A COGNITIVE SEMANTICS APPROACH TO DARWIN'S THEORY OF EVOLUTION

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ANNA DROGOSZ

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Dedicated to my Mother

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INTRODUCTION

For some, Darwin's theory of evolution is the only scientific theory that can explain the history of life, for others, it is a lie from the pit of hell. Few ideas have triggered so many debates and so much contention. The only indisputable thing about evolution is that it has exerted a tremendous influence on Western thought, widely beyond the biological sciences. As Lakoffand Turner observe, the theory of evolution in its folk understanding as a competitive struggle "is everywhere in our culture. It is used metaphorically to justify forms of free-market economics, educational reforms, the basis for legal judgements, and the conduct of international relations" (Lakoff & Turner 1999: 557).

While fully acknowledging the scientific value of the theory of evolution, we want to argue that its structure and logic depend heavily on conceptual metaphors and blends used to frame its major tenets. Moreover, the combination of metaphors and blends into a coherent whole enables them to function as a template for reasoning, not only about the organic world but also about any complex system. Consequently, the objective of this study is, in the first place, to identify the conceptual metaphors manifested in the text of *The Origin*[1] and to determine how they are integrated into the network of ideas known as the evolutionary theory. Another aim of this study concerns the role that specific metaphors play in the theory of evolution: in framing the theory and its expression in language, in reasoning about organic evolution, and even in determining the directions of scientific research. For these reasons, the analysis also covers samples of popular science literature on evolution and discusses the current use of Darwin's original metaphors. We believe that Cognitive Semantics is best suited for this purpose because it offers a systematic and principled methodology for analyzing metaphors. Next, we also hope that the findings about the metaphorical underpinnings of the theory of evolution will make it possible to formulate some generalizations about the functions of metaphors in scientific discourse. It is not the objective of this book to argue for the metaphorical nature of scientific discourse, because this has successfully been done by many philosophers of science and linguists whose work is discussed at length in the next chapter. We do not claim to discover metaphors in Darwin's language either. The first person

[1] Full title: *On the Origin of Species by Means of Natural Selection, or the Preservarion of Favoured Races in the Struggle for Life* by Charles Darwin (1859), henceforth *The Origin*.

to emphasize the presence of metaphors in *The Origin* was Darwin himself, and many of his contemporaries noted this fact as well. However, to the best of our knowledge there has been no systematic analysis of the conceptual metaphors present in the theory of evolution. Next to the study of metaphors and conceptual blends in Darwin's theory and in scientific discourse, we make some observations concerning personification – its definition and identification in discourse – provoked by the conceptualization of natural selection in the theory of evolution. We want to argue that the definition of personification should include a more encompassing characterization of its source domain (PERSON) and that personification should not be confused with agentification, a metaphor we propose to exist alongside personification.

The main body of data for our analysis is the first edition of *The Origin* by Charles Darwin (1859). Although five later editions of *The Origin* were published within Darwin's lifetime, many researchers believe that in the first edition, before he started to modify it in response to criticism, Darwin's ideas are presented in their purest form (see Dawkins [1987] 1996, Quammen 2002, Ruse 2003). On the other hand, some of the alternations Darwin introduced to the text are a valuable source of information on the effect that his metaphors had on his readers, hence reference to later editions is made as well. In this study, the pdf of the original 1859 edition by John Murray available on the Darwin Online webpage was used. Apart from *The Origin*, popular science texts on evolution are analyzed to investigate the developments of Darwin's metaphors. They include papers and books by distinguished evolutionists (*e.g.* Richard Dawkins, Steven Jay Gould), texts on evolutionary theory found on various internet sites, and graphic presentations of the theory.

We believe that the way Darwin's theory is communicated, both in verbal and pictorial form, provides rich and valuable material for research in Cognitive Semantics. Firstly, the data is plentiful, easy to obtain and diverse, including texts of various levels of formality, from scientific papers written by distinguished scholars to popular texts directed at young readers to texts produced by proponents and opponents of the theory. Although this book makes use only of a small sample of the available data, it highlights the possibilities for further studies. Secondly, early texts on evolution written by Charles Darwin provide a well-documented record of his framing of the theory. A researcher can study not only *The Origin*, but also Darwin's notebooks and letters, in which background information on some of the metaphors can be found. In other words, there is a record of the theory's creation and expression. Finally, because of the richness of the data and the historical perspective (over 150 years of evolution-related communication), it is possible to investigate the development of Darwin's original metaphorical framing of the theory. One can study the persistence or modification of metaphors in *The Origin*, their reception, and the use of new visual technologies (*e.g.* computer animation) to communicate them to the general public.

The book has the following structure. Chapter One presents an overview of Cognitive Semantics to provide the methodological background and terminology for the subsequent analysis. The main focus is placed on the assumptions of the Conceptual Metaphor Theory: experientialism, embodiment, image schemas, conceptual metaphor types, challenges to the framework and its developments. The chapter also outlines the main assumptions of the Blending Theory and Talmy's force dynamics.

Selected research on the role of metaphor in science and in biology is presented in Chapter Two. The first part of the chapter outlines the philosophical perspective of the functions of metaphors in formulating and expressing scientific theories and models. The second part of the chapter provides an overview of the existing literature on the role of metaphors in biological sciences and in Darwin' theory. We also provide reasons for the value of a Cognitive Semantics approach to the issue of metaphors in science.

The following three chapters investigate conceptual metaphors and blends in *The Origin*. Chapter Three addresses the concept of evolutionary change, pivotal for the theory of evolution. Metaphors and blends that underlie this concept are identified. These include: the journey metaphor and its connection with the phenomenon of apparent motion, metaphors of time, objectification of change, and the Changing Individual blend. This chapter also discusses such issues as the representation of genetic relationships among organisms as a tree diagram, the image schemas inherent in the Tree of Life, and the connections between Darwin's theory and the Great Chain of Being. Chapter Four analyses the struggle for existence, the most recognized Darwinian concept. In the course of the analysis, the integration network of input spaces, some of them cultural, that yields the concept of struggle for existence is identified. Additionally, three levels of antagonistic relationships in nature assumed by the evolutionary theory are discussed in terms of Talmy's force-dynamic patterns. In Chapter Five, Cognitive Semantics analysis is applied to natural selection, another key concept of evolution. Taking into account the Event-Structure model, the investigation will attempt to explain Darwin's persistence in personifying natural selection in all editions of *The Origin* in spite of criticism and misunderstanding on behalf of his readers. Each of these chapters ends with a discussion on the functions that the identified metaphors and blends have in Darwin's theory.

Contemporary developments and modifications of metaphors introduced by Darwin in *The Origin* are addressed in Chapter Six. Both verbal and graphic developments are considered with a view to capturing the impact that these metaphors have had on reasoning about evolution, to identify some consequences for research in the field of evolutionary biology and the ways in which natural history is presented. The conclusions from this analysis focus mainly on the functions that metaphorical conceptualizations have in the theory of evolution.

Chapter Seven changes the analytical perspective. Instead of focusing on conceptual metaphors and blends in evolutionary discourse, it investigates the possibility of redefining the metaphor of personification. In the chapter, various definitions of personification are presented together with a proposal for a revised definition utilizing human behavioral domains distinguished in cognitive archaeology. A metaphor of agentification, distinct from personification, is also proposed to account for some of the difficulties reported by researchers in identification of personification and to explain some controversies around the reception of Darwin's description of natural selection.

Finally, several clarifications need to be made. This book was written by a cognitive linguist, not an evolutionary biologist or a philosopher of science. Although we hope that biologists and philosophers may find some observations interesting, the methodology and focus of the research remain firmly linguistic. However, at places, it seemed necessary to provide some background concerning Darwin's work. While some evolutionary biologists may find such explanations simplistic or redundant, the explanations are aimed primarily at linguists. The next point of clarification concerns the analysis of *The Origin*. When exposed to numerous passages from Darwin's book illustrating conceptual metaphors, the reader may come to the conclusion that Darwin's language is extremely metaphorical. Hence, it must be stressed that in *The Origin* there are whole chapters presenting empirical data with no metaphors related to evolution. Moreover, when compared to some popular scientists, for example, by Richard Dawkins, Darwin appears to be very parsimonious with his use of metaphors. Thus, we do not want to argue that Darwin's language is metaphorical but that metaphors are important in framing the theory. Thirdly, and most emphatically, we do not want to make any claims about the validity of Darwin's theory. The mere presence of conceptual metaphors says nothing about accuracy of any scientific model. As philosophers of science noticed long ago, and as Cognitive Semantics confirms, all scientific theories are metaphorical in nature, and the evolutionary theory is no different in this respect.

1. Theoretical Background: Cognitive Semantics

1.0. INTRODUCTION

This chapter focuses on the main assumptions and numethodology of Cognitive Semantics and related approaches to language. The first and largest section of this chapter gives an account of the Conceptual Metaphor Theory (CMT). While there is no need to repeat after handbooks on conceptual metaphor, its main tenets and terminology must be presented for readers less familiar with this branch of linguistics. This section also covers the axiological aspects of metaphorization discussed by Krzeszowski (1997) and Szwedek's theory of objectification (e.g. 2000, 2002, 2011a). It ends by addressing criticism directed towards both the methodology and core assumptions of CMT. Sections 1.2. and 1.3. are devoted to theories which either extend and amend CMT (Blending Theory) or, while not part of Cognitive Semantics as such, provide useful tools for the analysis (Force Dynamics). The last part of the chapter briefly outlines the ways in which the methodology of Cognitive Semantics will be applied in the analysis of evolutionary theory.

1.1. THE CONCEPTUAL METAPHOR THEORY

The publication of *Metaphors We Live By* in 1980 by Lakoff and Johnson can be considered a symbolic milestone in metaphor studies. While acknowledging the role of earlier studies (*e.g.* by Richards [1936] 1964 or Black [1955] 1981), it can be safely said that Lakoff and Johnson have put a spotlight on metaphor study for the next few decades, and stimulated interest in metaphorical language in areas of research outside of linguistics. The core understanding, content, and terminology related to conceptual metaphor in this book come from *Metaphors We Live By*, because, although the body of research since the time of its first publication is enormous and the theory of conceptual metaphor has undergone significant modification, the ideas presented there have become well-established and widely used, even by critics.

The status of metaphor in CMT should be considered vis-à-vis the views on the possibility of description of reality through the medium of language and the distinction between the literal and figurative, the issues inevitably connected with science. Ortony (1993: 1–10) discusses two alternative approaches to these issues: constructivism and non-constructivism. The latter assumes that reality can be objectively described through the medium of literal language, that literal and metaphorical language can be precisely differentiated, and that only literal language is to be used in scientific discourse. Metaphor, in that view, is seen as deviant and parasitic upon normal, that is literal, language usage. The former view, on the other hand, assumes that "the objective world is not directly accessible but is constructed on the basis of the constraining influences of human knowledge and language" and cognition itself "is the result of mental construction" (Ortony 1993: 1). It emphasizes creative nature of language, thus undermining any sharp distinction between the metaphorical and literal, and finding for them no cognitive foundations. In this view, metaphor is postulated to play a central role in the way in which we think and talk about the world. CMT subscribes to the constructivist approach and Lakoff and Johnson make it clear right from the start when they say that "metaphor is pervasive in everyday life, not just in language but in thought and action" and that "our ordinary conceptual system, in terms of which we both think and act, is fundamentally metaphorical in nature" (1980: 3).

1.1.1. Embodiment and experientialism

The extensive body of research within the field of Conceptual Metaphor Theory operates on the basis of three fundamental assumptions:

- conceptual metaphors, understood as entrenched conceptual patterns, are ubiquitous in language and thought;
- metaphorical mappings are systematic and embodied;
- metaphorical mappings tend to be asymmetrical.

In the context of the current research on how the theory of evolution is communicated, the most important seems to be the embodiment hypothesis, or the claim that linguistic conceptualizations are grounded in physical, cognitive, social and cultural human experience. Broadly understood, "the embodiment hypothesis is the claim that human physical, cognitive, and social embodiment ground our conceptual and linguistic systems" (Rohrer 2007: 27). Within this definition two broad meanings of e m b o d i m e n t stand out: "embodiment as broadly experiential" and "embodiment as the bodily substrate" (Rohrer 2007: 31).[2]

The experiential sense of embodiment is chronologically the earliest and was brought to linguists' attention by Lakoff and Johnson (1980). While Lakoff and Johnson's main focus was on conceptual metaphors and their ubiquity in language and thought, they also noticed an intriguing directionality in metaphorical projections, a consistent tendency "to structure the less concrete and inherently vaguer concepts (like those for emotions) in terms of more concrete concepts, which are more clearly delineated in our experience" (Lakoff & Johnson 1980: 112). Johnson (1987) pursued the idea further by putting the hypothesis of embodiment in opposition to, what he called, the Objectivist view of meaning and rationality. He also collected converging evidence from various sources in support of embodiment: the role that the human body plays in categorization; the dependence of conceptual networks that provide reference for most human concepts on cultural experience, making them neither universal nor objective; the significance of metaphor in human understanding; the importance of metaphor and metonymy, grounded in human experience, in polysemic extensions and historical semantic change; the existence of non-Western conceptual systems manifested in non-Western languages; the contextual dependence of knowledge and rationality. He concluded that "any adequate account of meaning and rationality must give a central place to embodied and imaginative structures of understanding by which we grasp our world" (Johnson 1987: xi–xiii).

The idea of challenging the traditional, Objectivist, conception of thought and reason as the manipulation of symbols that correspond to an objective reality independent of the reasoning organism was further explored by Lakoff (1987). Widening the scope of the embodiment hypothesis, he proposed experientialism or experiential realism, as a philosophical and methodological perspective on thought and reason:

> On the experientialist view, reason is made possible by the body – that includes abstract and creative reason, as well as reasoning about concrete things. Human reason is not an instantiation of transcendental reason; it grows out of the nature of the organism and all that contributes to its individual and collective experience: its genetic inheritance, the nature of the environment it lives in, the way it functions in that environment, the nature of its social functioning, and the like. (Lakoff 1987: xv)

[2] For an extended list of senses of the term "embodiment" and their discussion see Rohrer (2007).

The other major meaning of embodiment mentioned by Rohrer (2007) relates to the physiological and neurophysiological substrate and is realized, among others, by studies investigating the neural structures and regions of the brain involved in metaphorical projection and image schema integration, as well as research in cognitive robotics. While we acknowledge the importance of this direction of research, it is not the concern of this study, and whenever the term embodiment is used in this book, it is in the experiential sense. We also follow Johnson (1987) in his understanding of the term experience:

> "Experience" is to be understood in a very rich, broad sense as including basic perceptual, motor-program, emotional, historical, social, and linguistic dimensions. [...] [E]xperience involves everything that makes us human – our bodily, social, linguistic, and intellectual being combined in complex interactions that make up our understanding of our world. (Johnson 1987: xvi)

Consequently, both embodiment and experience are given very wide scope in CMT, not limited in any way to biological endowment.

Let us stop for a while to look at embodiment from a wider perspective of the mind and body dualism. The dichotomy between the mind and body is part of a series of dichotomies identifiable in the Western philosophical tradition. They include the opposition between our conceptual and perceptual, formal and material, rational and emotional side. As Johnson puts it, the consequence of these systematic dichotomies is that

> all meaning, logical connection, conceptualization, and reasoning are aligned with the mental or rational dimension, while perception, imagination, and feeling are aligned with the bodily dimension. As a result, both nonpropositional and figuratively elaborated structures of experience are regarded as having no place in meaning and the drawing of rational inferences. (1987: xxv)

The mind-body dualism, present in the Ancient and Christian traditions, became an important part of Cartesian philosophical system. Descartes argued that "the world consists of physical substances (bodies) and mental substances (minds)" and that rationality is essentially disembodied, as "the body does not play a crucial role in human reasoning" (in Johnson 1987: xxvi). Such views gave rise to two kinds of problem, one ontological, the other epistemological. The ontological problem pertains to the question of how to bridge the gap between mind and body, reason and sensation, if they are taken to be separate. The epistemological problem concerns the source of certain

2. Metaphors in Science and Biology

> Hypotheses and theories used in science are metaphorical in nature. (Brown 2003: 180)
> Anyone who wants to make sense of the shape of scientific explanation must understand the powerful grip that certain metaphors have on our thinking. (Lewontin 1982: 151 in Bradie 1999: 163)
> No scientific characterization can ever hope to be free of metaphors. (Bradie 1999: 165)

2.0. INTRODUCTION

The quotations above introduce the topic of this chapter, which is metaphor in scientific discourse. There is no need to prove the importance of metaphor in science. Other scholars have done more than enough in that respect providing us with a vast body of converging evidence coming both from philosophers of science (*e.g.* Thomas Kuhn, Mary Hesse) and practicing scientists (*e.g.* Theodore L. Brown). In that respect, our study only reconfirms their findings. This chapter, however, is intended to give credit to some scholars who very clearly declared the indispensability of metaphor in scientific reasoning well before the advent of Cognitive Semantics.

The chapter is divided into two parts. The first part approaches the issue of the role of metaphor in scientific theory with the objective of putting the topic of metaphors in evolutionism in the broader context of the philosophy of science. The other part provides an overview of research on the role of metaphor in biology and evolutionism.

2.1. METAPHOR AND PHILOSOPHY OF SCIENCE

How we see the role of metaphor in science depends not only on our understanding of metaphor but also on our understanding of science. More specifically, the degree of significance that we are ready and willing to ascribe to metaphor in science depends largely on whether we take a Popperian objectivist view or Kuhnian subjectivist view on science. In what follows, these views are briefly outlined on the basis of the account by Michael Ruse, a recognized philosopher of science.

According to Ruse (1999: 15–36), Popper held to a correspondence theory of truth, that is the idea that truth consists in getting ideas to match reality exactly. As a determined realist, Popper assumed the existence of the world independent of people, and believed the aim of science was to map this reality. This was to be done by postulating theories that would attempt to map the regularities that govern the world through general claims, *i.e.* hypotheses, which would be tested by empirical evidence. Consequently, the scientific process operates through proposing and testing explanations for problems that appear in gathered empirical data. Popper applied the evolutionary perspective by assuming that ideas and theories compete with one another and that the best ones survive, at least until another problem demanding an explanation appears. At the same time, he emphasized that positive or successful tests of a hypothesis can never be final, but such falsifiability is the mark of genuine science. In Popper's view, science is a cumulative process, exercised through constant testing, which yields objective "knowledge without a knower" (Popper 1972: 109), independent of the individual scientists who produce it, their cultural background, sex, religion or any subjective believes. This perspective cannot ascribe a significant role to metaphors in scientific reasoning, even if they are recognized as part of scientific discourse serving rhetorical or explanatory purposes.

Kuhn's perspective on the nature of science gives an alternative status to scientific metaphor. His key concept is that of a paradigm: "a work or body of work which captures the scientific imagination – which commands allegiance from a group of workers and provides tasks for them to undertake" (in Ruse 1999: 19). In Kuhn's own words: "By choosing it [a paradigm], I mean to suggest that some accepted examples of actual scientific practice – examples which include law, theory, application, and instrumentation together – provide models from which spring particular coherent traditions of scientific research" (Kuhn 1962: 10). It is the paradigm that gives rise to "normal science," as Kuhns calls it, and which sets rules, challenges and limits. The limiting role of the paradigm is particularly important:

> Closely examined, whether historically or in the contemporary laboratory, that enterprise seems to attempt to force nature into the preformed and relatively inflexible box that the paradigm supplies. No part of the aim of normal science is to call forth new sorts of phenomena; indeed, those that will not fit the box are often not seen at all. Nor do scientists normally aim to invent new

> theories, and they are often intolerant of those invented by others. (Kuhn 1962: 24)

Unlike Popper, who assumes cumulative change in science through constant testing and modification, Kuhn sees change through scientific revolutions: when an existing paradigm cannot deal with the anomalies it encounters, a new paradigm is put forward. This new paradigm

> solves or avoids the difficulties of the old paradigm, at the same time that it offers the prospect of much new work in its own right. The community's allegiance switches to this newcomer, and in just a short while normal science resumes again. (Ruse 1999: 20–21)

Like Popper, Kuhn makes an analogy between change in scientific theories and the theory of organic evolution but drew different conclusions. For him, change in science leads to more complex and sophisticated paradigms rather than a more accurate or faithful picture of objective reality.

These revolutions reveal the most controversial aspects of Kuhn's theory of science. Since paradigms structure observations, they define reality as described by science. Thus, revolutions are much more than reinterpretations of data, which themselves are not stable, but theory-laden.

> Paradigm changes do cause scientists to see the world of their research-engagement differently. In so far as their only recourse to that world is through what they see and do, we may want to say that after a revolution scientists are responding to a different world. (Kuhn 1962: 111)

One logical consequence of this view of science is that paradigms are incommensurable. Not only do theories have their own specialist vocabulary, but there is also "no neutral language into which both theories as well as the relevant data may be translated for purposes of comparison" (Kuhn 1993: 540), which precludes any reasonable argumentation across these paradigms. Another consequence is that one cannot distinguish the person from science: the context of a discovery and the scholar behind it become relevant for the development of the paradigm. Kuhn's perspective makes Popper's "knowledge without the knower" impossible. One more consequence is the special place that Kuhn's view on science reserves for metaphor. Metaphors are part of a paradigm, its structuring of reality, and they change together with theories they serve:

> Metaphor plays an essential role in establishing links between scientific language and the world. Those links are not, however, given once and for all.

> Theory change, in particular, is accompanied by change in some of the relevant metaphors and in the corresponding parts of the network of similarities through which terms attach to nature. (Kuhn 1993: 539)

2.2. MODELS AND METAPHORS

Considerations regarding the role metaphor in scientific theories are inextricably connected with the role of models in science. The topic itself is vast and difficult, far beyond the scope of this study and the author's expertise, therefore, we limit our attention to what Max Black wrote on the issue in his *Models and Metaphors: Studies in Language and Philosophy,* published in 1962, with a special focus on the chapter "Models and archetypes."

Black begins by juxtaposing theoretical models, which are the focus of his attention, with scale, analogue and mathematical models. Unlike scale and analogue models, which

> must be actually put together [...], theoretical models [...] are not literally constructed: the heart of the method consists in *talking* in a certain way. [...] The theoretical model need not be built; it is enough that it be *described*. (Black 1962: 229, italics in original)

This linguistic aspect of a model becomes crucial when Black turns to the model/metaphor relation.

Black (1962) distinguishes fictitious and existential interpretation of theoretical models. The former is a case of *as if* thinking (*e.g.* thinking about the electrical field *as if* it were filled with a material medium), an approach that uses a detached comparison reminiscent of simile and argument from analogy. Following Maxwell (1890), Black sees such models as heuristic fictions devoid of explanatory power. The existential use of theoretical models, on the other hand, is a case of *as being* mode of thinking (*e.g.* thinking of the electrical field *as being* such a material medium) that requires an identification typical of metaphor. It is this use that Black finds most interesting:

> The existential use of models seems to me characteristic of the practice of the great theorists in physics. Whether we consider Kelvin's "rude mechanical models," Rutherford's solar system, or Bohr's model of the atom, we can hardly avoid concluding that these physicists conceived themselves to be describing the atom *as it is,* and not merely offering mathematical formulas in fancy dress. In using theoretical models, they were not comparing two

> domains from a position neutral to both. They used language appropriate to the model in thinking about the domain of application: they worked not *by* analogy, but *through* and by means of an underlying analogy. Their models were conceived to be more than expository or heuristic devices. (Black 1962: 228–229, italics in original)

To demonstrate the significance of theoretical models in scientific reasoning, Black provides an example of using a model coming from the theory of electrical networks to find solutions to problems in geometry and concludes: "I have been arguing that models are sometimes not epiphenomena of research, but play a distinctive and irreplaceable part in scientific investigation: models are not disreputable understudies for mathematical formulas" (Black 1962: 236).

Having asserted the importance of models in scientific methodology, Black moves to show the similarities between models and metaphorical thinking:

> Metaphorical thought is a distinctive mode of achieving insight, not to be construed as an ornamental substitute for plain thought.
> Much the same can be said about the role of models in scientific research. If the model were invoked *after* the work of abstract formulation had already been accomplished, it would be at best a convenience of exposition. But the memorable models of science are "speculative instruments," to borrow I. A. Richards' happy title. They, too, bring about a wedding of disparate subjects, by a distinctive operation of transfer of the *implications* of relatively well-organized cognitive fields. And as with other weddings, their outcomes are unpredictable. Use of a particular model may amount to nothing more than a strained and artificial description of a domain sufficiently known otherwise. But it may also help us to notice what otherwise would be overlooked, to shift the relative emphasis attached to details – in short, to *see new connections*. (Black 1962: 237, italics in original)

In the end, Black proposes a new term, a conceptual archetype, in place of metaphor, to mean "a systematic repertoire of ideas by means of which a given thinker describes, by analogical extension, some domain to which those ideas do not immediately and literally apply" (1962: 241). As an example, he provides the writing of Kurt Lewin, who describes psychological facts through a vocabulary indigenous to physical theory using words such as "field," "vector," "phase-space," "tension," "force," "boundary," and "fluidity," and notices that Lewin's followers were stimulated by this archetype to further empirical investigations. Black also predicts that archetypes that are fruitful enough will be represented in mathematical formulas: "Perhaps every science must start with metaphor and end with algebra; and perhaps without the metaphor there would never have been any algebra" (Black 1962: 242).

To summarize, Black makes a convincing case for the importance of models and metaphors in scientific theorizing. For Black, theoretical models are not disposable "crutches" that help in scientific reasoning, neither are metaphors merely ornamental devices. Both metaphors and models involve a transfer of vocabulary, facilitate scientific insight and reveal new relationships. To avoid confusion with metaphors, he proposes the notion of a conceptual archetype, which appears to be very similar to the notion of conceptual metaphor, the difference being the limitation of the former to scientific reasoning and language. However, while Black asserts the science-constructing power of models/metaphors/conceptual archetypes, he is well aware of a risk of using them metaphysically or even as self-deceiving myths.

Another philosopher of science who also argued for the importance of metaphor in science, especially in scientific explanation, is Mary Hesse. She opens her book *Models and Analogies in Science* with a rhetorical question relating the nature of scientific explanation:

> If a scientific theory is to give an "explanation" of experimental data, is it necessary for the theory to be understood in terms of some model or some analogy with events or objects already familiar? Does "explanation" imply *an account of the new and unfamiliar in terms of the familiar and intelligible* or does it involve only a correlation of data according to some other criteria, such as mathematical economy or elegance? (Hesse [1963] 1970: 1, emphasis – A.D.)

The italicized passage bears a striking resemblance to the definition of conceptual metaphor used in Cognitive Semantics, even though it was originally published in 1963, predating Lakoff and Johnson's proposals by almost two decades.[5] Later on, relying on Black's interaction view of metaphor, Hesse postulates to modify the model of scientific explanation so as to incorporate the significant role of metaphor: "The thesis of this paper is that the deductive model of scientific explanation should be modified and supplemented by a view of theoretical explanation as metaphoric redescription of the domain of the explanandum" (Hesse [1963] 1970: 157). Finally, in her 1996 paper, Hesse arrives at her conclusion regarding the logical priority of metaphor in scientific explanation:

[5] A similar expression can also be found in Abrams (1953), quoted by Black (1962: 240).

> In this paper I shall argue not just that metaphor is as apt as literal language to convey knowledge, but more radically, that metaphor properly understood has logical priority over the literal, and hence that natural language is fundamentally metaphorical, with the "literal" occurring as a kind of limiting case. (Hesse 1996: 352)

2.3. FUNCTIONS OF METAPHORS IN SCIENCE

Recognition of the importance of metaphor in science is inevitably connected with distinguishing the specific functions that metaphor can play in theory inception and articulation. The first distinction to be discussed here is between similarity-creating and similarity-based metaphors and their respective roles. According to Fojt, at the core of scientific discovery are "analogies [that] are created in the process of metaphorization rather than found beforehand and subsequently put into use in metaphor invention" (2009: 161), in other words, similarity-creating metaphors. The meaningful analogies involve a certain degree of alteration of the meanings of the concepts entering the metaphorical relationship, and "the outcome is a new, metaphorical understanding which is based on analogies that did not exist prior to the ontological redefinition" (2009: 161). Fojt accounts reports of scientists (*e.g.* Poincaré, Zeman and others discussed by Wolpert 1992), who recall a sudden realization of a novel way to approach a problem that they had been engaged in for some time, similar to a sudden realization of some previously unknown or unrecognized fact, and the feeling of revelation accompanying this experience which marked the outset of theory articulation. Interestingly, Charles Darwin admitted exactly the same experience. He openly and frequently wrote that his theory had become complete, and that he had found the mechanism by which new species may appear, as a result of reading about the struggle for existence in *An Essay on the Principle of Population* by Thomas Malthus (more on the metaphor of struggle in Darwin's theory in Chapter Four). In view of the above, the primary function of similarity-creating metaphor is to grant "cognitive access to phenomena otherwise unavailable to analysis" (Fojt 2009: 161) and thus to contribute to creativity and new knowledge production.

Similarity-based metaphors, motivated by pre-existing similarities, also contribute to the process of theory articulation. The functions mentioned below in reference to similarity-based metaphors, can also be performed by similarity-creating metaphors, though the reverse does not hold. In the first place, similarity-based metaphors "facilitate cognitive access through structuring the less familiar in terms of the more familiar, effectively reducing the conceptual effort in terms of the expenditure of cognitive processing" (Fojt 2009: 170). As an example, Fojt provides the representation of biological speciation as a tree, with the isomorphism between bifurcation of branches and the emergence of new species. Such a Tree of Life, already well established in the theory of evolution, makes it possible to capture the highly complex process of speciation through the simple and familiar concept of a tree branching. Secondly, similarity-based metaphors "guide or channel reasoning through emphasis distribution" (Fojt 2009: 170). Those aspects of a researched domain that are highlighted by metaphor become the focus of subsequent investigation. In this way, a metaphor may organize a research agenda.

The best recognized and, at the same time, the least controversial function of similarity-based metaphor discussed in the philosophy of science is "to introduce theoretical terminology where none previously existed" (Boyd 1993: 482), that is the catachretic function. "It has been taken for granted that the essence of a theoretical explanation is the introduction into the explanans of a new vocabulary or even of a new language" (Hesse [1963] 1970: 171) and metaphorical extension provides such vocabulary. As Boyd (1993: 483) puts it:

> I shall argue that the use of metaphor is one of many devices available to the scientific community to accomplish the task of *accommodation of language to the causal structure of the world*. By this I mean the task of introducing terminology, and modifying usage of existing terminology. (emphasis in original)

The following analogical statement is made by Soskice and Harré (1996: 304):

> It is the role of catachresis which is, in an indirect way, the reason why metaphor is so very useful in scientific theory making, for [...] it is not the model in itself as heuristic device that makes models indispensable in creative theory-making, but the fact that model gives rise, "spins off" a matrix of terminology which can be used by the theorist as a probative tool.

Boyd (1993) also introduces a distinction between theory-constitutive and exegetical (pedagogical) metaphors, and this distinction is of great significance for our further analysis. Exegetical, or pedagogical, metaphors "do not convey theoretical insights not otherwise expressible" but they "play a role in the teaching or explication of theories which already admit of entirely adequate non-metaphorical (or, at any rate, less metaphorical) formulations" (Boyd 1993: 485–486). In other words, as they only help articulate or explain ideas that can be expressed in metaphor-neutral terms, such metaphorical expressions can be removed from a theory through a literal paraphrase without affecting theory's logic or coherence. Theory-constitutive metaphors, on the other hand, relate to situations,

> in which metaphorical expressions constitute, at least for a time, an irreplaceable part of the linguistic machinery of a scientific theory: cases in which there are metaphors which scientists use in expressing theoretical claims for which no adequate literal paraphrase is known. Such metaphors are constitutive of the theories they express. (Boyd 1993: 486)

Boyd seems to place great emphasis on the potential paraphrase as a distinguishing factor between the two uses. An analogical observation is made by Knudsen:

> Paraphrase is the central tool in determining whether or not a given metaphor is absolutely necessary and indispensable in theory-construction. [...] A theory-constructive metaphor cannot be paraphrased without loss of information, because it is "catachretic," in the sense that it fills a lacuna, not only in the discipline's scientific vocabulary, but in its mental modal as well. A truly theory-constructive scientific metaphor is unique, whereas pedagogical metaphors can always be replaced by alternative or more original expressions. (2003: 1249–1250)

The functions of metaphor discussed above focus on the role of metaphor in scientific reasoning, theory inception and framing, and its articulation in language. All of the scholars whose views are discussed above, most of whom are professional philosophers, specifically emphasize that metaphor is not merely an ornamental device. This bias is fully justified given the centuries-long tradition of seeing metaphor primarily as an ornament; however, the rhetorical and aesthetic function of metaphor in scientific discourse should not be completely ignored. Most scientific texts are argumentative in nature, and metaphor can be a very powerful tool of persuasion. It also makes reading more interesting and pleasing, and that effect is desirable not only in popular science (see Gajda 2008, Zawisławska 2011). What is more, the current research indicates that a metaphor can serve several functions in one theory and its success to constitute a theory may be related to its rhetorical impact (more on this topic in Chapter Four where it is argued that the rich elaboration of the struggle metaphor in evolutionism is due not only to its constitutive function but also to the fact that it makes it possible to describe vague and static relationships in nature in a dynamic way).

2.4. CONSEQUENCES OF METAPHOR IN SCIENCE

Many scholars emphasize the positive role of metaphor in science in both sustaining scientific fertility and creativity and acting as a trigger to extend knowledge into the unknown (see Kuhn 1962, Hesse [1963] 1970, McCormack 1985, Ruse 1999, Brown 2003, Ruse 2005, Fojt 2009). On the other hand, they also point to some consequences resulting from using metaphors. One metaphor-related problem, especially acute in the case of Boyd's theory-constitutive metaphors, stems from the partial nature of metaphorical mappings (see Lakoff & Johnson 1999: 52–55, Tabakowska 2008, Zawisławska 2011: 107). Metaphor, by its very nature, highlights only some correspondences between the source domain and the domain of observation, making only part of the target "visible" and thus biasing the interpretation of data. Such distortion consequently affects research procedures preferred by a given theory because its research agenda is directed at supporting those aspects of the target that are highlighted. In Kuhnian terms, it could be said that a constitutive metaphor first helps to build a scientific paradigm and later to perpetuate it through supporting related research as well as providing specific language for describing it. At the same time, it impregnates the paradigm against data and interpretations not captured by its constitutive metaphor or proposed by other paradigms, thus leading to paradigm incommensurability. As Fojt (2009: 162) explains:

> While a given metaphor "unlocks" certain conceptualizations and invites the exploration of metaphor-generated inference, at the same time it precludes scientists from considering those aspects of the phenomena examined which cannot be accommodated within the metaphoric conceptualization. Metaphor can be said to exert an insulative or limiting force on conceptualization by generating specific inference-patterns while precluding other possible inferences that do not cohere with the metaphor.

As an illustration of simplification, Fojt (2009: 164) provides an example of a tree-of-life diagram used in evolutionary biology as a conceptualization of biological speciation in which new branches correspond to the appearance of new species. Thus, a two-dimensional picture with simple lines represents millions of years of modifications in millions of individual organisms. The metaphor of struggle is another example of the distorting effect of metaphor: it highlights competition and is blind to other forms of organic coexistence that do not correspond to antagonistic social behavior. Analogically, the metaphor of journey puts excessive emphasis on the role of intermediate forms between species. All these metaphors and their consequences for the theory of evolution are analyzed extensively further in the book.

Another negative consequence of scientific metaphors pointed out by Zawisławska (2011: 108) concerns the communication of an established theory and the catachretic function of metaphor. Metaphorical expressions introduced into a theory because of semantic gaps, because of their explicatory potential, or even because of their aesthetic appeal, in time become established specialist terminology. However, the original metaphor may be forgotten and the metaphorical model taken for a reality. Again, the theory of evolution provides us with an example: the description of evolutionary change as motion in space, initially fully metaphorical, has in time become the only available way to talk about the process of evolution and has been made "real" by numerous graphic depictions.

The example of the journey metaphor takes us to the last drawback of metaphor in science that merits attention. It derives, on the one hand, from the model-building role of metaphor and, on the other hand, from the obvious asymmetry between the source domain, of which we have extensive experiential knowledge, and the target domain, of which we may have very limited experiential knowledge. While some authors take it for granted that inferences resulting from metaphorical mappings are constrained by "the limiting power of the structure of the target concept network" (Fojt 2009: 161), we believe that this only works for those domains of observation for which there is some empirical knowledge to be accessed. However, in the case of more abstract theoretical constructs, like, for example, the concept of natural selection, there is very little empirical data or experiential knowledge to constrain the scope of metaphorical projections and inferences. As we are going to see in Chapter Five, depicting natural selection as an agent responsible for evolutionary change is part of the model developed by Darwin, but the degree of personification revealed in projections from the source domain person depends on the recipient's activity.