# Poetic Understanding and Scientific Knowledge: Models as Aesthetic Descriptions

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ARTICLE

# Poetic Understanding and Scientific Knowledge: Models as Aesthetic Descriptions

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**Abstract**
Modeling is an important scientific method of representing and understanding real world phenomena. Models provide idealized representations of their target systems in the sense that their description of those targets is intentionally inaccurate. However, given that science strives for correct knowledge about the world, the idealized nature of models raises an epistemological conundrum: How can one learn something true about real-world phenomena by studying models of them that are knowingly false? A modeling stance in science seems either epistemologically deficient or contrary to the realist aim of science. In this paper, Wittgenstein's method of aesthetic description is proposed as an alternative approach to scientific modeling that steers clear of the dilemma between epistemic futility and antirealism. Aesthetic descriptions explain perplexing phenomena by analogy with familiar objects or events, thus evoking a poetic understanding of these phenomena that defies conventional articulation and ultimately consists in a direct acquaintance with the phenomena themselves. From this, an aesthetic view of models is developed that can both sustain a realist stance toward science and explain why models are epistemically valuable. It also implies, however, a peculiar kind of scientific knowledge: one which is partly implicit and in a certain sense ineffable.

## 1 Models and the Puzzle of Idealization

Modeling is an important method of scientific inquiry. Scientists frequently use models—e.g., the billiard ball model, the Bohr model or the Lotka-Volterra model—to *represent* certain parts and processes of the world (gases, atoms, predator-prey interactions, etc.) and thereby *learn* something about them. There are a lot of different types of models in science and correspondingly many ways in which models may represent and teach us something about reality (cf. Frigg and Hartmann 2020). The focus of this paper, however, will be on what have been called theoretical models (cf. Black 1962; Achinstein 1965). For our pur-

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poses, a theoretical model can be minimally defined as a representational system consisting of (i) a set of assumptions about some object or system, and (ii) a set of (analytic and/or synthetic) inference rules that can be used to derive implications (predictions, explanations) about the respective object or system (cf. Achinstein 1965, 103; Schulz 2015, 425).

It is not yet clear from this definition what distinguishes theoretical models (henceforth simply models) from other types of scientific representation, especially theories. One distinctive feature that has been highlighted is that models, unlike theories, represent their real-world targets only *indirectly*, by directly (conceptually) representing only proxy objects or systems—hereafter also referred to as sources—which in turn directly (*via* some relevant analogy) represent the target (cf. Godfrey-Smith 2006; Weisberg 2013).

Another characteristic is that models are comparatively more *idealized* representations of their targets than theories. Models may be idealized in at least two ways (cf. Frigg and Hartmann 2020, Sect. 1). First, they may be *abstract* in the sense that they neglect certain features of their targets (e.g., the color of fluids, the weight of speaker-hearers, the material composition of moving bodies). Second, they may be *distorted* in the sense that they misrepresent their targets in certain respects (representing, e.g., planes as frictionless, economic agents as omniscient, biological populations as infinite). While abstractions still offer true, if incomplete, descriptions of a target, distortions yield truly inaccurate, i.e., false, representations of reality. The distinction, however, is not entirely clear-cut because some abstractions also lead to falsehoods, e.g., when causally relevant factors are neglected (cf. Mäki 1994).

Now, idealizations are not mere negligences or errors in the modeling process: they hark back to deliberate choices on the part of the modeler. This raises an epistemological conundrum, given that science strives for (reasonably) correct and complete knowledge about the world. For how can one learn anything true and comprehensive about real-world phenomena by studying models of them that are knowingly false and partial? Considering the realist aims of science, modeling methods appear to be epistemologically flawed. On the other hand, if one acknowledges the ubiquity and preeminence of models in scientific practice, the question arises whether science can—or wants to—deliver comprehensive truths about the world at all. After all, how can scientists aim for an accurate representation of reality while at the same time constructing intentionally inaccurate models of it? Thus, modeling practices seem to be caught in a dilemma between epistemic futility and antirealism. Whichever way one looks at it, the idealized nature of models gives rise to questions about their function in science—and about the chief aims and achievements of the scientific enterprise.

Philosophers of science have tried various strategies to solve this 'puzzle of idealization' (cf. Potochnik 2017, 43). These, as will be shown in more detail below (Sect. 2), have so far proved unsuccessful. This essay shall therefore propose a new approach that draws on a methodological concept from the late philosophy of Ludwig Wittgenstein: that of *aesthetic description*. Aesthetic descriptions in Wittgenstein's sense render phenomena that appear confusing and in need of explanation intelligible through *comparisons* with other, more familiar objects or events. In doing so, they transfer the latter's descriptions to the phenomena under consideration in a transformed, non-paraphrasable *secondary meaning*, thus evoking a *poetic understanding* of these phenomena that defies conventional articulation and ultimately consists in a *direct acquaintance* with the phenomena themselves (Sect. 3). As will be argued, one can develop from this method an aesthetic view of scientific models that can both sustain a realist stance toward science and explain why models are epistemically valuable. It will also be pointed out, however, that this view entails a peculiar kind of scientific knowledge, namely one that is partly implicit and in a certain sense ineffable (Sect. 4). Finally, some implications of the proposed view for the issue of scientific realism are addressed (Sect. 5).[1]

## 2 Epistemism and Pragmatism About Models

There are two general views about the function of models in science. According to *epistemism*, models, despite their idealized nature, help to discover truths about the world and to gain knowledge of those truths. According to *pragmatism*, models serve purely practical purposes like prediction, problem-solving and action.[2] In the epistemist view, models are strictly speaking false, but nevertheless truth-conducive inasmuch as they allow for 'surrogative reasoning' (Swoyer 1991). The conjecture is that, by studying models, one can learn something about their targets. Surrogative reasoning proceeds by performing demonstrations on a model, the results of which are then interpreted in terms of its target (cf. Hughes 1997; Suárez 2004; Contessa 2007). This process involves a *deidealization* of the model. Thus, the interpretation of a model's implications in terms of its target may supplement details of the target from which the model has abstracted or rectify aspects which have been distorted (cf. McMullin 1985).

Epistemism about models is compatible with (i) the fact that scientists often create and study models at least initially without explicit attention to their relationship with the world, (ii) the fact that models may often be applied to a broad range of targets and (iii) the fact that the targets of modeling are often quite unspecific or general in nature (cf. Levy 2015, 796–797). The very idea of surrogative reasoning, however, harbors a problem for epistemism. On standard accounts, surrogative reasoning is enabled and sustained by an investigation of the analogies and disanalogies between a model's source and its target (cf. Giere 2004; Weisberg 2013; French 2003; van Fraassen 2008).[3]

[1] In this paper, the following abbreviations for Wittgenstein's works will be used: BBB = *The Blue and Brown Books* (Wittgenstein 1969); CV = *Culture and Value* (Wittgenstein 1998); LC = *Lectures and Conversations* (Wittgenstein 1967); AWL = *Lectures, Cambridge 1932–1935* (Wittgenstein 2001); LW I = *Last Writings on the Philosophy of Psychology, Vol. 1* (Wittgenstein 1982); PG = *Philosophical Grammar* (Wittgenstein 1974); PI = *Philosophical Investigations* (Wittgenstein 2009a); PPF = Philosophy of Psychology—A Fragment (Wittgenstein 2009b); RPP I = *Remarks on the Philosophy of Psychology, Vol. 1* (Wittgenstein 1980a); RPP II = *Remarks on the Philosophy of Psychology, Vol. 2* (Wittgenstein 1980b). Numbers are page numbers unless otherwise indicated.

[2] This classification is in no way meant to deny that scientific models can achieve goals other than truth or practical success, such as explanation, unification, and understanding. Such achievements, however, may be regarded as subordinate to the supreme goals of truth or practical success. And whether they contribute to the achievement of the former or the latter also determines whether these other achievements are properly classified as epistemic or pragmatic. For reasons of space and simplicity, then, epistemism and pragmatism will be discussed only in terms of scientific models' specific contributions to the discovery of truths and facilitation of practical success, respectively.

[3] Deflationary accounts of surrogative reasoning (cf., e.g., Suárez 2004) deny this. According to them, the capacity to allow for surrogative reasoning is an irreducible feature of models that cannot, and need not, be given a deeper explanation in terms of underlying analogies between the model's source and target. In the final analysis, such accounts propose an antirealist approach to surrogative reasoning. To be sure, the specific inferences that a given model allows competent and informed agents to draw about a particular target are not supposed to be arbitrary—surrogative reasoning "requires strict normative criteria of inference" (Suárez

Thus, shared properties, similarities or isomorphisms between the source and the target may be exploited to translate solutions of the model into hypotheses about the target. Yet, on the face of it, investigating the (dis)analogies between a source and its target presupposes the possibility of investigating the properties of the target (as analogies are affirmed or negated by way of comparing the properties of the source with the properties of the target), hence, the possibility of direct (nonidealized) theorizing about the target. But then, surrogative reasoning turns out to be epistemically circular, and it is not clear what models actually contribute to our knowledge of a target. Models appear to be, not only inferior to their target theories in terms of representational accuracy, but also irrelevant to the epistemic process of constructing representationally accurate theories.

In reply, epistemists might insist that models are of immense *heuristic* value insofar as they "suggest" (Hesse 1966, 14) novel hypotheses about their targets that would not otherwise come to mind (cf. Leplin 1980; Wimsatt 1987; Morrison and Morgan 1999). Crucially, the way in which heuristic models 'suggest' such hypotheses is not justificatory but rather causal and thus epistemically opaque, hence, not dependent on prior inquiries into the target. This reply assigns scientific models to the context of discovery rather than that of justification—which need not discredit them as broadly epistemic devices per se (if only because the discovery/justification context distinction has frequently been criticized as being implausible, vague or inconsequential). But one must bear in mind that heuristic models, whatever epistemic worth they may have, still depend *logically* on the (posterior) possibility of direct theorizing. As auxiliary means for generating true scientific theories, models can be valuable only to the extent that they really generate such theories—and that, in turn, can only be determined *post hoc* by testing the resulting theories against their real-world targets (cf. Redhead 1980, 161).

It may even be argued that heuristic models depend *causally* on the (prior) possibility of direct theorizing. To that effect, it has to be noted that the novelty of the hypotheses that a particular model suggests (which is supposed to bestow heuristic value on the model in the first place) springs not so much from the demonstrated consequences of the model—these are usually derived from the model's assumptions using familiar calculi and are therefore unsurprising—but rather from the choice of the model itself (cf. Schulz 2015, 431–432). However, the decision to formulate a novel model for a particular target cannot be suggested by the model itself, but only by its target (cf. Schulz 2015, 429). But then, the model should not be regarded as *generating* novel insights; at most, it may be said to *express* insights that have been gained independently through precursory examinations of its target (cf. Schulz 2015, 429). It thus shows that the putative heuristic potential of models actually resides in their target theories; so, we are back in an epistemological circle. Again, it remains unclear just how models, as opposed to proper theories, promote scientific truth and knowledge.

The ultimate predicament of epistemism, however, is not merely that models depend (causally or logically) on the possibility of direct theorizing for their epistemic virtues—the trouble is rather that, in many cases, direct theorizing about a target is, for

2004, 776). Yet, the constraints imposed on valid inferences from the model to its target are fixed and maintained "by the intended representational uses of the [model] on the part of agents" (Suárez 2004, 768)—i.e., not by objective analogies between the target and the source, but by the norms and values of a (scientific) community. If so, however, deflationary accounts of surrogative reasoning can hardly implement an epistemist view of models: if it is essentially us who determine what may and may not be inferred about a target on the basis of a certain model, it becomes dubious what we can actually learn *about the target* by virtue of this model (cf. de Oliveira 2021, 223).

principal reasons, impossible. For example, several physical phenomena—such as drop formation in hydrodynamics, quantum dots and nonlinear oscillatory behavior—have been shown to be successfully predictable and explainable only under certain idealizing assumptions (cf. Batterman 2009; Bokulich 2012; Wayne 2011). Some authors even argue that scientific theories generally rely on models for their predictive and explanatory power (cf. Cartwright 1983; Lange 1993; Giere 1999). This, however, not only undermines the whole idea of surrogative reasoning, which rests on the prospect of arriving at deidealized theories; it also raises the question of how the predictions and explanations of a theory can actually be true. Thus, far from being solved at the level of models, the puzzle of idealization is just carried over to the level of theories.[4]

In view of epistemism's difficulties, pragmatism presents an alternative justification for the use of models in science which brackets their epistemic qualities and instead focuses on their practical benefits. In the pragmatist view, models are not only utterly untrue, but not even regulated by truth: they exclusively serve practical purposes, such as risk assessment (cf. Elliott and McKaughan 2014), design and engineering (cf. Diekmann and Peterson 2013), and policymaking (cf. Douglas 2009). Ultimately, such applications revolve around two practical goals: adaptation and intervention. Thus, models are alleged to furnish predictions and explanations which allow us to adjust ourselves to events in our environment or even manipulate and control them at will—irrespective of the models' veracity or fidelity to the facts.

Pragmatism about models is usually propounded, not as a corollary of instrumentalism, but as part of a pluralist view of science that distinguishes models and theories as different kinds of scientific constructs with specific aims and achievements. While models are supposed to be built in the service of developing techniques and technologies for the solution of practical problems, the alleged task of theories is to discover truths and understand nature. In this way, pragmatism about models is reconciled with an overall realist stance on science (cf. Isaac 2013, 3621). The envisaged scientific pluralism is not without problems, though. While the idea of an epistemic and pragmatic division of labor between theories and models may have some initial plausibility in the applied sciences and crafts, it is much less convincing in the fundamental sciences where models are rarely deployed for the application of theories to practical contexts but frequently supply the highest available theoretical understanding (cf. Levy 2018, 239). These qualms aside, the tenability of a scientific pluralist view that reserves a wholly pragmatic role for models crucially depends on whether models can perform their assigned pragmatic functions independently of any epistemic one. This is all but clear. In a scientific realist framework, it is typically assumed that there is a close connection between practical success and truth to the effect that the practical—i.e., predictive and explanatory—success of a scientific representation justifies the belief in its (approximate) truth. The inference is usually licensed on abductive grounds and lays the foundation of the most important argument for scientific realism, the so-called miracle argument, which infers the truth of our advanced scientific theories as the best (because

4 Some epistemists wish to show, *via* so-called robustness analyses in which the idealizations of a model are varied and then the model is checked to see if it retains its predictive and explanatory power across these variations, that the idealizing assumptions of a model, even if they cannot be corrected or eliminated, are irrelevant to its predictive and explanatory success (cf. Weisberg 2013; Ch. 9). However, even if this can be shown for each of its *specific* idealizations, such analyses still cannot free a model from its *generally* idealized nature. *Some* idealization seems necessary to make the model successful. But this leaves the puzzle of idealization as puzzling as before.

nonmiraculous) explanation of their tremendous practical success (cf. Putnam 1979, 73). Following this line of reasoning, however, truth should also be granted to models (as one kind of scientific representation) that prove practically successful. After all, there could be, on this account, no *other* evidence for their truth.[5] Yet, once such models are conceded to be true, the conundrum recurs how they can be true, given their idealized nature. Thus, pragmatism eventually gets into the same embarrassment as epistemism.

In reply, pragmatists might wish to qualify the notion of practical success for models. To be practically successful, they might argue, models need not be *maximally* predictive and explanatory, but only predictive and explanatory in a way that is *sufficient* under local conditions for the purposes at stake. For example, in risk management and technology development policies, the practical success of a model often consists in a trade-off between fairly accurate but quite slow or cumbersome prediction and explanation methods on the one hand, and less accurate but quick and manageable ones on the other (cf. Elliott and McKaughan 2014, 7–13). But where practically successful models are concededly predictively and explanatorily inaccurate, there is no reason to accept them as true, even under the general assumption of a symptomatic correlation of practical success and truth.

This reply, however, will not save pragmatism from the puzzle of idealization. Even with due regard to lowered standards of accuracy, practically successful models will be sufficiently predictive and explanatory to be esteemed as roughly true, or "true enough" (Elgin 2004, 114), within a scientific realist framework. But this conflicts with the often glaring idealizations contained in these models. Whatever divergences from the truth are deemed permissible, assumptions like point particles, infinite populations and perfectly rational agents cannot even be considered remotely true (cf. Levy 2018, 239). So, the puzzle remains how models which involve such assumptions can be anywhere near the truth.

A final defense strategy for pragmatists could only be to argue the other way around: that practical success cannot be the mark of truth, if notoriously false models are practically successful; and that it is, therefore, generally fallacious to infer a scientific representation's truth (or near-truth) from its practical success. This conclusion, however, would be devastating for proponents of the pluralist view of science outlined above insofar as a decoupling of practical success and truth defeats the basic rationale behind the master argument for one tenet of that view, namely, scientific realism (cf. Levy 2018, 242). In summary, pragmatism about models turns out to be an unstable position: it either relapses into an oblique form of epistemism (together with all its complications); or it escalates into full-blown scientific antirealism—foiling, either way, the intentions of the scientific pluralist view with which it is normally associated.[6]

[5] In this connection, it is useful to distinguish between scientific *aims* and *achievements*. Although models may not be aimed at truth in the pragmatist view, they may nevertheless achieve truth (*via* achieving practical success).

[6] I have addressed here as pragmatist only those approaches (such as Isaac's [2013]) that dissociate the practical success of scientific representations from their epistemological virtues, and which therefore, if they nevertheless wish to adhere to the realist aims of science, must adopt a pluralist strategy; and I have argued that such a strategy cannot be pursued consistently. Now, there are also pragmatist theories that take virtually the opposite approach and reject precisely the separation of a scientific representation's epistemic and pragmatic functions. (One need only think of William James's classical pragmatic theory of truth, which infamously equates truth with practical success; but one could also cite Chang's [2022] recent 'active realism' as an example.) Obviously, these theories do not have to rely on a pluralist strategy and thus escape the accusation of inconsistency raised here. Their shortcoming, however, is that they provide no genuine alternative to

## 3 Wittgenstein's Method of Aesthetic Description

The discussion of epistemist and pragmatist views of models yields two unpleasant results. On the one hand, epistemism can solve the puzzle of representation, if at all, only at the price of degrading the epistemic value and relevance of models in scientific research. On the other hand, pragmatism can solve the puzzle only at the price of abandoning scientific realism in favor of a downright instrumentalist stance toward science. Thus, the available options in the theory of models all prove inapt to establish model-building as a legitimate, beneficial or even indispensable epistemological method for scientific programs of firmly realist persuasion. Any advances in this direction must therefore invoke an alternative account of models: one which is neither epistemist nor pragmatist in the regular sense and steers clear of the dilemma between epistemic futility and antirealism. The thesis of this paper is that such an account can be obtained from Wittgenstein's method of aesthetic description.

Wittgenstein by no means proposes the method of aesthetic description as a theory of scientific models. However, he does not limit it to the realm of art and culture either. Rather, he sees it as a quite general method of understanding, which he himself occasionally transfers to the scientific sphere. Thus, he explicitly applies the idea of aesthetic description to Freudian psychoanalysis (cf. AWL, 40) and, without mentioning it by name there, also to Goethe's morphology of plants (cf. RPP I, § 950), the Copernican heliocentric model and Darwin's theory of evolution (cf. CV, 26). Insofar, it does not seem completely implausible and unjustified to put Wittgenstein's concept of aesthetic description to use for a theory of models.

So what is this concept about? By 'aesthetic' Wittgenstein first of all refers to a certain kind of impression that a person can get from a (natural or artificial) thing: the impression of beauty or ugliness, but more generally, the impression that something fits or not, makes sense or not, has meaning or not (cf. LC, 1–11). Impressions of fit, meaningfulness, etc., are typically accompanied by a sense of satisfaction—the feeling of *knowing* or *understanding* the thing in question. Impressions of incoherence and senselessness, by contrast, elicit discomfort and what he calls "aesthetic puzzles" (LC, 28). According to Wittgenstein, it is precisely the task of aesthetic descriptions to resolve such puzzles and thus to bring about an aesthetic understanding of things.

However, an aesthetic description is not about giving additional *information* to the ignorant. Characteristically, the one who is faced with an aesthetic puzzle already has all the relevant facts in front of them; yet, they still have to recognize how these facts belong together (cf. Säätelä 2013, 41). Accordingly, the aim of an aesthetic description is not to uncover or hypothesize 'missing links' among the puzzling facts (such as hidden causes) but to provide a synopsis or representation of the facts that exposes their *internal* relations to one another—to lay down the puzzle pieces, as it were, such that everything falls into place (AWL, 38; emphasis in the original):

epistemism; rather, they only give it a pragmatist interpretation. But then they are *prima facie* faced with the same problem of explaining how idealized, i.e. actually false, models can nevertheless somehow be true (i.e. for them: practically successful). In the worst case, they cannot even meaningfully formulate the *puzzle* of idealization (since, depending on how they spell out the equation of epistemic and practical success, practically successful models could by definition not be false, and *a fortiori* not idealized).

> In aesthetics we are not interested in causal connections but in description [sic] of a thing […]. Aesthetics is descriptive. What it does is to *draw one's attention* to certain features, to place things side by side so as to exhibit these features.

Both Wittgenstein's notion of aesthetic understanding and his method of aesthetic description can be illuminated by his remarks on the phenomenon of "noticing an aspect" (PPF, § 113) or "seeing-as" (PPF, § 199) which he discusses in the context of his analysis of the concept of perception. There, aspects are what strikes someone who, e.g., sees a likeness in two faces (cf. PPF, § 111), an ambiguous figure once as a rabbit, once as a duck (cf. PPF, § 118), or a human figure in a puzzle-picture (cf. PPF, § 131). What is noticed in such experiences are not (previously overlooked) parts or properties of the perceived objects, but a pattern or configuration of their parts and properties—a *gestalt* that ultimately determines just what kind of thing one recognizes in those objects. "Where there were previously branches, now there is a human figure. My visual impression has changed, and now I recognize that it has not only shape and colour, but also a quite particular 'organization'" (PPF, § 131). Wittgenstein suggests that aesthetic understanding essentially consists in the perception of aspects: "Here it occurs to me that in conversation on aesthetic matters we use the words 'You have to see it like *this*, this is how it is meant'" (PPF, § 178; emphasis in the original). Aspects determine what a thing *means* to someone (cf. PI, § 527); they are the features exhibited in an aesthetic description, the discerned connections of facts: "To tell a person 'This is the climax' is like saying 'This is the man in the puzzle picture'" (AWL, 38–39).

But how exactly can an aesthetic description 'exhibit' the aspects of something? Not simply by a description of the perceptible parts and properties of the object; for these are not what someone overlooks who misses the aspects in question (cf. PPF, §§ 232–3). What the "aspect-blind" (PPF, § 257) lacks is not a knowledge of the constituents of an object, but an idea of how the constituents relate to each other. Thus, to convey an aspect of the object, one has to describe its constituents in such a way that they combine into a coherent whole. According to Wittgenstein, this is best achieved by means of *comparisons* (RPP I, § 1072; cf. BBB, 166; PPF, § 120):

> Look at a photograph: ask yourself whether you see only the distribution of darker and lighter patches, or the facial expression as well. Ask yourself what you see: how would it be easier to represent it: by a description of that distribution of patches, or by the description of a human head?

To remove aesthetic puzzlements, an aesthetic description describes an object *in analogy to* others (cf. LC, 20, 29). More precisely, it employs concepts that properly belong to the description of other (real or imaginary) things to express certain aspects of the object under investigation and thus afford an aesthetic understanding of it (cf. RPP I, § 1030). Thus, to draw someone's attention to the face depicted in a photograph or painting, one might point to various parts of the picture and say, "Here are the person's eyes", "See here how they are smiling" and so on. Ideally, these descriptions will cause the parts in question to coalesce in the viewer's perception so that the latter comes to recognize the face in the picture.

It should be noted, however, that the concepts deployed for an aesthetic description generally undergo a *change of meaning* in the course of their transfer to the object of investigation: "The epithet 'sad', as applied, for example, to the face of a stick-figure, characterizes the grouping of lines in an oval. Applied to a human being, it has a different (though related) meaning." (PPF, § 227) Yet, *what* these concepts mean in their novel application (such as 'sad' in application to the grouping of lines in an oval) cannot, according to Wittgenstein, be paraphrased in terms that conventionally apply to the target domain. For, "if it amounted to this, I ought to know it. I ought to be able to refer to the experience directly, and not only indirectly" (PPF, § 117). As Wittgenstein implies, it is typically not possible to translate an aesthetic description away: The experience of looking at a portrait can simply not be better captured than by means of concepts that otherwise serve to describe real persons. It is these very concepts (and not, for example, terms for describing surfaces, lines and colors) that provide the "most exact description" (LC, 33)—the "mot juste" (PPF, § 266), so to speak—for what one perceives in the picture.

It is of utmost importance to appreciate the full import of this idea. Wittgenstein calls the transformed meaning of the concepts in an aesthetic description "a secondary one" (PI, § 282). Secondary meanings, according to him, relate to the primary meanings of concepts such that: (i) the primary meaning of a concept is its usual one (cf. PPF, § 274); (ii) nevertheless, it is not illegitimate to use this concept (unusually) in a secondary meaning—its secondary meaning is not nonsensical (cf. PPF, § 274); (iii) the secondary meaning of a concept cannot be explained but in terms of its primary meaning (cf. PPF, § 275); and therefore (iv) only someone who knows the primary meaning of a concept can use it in a secondary one (cf. PPF, § 276). One of Wittgenstein's prime examples is the use of color terms to describe certain qualities of vowels (BBB, 138–139; emphasis in the original; cf. PPF, § 278):

> B has been taught a use of the words "lighter" and "darker". He has been shown objects of various colours and has been taught that one calls this a darker colour than that, […] etc. Now he is given the order to put down a series of objects, arranging them in the order of their darkness. He does this by laying out a row of books, […] and by writing down the five vowels in the order u, o, a, e, i. We ask him why he put down that latter series, and he says, "Well, o is lighter than u, and e lighter than o".—We shall be astonished at his attitude, and at the same time admit that there is something in what he says. Perhaps we shall say: "But look, surely e isn't lighter than o in the way this book is lighter than that".—But he may shrug his shoulders and say, "I don't know, but e *is* lighter than o, isn't it?".

At first glance, the application of color terms to vowels commits a category mistake. Nevertheless, it seems to make sense: Color terms seem to be able to express real qualities of vowels. Moreover, it seems that these qualities—which of course are not *really* colors—could not be expressed more aptly than by color terms. Accordingly, the meaning that these terms have in application to vowels can only be explained by themselves (or their usual paradigms, i.e., colors); and all that can be said about the qualities they express in this application is that they *are* colors—not in the primary sense, it is true, but in a secondary one.

Primary and secondary meanings are not simply cases of ordinary ambiguity. For while the merely different meanings of an ambiguous term (like 'bank' in 'river bank' and in 'Bank of Scotland') can be defined independently of each other (cf. BBB, 138), the primary meaning of a term always precedes and shapes its secondary meanings—just as the meaning of 'darker' in relation to colors precedes and shapes its meaning in relation to vowels—with the effect that the secondary meanings of the term cannot be expressed in any other way than by means of its primary meaning (cf. PPF, § 278). If anything, secondary meanings could perhaps be compared to metaphorical meanings—but only if metaphors are not understood in the traditional (Aristotelian) sense, i.e., as substitutes for some literal expression that says the same thing. While metaphors in this traditional sense serve at best stylistic or decorative functions, secondary uses of words have a real cognitive surplus value which, again, could not be communicated in any more 'direct' or 'literal' ways (cf. PPF, § 278; LW I, §§ 797–799).

This underscores the perhaps most dazzling aspect of Wittgenstein's method of aesthetic description. For the meaning of such descriptions turns out to be *ineffable* in an important sense. What is understood in an aesthetic description—certain aspects of an object—is not something that could be said just as well, or even better, in other terms, but rather "something that is expressed only by these words in these positions" (PI, § 531). It is an understanding that eludes any straightforward articulation and can only be hinted at (cf. PPF, § 49) by the secondary use of concepts—not as actually uttered, but as unutterably contained in what is uttered (cf. Engelmann 1967, 7). In this sense, it is a *poetic* understanding (cf. PI, § 531).

Notwithstanding its ineffability, Wittgenstein provides further clues to the nature of the peculiar poetic understanding that one attains through an aesthetic description. Thus, he clarifies that "the substratum" of the experience of noticing aspects is not a subjective sensation or feeling, but rather "the mastery of a technique" (PPF, § 222): "Only of someone *capable* of making certain applications of the figure with facility would one say that he saw it now *this* way, now *that* way" (PPF, § 222; emphasis in the original). The aesthetic understanding acquired by someone who perceives an object under certain aspects is first and foremost a *practical knowledge* that manifests itself in how the person handles the object (cf. PPF, § 180). For example, someone who sees a certain figure as a face can engage with it in some respects as with a human face: study its expression, react to it as to the expression of the human face, etc. (cf. PPF, § 119).

According to Wittgenstein, such practical know-how involves a specific "familiarity" (PG, § 37) with the thing is that one learns to handle: a knowledge of *what* it is, how it can be manipulated, how it reacts to certain manipulations and so on (cf. PG, § 115). Wittgenstein is careful to distinguish this familiarity from recognition in the sense of correctly *naming* an object (or its features) according to a linguistic convention (cf. PG, § 116). Recognition in this sense is linguistically mediated knowledge (a 'transitive understanding', as Wittgenstein would say; cf. PG, § 37). It brings about familiarity with an object only by associating that object with something—a term or the things that term stands for—that is already familiar. Recognition hence presupposes familiarity and cannot account for it (cf. PG, § 130). Conversely, the latter cannot be linguistically mediated knowledge. Familiarity must rather be conceived as a *direct acquaintance* with an object (an "intransitive understanding"; PG, § 37)—which, as it turns out, one must have already made in order to be able to correctly name (and in this sense recognize) the object at all (cf. PG, § 118). It is a knowledge that essentially involves the thing *itself*, not any conceptual representation of it (cf. PG, § 54).

Now it is precisely this kind of direct acquaintance with which Wittgenstein identifies the ineffable poetic understanding of something prompted by an aesthetic description (PI, §§ 522–523; emphasis in the original):

> When I look at a genre-picture, it 'tells' me something, even though I don't believe (imagine) for a moment that the people I see in it really exist, or that there have really been people in that situation. For suppose I ask, "*What* does it tell me, then?"
>
> "A picture tells me itself" is what I'd like to say. That is, its telling me something consists in its own structure, in its own forms and colours.

In this context, the aesthetic description of the object under consideration (as showing, e.g., "people in a village inn"; PG, § 114) does *not* represent a rule-governed application of linguistic expressions, but is merely a spontaneous (linguistic) reaction to the object and its features, a *primitive expression* of one's familiarity with them—not much different from an exclamation or emotive interjection (cf. PG, § 116; RPP I, §§ 125–6, 861–2; RPP II, § 574).

This is not to say, however, that an aesthetic description cannot be evaluated with respect to its truth or adequacy. Admittedly, the secondary use of a concept in a novel field of application cannot be judged according to established criteria. (By such criteria, it would always have to be judged as incorrect.) It does, however, generate its own criteria of application insofar as concepts are never applied singly to a given domain, but always together with a whole system of semantically interrelated terms (a conceptual scheme) which has to prove itself in its overall application to that domain. Accordingly, the appropriateness of the secondary use of a concept can be assessed by checking the extent to which the semantic system to which the concept belongs matches the domain to which the concept is newly applied (PPF, § 297; emphases in the original):

> A *great deal* can be said about a subtle aesthetic difference […]. The first remark may, of course, be: "*This* word fits, *that* doesn't" […]. But then all the widespread ramifications effected by each of the words can still be discussed. That first judgement is *not* the end of the matter, for it is the *field* of a word that is decisive.

Thus, although their meaning is strictly speaking ineffable, aesthetic descriptions may well be true or false—namely, to the extent that their semantic associations conform or fail to conform to the actual propensities of the objects they describe. What is more, their truth or falsity can be discerned from the extent to which they afford successful interaction with the objects concerned. Thus, applied to a genre-picture in its primary meaning, a statement like 'Two people are sitting here' is of course false. Understood in a secondary meaning, however—as a circumscription of the specific arrangement of lines and colors within the picture—it may well be true: not merely in a special, 'secondary' sense of truth, but in the ordinary sense in which the statement's truth is corroborated by its practical success, in this case its facilitation and support of an appropriate intellectual and emotional engagement with the picture.

These considerations reveal the deeply *epistemic* dimension of aesthetic understanding as Wittgenstein conceives it. Contrary to widespread prejudices, the poetic understanding that arises in moments of noticing aspects is *not* merely an arbitrary subjective interpretation that imposes forms and structures on things that they do not have in reality. Rather, it consists in a *primordial responsiveness*, not propositionally mediated or reflected, but pretheticallly and tacitly exercised, to *objective features* of the objects of one's aesthetic attention.

"[The] 'poetic mood' […] is the mood of receptivity to nature & one in which one's thoughts seem as vivid as nature itself" (CV, 75).[7]

This, then, endows Wittgenstein's method of aesthetic description with a peculiar epistemological quality. Aesthetic descriptions produce, as it were, unadulterated knowledge about the world. The price for this authenticity is, of course, that ultimately this knowledge cannot be *said*, but can only be *shown* through the secondary use of concepts. Aesthetic descriptions thus put us in a contact with reality that is at once particularly direct and particularly elusive.

## 4 An Aesthetic View of Models

The proposal now is to construe scientific models as aesthetic descriptions in Wittgenstein's sense. Thus, models are to be understood as representations which describe certain (real-world) target systems in analogy to certain (idealized) source systems. Moreover, they are supposed to transfer the terminology of their source domain to their target domain in an ineffable secondary meaning that in a poetic way acquaints us directly with the target and its inner workings, thus affording a unified and integrated—in that sense aesthetic—understanding of its nature.

Take, e.g., the liquid drop model in nuclear physics, which treats the atomic nucleus as a drop of liquid and describes its properties in terms of parameters that are usually associated with liquids (volume energy, surface tension, compressibility, etc.). Surely, the model does not describe the atomic nucleus as *really being* a drop of liquid or as *really having* the properties of liquids. Yet, according to the aesthetic view proposed here, it is also not to be taken as describing the nucleus as merely *resembling* a drop (in *this* or *that* respect). Rather, the model should be understood as describing the nucleus, *through the simile of* a drop, as *what it really is*. The idea is that the idiom of the drop, in a sense essentially informed by—but not identical with—the ordinary notion of a drop of liquid, can highlight integral aspects of the atomic nucleus for which, as it turns out, there are no terms more suitable and fitting than those for the properties of liquids.

That models describe their targets by analogy to other (simpler or more familiar) systems is quite a commonplace. The key thesis of the present proposal, however, is that models apply the concepts of their source to their target in a secondary meaning. Following Wittgenstein, this meaning is not the usual (primary) meaning of the applied concepts, but cannot be expressed by other terms either. Rather, it is partly constituted precisely by the application of these concepts to the target. (And this application cannot itself be based on conceptual criteria—in the sense of correspondence rules, coordinating definitions, or bridge principles—for otherwise the concepts' secondary meaning *could* be explicated in terms of these criteria.) The target itself thus becomes part of the secondary meaning of the concepts in question—and our acquaintance with the former correspondingly part of our understanding of the latter. The concepts thus understood, in turn, become irreplaceable for the description of the target and, accordingly, indispensable for the mediation of knowledge about that target.

[7] At this point it should be recalled that Wittgenstein attributes to this form of understanding, even if he mostly illustrates it with examples of the reception of art, a wide range of application: "Here it is important to realise that instead of a picture one might have considered a slice of material reality" (PG, § 114).

The assumption that a model's terms shift from their primary to a secondary meaning when transferred from the source to the target system seems most natural in cases where the model's source comes from a different domain than its target (as in the liquid drop model). However, according to the aesthetic view, essentially the same poetic transformation of meaning is at work when the source is merely a simplified or smoothed version of the target, as in the case of the simple gravity pendulum. Indeed, the idealized parameters of the latter—such as the masslessness of its rod and the frictionlessness of the pivot—also take on secondary meanings when transferred to the model's real-world targets. They are not meant to impute unrealistic properties to pendulums, but rather to uncover their fundamental mechanics. The aesthetic view can even claim validity for models which, according to popular opinion, correspond least to the archetype of an aesthetic description, namely mathematical models. Ironically, these are perhaps the most poetic of all models, insofar as in them the difference between source and target domains is particularly stark. *Pace* the Pythagoreans, the universe is not *literally* made from numbers. So however much we are able to make sense of the world with the help of mathematical models, we must not take them at face value (cf. Bradie 1999, 163). They, too, must be regarded as poetic attempts to express, by means of the secondary use of mathematical concepts, structures of reality that in the strict sense are not mathematical at all.[8]

The understanding that scientific models convey about their targets by means of fruitful analogies and innovative secondary uses of concepts is, according to the present proposal, an aesthetic one. That is, it is an understanding that consists not so much in the recognition of individual parts or properties of the target as in an apprehension of its overarching 'design' and 'functioning'. This does not preclude that it also brings further features of the target into view: The liquid drop model, e.g., not only helped to unify experimental data by describing the energy relations in radioactive decay and nuclear reactions; it even made it possible to predict previously unmeasured nuclear masses and explain unanticipated phenomena such as nuclear fission (cf. Möller and Sierk 2013). It is just important to remember that even where a model ascribes novel features to its target (whether as causal conditions or consequences of its other properties), these ascriptions function as part of an aesthetic description that primarily serves to place the multiplicity of phenomena in an intelligible context. So in these cases, too, what comes to be understood about the target is above all connections, not facts.

It is furthermore important to keep in mind that such an aesthetic understanding—the sense of how the various features of a target fit together, what significance they have for each other—although it ultimately finds its poetic expression in the aesthetic description of the model, is not originally a conceptual knowledge, but one that arises from a direct acquaintance with the target, from an immediate impression, as it were, of what that target is like. To that extent it could be called experiential knowledge. Yet, this must not lead to it being mistaken as purely phenomenal knowledge or knowledge of one's inner perceptual states. (This would be absurd anyway in the case of target systems that are themselves unob-

[8] In line with this view, Gelfert characterizes mathematical formalisms in model-based science as "inferential and interpretative resources" (Gelfert 2011, 284) which, in the course of their application to physical systems, "come to embody theoretical, ontological, and methodological commitments and assumptions […] which determine, at least in part, which physically meaningful interpretations of a specific application are legitimate" (Gelfert 2011, 285). Mathematical formalisms thus "play a vital role in allowing us to go beyond routine methods, by constructing new representational devices, thereby extending the reach of our representational practices to ever new domains" (Gelfert 2011, 285).

servable, such as the atomic nucleus.) It would be better to characterize the aesthetic understanding conveyed by scientific models as *intuitive* knowledge that is wholly realized in the practical (yes, also linguistic) interaction with the model's target, recurrently expressed and actualized in the iterative process of intervening in and adapting to, testing and observing, modeling and remodeling, that target. As Wittgenstein would say, aesthetic understanding does not give one a feeling *of* a thing (in the sense of a sensation), but rather a feeling *for* this thing (in the sense of a competence to act), (cf. RPP I § 654; RPP II § 261; LW I § 362).

Nevertheless, although the aesthetic *understanding* that models evoke is ultimately not a propositional one, the aesthetic *descriptions* they deploy can still be true in largely the same way as any kind of scientific representation—namely, by embodying semantic structures that are isomorphic to the structure of their intended domain of application. The degree of their isomorphism is reflected in the degree of practical success that their application yields, which consequently forms the rational standard by which their truth is measured. In one respect, however, the concept of truth inherent in the aesthetic view is indeed stronger than the traditional one. Here, the truth of a model is not merely *inferred* from its practical success, but rather noninferentially *evident* in it (namely, through the familiarity with the target of the model that arises in this success).

As it turns out, the proposed aesthetic view of models offers a neat solution to the puzzle of idealization that avoids the pitfalls of epistemism and pragmatism. First and foremost, it unravels how apparently false models can be true after all, as in this view models are simply not false per se (neither 'miserably' nor 'felicitously' in the sense that they are false but somehow lead to truth), but *bona fide* true—albeit not in a literal sense, but in a poetic one. While in their primary meaning models such as the liquid drop model or the simple gravity pendulum provide obviously false, because idealized or otherwise inaccurate, descriptions of their targets, these descriptions may well be true when taken in a secondary meaning. Again, to say these models are poetically true is not to say they are actually untrue; nor is it to say they are true in a special (poetic) sense. The poetic truth of a model is not a specific kind of truth—it is just the truth (in the mundane, primary sense of 'truth') of the model in its secondary meaning.

Granting the truth-aptness of models, the aesthetic view is able to reconcile modeling methodologies with a realist approach to science. Most importantly, it can preserve the underlying assumption of scientific realism that practical success indicates truth. There is no longer the question of how practically successful models can be true once one takes their idealizations poetically, and hence no need to question the connection of truth and practical success as a whole. The proposed view even rebuts a related antirealist argument, which reasons from the observation that there are practically successful yet incompatible models of one and the same target system (e.g., the particle model and the wave model of light) to the conclusion that despite their practical success, not all of these models can be true (cf. Frigg and Hartmann 2020, Sect. 5.1). From an aesthetic point of view, such models need not be incompatible at all, as long as they are not considered in their primary but in some secondary meaning. For example, while the particle model and the wave model may seem to present mutually incompatible accounts of the fundamental nature of light, this appearance of incompatibility vanishes as soon as these accounts are recognized as giving aesthetic descriptions of different aspects of that nature. The description of light once as particle, once as wave thus need not ascribe contradictory properties to its target any more than the description of a figure once as duck, once as rabbit. To the extent, then, that both the particle model and the wave model prove themselves in practice, they can also both be true.

The aesthetic view can also explain why models are epistemically valuable in the first place. For according to this view, models are not only capable of truthfully representing the world and thus generating genuine knowledge about it. Moreover, the truth of their representation is inextricably tied to their very own mode of representing—as is accordingly the generation of the corresponding knowledge. What the liquid drop model tells us about the atomic nucleus can only be told in the terms of this model. It is therefore fundamentally misleading to think of models merely as surrogate theories that at best provide fragmentary and biased knowledge about the world, and of model-based reasoning as surrogative reasoning that ideally leads to more mature theories. Since the truths they impart can only be expressed through the aesthetic descriptions they provide (and cannot be paraphrased in plain speech), models cannot be translated (let alone 'deidealized') into alternative (allegedly 'more accurate') theoretical languages.

This is not to say that the insights models provide are always particularly illuminating or instructive. Aesthetic descriptions can be more or less inspired, and their revelations, however true, equally profound or trivial. The proposed view also does not deny that models can be extended, adjusted or specified *within* the framework of the aesthetic description that a model offers. For example, the liquid drop model was mathematically formalized by the Bethe-Weizsäcker formula. Such refinements, however, must be seen as refinements *of* the original aesthetic description, and thus as having a poetic content themselves, derived from the secondary meaning of that description. Thus, far from being mere pre-studies or interim solutions on the way to genuine scientific knowledge, models function rather as normative frames of reference for the entire scientific-epistemic process, guiding scientists' research and overturned only when the world too stubbornly resists being squeezed into their scheme. This fits well with the observation that scientists usually do not try to deidealize an existing model by hook or crook, but switch to an altogether different modeling framework when the refinements to be made become overwhelming—as in the case of the liquid drop model, which was ultimately superseded by the nuclear shell model (cf. Frigg and Hartmann 2020, Sect. 5.1).

## 5 Aesthetic Description and Scientific Realism

In the foregoing, Wittgenstein's method of aesthetic description was taken up to develop a theory of scientific models that can solve the nagging puzzle of idealization—the question of how models, despite their idealized nature, can contribute to the scientific pursuit of knowledge and truth. What has emerged is a view that conceives of models as more or less sophisticated poetic devices for understanding otherwise inarticulable aspects of their real-world targets. As has been shown, this view succeeds in securing models a genuine and significant epistemic role in the scientific process—albeit at the price of bringing modeling methodologies somewhat closer to the hermeneutic approaches of art, and the cognitive results of the former closer to the ineffable insights of the latter.

I would like to compare the proposed view only briefly with existing theories of scientific models. First of all, the aesthetic view is opposed to the widespread view that models are indirect representations. According to the present proposal, models provide as direct representations of their targets as any other forms of scientific representation, differing from the latter only in their higher degree of poeticity. In this respect, the aesthetic view has affinities to contemporary metaphor or fiction theories of scientific models which typically also reject the indirect representation view (cf. Levy 2012; 2018). However—as would have to be shown in more detail elsewhere—these approaches still commit the error of assuming some kind of translatability of metaphorical statements in order to explain how one can learn something from metaphoric models, thereby again depriving models of any intrinsic epistemic value. For example, Levy (2012, 743–744) suggests that we can extract "true beliefs about the world" from a model's metaphors, apparently assuming that these beliefs are expressed in a nonmetaphoric language. Elgin (2010, 10) similarly acknowledges that a model rarely imputes to its target exactly the properties of its source, but much more often "related" ones, without however specifying how one arrives at these properties in the modeling process. For this reason, Frigg and Nguyen (2016, 229) introduce a "key" into their account of scientific modeling that explicitly links the properties of a model's source to the properties that are actually to be attributed to its target. From a Wittgensteinian point of view, all these accounts fail to appreciate what is really epistemologically distinctive about models *qua* aesthetic descriptions: It is precisely their untranslatable, inexplicable poetic content, through which they are able to convey insights that cannot be conveyed otherwise, that earns models an eminent and irreplaceable role in the scientific process.

This may offend some philosophers of science whose epistemological ideal is that of unequivocal propositional knowledge. These philosophers might find solace in learning that the fundamental ineffability of meaning and knowledge is a feature not only of scientific modeling, but of all language and thought. For Wittgenstein, in fact, the poetic transformation of meaning is something that happens basically every time we apply a familiar concept to a new case (think of the concept 'game'; cf. PI, §§ 66–69). Whether the respective case is subsequently ranked as a primary or secondary use of the concept (whether, e.g., language is a game in the literal sense or in a poetic one; cf. PI, § 7) is for him a matter of pragmatics rather than semantics (cf. BBB, 139–140). What is crucial either way is that the extended or shifted meaning of the concept—or rather, what constitutes that meaning—cannot be described further than by recourse to what the concept originally means. To some degree, then, *all* meaning is ineffable, and *all* understanding is in part a poetic one. Seen from this perspective, Wittgenstein's aesthetic description appears much less as an extravagant method of understanding than as a natural extension of basal cognitive processes. This does not diminish its epistemic potential, but underscores its centrality to our cognitive-epistemic enterprise, including science. It does, however, also expose the ideal of univocal propositional knowledge, still prevalent among philosophers of science, as a misleading ideal, if not a chimera.

To conclude, it is worth noting some implications of the proposed aesthetic view of models for the issue of scientific realism. The latter is usually discussed along two (related) questions: first, whether scientific representations merely provide convenient descriptions of empirical regularities between observable events, or whether they actually explain these correlations by underlying causes; second, whether genuine reality should consequently be granted only to the referents of the observational terms of these representations, or also to the ostensible referents of their theoretical terms (cf. Nagel 2002).

At first glance, the aesthetic view may seem to side entirely with the nonrealist, descriptivist position. Thus, the proposed view might be interpreted as taking the atomic theory, e.g., to be no more than a poetic description, using the corpuscular talk of particles, of some complex traits of observable matter. In fact, however, the view largely abolishes the traditional dichotomies between scientific descriptivism and realism. First, it overcomes the epistemological distinction between the observable and the unobservable in a double way. For while observational knowledge is usually understood as knowledge that involves (a) a phenomenal presentation and (b) also some conceptual representation of the observed, the aesthetic view, with its notion of poetic understanding, acknowledges a form of knowledge that is not only not conceptually articulated, but also not phenomenally given, but rather incorporated in one's practical interaction with the known. For this view, the decisive epistemological distinction is accordingly not between the observable and the unobservable, but between the 'interactionable' and the 'noninteractionable', as one might say.

Second, from the aesthetic point of view, it is meaningless to ask whether scientific representations 'really' describe only empirical regularities between events, or rather underlying causes of these regularities; for this question again erroneously assumes a translatability of what are in effect poetic similes into a putatively literal language. Even if, e.g., the atomic theory claims 'only' in a secondary sense that all matter is composed of atoms, it still claims that all matter is composed of atoms—in secondary senses of these terms. And if this hypothesis is true, then all matter is—in this secondary sense—indeed composed of atoms. The contention of the proposed view is that it makes no sense to ask what the theory *literally* asserts and what *really* exists in the case of its truth. For whatever exists in that case, we could not better couch in other terms. This does not mean that the aesthetic description of the atomic theory is to be taken literally after all. It is rather part of the poetic understanding of this theory *as* an aesthetic description of the reality of matter that this matter does *not exactly* consist of smallest particles (at least not in the same way in which, e.g., a heap of sand consists of individual grains). Nevertheless, the theory reveals (or so we think) something true about the deep nature of matter, something that may be gestured at just best in the idiom of atoms.

These considerations would, of course, need to be explored in greater depth elsewhere. This essay could only be about presenting the program of an aesthetic view of scientific models—a view, incidentally, that might itself be regarded as an aesthetic description in Wittgenstein's sense: as an attempt, that is, to make modeling methods in science intelligible through their analogy with aesthetic descriptions. The sense in which models are aesthetic descriptions would then itself be a secondary one, i.e., a sense that could not be spelled out beyond this analogy. But if Wittgenstein is right, there would be no need to do so either: the aesthetic description of models as aesthetic descriptions would, if true, show what models are—with nothing left to say.

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