand my attempt to identify the epochal shift from the scientific to the technoscientific enterprise. I begin by acknowledging that I cannot compel my readers to see this shift. They can see it only if they willingly follow me to the particular vantage point from which it becomes visible. And by following me, they will see two projects: a historical project that is called "the scientific enterprise" and the technoscientific project which turns out to lack a historical mission and which thereby lies beyond modernity and its obsession with epochal breaks.

II.

To see the epochal break in question requires the adoption of a vantage point from which it becomes visible. What is this vantage point? It consists in the proper distance to scientific practice, one that is neither too remote from, nor too close to what is happening on the ground. Looking very closely at the particulars of research practice teaches us first and foremost that there is neither "science" nor "technoscience" but a multitude of ever-shifting disciplinary formations that are guided by specific epistemic values, experimental, observational and representational practices, patterns of explanation and intervention, etc. From this perspective, nothing could be more misleading than to speak of a transition from "science" to "technoscience." It is wrong even to posit a monolithic and idealized notion of "science" in the first place. Instead, there was and is a multiplicity of sciences. Some of them are strongly oriented towards the demands of practice and closely aligned with what is now termed technoscience. Others have fashioned themselves after an unattainable ideal of "pure" or "basic" science as an unfettered search for nothing but the truth. Indeed, no epochal break thesis should deny this multiplicity of the sciences and, happily, none does.[2]

It is less clear what one can learn from a rather remote perspective on this multiplicity of sciences. It produces useful generalities. They are useful in offering a conceptual frame that is broad enough to accommodate very heterogeneous practices. It is a frame within which one can differentiate disciplinary particulars. For example, one might say that all sciences seek an understanding of mechanisms by producing models that can be adapted to local phenomena. And one might add to this, that they do so even if their main purpose is not to seek understanding but to make things work. Since this general level of description is meant to subsume the specific differences between various modelling techniques, types of mechanisms, notions of understanding, it is easy to see that it will also subsume the difference between the scientific and the

[2] I cannot detail this here. Most open to the accusation might be John Ziman's "post-academic science" (2000). The proponents of "mode-2 research" have also been accused of this, but unjustly so.

technoscientific enterprise. Significantly – and, as such, radically dissimilar from earlier attempts to provide a unified characterization of the sciences[3] – these general descriptions avoid any attribution of a historical mission to research practice. The business of science is to engineer a fit between the phenomena and some set of conceptual tools. Whether we look at theoretical and the so-called applied sciences, they are all engaged in this "business as usual" – and this description already adopts a technoscientific point of view according to which all research is always in the business of designing a proper fit between general laws or theoretical ideas, models, and the phenomena and processes in the real world.

Since an epochal break is invisible from both these vantages points, it requires a third one to make it visible. It is a vantage point from which one does not see just the multiplicity of disciplines and practices, and from which one does not make out merely the technical features of the general business of explanation and understanding. Instead, it is the vantage point from which one can see "the scientific enterprise" with its historical mission and then "the technoscientific enterprise."

III.

To see "the scientific enterprise" is something other than seeing "the sciences" or "modelling," "specifying mechanisms," "(scientific) explanation," or the like. The term "scientific enterprise" is on a par with terms like "the Enlightenment project" or "modernity" and, indeed, closely related to them. As with modernity and the Enlightenment, we might have a hard time knowing just when and where the scientific enterprise began and whether it ended. But we are nevertheless quite confident that it did not exist everywhere at all times. It is the name for a common pursuit that orients the various sciences and influences their self-definition. It suggests that, separately or together, all the different ways of knowledge production contribute to a historical process that, citing Max Weber, might be referred to as a process of rationalizing or intellectualizing the world.

Taking a further cue from Max Weber, the scientific enterprise along with the Enlightenment project are committed to an unending quest for truth and thus obliged to a future state of knowledge. We do not live in an enlightened age, Kant wrote, but in an age of enlightenment, and this sentiment was echoed by countless philosophers until nearly the end of the 20th century. In Popper's philosophy of science, for example, it reappears as the edict that in the name of truth we formulate and criticize mere hypotheses but that the truth itself is an unattainable good that we can

[3] Regarding these “earlier attempts,” the Vienna Circle, Karl Popper, Thomas Kuhn, or Imre Lakatos referred general patterns in the development of science to the question of its historical purpose or mission. Typical names for this mission are “scientific progress,” “physicalism,” “unified science,” or “reductionism”.

approximate, at best. What I call the historical mission of the scientific enterprise is its orientation to truth, where "truth" might be taken as its telos, as its regulative ideal, as a correlate to a certain kind of intellectual control, or as the original for which weaker notions of empirical adequacy or instrumental capacity serve as proxy. Whether it proceeds in a linear and cumulative manner or by way of detours and upheavals, the scientific enterprise advances an ever more detailed and pervasive determination and rational control of reality. If the complete determination of reality is tantamount to the truth – an idea that one finds in such diverse philosophers as Peirce and the early Wittgenstein – the scientific enterprise progressively approximates that truth. And to this determination of reality, to intellectualization and rationalization of the world contribute also those endeavors that are not dedicated to truth-for-its-own-sake or to a theoretical description of the world. Louis Pasteur and Justus von Liebig, Adolphe Quetelet and Claude Bernard cannot be dissociated from the scientific enterprise and the Enlightenment project just because they developed tools and practices in the service of humankind.

The particular sciences are oriented towards the scientific enterprise each in their own way. Some assume the vanguard with a grand and arrogant gesture, defining a hierarchy of the sciences that sees them at the top. The more exclusively and directly it is committed to the scientific enterprise, the more basic or fundamental is the research in question. It is "pure" science precisely because its historical mission is unadulterated truth-seeking. All this may hold especially for theoretical physics and evolutionary biology. Other sciences put themselves humbly in the service of humankind, yet others plot along, confident and content to toss out a new theoretical challenge, an interesting discovery here and there – and the occasional inferiority complex of the "applied sciences" is just one way of acknowledging and reinforcing the need to coordinate one's self-definition with the overall ambitions of the scientific enterprise. And as long as established fields of inquiry and practice – from sociology and engineering to nursing – seek to become "sciences," they are claiming that they, too, can systematically contribute to the overarching scientific enterprise and historical mission of rationalization, intellectualization, or Enlightenment.

To be sure, the orientation of the sciences to an overarching scientific enterprise is not without consequence for the epistemic values that govern various research practices. This is most obvious, perhaps, for conceptions of objectivity. It may be fair to generalize that scientific (as opposed to technoscientific) notions of objectivity are framed in terms of history. Knowledge is said to be objective if it endures, if it can be separated from the historical contingencies of its discovery and formulation. The production of objectivity with its concern to separate lasting, if not eternal truths from changeable contexts and opinions is yet another instance of the previously cited work of

purification. This work of purification also requires that one can distinguish between immutable aspects of nature and the human interventions that are required to make these aspects visible in contexts of experimentation and observation. One way of doing so is to regard nature as a collection of dispositions or latent behaviors that are prompted by researchers to become manifest and observable. A laboratory experiment, for example, serves as a trigger that stimulates the exhibition of a certain reaction or behavior. Though humanly or technically induced, the manifestation is nothing but nature's own doing – the experiment is a stage that prompts nature to reveal itself. This conceptualization of the experiment is yet another example of the work of purification – it separates out the subjects of timeless scientific truth from the contingent particulars of human and technological intervention.[4]

The notion of the 'scientific enterprise' is meant to serve as a middle-term between the many particular sciences with their varied concepts of science and objectivity and the most general notions of how humans forge an agreement between their thoughts and the real world. Each scientific discipline may have its own paradigm and within each discipline there might be scientific revolutions that involve paradigm shifts. In and of themselves, however, these do not constitute epochal breaks. Accordingly, Blumenberg (1976,16) characterizes paradigm shifts as "a surrender of basic assumptions and the introduction of new elementary suppositions, which get rid of a desperate situation but do not necessarily rupture the identity of the movement of knowledge that had culminated in that situation." The scientific enterprise is that overarching movement of knowledge.

IV.

So much for the scientific enterprise. It is time to turn to the technoscientific enterprise, first to characterise it and then to reflect on the epochal break and the discontinuities that are signaled by it.

As for its characteristics, many of them emerge from the contrast with the scientific enterprise. The technoscientific enterprise is not a new paradigm within the traditional movement of knowledge but reorients the various old and new ways of knowledge production. This different orientation has been associated with postmodernity especially by Paul Forman (2007 and 2010). But rather than valorize postmodernity as a new epoch with its own historical mission and overarching movement of knowledge, it is sufficient to characterize it simply as the abandonment of

[4] To be sure, it needs to be shown that notions of objectivity in synthetic chemistry, the engineering sciences, and even the science of sociology also rely on attempts to separate immutable and systemic features from contingent interventions, if only by conditionalizing the latter ("to the extent that there can be objective sociological knowledge, it consist in statements of the form 'in this kind of social system, this would be observed").

the work of purification and of received notions of objectivity. Indeed, in the age of technoscience, the work of purification is no longer possible and no longer required. For an "in silico"-experiment that is performed in a computer model or for research on a genetically engineered laboratory model it becomes, as a matter of fact, impossible to conceptually determine where human intervention ends and the purely natural process begins. Since these experiments serve mostly to demonstrate practically achieved control of the phenomena, there is also no need to determine this – the achievement stands on its own.

To be sure, both aspects of this definition demand extensive substantiation. With the claims that the separation between nature and technology, between representation and intervention is no longer possible but also no longer required one reaches the point where the epochal break thesis becomes an empirical thesis about changes in the practice and orientation of knowledge production. Though many of the arguments for mode-2 research, the triple helix, post-normal science serve to corroborate these claims, the thesis cannot be fully supported here, but only a brief outlook provided at the very end of this essay. More pressing for the purpose of this essay is to spell out what is meant by saying that the work of purification has ceased and that objectivity is now conceived in an ahistorical manner.

The very term “technoscience” is testimony to giving up on the separation of “science” and “technology.” Though the two commingled in research practice throughout the history of science and the history of technology, we noted above at least one of the conceptual devices by which it was relatively easy to separate them out in the mind and assign each of to its own domain. Technology was said to provide interventions that serve as triggers or stimuli in an experiment, whereas the response to these stimuli was thought to be an aspect of nature and as such subject to scientific observation and inquiry. The separation between technology and science thus mirrors the separation – in the mind and only as a result of conceptual work of purification – between practical intervention in the world (technology) and theoretical representation of the world (science). It thereby also mirrors the distinction between contingent events and the immutable properties and processes that reveal themselves in response to arbitrary technical interventions: It is entirely contingent whether two substances are brought in contact with one another during an experiment, but their chemical reaction is a matter of natural lawfulness. These distinctions do no apply to technoscientific research. The objects of research cannot be separated from the technical interventions required to produce, maintain, or observe them. The carbon nano-tube or a genetically engineered animal model exhibits properties and processes that are themselves engineered – their relevant dispositions are aspects simultaneously of nature and culture.

When there are no distinct immutables features of nature as opposed to technology and culture, there is also no historical movement of thought that sets out to converge on these features and that seeks objectivity by gradually controlling for all sources of subjectivity in the course of producing intersubjective agreements. Instead, technoscientific objectivity results quite literally from objectification, that is, from the transformation of available knowledge, technology, and skill into material processes and things. Instead of seeking time-independence, technoscientific objectivity requires independence from place. Laboratory constructions need to become delocalized and achieve the robustness required for their survival in the outside world (Galison 1997). Technoscientific objectivity thus serves the so-called knowledge society that gears theoretical and instrumental tools to the solution of identified problems. This is a matter of innovation rather than progress. Accordingly, the technoscientific enterprise is not obliged towards the future for its fulfillment and its achievement of true or proper knowledge. For technoscientific innovation, the future is merely a repository of technical possibilities that await to be realized, but its task is framed entirely by the present as one matching up supply with demand, technoscientific capabilities with the societal or environmental problems that require technical solution.

The term ‘delocalization’ was discussed, perhaps introduced by Peter Galison (1997). Galison also speaks of ‘ontological indifference’ in order to characterize technoscientific research (Galison 2006; see also Daston and Galison 2007, 393, 414). Engaged in the work of purification, the scientific enterprise must be deeply concerned with what is and what is not an aspect of nature and what is therefore subject to scientific representation and truth-seeking. Ontologically indifference is indifferent to purification. Technoscientific research proceeds in a design or engineering mode and the hallmark of good technoscience is the acquisition and demonstration of basic capabilities and, beyond that, the creation of robust technical systems. Clearly, the achievement of these capabilities and the robustness of these systems do not require that the contributions of nature and human craft can be disentangled.

V.

This essay posits an epochal break between the scientific and the technoscientific enterprise. In particular, this amounts to the claim that the various scientific endeavors are oriented no longer towards the progressive historical mission of the Enlightenment project, but instead to innovative productions of a fit between available modelling tools and the phenomena, between achieved

capabilities and recognized problems. The empirical criterion for this shift is the abandonment of the futile and nevertheless ceaseless work of purification that characterizes modernity.

The significance of this break can hardly be overstated. At the same time, this break does not imply radical discontinuities in research practice. Indeed, some would argue (see section II above) that science has always been concerned to produce a fit between available modelling tools and the phenomena. There is nothing in my argument that would dispute this. Yes, such a description might yield a lowest common denominator for the scientific and the technoscientific enterprises. By the same token, it involves an impoverished description especially of the scientific enterprise (technoscientific research is rather more willing to embrace it). Scientists who are working in the lab to produce such a fit and who are also concerned to prove themselves as "scientists" are simultaneously pursuing bigger objectives and contributing to a larger project of Enlightenment.

Another dimension of continuity is that the technoscientific enterprise would not be possible if it couldn't draw on the knowledge and skill acquired in pursuit of the scientific enterprise. Indeed, the continuous progress of representational capabilities may well have given license to their use beyond representational purposes for the kind of substitutive, qualititative, interactive modes of reasoning about technoscientific complexities (Nordmann 2006). Yet another aspect of continuity takes us beyond the philosophical interests of these remarks into the realm of sociology. The technoscientific enterprise may have displaced the scientific enterprise in the rhetoric of funding, of justification, and of framing research, but it has not displaced it in the education of physicists or biologists. Many young researchers are introduced to the "life of science" and then find themselves operating in a world of "strategic research" that is shaped by very different values. Indeed, the presence and reality of the technoscientific enterprise calls attention to itself by way of ambivalence, that is, by way of research that comes from one place and finds itself in quite another, and that learns to play a new game with many of the old rules.

On the side of the researchers or the subjects, then, there is no clear division between the age of science and the age of technoscience. The epochal break runs right through them and is frequently experienced as an inner conflict. On the side of the objects of research, however, the division appears pretty clear.[5] For example, the objects of technoscience do not have fixed and definite substantial natures but are mere potentials. Substantial natures determine what something is – a stone is hard as a rock. Considered as a mere potential, the stone is what it might become, that is, a momentary configuration of atoms and molecules that could be turned into just about anything else.

[5] Accordingly, a project by Bernadette Bensaude-Vincent and Sacha Loeve, Alfred Nordmann, and Astrid Schwarz (Forthcoming) has set out to explore the "Genesis and Ontology of Technoscientific Objects".

Similarly, the computer's ability to solve humanly intractable equations affords not just an improvement of extant modelling techniques but is radically discontinuous with the past – where models used to mediate between theory and reality and thus highlighted the distance between theory and reality, theory now offers algorithmic building blocks to construct a substitute reality that is hardly less complex than its original. And so, the list of discontinuities may be continued to include the role of conservation laws, the very idea of knowledge expressed propositionally in theories and hypotheses, the roles of similarity or likeness in evidentiary reasoning.

VI.

In light of the various continuities and discontinuities in the shift from the scientific to the technoscientific enterprise, the question arises how it came to this shift and why the work of purification has been abandoned. To offer the requisite conjectures goes beyond the scope of this essay. I suggested above that such work or purification is no longer possible and no longer required today. Some of the preceding remarks offer hints why this is so. For example, improved methods for surveying and managing information from highly complex systems have advanced modelling techniques that are opaque and intractable to the human mind, that do not afford analytic understanding but perfectly robust technical and intellectual control of the phenomena. I have also suggested that the various dimensions of the epochal break thesis require a concerted philosophy of technoscience. Just like the philosophy of pure science, this philosophy of impure science is concerned with questions of epistemology, method, ontology, and representation. It will also seek to show how the various characterizations of technoscience complement one another – the epistemological characterization according to which technoscience consists in acquiring and demonstrating basic capabilities of visualization, intervention, and control; the ontological characterization in terms of objects and processes that can be assigned neither to nature nor to culture; and the historical characterization in terms of an ontological indifference that could not be fully appreciated as long as the sciences were held to the ideal of purification. Work to more fully articulate such a philosophy of technoscience is beginning everywhere (e.g. Bensaude-Vincent 2008, Echeverria Ezponda 2003, Nordmann 2008 and 2010).

At the end of this essay, the urgent plea to acknowledge an age of technoscience is surrounded by an air of paradox. It posits an epochal break between a modern age of scientific revolutions or successive worldviews, and a postmodern age of technoscience that has no historical self-understanding but regards all research at all times as knowing by doing, as a means to create and

realize technical potential and thus to construct the world we live in. The very diagnosis of this epochal break is therefore a reaction against it. Seeking in a very modernist way to give voice to the spirit of my age and to answer the call of the day, I am reacting also against those historians and philosophers of science who have unwittingly embraced a technoscientific attitude already by seeing nothing unusual anywhere and only the endless toil of fitting in diverse ways bits of theory to bits of reality. What would awaken these philosophers from their slumber is the claim that technoscientific knowledge is inferior to that of the sciences, that our theories and our technologies are becoming unreliable.

This is not, however, what I mean when I say that the significance of the epochal break can hardly be overstated. On the contrary, though nearly as opaque and complex as reality itself, technoscientific knowledge may well be more robust and reliable than that of the traditional sciences. The significance rests in the dissolution of the alliance between science and enlightenment and thus in the loss of an institution for organized scepticism – even if this institution rarely lived up to its promise, in the age of technoscience that promise itself has lost its meaning.

Contact

Alfred Nordmann
Professor of Philosophy
Technische Universität Darmstadt

nordmann@phil.tu-darmstadt.de

References

Bensaude-Vincent, Bernadette (2009) Les vertiges de la technoscience: Façonner le monde atome par atome, Paris: Editions La Découverte.

Bensaude-Vincent, Bernadette, Sacha Loeve, Alfred Nordmann, and Astrid Schwarz. Forthcoming. “Matters of Interest: The Objects of Research in Science and Technoscience.” Journal for General Philosophy of Science.

Blumenberg, Hans (1976) Aspekte der Epochenschwelle. Frankfurt: Suhrkamp.

Daston, Lorraine, and Peter Galison. 2007. Objectivity. New York: Zone Books. Echeverria, Javier. 2003. La revolucion tecnocientifica. Madrid: Fondo de Cultura Economica.

Forman, Paul. 2007. “The Primacy of Science in Modernity, of Technology in Postmodernity, and of Ideology in the History of Technology.” History and Technology 23: 1–152.

———. 2010. “(Re)cognizing Postmodernity: Helps for Historians—of Science Especially.” Berichte zur Wissenschaftsgeschichte 33: 157–75.

Galison, Peter. 1997. “Material Culture, Theoretical Culture, and Delocalization.” In Science in the Twentieth Century, edited by John Krige and Dominique Pestre, 669–82. Amsterdam: Harwood.

———. 2006. “The Pyramid and the Ring.” Lecture at the conference of the Gesellschaft für analytische Philosophie (GAP), Berlin. September.

Latour, Bruno. 1993. We Have Never Been Modern. Cambridge: Harvard University Press.

Nordmann, Alfred. 2006. “Collapse of Distance: Epistemic Strategies of Science and Technoscience.” Danish Yearbook of Philosophy 41: 7–34.

———. 2008. “Philosophy of Nanotechnoscience.” In Nanotechnology: Principles and Fundamentals, edited by Günter Schmid, 217–44. Weinheim, Germany: Wiley.

———. 2010. “Science in the Context of Technology.” In Science in the Context of Application, edited by Martin Carrier and Alfred Nordmann, 467–82. Dordrecht: Springer.

Weber, Max. 1919 [1946]. “Wissenschaft als Beruf.” English translation in From Max Weber: Essays in Sociology, edited by H. H. Gerth and C. W. Mills, 129–56. New York: Oxford University Press.

Ziman, John. 2000. Real Science: What It Is and What It Means. Cambridge: Cambridge University Press.