Fictions in Science

Philosophical Essays on Modeling and Idealization

Edited by Mauricio Suárez

Routledge
Taylor & Francis Group
New York London

First published 2009
by Routledge
270 Madison Ave, New York, NY 10016

Simultaneously published in the UK
by Routledge
2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN

Routledge is an imprint of the Taylor & Francis Group, an informa business

Typeset in Sabon by IBT Global.
Printed and bound in the United States of America on acid-free paper by IBT Global.

The essay in chapter 1 first appeared as Fine, A. (1993), "Fictionalism," *Midwest Studies in Philosophy*, Vol. 18, pp. 1–18, and is reprinted here courtesy of Blackwells' publishers.

Library of Congress Cataloging in Publication Data

Fictions in science : philosophical essays on modeling and idealization / edited by Mauricio Suárez.
p. cm. — (Routledge studies in the philosophy of science ; 4)
Includes bibliographical references and index.
ISBN 978-0-415-99035-6
1. Science—Philosophy. 2. Science—Methodology. I. Suárez, Mauricio.
Q175.F474 2009
501—dc22
2008018425

ISBN10: 0-415-99035-1 (hbk)
ISBN10: 0-203-89010-8 (ebk)

ISBN13: 978-0-415-99035-6 (hbk)
ISBN13: 978-0-203-89010-3 (ebk)

Contents

Acknowledgments

The idea for this volume came to me during a small workshop that took place in February of 2006 at Complutense University in Madrid. Some of the papers collected here were delivered then in an embryonic form. I would like to thank the participants at this workshop, as well as those contributors who joined the project at a later stage, for their enthusiasm and encouragement throughout. Arthur Fine in particular inspired my interest on fictionalism over a decade ago at Northwestern University, and his support has been constant and unfailing since. The award of a Leverhulme Trust Fellowship during 2001–2 allowed me to start working on this project. Later on, the institutional support from the Rector's Office at Complutense University, and in particular the Vicerectors of Research (Carlos Andradas) and International Relations (Lucila González Pazos), was decisive. Financial support is also acknowledged from the Spanish Ministry of Education and Science (research projects HUM2005–01787-C01–03 and HUM2005–0369). In addition I would like to thank all those people who chaired sessions and contributed to the discussions during the workshop. Thanks also to the members of my research team who helped with logistics and the organization. Albert Solé in particular provided editorial help in the final stages of putting the volume together. Erica Wetter from Routledge was an enthusiastic and supportive editor from the start. On a more personal note, Samuel Suárez taught me much about hobbyhorses, game-playing, and the imagination in general. This effort is dedicated to him.

Madrid, December 2007

Part I
Introduction

1 Fictions in Scientific Practice

Mauricio Suárez

1.1 FICTIONALISM IN THE PHILOSOPHY OF SCIENCE

This volume collects thirteen essays by prominent contemporary philosophers of science on the role that fictions and fiction-making play in the practice of theorizing and model-building in science. The topic itself is not new in philosophy of science, because fictionalism has a long history in the discipline that goes back at least to the writings of Hans Vaihinger in the early years of the 20th century. Although Vaihinger's work was very popular in his own time, it fell into a kind of oblivion for years afterward, coinciding with the rise of logical positivism. The topic made a return to the philosophy of science agenda about 15 years ago, partly in the wake of debates about Bas Van Fraassen's constructive empiricism, which can be construed as a kind of fictionalism about theoretical entities,[1] and partly as a result of the increased attention paid by philosophers to models and modeling in the sciences. However, within philosophy of science the discussion over fictions has so far been rather fragmentary, with references to fictionalism typically playing some minor rhetorical role in the realism–antirealism debate, and appeals to fictions and fictive entities appearing occasionally in diverse case studies devoted to modeling. This might be contrasted with the very extensive treatment of fictions in the philosophy of language and aesthetics literature over at least the last two decades.[2]

The present volume is intended to help to redress the balance. It is the first volume that treats fictions from a philosophy of science perspective.[3] It is also the first collection of papers entirely devoted to the topic of fictions and fictionalizing in scientific practice.[4] It represents the most recent and up-to-date thinking on the topic over a range of scientific disciplines in contemporary philosophy of science. The authors reflect upon the role and function of fictionalizing in the process of building models for natural and social systems. Hence the emphasis is markedly on case studies rather than general philosophical theory, because even the most general philosophical essays refer extensively to case studies from diverse sciences. Thus although the focus is often on the physical sciences, there are also

essays on biology and economics, and references to case studies in other areas of science appear throughout the essays.

1.2 FINE'S VAIHINGER

Although philosophers of science have paid scant attention to fictions, there have been some exceptions. In 1993 Arthur Fine published a seminal article entitled "Fictionalism" where he attempted to bring Vaihinger's philosophy of 'as if' back to the forefront of philosophical debate. Besides promoting a reevaluation of Vaihinger's work, this essay for the first time makes an explicit connection between fictionalism and the modeling literature in the philosophy of science of the last two decades or so. Fine's essay is already cited in anthologies as a classic "revival" piece, and it is the standard contemporary reference on Vaihinger among both philosophers of science and metaphysicians. And because most of the chapters in this volume refer to this essay, often quoting it as a source of inspiration, it is here reprinted as the starting chapter of the book. It appropriately sets the tone and the terms for most of the other essays in the book.

Fine's paper is not a piece of scholarly history but an interested commentary on a historical figure and its relevance for the contemporary debate. In other words, Fine's *Finehinger* is bound to differ from the original Vaihinger, and Fine himself acknowledges some unhistorical elements (Fine, this volume, section 8). The account is arguably anachronistic in the following two senses.[5] An earlier appeal to Vaihinger appears in Bas Van Fraassen's celebrated book *The Scientific Image* (Van Fraassen, 1980, p. 35–36), where Vaihinger's philosophy is cited in support of constructive empiricism's agnosticism regarding theoretical entities. More specifically, Vaihinger's fictionalism is invoked there as ammunition against the verificationist's commitment to the full theoretical equivalence of empirically equivalent theories (roughly, on this account, if two putatively different theories have exactly the same empirical consequences then they really are just the same theory). Van Fraassen argues that by contrast the fictionalist can claim that a theory that postulates a fictional unobservable entity is distinct from its empirically equivalent non-entity-postulating rival theories—even though none of these theories commits in fact to the reality of the entity. And this is just the constructive empiricist's response to the verificationist challenge. Thus, although Van Fraassen does not make the mistake of explicitly pinning the constructive empiricist commitments on Vaihinger, the reader of these passages might be led to suppose a strong association between Vaihinger's fictionalism and present-day antirealism of the constructive empiricist variety.

The association finds echoes in a few passages in Fine's piece, but it is definitely not Vaihinger's—who could not possibly have anticipated logical positivism's verificationism, Van Fraassen's response to it, or the main

arguments in the contemporary realism–antirealism debate. Vaihinger himself was not committed to a fundamental epistemological difference between our knowledge of the observable world and that of the unobservable world. It is even questionable whether he acknowledged the antecedent distinction between observable and unobservable entities or domains of the world.

Another anachronism is arguably Fine's close association of Vaihinger to Neurath. This nowadays looks out of place with Vaihinger's pronounced neo-Kantian *transcendentalism*.[6] The association probably responds to the attempts in the early 1990s to re-evaluate logical positivism by emphasizing its "sociological" strand, and the then comparatively neglected figure of Neurath. Fine is here trying to distinguish Vaihinger's project from Carnap's and Reichenbach's brand of "logicism," and the most straightforward way to do this in the climate of the early 1990s is to associate Vaihinger with the rising counterbalancing figure of Neurath. Arguably, the real Vaihinger is a little less committed to the particularism defended by Fine's Natural Ontological Attitude (NOA). After all, Vaihinger promotes a theory of scientific reasoning, and advances what he takes to be a general theory of the logic of scientific fictions. Both assumptions seem estranged from Fine's NOA, and would have been alien to Neurath. Crucially no anticipation is to be found in Vaihinger of Neurath's most valuable and long-lasting contribution to the theory of knowledge, namely: his holistic epistemology regarding empirical knowledge.

Regardless of any anachronisms, Fine's article has rightly set the agenda for the discussion of fictions in contemporary philosophy of science, and most of the essays in the volume refer to it in such terms.[7] In particular, Fine lays out the connection between fictions and the contemporary philosophical literature on modeling practice more carefully and helpfully than Vaihinger would have been able to do. For Fine the recent literature on idealization and abstraction in science backs up Vaihinger's views, whereas all cases of scientific model-building are instances of Vaihinger's fictionalism at work: "Preeminently the industry devoted to modeling natural phenomena, in every area of science, involves fictions in Vaihinger's sense" (Fine, this volume, p. 34). The essays in this volume address this claim in a variety of ways, sometimes by filling in detail through case studies, sometimes by adding philosophical flesh and argument, and yet at other times by taking issue with the claim or qualifying it to some extent.

1.3 A MAP OF THE BOOK

Part II of the book ("The Nature of Fictions in Science") contains two essays besides Fine's devoted to the nature of fictions in science. Joseph Rouse (Chapter 3) defends the radical thesis that fictions and fictionalizing are not only present in modeling, simulation, supposition, and thought-experimentation. These are activities that we may call "representational" in a broad sense, and may seem prima facie distinct from most of the activities

carried out in experimental science, which typically involve actual causal interventions on experimental systems in real laboratories. Fictions and fictionalizing have typically been thought to be confined to the realm of the "possible" within representational science. Rouse defends the view that fictionalizing also plays a role in the constitution of objects and procedures actually employed in the laboratory sciences. He appeals to case studies from genetics and thermometry in order to back up the claim that hypothetical entities and fictional assumptions are embodied in the material construction of these objects. (The same view is defended by Ankeny in Chapter 12 in relation to model organisms in biology.) The point of such entities and assumptions, according to Rouse, is to introduce alternative concepts, thus opening up a new space of reasons for the justification of scientific belief. Thus fiction-making in science can not be reduced, argues Rouse, to an exercise of expediency whereby false assumptions are employed for inferential or predictive gain. Fictional assumptions are not simply false-but-useful; they actually define both what is false and what is useful. This is a radical new proposal regarding the nature of fiction in science, going beyond the claims by most other contributors to the volume, but very much deserving to be explored.

In addition, Rouse's emphasis on activity and practice ahead of ontology is nicely in line with the rest of the essays in the volume. The contributors to this volume are neither distracted nor particularly concerned with questions regarding *ontology*. The purpose of the book is instead to focus on relevant aspects of the *activity* of model building. It might seem at first sight that Chapter 4 is an exception to this rule, because Barberousse and Ludwig's aim is to fill much-needed detail into the claim—a slogan, really—that scientific models *are* fictions. This *identity claim* about the ontology of models has been made before—for example, by Cartwright (1983, pp. 151–162)—but Barberousse and Ludwig point out that both sides of the identity need to be explicated to take it beyond a mere slogan.

Moreover, the slogan fails to capture the claims defended by the contributors to this book, which are fundamentally distinct. The essays here collected focus on the important role that fiction-making plays within the activity of modeling in science. But they remain on the whole silent on the question "what is a model?" which they tend to view as an issue of secondary importance.[8] However Barberousse and Ludwig's approach to this issue is of a piece with the book's outlook, because they claim that the slogan "models are fictions" is best filled in precisely by putting activity center stage, as opposed to structure or nature, as an account of both models and fictions. In particular they follow Currie (1990) and Walton (1990) in understanding fiction as the activity of imagining and role-playing, as opposed to any putative referential relations between "representans" and presumed "representanda." They then go on to use this view in order to provide a typology of models in terms of their functions (prospective, bridge, and what they call "anti-Duhemian" models).

In keeping with the book's outlook, part III ("The Explanatory Power of Fictions") swiftly moves away from issues related to the nature of fiction toward a discussion of one of the main and most controversial roles that fictional assumptions may play in modeling practice. Recent philosophy of science has emphasized the importance of explanatory virtues in the assessment and evaluation of theories and models alike. A widespread assumption is that false theories that are known to be false may never have explanatory power. Scientific realism backs this up by appeal to the idea that the explanatory power of a theory depends upon its closeness to truth. (So an inference to the most explanatory theory guarantees that the one closest to the truth is selected.[9]) The antirealist disagrees that this is a valid mode of inference (the most explanatory theory need not be closer to the truth), but still finds it difficult to articulate a notion of "explanation" that will fit this bill. So the question "do fictional assumptions have explanatory power?" goes to the heart of the realism–antirealism dispute. The three essays collected in this part of the volume answer this question differently.

First, Catherine Elgin (Chapter 5) argues for a move away from the notion of explanation and toward a more general notion of scientific understanding. Her view is that representation in science is best understood along the lines of Goodman's notion of "exemplification" of properties. Roughly, a model A exemplifies a property B if and only if A is denotative of B and moreover A possesses the property B. (So a concrete model of a building exemplifies fragility if it denotes fragility and *is* fragile.) The advantage of this account, according to Elgin, is that representation does not require actual denotation, but only that the 'representans' be a "denoting symbol or system." In other words, actual successful reference is less important for representation than the *function* of denoting. Because the representational character of models does not depend on successful denotation, a model can be representational just in virtue of purporting to denote, regardless of its actual success in doing so. This allows Elgin to develop an extremely interesting and novel account of explanation, which she refers to as "understanding as exemplification." On this account, fictions and the fictional assumptions made within modeling practice can play a fully explanatory role. Elgin then goes on to argue that there is nothing suspiciously subjective or arbitrary about this form of explanation.

In Chapter 6, Alisa Bokulich takes the issue of the explanatory power of fictions head on, and argues that fictions can definitely be used for explanatory purposes. Her argument proceeds by looking at the details of a case study from contemporary physics, namely, the appeal to fictional classical trajectories in explaining anomalous quantum spectra in the so-called "closed orbit theory" of the atomic nucleus. Bokulich displays textual evidence that scientists find such classical trajectories explanatory in spite of their being known to be fictional. She then puts these explanatory practices on the table as benchmarks for different theories of explanation, and argues that neither Hempel's covering law account nor Salmon's causal-mechanical

account can provide us with a similar philosophical understanding. Instead Bokulich shows that the practice of using fictions explanatorily points toward a further form of explanation, distinct from the previous ones, namely, what she calls "model explanation." In particular, she claims that the explanatory power displayed in her case study can be understood as a subspecies of this form of model explanation, namely, structural model explanation, where the model's structure is the key to the model's explanatory power.

In Chapter 7, Margaret Morrison takes up a famous case study from the history of 19th-century physics, Maxwell's model of the ether. This has of course come down in history as one of the most striking cases of fictions at work in science. Employed for all sorts of explanatory, predictive, and heuristic tasks, the mechanical models of the ether were self-conscious fictions for Maxwell and other Maxwellians throughout the 19th century. Morrison asks the question: How can this fictional assumption play a role in delivering accurate information regarding electromagnetic phenomena? She argues that these models play out their own story by constraining the values of certain important parameters. In addition, Morrison claims that in order to go beyond mere quantitative connections and understand how explanation works, we need to look into idealization and abstraction as separate from fiction. Morrison takes up a different case from genetics, the Hardy–Weinberg law, in order to illustrate these alternative possibilities. So for Morrison it is not the case that every unrealistic assumption employed in science is fictional. This seriously qualifies Vaihinger's original claim for the "ubiquity of fictions in science," restricting its domain of applicability. On the other hand, Morrison agrees that fictions do serve the maxim of expediency—in both reasoning and inference. She does argue, however, that there is no one unique method whereby they achieve such aim in practice.

All three essays in part IV of the book devoted to physics ("Fictions in the Physical Sciences") assume such pluralism regarding the methods whereby fictional assumptions maximize expediency. First, in Chapter 8, Carsten Held focuses on the introduction of posits into theories, and the status of their referential relations. By means of a case study in quantum field theory, Held shows that this status may well change, and often does so throughout the history of the development of a theory. Thus a theory's posit that nowadays has stable reference need not have had it when first introduced. Held is here providing a very nice illustration of Vaihinger's claim that fictions, which are typically not up for empirical 'grabs,' often turn into testable hypotheses—and although sometimes such hypotheses turn out to be (illustrious) mistakes, as in the case of the ether, occasionally they "make it good," successfully achieving stability of reference.

In Chapter 9, I illustrate some of Vaihinger's fundamental distinctions by means of four case studies, two celebrated cases from 19th-century physics (Maxwell's ether and Thomson's atom), and a further two from contemporary physics (models of stellar structure in astrophysics and the

quantum model of measurement). The aim is to show that fictions are not just discarded suppositions of previous failed science, but they play a role in established and accepted science too. I argue that the quantum measurement models provide a striking illustration of the *full fictions* involving self-contradiction that Vaihinger used to talk about, and which most commentators had previously thought to be impossible. Building on Vaihinger's and Fine's claims (shared by Morrison, this volume) I defend the expediency of fictions in inference and reasoning. I go further in arguing that the maxim of expediency in inference (together with a requirement on the empirical testability of consequences when conjoined with further hypotheses) distinguishes appropriately the function of the fictions one finds in science from fictions elsewhere, particularly in the arts. I then show that the inferential conception of representation appropriately accounts for these distinctions, and in particular explains naturally why the fictions one finds in science are governed by the maxim of expedient inference.

In Chapter 10, Eric Winsberg takes up the most pressing objection to Vaihinger's "ubiquity of fictions" claim. Like Morrison, Winsberg argues that of course science is full of idealizing assumptions that are strictly speaking false, and often known to be false by those scientists who employ them. Idealized frictionless planes and penduli abound in scientific models since Galileo's time. But this does not mean, argues Winsberg, that these assumptions are fictional. To be fictional an assumption need not be false (although it may happen to be false), but rather *unconcerned* with the truth. This is an important insight shared by a number of essays in the volume (for more on this topic see section 1.5 in this introduction). But Winsberg goes on to show that it is an insight that does not compromise the fictionalist outlook. Although fictions may not be as ubiquitous in science as Vaihinger and Fine supposed, they are nonetheless often present. Winsberg describes a couple of case studies in support, from nanomechanics and computational fluid dynamics. In both cases fictions are invoked in order to bring or patch together at least two indispensable but otherwise incompatible accounts of the phenomena. The role of fictions is to avoid straight contradiction in such cases, allowing for a variety of empirical predictions to be carried out.

The fourth part of the book ("Fictions in the Special Sciences") takes us away from physics and into other disciplines, which so far have had limited exposure in the book. In Chapter 11, Rachel Ankeny advances the case for fictions in the biological sciences. She first argues that fictional assumptions can generally be mobilized in order to gain real knowledge of the world. A novel and important aspect of Ankeny's claims is that the fictional character of an assumption is not an absolute but a relative matter—it depends on what alternative assumptions it is contrasted with. Ankeny then provides a review of the literature on model organisms, in order to show that different kinds of model organisms in biology display all the characteristics of fictitious entities to some degree. In particular she argues that novel synthetic organisms

display a particularly striking form of fictitiousness: These are artificially constructed objects built and created in order to mimic certain salient aspects of real organisms. In other words, these systems provide an illustration of the thesis that we saw Rouse defending in Chapter 3, namely, that fictional assumptions can sometimes be embodied in real systems and objects.

Chapter 12 raises similar issues for economics. Tarja Knuuttila focuses in particular on the much-debated issue regarding the realisticness of the assumptions in economic models. The issue here is whether such assumptions may be used locally in order to generate models that are globally realistic, as has been argued for instance by Mäki (1994). Knuuttila raises a number of problems with this view in economics, and goes on to argue that a better way to approach the issue takes models to be autonomous and independent entities that can only represent indirectly, in agreement with a pragmatist and inferential conception of representation. Models are then seen to have some of the properties of fiction (while avoiding a wholesale identification of models with fictions). Knuuttila then faces up the greatest challenge for this view, namely: How can we learn anything about the world from considering such autonomous and independent entities? Her answer is of a piece with many of the book's other essays, and assumes that further assumptions will bring out the real-world, or at least empirical, consequences of the model.

The last part of the book ("Fictions and Realism") looks critically at the epistemological consequences of the book's overall fictionalist outlook, particularly as regards the debate over whether science aims at truth. These two essays, by Paul Teller and by Ron Giere, are among the most critical. They both argue that we should not generally identify scientific models with fictions, and that we should not therefore be led to believe that science does not aim at truth, or "truth enough." Although there are fictional assumptions made in the construction of many models, this does not mean that the models themselves are wholly unconcerned with the truth. Rather, the false assumptions made along the way may even help the model get overall closer to the truth. Like Morrison and Winsberg, Teller and Giere operate with a limited notion of fiction, and attempt to show that idealization and abstraction trade in falsity or omission too, but in ways that are innocuous to the realist. The contrast is greatest at this point with Fine, Rouse, Bokulich, Suárez, Ankeny, and Knuuttila—because all these authors tend to follow Vaihinger in looking at fiction and make-believe as a more general category that encompasses crucial aspects of the others. But as a matter of fact the disagreement is less than it might seem. Teller and Giere are particularly critical of the thesis that models are to be identified with fictions. But it has already been noted that the essays in this volume are not actually out to defend this thesis—some of the authors even make it explicit that they find the question about the ontology of models to be irrelevant, or uninteresting. And when it comes to the activity of model-building, Teller's and Giere's essays, like all the others in the book, are able to unearth a variety

of fictional assumptions made by scientists in both theorizing and modeling, thus contributing to the book's general outlook.

1.4 FICTIONALIZING: PRACTICE AHEAD OF ONTOLOGY

The book's focus is unashamedly on the practice of scientific modeling, rather than the abstract nature of models. This means that there is a preference for considering the nature and structure of models, if anything, within the context of the activity of model-building. And rather than considering the metaphysics of the relations of representational sources and targets, the essays focus on the kinds of activities that representations allow scientists to carry out. In other words, in terms of the usual dichotomies, the book emphasizes process over product, procedure over outcome, function over essence, praxis over axiom, activity over ontology.

Similarly, when it comes to fictions, questions about the nature, ontology, and essence of fictitious entities are always framed within the context of the activity of fictionalizing, make-believe, and fiction-making. There exists a huge philosophical literature on the metaphysics and semantics of fiction, with a strong focus on the ontology of fictional entities. The classic positions range from Meinong's notoriously reifying fictional entities to Quine's wholesale dispensing with any abstract entities altogether.[10] This literature links the question of the nature of fiction to the coupled issues of the ontology of fictional entities, and the semantics of the terms and names that our natural languages make available for the putative denotation of such entities. In other words, the issue of the nature of fiction has traditionally been linked to the issue of linguistic reference.

This book takes an alternative approach, which it believes to be more productive for philosophers of science. In particular, the contributors express no anxieties at the lack of a compelling *semantic theory* of fictional terms. Instead, the essays in the book focus on the myriad ways in which fictions are put to use in science, and the role that the activity of fiction-making plays in scientific modeling in particular. Thus although the issue of the nature of fiction is not avoided, it is not answered in any of the ways that would be typical of metaphysical inquiry. Questions regarding the nature of fiction are rather addressed by studying the cognitive functions that fiction plays in scientific inquiry, and in particular in the practice of model-building.

1.5 FICTIONS: TRUTH-CONDITIONAL VERSUS FUNCTIONAL ANALYSES

There is consensus throughout the book that fictions and fictional assumptions play a key role in modeling practice (with some qualified dissent

expressed in the essays by Paul Teller and Ronald Giere in the last part of the book). This is achieved in spite of an array of different views by the contributors on the defining conditions for fictions. Some of the essays (Bokulich, Morrison, Teller, Giere) tend to follow Vaihinger in viewing fictions in modeling as knowingly false assumptions about the systems modeled. A fiction on this account is a description that involves falsehood (or a representation that involves inaccuracy), and one that is known to involve it by the scientists who nonetheless employ it.

We may refer to this as the *truth-conditional account of fiction*, because for an assumption to function as fiction in a model it is required that its users understand the truth conditions of the assumption and be able to assess that it is false. (Or, for a representation, understand its application conditions, and assess it to be inaccurate.) On this account the assumption of the mechanical ether is a fiction for Maxwell, who always assumed his models of the ether to be false in terms of the real causes of the electromagnetic phenomena. But the very same assumption is not a fiction for Trouton or any of the other 19th-century physicists who believed in the reality of the mechanical ether.

However, other contributors (notably Rouse, Elgin, Winsberg) follow a distinct lead in Vaihinger's thought, and defend the view that fictions ought to be characterized functionally by their role in inquiry, rather than truth-conditionally. The character of fiction depends on this view upon the nature of the cognitive processes and functions that fictions allow scientists to perform; nothing substantial hinges on whether the fictions, or fictional assumptions within a model, are true or false. In fact on this, *the functional account of fiction*, the key to the nature of fiction in science lies precisely in the irrelevance of its truth value for its cognitive function. When the function within a model of an assumption about x, or a representation of x, is entirely independent of its truth value, or correctness, we are then in the presence of a fiction. The key to fictionalizing on this account is the free exercise of the imagination that comes with such a release from a concern with truth and truth-conditions. The scientists who employ fictions are required neither to understand their truth conditions nor to assess its truth value. On this account the mechanical models of the ether are fictional for Maxwell, Trouton, and all other 19th-century physicists, because its main role is to bring into agreement frameworks that would otherwise remain separate, and not to get at the truth. Winsberg's *silogens* are a remarkably clear instance of this view.

Finally there are mixed cases. Fine's Vaihinger endorses both the truth-conditional and the functional accounts—that is, fictions are in part defined by their being known to be false, and in part by their non-truth-driven function in inquiry. Both Held and Ankeny defend both accounts simultaneously too. Similarly, Suárez adopts both accounts for fictions in general, but employs only the functional account to distinguish specifically scientific fictions. Similarly, Knuuttila explicitly employs the functional account, but

takes fictions to provide arguments against realism—by assuming that the truth-conditional account results as a by-product.

1.6. FICTIONALIZING, IDEALIZING, ABSTRACTING: EPISTEMOLOGICAL DISTINCTIONS

We may in general distinguish two different kinds of falsehood for any assumption (or two kinds of inaccuracy for any representation). An assumption about some entity x may be false (or, a representation of x may be inaccurate) because there is no such entity in reality. We may refer to this as a *fictional* assumption (or, a *fictional* representation). On the other hand the same assumption may be false because the entity x, albeit real, is incorrectly described, perhaps because the properties that are ascribed to it in the assumption or representation are not the properties that x actually has. We may refer to this as a *fictive* assumption (or *fictive* representation). Both types of assumption or representation involve falsehood or inaccuracy, but the kind of knowledge that is required to establish their error is very different. (See chapter 9 for further elucidation of the distinction.) For 19th-century physicists the assumptions of the mechanical models of the ether are false in the latter but not the former sense: They are fictive but not fictional. By contrast from our own, post-Einsteinian, point of view all theories of the ether are fictional, because they attempt to describe nonexistent entities. The truth-conditional account of fiction is consistent with both but requires a very different assessment of the truth conditions for both types of assumptions. In particular, the falsity or inaccuracy of fictional assumptions and representations requires the knowledge that the entity in question does not actually exist.

The contributors to the volume differ in the extent to which they are prepared to accept fictive representation as a kind of fiction. Roughly for Fine, Barberousse and Ludwig, Bokulich, Held, Suárez, Ankeny, and Knuuttila, fictive assumptions and representations *are* fictions. We may say that these authors defend a thorough or "wide" fictionalism. By contrast, Morrison, Winsberg, Teller, and Giere think that what I have here called fictive representation is simply a case of idealization or abstraction. They instead choose to reserve the name "fiction" for fictional representations and assumptions only. Thus we may say that these contributors defend "narrow" fictionalism. *Wide fictionalism* takes it that idealization and abstraction are subspecies of fiction, and consequently that most modeling practice involves fiction and fictionalizing most of the time. *Narrow fictionalism* by contrast takes it that fictions are not idealizations or abstractions, and thus fictionalizing plays a less ubiquitous role in modeling. Perhaps not surprisingly, the promoters of *wide fictionalism* tend toward instrumentalism in the epistemology of science, whereas the defenders of *narrow fictionalism* are friendlier toward scientific realism.

The most pressing task for both *wide* and *narrow* fictionalism is to provide an account of the cognitive value of fictional assumptions within modeling practice. There is agreement throughout the book that in order to be cogent and cognitively useful the fictional world depicted by the model must incorporate plenty of assumptions derived from our experience. These further background assumptions will serve to extract consequences about the systems modeled from the fictional world depicted by the model. The instrumentalist will tend to think that the relevant experience is of the empirical kind; for the scientific realist this experience is of the real world. Similarly, the consequences extracted from the model will be about the empirical world for the instrumentalist, and about the real world in general for the scientific realist.

Those contributors who tend toward instrumentalism (particularly Fine, Suárez, and Knuuttila), also tend to think that *wide fictionalism* provides arguments for antirealism. Other contributors who promote *narrow fictionalism* (Morrison, Giere, and to some extent Teller) do not find that the presence of fictional elements is a threat to the scientific realist. On the contrary, they would argue that these elements of creativity, game playing, and imagination can help advance the realist cause. Hence the debate over the epistemology of science is not foreclosed once it is accepted that fictions play a role in scientific activity and modeling practice. The realism–antirealism debate instead takes on a new life, because both realists and antirealists must now bring their favorite arguments to bear on the matter.

Giere's concluding essay expresses with great clarity an objection against *wide fictionalism* that he takes to be fundamental. Giere claims that this all-reaching form of fictionalism poses a threat to scientific rationality, because it obliterates the distinction between science and other, myth-based systems of belief where fictions play a more ostentatiously prominent and ubiquitous role. However, the defender of *wide fictionalism* would deny this. He or she would point out that this is not the right 'joint' at which to 'carve' the undeniable differences between science and these alternative belief systems. Thus Giere's conjuring of the creationism debate, and the fictions of religious belief, is a timely warning and an important reminder that there *must be* differences between the roles of fiction and make-believe in science and elsewhere. It serves to remind us that there is important work for philosophers to do in carefully distinguishing such roles. But instilling a blanket fear of fictions in science would just be unproductive toward this goal. Fortunately, this volume ought to constitute good therapy against "fiction-panic"—for realists and antirealists alike. The book embraces the fictions that lie at the heart of science without complexes or fear. All the essays (including Giere's) make a sustained effort to bring out what is distinctly scientific about the use of fictions in science, in contrast to literary or artistic fiction. The authors of these essays avoid being swayed by mythological accounts of science—inspired by legend rather than fact—that presume at the outset that there is no room for game-playing or fictionalizing within

the "grown-up" rationality of science.[11] Instead they come to terms with the functions and roles of fiction and make-believe in *actual* scientific practice. And, as scholars devoted to a greater understanding of our actual science and rationality, should we not prefer the actual fictions of our real science to the virtual hard facts of some mythical and inexistent pseudoscience? These essays provide a compelling picture of the myriad ways in which scientists' imagination, game-playing, and conceptual creativity serve to advance the goals of our scientific objectivity, and to genuinely promote the growth of our scientific knowledge.

NOTES

1. See, e.g., Rosen (1994, 2005).
2. Some key classic texts include Lewis (1983), Currie (1990), and Walton (1990).
3. Kalderon (2005) is a nice recent collection—but it is mainly devoted to issues of ontology, and to comparisons with cognate positions in areas traditionally thought to be friendly to fictionalism anyway, such as moral expressivism and error theory in ethics. The only essay in that collection that addresses the sciences is Rosen (2005), but it is not focused on contemporary science, but mainly on the history of astronomy—again a discipline traditionally thought to be relatively friendly to fictionalism.
4. Mäki (2002) is mainly about the realism issue in economics. (See Chapter 12 in the present volume for a critical assessment of Uskali Mäki's own work on related themes.)
5. Fine argues that Vaihinger's work needs to be placed in the context of his own time, and similarly Fine's own piece needs to be placed in the context of the ongoing epistemological debates of the early 1990s—which is what I try to do in the main text earlier.
6. See particularly the long section in part 3 entitled "Kant's Use of the 'as if' Method" (Vaihinger, 1911, pp. 271–318). Thanks to Thomas Uebel for urging me to take account of Vaihinger's neo-Kantianism. Neurath's preference for the language of models over theories might certainly point to an affinity with contemporary philosophy of science's focus on modeling—see, e.g., Neurath (1983).
7. Including those essays by Rouse (Chap. 3), Morrison (Chap. 7), Suárez (Chap. 9), Winsberg (Chap. 10), Teller (Chap. 13) and Giere (Chap. 14) that in different ways take issue with some of Fine's and Vaihinger's claims!
8. Only Ron Giere (Chapter 14) comments on the slogan—but finds it defective. See section 1.4 in this Introduction for further justification for the book's outlook.
9. One locus classicus for a defense of inference to the best explanation is Peter Lipton (1991).
10. For a review of some of the relevant positions, see Sainsbury (2005).
11. '*Legend*' is Philip Kitcher's apt name for the account of scientific method as a superior and streamlined form of rationality that inevitably leads toward the discovery of truth, and the ultimate avoidance of fiction and error (Kitcher, 1993). Kitcher has now abandoned *legend* in favor of a pragmatist-inspired account of science that is prima facie compatible with the fictionalist outlook promoted in this book.