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# Models, Fictions & Realism: Two Packages<sup>1</sup>

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## Abstract

Some philosophers of science – the present author included – appeal to fiction as an interpretation of the practice of modeling. This raises the specter of an incompatibility with realism, since fiction-making is essentially non-truth-regulated. I argue that the prima facie conflict can be resolved in two ways, each involving a distinct notion of fiction and a corresponding formulation of realism. The main goal of the paper is to describe these two packages. Toward the end I comment on how to choose among them.

## 1. Introduction

Sometimes philosophers of science appeal to fiction by way of dismissal: misguided theoretical efforts – the positing of ether, epicycles, gemmules – are seen as “merely fictional”, mistakes which serve, at best, as stepping stones on the way to better science. But recent discussion has increasingly included an *interpretive* appeal to fiction. Here the idea is that certain aspects of theoretical science, especially modeling, can be illuminated by drawing an analogy to works of art such as novels and feature films. My interest here is in this interpretive project – specifically in its compatibility with some form of scientific realism. Viewing models as fictional implies that they are often untrue. More importantly, it means that they are, at least in the first instance, not regulated by truth. This implies that in order to hold on to realism we need to locate a locus of truth in modeling that is different than the models themselves, yet permits a stance that is appropriately thought of as realism about the fruits of

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<sup>1</sup> For oral and written comments I am indebted to Mauricio Suarez and Martin Thomson-Jones.

modeling. I will argue that this can be had, if both realism and “fictionalism”<sup>2</sup> are given the right formulation. Indeed, I will argue that there are two possible fictionalism-plus-realism packages. I’ll mainly describe these packages, but toward the end I discuss reasons for choosing among them.

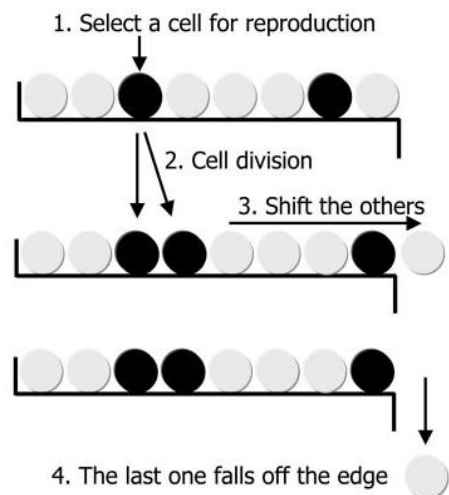
## 2. Setting up the Problem

Let me start by motivating the interpretive appeal to fictions, via an example drawn from recent theoretical work on the onset of cancer. Cancer often arises in small compartments within a tissue – e.g. so-called “crypts” in the colon. An important theoretical question is whether the architecture of such compartments affects the likelihood of cancer. The so-called “linear process model” represents one attempt to address this question (see Figure 1). In this model a compartment is described as a production line of sorts, in which cells “pop in” at one end and leave (i.e. die) at the other end. Martin Nowak and colleagues have shown that this kind of architecture substantially reduces the likelihood of cancer (Nowak et. al, 2003).

In a recent book (Nowak, 2006), the linear process model is introduced as follows: “One simple approach considers  $N$  cells in a linear array. At each time step a cell is chosen at random, but proportional to fitness. The cell is replaced by two daughter cells, and all cells to its right are shifted by one place to its right. The cell at the far right undergoes apoptosis [i.e. dies]. The cell at the far left acts as a stem cell. [i.e. continuously produces array cells]” (Ibid, p. 222. Comments in brackets added).

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<sup>2</sup> This term carries different meanings in various contexts (Eklund, 2007). I intend it only signify the interpretive appeal here described.



**Figure 1. The Linear Process Model (source: Nowak et. al, 2003)**

I think this text exhibits a certain, rather common, style of scientific thought and communication. The linear process is vastly simplified compared with actual colon crypts, and Nowak is well aware of this: he is not offering the model as an accurate portrayal of crypts. To understand the model, indeed to put forward such a model, one must, at least in some respects, forget about real crypts and entertain thoughts about the simple linear process. Nowak’s description does not correspond to any part of the natural, concrete actual world – the model crypt isn’t something we can observe under a microscope or diagnose at a clinic. It seems more appropriate to say that it is *a hypothetical version* of a real crypt. This already sounds close to saying that the linear process is, in some sense, an imaginary scenario or a fiction. But we can say more: Talk about models often admits of a distinction between internal and external statements. Internal statements such as “cells are arranged in a row“ are true or false only in a sense, only “according to” the model. In contrast, external statements treat the model as a model, either explicitly, as in “the linear process is the simplest possible model of crypt architecture”. Or implicitly as when model and target are compared, e.g. “the population dynamics of colon crypts are well approximated by a linear process”. Such external statements seem true or false *simpliciter*. A distinction between internal and external statements is often seen as a hallmark of fictional discourse (Kroon and Voltolini, 2011). There are further discursive markers that point in the direction of fiction. Like Nowak, modelers often introduce their work with locutions such as “consider...” or “imagine...” And in their more reflective moments, many tend to speak of their work as depicting “artificial systems”, “simplified scenarios” or “stylized versions” of the phenomena under study.

These observations suggest that models – at least some models, those that contain idealization, perhaps – bear important similarities to fictions. Indeed several recent authors have argued that modeling *is* a species of fiction-making (Godfrey-Smith, 2006, 2009; Frigg, 2010; Toon, 2010). I too find this suggestion attractive (although in a somewhat qualified form – see Levy, forthcoming). However, there is an immediate objection to the models-as-fictions view: if models are fictional, how can they embody knowledge about the non-fictional empirical world? (Giere, 2010). The issue arises not so much because fictions are often false – qua descriptions of actual, concrete phenomena – but because the making (and consuming) of fiction is *unconstrained* by truth. That is to say, in producing a work of fiction such as a novel, an author is typically not concerned with, or at least not bound by, facts. She is not obliged to conform in any definite way to known information about the concrete, actual, non-fictional world: she can make up characters and events ad lib. Nor is the consumer, say the reader of a novel, typically concerned with truthfulness. By many lights, such non-truth-guidedness is partly constitutive of being fictional (Sainsbury, 2009; Walton, 1990). But if models are a species of fiction, and if fiction is unconstrained by truth, then fictionalism about models appears to be in direct conflict with scientific realism. For, on at least most understandings of realism, scientific theorizing aims at truth, i.e. scientists seek to produce theories that are true<sup>3</sup>, where the truth in question is truth with respect to the real, empirical, concrete world of natural phenomena.<sup>4</sup> If modeling, like fiction-making, is unconstrained by truth, then viewing models as fictions is incompatible with the most basic tenet of realism, namely that attaining truth is a central aim of scientific investigation.

So stated, there is an incompatibility between the models-as-fictions approach and scientific realism. This is a serious problem, inasmuch as most advocates of fictionalism, myself included, would like to embrace realism as well. But the problem can be overcome, I think, if we reformulate the realist principle – retaining its spirit, but shifting the locus of truth, so to speak, from models elsewhere. In what

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<sup>3</sup> The question whether realism ought to be formulated in terms of truth (rather than, say, accuracy, or approximate truth) does not have a direct bearing on the claims I make here. So I will talk in terms of truth throughout.

<sup>4</sup> Not all realists treat truth-guidedness as a central part of realism. For some, realism's key tenet is simply that scientific theories and models are true (or approximately true, or belief-worthy). These two elements – truth and truth-guidedness – are logically distinct. But it is natural to suppose that if science attains truth, that is at least in part because scientists aim at truth. Most realists, I think, endorse something like this supposition.

follows, I argue that this can be done in two ways, depending on how one construes the idea that models are fictions.

### 3. The Two Packages

**3.1. Prelude: Two Types of Fiction.** Some fictional stories pertain, ostensibly at least, to imaginary things – characters, places and events which, in some sense, do not exist, such as Sherlock Holmes, Narnia and the war of the worlds. These are mere figments of the imagination, not real, actual entities and events one may encounter or witness. On the other hand, there are works of fiction that concern real places and real people and even real things that happened to them. A good example is historical fiction. *I, Claudius* – the book and the TV series – is a fictional version of the lives and times of Claudius, Augustus, Caligula and other prominent Romans. These are real historical people, and much of the plot traces back to genuine historical events.

This points to a general distinction between two types of fiction. We might call the first type *whole cloth fiction*. Here an author constructs an alternative “world”, appearing to create objects and events – inhabitants of a fictional realm, as it were. In the second type, which I’ll label *worldly fiction*, actual beings and things are described, albeit with creative liberty. Thus, one variety of fiction, the whole cloth variety, appears to involve reference to imaginary things; the other variety, worldly fiction, consists of imaginative description of real things. Both varieties exhibit the fictional hallmark of a lack of (or at least a much reduced) constraint vis-à-vis the truth. But the distinction nevertheless matters for present purposes. For we get a different fictionalism-plus-realism package, depending on which kind of fiction we identify models with. Or so I will argue next.

**3.2. First Package: Indirect Realism.** The first package consists of a whole cloth understanding of fiction, coupled to a version of the realist principle that treats modeling as resulting in comparative knowledge – knowledge about how the model matches up to the target. Let me explain.

Recall that on the whole cloth understanding fictionalizing is seen as the construction of an imaginary thing, a hypothetical version of the real world. On this picture, the model is, prima facie at least, an entity in its own right. The modeler uses this entity as a representational tool – a process not unlike the construction and use of a physical model. In the example cited earlier, Nowak set up a

hypothetical entity, *the linear crypt* as we might call it. We can derive precisely how the linear crypt will behave under various circumstances, such as the occurrence of cancerous mutations. On this way of thinking, what we learn from studying something such as the linear process model is, in the first instance, facts about that hypothetical entity, the linear crypt. However, our ultimate goal is to gain information about the real-world, i.e. to learn something about actual colon crypts. To this end we compare the model to the target of the investigation, a phenomenon in the actual world. In effect, such comparisons are a way of converting knowledge about the model to knowledge about the world.

I am staying deliberately non-committal about the relation that underlies this comparative operation, and on how the comparison is carried out. This topic has received considerable attention in the literature. Some think of the underlying relation as ordinary similarity, akin to that which obtains among actual concrete objects (e.g. Frigg, 2010a<sup>5</sup>; Giere, 1988; Weisberg, forthcoming). Others think in terms of structural correspondences, such as whole or partial isomorphism (e.g. Da Costa & French, 2003; French and Ladyman, 1999). This issue is orthogonal to the questions I am discussing here (and the authors I cite aren't necessarily fictionalists about models). But there's a shared underlying picture, a kind of indirect realism in which model-based knowledge takes the form of comparative claims about the goodness of match between models and empirical targets. The first package takes this shared picture and connects it with a conception of fictions on which they are standalone entities that may be informatively compared to real-world targets.

Van Fraassen, in the *Scientific Image*, defines realism as the view that “Science aims to give us, in its theories, a literally true story of what the world is like” (1980, p. 8). The claim made so far in this section is that under a whole cloth reading of the models-as-fictions idea, the realist must adhere to the letter of this definition: scientific models aim to tell us, quite literally indeed, what the world *is like*.

**3.3. Second Package: Modeling as Metaphor.** Consider now the second kind of fiction, earlier dubbed ‘worldly fiction’. This is fiction in low key: it does not involve imaginary things, but merely imaginative descriptions of real things. Suppose we regard models as worldly fictions. In one sense this is an easier thing to take on board, as we need not acknowledge even *prima facie* fictional constructs. All we assume is the mundane operation of deliberately mis-describing something – of ascribing to it properties one knows it not to have. However, because there is no invocation of fictional entities, the

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<sup>5</sup> In (Frigg, 2010b) the account of model-target relations allows for comparisons that are not based on similarity.

worldly fictionalist cannot avail herself of a notion of comparative knowledge, the key to the first package. There are no entities with which to compare target phenomena. On the other hand, a simple and direct understanding of realism as the view that science ought to aim at true models isn't available either. We know that models are often deliberately simplified or otherwise distorted versions of target phenomena. Indeed that was one of the main motivations for thinking of models as fictions. So the realist who wants to think of models along the lines of a worldly fiction cannot appeal to models themselves as the vehicles of scientific truth. What a worldly fiction says about the world cannot be a candidate for theoretical knowledge for a realist, because taken literally it is often untrue.

But the allusion to knowledge suggests another strategy for defining realism. In most formulations of realism the locus of the doctrine is seen as the content of the theory or model. The view is that scientists aim to attain true *models*. But we might also view realism as a doctrine concerning true *beliefs*. The idea would be, roughly, that realism is the doctrine that science aims to *allow us to acquire knowledge about the world*. To paraphrase van Fraassen's definition, we might take realism to be the view that science aims to supply us, in its models, with the means to form correct beliefs about target phenomena. At first this might not seem like a substantial shift. But in at least one way it is: if realism is a doctrine about knowledge, then theoretical science can be successful, from the realist's point of view, even if its immediate products, e.g. models, are false. Deliberate distortions of the truth are fine, so long as models allow us to form (and justify) correct beliefs about the world.<sup>6</sup> So we have a second package – a view of models as low-key, worldly fictions, and a knowledge-based formulation of realism.

In the first package, model-based science is conceived as comparative. The knowledge it affords is underpinned by a relation of model-world similarity. There is no need for such a relation in the second package. However, the second package raises an issue of its own: if fictional models are *imaginative* descriptions of (bits of) the real world, how can we glean veridical information from them? A response to this question may start by drawing attention to metaphor. Consider such pronouncements as that Juliet is the sun or that T.H. Huxley was Darwin's Bulldog. These are statements about Juliet and Huxley, respectively. But they ascribe to their subjects – at least at the literal level – properties that they do not have. However, in ordinary communication, metaphor can be an excellent means of gaining information and forming accurate beliefs. Although we know that Huxley is not a bulldog, nor Charles Darwin's pet,

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<sup>6</sup> Martin Thomson-Jones (Pers. Comm.) suggests that such a picture bears certain resemblances to Giere's view (see especially his 1988). I do not have the space to discuss this point here.



we understand – and can come to believe – that he was a zealous proponent of Darwinism, i.e. we can come to believe a truth. Everyday metaphors can convey more mundane, “dry”, information too, of a sort closer perhaps to scientific knowledge. Consider an example from Kendall Walton (1993): You inquire as to where in Italy the town Lecce is. I respond by pointing out that it is on the tip of the heel of the Italian boot. This statement will allow you – if you have the right background knowledge – to form true beliefs about the location of Lecce and to act accordingly.

An analogy with metaphor is only the beginning, however. The question is whether one can glean something useful from thinking of models in terms of metaphorical meaning and cognition. One way of going here would be to adapt a traditional way of thinking about metaphor as a device that reframes our perception and cognition of familiar objects and events. (Black, 1952 is the *locus classicus* of this view; see also Camp, 2009). On this view, metaphor imposes a certain conceptual structure on its subject-matter: its function isn't to inform by way of a novel comparison but by highlighting certain properties and suppressing others, making salient certain inferences and so on. Clearly this line of thought would have to be developed and adapted if it is to illuminate modeling, and there isn't sufficient space for this here. Still, the parallel with metaphor suggests that we can make sense of, or at any rate make good use of, worldly fiction in epistemic contexts.

## **4. Choosing a Package**

**4.1. Semantics and Ontology.** Having sketched the two packages, an obvious question is whether one of them provides a more compelling combination of fictionalism and realism. Discussing this issue in a comprehensive way is beyond the scope of the present paper. Moreover, I do not think the issue can be decided at present, since much of the philosophical groundwork, especially concerning fiction and metaphor, is under-developed. But I would like to point to a few central considerations.

It is possible to be a pluralist, asserting that some modeling is of the worldly variety, while other parts of the practice are akin to whole cloth finalizing. Indeed some of my comments below (§4.2.)

might be construed as supporting this option.<sup>7</sup> But I think it is most instructive to focus on considerations that pertain to choosing one package over the other.

To begin with the first package, it is obvious that one needs an account of fictional “things” in order to move forward. In the philosophy of art, several such accounts exist. They have merits and demerits qua accounts of artistic varieties of fiction (Kroon & Voltolini, 2011). But they also differ in their suitability as accounts of modeling. A key issue here is whether one can make sense of comparative knowledge of the sort discussed earlier. If comparison is to have its ordinary, bona fide meaning, then there must be two things, in some sense of ‘thing’, between which a comparison is drawn. Therefore, the first package requires that we make sense of reference to fictional entities – an issue that metaphysicians and aestheticians have long wrestled with. Let me sketch very briefly some central options and the issues they raise.

Some have taken fictional entities to be abstract, albeit not necessarily on the model of numbers or other familiar abstracta (Thomasson, 1999). This view has distinct advantages, but it requires that we understand the model-world relationship as a type of structural mapping, since there can be no ordinary similarity between abstract models and concrete phenomena (Thomson-Jones, 2010). Opponents of structuralism will therefore balk at this suggestion (not all structuralists would rejoice either).<sup>8</sup> Another possible view is that fictional entities are concrete possibilia – e.g. parts of possible worlds.<sup>9</sup> Such a view allows for model-world similarity relations, in an ordinary sense of similarity. But there are familiar, perhaps overwhelming, difficulties with possible worlds (see Weatherson, 2009, §6 for an overview).<sup>10</sup> A third alternative is a kind of eliminativist stance, on which prima facie fictional entities are seen as mere make-believe – imaginings in people’s minds (Brock, 2002; Currie, 1990; Walton, 1990). In the philosophy of art, this view commands considerable support. But, as I argue elsewhere (Levy, forthcoming) the idea of similarity or even the notion of a mapping between such non-entities and actual, real phenomena faces very serious difficulties. This means that the eliminativist view, despite

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<sup>7</sup> I thank Martin Thomson-Jones for helping me see this.

<sup>8</sup> Mauricio Suarez (pres. comm.) suggests that a formal mapping would be ruled out by the concrete nature of the target. If so, that would be another strike against the fictions-as-abstracta option.

<sup>9</sup> Thomson-Jones (2010b) discusses possibilia and the ontology of modeling at length.

<sup>10</sup> That said, some will think that it is best to embed an account of fictions, as well as models, within a grander system that encompasses modality as well.

(indeed, because of) its attractions as an account of Sherlock Holmes and Middle Earth, might not suit the needs of the fan of fictions in the philosophy of science.

Thus, the role of comparison generates problems for the various ways of handling the whole cloth approach. This may suggest that it is better to pursue the direct, worldly approach, where no comparison is involved. But that approach requires substantial elaboration, which I am unable to provide at the moment, and which may very well affect its attractiveness. If one thinks of worldly fiction as akin to metaphor, then the need arises to consider the issue of metaphorical content – how does one glean information from literally false statements? We know it to be possible, indeed common. But this observation only triggers the philosophical (also psychological) project of saying how metaphor works. I suggested earlier that a promising avenue is the idea that metaphors reframe our cognitive engagement with an object. But this is at best a first step.

In sum, the worldly approach is relatively free from metaphysical concerns (because it avoids reference to fictional entities). But until the notion of gleaning knowledge of a real-world target from an imaginary description of it is clarified, it is not obvious that it constitutes progress.

**4.2. Compatibility with Scientific Practice.** The questions I've considered so far in this section concern the semantics and ontology of fiction. Another set of considerations that could, in principle, distinguish the two packages has to do with their compatibility with the practice of modeling. We may ask: How do modelers view their work? Do they think of it as specifying standalone model systems that have a measure of independence from the world? Or do they treat models as creative portrayals of actual phenomena? Michael Weisberg (forthcoming) argues that the practice clearly favors a whole cloth approach. I am doubtful. It appears to me that most modelers do not commit one way or another on this question. This is not for the trivial reason that they haven't given the matter thought. Rather, it is because most models can be treated both ways. Recall Nowak's linear process model. We can treat it as specifying an imaginary linear crypt, a cellular chamber with the simple architecture Nowak describes. Alternatively we can read it as an imaginative description of real crypts: saying, in effect, that colon crypts have a simple linear architecture. Similarly, whenever a model has a definite enough target phenomenon, especially when modelers have a sufficiently clear idea which of their modeling assumptions apply to the target and to what extent, one can move between seeing the model as a specification of a construct and as a re-description of the phenomenon itself. Indeed I think we often

witness modelers talking both ways. And for good reason: Thinking of a model as a standalone entity can be convenient and theoretically liberating in some contexts, especially in the process of model development. It allows one to forge ahead without being overly concerned with the empirical plausibility of one's models. But thinking of a model as more closely anchored to a target phenomenon is essential to other tasks, such as experimentation and confirmation. The possibility of switching can be the subject of a separate discussion, and it connects, I believe, to judgments about progress in model-based science (Levy, 2011). The present point is that the practice can often be seen as either (or both) the direct, worldly kind of fiction or the indirect, whole cloth kind.

These practice-centered considerations might motivate pluralism: an acceptance of several modes of fiction in science. Or perhaps they suggest that if we are to choose between the two packages, we shall have to do so primarily on systematic semantic and metaphysical grounds having to do with how to best understand fiction.

## **5. Summary**

I have described two ways of handling the idea that models are fictions. The first package treats fictionalizing as an act of construction. One sets up a fictional system, the model system, then compares it to a real-world target. On this reading the kind of knowledge we gain from modeling is comparative in nature. The result is a picture that appears to be a natural elaboration of the idea that models are fictions. But there are difficulties, having to do with the ontological status of *prima facie* fictional entities, and with the semantics of comparing fictions with reality.

The second package involves a lower key notion of fiction. Here modeling is seen as directly about phenomena, portraying targets with deliberate distortion. We then have a corresponding conception of model-based knowledge that involves not the acceptance of true statements, but the gleaning of true beliefs from false models. This package involves relatively few ontological concerns, but the notion of "gleaning true beliefs from false models" stands in need of explanation. I drew an analogy here – perhaps it is more than an analogy – with metaphor. But more work is needed if the analogy is to carry real philosophical weight.

I closed by suggesting that within the practice of modeling switching between modes of fiction is common and reasonable. This implies that if we are to choose between the packages, we shall have to do

so primarily on metaphysical grounds, i.e. on the basis of an account of the ontology fiction and of the logic and semantics of comparing fictions with reality. Whether this is good news or bad news for the discussion of models and fiction depends on one's philosophical temperament.

## References

- Black, Max. (1962). "Metaphor." *Proceedings of the Aristotelian Society*, 55: 273–294.
- Brock, Stuart (2002). "Fictionalism about Fictional Characters". *Noûs*, 36(1): 1-21.
- Camp, Elisabeth. (2009), "Two Varieties of Literary Imagination: Metaphor, Fiction and Thought Experiments", *Midwest Studies in Philosophy*, 33: 107-130.
- Currie, Gregory. (1990). *The Nature of Fiction*, Cambridge: Cambridge University Press.
- Da Costa, Newton & Steven French. (2003). *Science and Partial Truth*, New York: Oxford University Press.
- Eklund, Matti. (2007). "Fictionalism". in *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.), URL: <http://plato.stanford.edu/entries/fictionalism/>.
- French, Steven & James Ladyman. (1999). "Reinflating the Semantic Approach", *International Studies in the Philosophy of Science*, 13: 103–21.
- Frigg, Roman. (2010a). "Models and Fiction". *Synthese*, 172: 251-268.
- Frigg, Roman. (2010b). "Fiction and Scientific Representation". In Frigg, Roman and Matthew Hunter (eds.): *Beyond Mimesis and Nominalism: Representation in Art and Science*, Berlin and New York: Springer, 2010, 97-138.
- Giere, Ronald. (1988). *Explaining Science: A Cognitive Approach*. Chicago: University of Chicago Press.
- Giere, Ronald. (2010). "Why Scientific Models Should not be Regarded as Works of Fiction" in Suarez, Mauricio. (2009). (ed.) *Fictions in Science: Philosophical Essays on Modeling and Idealization*. New York: Routledge.
- Godfrey-Smith, Peter. (2006). "The Strategy of Model Based Science". *Biology & Philosophy*, 21, 725-740.

- Godfrey-Smith, Peter. (2009). "Models and Fictions in Science", *Philosophical Studies*, 143 (1): 101-116.
- Kroon, Fred and Voltolini, Alberto. (2011). "Fiction", in *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.), URL: <http://plato.stanford.edu/entries/fiction/>
- Levy, Arnon. (2011) "Game Theory, Indirect Modeling & the Origins of Morality", *Journal of Philosophy*, CVIII (4): 171-187.
- Levy, Arnon. (forthcoming). "Fictional Models de Novo and de Re".
- Nowak, Martin. (2006). *Evolutionary Dynamics: Exploring the Equations of Life*. Cambridge, MA: Harvard University Press.
- Sainsbury, Mark. (2009). *Fiction and Fictionalism*, New York: Routledge.
- Thomasson, Amie. (1999). *Fiction and Metaphysics*. Oxford: Oxford University Press.
- Toon, Adam. (2010). "The Ontology of Theoretical Modelling: Models as Make-Believe". *Synthese*, 172: 301-315.
- Thomson-Jones, Martin. (2007). "Missing Systems and the Face Value Practice" (extended manuscript) <http://philsci---archive.pitt.edu/id/eprint/3519>
- Thomson-Jones, Martin. (2010a). "Missing Systems and the Face Value Practice", *Synthese* 172: 283–299.
- Van Fraassen, Bas. (1980). *The Scientific Image*. New York: Oxford University Press.
- Walton, Kendall. (1990). *Mimesis as Make-Believe*. Cambridge, MA: Harvard University Press.
- Weatherson, Brian. (2009). "David Lewis", in *The Stanford Encyclopedia of Philosophy*, Edward N. Zalta (ed.), URL: <http://plato.stanford.edu/entries/david-lewis/>
- Weisberg, Michael (forthcoming), *Simulation and Similarity: Using Models to Understand the World*, New York: Oxford University Press.