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Science after the End of Science?

An Introduction to the "Epochal Break Thesis"

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In the February 2008 issue of *Nature Nanotechnology*, physicist Philip Moriarty published a commentary that aims to reclaim academic science from postacademic science. Even though many of his readers are not at all familiar with the terms "academic" and "postacademic" science, Moriarty makes clear that the stakes are high. He is debating no less than the question whether it is still possible today to uphold an idea of science that values above all intellectual qualities like curiosity, creativity, and knowledge, and that does so for the sake of the public rather than the corporate good. At stake in reclaiming this idea of science is what might be called an "epochal break"—the idea that there has been a transformation in the relation of science, technology, and society so profound that our received notions of "science" have been superseded by something else.

It is telling that Moriarty's intervention appeared in a journal devoted to nanotechnology, which for some (for instance, Thomas Vogt, Davis Baird, and Chris Robinson [2007]) is the prime exemplar of a new age of technoscience. In the case of nanotechnology, Vogt, Baird, and Robinson argue, it is so utterly misleading to speak of "pure science" that it is actually morally bankrupt to pretend otherwise. Only those who openly acknowledge the technical, commercial, societal character of nanotechnological research can realize its potential to benefit humankind. Moriarty (2008, 61) responds: "It is the focus on market-driven wealth creation within publicly funded academic research, and not the distinction academics draw between 'pure' and 'applied' science, which is morally bankrupt." Another physicist, Richard Jones (2008, 448), comments on this exchange by remarking that scientists "for whom the traditional values of science as a source of disinterested and objective knowledge are precious" regard arguments for postacademic technoscience "as assaults by the barbarians at the gates of science."

Debates like this constitute one of the starting points of this edited volume. It is a debate about facts and about values. Has there been an epochal break or not? What happened to science as we knew it? And what does all this mean for science and society, for our intellectual traditions and the public good? Here, we first introduce the issue and the range of positions that have been adopted in the debate. In the second section we briefly summarize the chapters that make up this volume.

1. Introducing the Epochal Break Thesis

Almost every year serves as a banner year for science: 2009 was a case in point with the four-hundredth anniversary of Kepler's first two laws of planetary motion as well as Galileo's first use of a telescope for astronomical observations. Even more prominently, that year saw the celebration of the two-hundredth anniversary of Charles Darwin's birth and the hundred-and-fiftieth anniversary of his *Origin of Species*. Everyone recognizes the scientific accomplishments in all this—the advancement of knowledge toward a better understanding of the world, the conflict of science and religion, and a manner of inquiry that prizes critical thinking above all. Yet, even as we are celebrating these anniversaries and valorizing a certain image of science, we are expecting from contemporary research not primarily the discovery of truth but the solution of pressing problems—new ways to generate and store energy, cures for cancer and Alzheimer's disease, innovative ideas for sustainable economic development. Evolutionary biology, the neurosciences, and theoretical physics still command interest and curiosity, but the most prestigious research nowadays comes under the headings of nanotechnology, genetic engineering, biomedical research, or synthetic biology. So, when we celebrate Kepler, Galileo, and Darwin as great scientists, are they representatives of science as we value it today?

Answering this apparently simple question proves to be a difficult and controversial affair, and as Moriarty has demonstrated, there is a good deal at stake. Of course, one can quickly come up with symptomatic descriptions of changing conditions under which scientific research is undertaken—universities as patent holders, the computer as a powerful new tool, corporate sponsorship of research, and so on. However, this collection seeks to go beyond description. It also debates the meaning of these changes, since what is at stake is no less than a revered social institution that claims to provide an independent voice of reason for society to critically reflect upon itself. To abandon this institution would be tantamount to severing the alliance between science and the Enlightenment. Some argue that just this has happened in recent years. They maintain that there has been an epochal break that produced a profound reorientation of research practice. Others believe that there is nothing to worry about and that the situation today is not that different from the past. Yet others claim that this alliance has never really existed anyhow and that all-too-lofty views of science or of the Enlightenment never were anything but ideological.

This much is clear enough and not contested by anyone: science has never been free of interests and has always been conducted in a context of application. At least since the time of Francis Bacon (1561–1626), societies have looked to science to provide answers to their problems, to stimulate the economy, to inspire generally useful applications. Arguably, research scientists didn't live up to these expectations until sometime in the nineteenth century. These expectations were epitomized in the motto for the 1933 Century of Progress exhibition in Chicago: "Science finds, industry applies, man conforms." This slogan suggests a linear progression from scientific research to its technical applications and societal impacts. On this account, science enters a context of application only when it is very far along. Not until fairly recently has an awareness risen of rather more complicated interactions between science and technology. For example, we increasingly view the world around us as a product of science and technology and understand that science does not take its problems only from nature. Instead, many scientific problems arise from our reliance on the technological uses of science itself. These problems—like global warming, the toxicology of nanoparticles, or the exploitation of renewable energies—surface from complex interactions between social, technical, and "natural" factors. Science in the context of application is challenged to gain a new understanding and control of complexity—it cannot seek shelter in an idea of "pure science" or retreat to an imagined ivory tower.

This suggests that there are various ways for science and technology to interact in the context of application. Of the following three ways, the first two recapitulate familiar views of the relation, while the third may reflect a more troubling and more contemporary situation.

- Scientific research creates new technical capabilities that are then developed in engineering contexts. A prime example of this would be Heinrich Hertz's experimental and theoretical investigations of electrodynamics, which gave physical meaning to Maxwell's equations. A few years later, Guglielmo Marconi built on Hertz's findings to develop wireless telegraphy and thus prepare for the radio.
- Technological innovation gets ahead of scientific understanding and prompts research activity to attain comprehensive knowledge of its basic principles. The classic example is the construction of the steam engine, which proceeded mostly by trial and error without systematic understanding of the relation between work and heat. It was the steam engine itself and its successful operation that prompted scientists to study and finally understand this relation.
- Piecemeal research activities are commissioned to manage the complexity of sociotechnical systems with no particular expectation of comprehensive understanding. Take, for example, research to determine whether a certain salt mine is suitable for long-term storage of nuclear waste. This can involve a sizable interdisciplinary team of researchers for a number of years. What is here considered to be successful or conclusive research depends to a considerable extent on the informational demands of the decision-makers.

If recent developments force upon us a broad perspective on science and technology in the context of application, it is yet not broad enough. There is more that calls for our attention than the various relations of science and technology. The context of application is characterized not only by questions of use, by demands for theoretical understanding and public utility, and by the intended and unintended effects of scientific and technological innovation. The context of application is also a public sphere and a media culture, it is shaped by a variety of actors and institutions, by the pictorial representations of data and the resonance of visions.

The practical relevance of science, its great technological ambitions, its public appeal, and the heavy application pressure under which it operates today have prompted a flurry of analyses. A brief survey will show that they converge in the claim that science has undergone a profound methodological and institutional transformation during the past decades, perhaps an epochal break. With the flurry of analyses came a somewhat bewildering multitude of labels to designate the difference to traditional academic or theoretical science. Our quick overview will introduce some of the catchwords that are used to flag this transformation, though one should keep in mind that the following chapters are not so much concerned with the specific catchwords and labels but rather investigate the motives or causes that might have led so many to diagnose a profound transformation of science in the first place.

Most of the labels and diagnostic analyses in question originate in observations of the social and political conditions that influence science policy and research funding. In the 1990s, Henry Etzkowitz (2003; Etzkowitz and Leydesdorff 1998) began promoting the notion of a *triple helix* of *entrepreneurial science,* emphasizing how academia, industry, and government have become intertwined in the pursuit of research agendas. John Ziman (2000) complements this perspective with his discussion of *postacademic science* and the norms that guide it. According to Ziman, it is proprietary (rather than communal), local (rather than universal), authoritarian (rather than disinterested), commissioned (rather than original), and expert (rather than sceptical). Where Etzkowitz explores new opportunities for triple helical science policy, Ziman notes with a bit of alarm that the ethos of academic science is challenged by that of industrial or entrepreneurial science. Further studies have documented the profound effects of commercialization on university teaching and administration, and have related these phenomena to the rise of a neoliberal worldview and politics.

A mostly sociological and political characterization of the "new production of knowledge" has been offered also by Helga Nowotny, Peter Scott, and Michael Gibbons (2001), among others. They foreground a new social contract between science and society. Traditional or "mode-1 research" followed a trajectory of internally generated problems and procedures and was conducted in a setting where the pursuit of scientific questions was fairly well insulated and protected against immediate external interference and demands for accountability. This insulation is exemplified by large research laboratories and their closed walls behind which experiments are performed. This kind of research still exists today, of course, but it is being displaced by "mode-2 research," which is a more open undertaking that is characterized by a transdisciplinary orientation toward social, environmental, industrial, or medical problems. The fact that the boundary between science and society has become increasingly porous is seen as a cause for celebration because it suggests new opportunities for the social shaping of science and technology.

In a rather different setting arose the term "technoscience," which was introduced by Gilbert Hottois and popularized by Bruno Latour (1987, 1993) and Donna Haraway (1997). These rather more philosophical analysts of science do not use the term to claim that today's technoscience is radically dissimilar from previous science. What has changed is the way we look at science. For a long time, there was an effort to keep science as a quest for knowledge separate from technology as a way of changing our living conditions. This separation mirrors the effort to distinguish nature as a given, mind-independent reality from culture as the product of human action. But these attempts, Latour and Haraway agree, are futile, and under the label of technoscience we can now admit to that. The term fuses two words and it designates the ubiquity of hybrids. In technoscience, heterogeneous actors draw on conceptual and material resources to forge new kinds of entities, including technical artifacts. This perspective on science and technology, Paul Forman (2007) argues, coincides with postmodernity. In the modern age technology was viewed as applied science, while in postmodernity science is regarded as a kind of applied technology—its intellectual and physical control of phenomena depends on technology and a technological mode of thought. Again, these various thinkers evaluate technoscience rather differently. Latour and Haraway emphasize primarily that this new understanding enables new ways of acting and interacting, while Forman laments that science has become subservient to the realization of desired ends by any means necessary.

Forman does not introduce specific labels for the different ways of conceiving the relationship between science and technology. Though he attributes the current way of thinking to postmodernity, he does not speak of "postmodern science." That label has been used by others without catching on as of yet. For some, like Stephen Toulmin (1992), postmodern science is a program more than a reality. It is a kind of disunified science that recognizes a multiplicity of standpoints and respects local conditions. Others, like Jan C. Schmidt (2007), use postmodern science, or *nachmoderne Physik,* to designate research that draws on theories of complexity and self-organization rather than privilege isolable cause-effect relations. The identification, characterization, simulation, and "domestication" of particular highly complex phenomena resembles a "new natural history," as Arie Rip (2002) has pointed out.

Along some of these same lines, the term "postnormal science" has gained some prominence. It is associated primarily with Silvio Funtowicz and Jerome Ravetz (1993, 2001) and deals with scientific inquiry in high stakes situations where the disciplinary knowledge of normal science needs to be extended in various directions to cope with real-world complexities and the irreducible uncertainties that attend them. The production of new forms of ignorance in the course of scientific and technological development has been said by Ulrich Beck, Anthony Giddens, and Scott Lash (1994) to give rise to a "second modernity" or "reflexive modernization." This form of modernization mobilizes novel approaches to governance but also to the production of scientific knowledge in order to deal with the often unintended and unpredictable effects of modernization. In particular, it necessitates systematic reflection in order to cope with the risks of the uses of science itself.

These catchwords are by no means the only ways by which various authors seek to express what they perceive to be distinctive of much contemporary research. In the 1970s already, Gernot Böhme, Wolfgang Krohn, Wolfgang van den Daele (1973), and Wolf Schäfer (1983) spoke of "finalized science." Once the business of internal theory development has been finished, research needs to orient itself explicitly toward specific social or technical ends that are to be achieved. Much more recently, Peter Galison (2006) began speaking of an "engineering way of being in science" that is characterized by "ontological indifference," while Ann Johnson (2009) employs the notion of "research in a design mode." These terms capture the fact that many current research activities are more concerned with building or making than with knowing. Media theorists, art historians, and philosophers of modeling each from their own disciplinary perspectives ask whether there has been a major shift in the representational practices of science. And so, the list can be continued.

Some of these terms—"technoscience" and "mode-2 research" in particular—will reappear throughout this book and to the astute reader, they may lack a proper definition. Indeed, more often than not, they are loosely descriptive of a phenomenon that remains to be fully understood. It is for this reason that these chapters seek out what it is that motivates all these various descriptions: What is the significance of the purported changes that draw so much attention? What, if anything, is new here? Ought we welcome this novelty or be troubled by it?

There is another reason why the chapters herein do not enter the thick of labels, adjudicating and comparing them one by one and one against the other. Rather than become entangled by them, it is important to reclaim the critical distance that allows us to ask what is at stake in these various descriptions and redescriptions of research practice. Only when this distance is maintained, the various accounts of the distinctiveness or novelty of contemporary research do not end up as self-fulfilling prophecies. Such a pattern can indeed be observed when, for example, the diagnosis of "triple-helical" or "mode-2 research" is taken up by science observers, foresight analysts, or policy makers, and when it becomes institutionalized in transdisciplinary funding practices that set out to enable a more effective technology transfer. Soon enough, philosophers, historians, and sociologists of science have themselves become caught up in the context of application—engaged in *sozialwissenschaftliche Begleitforschung*, "ELSA-studies," or the facilitation of responsible development of emerging technologies. Against this background, this edited volume attempts to reclaim a critical perspective on contemporary developments.

Finally, the problem of definition also applies to the term "epochal break." Whether one ends up proclaiming such a break depends on what one imagines an epochal break to be. Are we taking as our model the epochal break between the medieval "dark" age and the renaissance with its light of reason? On this model, the burden of proof would be quite high, but a case might be made, for example, by arguing that we are moving from a period of disenchantment, rationalization, and intellectualization to an age where the technoscientific world of our own creation becomes an enchanted, magical place. Less ambitious claims confront difficulties of their own. We might take as our model, for example, a so-called Kuhnian scientific revolution or paradigm shift, though paradigm shifts typically occur within physics, chemistry, or other disciplines, whereas "technoscience," "mode-2 research," and the like refer to changes that affect all disciplinary research across the board. However, a case might be made for the Kuhnian model by speaking about the recent emergence of new disciplines with new paradigms and problems somewhat along the lines of the emergence of molecular biology many decades ago. The so-called Hacking revolutions provide a third model. These refer to a conceptual or technical innovation that can mark a point of no return. Similar to the "probability revolution" of the eighteenth and nineteenth centuries, for instance, the introduction of desktop computing and simulation modeling may have changed forever and for everyone the rules of the game of explanation and understanding, predicting and controlling the world—irrespective of whether an individual researcher employs such models or not.

These three models do not exhaust the many ways of speaking about an epochal break. For example, we saw Forman (2007) modeling the epochal break on the transition from modernity to postmodernity, by which he does not mean a break on the level of practice but on the level of ideology, interpretation, or cultural prestige. Media theorists refer to the epochal transition from analog to digital imaging, which severs the traditional causal chain from the original to its representation and allows any kind of data to be rendered in any number of visual forms. Yet another model is associated primarily with Michel Foucault's notion of "epistéme" and a shift in the order of discourse—that is, in the presuppositions that accord power and efficacy to certain kinds of knowledge. In light of these various meanings of core concepts, the question this book asks does not have a straightforward answer. Is the manner in which knowledge is produced business as usual, or do changing relations of science and technology signify an epochal break? The different ways of approaching this question illustrate the many ways of reflecting upon our age and the contemporary significance of science in and for society.

2. Debating the Epochal Break Thesis

The chapters included in this edited volume address the epochal break thesis from a variety of disciplinary backgrounds, including philosophy and history of science, social studies of science and technology, and cultural and media studies of science and technology. The subsequent chapters are divided into two groups. The first group of chapters seeks to adjudicate the proposed claim of an epochal break as a whole. It opens with several chapters that start the discussion by providing strong views in favor of or against the idea that during the past decades there has been a profound reorientation of the scientific enterprise. The authors in the second group approach the thesis from more specific perspectives. They foreground certain concepts, single out specific technical developments, or consider particular practices and contexts of application. These specific concepts, technologies, and fields of practice serve as a testing ground for the larger thesis.

Alfred Nordmann interprets the epochal break as a shift from the scientific enterprise to the regime of technoscience. Characteristic of the scientific enterprise is that representing and intervening—nature and culture, science and technology—are taken to be distinguishable. The critical point of distinction, then, is that for technoscience this purification (of nature from culture and so on) is no longer possible and no longer required. Methodologically, Nordmann argues in his chapter that this thesis cannot simply be inductively proven in an empiricist way but requires the reasoned adoption of a specific vantage point. However, the thesis can and should be empirically articulated and supported by specifying in detail how both the separation and the conflation of science and technology work out in actual scientific and technoscientific practices.

In his chapter Gregor Schiemann addresses the issues through the notion of a scientific revolution and claims that at present we are not witnessing a new scientific revolution. Instead, Schiemann argues that after the so-called Scientific Revolution in the sixteenth and seventeenth centuries, a caesura occurred in the course of the nineteenth century that constituted a departure from the early modern origins of science. This change was characterized by the loss of certainty on the part of the scientists, by the steadily increasing importance of scientific communities (rather than individuals), and by the systematic intertwinement of scientific and societal development. As to present science, Schiemann admits that important changes have occurred, but he denies the conflation of nature and culture: even the OncoMouse is a natural organism, though a seriously damaged one.

Martin Carrier then offers a radical counterpoint to the epochal break thesis. Instead of claiming that science is *no longer* interested in a theoretical understanding of the world and that it is *now* in the service of ambitions to make and remake the world, one should realize that modern science has always pursued the latter ambition but is only now able to deliver on its promises. The notion of science as a theoretical enterprise that is ultimately interested in truth was offered as the royal road to the larger aim of utility and benefit. Throughout its history, and still today, theoretical understanding was required for the advancement of technical goals. In this sense modern science was and continues to be an epistemic enterprise. As it delivers on its promise, however, there is a change at the ontological level: many or most of the objects studied in present-day sciences, such as nanotubes or nonsteroid anti-inflammatory drugs, are not part of an untamed nature but the result of artificial human creation.

From his historical perspective, Cyrus Mody is skeptical of any grand claim about epochal breaks. Thus he argues that key aspects of current technoscience can be found in postwar nuclear physics (Alvarez and nuclear weapons), in early-twentieth-century physical chemistry (Langmuir and lightbulbs), in the study of electricity and magnetism in the second half of the nineteenth century (Kelvin and the telegraph), and even in seventeenth-century mechanics (Galileo and the Medicis). Mody points out that announcements of epochal breaks are often interested and do have real consequences—for instance, in terms of funding policies. He concludes that the scholarly study of science should be wary of epochal break talk and keep firmly in mind that one particular vantage point is as good as any other.

A different but equally critical view is taken by Mieke Boon and Tarja Knuuttila. They discuss the alleged divides between representing and intervening and between basic and applied research. Here representation and basic research would be typical of mode-1 research, while intervention and applied science would characterize mode-2. Because models are multifunctional epistemic tools, the uses of which may include both representing and intervening, and since modeling is, and has been for long, the core of the natural and in particular the engineering sciences, the epochal break between mode-1 and mode-2 research collapses. Like Carrier, Boon and Knuuttila suggest that there has never been mode-1 research. What has changed, though, is the political rhetoric that exploits mode-2 talk for legitimizing short-term accountability and commodification.

Hans Radder's chapter exemplifies a more differentiated approach. It points out that human intervention in nature has been an essential dimension of the experimental tradition since its inception in the Renaissance. It also questions the philosophical and empirical claims about the absence of purification work in present-day science. However, Radder argues, this does not mean that recent science is business as usual. In particular, he points to the rise of important, nonlocal patterns, such as the significance of the external validity of scientific knowledge and methods and the commodification of academic research. The identification and explanation of such nonlocal patterns requires a subtle and reflexive methodology, which precludes the positing of Great Divides and acknowledges the unavoidable value-ladenness of this type of historical-philosophical research.

The chapter by Andrew Jamison provides a brief account of the changing contexts of science and technology since the 1940s. He distinguishes a mode-1 phase of disciplinary little science (before World War II), a mode-1½ phase of multidisciplinary big science (the 1940s through the 1960s), and a mode-2 phase of transdisciplinary technoscience (since the 1970s). In response to the criticisms of commercialized technoscience, Jamison claims that we cannot return to a mode-1 science that is no longer meaningful, and he tentatively argues for a mode-3 phase as a desirable synthesis of traditional and commercial research cultures. As for the idea of an epochal break, Jamison speaks more carefully of "changing contexts," while the notion of a mode-1½ phase suggests a transitional process.

In the following chapter Chunglin Kwa admits that nowadays science is primarily seen as technoscience. But although the idea of technoscience seems to imply a primacy for technology with respect to science, he offers an alternative model for the interaction between science and technology. Building on A. C. Crombie's work on the six styles of scientific thinking, Kwa proposes design, in the literal sense of *disegno* or drawing, as the core of a technological style. In technoscientific practice this technological style may forge a variety of alliances with other scientific styles. The approach is illustrated by analyzing several alliances of airplane design with instances of other scientific styles. The idea of alliances entails that technology, or a technoscientific enterprise, is combined with, and hence has not replaced, science or a scientific enterprise.

The chapters in the second part of the book address more specific aspects of the epochal break thesis. This does not mean that they deal with minor details, because they do discuss substantial patterns or trends in the history of recent science. Astrid Schwarz and Wolfgang Krohn begin by showing that the concept of "experiment" has undergone a major shift that prepared or accompanied a more general reorientation of the relationship between science and society. As long as experiments were confined to the laboratories of the classical natural sciences, this relationship was defined by a clear separation of spheres. The increased significance of field experiments, which do not rely on the isolated space of the laboratory but transform a field site or social setting into a laboratory of sorts, prepared an understanding of large-scale "real-world experiments" that serve as sites for social learning.

Valerie Hanson's chapter focuses on the characteristics of the strongly increased uses of digital imaging in science. An important new aspect of these visualizations is that they enable the viewers to interact with the objects of study. Making such images—for instance, of molecules and molecular processes in chemistry—becomes an exploratory, experimental procedure. Furthermore, this technology entails new rhetorical strategies for disseminating knowledge, both among the scientists themselves and among the general public. Although digital imaging possesses several features that are different from analog visualizations, Hanson emphasizes that it is not fully novel. Hence her conclusion is that the effects of digital media on scientific practice are a matter of intensification, not of full transformation.

In contrast, Angela Krewani considers a fundamental change in the representational practice of the sciences. With digital media technologies, she explains, any set of data can be rendered as an image and any image can be decomposed into a data-set. She shows how analog and digital media technologies condition behavioral attitudes that simultaneously constitute the scientific object and the scientific observer of that object. Even though digital imagery is sometimes used merely to emulate analog imaging techniques, this should not detract us from the fact that digital technologies presuppose and enable a different kind of interactivity and thereby also a different spatial relation between objects and subjects of research.

The recent developments in robotics and human-robot interaction are the topic of Jutta Weber's contribution. She documents the shift, in the late 1980s and the 1990s, from robots as industrial tools to a focus on personal-service robots. The latter are claimed to be not just devices but rather artificial creatures, possessing cognitive, affective, and communicative capabilities. Up to now, the cultural significance of humanoid robotics is primarily symbolic: it represents glamour science, it provides edutainment, and it shows that science can be fun. At a more basic level, however, human-robot interaction challenges fundamental assumptions about what it is to be human. Regarding the theme of this book, humanoid robotics should be seen as a full-blown technoscience. It is neither about representing nor about intervening, but rather about constructing and reconstructing hybrid cyborg worlds.

In his chapter, James Robert Brown observes that one aspect of the science-technology relationship has been underexposed thus far—namely, the erosion of scientific quality under the influence of technological and commercial interests. With the help of detailed examples, he demonstrates that such erosion has occurred, and still occurs, in medical science. Furthermore, the positive impact of pharmaceutical research is much smaller than often claimed. Solving these problems, he argues, requires some radical changes: not merely stricter regulation and public control of clinical trials, but also the abolishment of all intellectual property rights and a policy of full public funding. Brown concludes that although there has been an (undesirable) epochal break in medical research, this cannot be generalized to other areas, such as high-energy physics.

Finally, Ann Johnson and Johannes Lenhard discuss the rise of cheap and widely available personal computers during the 1990s and argue that this development has led to “a new culture of prediction.” The performance of computational models is often opaque, and usually the models themselves cannot be interpreted as a realistic representation of the way the world is. What such models do possess, however, is a substantial predictive power. Philosophers of science often focus on explanation, but the more prominent role of prediction requires an independent historical and philosophical analysis and assessment. Johnson and Lenhard conclude that prediction is the key to technological control. Moreover, the increasing impact of opaque computational modeling demonstrates that such control can be achieved without in-depth theoretical understanding.

The epilogue, written by Hans Radder, is of a different nature. It does not argue for or against the epochal break thesis or some of its aspects. Instead, it attempts to extract from the preceding chapters a number of issues that can be expected to remain the focus of sustained research and debate. These “sticking points” include historiographical questions of how to support a comprehensive historical thesis like the epochal break thesis, ontological and epistemological issues about the nature and development of the sciences, empirical and theoretical accounts of the role of old and new methodologies, social-scientific inquiry into the relationships between science, technology, and the wider society, and normative concerns about the sociocultural roles of science and technology.

This introductory overview offers no more than a sketch of the main points of the chapters. In fact, the chapters cover a richer set of relevant subjects and a more subtle variety of arguments and positions than can be covered in this introduction. To discover this richness and subtlety, please read on and see for yourself.

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