[Manuscript version. Please cite published version in A. James, A. Kubo and F. Lavocat, (eds.) *The Routledge Handbook of Fiction and Belief* (pp.115-125). Abingdon: Routledge]

Fiction and scientific knowledge

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Abstract

What has fiction to do with science? At first glance, the two activities seem to have entirely different aims and products. Science aims at truth, while fiction can deviate wildly from it. Science produces theories, which we are asked to believe. Fiction produces stories, which we are asked to imagine. Given these differences, associating science and fiction might seem like a serious mistake, or even a threat to science. And yet many authors have tried to understand science by looking to fiction. This article will consider three strands of thought on the topic: Hans Vaihinger's classic work on fictions; fictionalist views, especially van Fraassen's constructive empiricism; and recent work on models and fiction. As we will see, none of these strands pose a threat to science. Instead, each tries to understand the nature of scientific knowledge by drawing on fiction in different ways, and for different theoretical purposes.

Introduction

What has fiction to do with science? Setting aside the stories of H. G. Wells or Jules Verne, the answer seems to be “not much”. At first glance, science and fiction would appear to have entirely different aims. After all, science aims to discover the truth. In contrast, fiction seems to be relatively unconcerned with truth. Instead, it aims to be profound, moving, satirical, or perhaps just entertaining. We also seem to take a different attitude towards the products of these activities. If presented with a scientific theory, we are invited to believe what it says. We are invited to believe that the world contains atoms, electrons, or black holes. If presented with a novel (or play, or film), we are invited not to believe, but to make-believe. We are invited to imagine or pretend that that the world contains unicorns, Sherlock Holmes, or Mickey Mouse. Given these differences between science and fiction, associating the two looks like a serious mistake, which can only lead to confusion. Indeed, it might even seem dangerous, liable to encourage all manner of worrying threats to scientific authority, from Creationism to “post-truth” politics (Giere, 2009; see also Appiah, 2017).

These concerns are certainly not to be taken lightly. The term “fiction” is ambiguous, and its use in some contexts can be highly charged. Any simple declaration to the effect that science is fiction (or involves fiction, or is like fiction, etc.) runs the risk of generating more heat than light. If we want to draw parallels between science and fiction, we must make clear exactly what we are saying, and what purpose it serves. In this paper, I will examine three strands of thought that, in one way or another, seek to understand science by looking to fiction. As we shall see, each of these strands draws on fiction in different ways and for different theoretical purposes. The first strand uses a technical notion of fiction taken from the work of Hans Vaihinger; the second compares our talk about theoretical entities to talk about fictional characters; and the third compares scientific models to works of fiction. None of these ideas seek to undermine science or reject outright its claim to discover truths about the world. Taken together, however, they do suggest that the quest to discover the truth is not as far removed from the activity of telling stories (or putting on plays or making films) as we might like to think.

Fictions

Our first notion of fiction comes from Hans Vaihinger and his classic work, *The Philosophy of "As If"* (1924). (The original German edition was published in 1911.) Vaihinger distinguishes between *hypotheses* and *fictions*. A *hypothesis* is a claim about the world, whose truth we wish to determine. In contrast, for Vaihinger, a *fiction* is a statement that is false, and known to be false by those who use it. Vaihinger also distinguishes between scientific and unscientific fictions: a *scientific* fiction is one that proves useful; an *unscientific* fiction is one that does not. It is no surprise that science is full of hypotheses, of course. We expect scientists to make claims about the world, and check if they are true. At first glance, however, it is difficult to see why science should involve fictions. If science aims to discover the truth, why would it find any place for statements that are known to be false? Why should there be any scientific fictions?

One reason that science involves fictions has to do with discarded hypotheses. There are many theories that we once thought were true, but now know are false. Vaihinger gives the example of the Ptolemaic system, which takes the earth to be at the centre of the cosmos. Once, this might have been a hypothesis, at least for some of its proponents. Indeed, it might even have been taken to be true. Nowadays, of course, we know that it is false. And yet, we can still use the Ptolemaic system to predict the positions of the planets in the night sky. If we do so, we have a fiction, in Vaihinger's sense: we have a set of statements that are false, and known to be false, but which are still useful for some purpose. (In fact, early astronomers' attitude towards the Ptolemaic system is a matter of debate. Duhem (1906) argues that it was commonly understood as a sort of fiction, including by Ptolemy himself. For critical discussion, see Lloyd (1978) and Rosen (2005).) In a similar manner, we still use Newtonian mechanics to design airplanes and build bridges, even if we know that, strictly speaking, it is false, and has been superseded by quantum mechanics or relativity theory.

Some fictions are thus discarded hypotheses—claims that we now know are false but still keep on the books for certain purposes. This is not the only way in which fictions can arise in science, however. Even more important is their role in modelling and idealisation. Consider the billiard ball model of gases (Hesse, 1966). This model allows us to understand the behaviour of a gas by treating its molecules as a collection of tiny billiard balls whizzing around randomly in a container. The model involves several hypotheses about gases. For instance, it claims that gases consist of molecules, that the temperature of a gas depends on the kinetic energy of its molecules, and that these molecules exert pressure when they collide with the walls of the container. Along with these hypotheses, however, the model also involves various simplifying assumptions. For instance, it assumes that molecules only act upon each other in collisions and that, when they do collide, they do so perfectly elastically, without losing any energy. In reality, we know that the situation is more complicated: molecules do exert forces on each other between collisions, and their collisions are not perfectly elastic. And so, these assumptions also count as fictions, in Vaihinger's sense. They are statements that are false, and are known to be false, but which are still useful for certain purposes.

Why do we invoke these fictions? Why make assumptions that we know to be false? Because reality is complicated. In most cases, we can only hope to make sense of it by introducing a whole host of simplifications or idealisations. Otherwise, we would scarcely know where to begin. If we tried to take account of each and every aspect of the behaviour of each and every one of the countless molecules that make up the gas, our task would be impossible. On the other hand, if we make our simplifying assumptions, we can begin to see how to turn our problem into a more familiar and tractable one—i.e., describing the behaviour of a set of billiard balls (or, speaking more precisely, a set of simplified and idealised billiard balls). In some cases, it is possible to bring our assumptions a little closer to reality. For instance, we can introduce an equation to account for the forces that molecules exert on each other between collisions. And yet, even if we do this, fictions will remain. For instance, we will probably still assume that, like billiard balls, molecules are hard and spherical, even though we know this is false. It is important to emphasise that this is not somehow a failing of the billiard ball model in particular—if it is even a failing at all. In fact, the situation that we find here is the norm in science, rather than the exception. As Nancy Cartwright (1983, p. 158), puts it ‘a model – a specially prepared, usually fictional description of a system under study – is employed whenever a mathematical theory is applied to reality’.

The use of fictions, in Vaihinger’s sense, is therefore widespread in science. Indeed, in an influential article, Arthur Fine (1993, 16) writes that

> Preeminently, the industry devoted to modeling natural phenomena, in every area of science, involves fictions in Vaihinger’s sense. If you want to see what treating something “as if” it were something else amounts to, just look at most of what any scientist does in any hour of any working day.

Fine’s article helped to recover Vaihinger’s ideas for contemporary debate in philosophy of science and has inspired much recent work on fictions in science (e.g., Suarez, 2009). Vaihinger’s own interests extended far beyond science, however. In his view, fictions can be found in many domains of human thought, including mathematics, metaphysics, ethics, law, and theology. In a recent, and similarly wide-ranging, discussion, Kwame Anthony Appiah (2017, p. 127) characterises Vaihinger’s central ideas as follows: “first, that in idealization, we build a picture—a model—of something that proceeds as if something we know is false were true; and second, that we do so because the resulting model is useful for some purpose”. In the case of scientific modelling, our purpose is usually to predict or control the behaviour of some part of the world. In other cases, fictions might serve very different purposes. For instance, an atheist might use religious doctrines to guide their ethical views, even if they take those doctrines to be false.

Fictions are “useful untruths” (Appiah 2017, 1), and their usefulness can take many different forms, from managing the world to “manag[ing] our selves” (2017, 26).

Let us accept that science is full of fictions, in Vaihinger’s sense. What should we make of this? Does the role of fictions pose a threat to science? The first point to emphasise is that much of what I have said so far would come as little surprise to practicing scientists. The scientists (or engineers) who use Newtonian mechanics to build a bridge know that, strictly speaking, Newton’s laws are false. But they also know that these laws are well suited to the job of building bridges, and that if they tried to use quantum mechanics instead, they wouldn’t get very far. Similarly, scientists who build a model are usually perfectly well aware that it involves various simplifications or idealisations. Indeed, an important part of their work consists in selecting the right assumptions for the task in hand. For instance, physics or chemistry textbooks will normally list the simplifying assumptions involved in the billiard ball model. They will also explain the range of circumstances in which these assumptions are likely to lead us astray (e.g. at high pressures, when the interactions between molecules outside collisions become increasingly significant). From this perspective, to say that science involves fictions in Vaihinger’s sense is simply to point to a familiar fact about scientific practice.

And yet, once we reflect on the role of fictions in science, we see that it challenges many of our ordinary ways of thinking about scientific knowledge. Consider the hypothesis that gases consist of molecules. Suppose we ask: do we know that this hypothesis is true? After all, we can’t see molecules. Philosophers of science who are *realists* (and no doubt many scientists too) would say that we do know that this hypothesis is true. In fact, we know that gases contain molecules precisely because of the success of the billiard ball model (and other models like it). There are two standard realist arguments here. The first is *inference to the best explanation* (Lipton, 2004). According to inference to the best explanation, we should infer the hypothesis that would, if true, provide the best explanation for the evidence. For instance, if the hypothesis that gases contain molecules provides the best explanation for their behaviour, we are entitled to conclude that this hypothesis is true. The second realist argument is the *no miracles argument* (Putnam, 1981). It also takes the form of an inference to the best explanation. According to the no miracles argument, if a hypothesis is successful (e.g. if it provides true predictions), the best explanation for its success is that it is true. And so, we should conclude that the hypothesis *is* true. If it weren't true, says the realist, its success would be a miracle.

These realist arguments have considerable intuitive force. Taken together, they underlie the confidence that many of us feel in the scientific worldview. The difficulty is that, despite their undoubted appeal, both arguments start to look more problematic once we reflect upon the role of fictions in science. After all, to say that our theories involve fictions, in Vaihinger's sense, is to say that they are false! For instance, our hypothesis that gases contain molecules was part of the billiard ball model and we know that, strictly speaking, this model is false. This immediately raises a host of questions. Can false theories explain things? Intuitively, many feel that only true theories can explain. And yet, if science is full of fictions, then insisting on truth means that we risk finding that it has explained very little. (For further discussion, see Bokulich, 2012 and de Regt, 2015.) Even if we allow that false theories can explain, this seems to cause trouble for inference to the best explanation. It told us to infer that our best explanation is true. And yet now we see that even our best explanations are typically false. The no miracles argument also starts to look less compelling (Fine, 1993). It said it would be a miracle if a false theory gave true predictions. And yet now we see that even our most accurate predictions usually come from false theories.

Fictionalism

The widespread role of fictions in science therefore seems to cause trouble for standard arguments for scientific realism. One way to respond to these worries is to abandon realism. There are many different forms of anti-realism. Historically, an important form of anti-realism was *logical positivism*. Positivists tried to rid science of talk about unobservable entities, like molecules or electrons, by reducing claims about unobservable entities (also called *theoretical statements*) into claims about observable ones. For instance, a positivist might try to reduce claims about the behaviour of molecules in a gas into claims about its pressure or temperature, which we can check using instruments. Nowadays, this task is widely thought to be impossible. Despite the positivists' best efforts, it seems that science simply cannot do without talk about unobservable entities. A more popular form of anti-realism today is Bas van Fraassen's *constructive empiricism* (1980). Unlike the positivist, van Fraassen concedes that scientists make claims about unobservable entities, and that there is no way to do without them. It is simply that, unlike the scientific realist, Van Fraassen says that we shouldn't believe these claims. Instead, we should remain agnostic: we should continue to use theoretical statements for various purposes (e.g., to make predictions about the observable world), but suspend judgment regarding their truth.

Van Fraassen's position is often described as a form of *fictionalism* (e.g. Kalderon, 2005b; Rosen, 1994). Van Fraassen (1980, pp. 35-36) also refers briefly to Vaihinger when developing his approach. There are certainly similarities between Van Fraassen's view and Vaihinger's. Both authors emphasise that statements can be useful, even if they are not true or taken to be true. There are also important differences, however. The first is that, for Vaihinger, fictions are false, and known to be so. Van Fraassen does not say that theoretical statements are false; he simply says that we should suspend our judgement. In his view, the appropriate attitude to take to these statements is not disbelief, but agnosticism. The second important difference between Vaihinger and Van Fraassen's views is more subtle and contested. We've seen that the idea that science uses fictions in Vaihinger's sense would come as little surprise to scientists themselves. In contrast, it seems likely that scientists would object to Van Fraassen's take on things. For many scientists, theoretical statements are hypotheses that, in some cases at least, we have reason to think are true. They might therefore be reluctant to follow Van Fraassen's advice and remain agnostic. (For discussion of whether constructive empiricism is at odds with scientists' views, see Rosen 1994 and van Fraassen 1994.) Still, it is important to emphasise that, although he urges caution regarding theoretical statements, Van Fraassen does not seek to undermine the authority of science. For the constructive empiricist, science is still a rational enterprise, which aims to discover the truth about the observable world, and often succeeds in doing so.

Fictionalist approaches have been developed in many fields, including philosophy of mathematics (e.g. Field 1980, Yablo 2002, Leng 2010), the metaphysics of modality (e.g. Rosen 1990), moral philosophy (e.g. Joyce 2001, Kalderon 2005a), and philosophy of mind (e.g. Demeter 2013, Toon 2023, Wallace 2022). In each case, we find a predicament like the one concerning unobservable entities in science. Our discourse seems to talk about certain entities that, for whatever reason, we find problematic: unobservable entities, Platonic objects, possible worlds, moral properties, mental states, and so on. We find that we cannot avoid talking about such things. And yet we also find it difficult to commit ourselves to their existence. Fictionalism seems to offer a middle way: keep talking about unobservable entities (or Platonic objects or possible worlds or moral properties or mental states, etc.), because such talk is useful, or even indispensable; just don't believe it—either because you think it is false, or because you want to remain agnostic. It is common to distinguish between *hermeneutic* and *revolutionary* fictionalism (Burgess 1983 and Stanley 2001). Hermeneutic fictionalism aims to interpret a discourse as it is: it claims that the discourse is already fictionalist in spirit. Revolutionary fictionalism aims to reform the discourse: it says our existing discourse isn't fictionalist but should be. In these terms, many (though not all) of Vaihinger's views on science are (arguably) hermeneutic, while Van Fraassen's are (arguably) revolutionary. In contrast, Vaihinger's views on religion as a useful "myth" are more likely to count as revolutionary, at least to many followers of those religions.

Vaihinger's notion of fiction is a technical one, which seems far removed from our ordinary use of the term in connection with novels, plays, films and the like. Fiction in this ordinary sense need not be false, of course. Most novels (or plays or films) are full of true, often quite humdrum, facts about people, places and events. Even if there is no Sherlock Holmes, much of what we read in *The Hound of the Baskervilles* is perfectly true: it is true that Baker Street is in London, that phosphorous emits an eerie glow, and that Dartmoor can be a dangerous place to go walking at night. And, of course, many will argue that fiction can reveal deeper truths too—about human nature, perhaps, or our relationships with others (for a helpful overview of this debate, see Gaut, 2003). It is also debatable whether ordinary fiction need be useful, in Vaihinger's sense. Isn't fiction often wonderfully lacking in purpose? At first glance, fictionalist views like Van Fraassen's might seem equally distant from the world of novels, plays or films. And yet fictionalists often draw parallels with ordinary fiction. Typically, these parallels are concerned not so much with works of fiction themselves—the text of a novel, for instance, or a performance of a play—but with the way that we talk about these works.

The fictionalist's central idea is that we can talk about certain objects (e.g. unobservable entities in science) without committing ourselves to their existence. It is here that the fictionalist sees a parallel with ordinary fiction. After all, don't we talk about fictional characters without committing ourselves to their existence? If we say, "Holmes lives at 221B Baker Street", we are not claiming that there is a real, flesh-and-blood detective who lives on a certain street in London. And yet we can still talk meaningfully about Holmes and what we say can be right (e.g. "Holmes lives at 221B Baker Street") or wrong (e.g. "Holmes lives at 222B Baker Street"). The fictionalist suggests that we might understand talk about problematic objects in a similar manner. Consider theoretical statements in science. According to the fictionalist, if we say, “electrons are negatively charged”, we are not (or should not be) claiming that there is a real, subatomic particle that has this property. And yet we can still talk meaningfully about electrons and what we say can be right (e.g. “electrons are negatively charged”) or wrong (e.g. “electrons are positively charged”).

Is this analogy successful? One worry is that fiction itself is far from straightforward. There are significant debates amongst philosophers of fiction about the correct way to understand our discourse about fictional characters. For instance, *realists* about fictional characters think that our discourse about them commits us to their existence: they think we need to grant that Holmes exists in some sense (e.g. as a non-existent or abstract entity) to make sense of the way that we talk about him (e.g. Meinong 1960, Thomasson 1999). *Anti-realists* about fictional characters deny this (e.g. Russell 1956, Walton, 1990). The mere fact that there is such a debate suggests that the fictionalist’s analogy might not provide such an easy way to avoid ontological commitment. Another worry is that, when we look at fictionalist analyses more closely, we can find that the analogy with fiction plays a fairly limited role. For instance, fictionalists often claim that talk about fictional characters avoids ontological commitment because it has an implicit “story prefix”. On this analysis, our statement about Holmes is short for “In the Holmes stories, Holmes lives at 221B Baker Street”. This analysis is disputed by some philosophers of fiction (e.g. Walton 1990). Even if we assume that the analysis works, however, the reason it works might have little to do with fiction *per se*. As Gideon Rosen points out, “the story mentioned in a story prefix need not be a literary fiction, nor for that matter, any sort of fiction in the usual sense. [It] can be *any representation whatsoever*: a story, a scientific theory, or a metaphysical speculation. The basic point is unaffected: so long as you are not independently committed to regarding this representation as true, when you assent to 'In F, P' you incur no obligation to assent to 'P' by itself" (1990, 331-2; emphasis in original).[1]

Models and fiction

Our final strand of thinking about science and fiction also focuses on models and idealisation. Unlike Vaihinger, however, it does not operate with its own, technical notion of fiction. Instead, it suggests that we can understand the practice of scientific modelling by looking to fiction in the ordinary sense of novels, plays and films. To see how this is supposed to work, it will help to consider the contrast between *physical modelling* and *theoretical modelling*. Imagine that an engineer wants to build a new airplane. One way to test her designs would be to build a scale model. For instance, she might build a scale model of the plane's wing and put it through tests in a wind tunnel. By finding out about the properties of her scale model, the engineer hopes to find out about the properties of

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[1] My thanks to Stacie Friend for many helpful and illuminating discussions on the relationship between fiction and fictionalism.

the plane itself (e.g. how much lift its wings will generate). This is an instance of *physical modelling*, since the engineer's model is an actual, physical object (e.g. a two metre-long wing built out of balsa wood or fibreglass). Now recall the billiard ball model of gases. This is a case of *theoretical modelling*. Unlike the engineer, the scientists who use this model do not build an actual, physical object to serve as their model. Instead, they simply write down a set of equations and assumptions. As we've seen, real gases do not satisfy these assumptions. In fact, *no* actual, concrete object satisfies all the assumptions made by the billiard ball model of gases. Even ordinary billiard balls are not perfectly spherical, and will lose some energy when they collide.

Despite the obvious differences between physical and theoretical modelling, we find that scientists often talk about the two activities in similar sorts of ways. The engineer finds out about the properties of her airplane by first investigating the properties of her scale model. Likewise in theoretical modelling, it is said, scientists find out about the world by first investigating the properties of a simplified or idealised version of it, called a *model system*. For instance, the model system of the billiard ball model is a set of tiny, perfectly spherical billiard balls that obey the scientists' assumptions. This isn't a real collection of billiard balls that the scientists can set up in the laboratory, of course. Their model system doesn't exist in the way that the engineer's scale model does. And yet, scientists still talk as if they can use this model system in a similar manner to the engineer's scale model. First, they apply Newton's laws to investigate the properties of their simplified and idealised model system. Next, they use what they have learned to find out about the more complex behaviour of molecules in a gas. In fact, a considerable part of scientific practice seems to involve constructing model systems, learning about their properties, and (if we are lucky) using these model systems to understand the real world.

Once we look at theoretical modelling in this way, it can start to seem like a rather odd and surprising sort of activity. On the face of it, we might expect scientists to be concerned with describing the world as it is. And yet, when we look more closely, we find that scientists spend a lot of their time talking about things that don't exist, like collections of tiny, perfectly spherical billiard balls whizzing around in imaginary containers. The reason they do this is familiar from our discussion of Vaihinger, of course. The real world is complicated. To make progress, we need to start by investigating something simpler and more tractable. In the case of physical models, this seems straightforward, at least in principle. If our model is a physical object, it is easy to see how we might go about investigating its properties: we might put it in a wind tunnel, measure how it reacts under different conditions, take videos of different test runs, and so on. Theoretical modelling is more puzzling. After all, it looks like there is no object for us to investigate! There are no actual, concrete objects to serve as our model systems. As a result, theoretical modelling raises various questions. What exactly are scientists doing when they construct a theoretical model? How can they talk about systems that don't exist or learn about their properties? And how can learning about systems that don't exist tell us anything about the real world?

To answer these questions, some philosophers of science have suggested we should compare scientific models to works of fiction. There are two different versions of this approach: *indirect fiction views* and *direct fiction views* (for more on this distinction, see

Toon, 2016). Indirect fiction views compare the equations and assumptions that scientists write down when constructing a theoretical model to passages about fictional characters. Consider this passage from J. B. Priestley's novel *The Good Companions:*

> Somewhere in the middle of this tide of cloth caps is one that is different from its neighbours. It is neither grey nor green but a rather dirty brown. Then, unlike most of the others, it is not too large for its wearer but, if anything, a shade too small, though it is true he has pushed it back from his forehead as if he were too hot — as indeed he is. This cap and the head it has almost ceased to decorate are both the property of a citizen of Bruddersford, an old and enthusiastic supporter of the United Football Club, whose name is Jesiah Oakroyd. He owes his curious Christian name to his father, a lanky weaving overlooker who divided his leisure, in alternating periods of sin and repentance, between *The Craven Arms* and the Lane End Primitive Methodist Chapel, where he chanced to hear the verse from First *Chronicles*, "Of the sons of Uzziel; Micah the first, and Jesiah the second," the very day before his second son was born. (Priestley, 1929, p. 4)

When he wrote this passage, Priestley was not describing a real, flesh-and-blood citizen of Bruddersford and supporter of United called Jesiah Oakroyd. There is no such town, no such football club, and no such person. And yet, once Priestley has written this passage—and the many other passages that make up the novel—we can talk meaningfully about Jesiah Oakroyd. In fact, we often talk about fictional characters as if they *were* real, flesh-and-blood people: we might say that Jesiah Oakroyd is a working man, supports United, and wears a brown flat cap. The indirect fiction view sees a parallel here with theoretical modelling. When scientists write down their equations and assumptions, they are not describing an actual, concrete object. There is no such object. And yet, once the scientists have written down their equations and assumptions, they can talk meaningfully about their model system. In fact, they often talk as if it were an actual, concrete object, whose behaviour they can investigate.

According to the indirect fiction view, then, when scientists write down their equations and assumptions, they are doing the same sort of thing as an author describing a fictional character. Just as Priestley asks us to imagine a fictional citizen of Bruddersford who wears a flat cap, so scientists ask us to imagine a collection of tiny billiard balls whizzing around in a container. In the same way that Priestley conjures up Jesiah Oakroyd, so scientists conjure up their model system. Scientists' subsequent talk about their model system is to be understood in the same way as talk about fictional characters. Crucially, fictional characters have properties that go beyond those explicitly stated in the text. We assume that Jesiah Oakroyd has blood in his veins and needs oxygen to survive, even if Priestley never bothers to say as much. Likewise, model systems have properties that go beyond those specified in scientists' initial equations and assumptions. This explains how scientists can learn about their model system. We learn about the real world by comparing our model systems to the world. A key problem for this view arises when we ask: what exactly *are* model systems? We've seen that they are supposed to be like fictional characters. But what are fictional characters? As we've noted already, philosophers of fiction are divided on this question. Realists about fictional characters think they exist in some sense (e.g. as nonexistent or abstract entities), while anti-realists deny this. Similar disagreement exists over the nature of model systems. Some authors are realists about model systems (Contessa 2010, Thomasson, 2020, Thomson-Jones 2020), some are anti-realists (Frigg 2010), and some remain neutral (Godfrey-Smith, 2006). None of these alternatives is without difficulties, however (Friend 2020, Thomson-Jones 2007, Toon, 2012).

The *direct fiction view* hopes to avoid these problems with fictional characters. To do so, it proposes a different analogy between models and works of fiction (Toon, 2010, 2012; for a related approach, see Levy, 2015). Rather than comparing scientists' equations and assumptions to descriptions of fictional characters, it compares them to works of fiction that represent real people, places, and events. Consider the following passage from the historical novel *Q* by Luther Blissett, the Italian writers' collective:

> The prophet of Münster passes through the Ludgeritor and leaves the city behind him, escorted by a dozen men. No one else has been able to follow him: everyone has his role in the Plan.
>
> We crowd on to the city walls.
>
> The bishop prince's camp is clearly visible a short distance away, slightly blurred by the mist rising from the damp earth.
>
> We see them advancing towards the embankment dug by the bishop's mercenaries. There is commotion in their ranks, they take aim with their hackbuts.

Matthys gestures to his men to stop.

Matthys walks on alone. (2003, p. 230).

Unlike Priestley's description of Bruddersford and Jesiah Oakroyd, this is not simply a description of a fictional town and its inhabitants. Instead, it represents a real town, Münster, and a real person, Jan Matthys, the leader of the Münster rebellion. More specifically, it represents Matthys' fateful actions in Münster on Easter Sunday 1534. Some of what the novel asks us to imagine about Münster, Matthys and the rebellion is true (e.g. that the rebellion was led by Anabapists, that Matthys was captured and brutally executed) while much of it is made up by the authors (e.g. that the events were closely followed by a mysterious Catholic spy named *Q*). The direct fiction view sees a more appropriate parallel here for theoretical modelling in science. Like historical novels, scientists' equations and assumptions ask us to imagine the world in a certain way. Some of what they ask us to imagine is true (e.g. that gases consist of molecules, that they collide with the walls of the container), while some it is false (e.g. that these molecules are spherical, that the collisions are perfectly elastic).

The indirect fiction view claims that scientists represent the world indirectly, via model systems. In contrast, the direct fiction view claims that scientists represent the world directly, by asking us to imagine things about it. There are no model systems. There are simply equations and assumptions that scientists write down, norms that govern their interpretation, and the imaginings that they prescribe. Why do scientists talk as if there were model systems? Toon (2012) argues that they are engaging in make-believe. The scientists are pretending—they are "going along with" the model to tell us what it asks us to imagine. For instance, suppose that a scientist using the billiard ball model to predict the behaviour of a gas remarks that, “the molecules collide elastically”. According to the direct fictions view, the scientist is not describing a collection of fictional molecules; she is telling us to imagine this about the real molecules. On this view, we learn about a model by tracing out the implications of our initial equations and assumptions. For instance, we learn that if we imagine that gas molecules only act upon each other in collisions, collide elastically and so on, then the pressure of the gas will be proportional to its temperature. In this way, the direct fiction view hopes to provide a deflationary analysis of theoretical modelling, which does without the need to posit model systems. Its critics feel that these hopes are in vain and that we still need model systems to make sense of theoretical modelling and the way that scientists talk about it (Weisberg, 2013, Thomasson, 2020).

How does recent work on models and fiction relate to the other strands of thinking about science and fiction that we considered earlier? It shares Vaihinger’s interest in modelling and idealisation, of course. Unlike Vaihinger, however, it tries to understand these aspects of scientific practice by looking to works of fiction in the ordinary sense. In this respect, work on models and fiction resembles fictionalist views like van Fraassen’s constructive empiricism, which also see parallels between theoretical claims in science and our talk about fictional characters. The scope of this analogy is more restricted, however: for authors on models and fiction, the analogy applies only to scientists’ claims about model systems, not all theoretical statements. The reason is that, unlike van Fraassen, work on models and fiction is not motivated by worries about the status of unobservable entities, like molecules or electrons. Instead, its central aim is to make sense of the practice of modelling, although the direct fiction view also hopes to achieve this in a way that it metaphysically parsimonious. Whether or not it is ultimately successful, such work brings philosophy of science closer than we might expect to debates in philosophy of fiction.

Conclusion

On the face of it, science and fiction seem to ask us to adopt different attitudes: science asks us to believe what it says, while fiction asks us to engage in make-believe. As we have seen, however, matters are not quite so straightforward. Many statements we find in science are what Vaihinger calls *fictions*. We use these statements to manage the world, but we do not believe them. Anti-realists like van Fraassen urge us to adopt a similar attitude to all theoretical claims: we should use statements about unobservable entities to make predictions or build machines, but we should not believe them. Some authors see a parallel here with our talk about works of fiction. Recent work on models and fiction develops this parallel further. On this view, it is not only that scientists do not believe their idealizations and assumptions; they are also engaging in make-believe. Like novelists or playwrights, scientists often ask us to imagine the world in a certain way so that we can understand it better.

Further reading

Vaihinger's classic work on fictions is *The Philosophy of "As If"* (London: Routledge, 1911/1924). Recent discussions and applications of Vaihinger's ideas include M. Suárez (ed.) *Fictions in Science* (London: Routledge, 2009) and K. A. Appiah, *As If: Idealization and Ideals*. (Cambridge, Massachusetts: Harvard University Press, 2017). The key source for van Fraassen's constructive empiricism is *The Scientific Image* (Oxford: Clarendon Press, 1980). On van Fraassen's view as a form of fictionalism, see G. Rosen, "What Is Constructive Empiricism?", *Philosophical Studies* (1994). P. Godfrey-Smith, "The strategy of model-based science," *Biology and Philosophy* 21 (2006) and R. Frigg, "Models and fiction", *Synthese* 172 (2010) endorse the indirect fictions view. A. Toon, *Models as Make-Believe: Imagination, Fiction and Scientific Representation* (Basingstoke: Palgrave Macmillan, 2012) and A. Levy "Modeling without Models," *Philosophical Studies* (2015) both develop versions of the direct fiction view.

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