

Hermeneutics and the natural sciences: Introduction

ROBERT P. CREASE

Department of Philosophy, SUNY, Stony Brook, USA

One of the oddest quirks of the development of 20th century Continental thought has been its default of the investigation of the natural sciences.

It is true that scientific literature strives to adopt the pose of an objective speaker in a way that seemingly denies a foothold for a philosophy that grants priority to lived experience. Analytic philosophy of science took this guise at face value, and developed at the expense of the incorporation of elements of culture and history. Analytic philosophers of science viewed their job as formalizing the methods of natural science, directing their interests away from the process of discovery and other areas in which social, cultural, and personal factors can become decisive. Yet scientific knowledge, like all knowledge, involves a disclosure (saying) of something to somebody. It deals with meanings that are social entities, embodied in language, altered or fulfilled in experience, and passed on in laboratory praxes and scientific literature and culture. It is tempting, yet an error, to take such meanings as ahistorical forms or “natural kinds” that have a transcendent or, perhaps, transcendental origin. On the other hand, it would equally be an error to claim that the results of science are arbitrary or mere artifacts of discourse; science has a historical space, or “here and now,” with its own reference to an (historical) authenticating judge and witness. Hermeneutical philosophy supplies the philosophical foundation for reintroducing history and culture into the philosophy of the natural sciences.

Early phenomenologists were keenly aware of the role that hermeneutical philosophy could play in understanding science. Husserl had a deep appreciation for mathematics and natural science; as Patrick A. Heelan among others have stressed, Husserl’s objection was not to science itself, but to the Galilean assumption that the ontology of nature could be provided by mathematics alone, bypassing the life-world.¹ That is why Heidegger, in *Being and Time*, insists on calling theoretical knowledge a founded mode of Being-in-the-world, to be interpreted not merely as an aid to disclosure but as a special and specialized mode of access to the real itself. For both Husserl and Heidegger, this Galilean development was not merely a disciplinary matter, but one manifestation of a historical crisis which they attributed to the hegemonic

[1]

role of theory in the arbitration of meaning, the effacement of the role of the embodied human subjects in the constitution of knowledge, and the implicit assumption, characteristic of modernity, that the natural sciences provides the privileged model for human inquiry. Given the vast cultural influence of modern science, therefore, one would expect that the systematic exploration of the nature, practice, and effects of the natural sciences would be a major thrust of contemporary Continental thinking.

This did not occur, for reasons that are also largely historical. Hermeneutics, originating in the interpretation of sacred texts and historical sources, rooted in the humanities, and devoted to the interpretation of texts and cultural sources, developed for a long time without reference to the explanatory dimension of natural science; positivist philosophy, meanwhile, held the natural sciences aloof from other human endeavors as embodying a superior form of rationality. Even when, at the hands of Heidegger and Gadamer, hermeneutics was shown to be involved not only in fields like art, law, history, and literature, but in the entire scope of human engagement with the world, hermeneutically trained philosophers reacted to the hegemony of positivism by saying to the natural scientists and to their philosophical defenders, “Hands off the human sciences!” – thereby implicitly sanctioning the positivist self-portrait of the natural sciences. In his paper below, Don Ihde characterizes the situation as the “H/P [hermeneutic-positivist] binary,” in which each pole seemed to cede territory to the other, although the hermeneutical pole was reactive. Hermeneutical-phenomenological thinkers who followed Husserl and Heidegger tended to interpret natural science *as* the search for theory, and therefore as abstract and derivative with respect to the life-world. If this were so, Gadamer and others claimed, then there could be no possibility of a hermeneutics of the natural sciences, and indeed a traditional way of characterizing the difference between the human and natural sciences involved whether or not hermeneutical methods were explicitly used or acknowledged. While a number of critical moves have been mounted to explore the positivist pole, of which the outcome has been to undermine its claims to autonomy, insularity, and a privileged form of rationality – made by Thomas Kuhn initially, and then by adherents of the “strong program” of the sociology of science – there has been little attempt to engage the other side of the binary, leaving the hermeneutical pole unexplored as a potential resource. Thus, while exposing weaknesses of the positivist-inspired understanding of science, these weaknesses have not been compensated, as they should, by a deeper appreciation of the full hermeneutical dimensions of the natural sciences.

A few thinkers have opposed the traditional view – most notably Paul Ricoeur, who has been unrelenting in his insistence that hermeneutics is not a method but a philosophy. A few Continentally-trained professional

philosophers with both hermeneutic-phenomenological and scientific backgrounds (such as Heelan, Ihde, Theodore Kisiel, Joseph Kockelmans) have begun to read the work of Heidegger, Merleau-Ponty, Gadamer, and others as also entailing a positive re-evaluation of practices of the natural sciences. A few professional scientists with a scholarly background in hermeneutic-phenomenological philosophy (among whom is Martin Eger) have begun to do the same. A number of more mainstream philosophers of science are utilizing hermeneutical insights effectively and perceptively (Joseph Rouse), while many sociologically-trained scholars who speak with the terminology and often the assumptions of analytic philosophy reveal in their work a deep appreciation for the hermeneutical insight into the nature of historically situated knowledge (Harry Collins, Bruno Latour, Andrew Pickering, Simon Schaffer, Steve Shapin and others influenced by social constructivism). All of these initiatives manifest the rediscovery that all discourse is situated culturally and historically. The days are gone when it could be seriously debated whether a hermeneutical perspective on the natural sciences exists.² The challenge remains today to understand more explicitly the hermeneutical dimension of the natural sciences in terms of an overarching hermeneutic of all knowledge.

The articles in this issue are among those presented at the fourth annual meeting of the International Society for Hermeneutics and Science (ISHS), held in 1996 at the State University of New York at Stony Brook. The ISHS began in 1993 as a European initiative (its first two meetings were in Hungary, the third in the Netherlands) as a by-product of the resurgence of interest in hermeneutic-phenomenological philosophy following the end of the Soviet domination of academic circles in Eastern and Central Europe. The ISHS, composed primarily of European scholars, quickly helped coordinate and focus the interests of a number of U.S. researchers who had been working relatively independently. Its members have found a wide variety of issues in the natural sciences to be clearly and readily amenable to hermeneutical investigation including: How do individuals or groups come to terms with the particular problem situations in which they find themselves by drawing on the available conceptual and practical resources that structure that situation? How does meaning arise out of laboratory situations? What is the phenomenology of scientific perceptual praxis? Papers presented at the first ISHS meetings ranged from general discussions of the nature and development of hermeneutics, applications of hermeneutics to different areas of science, debates about the role of hermeneutics in science, past hermeneutical thinkers about science, and future directions of hermeneutical inquiry into science.³

While it would be incorrect to characterize hermeneutical perspectives on science as constituting a “program,” given the healthy, and predictable,

diversity of such perspectives that has emerged, it is nevertheless possible to point to a constellation of orienting ideas.

A first might be called the *priority of meaning over technique*. Science is wholly mischaracterized as solely consisting of *praxes*, of the application of techniques or calculational methods, because data, results, and laboratory events come into being by interpretation and will be mistakenly described if interpretation is poorly done. This idea, of course, amounts to a critique of positivist and mainstream philosophy of science. For an essential hermeneutical insight is that the generation of meaning, in science as in other human activities, does not proceed solely by moving from part to whole, but by a process in which phenomena are projected upon an already-existing framework of meaning, the assumptions of which are at least partially brought into question, and by this action further reviewed and refined within the ongoing process of interpretation. When one acts interpretively, one can bring to bear on the situation anything that has been historically and culturally transmitted, especially when one chooses to act within an original initiative for the purpose of obtaining a deeper and richer connection with the world. Thus the nature and range of interpretive practices is one subject of hermeneutical research in the sciences.

A second orienting idea might be called the *primacy of the practical over the theoretical*. The framework of meaning in terms of which phenomena are interpreted is not comprised merely of tools, texts, and ideas, but involves a culturally and historically determined engagement with the world which is prior to the subject and object separation. The hermeneutic relationship in the early Heidegger, Kisiel points out, is simply “the understanding familiarity that comes from living bodily with others among things in the world.” Kisiel continues, “The point behind Dasein’s identification with its understanding of being is simply that the hermeneutic/interpretive habit lies at the core of being human. This habit or ethos is primordially present in all of our protopractical engagements that define ‘the way things are’ . . . In the Greek ‘ethical’ terms that hermeneutical philosophers seek to revive, the core of living well, being fully human, being ontologically ‘authentic,’ resides not in the theoretical virtues but in the practical virtues, the ‘art’ (τέχνη) of doing well in the workworld and the ‘fact’ (φρόνησις) of acting well in the polity.”

A third orienting idea might be called the *priority of situation over abstract formalization*. Truth always involves a disclosure of something to someone in a particular cultural and historical context. Even scientific knowledge can never completely transcend these culturally and historically determined involvements, leaving them behind as if scientific knowledge consisted in abstractions viewed from nowhere in particular. The particularity of the phenomena disclosed by science is often covered up by the fact that they can

show themselves in many different cultural and historical contexts provided that the scientific (laboratory) environment is right. This generality can give the illusion of disembodied knowledge. Since scientific work begins with an already existing involvement with, and understanding of, a concrete situation, it never leaves concreteness behind; no understanding ever escapes the hermeneutic circle. In vague, enigmatic, or paradoxical situations, the attainment of meaning is not a transcending or an abstraction from, but a deepening and extension of one's relations with the world. Hermeneutical understanding achieves, not the correction of false ideas, but extension of language reflecting an extension of concept.

The articles selected here, from the most recent meeting of the ISHS and including mainly U.S. researchers, fall into three groups: one set whose focus is on recalling and applying existing resources of hermeneutical phenomenology, one set whose focus is to articulate the distinctiveness of the hermeneutical approach vis-a-vis others (such as mainstream philosophy of science, cultural studies, and social constructivism), and one set which seeks to forge new directions and tools.

In "Why a Hermeneutical Philosophy of the Natural Sciences?" Patrick A. Heelan lays out the general case for a hermeneutical approach to science, in the course of which he shows how the three orienting ideas mentioned above are grounded in the work of the canonical hermeneutical thinkers. One of Heelan's principal contributions to phenomenology, elaborated most extensively in *Space-Perception and the Philosophy of Science*, is his observation that perception is not an automatic act by an independent subject (i.e., free of cultural and determination), but is *hermeneutical* insofar as it is an interpretive act guided by human involvement with the perceived, (i.e., by the world).⁴ Heelan's principal contribution specifically to the phenomenology of science is his observation (which draws on Heidegger's description of Dasein as being-in-the-world and on Merleau-Ponty's analysis of instrumentally mediated experience) that the life-world of contemporary culture already and inevitably involves scientific instruments and scientific *phenomena* which share the same general structure as other life-world phenomena. Heelan's observation not only explains why scientists are "realists in the lab," instinctively treating the phenomena they encounter there as naturalized citizens of the life-world, but rebuts the arguments of those who, stressing the praxical, apparently social constructivist side of science, argue that perceptibility only falls on instruments and not on the theoretically described entities that move them.⁵ For Heelan, theory can neither be viewed as merely instrumental, nor as picturing entities that exist apart from the life-world; theory is "praxis-laden," always connected with equipment that fulfills some cultural function. Even the process of "measurement," far from consisting of mere passive

observation, is only possible within a hermeneutically structured culturally designed activity of preparation, presentation, and fulfillment. “Science and the philosophy of science,” Heelan points out, are prone to forget “the necessary connection of theory to a praxis-laden cultural *explanandum*,” adding that “hermeneutic philosophy is particularly concerned with the dangers of forgetting this nexus.” Forgetting this nexus is the chief obstacle to unravelling a number of key unresolved issues in the philosophy of science, including the mysteries and paradoxes associated with quantum phenomena and theory. Heelan (himself a physicist) has developed this idea more elsewhere; here he devotes some discussion to the Schrödinger Cat Paradox.⁶ A hermeneutical understanding of science, he claims, might also help re-establish a dialogue between the scientific community and its clients, supporters, academic interpreters, and the public at large, the breakdown of which is manifested in a number of contemporary events that include the so-called “science wars.”

Joseph Kockelmans, in “On the Hermeneutic Nature of Modern Natural Science,” focuses more narrowly on a specific arena in which scientific work depends on a pre-existing framework of meaning. Kockelmans is one of the originators of the hermeneutical-phenomenological study of science, and most recently has summed up his work in *Ideas for a Hermeneutic of the Natural Sciences*.⁷ In this paper, he shows how the priority of interpretation over technique is illustrated in the way several key figures in the rise of early modern science each “projected observed phenomena upon frameworks of meaning that were developed totally independently of his own observations.” Kepler’s understanding of Copernicus and of existing astronomical data in terms of a mixture of religious and Pythagorean-Platonic ideas, Galileo’s understanding of his observations in the light of Aristotelian philosophy, and Newton’s reliance on the assumptions of his predecessors all illustrate how, in scientific theorizing, there are always “a number of assumptions or pre-judgments, on the basis of which natural phenomena are interpreted in harmony with what in hermeneutic phenomenology is called the objectifying thematization.” As a result, “all forms of scientific description, explanation, and understanding are sophisticated forms of interpretation,” which entails, in turn, that scientific statements can “state something that is true without ever exhausting the truth about what is.”

An example of applied hermeneutics is “Understanding Sustainability,” Bart Gremmen and Josette Jacobs, of Wageningen Agricultural University in the Netherlands. These authors attempt to show how it might be possible, in situations involving different conceptions of sustainability by different economic sectors, to avoid having to choose between competing and mutually destructive conceptions by applying a Gadamerian-like dialogue that moves between a general and vague concept of sustainability and the local situation.

This kind of conflict resolution is impossible to explain from mainstream perspectives that assume such types of conflict to involve, most importantly, competitors who bring to the table conscious and fully formed principles, thoughts, and belief structures. A hermeneutical approach, by contrast, sees the parties as coming from different existential situations, and as perpetually open to a new understanding of themselves and their situation through dialogue with other parties; to think of them as competitors falsifies the picture from the start. Another interesting feature of this paper is the way it uses a hermeneutical approach to criticize positions that treat ecosystems as social constructions and conflict resolution between competing sectors as negotiations that preclude dialogue: “differend,” in Lyotard’s terms, rather than controversy.

A second set of papers focuses on explicating the difference between hermeneutical approaches to science and other, related, approaches. In “A Hermeneutics of the Natural Sciences? The Debate Updated,” Kisiel points to flaws in the arguments of those who attempt to deny the possibility of such a hermeneutics. Gadamer is one; but citing Hermann von Helmholtz, one of Gadamer’s key sources, Kisiel notes that the rationale for that claim is not as clear as Gadamer would make it out to be. Kisiel next takes up the argument of Gyorgy Markus, who claims, quite dramatically, that “the natural sciences, in practice, seem to be in no need of a hermeneutics;” the “cultural hermeneutics” of science that he then proposes in fact involves a substantial role for a Heideggerian practical hermeneutics. However, as Heelan has convincingly demonstrated, a Heideggerian-style hermeneutics is involved in precisely those areas from which Markus excludes them. Rouse has made two exemplary moves: he has resisted the denaturing of Heideggerian practical hermeneutics in the direction of Quinean theoretical hermeneutics (drawing heavily on Foucault in the process), and he has resisted the attempt to use alleged different roles for hermeneutics as a way of distinguishing between the human and natural sciences (the issue of the “double hermeneutic”). But while Rouse has continued to carry out a hermeneutical perspective on science he has ceased to describe what he is doing with that word – and also with reference to the tradition that goes with it – perhaps seeking a terminology more familiar to mainstream philosophy of science.⁸

In a trio of insightful essays, Martin Eger has suggested that hermeneutical philosophy involves an alternative to and a *critique* of constructivism.⁹ Here, in “Achievements of the Hermeneutic-Phenomenological Approach to Natural Science: A Comparison with Constructivist Sociology,” he makes his argument against the social constructivist position more explicit. Social constructivism involves the view that science can claim to know only the products of human construction and not any reality independent of that process. Social

constructivism is often confused with the program of the social studies of knowledge that aims to highlight the social meanings implicit in science and shape its practice, which to that extent is hermeneutical.¹⁰ What is disturbing about constructivism, says Eger, is the arrogant confidence it displays its product, and he is concerned to expose the shallowness of the position that the results of science are to be identified with mere artifacts of the discourse of its practitioners.¹¹

Eger notes that the key term in the social constructivist arsenal is “negotiation,” understood to mean the process by which individuals with opposing interests settle conflicts by trading off those interests. Quoting Collins, Eger points out that negotiation “is characterized as ‘funneling in’ social interests, turning them into non-scientific negotiating tactics, and using them to ‘manufacture certified knowledge,’” the effect being to lump together “very different kinds of activity under the same rubrick, and label them all ‘social.’” This is a methodological fiction which, however convenient, stands in the way of our recognizing and noticing the rich intricacy of the scientific process; for one thing, it entails “the flat-footed conflation of the production process involved in an experiment [with] the performance of the experiment.” To illustrate, Eger re-examines a favorite case study by Pinch and Collins of an experiment by Brookhaven National Laboratory physicist Raymond Davis in which he first detected the existence of solar neutrinos. In their analysis, the authors classified as “negotiation” both Davis’s search for permission to ask the Atomic Energy Commission for funds to conduct the experiment, and Davis’s incorporation of improvements in his experimental apparatus. “To place the two under the same heading is not just crude,” Eger writes, “it is an inexcusable blurring of the picture and a mystification of science.” For him, the tangle of instruments, practice, and pre-conceptions is addressed by the hermeneutic approach far better than by the expose style of the constructivists.

Don Ihde’s work, especially in *Instrumental Realism*, draws upon traditional phenomenological interests in perception and the body to articulate the materiality of the instrument in the process of producing readable but perceptual objects in the laboratory.¹² In his article, “Thingly Hermeneutics/Technoconstructions,” Ihde further elaborates this work by connecting it with some of Bruno Latour’s insights. “‘Nature’ has been prepared in the laboratory, to show itself as the inscription-visual display which can be ‘read’ through scientifically trained perception.” But while some visual displays have what Ihde calls “a vestigial isomorphic realism” in that they retain a ready reference to a discrete object even if scale varies (X ray to body part, DNA model to acid molecule), other laboratory products involve many complex layers of constructivity. These “technoconstructions,” as he calls them, are neither texts (hence, yielding their meaning to reading alone) nor pictures

(intuitable by sight alone); rather, they are “seen-read” hybrids that combine “perceptual gestalt qualities with inscriptive ‘textual’ qualities through which the scientific result – knowledge – is produced.” Indeed, Ihde points out, the amount of information contained in the display can increase with the level of technoconstruction, illustrating the point with the aid of what he calls “Whole Earth Measurements.” Ihde’s work reveals “a deep hermeneutic epistemology for contemporary science at its very core,” and lays the groundwork for a much more sophisticated appreciation of laboratory experimental practices and especially imaging practices – a superior groundwork than would be achieved by treating “the full gamut of scientists’ representational practices,” in Steve Fuller’s hyperbolic phrase, as “a corrupt realm of privileged objects.”¹³ Ihde’s contribution also contains significant implications for hermeneutics itself, insofar as it helps to liberate hermeneutics from its preoccupation with textuality.

Eugene T. Gendlin’s paper, “The Responsive Order: A New Empiricism,” is not only written in a distinctive style, but actually succeeds in moving some way beyond the particular predicament in which hermeneutics has shown modern philosophy to have become entrapped. The predicament involves having to choose between: on the one hand, the assumption that somewhere in nature lies concealed a fixed, stable order, and on the other hand the view that all order is imposed from the outside, and that any patterns we see in it represent merely an artifact of the forms, conventions, history, traditions, and interests with which it is approached. The faults of the former, which involve the assumption that, say, medieval and Newtonian natural philosophy are upward steps in a progression towards “the truth,” have been thoroughly explored beginning with Kuhn and continuing through the social constructivists. However, to subscribe to the alternate view is to imagine nature as simply a cultural-historical idea, which makes research incapable of accessing anything but human constructions.

Gendlin’s work allows us to begin to develop terms with which to think beyond the double negative involved in denying both alternatives. Many times, Gendlin points out, we encounter a greater kind of order in which we get back from a situation new meanings and effects which did not follow from what we brought to it. As Wittgenstein showed, for instance, the use of a word in an unusual situation can allow it mean something quite precise that nobody ever said before. Gendlin calls this a *responsive order*, by which he means not something we refer to, but are already inside of. By saying that nature has that kind of order he keeps the insight that forms, conventions and interests are always involved in our dealings with nature, without that entailing arbitrariness. What we get back from our dealings is not arbitrary, because nature is really engaged, but differently, by different activities. “Although the

empirical is responsive to, not separable from our procedures and concepts, its roles are independent of them in certain specifiable respects.” In specifying these effects and their implications throughout his paper, Gendlin is working out what he calls a new empiricism, one that is not naive.

As the papers in this issue suggest, the hermeneutical approach explicitly addresses and can help to resolve numerous perplexing issues in the philosophy of science, including the natures and roles of the social dimensions of science, the peculiar status of imaging techniques, and the “mysteries” of quantum mechanics. But as Eger, Heelan, and Ihde say all insist, though in different ways, the working-out of a hermeneutical approach to science has become increasingly urgent. One reason is simply the growing complexity of science, and the need for conceptual tools adequate to the task of understanding things like the integrative changes brought about by advanced computational infrastructure, knowledge networks, and universal information flow, which promise to work important changes on social life. Eger has also noted the importance of addressing again the question of meaning in and of science, to cope with various contemporary crises in science education as well as in the public understanding of science.¹⁴

A hermeneutical perspective on science is essential, too, now that the notion of a book of nature, or sacred structure that organizes and explains the world, has lost its persuasive force. The desire to see science as involving a reference to a deeper truth or field of essences in nature – as well as the reactive move that asserts that there is nothing beyond ourselves and that any description we give of nature is merely an arbitrary projection of our own interests – is hangover from positivism from which the hermeneutical perspective can help rid us. With a hermeneutical perspective, one is not faced with having to choose between postulating a final, hidden truth on the one hand, or calling truth a matter of arbitrary convention on the other.

But for many of these authors, developing a hermeneutical philosophy of science is also essential for the future of hermeneutics itself. For Gendlin, developing the concept of responsive order is crucial to moving beyond a philosophical dead-end in which we have become entrapped. For Ihde, an adequate account of things like technoconstructions helps free hermeneutics from its ability to see meaning only where it sees text. For Heelan, the elements that a hermeneutical approach reintegrates into the philosophy of science are essential “if philosophy is to have a fair chance of fulfilling its role as a universal reflection on natural science and all *Wissenschaft*.”

Less than three years hence, the key figures of the hermeneutical canon (including Heidegger, Wittgenstein, Merleau-Ponty, Ricoeur and Gadamer) will become thinkers of the previous century. These thinkers, it is safe to say, did not sufficiently appreciate the significance of hermeneutics for the natural

sciences. For various reasons, they were uninterested in the philosophy of science *per se*. Some (such as Heidegger) focus on other issues (the Being-question), with science of interest only when and if it includes or helps to elucidate these issues. Others (Gadamer) are interested in science only as a phenomenon to be integrated back into the rest of life. Still others are more interested specifically in the human sciences. None of these figures appear to have realized how obstinately the idea of natural science as a privileged model for human inquiry would sustain itself in spite of all their work. None of these figures appear to have realized how complex and rich the project of contextualizing the natural sciences would turn out to be. And understanding natural science is difficult and time-consuming for outsiders: while Husserl was a mathematician able to speak first-hand about the practice of mathematics, none of the thinkers mentioned was able to speak similarly from experience about the ways in which natural science is a hermeneutical activity. A wide range of topics in the hermeneutics of the natural sciences is therefore open for exploration. Just to mention the one on which I have written, hermeneutics is involved in the process of experimentation, or the staging of an action in order to understand the still enigmatic present. Experiments are first and foremost material events in the world. Events do not produce numbers – they do not measure themselves – but do so only when the action is properly planned, prepared, and witnessed. An experiment therefore has the character of a *performance*, and like all performances must be understood as a historically and culturally situated hermeneutical process.¹⁵ Developing this and other topics offers an opportunity to carry forward the work of the figures of the hermeneutical canon in a way that will make hermeneutical philosophy itself more effective and influential.

Notes

1. For a set of references to Husserl's philosophy of science by Heelan (and others), see Robert P. Crease, *The Play of Nature: Experimentation as Performance* (Bloomington: University of Indiana Press, 1993), p. 191 fn. 12.
2. The last serious exchange in this debate was perhaps Gyorgy Marcus, "Why is There No Hermeneutics of the Natural Sciences? Some Preliminary Theses", *Science in Context* 1987, pp. 5–51, followed by Patrick A. Heelan, "Yes! There is a Hermeneutics of Natural Science: Rejoinder to Marcus," in *Science in Context* 3, 1989, pp. 477–488.
3. The proceedings of the third annual meeting of the ISHS are in: M. Feher, O. Kiss and L. Ropolyi, eds.: *Hermeneutics and Science* (Dordrecht: Kluwer, forthcoming).
4. Patrick A. Heelan, *Space-Perception and the Philosophy of Science* (Berkeley: University of California Press, 1983). I am grateful to Patrick A. Heelan for his comments on this introduction.
5. A more extended discussion of the arguments and counterarguments can be found in Crease, *Play of Nature*.

6. Patrick A. Heelan, “*Hermeneutique de la Science Experimentale: La Mecanique Quantique et les Sciences Sociales*”, in *Hermeneutique: sciences et textes* (Paris: Presses Universitaire de France, 1997); or “Quantum Mechanics and the Social Sciences: After Hermeneutics,” in *Science & Education*, 4 (1995), pp. 127–136.
7. Dordrecht: Kluwer, 1993.
8. See Rouse’s most recent work, *Engaging Science: How to Understand its Practices Philosophically* (Ithaca, NY: Cornell University Press, 1996).
9. “Hermeneutics and Science Education: An Introduction,” *Science and Education* 1 (1992): pp. 337–348; “Hermeneutics as an Approach to Science,” Part I, *Science & Education* 2 (1993): pp. 1–29; Part II, *Science & Education* 2 (1993): pp. 303–328. See also the special issue of that journal devoted to discussions of Eger’s articles: *Science & Education* 4:2 (1995).
10. Such a mistake is often made by detractors of hermeneutics and social constructivism as well; the title of Alan Sokal’s famous hoax/exposé mainly of social constructivist authors writing about science was “Transgressing the Boundaries: Toward a Transformative Hermeneutics of Quantum Gravity,” *Social Text* pp. 46–47 (1996): 217–252. Replies to Sokal are found in Andrew Ross, ed., *Science Wars* (Durham, NC: Duke University Press, 1996, and in Rouse 1996 pp. 9–12; 15–21, 237–259).
11. This is the position that many practitioners of social constructivism often speak, at least, as if they hold. In a work about early modern science, Steven Shapin and Simon Schaffer write that “The objectivity of the experimental matter of fact was an artifact of certain forms of discourse and certain modes of social solidarity;” matters of fact, they claim, are but “conventions” resulting from “negotiations between experimenters” (*Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*, Princeton: Princeton University Press, 1985). Collins and Trevor Pinch write that “Scientists at the research front cannot settle their disagreements through better experimentation, more knowledge, more advanced theories, or clearer thinking” (*The Golem: What Everyone Should Know About Science*, New York: Cambridge University Press, 1993). But while both sets of authors are speaking of the way scientific representations are constituted, they need not necessarily be interpreted as addressing the nature of the scientific object that is so represented, though that is often what they say.
12. Bloomington: Indiana University Press, 1991.
13. Steve Fuller, “Back to Descartes? The Very Idea!” *Social Studies of Science* 19 (1989): 357–360 at p. 358.
14. Eger 1993.
15. Crease 1993.