DICTIONARY OF CONCEPTS IN THE PHILOSOPHY OF SCIENCE

Paul T. Durbin

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Series Foreword

In all disciplines, scholars seek to understand and explain the subject matter in their area of specialization. The object of their activity is to produce a body of knowledge about specific fields of inquiry. As they achieve an understanding of their subject, scholars publish the results of their interpretations (that is, their research findings) in the form of explanations.

Explanation, then, can be said to organize and communicate understanding. When reduced to agreed-upon theoretical principles, the explanations that emerge from this process of organizing understanding are called concepts.

Concepts serve many functions. They help us identify topics we think about, help classify these topics into related sets, relate them to specific times and places, and provide us with definitions. Without concepts, someone has said, "man could hardly be said to think."

Like knowledge itself, the meanings of concepts are fluid. From the moment an authority introduces a concept into a discipline's vocabulary, where it is given a specific meaning, that concept has the potential to acquire a variety of meanings. As new understandings develop in the discipline, inevitably the meanings of concepts are revised.

Although this pattern in the formation of the meaning of concepts is widely recognized, few dictionaries—certainly none in a consistent manner—trace the path a concept takes as it becomes embedded in a research topic's literature.

Dictionaries in this series uniformly present brief, substantive discussions of the etymological development and contemporary use of the significant concepts in a discipline or subdiscipline. Another feature that distinguishes these dictionaries from others in the field is their emphasis upon bibliographic information.

Volumes contain about 100 entries. Consistently, entries comprise four parts. In the first part, brief statements give the current meaning of a concept. Next,

discursive paragraphs trace a concept's historical origins and connotative development. In part three, sources mentioned in part two are cited, and where appropriate, additional notes briefly highlight other aspects of individual references. Finally, in part four, sources of additional information (that is, extensive reviews, encyclopedia articles, and so forth) are indicated.

Thus, with these volumes, whatever the level of their need, students can explore the range of meanings of a discipline's concepts.

For some, it is the most fundamental need. What is the current meaning of Concept X? Of Concept Y? For others with more intensive needs, entries are departure points for more detailed investigation.

These concept dictionaries, then, fill a long-standing need. They make more accessible the extensive, often scattered literature necessary to knowing a discipline. To have helped in their development and production is very rewarding.

Raymond G. McInnis

Preface

This small book has taken a large amount of time and effort to complete. Ray McInnis came up with the idea, importuned me to undertake the task, and has borne with me patiently for several years. He gets my thanks but can take none of the blame for anything that is wrong; that is all my fault. I also owe a debt of gratitude to Deborah Poff of Mount St. Vincent University, Halifax, Nova Scotia. When I got bogged down, she agreed to do a portion of the book and then signed on as coauthor. As things turned out, her chores as women's studies director forced her to abandon the task, but not until after she had provided the first drafts of about ten of the entries—and her influence shows up in other unmistakable ways.

I would like to dedicate this book to the memory of two people—my mother, Catherine Durbin, and the medieval polymath, Albert the Great. When Albert died, someone is supposed to have said of him, "Omne scibile scisti" ("You knew everything there is to know"). When I was growing up, my mother never dissuaded me from becoming a know-it-all; indeed, she encouraged it, little knowing what havoc it would wreak.

Nowadays, no one can know it all. To summarize all of human knowledge takes an army of encyclopedists—and they have to start all over the day the encyclopedia is published. Even in a single field like philosophy of science (and I was originally supposed to cover the history of science too!), it takes a small squadron to cover the field at all adequately; see, for instance, Peter Asquith and Henry Kyburg, eds., *Current Research in Philosophy of Science* (1979), and Guttorm Fløistad, ed., *Contemporary Philosophy: A New Survey*, vol. 2: *Philosophy of Science* (1982). These two works, and the others to be mentioned here, are cited *by short title only* in the Sources of Additional Information section of many entries. Full citation is provided at the end of the book, on p. 345.

Other books that I have found helpful include the following: W. F. Bynum, E. J. Browne, and Roy Porter, *Dictionary of the History of Science* (1981); Paul T. Durbin, ed., *A Guide to the Culture of Science, Technology and Medicine* (1980, 1984), and especially in that volume the survey of philosophy of science by Alex Michalos; Mortimer J. Adler, *The Great Ideas: A Syntopicon of Great Books of the Western World* (1952); and Paul Edwards, ed., *The Encyclopedia of Philosophy* (1967). For the ten or so entries that touch on the social sciences, I was aided by David L. Sills, ed., *International Encyclopedia of the Social Sciences* (1968).

There are two especially useful histories of philosophy of science that I found helpful: Ralph M. Blake, Curt J. Ducasse, and Edward H. Madden, *Theories of Scientific Method: The Renaissance through the Nineteenth Century* (1960); and John Losee, *A Historical Introduction to the Philosophy of Science* (1972, 1980). These books are also cited often.

This work is intended to complement textbooks in the philosophy of science. The two best are still Carl G. Hempel, *Philosophy of Natural Science* (1966) for beginners, and Ernest Nagel, *The Structure of Science* (1961) for advanced students. The only other textbook that even comes close to covering the whole range of the philosophy of science, as the field is envisioned here, is Frederick E. Mosedale, *Philosophy and Science: The Wide Range of Interaction* (Englewood Cliffs, N.J.: Prentice-Hall, 1974), though I have not cited it. Throughout, I have shamelessly used my own textbook, *Philosophy of Science: An Introduction* (1968), even though it has long been out of print.

The task of completing the volume could never have been carried out without the diligent and untiring efforts of the secretaries in the Department of Philosophy at the University of Delaware. Mary Imperatore has put up with my demands throughout the project, and over the years she has been assisted by Teresa L. Brooks, Elizabeth H. Pierce, Isabelle E. Nye, and Dorothy J. Milsom. Thanks to all of them.

Thanks, too, to my wife, Lydia Robb Durbin, and to my children and stepchildren.

Introduction

This book was originally conceived as a dictionary of controversial concepts in the history and philosophy of science, designed to accompany a set of similar concept dictionaries covering various fields in the social sciences. As contrasted with the natural sciences, the social sciences are generally thought to be younger and less well developed. Social scientists are accordingly more likely to devote a significant portion of their efforts to methodological and other foundational concerns than are natural scientists. The latter tend to worry about foundational issues mainly at times of great upheaval—for instance, during the Einsteinian or quantum revolutions in physics in the early twentieth century or during the period when plate tectonics was a new theory in mid–twentieth-century geology. In the social sciences, many people agree, controversies over methodological foundations go on all the time. This suggests that a book on concepts in the philosophy of science would make a good companion to a series on concepts in the social sciences.

THE USEFULNESS OF PHILOSOPHY OF SCIENCE

Philosophy of science as currently practiced in academic circles in the United States and other English-speaking countries, however, as it turns out, is much more concerned, directly, with the natural than it is with the social sciences. The relevance of philosophy of science to social science procedures, in most cases, is indirect. Philosophy of science is concerned in general with what it means for any science to be scientific, with how theories relate to facts in science, and sometimes with how science compares with other intellectual disciplines.

This book, then, reflects the state of the art in contemporary academic philosophy of science to a much greater degree than it serves as an adjunct to a

series on concepts in the various social sciences. What it is, in short, is a summary of approximately one hundred basic controversies (or would-be controversies) covering all the subfields in contemporary philosophy of science—including the philosophy of social science. The most likely users of the book are upper level undergraduate students taking a philosophy of science course or thinking about doing so, graduate students similarly situated, or educated general readers who would like to know what all the fuss is about when those esoteric philosophers of science get together to debate. No previous acquaintance with academic philosophy of science is assumed, and every effort has been made to translate technical jargon (a singular failing in the field) into tolerably readable ordinary English. More advanced students and professionals in the field may complain that the concepts have been watered down; hopefully, on examination, they will agree that there is no more distortion than popularization or simplification requires.

HOW TO USE THIS VOLUME

One of the key features of this volume—perhaps more important than the encyclopedia-like entries themselves—is the bibliography that accompanies each major entry. Great care has been taken to make the bibliographies both historically representative—showing how controversies have developed over the years, often over the centuries—and genuinely helpful to beginning students. In a field as technical as the philosophy of science has become in the past half century, it is impossible to avoid all technical concepts. It would not even be useful to do so. But wherever possible introductory references are given along with references to major contributors to the controversies.

As with any encyclopedia-like work, it is not expected that readers will go through the volume from beginning to end. Its chief utility is as a sampler, but it also serves as a guide to controversies the reader has already at least heard of. Though each entry has a concept heading, like a dictionary, the focus in each case is on the controversy or controversies that has or have grown up around the concepts. Some roughly similar volumes include a list of fields with references to related controversies; that has not been done here on the assumption that anyone likely to pick up the volume already has key controversial ideas in mind to look up. In short, this is a volume to be dipped into at selected spots—though an effort has been made to cover at least the major controversies in the myriad subfields of contemporary philosophy of science.

In this respect, the volume does not in fact stand alone. It will be useful primarily as a supplement to a textbook or some other introductory survey. But in the contemporary situation in the philosophy of science, the volume also needs supplementation in another respect. Today, the philosophy of science is much more history oriented than it was twenty-five or thirty years ago. As originally envisioned, this volume, in fact, was to have been a survey of concepts in the history as well as the philosophy of science; but before the project was well

begun, the *Dictionary of the History of Science* appeared, edited by W. F. Bynum, E. J. Browne, and Roy Porter. The serious student will want at all times to keep that volume next to this one—and consult both. The *Dictionary* even has entries on the philosophy of science, though only rarely are the bibliographical references as complete or as tailored to beginners as they are in this volume.

HISTORY AND PHILOSOPHY OF SCIENCE

Reference to the history and philosophy of science in the same breath—and the linking of the two, occasionally also with social studies of science, in academic institutions—requires a word about the attitude in this volume toward that issue, which remains controversial. The overriding assumption here is that controversies in the philosophy of science arise in historical context. Philosophers of science sometimes behave as if all their controversies were "internal," generated exclusively by one philosopher's reading of another philosopher's work. But this surely is a matter of myopia or disciplinary narrow-mindedness. At the very least, controversies in the philosophy of science have arisen in response to developments in the history of science, but it seems equally sure (though the claim is controversial) that philosophers of science end up debating, in their fashion, the same sorts of issues that are debated at any given time in general intellectual circles. The most obvious examples are the rise of academic philosophy of science itself in the first place—as an offshoot of logical positivism, which clearly reflected the antireligious and antimetaphysical views of its founders—and, more recently, debates about the merits of sociobiology or of the claims of inherited differences in IQ, directly paralleling public debates in other fields over racism and similar issues.

HISTORY OF SCIENCE AS A SOURCE OF PHILOSOPHICAL CONTROVERSY

If we leave the more controversial aspects of this history-is-basic claim aside, it remains relatively less controversial to say that most problems in the philosophy of science have appeared as a result of developments in the sciences. What follows is a sampler.

The oldest and most obvious example of the influence of developments in the history of science on the philosophy of science is astronomy—from the earliest rise of philosophical speculation out of primitive astronomy (or astrology) to the Copernican revolution to Albert Einstein's (1879–1955) astrophysical theories about the finitude of the universe. However, anatomy was only slightly less influential during the rise of modern science; indeed, in one respect—the dissection of cadavers and the utilization of surgery to provide a basis for experimentally verified anatomy—anatomy has been called crucial to the development of modern science, especially modern biology. Leonardo da Vinci (1452–1519) is often credited with being among the first to break the taboo on dissecting

corpses, and Andreas Vesalius' (1514–1564) *De corporis humani fabrica* (published in 1543, the same year as Nicholas Copernicus' [1473–1543] *De revolutionibus orbium coelestium*) led almost immediately to such experimental work as William Harvey's (1578–1657) *De motu cordis* (1628). Though the "new science" as a name for the revolutionarily different approach to nature—relative to medieval natural philosophy—is generally associated with Galileo Galilei (1564–1642) and his astronomical theories, experimentalism came in with anatomy every bit as much as with physics (and, obviously, more than with astronomy). These scientists can be looked up in Charles Gillispie, ed., *Dictionary of Scientific Biography* (New York: Scribner's, 1970), or in Isaac Asimov's *Biographical Encyclopedia of Science and Technology* (Garden City, N.Y.: Doubleday, 1964, with later editions, but no references).

Broadening our scope and looking at the history of biology more generally, it is hard to see how anyone could deny that developments in the philosophy of science—and, more recently, in the special subfield of the philosophy of biology—have closely paralleled developments in biology. At the very beginning, a philosophical approach to biology, that of Aristotle, grew out of studies in natural history; some people even claim that Aristotle's whole philosophy—quite scientific in its orientation when contrasted with the philosophy of Plato—was biologically oriented and rooted in his (and others') natural history studies. However, natural history only finally attained the status of a scientific discipline, by modern standards, in the eighteenth century with the work of Carolus Linnaeus (1707–1778) and Georges Buffon (1707–1788) shortly after Newton's systematization of physics and astronomy. Along with anatomy, then, natural history took its place as one of the "new sciences" in the revolt against medieval natural philosophy. Then, in the nineteenth century, there was a veritable explosion of biological discoveries—the new cell theory of Matthias Schleiden (1804–1881) and Theodor Schwann (1810–1882); J. J. Berzelius' (1779–1848) studies in biochemistry and Justus Liebig's (1803–1873) applications to agricultural experimentation; Charles Darwin's (1809–1882) publication of *On the Origin of Species by Means of Natural Selection* in 1859 and Gregor Mendel's (1822–1884) publication of his paper on genetic inheritance in 1866—and every single one of these biological advances provoked discussion in philosophical circles (Mendel's after the genetic mechanism was independently rediscovered around 1900). And, of course, everyone knows about the philosophical turmoil created by twentieth-century advances in biology, from genetics to neo-Darwinian evolutionary theory to the structure of DNA to recombinant DNA. It might even be said that biology, in its long history since the beginnings in ancient Greece, has given rise to more philosophical controversy than any of the sciences—though the focus of most philosophers of science on physics and the relatively small size of the philosophy of biology subfield does not accurately reflect that situation. The best sources for the influence of biology on philosophy are William Coleman, *Biology in the Nineteenth Century* (New York: Wiley, 1971); David L. Hull, *Darwin and His Critics* (Cambridge, Mass.: Harvard University Press,

1973); and Garland Allen, *Life Science in the Twentieth Century* (New York: Wiley, 1975).

A closely related example, the role of the so-called germ theory of disease in the development of modern scientific medicine, can be mentioned much more briefly. For those who see the work of, for instance, Louis Pasteur (1822–1895), Joseph Lister (1827–1912), and Ignaz Semmelweiss (1818–1865), or Walter Reed (1851–1902), as inaugurating a new science-based medicine, the discovery of the transmission of diseases by germs or bacteria represents a major advance in the history of both medicine and science. See Charles E. Winslow, *The Conquest of Epidemic Disease* (Princeton, N.J.: Princeton University Press, 1943). On the other hand, other authors maintain that modern public sanitation and public health movements have done as much to eradicate disease as any cures aimed at attacking germs or bacteria or viruses. See, for instance, Thomas McKeown, *The Modern Rise of Population* (New York: Academic Press, 1976). In philosophical terms, this is one version of the popular argument over curative versus preventive or environmental medicine.

Chemistry in general has produced fewer philosophical controversies than other sciences. Nonetheless, in the nineteenth century a number of philosophers joined with many scientists in expressing doubts about the new atomic theory, and in the twentieth century applied chemistry and chemical engineering in industrial settings have given rise to philosophical controversy—especially over the ecological damage that seems so often to be a concomitant of industrial development.

Geology has not often been a science that has captured the popular imagination. In the early nineteenth century, the work of Charles Lyell (1797–1875) on geological eras seems to have contributed to popular receptivity toward the idea of evolution. See Charles C. Gillispie, *Genesis and Geology: A Study in the Relations of Scientific Thought, Natural Theology, and Social Opinion in Great Britain 1790–1850* (Cambridge, Mass.: Harvard University Press, 1951). However, it was more than a hundred years before geology became popular again, this time when the theory of tectonic plates or continental drift began to take hold. And, sure enough, within a decade or so, philosophers of science took notice. See, for example, Henry Frankel, "The Career of Continental Drift Theory: An Application of Imre Lakatos' Analysis of Scientific Growth to the Rise of Drift Theory," in *Studies in the History and Philosophy of Science* 10 (1979): 305–324; or the interchange between Rachel Laudan, "The Recent Revolution in Geology and Kuhn's Theory of Scientific Change," and Michael Ruse, "What Kind of a Revolution Occurred in Geology?," both in P. Asquith and I. Hacking, eds., *PSA 1978*, vol. 2 (East Lansing, Mich.: Philosophy of Science Association, 1981), pp. 227–39 and 240–73.

Finally, and of course, physics has generated seemingly unlimited debates in the philosophy of science. Whether in the beginning of philosophy when Aristotle debated with the ancient atomists over the constitution of matter, or with the rise of the "new science" in the seventeenth century (Galileo versus the medieval

speculative natural philosophers), or after the publication of Isaac Newton's (1642–1727) synthesis—David Hume (1711–1776) and Immanuel Kant (1724–1804) are just two of the famous philosophers who thought that the direction of philosophy should be set by Newtonian physics—or in the twentieth century, for example, the philosophical debates over relativity or quantum mechanics, in every era in Western history developments in physics have generated controversies for philosophers of science. As one fine example, see Milic Capek, *The Philosophical Impact of Contemporary Physics* (Princeton, N.J.: Van Nostrand, 1961).

There may be more controversy over general historical influences on the philosophy of science, but there ought to be little controversy over the fact that developments in the sciences almost always lead to controversies in the philosophy of science. At any rate, that has been a leading assumption in this book. The examples cited here—of anatomy and biology (including genetics) and the germ theory of disease, of chemistry and geology and physics—are not given separate entries in the text. Other sciences, such as anthropology, astronomy, and social science—where philosophical controversy seems inescapable—do have separate entries.

BON VOYAGE

One thing it is hoped this volume might accomplish is to help students of the sciences to recognize that science is as controversial a field of human intellectual endeavor as any other. Scientists strive to be objective, and they hope their controversies will be resolved in an experimental fashion (in some broad sense). But science is, like any creative endeavor of the human mind, primarily a matter of intellect and imagination; and controversies are thus inevitable—and welcome. Hopefully, students will learn from the study of controversies in the philosophy (and history) of science that argumentation and debate are good things; they may even learn thereby to be more critical and challenging in their approach to the study of the sciences.

DICTIONARY OF CONCEPTS IN THE PHILOSOPHY OF SCIENCE

Contents

A

ANALOGY. 1. A comparison, usually one based on limited likeness; in this sense, related to the use of METAPHOR. 2. More technically, a class of predicates (or predications) distinguished from ''univocal'' predicates (which have a single, clear, unambiguous meaning or referent) at one extreme and from complete ''equivocation'' (same term with totally unrelated meanings) at the other extreme. Obviously, this broad categorization allows much ambiguity about what counts as analogical, between almost unambiguous meanings and limited—sometimes deliberate or calculated—equivocation; this definition also does nothing to clarify various uses of analogy, nor does it clarify the relationship between analogy and metaphor. 3. Again technically, isomorphism or a relation between two formal systems (in logic or mathematics) according to which the relations within one system are the same as those of the other—but not so much the same that the two are logically equivalent. 4. An inferential procedure involving any of the above (1–3), especially one utilized in the discovery process in science, in invention or technical design, or, more broadly, anywhere there is an imaginative search for new knowledge or meanings. (See MODEL and SYMBOL.)

It was Aristotle who first explicitly recognized a sort of meaning lying between the unambiguous (or univocal) and the clearly ambiguous (or equivocal), even occasionally using the term ''analogical.'' Aristotle also explicitly recognized that the predicate ''being'' may legitimately be applied to a wide variety of subjects, not all of them ontologically (or epistemologically) on the same level (*Metaphysics*, book IV, chap. 1).

Medieval philosophers and theologians greatly expanded on this because they saw the ''analogy of being'' as a convenient way of dealing with problems associated with the knowledge of God, especially in relation to creatures. They distinguished at least two kinds: analogy of ''attribution'' and analogy of (proper)