

*Introduction*  
*The Pluralist Stance*

Stephen H. Kellert, Helen E. Longino, and C. Kenneth Waters

MINNESOTA STUDIES IN THE PHILOSOPHY OF SCIENCE

VOLUME XIX

*Scientific Pluralism*

STEPHEN H. KELLERT, HELEN E. LONGINO,  
AND  
C. KENNETH WATERS, EDITORS

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# SCIENTIFIC PLURALISM



*Stephen H. Kellert,  
Helen E. Longino, and  
C. Kenneth Waters, Editors*

MINNESOTA STUDIES IN THE  
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XIV

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## VOLUME XIX *Scientific Pluralism*

STEPHEN H. KELLERT, HELEN E. LONGINO,  
AND  
C. KENNETH WATERS, EDITORS



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# *Introduction*

## *The Pluralist Stance*

### **Background and Motivation**

In recent years, a number of philosophers as well as some scientists have advanced various forms of pluralism about the theories or methods of science. The general idea is that some natural phenomena cannot be fully explained by a single theory or fully investigated using a single approach. As a consequence, multiple approaches are required for the explanation and investigation of such phenomena. In some cases interest in pluralism is motivated by analysis of particular issues within a science, and in other cases it is motivated by analysis of general philosophical and methodological questions. How pluralism is understood—whether, for instance, it affirms radical ontological or epistemological heterogeneity or merely the diversity of mechanisms in nature—varies from thinker to thinker and topic to topic.

Early discussions of pluralism were usually carried out in the context of debates about the unity of science thesis. In his presidential address to the Philosophy of Science Association in 1978, Patrick Suppes issued a manifesto for pluralism (Suppes 1978). He claimed that the time for defending science against metaphysics (which he took to be the original rationale for the unity of science movement) had passed. A close examination of scientific developments since the heyday of the unity of science movement warranted instead an embrace of pluralism. Suppes argued that neither the languages of scientific disciplines nor their subject matters were reducible to one language and one subject matter. Nor was there any unity of method beyond the trivially obvious such as use of elementary mathematics. With a few notable exceptions, philosophers of science hesitated to take up Suppes's ideas.

Among the exceptions were Nancy Cartwright and her collaborators who explored an alternative vision of the “Unity of Science” offered by the work of Vienna Circle cofounder Otto Neurath, which sees an irreducible variety of scientific disciplines cooperating for concrete purposes (Cat,

Cartwright, and Chang 1996; Cartwright et al. 1996). In his contribution to the present volume, Alan Richardson extends this vein by examining the history of unity/disunity themes. He demonstrates that there is greater flexibility in the older ideas than was appreciated in mid- to late twentieth-century philosophy of science.

With regard to more metaphysical issues, Cartwright also has promoted a pluralistic account of a “dappled world” composed of distinct realms (Cartwright 1999). According to this view, laws of limited scope apply to these realms, but the laws form a loose patchwork rather than reducing to a compact, unified set of fundamental laws. John Dupré advanced pluralist positions in both epistemology and metaphysics. His epistemological pluralism seeks to move beyond the search for demarcation of science from nonscience to an account of the epistemic virtues that characterize the variety of scientific enterprises. He argues that the kinds named by conflicting systems of classification are real because they serve the various purposes of the humans classifying things. He calls his metaphysics “promiscuous realism” (Dupré 1993).

Although early work on pluralism tended to focus on issues related to the unity of science thesis, recent discussions have taken up a number of philosophical issues ranging from concrete debates within particular sciences to debates about metascientific concepts to discussions about how philosophical, historical, and sociological accounts of science relate to one another. On the concrete level, pluralism has been invoked to account for the problems concerning interpretations of quantum mechanics (Cushing 1994) and the status of laws in physics (Cartwright 1983), puzzles concerning the relation of quantum mechanics to other branches of physics (Morrison 2001; Teller 2004), the problem of species (Mishler and Donoghue 1982; Mishler and Brandon 1987; Ereshefsky 1998, 2001), the controversy about the level of selection in biology (Dawkins 1982; Waters 1991, 2005), and the relation between genetic and environmental explanations of differences (Longino 2001), to name just a few.

Philosophers of science have begun to advance pluralism at the metascientific level, most notably with respect to epistemic virtues. A variety of views regarding the role, status, and identity of scientific or epistemic virtues has been advanced in the philosophical literature. Some philosophers treat empirical adequacy, consistency, simplicity, explanatory power, and refutability as truth indicators (McMullin 1983). Others treat them as markers of scientificity (Kuhn 1977), while still others emphasize their incapacity to be maximally realized at one time by any given theory (van Fraassen 1989). Despite these disagreements, philosophers typically assumed that there must be one foundational set of virtues, whatever their role or status in science. Hence, some philosophers advocate for one or

another within the set (e.g., explanatory power against empirical adequacy and vice versa [Churchland 1985]) or advocate different virtues altogether, such as heterogeneity or social utility (Longino 1996). But now there is talk of a pluralist solution that would claim that which virtues should hold what degree of regulative status in any given research project is a function of features specific to the problem and of the particular aims of the research (Longino 2002).

The appreciation of the need for interdisciplinary approaches in science studies aligns with pluralism at the metaphilosophical level. Because the scientific enterprise is itself a complicated phenomenon, no single disciplinary approach can provide a fully adequate account of its conceptual, technical, cognitive-psychological, social, historical, and normative aspects (Bauer 1990; Stump 1992; Wylie 1995; Giere 1999). The pluralist interpretation might be pushed one step further: no single disciplinary or interdisciplinary approach can provide a full account.

The idea of pluralism is certainly “in the air,” but one might ask whether appeals to pluralism, such as the ones mentioned here, are merely opportunistic gestures intended to avoid answering difficult questions. Can pluralism be consistently advanced in philosophical interpretations of science? If so, what are the implications of taking a consistent stand on pluralism? The aim of this book is to answer these questions by investigating a number of topics and areas of the sciences.

### **Distinguishing between Fact and Interpretation: *Plurality* in the Sciences Contrasted with *Pluralism* about the Sciences**

It is useful to distinguish between *plurality* in the sciences and *pluralism* about the sciences. The former is a feature of the present state of inquiry in a number of areas of scientific research, such as those listed above. These are characterized by multiple approaches, each revealing different facets of a phenomenon. There can be plurality of representational or classificatory schemes, of explanatory strategies, of models and theories, and of investigative questions and the strategies appropriate for answering them. *Pluralism* is a view about this state of affairs: that plurality in science possibly represents an ineliminable character of scientific inquiry and knowledge (about at least some phenomena), that it represents a deficiency in knowledge only from a certain point of view, and that analysis of metascientific concepts (like theory, explanation, evidence) should reflect the possibility that the explanatory and investigative aims of science

can be best achieved by sciences that are pluralistic, even in the long run. Philosophers can ground their pluralism in studies of particular cases, in the findings of cognitive science, or in a priori reflection about such matters as the vagueness of scientific predicates. Philosophers who advocate pluralism can and do differ as to the extent of the plurality they attribute to the sciences, the strength of the pluralism they adopt, and the broader philosophical implications they draw from it.

## Interpretations of Plurality

### Monism versus Pluralism about Plurality in the Sciences

We take *scientific monism* to be the view that

1. the ultimate aim of a science is to establish a single, complete, and comprehensive account of the natural world (or the part of the world investigated by the science) based on a single set of fundamental principles;
2. the nature of the world is such that it can, at least in principle, be completely described or explained by such an account;
3. there exist, at least in principle, methods of inquiry that if correctly pursued will yield such an account;
4. methods of inquiry are to be accepted on the basis of whether they can yield such an account; and
5. individual theories and models in science are to be evaluated in large part on the basis of whether they provide (or come close to providing) a comprehensive and complete account based on fundamental principles.

*Scientific pluralism*, in contrast, holds that there are no definitive arguments for monism and that the multiplicity of approaches that presently characterizes many areas of scientific investigation does not necessarily constitute a deficiency. As pluralists, we do not assume that the natural world cannot, in principle, be completely explained by a single tidy account; rather, we believe that whether it can be so explained is an open, empirical question. Although we often write “the world,” we also question whether *parts* of the world investigated by different sciences (e.g., the world economy or the system within an organism) can be completely accounted for by a single, comprehensive theory. Treating this tenet of monism (tenet 2 above) as an open question rather than as a metaphysical truth undermines the remaining tenets of monism. It undermines tenet 1 because if we don’t know whether the world can be fully accounted for by

a single comprehensive account, then it seems unreasonable to assume that the ultimate aim of science is to achieve such an account. If the world cannot be fully accounted for by a single comprehensive account, then there cannot be methods of inquiry that if correctly pursued would yield such an account. Hence, we should not assume that tenet 3 is true. And if we don't know whether the world can be fully accounted for by a single, comprehensive account, then it seems unreasonable to accept or reject scientific methods according to whether they can yield such an account (tenet 4) or to evaluate scientific theories in terms of how close they come to providing a complete and comprehensive account (tenet 5).

Monists might admit that a plurality of approaches and models can meet appropriate scientific standards (or satisfy the corresponding epistemic values) but insist that this is only because today's science is incomplete. The ultimate aim of science, according to the ideal of monism, is to have for any given phenomenon the complete description of its essentials. But we do not believe that the plurality in today's science is necessarily a temporary state of affairs. We think that some phenomena may be such (e.g., so complicated or nebulous) that there can never be a single, comprehensive representation of everything worth knowing, or even of everything causal (or fundamental), about the phenomenon. If this is the case, that is, if the nature of the world is such that important phenomena cannot be completely and comprehensively explained on the basis of a single set of fundamental principles, then the aims, methods, and results of the sciences should not be understood or evaluated in reference to the monist quest for the fundamental grail. Hence, we believe philosophy of science should rethink those of its concepts that rule out the possibility that ultimately the best way to investigate and explain the natural world is through multiple investigative approaches and representational systems. This view is supported by the chapters in this book because they establish the possibility that the world is too complicated or too indeterminate and our cognitive interests too diverse for the monist ideals, and they establish this result across a broad swath of sciences including behavioral, biological, physical, and mathematical sciences.

### **Modest Pluralist Interpretations**

Some forms of pluralism acknowledge the present state of plurality, but treat it as resolvable at least in principle. One form of pluralism in the literature recognizes that the world is patchy and that one model or theory might explain phenomena in one patch while a different model or theory would be necessary to explain similar phenomena in a different patch. Some scientists and philosophers advance this view at the local level of

scientific domains. Sandra Mitchell's pluralism seems to be of this type: nature varies in its strategies, using different strategies to achieve the same end, but for each situation in the natural world there is a single complete and comprehensive account that can be given (Mitchell 2002). But this view about the disunity of science seems to reduce to (nonfundamentalist or nonreductionist) monism because it is consistent with the idea that for every particular phenomenon, there is a single, best account. Philip Kitcher accepts a stronger view (Kitcher 2001). He concedes that classificatory concepts and systems reflect different interests and that the legitimate persistence of such varied interests permits the articulation of different theories about one and the same phenomenon. Nevertheless, he seems committed to the assumption that all truths in one theory of X must be translatable into truths in the other theories of X. This view, while nonreductionist, also seems to reduce to monism, because it implies that a single, consistent theoretical system can accommodate all explanatory interests. It is consistent with the idea that different true theories of the same phenomenon are, from a logical point of view, only notational variants of one another. Might the plurality of models and representations arise not simply because some parts of the world are different than others, or because different, but intertranslatable, classification systems respond to different interests, but because some parts of the world are so complicated that they cannot be fully accounted for from the perspective of a single representational idiom? We believe it is metaphysical prejudice to deny this possibility, and we fail to see what is to be gained by this denial. We worry that insistence on this abstract metaphysical point sometimes leads philosophers to three errors: (1) to minimize or overlook important differences among scientific approaches, (2) to dismiss from consideration legitimate scientific approaches that seem to lie outside the mainstream, and (3) to exaggerate the explanatory importance of scientific approaches that are in the mainstream.

Another form of modest pluralism tolerates a plurality of theories, not because there is something importantly right about one that cannot be captured by another (and vice versa), but because it is difficult to predict which research program (or preliminary theory) will lead to a theory that provides a complete account of the phenomena. This view endorses a division of cognitive labor in the short term as a means to achieving the putative long-term goal: a single, all-encompassing, true theory. But again, this form of pluralism seems to reduce to monism. Certainly the division of labor is a good strategy under certain conditions of uncertainty, but we believe the plurality exhibited throughout the sciences involves more than the hedging of bets about which approach will lead to the complete and comprehensive account that supposedly awaits discovery.

## **Radical Pluralist Interpretations**

Constructivists admit an indefinite number of theories, the only constraint being human ingenuity. But they are also anti- or nonrealists. A realist version of the thesis is offered in a radical form of pluralism advanced by John Dupré (1993). According to his “promiscuous realism,” there are an indefinite number of ways of individuating and classifying the objects in the world, each of which is responsive to different interests, and no one of which is more correct than the others. All are equivalently referential: any kind term that has a role in a system of understanding refers to a kind. There is an indefinite number of sets of kinds. But just as modest pluralisms are difficult to distinguish from a sophisticated form of monism, promiscuous realism is hard to distinguish from radical relativism. We are committed to the idea that there are constraints that limit the variety of acceptable classificatory or explanatory schemes. It is worth emphasizing that the case studies in this book do not deny the existence of such constraints. An important question they address is whether constraints limit sciences to single schemes for the parts of the world (or individual instances) investigated by particular sciences. We believe the question of whether the constraints on scientific inquiry lead to monism should be treated as an empirical question.

## **An Empirically Based Interpretation: The Pluralist Stance**

The form of pluralism we advance in this essay is not based on metaphysical assumptions. We have no a priori basis for assessing the monist assumption that the nature of the world is such that its parts can be completely described or explained by a comprehensive account grounded on a consistent set of fundamental principles. We also lack an a priori basis for affirming (or denying) universal aims for science such as the monist aim to acquire a single, complete, and comprehensive account of the natural world. The form of pluralism we advance on the basis of the chapters that follow is empirically motivated. The argument we sketch begins with considerations from contemporary psychology about human perception and continues by appealing to detailed case studies about how the plurality in particular sciences ought to be understood. The studies in this book lead, we argue, to a substantial and consistent form of pluralism that is not so much a metaphysical or ideological position about the fundamental character of the world as an approach to interpreting the content and practices of scientific inquiry. We call this approach “the pluralist stance,” by which we mean a commitment to avoid reliance on monist assumptions in interpretation or evaluation coupled with an openness to the ineliminability of multiplicity in some scientific contexts. (By “we,” we mean the authors of

this essay. We are advancing this as our own view, not as a collective view of the contributors to this book. We maintain, however, that the arguments offered by the case studies in this book substantiate the view we are advancing here.)

According to the pluralist stance, the plurality in contemporary science provides evidence that there are kinds of situations produced by the interaction of factors each of which may be representable in a model or theory, but not all of which are representable in the same model or theory. Each factor is necessary for the phenomenon to have the various characters it has, but a complete account is not possible in the same representational idiom and is not forthcoming from any single investigative approach (as far as we know). A more complete representation of some phenomena requires multiple accounts, which cannot be integrated with one another without loss of content. We do not hold that for every phenomenon there will inevitably be multiple irreducible models or explanations. We hold that the task of identifying which situations require multiple approaches requires empirical investigation. We believe that the pluralist stance has important implications concerning metascience and the public consumption of scientific knowledge.

The pluralist stance differs from more modest versions of pluralism because it acknowledges the possibility that there may be no way to integrate the plurality of approaches or accounts in a science. For example, we do not believe that the tension among different models can always be resolved by partitioning the domain so that the conflicting models apply to different subdomains. In addition, we do not assume that the plurality of accounts should be consistent, that all truths from one accepted account must be translatable into truths of the other accepted account(s). Perhaps the approaches and accounts within the plurality cannot be combined and perhaps they even disagree with one another about certain points. How might this be possible? In many complicated situations, investigation is not feasible unless investigators parse causes. In some cases, there are alternative ways to parse causes and one cannot parse the causes in the alternative ways at once. Some parsings are advantageous for explaining (and/or investigating) some aspects of the situation, other parsings are advantageous for accounting for other aspects. In such cases, we could say that each account emphasizes some causal aspects of the situation while obscuring others. In fact, an acceptable scientific model might describe some facets of the situation extremely well (e.g., the potential causal influence of some factors) while actually distorting other facets (the potential causal influence of other factors). If this is the case, and if two models distort some of the same aspects, they might distort these aspects in different ways, giving

rise to inconsistencies. This is just one kind of situation in which a plurality of inconsistent approaches might be defended.

An epistemology of monism would insist that at most one of the theories is true and scientists should figure out which one. A pluralist would draw this conclusion in some cases, but a pluralist is also open to the possibility that the situation is such that it is impossible to accurately represent all aspects (even all aspects of interest) with a single model. Seeking a proper plurality of models, each of which accurately accounts for some but not all aspects of the situation, might be preferable. What is the advantage of the pluralist interpretation? As some of the chapters to follow show, it provides a means of avoiding senseless controversies that do not lead to progress. It also helps emphasize the partiality of scientific knowledge. The monist interpretation can give rise to inflated confidence about the comprehensiveness of scientific knowledge. A pluralist stance keeps in the forefront the fact that scientific inquiry typically represents some aspects of the world well at the cost of obscuring, or perhaps even distorting, other aspects.

### **General Considerations in Favor of the Pluralist Stance Including an Argument Based on Perceptual Psychology**

Pluralism can be motivated on the basis of abstract considerations: all representations are partial in that any representation must select a limited number of aspects of a phenomenon (else it would not represent, but duplicate). This selective and partial character of representation means that alternative representations of a phenomenon can be equally correct. Hence, it should be obvious that different accounts, employing different representations, might be generated by answering different questions framed by those different representations. Monism holds that all such correct accounts can be reconciled into a single unified account or that there is a single perspicuous representation system within which all correct accounts can be expressed. The related view, *fundamentalism*, holds that there is one (or a very few) law(s) from which all correct accounts (with requisite empirical input) can be derived. The pluralist stance rejects both monism and fundamentalism. The plurality of representations and approaches in science is sustained by the complexity of nature, the employment of highly abstract representational models, and the diversity of investigative, representational, and technological goals.

Ronald Giere, in his contribution to this book, offers a general empirical argument for pluralism drawing on findings in perceptual psychology. Color perception offers a compelling example of perceptual perspectivalism.

Research on human vision identifies two types of light receptor: the rods, which have a uniform range of sensitivity and a common peak sensitivity and which constitute an achromatic system, and the cones. Cones are typically of three types, each containing a different pigment and each characterized by a distinctive peak sensitivity. The chromatic dimensions of human visual experience are produced by differences in activation of the light receptors. These findings about receptors provide explanations of various aspects of human color vision. Visual systems can be, and are, different from that of the typical human. Some species have a four-pigmented system, and many others have only two. Some humans are also only dichromats (e.g., those with red-green color blindness), and some have no conic receptors and thus experience the world only in black and white. Giere argues that there is no way to say which perspective is *correct*, although one perspective might be deemed richer in certain respects than another. He also maintains that there is no translation from one system to another. There is, however, no need to understand claims made about the same object from the vantage of different perspectives as incompatible as long as colors are understood as the product of an *interaction* between objects and particular types of visual systems, rather than as objective properties of objects. Our visual system affords us a particular perspective that may be different from, but is not incompatible with, that of others attending to the same object.

Giere proposes that we understand scientific observation as analogous to unaided vision, mediated by different instruments (e.g., light telescopes versus infrared telescopes), each enabling a different partial perspective and different partial representations of objects. Scientific theorizing could be partial in a similar way, capable of dealing, for example, with mechanical forces or with electromagnetism, but not necessarily capable of dealing with both kinds of phenomena with one set of principles.

## **Pluralities in Social, Behavioral, Biological, Physical, and Mathematical Sciences**

The contributors to this book identify a variety of ways plurality can characterize a particular area of inquiry and the various sources of plurality located within the complex of inquiry and object of inquiry. These include (a) the complexity of the phenomena—whether associated with crossing levels of organization or multiple factors within the same level of organization; (b) the variety of explanatory interests; (c) the openness of constraints—whether from above or below; and (d) the limitations of particular explana-

tory strategies vis-à-vis the phenomena. These essays span physics, mathematics, biology, and social and behavioral science, showing that plurality is not confined to any particular area of science. The essays also offer a variety of arguments for taking a pluralist stance toward the plurality they document. In this section, we briefly describe the pluralities. In the next section, we will consider why the authors believe pluralism offers the best interpretation of the pluralities they document.

In some cases formal constraints imposed by higher-level theory leave certain options at a lower level, options that are equally supportable given the evidence. Michael Dickson argues that the mathematical constraints of quantum theory are insufficient to pick out one of several dynamics. In their jointly authored essay, Geoffrey Hellman and John Bell show that both classical and intuitionist logics satisfy the basic logical requirement of consistency. In both the physics and the logic case studies, the authors identify pluralities that are preserved because different cognitive interests are satisfied by different formalizations.

Other authors argue that the complexity of the phenomena generates the possibility for a plurality of scientific approaches. Carla Fehr examines the scientific literature on the evolution of sex and identifies a number of different explanations, explanations that are typically viewed as opposing one another. Fehr argues that the multiplicity of explanations stems in large part because sexual reproduction involves processes occurring at multiple levels of organization. Different accounts of the evolution of sex focus on processes at different levels (meiosis at the cellular level and outcrossing at the organismic level) that are subject to different selective pressures and cannot be collapsed into one.

Esther-Mirjam Sent documents an oscillation between monism and pluralism in economics. At the beginning of the twentieth century, both institutionalist and marginalist (neoclassical) approaches coexisted as jointly necessary to fully cover economic phenomena. At midcentury, the neoclassical approach achieved near-hegemonic status (at least in the United States), and its proponents sought to bring all kinds of social phenomena under its uniform explanatory umbrella. The resistance of some phenomena to neoclassical treatment has led a number of economists to think that alternative approaches are necessary for at least some phenomena and thus also to advocate pluralism.

Helen Longino examines scientific studies of behavior. Researchers agree that there is a multiplicity of causal factors involved in behavior. Longino points out that since it is impossible to measure all of them simultaneously, research approaches must inevitably select from among these the ones they will measure. Each selection constitutes a different parsing of the causal universe, creating different effective sets of alternative

causes. These support different research approaches, each able to answer a distinctive subset of the possible research questions one might have.

Stephen Kellert's case study is focused on metascience rather than the object sciences themselves. Kellert suggests that interdisciplinarity, understood as the need for multiple disciplinary approaches, arises because of the complexity of the phenomena to be known and the partiality of the individual disciplines.

In other cases, it is not so much the complexity of the phenomena as a certain fundamental openness or indeterminacy that generates plurality. In mathematics, Hellman and Bell note, it has become standard to treat sets as the fundamental mathematical entities. Category theory, however, proposes a mathematical universe constituted by topoi (toposes) or categories. Suitably enriched, category theory provides an autonomous ontology for mathematics, an ontology free of the constraints required to avoid paradox in set theory. Here again, different mathematical interests will dictate which ontology is preferable in a given situation. Economics, too, can, in fact must, support different ontologies. Sent suggests that, once the no-trade theorems force one to give up any assumption that economic agents are uniform, the variety of distributions of different kinds of agent will determine different kinds of economic structures, no one of which is any more fundamental than any other.

### **Reasons for Favoring a Pluralist Interpretation of the Pluralities Identified in the Case Studies**

The pluralities identified in the case studies can be variously interpreted. A monist or modest pluralist will either treat them as temporary—as stages on the way to a unified treatment of the phenomena—or as steps to a comprehensive resolution that will provide for each instance a single, best way to account for the instance. Philosophers and scientists are inclined to monism or modest pluralism for different reasons, requiring different responses from bolder pluralists. For example, some evolutionary biologists adopt a strictly monist perspective and assume that only one of the diversity of evolutionary explanations of sex is correct and have entered into a debate about which account is the right one. Fehr argues against this monist interpretation by pointing out that the persistence of sexual reproduction in a species involves different and continuing costs. It is often impossible to settle on one account even when limiting the domain to a narrow lineage. Which explanation is appropriate depends on the precise question one is asking. Other biologists have advanced one or another form

of modest pluralism. One of these suggests that it is possible to decompose sex into its constituent parts, for each of which a distinct evolutionary account can be given. This interpretation corresponds to Mitchell's above-mentioned idea that situations of pluralism are resolvable by separating apparently complex phenomena in such a way that the conflicting explanations apply to different cases that are part of a family of related but distinct phenomena. Fehr argues, to the contrary, that the components of sex cannot be separated in the way demanded by this modest form of pluralism. Other biologists have dealt with the plurality of explanations by holding that the different explanations must be integrated in order to identify a net resultant force responsible for the emergence and persistence of sex. Fehr holds that combining or integrating the explanations would have the effect of decontextualizing them and depriving each of the detail and information that is the source of its explanatory value.

Kenneth Waters argues that the pluralist interpretation applies even to cases where science doesn't exhibit much plurality. His case study involves genetics and molecular biology. Scientific explanation and investigations in these sciences are largely centered on the role of genes. Philosophical critics have advanced an alternative, called developmental systems theory (DST), that treats organisms as systems and genes as just one of many different kinds of equally important developmental resources. They argue that DST should replace the now-dominant gene-centered approaches because the gene-centered approaches leave too much out. Thus, the proponents of DST contend that only an approach that incorporates all the causal factors and their interactions can be correct. Waters maintains, contrary to the critics, that gene-centered accounts are not incorrect. Rather, they are partial accounts of complex processes that could be approached in a variety of ways. Gene-centered accounts provide correct answers to some, but not all, of the questions that can be asked about development. Nongenetic factors of a system, e.g., cytoplasmic elements, at the same level of organization as genes (intracellular), could be emphasized in one's research questions, leading to different but not necessarily contradictory accounts of particular developmental processes. Waters claims that the monistic call for comprehensiveness obscures the significant achievements of approaches, like the gene-centered one, that focus attention on only one kind of causal factor.

Waters's case is different from the other cases examined in this book because the other cases argue for pluralist interpretations of sciences exhibiting a plurality of theories or approaches. Waters argues for a pluralist interpretation of a science that does not exhibit a plurality of theories or approaches. He argues that the problem with the monistic interpretation of his case is that it leads proponents of gene-centered science to infer

that because the science is successful it must be based on a comprehensive theory that can explain all the essentials of development (genetic determinism). Opponents reject this conclusion because they recognize that the theory behind molecular biology is gene-biased and obscures a lot of factors crucial for development. But monism leads the opponents to conclude that the success of molecular biology is illusory and to seek a replacement. Waters argues that a pluralist epistemology can enable us to acknowledge that gene-centered molecular biology is successful without buying into the idea that the gene-centered perspective offers a comprehensive account of the essentials of development.

Wade Savage takes a somewhat similar line with respect to neuroscience. Although research into sensory and motor capabilities seems to vindicate physicalism (as opposed to dualism), Savage explores the possibility that the psychophysical identity principle that underwrites this research should be interpreted as a methodological principle, consistent with dualism. He proposes that there are multiple senses of identity and that the apparently conflicting conclusions reached about physicalism and dualism can be resolved by distinguishing between empirical identity (the sense at issue in the methodological principle) and logical identity (the sense at issue in contemporary defenses of dualism).

Other contributors (Hellman and Bell, Longino) point out that monism on the part of researchers, especially when motivated by commitment to their chosen theory or approach, fuels sterile and unproductive debates. Adopting a pluralist attitude encourages scientists to pursue interesting research without having to settle questions that cannot, in the end, be settled.

Philosophers advocating monism or modest pluralism worry that tolerating any stronger form of pluralism is equivalent to tolerating contradiction. Thus Kitcher, as noted above, constrains his pluralism by requiring that different languages in which different theories are expressed be intertranslatable so that a truth in one can be translatable into a truth in the other. A pluralism that tolerates inconsistencies is apparently an invitation to incoherence. But Dickson maintains that inconsistencies among different dynamics for quantum theory should be tolerated. He argues that solving the measurement problem requires supplementing quantum theory with a dynamics. Although constraints rule out many dynamics, a number of alternative dynamical accounts are consistent with quantum theory (and with the empirical predictions made on behalf of quantum theory). It turns out that a single dynamics will not serve all the explanatory goals of physicists. To illustrate this point, Dickson considers two different explanatory contexts that call for quantum theory to be supplemented by a dynamics. One explanatory context requires invoking the principle of relativity, and the other context requires the principle of stability. It turns out

that no single dynamics is consistent with both principles. Hence, providing an explanation in one context requires supplementing quantum theory with a dynamics that violates the stability principle, and the other context requires supplementing quantum theory with a dynamics that violates the principle of relativity. Dickson argues that physicists should tolerate a contradiction among dynamical accounts because the multiplicity of contradictory accounts is needed for explanatory purposes and because the contradictions do not lead to contradictory predictions about the observables. This is perhaps the clearest example illustrating the following point, which modest pluralism overlooks: there can be a tension within the plurality of accounts even though each account correctly describes, models, or explains an important aspect of the same part of the world toward which it is aimed.

Contributors to this book hold not only that the situations they analyze resist requirements of monism or modest pluralism, but also that scientific knowledge would suffer by their imposition. Scientists sometimes must make decisions about whether to pursue or to defer the quest for comprehensive or convergent accounts. A pluralist approach advocates that such decisions be made on empirical, case-by-case, pragmatic grounds rather than on the basis of a blanket assumption. We expect that decisions made on these grounds will yield more fruitful and effective results.

As has been seen, our contributors have a variety of ways of arguing that the strong pluralism they advocate for their respective areas of investigation does not issue in a debilitating contradiction. They argue further that less ecumenical views would result in a loss to knowledge. Tolerating nonconvergence of approaches avoids the mistake of a priori restricting what can be known and how. Thus, Longino maintains that the approaches to behavior she discusses are not intertranslatable because each parses the (same) causal universe differently. Each is nevertheless capable of producing knowledge, and to restrict research to one or to those that produce intertranslatable sentences is to eliminate avenues of inquiry that have produced important insights. Waters makes a similar case with respect to the demand that an acceptable approach for investigating biological development must include all the causal factors. It is simply not possible to design a research program that takes all factors into account at once. Insisting on a single, comprehensive investigative approach or explanatory account will cut off avenues of knowledge.

In addition to avoiding sterile debates, pluralism underwrites the explanatory flexibility that is one of the strengths of the sciences. Fehr notes the loss of information that would perforce accompany attempts to integrate the different explanations of sex. Hellman and Bell note that classical and intuitionist logic each answer to different interests, truth preservation

and computability (or constructability) respectively. Neither can be given up, nor should be. Similarly, while not wishing to give up on set theory, they state that the broader ontologies defined by category theory permit the practice of forms of mathematics not possible if sets are taken as the fundamental mathematical entities. Dickson, too, affirms the ineliminability of the explanatory contexts and questions to which the different (and inconsistent) quantum dynamics are addressed. Sent argues that economics will be better able to address the variety of economic phenomena if it embraces a plurality of approaches rather than insisting that one approach must fit all. Finally, as Richardson notes, pluralism enables a deeper connection with social and political concerns than advocacy of a single approach does.

We started from the premise that the world might not yield to the demands of monism. The case studies in this book indicate that science provides good evidence that the world is indeed such that it will not be fully explained on the basis of comprehensive theoretical accounts that identify all the essentials of any given phenomenon. It appears that some parts of the world (or situations in the world) are *such* that a plurality of accounts or approaches will be necessary for answering all the questions we have about those parts or situations. But this raises an important question. What is the “such”? That is, what is the nature of the world such that it, and many of its parts, are not amenable to a single, comprehensive account? The answer seems to differ for different patches of the world. For biological and social patches, the world seems too complicated or complex: many processes involve interaction of multiple causal processes that cannot be fully accounted for within the framework of a single investigative approach. For the domain studied by quantum physics, the situation doesn’t seem so much complicated in that sense as perplexing. Our ordinary physical intuitions, which work at the level of the classical physics of midsize objects, seem to fail us at the quantum level (see Morrison 2001). So, while our case studies suggest that interactions of multiple causal processes in the biological and social cases could make it impossible to fully account for the phenomena within a single framework, they do not give a clear indication of what could be making it impossible (if indeed it is impossible) in the quantum domain.

We believe that Dickson’s contribution provides evidence that the quantum world is such that a comprehensive, monistic explanatory account is not forthcoming. He makes a strong case that accepting a plurality of dynamics serves divergent interests of physicists that cannot be served by a single dynamical theory (or by leaving out a dynamical theory). He reaches this conclusion while maintaining that these dynamical theories are mutually incompatible and that the formalism of quantum theory does not

provide constraints for deciding among them. We admit, however, that we do not know how to describe the nature of the quantum world that makes it resistant to a single, comprehensive account. We are, of course, not alone here. Dickson suggests that the alternative dynamical accounts be thought of as complementary, along the lines that concepts involving observables are said to be complementary. Although this suggestion is promising, it is still not obvious that the need to appeal to alternative complementary concepts or dynamical accounts stems from something akin to the need for plurality in the biological and social contexts. But we do not think our inability to describe the “such” in the case of quantum theory, or other cases for that matter, means that we ought to adopt monism by default.

Although we believe that frameworks for the interpretation of science should not presuppose a metaphysics of monism, it should be clear that we ourselves do not have a general metaphysics. We do not, for instance, insist that all parts of the world are such that they cannot be comprehensively accounted for by a single theory. Furthermore, we do not maintain that there is a common ontology shared by those parts of the world that cannot be fully explained in terms of a single, comprehensive account. Our general thesis is epistemological: the only way to determine whether a part of the world will require a plurality of accounts is to examine the empirical results of scientific research of that part of the world. The case studies in this book are consistent with this general epistemological stance. While contributors concede some of the attractions of monism (e.g., unproblematic commensurability and comparative assessment, singularity of approach, hegemony), they show that in the particular cases being examined, plurality is ineliminable. They argue that a strongly pluralist interpretation of that plurality is more faithful to the scientific situation. In contrast to more radical forms of pluralism, none affirms that nonconvergence is the rule across the sciences. The pluralism advocated is local, rather than universal. The contributors follow the advice from Dewey quoted by Richardson: to avoid being “false to the scientific spirit” by holding a priori to metaphysical doctrines. As Giere puts it, the case studies reject a priori commitments to either unity or multiplicity and allow the evidence and practical success (or failure) to decide.

### **Consequences of Assuming the Pluralist Stance**

The basic point that scientific models generally obscure some aspects of complex phenomena in order to elucidate others has been increasingly accepted in philosophy of science, but the implications we draw from it have not. The implications contradict some deeply held views in the philosophy

of science. These are the more difficult aspects of pluralism to accept, as our own occasional unthinking reversion to monist formulations attests. One implication of our pluralist outlook is that scientific approaches and theories should not be evaluated against the ideal of providing the single complete and comprehensive truth about a domain. This implication undermines a good deal of argumentation in the philosophy of science literature. For example, philosophers of biology have often argued that gene-centered explanations should be replaced by DST explanations on the grounds that gene-centered explanations leave out important causal factors. The underlying assumption is that any acceptable theory must include all the causal factors because the aim of science is to identify the single, comprehensive truth about development. Scientists and philosophers should recognize that different descriptions and different approaches are sometimes beneficial because some descriptions offer better accounts of some aspects of a complex situation and other descriptions provide better accounts of other aspects. And this may be the way it will always be.

The pluralist outlook suggests that there are serious limits for drawing metaphysical conclusions from science. While our empirically based pluralism is neutral with respect to realism in the sense that it does not require us to abandon realism, it does imply that realism needs to be tempered. Some philosophers and scientists argue that insofar as we seek answers to metaphysical questions, we should turn to the best contemporary scientific theory related to the question. While modest versions of this project might be sustained (perhaps certain metaphysics can be ruled out), the pluralist stance accepts that science has not and probably will not provide reliable answers to many of the big, interesting metaphysical questions. Is the world fundamentally deterministic? According to the Copenhagen interpretation of standard theory, it is not. According to the Bohm theory, it is. An empirical pluralism is open to the possibility that both accounts of quantum mechanics describe certain aspects of the phenomena well, and both could provide a basis for advancing inquiry. What is the level of selection? According to genic selectionists, it is always exerted at the level of individual genes. According to others, in some cases selection is exerted only at higher levels of organization, in other cases only at lower levels, and in still different cases at multiple levels. An empirical pluralism is open to the possibility that some aspects of a single case of natural selection might be best accounted for by modeling the process only at the genic level, and other aspects of the same selection process might be best accounted for by modeling the process at a higher level (or at multiple levels). If this is right, then science won't answer many metaphysical questions associated with scientific inquiry, such as questions about determinism or *the* level

of selection or whether the world is such that a unified comprehensive account of it is possible.

The pluralist stance also has implications for philosophers who draw on philosophy of science to form conclusions about other areas of inquiry. For example, Bernard Williams, in *Ethics and the Limits of Philosophy*, writes, “In a scientific inquiry there should ideally be convergence on an answer” (1985, 136), and he takes this convergent monism in science as a sign of its objectivity, in sharp contrast to the community-bound nature of ethical discourse. Although we are pluralists, we do not assert plurality or the lack of convergence in the sciences. Instead, we deny the presumption of unity made by authors such as Williams. And in this denial, we leave open the possibility that ethical discourse can be as objective as scientific discourse.

Adopting a pluralist stance also has important consequences for the practice of philosophy of science. Pluralists might see the plurality in the local context of a scientific controversy as reflecting the complicated, multifaceted nature of the processes of interest. A monist will look at the same case of plurality and claim that the scientists in this local situation, as scientists in every local context, ought to be guided by the universal goal of uncovering the comprehensive account of the processes being investigated. Monism leads many philosophers to search for the concepts that will enable the pieces to fall into a single representational idiom. For example, philosophers were not content to identify a plurality of fitness concepts that could be drawn on to describe different aspects (or even different instances) of evolution. The explicit aim was to clarify *the* fundamental concept that underwrites all explanations invoking natural selection. The unspoken assumption was that there must be some underlying causal parameter, fitness, that would be the basic cause for all cases of natural selection. Pluralism denies this assumption. Or to be more precise, the pluralist stance refrains from adopting this tenet without empirical evidence. Pluralists do not assume that if we could just “get clear” on essential concepts, biologists could empirically determine how everything can be explained by a single account based on a few fundamental principles. By denying such assumptions, the pluralist stance requires us to revise the way we analyze concepts, both those of science and metascience.

Much of the analysis of concepts such as fitness in biology, function in psychology, and force in physics hinges on finding counterexamples against various proposed analyses. The unspoken assumption behind the method of counterexample is that there must be one kind of abstract thing that counts as fitness, function, or force. If one finds something that a proposed analysis can’t account for, then the analysis is taken to be refuted. To

return to the fitness example, if a proposed analysis of fitness can't account for the long-term, as opposed to the short-term, evolution of a trait, then it is rejected. The idea behind such an argument is that the counterexample proves that the proposed analysis must not capture "the" concept of fitness because the right interpretation of fitness will be useful for understanding all important aspects of a complex evolutionary process. Scientific pluralism, however, acknowledges that different aspects of a sufficiently complex example of natural selection might be best accounted for by different models, which in turn might employ different concepts of fitness. It is not that any analysis of a term will do. But which analysis is best sometimes depends in part on what aspect of a complex situation is of greatest interest, and hence there might be more than one correct analysis. We believe that terms such as "chaos," "electron," and "function" exhibit the same polysemy.

Philosophers of science have also employed the method of counterexample in their analyses of metascientific concepts such as theory, explanation, cause, and probability. Does consistency require scientific pluralists to be pluralists about the analysis of these concepts? We think it does. Philosophers should not *assume* that the nature of science is such that it can be comprehensively accounted for by a single set of concepts that capture the fundamentals of science. This means, for instance, that the assumption that there is one abstract kind of thing, "scientific explanation," may be mistaken. Perhaps accounting for different aspects of scientific understanding will require different accounts of explanation. The monists' essentialism about metascientific concepts is unjustified. It follows that the familiar method of counterexample needs to be revised for our analysis of metascientific concepts as well as scientific concepts. Conceptual analyses ought to be evaluated on the basis of what they help us understand and investigate, not on the basis of whether they identify the single, essential way of understanding. One might extend this critique to analytic philosophy more generally and challenge the assumption that justice, knowledge, or consciousness must have uniform essential meanings that can be determined by the method of counterexample.

It should be evident that just as we take a pluralist stance on scientists' understanding of complex phenomena in the natural and social world, we also favor a similar stance on our own understanding of the multifaceted nature of scientific knowledge. This means that, like physicists trying to answer the most fundamental questions about the physical world, philosophers should acknowledge that there might not be answers to many of the most fundamental questions about science. Might the debate between Bayesians and their foes be futile, not simply because of lack of compel-

ling evidence, but also because neither approach can (in principle) offer a comprehensive account of the basis of scientific inference?

Reflexivity also raises questions about the relation between philosophy of science and other areas of science studies. What does pluralism imply about the relation between the approaches of philosophers and those of historians, sociologists, and rhetoricians? As Kellert argues in his defense of the cross-training metaphor for interdisciplinarity, different perspectives on science, including the historical, normative-philosophical, and social-scientific, can shed light on different aspects of the multifaceted enterprise. Trying to force them into a convergent viewpoint or demanding a choice among them is counterproductive. Adopting a single approach would obscure certain aspects of science, perhaps limiting the advancement of that approach and certainly limiting our understanding of science as a complex phenomenon. As with our pluralism about science, we are not promoting an “anything goes” view. There are instances of poor research in every branch of science studies. Some of the most glaring examples of substandard work involve promoting a favored approach by trying to demolish what are viewed as opposing approaches for understanding science. These critiques are typically carried out within the perspective of the favored approach and assume the ideal of monism. That is, they assume that we should adopt just one approach, the one that promises to offer a complete account of the “essentials” of science. It is time to reject this ideal, for both science and the study of science. We should acknowledge that whether the world can (even in principle) be explained in terms of a single explanatory idiom or investigated by a single approach is an open question. We should adopt the pluralist stance.

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