

**Ana Katić**

*THE EPISTEMIC ROLE OF FICTION IN SCIENTIFIC MODELS*

*ABSTRACT: Giere's analysis of the epistemic role of fiction in science and literature is the representative of antifictionists. Our research finds the three inconsistencies in his main paper regarding the comparison of fiction in scientific models and literary works. We analyze his argument and offer our solution to the issue favoring the perspective of fictionalism. Further, we support a typological differentiation of false representation in science into fictional and fictitious. The value of this differentiation we demonstrate by giving the example of digital organisms in system biology. The paper aims to help better understanding of fiction in science and to avoid the oversimplification of literary fiction.*

*KEY WORDS: digital organisms, artificial evolution, complexity, two types of fiction*

“Humanity certainly needs practical men, who get the most out of their work, and, without forgetting the general good, safeguard their own interests. But humanity also needs dreamers, for whom the disinterested development of an enterprise is so captivating that it becomes impossible for them to devote their care to their own material profit.”

Ève Curie, *Madame Curie*<sup>1</sup>

Scientific models are idealized structures that scientists use to represent the world<sup>2</sup>. The main purpose of the models is to introduce complex, dynamic, and/or unobservable entities and processes into the scientific context of research. In the contemporary philosophy of science, the important topic is whether we should consider the scien-

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1 Quotation is from the book *A Cultural History of Physics*, Károly Simonyi (translated by David Kramer), CRC Press, 2012., p. 500.

2 This definition and the following model characteristics are from the PhD course on scientific models: lecturer Eva Kamerer, school year 2014/2015., Faculty of Philosophy, University of Belgrade.

tific models<sup>3</sup> as work of fiction, similar to literary fiction. One reason for this theoretical problem is the proliferation of model diversity and its increase in complexity, especially in the natural sciences. This type of discussion focuses on analyzing the epistemic<sup>4</sup> meaning of fictive elements in models. Thus, the main questions are whether fiction can have epistemic functions in scientific inquiry, what exactly, and to what extent.

With relation to the answers to these questions, positions divide into two opposing types usually, referred to as wide fictionalism and narrow fictionalism. For our research, we denote them differently. The first position is fictionalism, and its representatives are Suárez, Frigg, Ankeny, Fine, Rouse. They argue that we are dealing with fiction in specific types of scientific models and we cannot reduce that fiction to form of idealization, abstraction, or approximation. The second position represents the authors like Giere, Teller, Morrison, Winsberg. They consider models to be products of the processes of idealization, abstraction, and approximation exclusively. For them, even if we have fiction involved in the modeling strategy, it is not useful and instructive to name the model as a work of fiction. Therefore, instead of calling them narrow fictionalists, we call them antifictionalists.

We focus on Giere's argument on this topic because his paper is representative of the antifictionalist camp. The goal is to respond to his sharp critique of the fictionalism. In the first section, we analyze the three inconsistencies that we find in his main paper regarding the comparison of fiction in models and literary works. We hypothesize that literary fiction has a value not only as of the aesthetic but as the epistemic also. In the second section, we briefly describe the differentiation of two types of fiction into fictional and fictitious. In the third section, we demonstrate the value of this fiction differentiation by using a specific example from system biology, which is digital organisms. In the final section, we summarize our argument and conclusion. The general goal of our research is to contribute to overcoming the common misunderstanding of fiction in science and the inadequate simplification of literary fiction.

## **1. Giere's critique of the epistemic role of fiction**

Giere states that scientific models and literary fiction, although maybe the same ontologically, as representing what does not exist in reality, have a completely different epistemic function (Giere 2009). Models serve as scientific tools for representing aspects of the world with its accuracy, precision, and detail, and works of fiction do not. In other words, the main question is if we should characterize models as work of

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3 Primarily applies to complex computer models/simulations here.

4 In this paper, we use the term epistemic in a broad sense and as a synonym for cognitive too.

fiction, analogous to literary works, and Giere's answer is negative. On the contrary, we claim that if we interpret specific types of models as fiction, we will epistemically benefit from it.

The first premise of his argument is that fiction is a product of individual imagination, while the scientific community creates models. We find this statement, inherently quantitative, weak. Literary fiction can be a product of joint effort as well and very successful. Great books inspire great scenarios and give great movies, later on. And this joint effort stands for co-authorship, as well as for the relationship between the writer and the readers. Moreover, the essential value of a literary work locates within the relation between the writer and the audience. The audience potentially enhances the value of concrete literary fiction with their impressions produced by their knowledge and personal imagination. That is why some literary works do not appreciate in their time, but sometimes decades later. The collective knowledge could be at a considerably lower or strikingly different level than of the writer's. Or, a genius might have a vision, like in science fiction genre, in which few people can find meaning and importance. Once the anticipated events/concepts actualize, the specific work receives its well-deserved attention.

Further, the fact that many scientists (that is, many consciousness, as Giere states), design models can refer to that the models are the result of many imaginations altogether, and nothing more. In scientific practice, this is rarely the case. But, the argument based on the number of consciousness that creates fiction/model is not particularly tenable. The number of creators does not imply different epistemic role. And secondly, there is no logical necessity to regard the concept of an imaginary entity as free from certain rules corresponding to reality and knowledge, even in a literary work. Thus, fiction, as a product of individual consciousness, can play a crucial role in understanding the real world itself also.

We paraphrase Giere's second premise. It claims that we are capable of distinguishing between fiction and non-fiction. Even if the boundary is not clear, every rational person can recognize it and understands where the boundary is. Giere claims that there is a decisive difference between creation by well-known scientists and the creativity of a writer. Even when the scientific hypothesis represents a construct stranger than fiction, the authority of a constructor/s empowers the guarantee of its non-fictional character. So, in his opinion, a certain authority grounds the boundary between fiction and non-fiction:

"Even books describing 11-dimensional vibrating membranes or multiple universes, which sound to many ears as being 'stranger than fiction,' are classified as nonfiction as long as they are written by recognized scientific authorities and intended as at least possible scientific descriptions of the world." (Giere 2009: 251)

We do not underrate the scientific authority, as such, but we are questioning the way Giere interprets that authority and domains of its crucial power. Science is a constantly

developing and evolving system. This complex system has its heterogeneous subsets and dynamics. Science changes its complexity and ways of functioning along with the evolution of human species. In this relationship between man and science, both types of causality play a role: bottom-up and top-bottom. Individuals, as elementary agents, change the trajectories of evolution, just as the scientific collective, as a whole, changes paradigms. Therefore, scientific authority should be a result of the functional solutions and realized experimental predictions. It must not be a guarantee by itself, that is, a guarantee of the *scienceness* of the materialized ideas of people with a degree.

Giere assumes criticism similar to ours and answers in advance. When the model omits to represent a target system in a precise and accurate manner, the scientific community reacts to discovered errors and flaws. The wrong model rejects as inadequate eventually. Giere sees here the additional reason for the inappropriateness of comparing models to literary fiction. He believes that in the case of fiction, such a critique of potential deviations and errors if it exists, would be inappropriate. We disagree with Giere. Quite similar to the epistemic evaluation/ justification of scientific models which turned out to be wrong (to name just a few in biology: spontaneous generation, vitalism, preformationism), literary fiction undergoes evaluation, too. As Giere states that we understand the difference between fiction and non-fiction, although the boundary is not clearly defined, so do we distinguish between good and bad novels. A good book is one in which the author writes prudently controlling his or her imagination so that we trust the story. And, we not only believe in style or aesthetics of the story, but we evaluate an information system as a totality.

A *nonwriter* is struggling to create something potentially interesting and valuable. Although, it is clear that value differences are subtle, and a matter of personal taste, we know when the story rejects us. It is because the story lacks spontaneity and naturalness, it has nothing more than its *fictiveness*. That is the reason why there are categories, such as bestsellers, unsuccessful novels, and classics. They are all a product of fiction, but they are not just that. The story has its value, which is not a purely artistic result, but also the result of the achieved purpose. The purpose goes beyond aesthetic experience and aspirations, and reaches our deeper knowledge, whether it is conceptual, emotional, factual, or psychological knowledge. Hence, fiction has universal principles as well.

To Giere, and this is his third premise, equating models with fiction seems to have its cause in the over-emphasized concept of non-fiction. Consequently, as if science is under a heavy burden of demand that everything that happens in it must represent truth and only truth. He believes that we should allow it to be acceptable that no model fits perfectly with its target system. This does not mean that it is justified to characterize all models as fiction.

On the contrary, we think that Giere's criticism and his categorical rejection of fiction, are overstated. Scientific knowledge implies that it refers to the real world, in

the final instance. The question is what epistemic role models play in our attempts to explain the complex world around us. Authors who claim models are fiction in a specific sense, say no more than what Giere himself admits, that is all models are intellectual or imaginary creation. There are significant differences among models within the same scientific discipline, as a consequence of the rapid technological development of research tools. We need to understand the nature of these differences and their meaning, to explain models of fundamentally different cognitive roles. Therefore, we need the notion of fiction in science to succeed in separating one type of model, which is a completely new creation, from a model that is a representation. To analyze the distinction between a digital organism, as a new generation modeling tool of system biology, and model organism in the classical biological sense, we briefly explain the difference between the two types of fiction in the next section.

## 2. Two types of fiction: fictional and fictitious

The most common definition of a scientific model is that it is an abstract, conceptual or mathematical, representation of something else. In this generally accepted definition, we omitted the following part of the sentence: "...of a real phenomenon that is difficult to observe directly"<sup>5</sup>, intentionally. We want to emphasize that science knows about the feature called radical emergence nowadays. There are scientific interdisciplinary projects concerning specific complex systems which are essentially radically emergent. These systems are complex in such a way that they are *unprestatable*. For example, there is no equation we can calculate for all possible Darwinian preadaptations. We cannot predict in a finite number all the possible outcomes of the biosphere (Korenić, Perović, Ćirković & Miquel 2020; Longo, Maël & Kauffman 2012). Therefore, there is distinct scientific research concerning, for example, the future planetary climate changes, environmental risk assessment, cosmological explanation of the origin of the universe, or the search for the origin of life (within biology and astrobiology). In this research, we have already had the frequent use of simulation, as a legitimate scientific methodology. And simulation is not just a representation of a phenomenon difficult to observe, rather its re/design, or its anticipation, as well. This applies in particular to scientific disciplines concerned with the understanding of the origin and development of dynamical systems, such as those that evolutionary theory or astrobiology study. The vast temporal distance and complexity of the factors (key parameters), that influence developments in such systems, impose the use of simulated scenarios. In these scenarios, complexity decomposes and the relevant agents recombine to grasp a deeper understanding of the origins of the universe and life (Damer & Deamer 2019; Damer 2016; Vukotić et al. 2016).

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5 <https://www.britannica.com/science/scientific-modeling>, visited on 24. January 2020.

Consequently, there are two ways in which the representation of a phenomenon in scientific modeling can be fiction in a general meaning. Representation of an  $x$  is false when it represents an entity that does not exist in reality. Following Suárez's initial idea about the two types of fiction, we call such a representation fictional. Representation is incorrect when an entity  $x$  exists in a reality, but not entirely as model represents it. That is, some new properties emerge in this type of a representation called fictitious (Suárez 2009). We should notice that both types of representation are inaccurate in some sense and we need the appropriate knowledge to help us determine where the inaccuracy hides.

Distinguishing between these two types of false representation is crucial for our topic. Based on its division, we analyze the views on the epistemic role of scientific models. To remind, fictionalists state that false representation is fiction subtype. Therefore, they consider the specific category of models in science as fiction in a certain sense. This sense is different from the meaning of idealization, abstraction, and approximation. Antifictionalists are not ready for such a conclusion considering it as too radical. They, however, believe when we say that a representation is false, we do not claim anything more than it is merely a case of idealization, abstraction or approximation.

Such divergences also affect answering on epistemological questions. Those who are close to the fictionalism, support the instrumentalist standpoint in the epistemology of science. On the contrary, those who are antifictionalists tend to be scientific realists. The question follows: if we give fiction a significant epistemic role in modeling strategy, do we regard models as instruments by which we discover new aspects of scientific imagination, new concepts and the new goals, or we put ourselves in the risk of nullifying the difference between the science and non-science? We answer this question in conclusion section.

Models represent a variety of phenomena. Among many model determinations, we accept that the model is an imagined physical system, that is, a hypothetical system (Frigg 2010). A hypothetical model or simulation is a complex information system. Developers insert the initial information into the system, and they put simulation to work. As a complex system, one of its features is emergence. That is, the whole has causal powers not possessed by the parts (Kauffman, Clayton 2005). The definition of the emergence applied to this case means that the program can make its own decisions. Hence, in the beginning, we have starting information and rules, and after enough work time (*enough* time is relative to research context/target), we have a feedback results or outcomes that we could not predict.

So, in the very nature of a complex hypothetical model is its epistemic role in revealing trajectories and outcomes that we are unable to predict otherwise. In other words, the simulations enable scientific discoveries of new physical properties, new causal dynamics, and mechanisms that we have not seen in a particular target system yet. The purpose of the model is to experiment indirectly with its target system. Sci-

entists create a hypothetical model for a better understanding of what concrete phenomenon could be like if it existed as such in reality. The potentiality of its existence and appearance can be related to the past and the future as well.

To support the relevance of the explained distinction between two types of fiction and the fictionalist position, we illustrate and analyze the concept of digital organisms in biology.

### **3. Digital organisms**

Antifictionalists use models in physics as examples to support their point of view. They hypothesize that each scientific model, no matter how distant it seems from reality, represents a construct of the real data using the processes of idealization, abstraction, and approximation only.

Going a step further in our research, we choose a particular biological example, for a change. Our field of interest is system biology and its model organisms called digital organisms. System biology is a rapidly growing trans-disciplinary research field. It concerns with quantitative analysis of the dynamic interactions within complex biological systems. Its goal is the understanding of the behavior of these systems, the ability to predict their changes over time, and the conditions that affect these changes. This scientific research paradigm is relevant to solving health and environmental issues primarily. These issues require the use of system theory, and methods such as biological experimentation, mathematical modeling, and computational simulations.

Digital organisms are computer programs or simulations. These programs are self-replicating and capable of mutating and evolving (Lenski et al. 1999). Using these programs, scientists (re)design complex natural phenomena as an experiment in a simulated environment. Therefore, we can speak about artificial evolution in a new meaning of evolving genetic algorithm and its controlled evolutionary procedures replication, mutation, and selection. One of the purposes of this digital experimental evolution is to discover unknown trajectories of natural selection and evolution in general. The other purpose is to explore known evolutionary mechanisms that are difficult or impossible to observe in a natural sequence of events, such as the dynamics of long-term adaptation, the distribution of epistatic interactions among mutations, and quasi-species dynamics (Wilke, Adami 2002).

In his *Origin of Life*, Darwin envisions change (it regards mutations, nowadays) and survival (natural selection) over long periods as major evolutionary mechanisms crucial for the emergence of new species. It is very difficult to directly track macro-evolutionary changes on long timescales. And, it is impossible to experiment with this kind of adaptation (long-term adaptation), because we cannot change the key parameters. The exceptions are bacteria and viruses – organisms with extremely short gen-

eration times. But still, it takes a couple of years for them to grow new populations in thousands of generations (Wilke, Adami 2002). So, scientists invented a solution in the form of models called digital organism. It takes just a couple of days for them to propagate that many generations. Later, it appeared that digital organisms were not only a compromise solution but a completely new inquiry tool, with an unexpectedly wide range of experimental possibilities.

There are two types of digital organisms: simple and complex. The simple programs can replicate only. Complex programs conduct mathematical operations that speed up replication through a series of predetermined ‘metabolic’ rewards (Lenski et al. 1999). The first functional digital life system called “Tierra” creates Tom Ray in 1992. This program is self-replicating and solely the ability to contribute to the offspring of future generations determines its fitness. And, in California, “Avida” develops to study the evolution of complexity in biology (Adami 2013). This program has proven to be appropriate to research complexity in the domain of fundamental evolution and to study the evolution of intelligence, as well (Beckmann, Grabowski, McKinley & Ofria 2008).

So, the difference between simple and complex digital organisms is not trivial, but rather, sophisticated. Both of them are computational simulations and, at first sight, they have nothing in common with real natural systems. One of the goals is to reconstruct the selected phenomena and explain their dynamics. Digital life has been developed to such a degree, that it enables simulation of neural connections, visualization of the processes of embryogenesis, three-dimensional mappings of cell position (Ankeny 2009). Digital organisms allow scientists to test certain generalizations that are very difficult to observe in real-time monitoring. These generalizations concern higher life forms, usually. Like, for example, the neural networks visualization, for demonstrating, and further understanding of their complex behavior.

It is important to note that such simulations always involve neglecting the details of the target system, to a greater or lesser degree. We can define different forms of detail omission as processes of idealization, abstraction, or approximation. But we cannot define a model, as a totality, that is solely the product of these processes. Digital simulation is a new design inspired by information from natural system and its various complexities, but we cannot reduce it to that information. Especially because it is often designed to deviate from the target system. Therefore, digital organisms are of distinct ontological status and bring different epistemic roles into science, unlike model organisms in evolutionary biology.

In evolutionary biology, we have two types of model organisms a) exemplary and b) surrogate models, and accordingly, two modes of representation (Bolker 2009). Exemplary models serve literally as representatives of a broader species group, and they are the oldest and most famous models in biology, such as yeast and fruitfly. Research with these models is based on inductive inference, going from a single in-

stance (observed mechanism or pattern) to the universal conclusion (generalization applied to the higher taxon), (Weber 2005). Surrogate models serve in bio medics dominantly. Research with this kind of model is based on direct substitution. For example, the observed side effects of the drug in rats are also considered valid for humans.

With this brief introduction to the topic of model organisms in evolutionary biology, we open the space for its clear comparison to digital organisms in system biology. Conclusions from model organisms are empirical extrapolations (Levy, Currie 2015). In this sense, model organisms are the constructs produced by the processes of idealization, abstraction, and/or approximation, as the antifictionalism claims. We change their natural forms, functions, and genes, environmental conditions, and grow them artificially. But, they are still scientific tools for empirically gathered data only. Like in any induction process, model organisms' based research starts with particular assumptions (inductive premises) and aims to achieve understanding phenomenon and its fundamental characteristics as a whole (generalization). Maybe we can say that the bottom-up causation is inherent to this kind of exploration. That is, the experiment begins with a hypothesis about assumed elementary agents of some system, and then goes further towards deriving general conclusions, that can be applied to a wider group of species or mechanisms.

On the contrary, in digital organisms, the research methodology is not based on 'observing' a phenomenon to detect its characteristics. It starts with the complex system as a given outcome that needs to be reconstructed, instead. Therefore, as if we have top-down causation in this context - it is only when we get the targeting outcome, we manage to retrospectively understand how a particular phenomenon potentially originates and functions. Therefore, we can argue that these types of experiments start with an assumed conceptual/abstract hypothesis about the system as a whole, and goes further to test some of its potential aspects. This means that it is not an empirical exploration in the usual meaning of the word empirical, but a dynamic, creative relation between scientific data and scientific imagination. As Levy and Currie (2015) say, there is an intimate relationship between modeler's knowledge about the model he/she creates and the model itself.

This kind of intimate relationship between the scientist and the model does not exist in the model organism domain. There is always an actual distance produced by the fact that we are not the creators of the model because the creators are complex, regular and emergent, historical evolutionary processes. Hence, the model organism's conclusions are based on the predetermined empirical boundary conditions and extrapolated to the level of general principles of evolution.

Inferences from digital organisms are mathematical and statistical in very nature, which is abstract and holistic, rather than reductionistic. Modelers start with system theory in a particular context and then look for how the designed model can produce

the right feedback. So the authentic and educated imagination is necessary for this context of research.

These important differences between model organisms and digital organisms are linked with the question of fiction in science and with their different epistemic roles. Model organisms are representatives of a larger class of specimens for what scientists learn and detect. Digital organisms are especially good in the early stages of a new experimental project. They are a good starting point for a hypothesis selection, directing testing, and prediction, as well. Scientists experiment and look for new evolutionary pathways, and they study them further in natural systems/organisms. In this way, they manage to conceptualize interactions, with both local and global properties. And these are all epistemic roles of digital organisms in science, even though digital life is not directly related or dependent on actual systems.

#### **4. Conclusion**

Our research is inspired and organized in response to Giere's clear and detailed critique of the comparison of fiction in scientific models with literary works. We analyze three inconsistencies in his major paper on the subject, and we build our argument in support of a fictionalist perspective. We claim that literary fiction is not as simple and trivial as Giere assumes. Literary work is an imagined information system with both aesthetic and epistemic values. The number of consciousnesses that create fiction says nothing about its potential epistemic role. The epistemic value of literary fiction is something that arises from the relationship between the writer and the audience. Knowledge and imagination, that is, the cognitive capacity for a vision and deeper understanding of unpredictable processes, both in the writer and in the audience, play a creative and decisive role in this relation. This is most strikingly seen in the science fiction genre. Although we know that the theme/subject<sup>6</sup> of the science fiction novel does not exist, it is significant whether its imagined existence is intrinsically and relevantly related to the current world and its possible actualizations.

We argue that it is epistemically useful to accept the notion of fiction in scientific modeling. Because there are complex phenomena, like biological organisms, and there are complex processes, like a historical contingency. Neither of these we cannot explore without the use of fiction. The notion of fiction, we emphasize in this paper, involves two meanings: when it relates to what does not exist (fictional), and when it relates to what exists, but it is not accurately represented (fictitious). Only when we

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6 In this context, the theme can be a hypothetical system of future evolutionary pathways, of the development of the technological aspect of life and its impact on our postbiological values, and so on.

accept that there is fiction in specific modeling strategy, we can distinguish between two types of models. On one side, there are newly created models (like digital organisms) that enable predictions about the emerging evolutionary trajectories or concepts, and these are not a direct representation of the empirical data we currently have. On the other side, models are representing more or less precisely real-world aspects. They are the constructs of processes of idealization, abstraction, and approximation solely (like model organisms), and its inferences are empirical extrapolations. The research strategies that create these two types of models are not demarcated, rather, they are complementary. Therefore, fiction analysis has theoretical benefits, as it highlights the variety of epistemic roles that models can play in science, such as discovering new aspects of scientific imagination, new concepts, and the new goals. Rather than avoiding the notion of fiction, which, as Giere says, is far too loaded notion, we should focus on its rich and robust meaning, and present it in a new light for future paradigms.

At the highest conceptual level, imagination is a necessary tool, along with reasoning, logic, and mathematical abilities. Maybe the more we learn about the world and its complex, emergent nature, the more science and art converge with one another. In this convergence, we should not fear that the boundary between science and nonscience vanishes. Fiction is not the point at which this distinction becomes vague. Since, the experimental nature of science, its verifiability, and its methodology that produces predictions as functions of the real world are what make science an unambiguously scientific.

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### **Epistemička uloga fikcije u naučnim modelima**

(Apstrakt)

Giereova analiza epistemičke uloge fikcije u nauci i književnosti reprezentativna je za antifikcioniste. Naše istraživanje otkriva tri nedoslednosti u njegovom glavnom radu u vezi sa upoređivanjem fikcije u naučnim modelima i književnim delima. Analiziramo njegovu argumentaciju i nudimo rešenje ovog problema favorizujući perspektivu fikcionalizma. Cilj rada je da doprinese boljem razumevanju fikcije u nauci i izbegne pojednostavljivanje književne fikcije.

KLJUČNE REČI: digitalni organizmi, veštačka evolucija, kompleksnost, dva tipa fikcije