

## 23. Concealed and Explicit Fictions in Biomedical Research: From Animal Models to In Vitro Systems

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**Abstract:** Biomedical research has long been structured by fictional realities. Animal models exemplify this: a mouse is not a human, yet research proceeds as if it were. This fiction of similarity is not a falsehood but a productive device, enabling discoveries that have shaped modern medicine. Still, it operates as a concealed fiction, one that presents itself as continuity with the entity it tries to model while differences are nonetheless evident. Such animal-as-human equivalence is useful but limited both epistemically and ethically, since it obscures the gap between biological analogy and human specificity. A transition is now emerging toward *in vitro* and organ-on-chip systems, which embody a different fictional reality. These models do not masquerade as natural organs; they openly declare themselves as engineered constructs designed to reproduce selected physiological functions. Their value lies not in equivalence but in their status as transparent fictions: partial yet rigorous stand-ins that clarify what can and cannot be inferred. This represents an epistemological shift: knowledge is no longer grounded in assumed similarity but in explicit construction, where the fiction itself is acknowledged as the condition of discovery. The aim of this paper is to analyze this ongoing transition in biomedical research through the lens of fictional reality, showing how both animal models and *in vitro* systems can be understood as fictions that act. By framing biomedical progress as the refinement of fictions, from concealed similarity to transparent construction, the paper argues that these models are not distortions to be overcome but epistemic tools to be cultivated. Such a perspective highlights the deeper philosophical stakes of current biomedical practices: fictions, when made explicit, become the very medium of knowledge, discovery, and ethical responsibility. To recognize this is to see medicine itself as a field where representations do not merely simulate reality but generate

it, where fictions act not as distortions of truth, but as the conditions of its emergence.

**Keywords:** Biomedical research, animal testing, animal model, in vitro model, fictional reality

## Introduction

The concept of fictional reality has been used in philosophy to describe entities, structures, or representations that do not coincide with reality as such, yet nonetheless operate as real within specific practices. Fiction, in this sense, is not synonymous with falsehood or illusion. Rather, it designates a mode of construction through which reality becomes intelligible, manageable, and actionable. Philosophical discussions of fiction have long emphasized that human understanding relies on entities that are feigned for the purpose of discourse<sup>1</sup>, yet once introduced, function as if they were real. Such fictions may organize perception, guide action, and shape institutions, even while their constructed status remains partially or fully acknowledged.

Across different philosophical traditions, fictional realities have been understood as mediating structures between the world and our access to it. In critical philosophy, fiction appears as a regulative element of knowledge, an idealized construct that cannot be realized empirically but nonetheless orients cognition<sup>2</sup>. In phenomenology, fiction plays a methodological role in distinguishing between what is given as real and what is imaginable, without reducing the latter to mere unreality<sup>3</sup>. In social and political philosophy, fictions have been described as entities that stabilize practices and norms while concealing their own constructed nature, thereby acquiring the force of reality<sup>4</sup>. More recently, analyses of hyperreality have emphasized how representations can cease

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<sup>1</sup> Jeremy Bentham, "Of Ontology," in *The Works of Jeremy Bentham*, vol. 8, ed. John Bowring (Edinburgh: William Tait, 1843), 193–211.

<sup>2</sup> Immanuel Kant, *Critique of Pure Reason*, trans. Paul Guyer and Allen W. Wood (Cambridge: Cambridge University Press, 1998).

<sup>3</sup> Edmund Husserl, *Ideas Pertaining to a Pure Phenomenology and to a Phenomenological Philosophy, First Book*, trans. F. Kersten (The Hague: Martinus Nijhoff, 1982).

<sup>4</sup> Louis Althusser, "Ideology and Ideological State Apparatuses," in *Lenin and Philosophy and Other Essays*, trans. Ben Brewster (New York: Monthly Review Press, 1971), 127–186.

to refer to an underlying original and instead become operational realities in their own right<sup>5</sup>. What unites these perspectives is the recognition that fictional realities are not distortions external to truth, but internal conditions of how truth, meaning, and action are produced. Fiction does not merely accompany reality; it participates in its constitution. This insight acquires a specific epistemic significance in the context of scientific modeling. Scientific models do not provide unmediated access to their target systems; they operate as constructed stand-ins that mediate between theory, evidence, and the world. In this setting, fiction does not denote arbitrariness or invention detached from empirical constraint, but the deliberate construction of entities, systems, or relations that are not literally instantiated in the world, yet function as epistemic mediators within scientific practice. Such constructions are constrained by theory, evidence, and purpose, and derive their legitimacy from their capacity to enable reliable inference under conditions where direct access to the object of study is limited or impossible. Whether models are described as fictional, representational, inferential, or engineered artifacts, they share a mediating function within scientific practice. Recent philosophical debates on fictional models highlight this plurality of roles, showing that the fictional status of a model does not undermine its representational or inferential capacity, but clarifies how such capacities are epistemically secured, by rendering otherwise inaccessible domains scientifically tractable through structured substitution<sup>6</sup>. This mediating function becomes particularly important in domains where direct experimental access to the object of study is structurally constrained.

Biomedical research constitutes a paradigmatic case of this mediating dynamic. The human body is not directly available for experimental manipulation in most contexts, and knowledge of human health and disease must therefore be generated through models. These models are not neutral mirrors of reality, but constructed stand-ins that function within research practice as if they were representative of the human condition. In this sense, biomedical research is structured by fictional realities that are epistemically productive rather than epistemically defective. Traditionally, animal models have played a central role in this process. They operate

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<sup>5</sup> Umberto Eco, *Travels in Hyperreality*, trans. William Weaver (San Diego: Harcourt Brace Jovanovich, 1986).

<sup>6</sup> Lisa Zorzato, "The Puzzle of Fictional Models," *Journal for General Philosophy of Science* 55, no. 1 (2024): 1–20.

through a fiction of similarity: non-human organisms are treated as sufficiently analogous to humans to allow inference about human physiology and pathology. This fiction is neither naïve nor accidental. It is a methodological assumption that enables experimentation under controlled conditions and has supported major advances in medicine. At the same time, it remains largely implicit. Animal models are often presented as a natural continuation of human biology, even though the gap between analogy and specificity becomes evident when translation to human outcomes fails or when ethical concerns are raised. In recent decades, biomedical research has increasingly incorporated *in vitro* and organ-on-chip systems. These models instantiate a different form of fictional reality. Rather than relying on implicit biological equivalence, they are explicitly constructed to reproduce selected human physiological functions. Their fictional status is transparent: they do not claim to be organs or organisms, but engineered systems designed for specific investigative purposes. The fiction here is not concealed but declared, and its limits are articulated as part of the model's epistemic role. This shift reflects more than a technological innovation. It marks an epistemological transition in how biomedical knowledge is generated and justified. The basis of inference moves from assumed similarity to explicit construction, and fictional reality becomes a visible and deliberate component of scientific practice rather than an implicit background condition.

The aim of this paper is to analyze this ongoing transition in biomedical research through the concept of fictional reality. By examining animal models and *in vitro* systems as two distinct modes of fictionality (one grounded in similarity, the other in construction) the paper argues that biomedical progress does not consist in eliminating fiction, but in transforming and refining it. From this perspective, fictional realities are not obstacles to scientific knowledge, but the epistemic medium through which biomedical research operates. The paper proceeds by first clarifying the epistemological role of fiction in scientific modeling, before turning to animal models and *in vitro* systems as contrasting fictional realities within contemporary biomedical research. It then examines how the transition between these models reflects a broader reconfiguration of epistemic responsibility, transparency, and justification in the life sciences.

## Fictional Reality and Scientific Knowledge

To understand the role of fictional reality in biomedical research, it is first necessary to clarify how fiction functions within scientific knowledge more generally. In the philosophy of science, fiction does not denote invention detached from reality, but a specific epistemic strategy: the construction of entities, systems, or assumptions that do not fully correspond to the world, yet enable reliable knowledge about it. Scientific practice routinely relies on such constructions, particularly where direct access to the object of study is limited, ethically constrained, or technically impossible<sup>7</sup>. A useful starting point is the distinction between fiction, idealization, and approximation, which has been widely discussed in the philosophy of scientific modeling. Idealizations deliberately distort features of a system, such as frictionless planes or perfectly rational agents, in order to isolate relevant variables<sup>8</sup>. Approximations, by contrast, aim to remain close to empirical reality while tolerating a quantifiable degree of error. Fiction differs from both as it introduces entities or relations that are not merely simplified versions of reality but stand-ins that function *as if* they were real within a specific epistemic context<sup>9</sup>. Fictional entities are not expected to be corrected into reality, and models should not be understood as mirrors of reality but as epistemic tools that reorganize phenomena into forms amenable to investigation<sup>10</sup>. From this perspective, fictional reality refers to the domain in which such models operate: a space where constructed systems acquire operational reality within scientific practice, despite their partial or non-literal relation to the world. Their epistemic value does not depend on literal correspondence, but on their capacity to support robust inference across contexts, allowing the generation of understanding, prediction, or

<sup>7</sup> Hans Vaihinger, *The Philosophy of "As If"* (London: K. Paul, Trench, Trubner & Co., 1924); Nancy Cartwright, *How the Laws of Physics Lie* (Oxford: Oxford University Press, 1983).

<sup>8</sup> Ernan McMullin, "Galilean Idealization," *Studies in History and Philosophy of Science* 16, no. 3 (1985): 247–273.

<sup>9</sup> Hans Vaihinger, *The Philosophy of "As If"* (London: K. Paul, Trench, Trubner & Co., 1924); Mauricio Suárez, "Fictions in Scientific Practice," in *Fictions in Science: Philosophical Essays on Modeling and Idealization*, ed. Mauricio Suárez (London: Routledge, 2009).

<sup>10</sup> Mary S. Morgan and Margaret Morrison, *Models as Mediators: Perspectives on Natural and Social Science* (Cambridge: Cambridge University Press, 1999).

control. This view challenges a residual realist assumption according to which scientific progress consists in the gradual elimination of fictional elements. Instead, fiction appears as a permanent and necessary feature of the production of knowledge. Scientific understanding advances not by removing mediation, but by refining it, by designing fictions that are increasingly explicit, constrained, and purpose-sensitive<sup>11</sup>. The epistemic question is therefore not whether science employs fictions, but how these fictions are structured, acknowledged, and justified within scientific practice.

In this context, a crucial distinction emerges between concealed and explicit fictions. Concealed fictions operate by presenting themselves as natural continuities with reality. Their fictional status remains implicit, often stabilized by disciplinary convention or habitual use. Explicit fictions, by contrast, openly declare their constructed nature and delimit in advance the scope of their applicability. This distinction has important epistemological consequences. When fiction remains concealed, its limits tend to emerge only retrospectively, for instance when predictive or translational failures occur. When fiction is explicit, its limits are integrated into the logic of inference from the outset, allowing for more controlled interpretation and validation<sup>12</sup>. Scientific knowledge thus depends not only on the presence of fictional constructions, but on how these constructions are positioned within epistemic practice. Transparency about fictionality does not weaken scientific claims; rather, it clarifies the conditions under which those claims hold. Fiction becomes an epistemic resource precisely insofar as it is recognized as such, rather than tacitly naturalized. This framework is particularly relevant in the life sciences, where the objects of interest, organisms, organs, and physiological systems, are complex, dynamic, and ethically constrained. In biomedical research, fictional realities take the form of models that substitute for the human body while enabling experimentation. These models do not aim to reproduce the human organism in its entirety; in-

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<sup>11</sup> Nancy Cartwright, *How the Laws of Physics Lie*; Roman Frigg and Stephan Hartmann, "Models in Science," *The Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta, last modified September 30, 2020, <https://plato.stanford.edu/entries/models-science/>.

<sup>12</sup> Mauricio Suárez, "Fictions in Scientific Practice," in *Fictions in Science: Philosophical Essays on Modeling and Idealization*, ed. Mauricio Suárez (London: Routledge, 2009).

stead, they selectively reconstruct aspects deemed relevant to specific research questions. Their fictional character lies not in their inaccuracy, but in their status as constructed surrogates that mediate access to human biology.

Understanding biomedical models as fictional realities therefore allows for a more precise analysis of how knowledge is generated in this domain. It shifts attention away from a binary opposition between realism and artificiality and toward the epistemic functions of substitution, construction, and mediation. This perspective prepares the ground for examining how different modeling strategies, specifically animal models and *in vitro* systems, instantiate distinct modes of fictionality, and how the current transition between them reflects a broader reconfiguration of epistemic assumptions in biomedical research.

### **Animal Models as Concealed Fictional Realities**

Animal models have long occupied a central position in biomedical research. Their use is grounded in the assumption that non-human organisms can serve as reliable proxies for human biological processes, an assumption supported by evolutionary continuity, genetic homology, and shared physiological mechanisms. From an epistemological standpoint, however, animal models do not function as direct representations of the human body. Rather, they operate as constructed stand-ins that mediate access to human biology through a logic of substitution. Animals are not treated as identical to humans, but as sufficiently similar for specific experimental purposes. This sufficiency is not an empirical fact given in advance, but a methodological commitment that allows experimentation to proceed under controlled conditions. In this sense, animal models instantiate a fiction of similarity: they function as if the biological processes under investigation could be extrapolated to humans within a scope that is rarely fully articulated in advance.

This fiction is epistemically productive. Animal models have supported major advances in biomedical knowledge, including the development of vaccines, pharmacological treatments, and surgical techniques. Their epistemic legitimacy does not rest on perfect predictive success, but on their capacity to generate mechanistic insight, guide experimentation, and delimit the space of possible biological responses. Translational failure does not negate this productivity; it reveals the bounded domain within which the fiction of similarity operates. For this

reason, the scientific value of animal models is not in question. What requires scrutiny is not their legitimacy, but the epistemic status of the fiction through which they operate. Although scientists are fully aware that animals are not humans, the substitution performed by animal models is commonly treated as a natural biological continuation rather than as a constructed epistemic strategy. Similarity functions as a default background assumption, sufficient to justify inference unless and until empirical evidence demonstrates otherwise.

This naturalisation is reinforced by modeling language itself: mouse models are routinely described as “models of Alzheimer’s disease” or “models of Parkinson’s disease,” despite the fact that these conditions are defined in humans not only by molecular mechanisms but also by cognitive, behavioural, and experiential dimensions that cannot be reproduced in animals. The animal system is thus framed as instantiating the disease itself, rather than as selectively reproducing particular features of it. The concealment of this fiction has important epistemological consequences. Divergence between animal and human outcomes is typically addressed retrospectively, following translational failure. Compounds that prove effective or safe in rodents but fail in clinical trials are explained *post hoc* in terms of species-specific metabolism, immune response, or signalling pathways. Such explanations acknowledge difference only after expectations of relevance have already been established. The limits of inference are therefore revealed after the fact, rather than integrated prospectively into the model’s epistemic design. This pattern is well documented in fields such as oncology and neuropharmacology, where extensive pre-clinical validation frequently fails to translate into clinical efficacy. Routine experimental practice further stabilizes this concealed fiction. Animal models are embedded in standardised pipelines for drug development and regulatory approval, where their use is often presupposed rather than epistemically re-justified for each research question. Once a particular model (such as a transgenic mouse line) becomes established, its relevance is rarely interrogated at the level of epistemic construction. Instead, it functions as a taken-for-granted reference point within common scientific practice. In this context, the fictional character of the model becomes methodologically invisible, not because it is denied, but because it is absorbed into disciplinary conventions.

This epistemic concealment also shapes how uncertainty is managed. Species-specific differences are acknowledged, yet treated as

sources of variability or noise rather than as indicators of the model's fictional structure. The animal model thus retains the status of a quasi-natural reference point even as its limits are repeatedly encountered. The so-called translational gap reflects not merely technical insufficiencies, but an epistemological tension inherent in the fiction of similarity itself: the model enables translation to be attempted while simultaneously delimiting the conditions under which it can succeed. Ethical considerations further illuminate the significance of this concealment. Ethical justifications of animal experimentation frequently appeal to scientific necessity and predictive value. Yet these appeals presuppose the reliability of the fiction of similarity on which animal models operate. When that fiction is treated as natural rather than constructed, ethical evaluation risks resting on unexamined epistemic assumptions. In this sense, ethical responsibility in biomedical research cannot be separated from epistemic responsibility: to clarify the fictional status of a model is also to clarify who bears the consequences of its limitations. The persistence of this concealment is not accidental, nor does it primarily reflect individual oversight or bad faith. Rather, it emerges from the convergence of epistemic, institutional, and ethical pressures within biomedical research. Treating similarity as a natural biological continuation stabilizes inference, allowing experimental results to circulate without continuous renegotiation of their scope. Institutional frameworks for funding, regulation, and publication further reinforce this stabilization by presupposing the relevance of established animal models. Ethical justification, in turn, often relies on claims of scientific necessity and predictive value that are easier to sustain when the fictional status of the model remains implicit. In this way, epistemic concealment and ethical justification mutually reinforce one another: the more natural the substitution appears, the less its assumptions are scrutinised, and the more ethical responsibility is deferred until translational failure renders those assumptions visible.

Within this perspective, understanding animal models as concealed fictional realities does not undermine their scientific value. Rather, it situates that value more precisely. Their authority derives not from direct representation of human biology, but from a historically stabilized mode of substitution that has proven productive under specific constraints. Recognising this allows animal models to be understood not as imperfect mirrors of reality, but as epistemic tools whose fictional structure both enables biomedical knowledge and delimits its scope. This analysis prepares

the ground for examining emerging alternatives in biomedical research. As *in vitro* and organ-on-chip systems gain prominence, they do not eliminate fiction from scientific practice. Instead, they reorganize it, making explicit what has long remained implicit. The contrast between animal models and *in vitro* systems is therefore not one between fiction and reality, but between different ways of constructing, managing, and acknowledging fictional realities within biomedical research.

### ***In Vitro* and Organ-on-Chip Systems as Explicit Fictional Realities**

*In vitro* and organ-on-chip systems have emerged in biomedical research as models designed to investigate human physiology under controlled and ethically constrained conditions. Unlike animal models, these systems do not rely on interspecies similarity. Instead, they are deliberately engineered constructs that reproduce selected biological functions, cellular architectures, or dynamic interactions relevant to specific research questions. From an epistemological perspective, they instantiate a distinct form of fictional reality, one grounded not in analogy, but in explicit construction. The fictional status of *in vitro* and organ-on-chip systems is epistemically foregrounded rather than naturalised. Their relevance to human physiology is established through explicit design choices, such as the selection of cell types, mechanical cues, or biochemical gradients, each justified in relation to a defined research aim. As a result, these models are not presented as embodiments of diseases or organs themselves, but as platforms for investigating specific mechanisms or interactions. Divergence from human outcomes is therefore not framed as an unexpected deviation, but as an anticipated limitation inherent to the model's construction. This explicitness has important epistemological consequences. The scope of inference is specified prospectively as part of the model's design, and constraints are articulated in advance rather than discovered retrospectively. When *in vitro* systems fail to reproduce human responses, failure is typically attributed to identifiable aspects of construction, such as missing cellular components, oversimplified architectures, or unmodeled interactions. Failure thus functions as a diagnostic of design, guiding iterative refinement rather than retroactive reinterpretation. The fictional character of the model remains visible throughout this process, operating not as a concealed background condition, but as an explicit and revisable feature of biomedical inquiry. The fictional reality embodied by *in vitro* systems lies

in their selective reconstruction of biological processes. These models do not aim to replicate the human organism in its entirety. Instead, they isolate and reassemble components according to experimentally defined priorities. Decisions about inclusion, exclusion, and idealization are made explicitly and justified with respect to the intended epistemic goal. The resulting system is not a reduced version of the organism, but a purpose-built surrogate whose limits are constitutive of its epistemic role. Because the fictional status of these models is acknowledged from the outset, inference proceeds through controlled functional correspondence rather than naturalised similarity. Knowledge generated within this framework is therefore conditional by design: it is evaluated with respect to the specific features that have been constructed and the domain of validity that has been defined in advance. Fiction here is not something to be corrected away, but something to be managed, refined, and made epistemically productive.

This explicit mode of construction also carries ethical implications. Because *in vitro* and organ-on-chip systems openly declare their limits, ethical responsibility is assumed at the level of design rather than deferred until translational failure. Decisions concerning which biological features are included, which are omitted, and which forms of variability are bracketed become epistemic choices with ethical significance. Ethical concern thus arises not from concealed substitution, but from deliberate construction and omission, embedding responsibility prospectively within the modeling process itself. The increasing adoption of organ-on-chip technologies extends this logic without abandoning it. By integrating microfluidics, mechanical stimulation, and multicellular organisation, these systems introduce greater physiological complexity while remaining explicitly constructed environments. Their epistemic role is not to replace the human body, but to provide experimentally accessible spaces in which specific hypotheses about human biology can be tested under known and articulated constraints.

Understanding *in vitro* and organ-on-chip systems as explicit fictional realities clarifies their place within biomedical research. They do not represent a departure from fictional modeling, but a reconfiguration of it. Fiction becomes visible, engineered, and epistemically articulated. This contrasts with the concealed fiction of similarity characteristic of animal models, not by eliminating substitution, but by redefining how substitution is justified, managed, and held accountable within scientific practice.

## The Transition as an Epistemological Shift

The growing incorporation of *in vitro* and organ-on-chip systems into biomedical research is commonly framed in technical, ethical, or regulatory terms. From the perspective developed in this paper, however, this development is more fundamentally an epistemological shift in how biomedical knowledge is produced, justified, and limited. The transition does not mark a movement from fiction to reality. Rather, it reflects a reconfiguration in how fictional realities are constructed, positioned, and epistemically managed within scientific practice.

As the preceding analyses have shown, animal models and *in vitro* systems exemplify two distinct modes of fictionality. In animal models, inference is grounded in an implicit fiction of similarity, historically stabilized through evolutionary continuity, genetic homology, and shared physiological mechanisms. This fiction is empirically productive, but its constructed status remains largely unarticulated. As a consequence, the limits of inference tend to surface retrospectively, most visibly in cases of translational failure or ethical controversy, when divergence between animal and human outcomes must be explained after expectations of relevance have already been established. *In vitro* and organ-on-chip systems, by contrast, instantiate a fiction of construction. They do not rely on presumed biological equivalence, but on deliberate design choices through which selected human functions are reconstructed under controlled conditions. The relationship between model and target is specified through functional criteria rather than inferred from shared origin. Crucially, this fiction is explicit. Assumptions, constraints, and intended domains of validity are articulated in advance as part of the model's epistemic design. Knowledge claims generated within this framework are therefore conditional by construction rather than conditional by hindsight.

The epistemological significance of this shift lies in how uncertainty, limitation, and failure are conceptualised and handled. In animal-based research, uncertainty is typically absorbed into the background of biological variability, and failure is addressed *post hoc* through further experimentation or model refinement. In *in vitro* systems, uncertainty is foregrounded as a design parameter. Failures are more readily attributable to identifiable aspects of construction, such as missing cellular components, oversimplified architectures, or unmodeled interactions, and thus function as epistemic feedback guiding iterative redesign. The fiction does not recede in the face of failure; it becomes the object of

systematic refinement.

This difference reshapes the logic of justification in biomedical research. Inference grounded in similarity relies on analogical reasoning whose scope is difficult to delimit in advance and is often stabilized through use rather than explicit specification. Inference grounded in construction, by contrast, proceeds from clearly defined functional correspondences. While neither approach guarantees successful translation to human outcomes, the latter renders the epistemic conditions of inference more transparent. Fiction is no longer a tacit background assumption, but an articulated component of the knowledge-generating process.

From an ethical point of view, this epistemological shift should be evaluated in terms of responsibility. When fictional substitution remains implicit, ethical responsibility tends to be deferred until translational failure makes epistemic limits visible. When fictional construction is explicit, responsibility is assumed prospectively, at the level of design. Decisions concerning inclusion, omission, and simplification thus become epistemic choices with ethical significance.

Philosophically, this kind of transition is not without precedent. Scientific knowledge has repeatedly advanced through changes in how fictional constructs are deployed and understood. Classical mechanics relies on idealized entities such as point masses or frictionless planes, explicit fictions whose epistemic value lies precisely in the fact that their non-reality is acknowledged and controlled. Similarly, contemporary economic modeling constructs agents with explicitly defined preferences and constraints rather than treating rationality as a natural property of real individuals. In both cases, epistemic progress does not arise from eliminating fiction, but from making it explicit, constrained, and revisable. The transition unfolding in biomedical research follows this same pattern.

It is worth noting that this epistemological shift does not entail a linear replacement of one model by another. Animal models continue to play a role in biomedical research, just as idealized models coexist with empirical observation in other sciences. Nor do *in vitro* systems eliminate uncertainty or guarantee translational success. The shift is therefore not a narrative of progress toward greater realism, but a reorientation in how fictional realities are organised, justified, and integrated into scientific practice. Seen in this light, the increasing prominence of *in vitro* and organ-on-chip systems signals a broader, though uneven, reconfiguration of biomedical epistemology within parts of contemporary re-

search practice. Knowledge production moves away from reliance on concealed substitutions toward a mode of inquiry in which fictional construction is explicit, deliberate, and revisable. Fiction is not removed from science, but transformed, from an implicit condition of practice into an articulated epistemic resource. Understanding this transition clarifies why debates about biomedical models cannot be reduced to questions of accuracy or efficiency alone. What is at stake is how biomedical research conceptualises its own access to human biology. Fictional realities do not obstruct this access; they enable it. The transition currently underway thus reflects a deeper transformation in the epistemic self-understanding of biomedical research itself.

### **Fictional Reality and the Future of Biomedical Knowledge**

Understanding biomedical research through the concept of fictional reality has implications that extend beyond the specific comparison between animal models and *in vitro* systems. More broadly, it invites a reconsideration of how biomedical knowledge is framed, evaluated, and communicated in domains where direct access to the object of study is structurally constrained. From a philosophical standpoint, this reinforces a long-standing insight in the philosophy of science: fiction is not an accidental or transitional feature of scientific practice, but a constitutive element of how knowledge is generated under conditions of complexity and uncertainty<sup>13</sup>.

First, recognizing fictional realities as epistemic conditions rather than epistemic defects reframes debates about model validity. Biomedical models are often assessed primarily in terms of accuracy, predictive success, or translational efficacy. While these criteria remain essential, they do not exhaust the grounds of epistemic legitimacy. Scientific models do not derive their authority from correspondence alone, but from their capacity to mediate between theory and world under explicitly stated assumptions<sup>14</sup>. Seen in this light, fictional reality is not opposed to objectivity; it is one of its operational forms. The epistemic

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<sup>13</sup> Hans Vaihinger, *The Philosophy of "As If"* (London: K. Paul, Trench, Trubner & Co., 1924); Mary S. Morgan and Margaret Morrison, *Models as Mediators: Perspectives on Natural and Social Science* (Cambridge: Cambridge University Press, 1999).

<sup>14</sup> Nancy Cartwright, *How the Laws of Physics Lie*; Roman Frigg and Stephan Hartmann, "Models in Science," *The Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta, last modified September 30, 2020, <https://plato.stanford.edu/entries/models-science/>.

question shifts from whether a model is realistic to how its fictional structure enables, constrains, or redirects particular forms of inference.

Second, this perspective reshapes how uncertainty and responsibility are distributed within biomedical research. When fictional constructions remain implicit, their limits tend to surface only retrospectively, often after translational failure and at significant scientific, ethical, and economic cost. By contrast, models that explicitly foreground their constructed status integrate uncertainty into their epistemic design. This aligns with philosophical accounts that treat scientific knowledge as inherently conditional and revisable rather than cumulative and complete<sup>15</sup>. Epistemic responsibility thus shifts away from defending claims of realism and toward articulating the assumptions, constraints, and design choices under which knowledge is produced.

Third, an epistemology of fictional reality supports a pluralistic understanding of biomedical modeling. Rather than organising models along a single hierarchy ordered by presumed realism, different models can be understood as distinct fictional realities, each tailored to specific questions, scales, and mechanisms. This resonates with philosophical defenses of model pluralism, according to which scientific understanding often emerges from the coordinated use of multiple, non-reducible representations<sup>16</sup>. From this perspective, the future of biomedical research is not defined by the replacement of one model with another, but by the deliberate orchestration of multiple fictional constructions whose domains of validity are explicitly specified.

Finally, acknowledging fictional reality as a constitutive feature of biomedical knowledge has implications beyond the laboratory. Public trust in biomedical research often rests on implicit expectations of realism and direct representation. Yet philosophical analyses of representation and hyperreality have shown that representations can acquire operational reality without mirroring an underlying original<sup>17</sup>. Making the fictional character of biomedical models explicit does not undermine trust; rather, it aligns scientific communication more closely with actual re-

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<sup>15</sup> Ian Hacking, *Representing and Intervening* (Cambridge: Cambridge University Press, 1983).

<sup>16</sup> Sandra D. Mitchell, *Unsimple Truths: Science, Complexity, and Policy* (Chicago: University of Chicago Press, 2009).

<sup>17</sup> Umberto Eco, *Travels in Hyperreality*, trans. William Weaver (San Diego: Harcourt Brace Jovanovich, 1986).

search practice, fostering more realistic expectations about translation, efficacy, and risk.

These considerations suggest that the transition examined in this paper is not merely a local methodological adjustment, but part of a broader transformation in the epistemic culture of biomedical research. Fictional realities are becoming increasingly explicit, engineered, and revisable. This transformation does not signal a retreat from scientific realism, but a refinement of epistemic strategy, one in which fiction is no longer concealed as a background assumption, but articulated as a central resource for knowledge production.

## Conclusion

Biomedical research does not primarily operate in direct contact with human biological reality. Access to the human body has always been mediated by models that stand in for what cannot be directly experimented upon. Such mediation is not a temporary limitation to be overcome, but a constitutive feature of biomedical knowledge. Animal models and *in vitro* systems do not differ in their reliance on fiction; they differ in how that fiction is constructed, acknowledged, and epistemically managed. Interpreting animal models as concealed fictional realities and *in vitro* systems as explicit ones reveals that the ongoing transformation in biomedical research reflects an epistemological shift rather than a simple methodological upgrade. The transition underway does not move science closer to an unmediated reality, nor does it eliminate uncertainty or failure. Instead, it reconfigures the role of fiction itself, from a background assumption stabilized by practice to an articulated and revisable condition of inquiry. This shift invites a reconsideration of how biomedical knowledge understands its own limits. When fictional substitutions are naturalised, their constraints emerge only retrospectively, often at significant epistemic and ethical cost. When fiction is made explicit, limitation becomes a design parameter rather than a surprise. Knowledge does not become less provisional; it becomes more self-aware. In this sense, epistemic responsibility is redistributed: not toward defending claims of realism, but toward clarifying the assumptions under which knowledge is produced.

This perspective challenges a persistent narrative of scientific progress as the gradual elimination of fiction. Across the history of science, advances have often coincided with the refinement of fictional con-

structs rather than their disappearance. Biomedical research appears to follow this pattern. The increasing prominence of engineered, transparent fictional realities does not mark a retreat from truth, but a maturation in how truth is pursued under conditions of complexity, uncertainty, and ethical constraint. From this perspective, progress in biomedical research lies not in converging on a single privileged model, but in the careful coordination of multiple fictional realities, each suited to different epistemic aims.

Seen through the lens of fictional reality, the future of biomedical research is not one in which models finally coincide with the human body, but one in which the distance between model and reality is more carefully designed, explicitly acknowledged, and epistemically productive. Fiction, in this context, is not the opposite of reality, but the means through which reality becomes knowable at all. Making fictional construction explicit also clarifies how responsibility is distributed across scientific, clinical, and institutional contexts. To recognise this is not to weaken biomedical science, but to take seriously the conditions under which it has always, and will continue to, operate.