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AN ALTERNATIVE VIEW FOR SCIENTIFIC MODELS BASED ON METAPHORS: A CASE ANALYSIS FROM DARWIN'S USE OF METAPHORS

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Abstract. This paper aims to offer an alternative view for understanding scientific models based on metaphors. To accomplish this, we employ a special case of Darwin's use of metaphors, such as the notion of powerful Being, in order to show the presence of scientific models from metaphors in natural selection. Our proposal contributes to issues in the literature of scientific model, such as imprecisions in the understanding of scientific models, especially in models based on metaphors. Thus, our alternative view of models based on metaphors, and inspired by Darwin's use of metaphors, provides us with four features, a-simplification and selection; b-articulation of familiar-unfamiliar structures; c-accessibility and moderations of complexity, and finally d- local realism. We raise these features from the approach of Darwin's use of metaphors and the contemporary literature of scientific models. We conclude by saying that our proposal of metaphor's approach of models does not only contribute to the clarification of how these types of scientific models can be understood but it shows that metaphors can also contain a realist element that explains why scientists often use it in their practices of modeling the world.

Keywords: Local realism • metaphor approach • Darwin's models • deliberate distortions • powerful Being

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1. Introduction

This paper aims to offer an alternative account for understanding scientific models based on metaphors. To accomplish this, we analyze Darwin's use of metaphors, such as the notion of powerful Being and Struggle for Existence, in order to represent part of the process taking place in natural selection. The proposal emerges from two provocative issues. First, that the use of metaphors in philosophical and scientific literature is a form of approach that together with other "linguistic tropes in science dies hard" (Bailer-Jones 2002a; Keller 2002, p.117). Second, there are still unsolved problems in the literature of scientific models and debates using metaphors in science as the main epistemological approach.

Among the issues in the literature of scientific models, we can point out things such as the relation between theory and model, the model and the world or even the nebulous understanding of scientific models, which is found amid scientists and philosophers as well, nurturing the multiplication of types of scientific models. In order to address these issues, at least regarding the approach of scientific models through metaphors, we will present an alternative account based on four features. Our account also works in ways that explain how scientific practice develops interpretation of empirical information, that is, to "elucidate how scientists create and formulate interpretations of aspects of the empirical world" (Bailer-Jones 2002a, p.108). This addresses the problem of an approach of scientific models through metaphors as going beyond understanding, explaining, or communicating things which we do not know how to do in a literal sense. Therefore we add that in science we could also use metaphors to investigate a phenomenon while including empirical data (Bailer-Jones 2002a; Black 1962; Keller 2002).

Thus, metaphors could be used in sciences not only as analogies but as a path for our imagination, discovery and test of our hypothesis. This is why, beyond the disputes around the definition of scientific models, we are less interested in proposing a definition for the approach of metaphors in scientific models and more interested in offering an approach of its features and contributions.

Our view is an alternative to the conceptions of metaphor applied in scientific model that have none or just some of the four features we will introduce. As an example of opposite views to ours, we can mention conceptions of metaphors in scientific models that consider metaphors in science only as a tool for explanation, or only as a way to give a simplified representation of a more complex phenomenon, or as if metaphors were ultimately something eliminable.

In this sense, our proposal establishes four features for scientific models based on metaphor as necessary while we have no objection to considering them as insufficient. The first three features will be presented in section two, exemplified in section three, and the fourth feature, the local realist one, in section four.

The four features also dispute the idea that metaphors are too disconnected from the real world to be taken under a somewhat realistic perspective. To accomplish this, we analyze in the history of evolutionary biology how Darwin uses metaphors, such as the use of the metaphor of a powerful Being in Darwin's writings to represent natural selection (both in the *Essays* (1842-1844) and in the *Origin* (1859)). We conclude from this historical case that he starts the debate with metaphors and finishes the metaphors with a real world application of the metaphors. Thus, it is our conclusion that the use of metaphor as scientific model is present in biology since Darwin's *Origin*.

The four features that constitute our alternative view are introduced along the paper following this structure. The first three of them (a-simplification and selection;

b-articulation of familiar-unfamiliar structures; c-accessibility and idealizations) are presented in section two. The last one (d-realism), presented in section four after we have discussed the historical case in section three. We investigate our proposal from different philosophies about scientific models in order to approach them from a metaphor viewpoint (Bailer-Jones 2009; Carrillo and Knuuttila 2021; Cassini and Redmond 2021b; Frigg and Hartmann 2020; Gerlee and Lundh 2016; Richards and Ruse 2016; Wimsatt 2007).

From these features emerge our alternative account of scientific models based on metaphors in science. These features are noted in various philosophical discussions and we reproached them under our proposed structure. The reason for choosing these philosophers is their outstanding contributions to scientific models or Darwin's evolutionary theory debate. In section three, we explore our proposal from a historical case, through the metaphor of a powerful Being in Darwin's explanation of natural selection.[1]

According to our case, extracted from two main books of Darwin, the *Essays* (2009[1909]) and the *Origin* (2009 [1859]), we show how the introduction of the metaphor of a powerful Being, as if natural selection were a powerful all-seeing Being, not only meets our description of scientific models from metaphors but provides forms of tests for Darwin's theory. To accomplish this, Darwin finishes his metaphors by transferring some aspects found in the metaphors to the real world scenario. He illustrates this point with the example of the mistletoe that we will present in section three. Thus, to make it clear, we subdivided section three into two subsections to explore the prominent use of metaphors and their detailed relations with features that, we argue, fit in our description of scientific models from metaphor approach. In section four, we explore how the last step proposed from Darwin's uses of metaphor, presented in section three, is applied in the real case of the mistletoe, which brings philosophical implications to metaphor models. The main implication of our debate is the inclusion of local realism as found in Wimsatt (2007). We argue that scientific model based on metaphor approach dialogues with local realism. This is why we added to our list of three features of metaphors in scientific models this last one, local realism. As for the paper's conclusion, we hold how our account for scientific model based on metaphor approach helps to advance the general debate around this topic while reduces misconceptions about metaphors in science.

2. The need of models in science and its philosophical features

Nowadays, scientific model plays a central role in science and philosophy of science. Nonetheless this topic has been calling the attention of philosophers for some decades, especially since the works of Max Black (1962) and Mary Hesse (1965). Due to this relevance, models have remained an attractive topic for at least the previous past six or seven decades (Bailer-Jones 2002b; Cassini and Redmond 2021b). Not only this but the diverse comprehension of models and the place of models in science are issues that received much attention, attracting part of the interest in traditional topics of philosophy of science, such as the epistemology of scientific theories, methods, etc.

The way science deals with models attracted philosophical attention for many reasons. However, from the need to understand its definition in natural sciences as much as their relationship with theories and to the world, philosophers noted the increase of philosophical problems which were related to cases of conceptual clearness and other problems that exposed deep disagreements such as between realism and instrumentalism in their approach with respect to model (Bailer-Jones 2009). As in many cases of scientific research, the understanding of models is still surrounded with many doubts and conceptual imprecision (Fourez, Rouanet, and Fourez 1995). On the other side, it is also noted that the success of this task in understanding scientific models requires an interdisciplinary attitude, i.e., one that makes science cope with other areas. Areas like philosophy have already proved to be of value in the attempt to understand a phenomenon or a problem of research addressed by science by exploring the issue through its own perspective (Laplane et al., 2019).

For instance, despite the extensive use of models by science, there is not a large agreement among scientists or philosophers about what scientists mean by model. There is not a clear-cut agreement about the relationship between models and theory neither about its epistemic, methodological, and ontological extensions. Moreover, as Bailer-Jones has shown (2009) throughout a series of interviews with nine scientists, she concluded that the way scientists use, understand and define the concept of model, as much as its relationship with theories, is not only diverse but also sometimes conflicting. It became clear from these interviews that scientists' views of how model and theory are related could vary. This variation ranges from the radical concept that there is not much substantive difference between model and theory; to the general view that only models contain simplifications and idealizations (Bailer-Jones 2009; Cassini and Redmond 2021b; Frigg and Hartmann 2020).

Another example is the survey that Gerlee and Lundh (2016) conducted throughout interviews with ten scientists, each from a different field, about models and how to use them as much as the comparisons between theories and models. Accordingly, they concluded that "models differ between the disciplines", which suggests that the concept of model has an "immense scope" (Gerlee and Lundh 2016, p.66), which rather put things in terms of more than just one correct answer, and for the sake of our argument, it endorses the interdisciplinary nature of science with a strong need for dialogue with philosophy.

In addition to this wide range of views, and from years of investigating models, a significant variety of models has emerged. Among these we could mention types such as, among others, probing models, explanatory models, idealized models, abstract models, and theoretical models. Notwithstanding, what makes a model a scientific model? Until now, we had some progress in this subject but not much. For instance, we can say that theories and models do not have the need of an explicit agreement about their relationship, such as if they were interchangeable, or as if models were independent entities (Cassini and Redmond 2021a). In other words, there is a plurality of ways in which models are used and related to other more traditional elements of scientific knowledge. But from what we have said so far, it is clear why these are all open questions.

Nonetheless, as an attempt to move forward, conceding that the answer differs from one philosopher and scientist to another, let us try to highlight some elements of scientific model from metaphors found in historical cases. In this sense, throughout the paper, we will be able to present an alternative account of scientific models from metaphors about a specific phenomenon . To do that, we will take a metaphor case extracted from Darwin's theory of evolution (detailed in section three and four). Specifically, we will analyze the metaphors in Darwin's theory as a strategy of research comparable to what we contemporaneously call a type of scientific model. In it, Darwin provides justification grounds for his natural selection and struggle for existence (which is also referred by Darwin as metaphorical expressions). This use of metaphors and our interpretation of them as scientific model is completed when we observe (in section four) how Darwin used metaphors also as a testing tool to confront his theory against the real world. Thus, we will introduce and correlate three different general elements about scientific models, useful for establishing our alternative for scientific models in a metaphor perspective. Therefore, our proposal aims to offer an understanding of needed features (but not sufficient) for approaching scientific models through metaphors.

2.1. Simplification and selection in models

The first feature of our account is the notion of simplification and it is inspired by Wimsatt (2007). In the occasion Wimsatt says that "*[a]ny model* implicitly or explicitly makes *simplifications*, ignores variables, and simplifies or ignores interactions among the variables in the models and among possibly relevant variables not included in the model." (2007, p.96, italics added). In his chapter of models Wimsatt (2007) addresses how false models are used to get to provisional truths in a robust way.[2] His description of false models as means to truer theories is based on the idea that models are flexible to problems and interests, not necessarily committed to a global realism or instrumentalism, and models do advance through forms of simplification of the elements modeled (2007, p.94). For instance, in biology, neutral models represent baseline models for testing how the models hold up without selection processes involved. The general simplifications applied in modeling like these allows us to say that models can be deliberately false in terms of the variables outside the model. Wimsatt (2007) gives us many examples, but in one clear case extracted from the works of Kimura (1983) and Crow (1987), Wimsatt explains how these researchers used neutral models to evaluate their assumption that "selection forces on these variants [patterns of molecular variability] could be ignored." (2007, p.97, brackets added). In other words, how scientists applies models to study only one selected part of a phenomenon or variables while ignoring from this study and model everything else, i.e., simplifying the object studied, which ultimately makes it false in absolute terms.

The process of evaluation in neutral models upon the selective forces applied should not be confused with the idea that the "excluded variables are unimportant" (Wimsatt 2007, p.98). To think that the exclusion of variables is related with any degree of absolute importance to these variables is a blunt mistake only based on the fact that a model does not address the excluded variables under a given purpose (2007, p.98).

This is why, baseline models in biology "often represent the deliberate use of false models as tools to better assess the true state of nature" (Wimsatt 2007, pp.131–2). The meaning of false models is the idea that the models deal with only one part of variables and deliberately ignore the others, i.e., the model is in these terms simplifying the phenomenon and its variables in order to epistemologically focus on one part or some variables at a time. In few words, it does not mean that the results from this use of models are false or simple, but selected. From what we argued, our proposal of models from metaphor approaches could be stated in the following plain terms:

(a) Metaphor approach of model works through simplification and deliberated forms of selections of elements, goal, variables and interactions.

Thus, to render simplifications in a scientific modeling means that models need to make some form of selection of the variables of a phenomenon in order to offer explanations of a complex world, i.e., "the falsity of scientific models is in fact often essential to this role" (Wimsatt 2007, p.94). Nonetheless, by falsity we do not means any form of falsity. As we mentioned above, it is a systematical form, a selected form of falsity which, as such, shows that "deliberate falsehoods can be productive tools in getting to the truth" (Wimsatt 2007, p.132).

Comparing our proposed item "a" with the results obtained from the ten qualitative interviews that Gerlee and Lundh conducted, we notice something relatable, which is the argument that models "provide access to a reality that in almost all cases is of such complexity that it cannot be described or controlled without some prior simplification and abstraction" (Gerlee and Lundh 2016, p.66).

Roughly speaking, models are forms of focusing on something, X, which otherwise would be hardly accomplished (Black 1962; Odegard 1964) and also on something that concerns a scientist, which may or may not be related to one single theory, in order to, among many other things, better understand, explain, predict, represent or hypothesize the contextual behavior, property or relation of X to something else, like a phenomenon, systems, variables, theory, method, hypotheses, problem (the list of possibilities is not limited to these items).

2.2. Metaphor approach of models articulate the unfamiliar under the familiar structure

Our second proposed feature is inspired by a second author, Robert J. Richards (Richards and Ruse 2016), who says in a brief passage, without further details, that models are primarily a form of metaphor, in the sense that metaphors "depict a more familiar structure in order to articulate a less familiar one." (2016, p.155). As we saw previously and will better see in section three, as part of this form of depiction, metaphors offer an access on the subject matter at hand. This is why simplification in this context of metaphors has more to do with building a familiar structure for understanding it and less to do with make things themselves easy .

The idea of building a familiar structure here means that the idea of turning something complex where many parts are unknown into something recognizable implies that this is a possible task. It means that one is familiar with the elements used in the depiction of the unfamiliar and that this familiarity goes to the point where one is able to use these elements in another context, which is simpler in one sense at least, that is, to help us to make sense of something (Keller 2002), but yet simpler, which is relative concept, is different of just simple.

Of course, part of this idea works because the elements involved in the articulation from an unfamiliar element to a familiar one appeal to some established similarities (Black 1962; Keller 2002). For instance, in his seminal book, Max Black (1962) related the function of metaphors to that of models (calling it analog-models). Accordingly, metaphors link two systems which their two words evoke but the linkage works "by calling forth *similarities*, by leading the reader to *selectively focus* on those properties of each system that make a fit between the two terms possible" (Keller 2002, pp.118–9, italics added). In a few words, this means that our previous item "a" not only fits well into Black's viewpoint of metaphors, but that our next item "b" does it too.

In this account, a metaphor can selectively relate two systems in order to achieve different goals. Furthermore, metaphor approach builds alternative forms of access to the subject at hand which otherwise would not be possible or that would be unnecessarily problematic by direct approach (García-Carpintero 2021; Walton 1993).

Thus, scientific model based on metaphor can deal with specific problems through this articulative process, where less familiar structure of a subject matter and its many variables could be made workable through more familiar forms of representations. From what we argued, in analytical terms, our proposal of models from metaphor approach

(b) provides a unique relationship between two or more subjects under an articulative approach that goes from unfamiliar structure to familiar structure .

The metaphor approach of scientific models has among its advantages the fact that it articulates the unfamiliar into the familiar, albeit the very use of metaphors also has its disadvantages. Bailer-Jones argued that the claim that models are metaphors was a radical thing to say in the 1950s, but nowadays it is not, although it has limitations since "not all models carry the features of metaphor." (2009, p.208). This is undoubtedly true, and one reason is that many models, like the phenomenological ones, have other goals and aspects.

Nonetheless, Bailer-Jones also sustains that models are forms of scientific illustration about the natural world, and "the metaphor approach to scientific models can elucidate how scientists create and formulate interpretations of aspects of the empirical world." (Bailer-Jones 2002a, p.108).

In a few words, although a defense of metaphor as a sufficient type of model was defeated a long time ago, the defense of some of the advantages of metaphor remains acceptable, and among these advantages, we found the item "b" that we just explained, i.e., that metaphor approach of scientific model opens unique approaches to make a phenomenon understandable (Bailer-Jones 2002a; Black 1962; Carrillo and Knuuttila 2021; García-Carpintero 2021).

2.3. Metaphor approach of scientific models as idealized forms to render accessibility

The third feature was inspired by Cassini and Redmond (2021a) and by Carrillo and Knuuttila (2021). In an enlightening text, where they mark the heterogeneous understandings around scientific model and its functions, uses, meanings, and employability, the authors also offered a general insight into the nature of scientific model which turns out to be helpful for our metaphor approach. According to them, every scientific model is "idealized in some way or another and to a certain degree. This property of models is *the key* for gaining *access* to phenomena that are too complex to be described or understood in all their details" (2021a, p.15, italics added). This being the case, Robert (2016) was somewhat correct in stating that models depict unfamiliar structures into familiar ones regarding some subject matter.

However the way models idealize the phenomenon is not in a romantic or flowery manner where all sense of reality is lost and an emptied version of the phenomenon is proposed (Black 1962; Cassini and Redmond 2021a; Morgan and Morrison 1999). This romantic manner is related to an inadequate view of thinking about idealization which ultimately aims for "de-idealization" (Carrillo and Knuuttila 2021, p.52). Obviously we will not support this. Yet, to realize this aim of de-idealization, the deficient view focuses on how idealizations are mainly used to make things simpler and "achieving tractable representations", at least, until the advancement of science could "deliver more accurate representations of worldly target systems" (Carrillo and Knuuttila 2021, p.52).

From our proposal, there should not be anything such as de-idealization of models because idealization is a key feature in every scientific model. Thus, the maintenance of idealization is seen as one epistemic benefit for our alternative account, and as such, it does help with other epistemic goals, like explanation and understanding. However, it does help through a manner which "in scientific modeling a detailed depiction is not often sought for." (Carrillo and Knuuttila 2021, p.52).[3]

In this account, as Cassini and Redmond (2021a) pointed out, scientific model idealize the variable of interest. To achieve this, what scientific model does, based on a fundamental conception existing in many "if not most of these accounts [. . .]: [is to] introduce distortion into models" (Carrillo and Knuuttila 2021, p.52, brackets added). However, these distortions are not involuntary introduced, rather and within a traditional view, the distortions are needed, and by doing so idealizations have been traditionally understood as deliberated misrepresentations (Carrillo and Knuuttila 2021, p.52).[4] This being the case, we could ask to what purpose models deliberately misrepresent. The answer, given by Cassini and Redmond (2021a) and by Carrillo and Knuuttila (2021), is that scientific model is a manner to give us access to phenomena. As clearly stated by Carrillo and Knuuttila (2021), scientific model has multipurpose shape and it renders "certain scientific problem more accessible and manageable, helping scientists to address it in a systematic manner." (2021, p.56).

Thus, the presence of idealizations in scientific models is introduced in a fundamental way, that is, in a way that "would not be possible without it" (Black 1962; Carrillo and Knuuttila 2021, p.52) if we want to gain access to the subject matter we are investigating. From what we argued, in analytical terms, our proposal of models from metaphor approaches:

(c) nurtures a form of access to the subject matter throughout idealizations as deliberate distortions.

In this account, scientific model addresses problems involved in the direct approach of a complex subject matter, and idealizations furnish specific forms of accessibility through distortions. Nevertheless, there is a price to pay, like the loss with direct and unchanged view of the phenomenon.

At this point, we can ask, is it possible to understand a complex and multifaceted phenomenon *all at once* and without distorting it and manipulating it? From within the limits of a metaphor approach, there is not. This is a key aspect of all scientific models until now. It is supposed to be this way, so the kind of idealization we are thinking does not start modelling anything by expecting that we will have a "straightforward comparisons between models and their supposed target systems." (Carrillo and Knuuttila 2021, p.52).

The advantages of the metaphor approach to scientific model rest upon this form of partial distance and not straightforwardness comparison to the phenomena. Due to the way metaphors work, building articulations between familiar and unfamiliar structures, distorting and cutting out elements, it allows the model to open research opportunities that only idealizations can provide in order to access the problem at hand. These open opportunities are routes to better understand and explain some phenomenon or variable, and ultimately aim to furnish access to the issue we are interested in study.

In the next session, we will see how these three features (a, b, c) are present in one of the most successful theories of science, Darwin's theory. We will see how Darwin uses the metaphor of a powerful Being to explain and test some mechanisms of the process of natural selection. We will argue that Darwin was actually offering more than just a flowery metaphor, and nowadays with the advancements in the debates respect scientific model, we argue that his metaphors fit the role of a scientific model based on metaphor approach. Moreover, we find in his metaphors the elements introduced in this section-2, which helped him to justify, test, and explain his evolutionary theory.

3. Darwin's use of metaphors in his argumentation

Darwin applied many metaphors, abstractions and idealizations for wide range of reasons. He applied metaphors for elucidation, to testing the basis of his arguments, and also to minimize conflicting and ambiguous perspectives operating within his theory.[5] According to Delisle (2019), there were many problems in Darwin's theory that required attention and creative answers such as metaphor.

For instance, Darwin introduced his theory with two conflicting views, the "'flat' or 'horizontal' view" (2019, p.69) of evolution as presented along chapters 1 to 5, and also "[a]gainst the arguments presented in the first five chapters, Darwin offers in Chapters 6 and 7 an entirely different picture of evolution", that is, the "vertical and directional view of evolution." (2019, pp.69–70). According to the vertical view in chapters 6 and 7, "natural selection is depicted as a brute force to which nothing can resist" (2019, p.70).

Clearly, Darwin had a lot to explain, consider, understand and prove about his theory, i.e., about the process (natural selection) and the pattern (divergency) that was going on in it (2019). In this scenario, metaphor imposed itself as a necessary, practical and efficient answer to some of his concerns.

For instance, Darwin said that he used "the term Struggle for Existence in a large and metaphorical sense" (Darwin 2009[1859], p.50), pointing out the representation of that struggle in nature. He wanted to emphasize the kind of complexity of features, relations and entities involved in the struggle for existence, which seemed not to be possible without metaphors. That is, the use of metaphor does not fulfill a linguistic flowery but a necessity. Darwin did not hide how metaphors contributed to the understanding and to the argumentative strategy he applied to explain, prove and convince the scientific community about his theory. He uses metaphors even as an explanatory strategy for economic purposes, such as when he says "I speak of natural selection as an active power or Deity" although what "is implied by such metaphorical expressions [...] are almost necessary for brevity." (Darwin 2009[1859], p.63).

From our perspective, Darwin's use of metaphor goes beyond economic purposes. Solely based on these two quotes above where Darwin directly states the use of metaphors, we can begin to show how his application of metaphors fits into our general features of scientific models from metaphors.

For instance, Darwin uses the term Struggle for Existence in a metaphorical sense because he is trying to explain blind natural laws which could not be explainable if taken literally. The amount of details and complexity required to describe the nature of this Struggle could not be made in one paragraph, or a few pages, as Darwin primarily wanted at this point. Thus, the task was accomplished with metaphor.

One clear example is the case of plants in a desert struggling "against the drought" (Darwin 2009 [1859], p.50). Have we ever seen a plant fighting against 'The' drought as if it were alive and actively fighting? The way Darwin found to communicate this struggle (as much as to condense all the information involved in it) was through the benefits of metaphor. The communication through the use of metaphors goes beyond brevity. It actually allows Darwin to build a familiar structure upon which the unfamiliar structure of his theory about this form of interaction prevails (between organic and inorganic). Through the metaphor of the struggle between organic and inorganic, he articulates two systems (ordinary language and scientific language as much as the differences in their ontologies), through a competitive and natural selective process (item b).

Similarly, when Darwin says that he occasionally takes the expression natural selection under a metaphorical approach for the sake of brevity, the reason he says this is due to his need to focus on less variable elements in natural selection (not domestic). In a sense, he is simplifying the complexity of how different kingdoms and elements interact under the means of natural selection (item a). He needs this in order to show how two different systems have similarities if we analyze them, and the many laws involved, with the help of idealization and deliberated distortions, which offers some accessibility to the phenomenon (item c).

Of course, there was a cost. For instance, in the above quote, he takes natural selection as an active power. Darwin was aware of how the use of active power would serve some purposes but brought some problems, such as blurring the distinction between natural theology and revealed theology. For instance, Darwin says that natural selection as an intelligent mind was just a stylistic metaphor. According to this literary linguistic approach, it would be a mistake to surrender to the temptation to speak of natural selection as an active power or Deity considering natural selection as a person. From the difficulties to avoid this linguistic trap no one should imply any realistic commitment with a superior Being, after all, "[e]very one knows what is meant and is implied by such a metaphorical expressions" (Darwin 2009[1859], p.63). Darwin even mentions Newton as an example of this same linguistic trap. He says that nobody "objects to an author speaking of the attraction of gravity as ruling the movements of the planets" (Darwin 2009[1859], p.63). In a word, he does not want to talk of natural laws of evolutionism under terms of the Creator (supernatural approach) because he wants to speak of it in terms of blind natural laws, that is, "the aggregate action and product of many natural laws, and by laws the sequence of events as ascertained by us" (Darwin 2009[1859], p.63).

Darwin takes natural selection in a metaphorical sense because if it is used in the "literal sense of the word, no doubt, natural selection is a false term" (Darwin 2009[1859], p.63). To put it simply, metaphor is a necessity for Darwin's strategy of long argument although he does not want the reader to surrender to the temptation of taking in the literal sense something that is used in a metaphorical sense.

Of course, by then, Darwin could not know that one reason for his need of metaphors in science comes from the exclusive advantages of metaphors, especially in scientific models, such as the specific and not literal form of accessibility to investigated phenomenon (Black 1962; Carrillo and Knuuttila 2021; Keller 2002).

Nonetheless, as Darwin rejects teleology, he had a problem with respect to a metaphysical issue regarding his natural selection, i.e., about how to sustain the metaphorical representation of it as an active power without falling into the traps of teleological world guided by revealed theology. Let us remember that he does not only use metaphors to talk about natural selection as an active power, he also uses terms very much related to some teleology, such as "given by the hands of Nature", or the "face of nature bright with gladness" (Darwin 2009[1859], p.49).

Darwin's argumentative strategy was not always good for keeping separated the scientific and the religious ontologies. Sometimes, the terms chosen gave the opportunity to think, under a Victorian worldview, in terms of an intelligent mind in Nature that seeks happiness, and when necessary, takes and gives help as it pleases. According to Delisle (2019) one reason for such application of these terms and linguistic ambivalence in Darwin's argument is due to the fact that he "inherited from the previous centuries a number of concepts that guided him in his thinking: stability, completeness, timelessness (eternity), unity (within classes), permanence, and uniformity." (2019, p.60). Furthermore, as Delisle explains, although scholars of the Darwin industry focused on the methodological aspects of this debate and commitments, there are also reasons to believe that the "analysis should also be extended to cover its ontological aspect" (2019, p.60).

This being said, a revealed theology was definitely out of the way, but not a natural theology, and with it, Darwin's argumentative sometimes made hard the distinctions that he needed, like the causality problem (Delisle 2019; Richards and Ruse 2016; Ruse 1999). For instance, Darwin needed to focus on the separation between primary and secondary causes for natural phenomena. He reinstates that to his mind, "it accords better with what we know of the laws impressed on matter by the Creator, that the production and extinction of the past and present inhabitants of the world should have been due to secondary causes" (Darwin 2009[1859], p.428). Here, primary causes were those related with supernatural powers while secondary ones with natural and blind laws. Of course, separation does not mean that he denied primary causes.

For Darwin, by the time he finishes the *Origin*, "he still believed that something like mind governed the universe. *The Origin* itself demonstrates [...] that Darwin's theistic belief helped structure his views about natural laws as secondary causes, with the divine mind as the primary cause." (Richards and Ruse 2016, p.224). For the sake of our paper, we will not discuss the role of natural theology in Darwin's book.[6] What matters for us is how Darwin wanted to set apart scientific and religious business, addressing secondary causes as adequately belonging to scientific interests, although he still needed to use metaphors to guide (through model) and persuade some of his scientific colleagues of his theory. Thus, as Robert Richards underlines, the "metaphor of an intelligent mind" has structural consequences for the understanding of Nature (Richards and Ruse 2016, p.155), which unsurprisingly serves Darwin's argumentation as well.

3.1. Two plants on the march against each other: metaphor approach to model

To explore how our alternative account of metaphor as a scientific model can fit into Darwin's use of metaphors, such as a powerful and all-seeing Being and, therefore, how a scientific model based on metaphor helped Darwin with his theory, we must first look at a case that does not involve a powerful Being. Thus, we will go deeper into the presence of metaphors in Darwin's book, and its relations to our description of scientific models. To do so, let us take the case of how parasitic plants manage to survive.

The example intends to reveal that the Struggle for Existence is somewhat idealized, the variables and interactions simplified (item a), and the details avoided in order to gain some level of accessibility to the phenomenon (item c) under a familiar depiction from the unfamiliar structure or elements (item b).

According to our example, Darwin says that "the mistletoe is disseminated by birds, its existence depends on them; and it may metaphorically be said to struggle with other fruit-bearing plants, in tempting the birds to devour and thus disseminate its seeds." (Darwin 2009[1859], p.50).

This example has many aspects that we must address which point to metaphors. First of all, it starts from how Darwin portrays a case that is easily observable in nature, although, by itself, it is an already idealized and simplified portrayal of the Struggle for Existence with the help of metaphor. Second, and what attracts the attention, is the description of how two living organisms with no apparent agency, and from the same kingdom (*Plantae*), interact and struggle with each other as much as with the third part belonging to a different kingdom (*Animalia*). How can such an apparently improbable relation be conceived under terminological terms as struggle? How can a plant struggle with other plant or yet tempt a bird? This example shows a bit of the audacity of Darwin's theory in a scientific community where even amid the evolutionary supporters such as Herschel, Gray, Wallace, Lyell or Huxley, some level of teleology was preferred (Hull 1973, p.77).

The complexity involved in such an example given is remarkable. However, Darwin knows it well, and in order to render it understandable and persuasive, he uses some metaphors, like 'tempting', or 'the mistletoe. . . struggle with plants', which in some sense relates to the ordinary use of these words, i.e., a familiar grammar from an unfamiliar context of this theory. From our example of mistletoe, plants had no agency as humans do, and they could not actively tempt other species as most animals do. Plants cannot fight literally by throwing rocks, punches or sticks. Therefore, Darwin highlights his metaphorical strategy in the example.

In the mistletoe's scenario proposed by Darwin, the way he puts it, it looks like the mistletoe and other parasitic plants have agency and seductive skills. However, Darwin knew that this was not a *true* use of the term Struggle, a literalism, since the Struggle for Existence fits better in scenarios as those of wolves, i.e., where two "canine animals, in a time of dearth, may be *truly* said to struggle with each" (Darwin 2009[1859], p.50, italic added).

The use of the expression of metaphorical struggle in the above quote (Darwin

2009[1859], p.50) reveals more than just brevity. After all, in the example given, many vital interactions and variables of Darwin's natural selection are ignored (and yet remain important), like the preservation of traits or reproduction rate. The variables are ignored in order to drive the researchers attention towards one direction, i.e., the way species of different kingdoms metaphorically struggle with each other. It is a form of idealization, where the interactions only happen between the referred species, just as if they were in a controlled environment freed of other interferences and relationships.

Generally, a metaphor approach of scientific model furnishes these aspects, and because it uses familiar structures for addressing unfamiliar ones, it aims to nurture some accessibility to the phenomenon, like understanding the mechanism behind the mistletoe's survival and species' interdependence.

In the case of the mistletoe, Darwin tried to express the relation of the actual working of selection in mistletoe with a simple linguistic metaphor. However, by the end of this hypothetical scenario, he was actually offering what today we consider to be scientific model, based on a controlled scenario of explanations of mechanisms, variables, simplifications, idealizations, articulation of systems. Therefore, ultimately, by this scientific model, he could submit his theory to tests against experiments, other theories and models.

3.2. Modeling a powerful Being in Nature

In a certain way, Darwin repeatedly postulates metaphor models (at least in the sense we are proposing) in his book to debate some aspect found in natural selection or, more interestingly, to provide theoretical support for his arguments, whether for insufficient epistemic explanation or lack of empirical evidence in the traditional sense, according to the patterns of the Royal Society and the Newtonian paradigm (Hull 1973; Ruse 1999). Direct evidence or proof was, in many cases, a problem for Darwin since some of his critics "objected to his evolutionary theory as hypothetical and speculative" (Hull 1973, p.49).

This is not a minor issue, and suffice to remember what Newton has said about it, i.e., "for whatever is not deduced from the phenomena is to be called an hypothesis; and hypothesis, whether metaphysical or physical, whether of occult qualities or mechanical, have no place in experimental philosophy." (Newton 1973[1686], p.547). According to Ruse (1999), William Hopkins, the mathematician and geologist, by reviewing Darwin's methodology in 1860, took the Newtonian astronomy as scientific paradigm of scientific theories. Unsurprisingly, Ruse summarizes Hopkins' review by marking the difference between Newton and Darwin's theories. Ruse says that for Hopkins "the greatness of Newton's theory lies in the exactness with which claims deduced from his premises about physical causes correspond with facts in the world.

But when we come to Darwin's theory, the situation is quite opposite." (Ruse 1999, p.238). According to Hopkins himself, in an article published in *Fraser's Magazine* (June 1860), naturalists in the pursuit of knowledge about nature do not merely assert their *belief* of the causalities motivated by their hypotheses as "capable of producing the phenomena thus referred to them. They *prove*" them (Hopkins apud Hull 1973, p.239).

In this sense, what is scientifically expected, is theory resting on proofs, that is, a "phenomenon is properly said to be *explained*, more or less perfectly, when it can be proved to be the necessary consequent of preceding phenomena" (Hopkins apud Hull 1973, p.267). Under Hopkins view, Darwin did not fulfill this criterion. Hopkins then says, "Mr. Darwin's theory can explain nothing in this sense, because it cannot possibly assign any necessary relation between phenomena and the causes to which it refers them. [...]. But all that is attempted to be done is to *assert*, not to *prove*, that the facts are consistent with the theory" (Hopkins apud Hull 1973, p.267).

Hopkins and Newton's failures to consider that celestial mechanics was not based on direct evidence and neither a necessary causality that proves "a mode of investigation which cannot be wrong" (Hopkins apud Hull 1973, p.239) opened the road for their criticism upon Darwin's theory. However, differently from Newton, Darwin was aware of this epistemological difficulty around direct proof, so he mentioned it in many cases. One specifically is the letter sent to F.J.Pictet (Darwin, April 1 1860). In it, Darwin emphasizes that to expect to see one species changing into another by direct observation is the kind of evidence nobody could see because evolution was a slow process, with a selection of slightly imperceptible variations and the preservation of traits.[7] In other words, certain types of direct evidence were not possible at all for evolutionary theory.

To the scientific community, a basic issue of Darwin's evolutionism was direct evidence, but not only that. The theoretical process of Natural selection was also a problem. For instance, prediction of actions by natural selection upon organisms, as a general scientific value, was also an issue, as were the disputes about the necessary time and conditions for species to evolve or the outcomes of it, i.e., the question of "how nature could operate over vast periods of time" (Richards and Ruse 2016, p.155). For Darwin, it made sense to argue that some of these things could not be asserted by the cognitive powers of humans, for instance, that our "mind cannot possibly grasp the full meaning of the term of even a million years; it cannot add up and perceive the full effects of many slight variations, accumulated during an almost infinite number of generations." (Darwin 2009[1859], p.422).

Therefore, there were no means to predict what kind of variation and transmutation would result from natural selection after one million years. Darwin says that in artificial selection, we breed "only on external and visible characters", and that we do it for our own benefit (Darwin 2009[1859], p.65). However, he says, "the blind foolish man", who performs artificial selection, cannot conceive all the details going on in natural selection (2009[1909], p.6). The meaning of this is that no human can foresee the extension of actions of a superior mind, that is, what only an "all-seeing being in thousands of years could effect" over species transmutation (Darwin 2009[1909], p.6).

Darwin's metaphor about an all-seeing Being gives him support to modeling the notion of imperceptible variations without falling into the contradiction by human limitations seen in artificial selection, while avoiding the problem of lacking of direct proof, which he admittedly did not have.

Moreover, his theory had some problems when confronted with other scientific theories found in physics, embryology, orthogenesis, and paleontology. By the turn of the century, things did not get better for Darwin because geneticists "such as de Vries and Morgan were claiming that mutations were discrete, not gradual" (Hull 1973, p.34), taking a stand against one of the basic theoretical principles in Darwin's theory.[8]

On this account, what are the limits of human minds about a phenomenon happening right now and everywhere, but whose outcomes could not be directly observed and generally take millions of years? According to Delisle (2019), this was an argumentative strategy that Darwin tried to push into the scientific community about the impression of a vertical time, when in fact all he had was the flat timescale, a horizontal time (known as the present).

Since the emergence of slight variations from infinitely complex relations of organic beings and their physical conditions is hardly noticeable by humans, then the division and connection between primary and secondary causes may help us put things in perspective (Darwin 2009[1859], p.428). Thus, secondary causes were proper to scientific interests and the while primary causes were not, although it could still play some part in science, even like a harmless metaphor.

However, a seemingly harmless metaphor helped Darwin to model and illustrates some of the secondary causes by furnishing a familiar structure, as the notion of a powerful Being, and addressing complex questions, such as the way Nature or a Being, with powers of penetration beyond human perception, selects imperceptible variations in species, and preserves them. Richards (2016, p.125) points out, remembering a passage from Darwin's Essays in 1842 and 1844, how a model of a powerful mind tackles questions like these.

In the mentioned essays, Darwin renders a supposition regarding how an organism, on a volcanic island with extraneous conditions and under formation, would be affected by such an environment, and then "from inexplicable influences even special parts and organs of the body", as the reproductive system and the structure of the offspring, would also be affected (Darwin 2009[1909], pp.84–85). By this supposition, we can point to some features of our alternative account of metaphor models such as the intent to gain access to a phenomenon, articulation between two systems, idealization, and simplification of interactions.

However, Darwin pushed forward the example to test the effects of natural selection. He says that on such an island, the organism and the variations are not facing selection (which is something we explained in section 2.1 with the so called neutral model).

Thus, without selection, the variations from the typical form of the organism in slight degrees would occur "in no determinate way, and [...] the free crossing of these variations (together with the tendency to reversion to the original form) would constantly be counteracting this disturbing effect of the extraneous conditions on the reproductive system" (2009[1909], p.85).

This lack of selection, Darwin says (2009[1909]), would not present a crucial result for the sake of evolution and origin of new species because its absence entails a lack of commitments with progression and direction of transmutation, as much as with the preservation of the advantageous traits. Nonetheless, Darwin asks through a metaphor, what happens if we added an *unerring* and *caring* form of selection to this island scenario? To make his point clear, he proposes the following example:

> Let us now suppose a Being with penetration sufficient to perceive differences in the outer and innermost organization quite imperceptible to man, and with forethought extending over future centuries to watch with unerring care and select for any object the offspring of an organism produced under the foregoing circumstances (Darwin 2009[1909], p.85).[9]

Such a powerful and infallible Being would theoretically fulfill gaps and test consequences of Darwin's theory, as inexplicable influences and actions of natural selection imperceptible to humans. Furthermore, since "natural selection works solely by and for the good of each being", then all qualities and abilities inherited "will tend to progress towards perfection" (Darwin 2009[1859], p.428).

This powerful Being wishes to select organisms adapted to new ends based on carefulness and forethoughtfulness. However, not only these qualities would constitute such a Being. Considering the plasticity of the structure of the reproductive system of the organism on which this Being is working, if given sufficient time, this super-agent "might rationally (without some unknown law opposed him) aim at almost any result" (Darwin 2009[1909], p.86). A very illustrative case of such a work of this imaginary Being is giving in the 1844 *Essay* edited by Francis Darwin as *The Foundations of the Origins of Species – Two Essays Written in 1842 and 1844 by Charles Darwin* (2009 [1909]). In it, is said that the struggle could follow the wish of this imaginary Being. In this sympatric model,[10] this Being would give power to a plant to grow on the rotten stems of trees in a forest. In this scenario, this Being who is caring, forethought, selector and rational (respectful of natural laws impressed on nature),

> . . . would commence selecting every seedling whose berries were in the smallest degree more attractive to tree-frequenting birds, so as to cause a proper dissemination of the seeds, and at the same time he would select those plants which had in the slightest degree more and more power of drawing nutriment from rotten wood; and he would destroy all other seedlings with less of this power. He might thus, in the course of century after century, hope to make the plant by degrees grow on rotten wood, even high up on trees, wherever birds dropped the non-digested seeds. He might then, if the organization of the plant was plastic, attempt by continued selection of chance seedlings to make it grow on less and less rotten wood, till it would grow on sound wood. (Darwin 2009[1909], p.86)

From this quote, a powerful Being would favor one plant, which already has slight advantages, over others. The Being would destroy other seedlings, and throughout the centuries push the transmutation of the species through slight degrees of variations. In addition, Francis Darwin, the editor of the book *Essays*, points out in a footnote that this plant illustrates that mistletoe that we illustrated in section 3.1 and which was also introduced in the *Origin* (1859).

It is noticeable how, based on the metaphor of a powerful Selector, Darwin wants to advance a test of his proposal of variation and natural selection through some modeling. Darwin builds a controlled scenario where unfamiliar elements (as Natural Selection and variations) are replaced by more familiar ones (forethought and infallible caring Being) in an articulative, idealized and complexity-reduced approach.

In addition, Darwin proposes a similar case. He asks that we imagine the same situation as the plant in the above quotation, but now one in which the proper dissemination of the seeds, from freely non-impregnation, failed. What could that powerful Being possibly do about it? Darwin answers this in a fashion that gives support for our alternative account of the scientific model from metaphor. He says that to address the problem, the powerful Being

> . . . might begin *selecting* seedlings with a little sweeter (or) differently tasted honey or pollen, *to tempt* insects to visit the flowers regularly: having effected this, he might *wish*, if it profited the plant, to render abortive the stamens and pistils in different flowers, which he could do by continued selection. (Darwin 2009[1909], p.86, italic added).

With this metaphor, Darwin tackles how his proposal of natural selection would act, throughout the centuries, over organisms' variations. By such an elaborated metaphor (which in the *Origin* is repeated although in less detail) a road is opened to other naturalists so that they can test these physiological and behavioural aspects in the real world.

By this second example, Darwin introduced an obstacle to the process he was advocating (Natural Selection). So he builds a scenario of challenges for his theory and tried to show how his theory still offered an answer to them, how it gained access to the phenomenon with respect to the appearance of variation and its preservation. Nonetheless, giving the problem respect the time needed for evolution to happen, and the prediction of natural selection, he had to employ a metaphor, a simplification of the infinite complexities interwoven in natural selection.

After preparing the foundations of his argument using metaphors, Darwin was finally ready to invite the reader to cross the bridge from a metaphor to the real world giving now details of the organisms he had at mind. Darwin says that by such a step, the Being "...might aim at making a plant as wonderfully related to other organic beings as is the mistletoe, whose existence absolutely depends on certain insects for impregnation, certain birds for transportal, and certain trees for growth." (Darwin 2009[1909], p.87).

From this step, Darwin closes the circle of aspects of his model, which started from a harmless metaphor of a powerful Being with some features (careful, forethoughtful, rational, nosing around, old, powerful, etc.) moving towards what is now a concrete case of selection of the fittest in the real world, i.e, the concrete case of struggle for existence involving real birds, insects and plants. Darwin's step led us to a final issue, the scientific model of metaphor and its realistic aspects.

4. Realism and scientific model in Darwin's metaphor of a powerful Being

Despite Darwin's efforts to focus on secondary causes and well-delimited examples and modeling, his peers pressured him to extend his investigation beyond secondary causes and metaphor of powerful Being. Darwin was pressured to build a bridge between something scientifically measurable and empirical with this metaphor of powerful Selector. One example of this type of pressure, from a respectable philosopher, came from Stuart Mill, who on the one hand said that the principle of the survival of the fittest could find rational and empirical evidence in its favor, but only when "the adaptations in Nature afford a large balance of probability of creation by intelligence" (Mill 1969[1874], p.174).

Considering what we have explained about primary and secondary causes, Mill pushes Darwin beyond the line that he wanted to go. Mill's request tacitly assumes an epistemic position that imposes an ontological condition for accepting evolution which, if taken, would undermine Darwin's idea of transmutation and blind natural laws. Maybe we can agree that many of Darwin's argumentation strategies were problematic and even fueled the fire of disputes between teleological and non-teleological evolutionists. Nonetheless, if Darwin assumed the reality of transmutation of species from a global realist view of a divine entity, the consequences of the existence of such an entity would undermine his effort to keep these things separated.

Although Darwin respected Mill, his proposal to mix secondary and primary causes does not seem to be of Darwin's interest, so he says that even if hypothetically getting on board with the idea by which "this universe seems governed by the Creator" (Darwin 2009[1909], p.87), if we want to understand natural selection, then what we should focus on is "whether there exists any secondary means in the economy of nature by which the process of selection could go on adapting, nicely and wonderfully, organisms, if in ever so small a degree plastic, to diverse ends." (Darwin 2009[1909], p.87).

In this account, Darwin poses a hypothetical scenario where he seems to apply his metaphor of a powerful and all-seeing Being under a scientific model and a local realism restricted to realistic, contextual and pinned-down situations. His theory would be as universal and structural of natural phenomena as was Newtonian physics. But Darwin's models based on metaphors do not need to go that far. The metaphor of a parasitic plant, which later on was directly linked to a real specific case of mistletoe, shows how Darwin is less concerned with the primary cause, even if it governs the universe or not, and more concerned with practical examples from which predictions are possible, interactions established, distortions and simplifications performed. This is specially true when modelling a parts of his theory (as isolation and speciation).

According to section two of our paper, Wimsatt (2007) mentioned that generally, scientists are more involved in local realism when they do scientific modeling, and we also mentioned that, according to Cassini and Redmond (2021a), gaining access to the phenomenon is a critical point in modeling.

We argued that the gain of access would at most provide a kind of provisional truth about a specific phenomenon, as Wimsatt (2007) points out with his local realism. Wimsatt says that most scientists use and "defend a more modest (or local) realism" (Wimsatt 2007, p.95). By these terms, he means that on specific grounds, such as when the existence of an entity or property is defended "through a variety of independent means" (building robustness), and consequently, "scientists would argue that an entity or property is real, [in the sense that] they cannot imagine plausible or possible theoretical changes that could undercut this conclusion" (Wimsatt 2007, p.95, brackets added).

We need to be careful here because there are some implicit meanings in this definition such as the view that 'they cannot imagine' other scenarios. This entails something like a paradigm within a scientific community and its difficulties of imagination of alternatives in the face of problems to be managed locally. However, Wimsatt does not mean that scientists are not pluralists in terms of the pursuit of worthy theories.

A decade after Wimsatt's book (2007), it is still claimed that when it comes to debate realism, we should look at the science on the ground (Henderson 2017). More than that, realism should be local, since "a more effective and productive approach for the scientific realist is to 'go local'." (2017, p.151). But what does it mean to be a local realist in science? According to Henderson (2017), to be a local realist means that scientists usually push forward the debate about what is real and what is not real from "particular elements of scientific theories on a case-by-case basis based primarily on the first-order scientific evidence." (2017, p.151). In this account, localism means not only that our interest lies in particular evidence, entities, properties or parts of scientific theories, it also refers to an epistemological strategy whose investigation about something "recommends a 'local strategy' for answering it." (2017, p.154).

In this sense, from Wimsatt and Henderson's views we could be local realist about one aspect, entity or property of Darwin's theory without having to assume others. For instance, we could be realists about evolution by natural selection without assuming a monophyletic hypothesis (one primordial form). Darwin himself said that about natural selection with divergence he advocated for monophyletic view, although "this inference [monophyletic] is chiefly grounded on analogy, and it is immaterial whether or not it be accepted" (Darwin 2009[1859], p.425). Generally, scientific model does not address the whole theory and all principles, entities and problems that exist in it.

This being said, if we combine all three previous aspects of metaphor approach for scientific models, plus Wimsatt's general argument for a local realism as much as how Darwin takes some steps into realism, then we will arrive at the conclusion, turned into a fourth aspect of our alternative account of scientific models of metaphors, which postulates that:

(d) the kind of access to be achieved by a model about a phenomenon (or problem) is the local realist kind of access.

This aspect not only brings metaphor and reality together at some point of the investigation through models, it does that with some modesty in mind about the achievements of the scientific model applied. In this sense, accessibility is constructed on a case-by-case basis. But this does not mean that metaphor model in Darwin must assume the reality of powerful Being. Darwin had other concerns, and local realism complemented his argumentative strategy just fine, making it fit into one specific kind of scientific model, the metaphor approach of model.

5. Final Considerations

The debates surrounding scientific models are wildly divergent and change according to the type of scientific model we are addressing. Moreover, each scientific model concerns a specific issue, object, property, or entity. The relationships between scientific model and theory also differ from author to author, problem to problem, goal to goal.

Amid this wide range of possibilities, we addressed one specific type of model, the metaphor approach, by introducing an alternative account. We also chose to present it throughout constituents features instead of a direct definition.

We argued that although metaphors are largely applied in science, we think that there is a lot of space in the literature to get a contributive proposal of metaphors as scientific models or even how metaphor approach of scientific model is constituted. For this reason, we argued in favour of an alternative account of metaphor as scientific models, and we presented four features to guide its constitution and application.

We argued how these conditions were assessed by Darwin's use of metaphor in his argumentation. Our account also tested why in the mid-1800s, Darwin's metaphor of a powerful Being would pose a question on topics like the separation between revealed religion and natural religion. It appears to us that our proposal was adequate to understand the use of metaphors as scientific models.

We also explained how although our four aspects seem necessary for understanding the metaphor approach of scientific models, they do not seem sufficient for us. Nonetheless, this insufficiency may be a necessary price to pay to avoid a sharp definition of models from a metaphor approach. After all, the more we zoom in on a sharp definition of metaphors as an approach for building scientific model, the more we risk to make it less metaphorical and more literal. By keeping an account of metaphor as a form of scientific model in a more general way, it seems to maintain the advantages of the metaphor approach while avoiding the disadvantages of other forms of scientific model, like computational or phenomenological.

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Notes

[1]It is important to highlight beforehand that this does not mean that Darwin was ultimately an advocate of creationism with the presentation of his evolutionary theory. Darwin's approach of metaphors sometimes uses supernatural words for many reasons, and amidst them, there is his intent to make his own viewpoint clearer to some Victorian scientists, i.e., more digestible to some creationist scientists. In few words, there is link but also a difference between Darwin's evolutionary theory and Darwin's argumentation and use of metaphors of powerful Being.

[2]Generally, the concept of robustness is mostly found in Donald Campbell, with the idea of multiple determinations and invariances, from which Wimsatt describes four procedures of robustness analysis (a-variety of independent derivations; b-to look for things that are invariant or identical in the results of these processes; c-determinations of the conditions and scope of the processes on which their invariance depends; d-analysis and explanations of relevant failures of invariance) (Wimsatt 2007, p.44). An example of this is how a table is detected in a multi-modal sensory way (visually, tactually, aurally, orally) that roughly coincides, through time and across observers, with consistency (Wimsatt 2007, p.60). Thus, he says, in "appealing to the robustness of boundaries as a criterion for objecthood, we are appealing to this multiplicity of properties (different properties detected in different ways) and thus to a time-honored philosophical notion of objecthood." (Wimsatt 2007, p.60).

[3]Carrillo and Knuuttila (2021) wrote a very informative paper about how two opposing views of idealizations permeates many of the debates around the idealization of scientific models. They call these two views the deficiency account of idealizations and the epistemic benefit account of idealizations. Based on these views they argued for a middle ground account of idealization that goes beyond these two views in attending the features of idealization. They call their own view, which is a middle ground, the artifactual account of idealization.

[4]Carrillo and Knuutila (2021, p.57) do not think that we must attach ourselves to the accuracy/distortion debate of a model and they argue that their proposal of artifactual account of models does avoid this mistake. One of the arguments they present to diverge about it and to present the artifactual view is this: "While thus the artifactual approach to idealization

accommodates many important insights of deficiency and epistemic benefit accounts, it does not presume that idealization boils down to deliberately misrepresenting 'what the world is actually like' by introducing distortion to scientific representations through 'known falsehoods' (Levy 2018, p.8). One central problem of the idea of distortion is that it supposes too much to be known. It is as if in modeling scientists were representing systems of which they already had well-articulated and certified knowledge." (Carrillo and Knuutila 2021, p.58). However, as the reader can see in our paper, at least about this specific point, we still adhere to the traditional view of idealizations because in order to support deliberate falsehoods there is not need to assume these two things Carrillo and Knuutila did. First, we do not need to assume the idealizations boils down to deliberate misrepresentation. Second, there is no need to assume that deliberate misrepresentation entails that we already know too much about the system we misrepresent. Scientists apply deliberate misrepresentations for many reasons even without too much knowledge about the system and issues at hand. It can be because it will help the scientists to know better what they believe that is already known. It can be because they want to know what they do not know by testing hypothesis. There are other plausible explanations to make deliberate distortions. For instance, scientists can have both ways, that is, by theorizing that they are right about the system they think they know, a claimed certified knowledge, is not incompatible with attempts to push this knowledge further by introducing misrepresentations, after all, certainty is not longer part of the scientific knowledge. For instance, Keller says that this kind of assumption in the investigation process is common, thus typically, "models work in scientific explanations by choosing elements about which principles governing their behavior are already known" (Keller 2002, p.117). This approach of a phenomenon and use of models can still result in complete review of the certified knowledge, i.e., scientists do apply models upon phenomenon that they think they already know, but this does not imply that what is known is enough or it is not up to review. In scientific research, there are no guarantees or immunity to review.

[5]It is noteworthy to mention that our argument about metaphor approach of scientific model falls upon one part of his theory of evolution, which concerns the mechanism of natural selection (although Darwin himself did not use the word mechanism to refer to natural selection in the *Origin* (1859)). In this account, as well-known as it is, and clearly explained by many authors (Godfrey-Smith 2009; Okasha 2019), Darwin's evolutionary theory has three central claims (Okasha 2019, pp.9–10). Roughly speaking, the first one is that species are not fixed but they change and can adapt their characteristics. The second claim is that their species descended from one common ancestor (monophyletic descending). The third is that natural selection is the main means of evolution of species (Okasha 2019, pp.9–10). Also, natural selection has its own features, which if followed logically as an argument that moves from premises to conclusion, would be enough for evolution to happen. As Godfrey-Smith (2009) reminds us, in the classical sense, the summary of ingredients for evolution by natural selection boils down to three, that is, "variation, heredity, and differences in reproductive output, though sometimes the ingredients are broken down more finely" (Godfrey-Smith 2009, p.19).

[6]We must say that we do not agree that Darwin intentionally wants us to read Natural selection under anthropomorphic terms, and many scholars also think that he should not be read under such terms (Okasha 2019; Ruse 1999). However, we side with Delisle about Darwin's conceptual inheritance, which allows us to say that his use of metaphors causes

him some problems as well, such as a deceived perception of anthropomorphism of Natural Selection.

[7]To ask for direct evidence of natural selection, as Darwin made clear pointing out to Huxley, is like abandoning evolutionism completely. Additionally, as Darwin argued to Pictet, who some years later supported Darwin's natural selection, although direct proof was not possible, there were numerous indirect proofs of evolutionary theory and natural selection (Darwin, April 1 1860; Hull 1973; Ruse 1999). Among the numerous indirect proofs, Darwin (2009[1859]) points to parallels with domestic animals, increasing instances of links in fossil records, arguments, metaphors, actual cases of Darwinian's selection at work (as wingless flies or moths in windy locations), and so on.

[8]It is a basic principle of Darwin's evolutionary theory for the following reasons. First, Darwin's theory coupled with Lyell's geological view of the Earth, based on three principles (Uniformitarianism, Steady-state, Actualism), according to the causes of changes in geological phenomena were the kind operating now, and of the same degree as they are today, and in a perpetual cycle of eruption and decay, which is contrary to what Catastrophists sustained (Ruse 1999, p.40). In addition, after Darwin had abandoned his idea of saltatory evolution in his first notebook, he embraced a gradual evolution through small changes which was related with heredity. To Lewontin, (1985, p.76) there were three wide principles of evolution by natural selection, and the principle of heredity is the second one (the other ones are the principle of variation and the principle of differential fitness).

[9]The editor of the book, Darwin's son, draws our attention to the fact that in the *Origin*, Darwin replaces a selecting Being by the word Nature. For practical purposes about models, it makes no difference here since we are not debating Darwin's literal anthropomorphism but instead his use of metaphors.

[10]According to Delisle (2019), Darwin was at pains to convince his colleagues, like Moritz Wagner, William Hopkins and George Romanes, about the speciation theory presented in chapter 4 of his book. Part of the answer was dependent upon what kind of model he used to explore the intricacies of his theory on how species split. One of the approaches took the so-called allopatric model of speciation, "based on geographic isolation…", whereas sometimes he also took the sympatric model "…based on intense competition in the same place" (Delisle 2019, p.93). It is important to highlight "Darwin's indecisiveness over sympatric or allopatric speciation model" (2019, p.93). So we can find both models in Darwin's book. In the example settled by the quotation, it seems that we are looking at the sympatric model, although in the case of volcanic island previously approached, it looks like we were looking at an allopatric model.

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