WHY READ HEIDEGGER ON SCIENCE?

Trish Glazebrook

Heidegger wrote extensively concerning science for more than sixty years. Four aspects of his analysis in particular demonstrate the breadth and scope of his sustained critique of science, and indicate specific trajectories for its further development. First, he has much to say to traditional philosophers of science concerning the experimental method, the role and function of mathematics and measurement, the nature of paradigms and incommensurabilty, and realism versus antirealism. Second, his assessment of technology is incipient in and arises from his reading of the history of physics, so theorists who overlook this aspect of his work may find they are working with a deficient theoretical framework when attempting to come to terms with his critique of technology. Third, he offers rich conceptual resources to environmental philosophers, especially those who work at the intersection of environment and international development. Fourth, his arguments for reflection on science support a renewed sense of social obligation on the part of the sciences that should be of especial interest to science, technology, and society theorists.

I have examined these first two issues elsewhere.[1] Rather than repeating that work here, I situate this volume against traditional philosophy of science only by showing briefly how his concern with science begins with a tension in his thinking between realism and idealism. On the second issue, I show here only how Heidegger's thinking concerning *Ge-stell* arises directly from his prior thinking about basic concepts and the mathematical in science. The issues of ecophenomenology and the social obligations of the sciences are continuations of fertile and promising lines of thinking Heidegger opened. Thus, reading Heidegger on science brings one to these issues, and I have addressed them in the final chapter of this volume by developing Heidegger's thinking in contemporary contexts.

Heidegger's critique of science thus speaks to diverse audiences, and prompts a rethinking of the relation between human being and nature that has epistemological, ontological, and political consequences not only in philosophy but also for policy and practice. Before detailing these aspects of his analysis, however, preliminary qualifications of what he means by "*Wissenschaft*" and "modern" are called for.[2] Furthermore, concern that his analysis might be outdated, and dismissal of his critique on the basis that he is simply "anti-science," warrant response, lest the value and significance of his interrogation of science be prematurely forfeited.

"SCIENCE," "MODERN," AND CRITIQUING HEIDEGGER'S UNDERSTANDING

The word "science" can be difficult to pin down in both Heidegger's work and other discourses. The sciences simply do not unify easily. A totalizing conception of even natural science is inherently problematic, given diversity of method. For example, although mathematical physics is primarily a theoretical inquiry that collects empirical data through experiment in order to test and support hypotheses, geology and biology are both field sciences that use observation not only to establish evidence but also to generate research directives. Disciplinary tags like "political science" and the "social sciences" further complicate what "science" means. These disciplines are not scientific in the sense of using experimental methods, yet they can broadly be taken as scientific insofar as their research methods entail standards of rigor, and their evidentiary strategies rely on quantification. Nonetheless, to ignore the role and value of qualitative methods in the political and social sciences is to construe them reductively and fail to conceptualize their practices appropriately. Naming these disciplines "sciences" may serve little other purpose than establishing their validity on a par with the natural sciences that set definitive and paradigmatic epistemic standards in modernity.

The German distinction between *Naturwissenschaften* and *Geisteswissenschaften* is likewise not without difficulties. The term "*Geisteswissenschaften*" was coined in 1849 in reference to Mill's "moral sciences," which require methods of understanding significantly different from those of the natural sciences.[3] The "sciences of spirit," to translate the term literally, are directed at cultural projects like art, religion, and politics, and include disciplines like history, archaeology, languages and education, as well as philosophy,[4] and theology and jurisprudence have also come to fall under this disciplinary rubric. Consistent with the Cartesian separation between *res cogitantes* and *res extensae*, it may seem that *Geisteswissenschaften* deal with the nonphysical or mental and psychical, while *Naturwissenschaften* treat the physical. Yet since human being has both mental and physical aspects, human self-understanding needs both approaches. Indeed, psychology can be classified as both, so the separation between "natural" and "moral" sciences is not always exclusive. Alternately, mathematics is strictly neither. Heidegger himself most often uses "*Wissenschaft*" throughout his writing in reference to physics, but also to biology in the late 1920s. In other places, he refers to theology, philology, archaeology, art history, and history as *Wissenschaften*.[5] He is moreover well known for his argument in *Basic Problems of Phenomenology* that philosophy itself is inherently scientific, such that the expression "scientific philosophy" is a pleonasm. (GA 24, 15–19/11–15) Thus, it appears that Heidegger intends by "*Wissenschaft*" radically diverse realms of human enquiry and knowledge at different points in the development of his thinking.

Nonetheless, Heidegger is focally concerned with physics, and physics is typically what he intends by "science," especially "modern science." This preoccupation may have been intensified by the central role *physis* plays in his reading of the Greeks, and by the particular influence of Aristotle, whose *Physics* B.1 he examines in close detail in 1939. Alternately, these interpretive enquiries might in fact themselves have been prompted by his already explicit interest in science. As early as 1917, he uses Galileo to show that knowledge in modernity begins methodologically with projection of concepts rather than empirical observation. In *Being and Time*, when he makes the return in §69 to the question of phenomenological method promised in §7, the mathematical projection of nature is the focus of analysis. The 1917 essay and the treatment of Galileo and Newton in *Die Frage nach dem Ding* bookend the discussion in *Being and Time* with such similar language and analysis that his insights in 1927 are unlikely to have been directed at anything other than physics—modern physics is the enactment and origin of the mathematical projection of nature. That "science" means for him not exclusively but first and foremost physics indicates not a commitment to reductionism, in which all natural sciences are taken to boil down to physics, but his insight that the conceptual framework Galileo and Newton bring to bear on nature is determinative of modern ontology and epistemology.

His engagement with science may accordingly seem outdated, given recent moves to displace the paradigmatic function of physics in favor of alternative conceptual models.[6] The role of the ontology and epistemology of physics in determining the modern lifeworld should not, however, be underestimated. Much development policy is, for example, informed by conceptions of objectivity implemented by early modern physicists and still pervasive. Development theorists have long argued for "appropriate technologies," over and against noncontext-sensitive initiatives introduced on the assumption that the universality of knowledge allows its applications to function effectively independent of cultural, and in other ways particular, situation. The latter approach has exacerbated problems with respect both to sustainability and social justice. Likewise, feminist theorists do not support scientific methods that produce different results depending on serendipitous factors like personal bias, but nonetheless argue that science is not a value-free enterprise.[7] The physicist's ideal of objectivity has exceeded its context in scientific knowledge production, and been imported into policy and practice in nonconstructive ways. Heidegger's view of science is consistent with these criticisms, and he argues moreover, as detailed below, that the notion of objectivity impedes analysis of the ways in which science itself is a situated project. The separation between science and ethical obligation that arises in consequence of the ideology of objectivity has historically supported racist, sexist, imperialist, and unsustainable attitudes and practices.[8] Heidegger's lifelong critique remains significant and timely because his insight that the ontology and epistemology of physics inform the modern experience leads him to question the value of both the mathematical projection of nature and the epistemological ideal of objectivity in his ongoing critique of representational thinking.

The meaning of "modern" in the phrase "modern science" is also slippery. Co-teaching with Shimon Malin, a physicist at Colgate University, I quickly realized that we were using the term quite differently. He meant twentieth-century physics. Philosophical analyses of "modern science" generally intend rather Galilean-Newtonian physics, as "modern philosophy" likewise begins with Descartes. Philosophically speaking, modernity starts in the mid-seventeenth century. Because this is also true for Heidegger, a second reason emerges for thinking that perhaps his analysis is outdated. Several developments in twentieth-century physics challenge assumptions basic to Galilean–Newtonian physics, and accordingly many scientists and science analysts take the so-called "new" physics to be fundamentally different.

For example, the Newtonian universe is fundamentally deterministic, but chaos theory suggests that some events or processes are nondeterministic. One such process is radioactive decay: The decay of a single particle cannot be predicted, despite half-life calculations. Similarly, a pendulum hung from a bar that is pushed back and forth along one axis by a motor will suddenly leave that axis of swing and move erratically; the moment at which it will do so cannot be predicted in advance. Chaos theorists claim that such unpredictability is not epistemological, that is, the consequence of insufficient data concerning the system's initial state, but inheres ontologically in the system. Likewise, experiments testing Bell's inequalities in quantum physics challenge Newton's deterministic model by demonstrating that correlations in particle spin exceed the predictions of statistical probability. There is much debate about how to interpret these results. One suggestion is that local causality is breached, that is, contrary to special relativity, information has traveled faster than the speed of light; others argue that some hidden variable is at work. Furthermore, quantum theory has proven difficult to reconcile with gravitational theory. The fundamental forces operating in the universe, that is, gravity and the forces holding atomic particles together, are not yet understood in relation to each other. String theory potentially resolves this problem, despite disputed details, competing variations, and controversy concerning its status as a theory.[9] Supersymmetry also offers hope for reconciling at least three of the four fundamental forces, but falls prey to the so-called "hierarchy problem" in which its predictions exceed empirical indicators. Although human understanding of the cosmos is by no means complete, chaos, quantum, and string theory, as well as supersymmetry, are significant developments in the human understanding of the physical universe. They all converge on one point: Newtonian physics is not the last word on the nature of the universe.

Heidegger says nothing about chaos and string theory. Concerning quantum theory, Father Richardson argues that Heidegger's conception is inadequate because he never acknowledges its radical break with the Galilean–Newtonian paradigm.[10] Yet, as Kockelmans notes, "Heidegger had a remarkable knowledge of both physics and biology and . . . was able to conduct a penetrating discussion on important topics with leading scientists."[11] Heidegger does in fact see significant differences between Newtonian and quantum physics, e.g. the latter's reliance on statistical mechanics (VA, 56–7/172–3), but clearly believes that they are *essentially* the same: in both, "nature has in advance to set itself in place for the entrapping securing that science, as theory, accomplishes." (VA, 57/172–3) Physics projects an interpretive framework in which nature appears as "a coherence of forces calculable in advance." (VA, 25/21) This is just as much the case for quantum theory as for Newtonian physics, and indeed a central issue in string theory and supersymmentry is precisely to establish the coherence of fundamental forces. Furthermore, he argues that what is distinctive of modern physics is that it is mathematical, (FD, 50/271, *et passim*) and indeed, like quantum theory, neither chaos nor string theory nor supersymmetry can "renounce this one thing: that nature reports itself in some way or other that is identifiable through calculation and that it remains orderable as a system of information" (VA, 25/23). Chaos theory only became practicable when computer systems achieved adequacy for its massive calculations, and the mathematics of string theory entails extra dimensions for which empirical evidence continues to be evasive. Contemporary physics is very much a case of mathematics preceding physical interpretation. The idea that the universe "is written in the language of mathematics" is as old as the Pythagoreans, and made definitive for modern physics by Galileo.[12] None of the new physics of the twentieth century challenges this mathematical projection. If Heidegger is right 1) that "modern physics is the herald of Enframing" (VA, 25/22) insofar as "nature . . . is identifiable through calculation and . . . remains orderable as a system of information" (VA, 26/23); 2) that Enframing is the essence of technology as the "gathering [that] concentrates man upon ordering the real as standing-reserve [Bestand]" (VA, 23/19); and 3) that technology enacts "the organized global conquest of the earth" (GA 6.2, 358/248), then his alleged failure to account for the new physics is no basis for rejecting his views as outdated and inadequate. Rather, his critique stands as an urgent challenge to the contemporary scientific establishment to think through how science is complicit in its ideology and method with global environmental destruction.

One final reason for questioning the validity of his analysis needs response. Heidegger is not opposed to science *per se* insofar as he does not reject the human project of understanding nature. The most well-known basis for dismissing him as simply "anti-science" is the claim he makes repeatedly in *Was Heisst Denken?* that "science does not think" (WD, 4/8, *et passim*). But he also says often in this text that "most thought-provoking of all is that we are still not thinking" (WD, 2/4, *et passim*). His objection is not so much to science as to scientism, that is, the preclusion of other ways of thinking by the representational thinking of the sciences, and the marginalization, displacement, and devaluation of other methodologies and bodies of knowledge by the scientific standard of objectivity that has become epistemologically dominant in modernity. He argues the latter point originally in the mid-1930s. In §76 of the *Beiträge*, he observes that scientific ways of thinking have permeated other disciplines, and he distinguishes historical science (i.e., the journalistic collecting of facts) from the discipline of history, which takes an interpretive stance toward facts and endows them with meaning. Of course one always has an interpretive basis for what counts as a fact to be collected, but the point is that a scientistic view of history, in claiming objectivity, denies its perspectival stance. If history and philosophy are infected by scientism, then the possibility of critically understanding the place of science in modern thought is precluded (GA 65, 151–5/104–5). In other words, if the sciences allegedly uncover truths that are universal and thus ahistorical, and the discipline of history itself becomes scientific, then such history cannot uncover the historical significance of the sciences—that they are not contingent but rather a human destiny (i.e., a situated realization of the urge to know that determines what it means to be human in modernity). The sciences therefore are not intrinsically or inherently destructive for Heidegger. Rather, it is uncritical acceptance of their role and function in determining modernity that is threatening. They are an historical project, and as such, their ontology and epistemology warrant delimitation. In "Science and Reflection" he thus calls for critical interrogation and evaluative assessment of the sciences, much as he argues for poetic assessment of technology in the technology essay.

Having given some account that what Heidegger means by "science" is primarily natural science and paradigmatically physics despite the complexities of the term, and having responded to criticisms that his view is outdated, or that he can be dismissed as simply "anti-science," I can now proceed directly to the positive account of why to read Heidegger on science. I first argue that his phenomenological approach is useful to the philosopher of science working in the Anglo-American tradition insofar as it uncovers how the realist and antirealist are working at cross-purposes. Second, I show the significance of his reading of the history of physics for technology theorists whose efforts are informed by his questioning of technology. The third reason (that he makes rich conceptual resources available to environmental philosophers, especially those working at the intersection of environment and international development), and the fourth (that his arguments for reflection on science call for a renewed sense of the social obligations of the sciences) are treated in the final chapter in this volume.

REALISM AND IDEALISM

Heidegger's engagement with science arises in large part out of a tension in his thinking. He begins his career with a thorough commitment to realism. In 1912, he came out strongly with what is now called instrumental realism in "Das Realitätsproblem in der modernen Philosophie." He argues that the "healthy realism [*gesunden Realismus*]" of empirical, natural science has produced such "dazzling results [*glänzenden Erfolge*]" that science stands as an "irrefutable, epoch-making fact [*unabweisbare, epochemachende Tatbestand*]" (GA 1, 3–4). He poses a problem for philosophers: Although philosophy since Berkeley has moved toward the claim that "even the mere positing of an external world independent of consciousness is inadmissible and impossible" (GA 1, 3), the sciences are convinced that their analysis goes beyond sense data to objects that exist independently of research. Scientific methodology entails an ontological commitment ("background realism" in traditional, analytic philosophy of science) by which only philosophers are troubled. Thus in *Being and Time*, Heidegger calls philosophical demands for proof of realism scandalous.[13] The task of the sciences is to explain experience, and in his analysis, they do what is referred to in traditional philosophy of science as "saving the phenomena": They take their objects at face value empirically. Dasein is not an isolated subject that must secure access to an equally independent object. Rather, being-in-the-world is Dasein's "basic state" (SZ, 52/78), such that Dasein is already submerged amongst objects in its practices, including science, and need not worry how to bridge the gap between subject and object (cf. SZ, 60/87). Heidegger does not attempt to establish a correspondence between ideas and what they represent, but extends a praxical assumption of the quotidian (i.e., background realism) into the sciences. For they do not arise *ex nihilo*, but from the lifeworld. The early Heidegger is, then, a naive realist.

At the same time, however, *Being and Time*'s existential analytic is a renewed inquiry into transcendental subjectivity in response to the Kantian insight that experience is structured by categories of understanding. Dasein interprets its world on the basis of already determined structures of understanding (SZ, 151/191). Heidegger's realism is thus in conflict with his acknowledgment of the *a priori* nature of understanding: Access to reality cannot be had independent of structures of mind. How can the sciences describe and explain objects experienced as independently constituted, if understanding is projective? This question is answered by the ontological difference (i.e., the difference between being and beings: "The being of entities 'is' not itself an entity").[14] In *Being and Time*, "entities *are*, quite independently of the experience by which they are disclosed," yet "Being 'is' only in the understanding" (SZ, 183/228). Similarly, in *The Metaphysical Foundations of Logic*, "the cosmos can be without humans inhabiting the earth, and the cosmos was long before humans ever existed" (GA 26, 216/169), yet "there is being only insofar as Dasein exists."[15] Beings exist without Dasein, but being does not. Being confers not ontological status, but intelligibility. Accordingly, Heidegger does not take the objects of science to be mere theoretical constructs, yet by the late 1920s his realism is no longer naïve: Although the entities described by science do not depend ontologically on human knowing, there is no access to them outside an interpretive framework. Thus he holds the realist thesis that scientific objects exist independently of human consciousness, but also the antirealist thesis that objects outside human consciousness are unintelligible. Things in the scientist's world may therefore turn out to be fictitious (e.g., phlogiston or caloric), but the hermeneutic nature of scientific understanding does not imply global error of the kind threatened by Descartes' evil genius or the film *The Matrix*.

Accordingly, Heidegger looks like an internal realist, that is, an antirealist who accepts the reality of objects within conceptual schemes on the basis that representations constitute the real. This is, however, idealism. Heidegger is not committed to the thesis shared by the idealist and the internal realist that *a priori* structures of understanding *constitute* the real. therefore, he can agree with the analytic philosopher of science that scientists must return to the phenomenon for final arbitration of a theory's success, for theories can be more or less hermeneutically violent and should be open to revision. Both he and the traditional philosopher of science are working under Kantian insight into transcendental subjectivity. But Heidegger is also writing out of the German tradition of phenomenology, and against its idealism. Thus, his analysis shows that the realist and the antirealist are at cross-purposes insofar as the latter's thesis is epistemological, while the former's is ontological. The antirealist need not be an idealist: Acknowledgment of the hermeneutic nature of scientific inquiry can be coupled with a commitment to the transcendent reality of the objects of science. The fact that the objects of science do not reduce ontologically to the conceptual scheme in which they figure does not mean it makes sense or is useful to talk about them as independent of any conceptual scheme.

THE QUESTION CONCERNING TECHNOLOGY

The question of science is further significant for Heidegger because therein begins his critique of technology. In 1917, he tells a reductive yet insightful story about the history of science in which he contrasts Aristotle's method for studying *ta physika* against Galileo's approach to the problem of freefall:

> The old contemplation of nature would have proceeded with the problem of fall such that it would have tried through observation of individual cases of falling phenomena to bring out what was now common in all cases, in order . . . to draw conclusions about the essence of falling. Galileo does not start with the observation of individual falling phenomena, but on the contrary with a general assumption (an hypothesis) which goes: bodies fall—robbed of their support—so that their velocity increases proportional to time ($v = g \cdot t$), that is, bodies fall in uniformly accelerated motion. (GA 1, 419)

Whereas Aristotle makes generalizations on the basis of observation, Galileo hypothesizes a universal law and then seeks its experimental validation. Modern science is thus axiomatic—it begins with axioms, which (Heidegger notes twenty years later) Newton also calls "laws," of motion (FD, 71–2/291–2). Heidegger does not fully assess the consequences of this methodological difference between ancient and modern science until his 1939 lectures on Aristotle's *Physics*.

In these lectures, Heidegger points to Aristotle's definition of *ta physei onta*: "they have within themselves a principle of movement (or change) and rest."[16] Artifacts have no such internal principle of motion, except insofar as they are made from some natural material that retains its principle of movement; for example, as Antiphon points out, if one planted a wooden bed, and anything grew, it would be wood, not a bed. Definitive of artifacts for Aristotle is their formal conception in the mind of the artist prior to production.[17] That is to say, artifacts, unlike natural entities, have their origin and developmental principle not in themselves, but in the artist. Hence Galileo and Newton dispense methodologically with the Aristotelian distinction between two separate kinds of knowledge, production (*techne*) and the study of nature (*physis*), when they begin their physics with hypotheses, i.e., ideas in the mind of the physicist. Herein lies incipient Heidegger's later claim that "Modern science is grounded in the essence of technology,"[18] expressed in 1976 in the form of a question: "Is modern natural science the foundation of modern technology—as is supposed—or is it . . . already the basic form of technological thinking?"[19] In light of the 1917 text and the 1939 treatment of Aristotle's *Physics*, his answer to this question cannot but be the latter: modern science is already the basic form of technological thinking.

In the technology essay, Heidegger names the "basic form of technological thinking" "*Ge-stell*." "*Ge-stell*" is a development of what begins in *Being and Time* as "basic concepts" but is already complicated in that text by analysis of the transition from *Zuhandenheit* and *Vorhandenheit*. He subsequently names this concept "the mathematical" in *Die Frage nach dem Ding*. Understanding this central moment in the technology essay therefore requires understanding the development of his on-going assessment of science. What Heidegger intends by "basic concepts" in *Being and Time* is explicit in *The Basic Problems of Phenomenology*: Basic concepts define regional ontologies by representing the object of a specialized science. They delimit, for example, "the 'world' of the mathematician" by signifying "the realm of the possible objects of mathematics" (SZ, 64–5/93). This is the sense in which sciences are positive: They "have as their theme some being or beings . . . posited by them in advance" (GA 24, 17/13). Biology, for example, begins with an understanding of what life (*bios*) is, whereas zoology takes as its starting point an *a priori* conception of the animal (*zoon*). Common ground exists here between Heidegger's analysis and Kuhn's account of paradigm shifts in 1962, insofar as Heidegger argues in 1927 that a crises occurs in a science when its basic concepts undergo revision.[20] Yet in *Being and Time* already, what a science projects to make theoretical enquiry possible goes beyond mere delimitation of its subject area. In the move from everyday dealings to the theoretical attitude, the understanding of being changes over from readiness-to-hand (*Zuhandenheit*) to presence-at-hand (*Vorhandenheit*). Analysis of the basic concepts of the theoretical attitude uncovers much more than a science's subject area here: it shows "the clues of its methods, the structure of its way of conceiving things, the possibility of truth and certainty which belongs to it, the ways in which things get grounded or proved, the mode in which it is binding for us, and the way it is communicated" (SZ, 362–3/414). Basic concepts thus do much more than simply posit the object-area of a specialized science. They provide an interpretation of being that defines the metaphysics, epistemology and methodology of the theoretical attitude. Thus they determine a human orientation toward beings that can extend far beyond any particular, specialized science.

In *Die Frage nach dem Ding*, Heidegger revisits this issue of what is posited a priori in science through analysis of "the mathematical." In identifying "the mathematical" as the definitive aspect of modern science, he does not just mean that science uses calculation. Rather, he argues that "*ta mathemata*" meant for the Greeks "what we already know [things] to be in advance, the body as bodily, the plant-like of the plant, the animal-like of the animal, the thingness of the thing, and so on" (FD, 56/251). The mathematical is what is brought to enquiry by the understanding. It is the "the fundamental presupposition of the knowledge of things" (FD, 58/254). Like basic concepts in *Being and Time*, the mathematical is not just metaphysical, but also epistemological insofar as it establishes the nature of knowledge. The "fundamental presupposition" of modern science is that the sciences have their foundation not in their object but in reason. When Descartes grounds knowledge in the self-certainty of the *ego cogito*, he establishes representational thinking as the ground of objectivity. Thus Descartes validates philosophically the Galilean–Newtonian method of beginning with rational hypotheses on the basis of which evidence-providing experiments can be devised. Accordingly, *Ge-stell*, representational thinking (which in the case of the essence of technology takes all beings in advance as standing-reserve), is at work at the heart of modern science, which determines the real a priori as what can be represented as object. Hence modern science is already inherently technological insofar as it functions on the basis of representational thinking, but the reduction of the real to standing-reserve can only happen because the real is already reduced to the representational object. Further analysis of objectivity makes this clearer.

Objectivity is the certainty that knowledge is impartial and disinterested, that is, that one has not committed error as Descartes characterizes it in the fourth of his *Meditations*: a libidinal economy in which will exceeds understanding. To avoid such error is to know how things are, rather than how one wants them to be. Thus, science appears to describe "the way the world is," rather than providing perspectival and situated analysis. Accordingly, technology, if it is understood as nothing more than applied science, that is, the ordering by instrumental reason of nature uncovered impartially by theoretical reason, "threatens to sweep man into ordering as the supposed single way of revealing [*Entbergung*]" (VA, 36/32), and thereby precludes other ways of understanding. Modern physics may precede technology by a couple of centuries, but it prepares the way for technology because it already has the essence of technology, *Ge-stell*, at its heart (VA, 25–6/21–2) insofar as it founds knowledge on the certainty of subjective representation (i.e., objectivity). Scientific objectivity thus prepares the way for the essence of technology to hold sway. That is, science and technology each begin with an a priori projection of a concept of nature, much as ancient *technê* began with an idea of the thing to be produced. Modern science conceives *ta physika* as objects, that is, spatiotemporally extended bodies subject to "a coherence of forces calculable in advance" (VA, 25/21). Technology brings to nature an a priori conception of *Bestand* in which nature is revealed as resource (i.e., as a source of energy that can be stockpiled.) Modern physics is "the herald of Enframing" (VA, 25/22) because objectivity already contains a commitment to nature's quantifiability that plays out in technology as its economic reckonability. Accordingly, analysis of "basic concepts" and "the mathematical" are formative for Heidegger's later position on "*Ge-stell*."

Science and technology are thus for Heidegger both truths, that is, ways of revealing in which beings are uncovered by human understanding. To read Heidegger on technology without coming to terms with his analysis of science is therefore to work with a deficient theoretical framework. For his critique of technology arises in consequence of his analysis of the history of science: it is in his ongoing treatment of science as the mathematical projection of nature that his conception of *Ge-stell* has its origin. Nor can his account of the historical emergence of modern technology, only hinted at in the discussion of the relation between science and technology in the technology essay, be understood apart from his long-standing critique of the modern scientific mathematization of nature. Scholars who do not follow this path in the development of his thinking risk falling into the postmodern trap of nihilistic technics, that is, the play of empty forms. Derrida, for example, uses the metaphor of the bottomless chessboard to express the infinite possibility of interpretations.[21] For Heidegger, the chessboard is not bottomless. In the case of neither science nor technology is human being thrown into an abyss of nothingness. Heidegger began his *Antrittsrede* in 1929 with the nothing beyond beings that is rejected by science, and he developed that beginning into his concluding question, "Why are there beings at all, and why not rather nothing?" (GA 9, 122/110). In both science and technology, human being is thrown against the plethora of nature. His subsequent analyses of science and technology suggest that there is something beyond both that is reducible to neither: nature. Science and technology are ways of revealing that project an interpretation (an "as-structure") onto nature: Natural entities are interpreted first and foremost as object for science, and as resource for technology. These projections are deeply and historically related insofar as modern technology is possible because its essence, *Ge-stell*, is *already at work* in modern science. It is the mathematical projection of objectivity onto nature in science that heralds the subsequent technological projection of reckonable resource. Science and technology are deeply complicit and inseparable ways of understanding nature for Heidegger, and he believes other ways are possible that do not set upon nature in such over-whelming assault.

NOTES

1. Trish Glazebrook, *Heidegger's Philosophy of Science* (New York: Fordham University Press, 2000); "Heidegger and Scientific Realism," *Continental Philosophy Review* 34, no. 4 (December 2001), 361–401; and "From *physis* to nature, *technê* to technology: Heidegger on Aristotle, Galileo and Newton" *The Southern Journal of Philosophy* 38, no. 1 (2000), 95–118.

2. For a discussion of the German "Wissenschaft" in distinction to the English word "science," see Babette Babich, "Nietzsche's Critique of Scientific Reason and Scientific Culture: On 'Science as a Problem' and 'Nature as Chaos,'" in Gregory M. Moore and Thomas Brobjer, eds. *Nietzsche and Science* (Aldershot: Ashgate, 2004), 133–53.

3. Gadamer notes that the word was made popular by translator's of Mill's *Logic* (H-G. Gadamer, *Truth and Method*, tr. J. Weisenheimer and D. G. Marshall, New York: Continuum, 2000, 3). Cf. the discussion in Wikipedia available online at http://de.wikipedia.org/wiki/Geisteswissenschaft, and *Deutsches Wörterbuch* von Jacob Grimm und Wilhelm Grimm (Leipzig: S. Hirzel, 1971) available online at http://www.woerterbuchnetz.de/woerterbuecher/dwb/wbgui?lemid=GG05820.

4. Cf. Mill *A System of Logic* (London: Longmans, Green and Co., 1900), 554: "moral sciences" are the sciences of the thoughts, feelings, and actions of human beings, including the study of the laws of mind, human nature, society, political economy, and history.

5. Cf. esp. GA 25, 25; GA 65, 142/99 and §76.

6. One such conceptual model comes from biology; cf. Rupert Sheldrake, "The Laws of Nature as Habits," *The Reenchantment of Science*, ed. David Ray Griffin (New York: State University of New York Press, 1988). Another, perhaps less promising, from geology; cf. Frodeman's "Preface" in *Earth Matters: the Earth Sciences, Philosophy, and the Claims of Community*, ed. Robert Frodeman (Upper Saddle River, NJ: Prentice-Hall, 2000), vii–xiii, as well as Victor Baker, "Conversing with the Earth: The Geological Approach to Understanding," and Christine Turner, "Messages in Stone: Field Geology in the American West," in this anthology.

7. On the gender politics of objectivity, see Sandra Harding, *Whose Science? Whose Knowledge?* (Ithaca, NY: Cornell University Press, 1991) and *Is Science Multicultural? Postcolonialisms, Feminisms, and Epistemologies* (Bloomington: Indiana University Press, 1998), and Nancy Tuana, ed., *Feminism and Science* (Bloomington: Indiana University Press, 1989).

8. On imperialism and racism, see Trish Glazebrook, "Global Technology and the Promise of Control," *Globalization, Technology and Philosophy*, eds. David Tabachnik and Toivo Koivukoski (Albany: State University of New York Press, 2004), 143–58. On sustainability, see Trish Glazebrook, "Art or Nature? Aristotle, Restoration Ecology, and Flowforms," *Ethics and the Environment* 8, no. 1 (2003), 22–36, and "Gynocentric Eco-Logics," *Ethics and the Environment* 10, no. 2 (2005), Special Issue, ed. Christopher Preston, 75–99.

9. David Gross, who received a Nobel prize for his work on strong nuclear forces and has been a strong advocate of string theory, in his closing remarks at the twenty-third Solvay Conference in Physics in Brussels in December 2005, suggested that something absolutely fundamental and profound is still missing from string theory. Leonard Susskind, who invented it, still defends it against multiple criticisms (see his interview in *New Scientist* 2530, December 17, 2005, 48–50; cf. the letter from Michael Duff 2533, January 7, 2006, 16).

10. This paper is included below, so I do not detail his arguments here. I have responded directly to his criticism in Glazebrook, *Heidegger's Philosophy of Science*, 247–51.

11. Joseph Kockelmans, *Heidegger and Science* (Lanham, MD: University Press of America, 1985), 17.

12. *Discoveries and Opinions of Galileo*, tr. Stillman Drake (London: Anchor Books, 1957), 238.

13. SZ, 205/249. His view warrants comparison with Fine's "Natural Ontological Attitude," or what is called "background realism" in traditional philosophy of science. Cf. Glazebrook (2001), 376–382.

14. SZ, 6/26. Cf. John Haugeland, "Truth and Finitude: Heidegger's Transcendental Existentialism," *Heidegger, Authenticity, and Modernity*, eds. Mark A. Wrathall and Jeff Malpas (Cambridge, MA: MIT Press, 2000), 43–77: 47.

15. GA 26, 195/153. I have modified the translation to render it more consistent with Heidegger's phrase "es gibt."

16. *Physics, Books I–IV*, trs. P. H. Wicksteed and F. M. Cornford (Cambridge, MA: Harvard University Press, 1929), 192b8–11; GA 9, 247–8/228.

17. *Parts of Animals*, tr. D'Arcy Wentworth Thompson, *The Basic Works of Aristotle*, ed. Richard McKeon (New York: Random House, 1941), 640a32; cf. *Nicomachean Ethics* tr. H. Rackham (Cambridge, MA: Harvard University Press, 1934), 1140a13.

18. WD, 155/135. I have modified the translation since translating "*Wesen*" as "nature" obscures my point. "Essence" is commonly used to translate Heidegger's "Wesen."

19. Martin Heidegger, "Neuzeitliche Naturwissenschaft und Moderne Technik," tr. John Sallis, *Research in Phenomenology*, 7 (1977), 1–4: 3.

20. Thomas Kuhn, *The Structure of Scientific Revolutions* (Chicago: University of Chicago Press, 1962); cf. SZ 9/29.

21. Jacques Derrida. "Différance," *Margins of Philosophy*, tr. Alan Bass (Chicago: University of Chicago Press, 1982), 3–27.