Reality and Rationality

Wesley C. Salmon

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EDITED BY

Phil Dowe and Merrilee H. Salmon

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Editors' Preface

Wesley Salmon (1925–2001) has been aptly described as one of the most influential philosophers of science of the second half of the twentieth century. His work falls into three main areas: explanation and causality, space and time, and inductive reasoning. *Causality and Explanation* (New York: Oxford University Press, 1998) nicely anthologized his work in the first area. This collection attempts to do the same for the third.

"Reality," the first part of the book, presents Salmon's view that scientific realism is true and is appropriately defended by empirical arguments. The second part, "Rationality," lays out his characteristic inductivist and Bayesian account of how empirical reasoning best operates. Both parts contain introductions especially prepared by the author and articles previously published throughout his working life, chosen and edited by him for this collection. Two of the chapters are not published elsewhere. He also wrote new appendices for several of the chapters. In addition to the works included here, he had intended to add a third part, entitled "Reactions," in which he responded to works of several other philosophers. He said that when the book was finished, he would feel that it presented a fair picture of his contributions on the topics of reality and rationality. Unfortunately, he did not live to complete the last part. Nevertheless, we believe that the chapters that make up this book form a lucid and cohesive account of the problems treated therein and that bringing these articles together provides a chance for readers to recognize important connections that would not otherwise be apparent.

In the fall of 2000, the Center for Philosophy of Science at the University of Pittsburgh held a workshop entitled "Induction/Probability and Causation/Explanation" in honor of Wes's retirement from teaching. In his moving closing comments, he said that he felt his work on these areas was largely completed and that he was happy to retire while knowing that the philosophical topics he cared most about were being left in the "younger and more capable hands" of

his former students and colleagues. In that spirit, we would like to dedicate the book to all those students and colleagues—as well as future students of his work.

The editors would like to thank Paul Humphreys, Patrick Maher, James Woodward, and Peter Ohlin for their helpful comments and support.

Author's Preface

Two perennial philosophical questions motivate this collection of essays. First, is science a rational enterprise? Second, does science yield objective information about our world, in particular, about the existence and nature of aspects that we cannot observe directly with our normal unaided sense organs? Although these questions have been addressed by many philosophers, two are at the front of my mind as I undertake these inquiries. The first is Thomas S. Kuhn, whose book *The Structure of Scientific Revolutions* (1962) led many philosophers to question the rationality of science. Although Kuhn has often been accused of denying that science is rational, he rejects the charge, maintaining instead that mature physical science is the best example of rationality we can appeal to. The problem, according to Kuhn, is to discover just what such rationality consists in. I want to join him in this enterprise. The second philosopher is Bas C. van Fraassen, whose 1980 book, *The Scientific Image*, argues that we cannot have knowledge of unobservable entities and processes. His *constructive empiricism* does not deny their existence but rather the possibility of our knowing anything about them. His position is therefore agnostic regarding many entities to which accepted scientific theories seem to refer. I want to show, to the contrary, that such knowledge *is* possible and how it is in fact achieved.

The two questions just mentioned intersect substantially, and the locus of intersection is in the area of scientific confirmation and inductive inference. I begin with the realism issue. Its consideration leads us directly into a careful examination of scientific confirmation and inductive reasoning. These in turn lie at the core of the rationality issue. Although it might seem logically preferable to begin with induction and confirmation, I believe it is heuristically desirable to start with the question of realism. We see in the first chapter that this question provides strong motivation for tackling confirmation, induction, and the rationality of science.

In *The Structure of Scientific Revolutions* (1960, 1972), Kuhn maintained that choices among scientific theories are based on considerations that go beyond observational data and logic, even if logic is taken broadly enough to include

scientific confirmation. In order to evaluate this claim we need to consider explicitly—*as Kuhn did not*—the nature of scientific confirmation. My conjecture is that Kuhn was thinking of scientific confirmation in terms of a simple hypothetico-deductive model. I argue that a Bayesian approach provides a more satisfactory conception of confirmation—one that allows us to construe "logic" in still broader terms, enabling us to incorporate within logic considerations that probably seemed to Kuhn to fall outside its scope. This approach allows us at least partially to bridge the gap between Kuhn's historically oriented philosophy and that of such logical empiricists as Rudolf Carnap, Carl G. Hempel, and Hans Reichenbach.

Empiricism is a major theme in van Fraassen's *Scientific Image*; indeed, it takes as its point of departure the thesis that empiricism and realism are incompatible doctrines. I claim, to the contrary, that they are fully compatible. In order to see how this can be, we need to look carefully at the meaning of empiricism—we must, in fact, see what constitutes its *key question*. Twentieth century empiricists have, to a large extent, focused their attention on the meanings of theoretical *terms*. This strikes me as a mistake. We should ask, instead, how—if at all—it is possible to confirm theoretical *statements*, that is, statements about unobservable entities. The key question that thus emerges is whether inductive logic contains the resources to provide legitimate inferences from data about observables to conclusions about unobservables. I offer an affirmative answer.

This book is divided into two parts, Reality and Rationality. The first part addresses the problem of scientific realism, the second deals with issues concerning scientific confirmation.

Part I: Reality

The first chapter in this collection, "Realism and Empiricism: The Key Question," attempts to articulate the question clearly, to place it in historical context, and to set out the fundamentals of the affirmative response. At the most basic level, I claim, reasoning from observables to unobservables involves inferences that are both causal and analogical. In the second chapter, "Scientific Realism in the Empiricist Tradition," I offer a critical examination of the approaches to realism of two philosophical giants: Rudolf Carnap and Hans Reichenbach. This discussion leads immediately to the third chapter, "An Empiricist Argument for Realism," which tries to show how the considerations that convinced serious physical scientists of the reality of atoms and molecules in the early years of the twentieth century provide a philosophically sound argument for realism that does not exceed the bounds of empiricism. This argument differs substantially from the many defenses of realism that have been offered in response to van Fraassen's book.

Part II: Rationality

Van Fraassen's basic answer to my defense of realism is to doubt that the sort of inductive logic I envision even exists. To answer this challenge I turn to a discussion of the Bayesian approach to confirmation and to the basic considerations

involved in my response to Kuhn. Any appeal to Bayes's theorem is bound to raise questions about the nature of prior probabilities; my answer is embodied in the fourth chapter, "Plausibility Arguments in Science."

When I first looked at Kuhn's *Structure*, I was shocked by his rejection of the distinction between the *context of discovery* and the *context of justification*. Because this distinction seems to me to have fundamental importance, I offered the reply contained in the fifth chapter, "Discovery and Justification." It seems to me likely that Kuhn's problem with the discovery/justification distinction might have arisen from a puzzlement about the role of plausibility considerations in the evaluation of theories. Reflection on the history of science shows, I believe, that plausibility arguments play an essential role; yet, by their very nature, they *seem* to pertain to the discovery rather than the justification of theories. My strategy is simply to identify plausibility assessments with the prior probabilities, which, as Bayes's theorem shows, constitute an indispensable part of the context of justification. This approach goes a long way in overcoming Kuhnian worries about considerations affecting theory choice that go beyond observation and logic—including confirmation. In the sixth chapter, "Rationality and Objectivity in Science," I bring these ideas to bear directly on Kuhn's problems concerning theory preference and theory choice. The seventh chapter, "Revisions of Scientific Convictions," also deals with prior probabilities, in this case as a response to van Fraassen's discussion of Bayesianism in his *Laws and Symmetry* (1989). The eighth chapter, "Dynamic Rationality" defines various grades of rationality and addresses the question of the relationship between rationality and objectivity within Bayesian confirmation theory.

Chapters 4 through 8 show how Bayes's theorem helps us to deal with certain profound and problematic issues in contemporary philosophy of science. The ninth chapter, "Hume's Arguments on Cosmology and Design," is a sort of encore, showing how the same theorem can be applied to the thesis that scientific evidence can be offered, in the form of the *design argument*, for the existence of God.

The remaining three chapters in this part take a deeper look at confirmation and induction—that is, at the foundations of rationality. The tenth chapter, "The 'Almost-Deduction' Theory," turns from Bayes's theorem to the theorem on total probability to undermine what might be called "the almost-deduction notion of induction" and to expose certain dangers that lie within it. The eleventh chapter, "The 'Partial-Entailment' Theory," considers the intuitively appealing idea of founding inductive reasoning on a relation of partial entailment in much the same way as deductive reasoning can be seen as founded on full entailment. This idea, which seems to have appealed heuristically to Carnap as well as many other philosophers, turns out to be unable to bear the weight. Incidentally, the original version of this chapter, which was published long before the notorious Popper-Miller 'theorem' on the impossibility of inductive support, shows clearly the defect in their 'demonstration'. The twelfth chapter, "Confirmation and Relevance," discusses ramifications of the fundamental distinction between two different senses of confirmation, namely, high degree of confirmation (or high probability) and incremental confirmation (or increase in degree of probability). As this chapter demonstrates, confusion of these two senses has led to serious difficulties in confirmation theory.

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Introduction

It is widely agreed that we live in a "postpositivist" era; these days the word "positivist" functions chiefly as an ill-defined term of abuse. Logical positivism is dead.[1] One cannot deny, however, that it was a potent philosophical force in the earlier part of the twentieth century; many conferences, books, and articles have endeavored to assay that influence. One conference, which generated such a book, was held in Pittsburgh in 1983.[2] The first chapter in the present collection was my contribution to that conference.

1. Realism and Empiricism: The Key Question

Logical empiricism is the direct descendent of logical positivism. For that reason I chose it as the focus of my paper for the conference on "The Heritage of Logical Positivism." It was also the dominant approach to philosophy of science in the pre-Kuhnian period. As its name implies, logical empiricism adopts an empirical approach to scientific knowledge, freely employing the tools of modern logic. After a brief nod to achievements in formal logic, I direct attention to empiricism and the problems it encounters. One of the most difficult questions concerns the possibility of knowledge of unobservable entities, that is, the problem of scientific realism. This issue was also a major point of disagreement between logical positivists and logical empiricists. The key question, as I see it, is "whether inductive reasoning contains the resources to enable us to have observational evidence for or against statements about unobservable entities and/or properties." I argue for an affirmative answer in part I. The main purpose of the first chapter is, however, just to state the question explicitly and urge its careful consideration. As I say immediately after articulating it, "The most surprising thing about the *key question* is how seldom it has been raised explicitly."[3]

2. Scientific Realism in the Empiricist Tradition

Rudolf Carnap and Hans Reichenbach were both born in 1891; in 1991 this dual centennial was celebrated at many conferences in Europe and America. One such meeting, sponsored jointly by the University of Pittsburgh and the University of Konstanz, was held in Konstanz (see Salmon and Wolters 1994). On that occasion the University of Konstanz conferred an honorary doctorate upon Carl G. Hempel, the most distinguished living representative of the logical positivist/logical empiricist movement. This is the paper I presented in his honor on that occasion.

Prior to 1933, when Hitler came to power, Carnap was a member of the Vienna Circle of logical positivists, Reichenbach was the leader of the Berlin group of logical empiricists, and Hempel was closely associated with both groups. Subsequently these philosophers became the most influential leaders of logical empiricism.[4] Over a period of several decades they struggled with problems concerning the existence and nature of unobservable objects and the meanings of theoretical statements and terms. Although, in my opinion, Reichenbach's position was the most tenable of the three, his exposition of that viewpoint was far from clear. Attempting to sort out the various arguments involved in the discussion among these three figures is both historically and philosophically illuminating.

3. An Empiricist Argument for Atomism

Taking atoms and molecules as prime examples of unobservable entities, I asked myself why contemporary scientists believe that there are such things. This approach to the fundamental issue of scientific realism reflected my general dissatisfaction with arguments offered by philosophers for or against the existence of unobservables. I was first led to address these questions in connection with concerns about the nature of theoretical explanation in the sciences.

John Dalton advanced his atomic theory in 1808, and the molecular-kinetic theory of gases had been elaborated in great detail before the end of the nineteenth century. Nevertheless, at the turn of the twentieth century knowledgeable physical scientists did not agree about the actual existence of atoms and molecules. During roughly the first decade of the twentieth century—1908 is an especially important year[5]—an almost universal consensus did emerge. As Mary Jo Nye (1972) made clear, the work of Jean Perrin on Brownian motion and Avogadro's number played a crucial role.[6] Avogadro's number can be viewed as *the link* between the microcosm and the macrocosm; given various macroquantities we can, with its aid, calculate numerous microquantities and vice versa. With the assurance that Avogadro's number is, indeed, the number of molecules in a mole of any given substance, we can establish many facts about unobservable entities.

Using a variety of historical sources, including Perrin's own account (Perrin [1913] 1916), I trace some of the most significant trials and tribulations of the

atomic/molecular theory of the constitution of matter from Dalton to Perrin, and I offer a philosophical reconstruction and analysis of Perrin's decisive argument. This argument seems to me to be cogent, and I commend it to those who are interested in scientific realism.

To this paper I have added an appendix dealing with a rather specific issue about scientific realism. It deals with a truly 'far out' form of antirealism; it is Ian Hacking's extragalactic antirealism. I argue that, contra Hacking, we have adequate evidence to believe in the existence of at least some types of entities located beyond the confines of our own galaxy.

Although all three chapters in part I have strong historical slants, they deal with issues that are very much alive today. Taken together they seem to me to provide the best contemporary answers to our questions about scientific realism.