Metaphors: Midwives of conceptual change in science

Li Xingming

Abstract

The American philosopher of science Kuhn, in the 1980s, studied the scientific revolution in depth from a unique perspective of the philosophy of language, seeing it as a change in the language of science, especially in scientific vocabularies or dictionaries. In this process of transformation, metaphors, analogies, and models play the role of midwives in the birth of new concepts. Based on the analysis of Kuhn's relevant insights, this paper identifies the nature and use of metaphor, analogy and model as well as the similarities and differences among them, arguing that analogy and model are special cases of metaphor and can be fully encompassed within the category of metaphor. Finally, the ontological, epistemological, methodological, linguistic, and linguistic philosophical perspectives are explored as to why metaphor is indispensable in scientific cognition and scientific revolution.

Key words

metaphor; analogy and model; Kuhn; scientific cognition and scientific revolution; philosophy of language

DOI: 10.47297/wspctWSP2515-470202.2018XX02

The American philosopher of science Thomas Kuhn (on, 1922-1996) proposed in his classic work on the philosophy of science, The Structure of Scientific Revolutions[1], published in 1962, that a scientific revolution is a paradigm shift in the scientific community, and that the old paradigm is incommensurable[1] with the new. Later, especially since the 1980s, Kuhn published several important papers, especially in a set of three Hillman

Memorial Lectures "The Science of Facing the Past"[2], where his views changed to some extent, at least in form[3]. At this point, Kuhn no longer sees the scientific revolution as a paradigm shift, but as a change in the language of science or a change in the way words are attached to nature[4]. In other words, he no longer uses the term "paradigm" and replaces it with "vocabulary" or "lexicon", and "incommensurability" is replaced by "intranslatable" and "truth-preserving translation". The "scientific community" then became a "speech community" with a homology of lexical structure In Kuhn's view, the basic concepts of scientific theory and the fundamental principles that comprise the basic relationships of the basic concepts are the essential building blocks of the paradigm and the nodes of the web of language in the scientific vocabulary or lexicon. In the period of conventional science, scientists were engaged in puzzle-solving or problem-solving activities within the framework of these concepts; in the period of scientific revolutions, old scientific concepts were in crisis and scientists had to invent new concepts to replace them. Thus, I have maintained for many years that the essence of scientific revolutions is a drastic and fundamental transformation of the basic concepts and principles of science.[1] But how do new scientific concepts emerge from the "ruins" of old concepts in scientific cognition and especially in scientific revolutions? In this regard, Kuhn makes clear that metaphors, analogies, and models are the midwives of the birth of new concepts and are powerful tools to guide scientific inquiry.

1. Insightful explanations from Kuhn

In The Structure of Scientific Revolutions, Kuhn hits the nail on the head when he argues that crises break down stereotypical frameworks and provide the accumulated information necessary for a fundamental shift to a new paradigm, and that the shift to a new paradigm is a scientific revolution. Sometimes, the form of the new paradigm is already foreshadowed in the structure that unconventional research imparts to the anomalous. More often, such structures are not consciously seen in advance. Instead, the new paradigm, or a sufficient hint to allow for later interpretation, emerges all at once, sometimes in the middle of the night, sometimes in the mind of a person deeply

troubled by a crisis. What is the nature of this final stage, and how does one invent (or find that he has already invented) a new way of organizing the now all-accumulated material? It must remain a mystery for the moment, and perhaps forever. But in his postscript to the book, written seven years later in 1969, he touched for perhaps the first time on the value of metaphors and the like in solving this "enigma":

Although the types of models vary from heuristic to ontological, they all have similar functions. For example, they provide the research community with favoured or permissible analogies and metaphor, thus helping to determine what can be accepted as an explanation and an answer to a puzzle; in turn, they help to determine the list of unresolved problems and to assess the importance of each of them[1].

In the 1980s, Kuhn systematically improved and refined his view of scientific revolution from the perspective of the philosophy of language, and at the same time, metaphor frequently entered his vision. What did Kuhn say about metaphors and the like? In his Hillman Memorial Lecture and other articles, he gleefully analysed three of his beloved cases. One is the change from Aristotelian mechanics' notion of "motion" meaning general change to Galileo-Newtonian mechanics referring only to the motion of objects changing position, which reverses the ontological hierarchy of matter and quality or property, and the asymmetry of qualitative change. The second is the model of the zinc and silver plates from Volt to the invention of the Leiden bottle and the establishment of the modern theory of electricity (from the contact theory to the chemical theory of the battery). The third is the concept of quanta and oscillators finally reached by Planck, inspired by Boltzmann's concept of primitives and resonators. All three cases imply a fundamental change in the analogies and models evoked by metaphor, that is, a change in the taxonomic categories characterizing certain similarity/difference relations, i. e., the similarity/difference relations, resulting in a change in the way words attach to or cut through nature. The change in the way words is attached to or cut through nature. Kuhn thus outlines some insights, the following of which are worthy of our attention:

1) Reflecting the subjectivity, ambiguity, and multiple ambiguities of words, does metaphor, which is so useful in the humanities, still play a marvellous role in the natural sciences, which are distinguished by objectivity, logic, and precision? To this, Kuhn's answer is yes. He said:

Students of literature have long taken for granted that metaphor, and the method that comes with it (which alters the interrelationship of words), provides a portal to new worlds and makes such practices untranslatable. Political life and, in the eyes of some, the entire field of the humanities, were also widely given this character. However, the natural sciences, which deal objectively with the real world, are generally considered unaffected. Scientific truths (and fallacies) are considered to be beyond the ravages of temporary, cultural, and linguistic change. I would caution that the natural sciences cannot do this. Neither the descriptive nor the theoretical language of the natural sciences can provide the building blocks for such transcendence.

2) Vocabularies can be acquired with the help of metaphors, and perception of the world and acquisition of vocabulary are simultaneous. Kuhn shows that if one has access to a glossary or a dictionary, one also has a highly refined tool best suited to describe the world. More specifically, if one can resort more or less to metaphors, what one gets is a taxonomy with names of things, activities and states that must be described, and names that facilitate the identification and description of their characteristics. And, if

carefully identified, for the process of fixing names to the things they name in order to obtain a vocabulary, two different kinds of names must also be connected! One is the name about the thing and the other is the name that describes the most salient feature of the thing. Description cannot begin until this learning process has reached a certain point. But by that time, people have learned much more than just the description again they have also learned a lot about the world to which this language also applies. To gain new knowledge, one has to pay the price of changing the language of description. The development of science ultimately depends not only on what people say about the world on a rotating basis, but also on what words people say on a rotating basis. The evolution of language, including the evolution of basic descriptive language, is also an aspect of science, as is the evolution of laws and theories.

3) The radical change of model, metaphor or analogy is one of the three features of the scientific revolution (the other two are: the revolutionary change is more or less holistic, with the lexical network leading to a homologous structure that mirrors the same world, and thus to the emergence of very different worlds; the revolutionary change is a change of meaning, or more explicitly, a change in the way in which words attach to nature, i.e., according to the change

in the way the objects of the words are determined, thus massively changing the situation of the objects to which these words are attached) one of the three features that are the most difficult to figure out, but the most conspicuous and probably the most significant. For analogy, it is the change in this one direction: what is similar to what and what is different from what. It is this pattern of similarity that makes some phenomena belong to the same natural family, thus attaching them all to nature by placing them in the same taxonomic category. Thus: The juxtaposition of classes of metaphors, which changes from time to time with the scientific revolution, is fundamental to the process of acquiring the language of science and other languages. Only after this process of acquisition or learning has reached a certain level can scientific practice begin. Scientific practice always involves the production and description of generalizations about the natural world; these activities presuppose a language with a minimum abundance; the process of acquiring such a language also brings with it natural knowledge.

4) Not only did metaphors play a pivotal role in the scientific revolution, but the same phylogenetic process of science had to be repeated when young members of the linguistic community underwent conventional training (the biological equivalent of individual development) during the conventional scientific period:

To introduce a new term into the scientific vocabulary, something metaphorical often has to be invited out. And in introducing this term, now established in the general usage of a profession, to generations of newcomers to science who have learned this usage, it is still necessary to invite it out again.

It is on the basis of the above that Kuhn is justified in seeing the development of science as a "metaphor-like process", a process that is accompanied by metaphors from the beginning to the end, a process that intermittently shifts analogies and models and adjusts patterns of similarity. Whatever the level of development of natural science, it can only face a linguistic world based on metaphors[2]

2. Metaphors, analogies and models

Kuhn sees metaphors, analogies, and models as midwives of conceptual change in scientific cognition, especially in scientific revolutions, and he sometimes refers to them in parallel, sometimes in a mixed way. He does not specifically explore the three per se, nor does he write about their similarities and differences. In this subsection, we intend to remedy this omission in a cursory manner.

According to Merriam-Webster's 9th edition explanation, the word metaphor, written as metaphore in medieval French, comes from the Latin word metaphora, which comes from the same Greek word that originally meant transformation, change. The English word metaphor appeared in 1533 and means a figure of speech in which a word or phrase that literally refers to one type of object or idea is used in place of another, thus suggesting a similarity or analogy between them. The German philosopher Cassir saw metaphor as "a way of representing one idea in a roundabout way to another", and he defined metaphor in the following way:

The name of the content of the other thought is consciously used to refer to the content of the other thought, provided that the content of the other thought is in some way similar to the content of the other thought, or more or less similar to it. In this case, the metaphor is a true "translation" or "transliteration"; the two concepts it interposes are fixed and non-dependent meanings; a conceptual process takes place between the two meanings as given origins and terminals, leading to a transformation from one end to the other, thus allowing one end to semantically replace the other.

It follows that the essential characteristic of metaphor is that it establishes a relation of contrast or correspondence between different worlds of experience or ideas based on similarity or resemblance. The essence of metaphor is that we metaphorically talk about the image of one familiar object and situation with the words of another unfamiliar thing, in order to try to grasp it and understand it.

Regarding analogy or similarity, Mach has long specialized in it and considers Kepler and Maxwell to be the representatives of scientists who are proficient in this scientific method[2]. In Mach's view, similarity is partial equivalence: similar objects are characterized by partial equivalence and partial difference; analogy is a more deep-rooted similarity, i.e., abstract similarity, and therefore there is a sound basis for considering analogy as a special case of similarity. He defines analogy as a relationship between systems of concepts in which we gradually become aware that the corresponding elements are different, while the corresponding associations between the elements are the same. Strictly speaking, inference from similarity and analogy is not a matter of logic, at least not of formal logic, but of psychology. Analogy brings the whole essence of any object clearly before our eyes, and its value in scientific cognition cannot be overestimated. Mach said:

Considerations of similarity and analogy are fruitful motivations for expanding knowledge in several ways. A still fairly unfamiliar range of facts, N, can show some analogy to another more familiar and directly intuitively more attainable range of facts, M: we feel immediately driven to seek in thought, observation, and experimentation what corresponds to the known features of M or to the relations between these features, which will usually reveal hitherto unknown facts about N, and thus discover them. Even if our hopes are frustrated and we discover unanticipated differences between N and M, we are not labouring in vain: we end up understanding N more fully, thus enriching our conceptual grasp of it.

Concerning the model, Duhem also discussed this long ago.[1] He saw the use of mechanical models, or the recovery of specific features of the elaborated theories by some more or less crude analogy, as a customary feature of British physics topical papers. This particular type of mind gives rise to a particular type of theory of physics; the laws of the same group of phenomena are not coordinated in a logical system, but are described by a model Moreover, this model may be a machine constructed from concrete objects, or an apparatus constructed from algebraic notation; in any case, the British type of theory does not in its development itself obey the laws of order and uniformity required by logic. Duhem admits that the use of mechanical models can guide certain physicists on the path of discovery, and that it can lead to other findings as well. However, it is at least certain that it has not brought about as much progress in physics as it boasts. The most distinguished physicists used this form rarely as a tool for discovery, but as a method of elucidation. As Lord Kelvin declared, such a concrete depiction was indispensable to help him understand, and without it he could not have reached a clear understanding of a theory. Duhem cautions against confusing the use of models with analogies.

The physicist seeks to unify and classify the laws of phenomena of a certain category with an abstract theory. He often lets analogies guide him in his own, and he sees similarities between these phenomena and those of another category. If the latter are already ordered and organized in a satisfactory theory, the physicist will try to gather the former in a system of the same type and form.

The history of physics shows us that the analogy between two different categories of phenomena is perhaps the most reliable and fruitful of all the steps that come into play in constituting a physical theory.

Duhem pointed out that Huygens' concept of light fluctuations came out of the analogy between the phenomena produced by light and the phenomena that constitute sound, and that Ohm transmitted the equations written by Fourier for the former to the second category of phenomena by means of the analogy between the propagation of heat and the propagation of electricity in a conductor. He gained insight from these cases that:

The use of analogies in physics tends to take a more precise form. That is, it may happen that the two distinct and unlike categories of phenomena reduced by an abstract theory are such that the equation used to elaborate one of the theories is algebraically equivalent to the equation representing the other theory. In this way, although the two theories are essentially heterogeneous by virtue of the nature of the laws they coordinate, algebra establishes a precise correspondence between them. Every proposition of one of the theories has its counterpart in the other; the problem solved in the first theory is posed and solved similarly in the second.

According to Duhem, this algebraic correspondence or abstract analogy is a thing of infinite value: not only does it bring significant intellectual economy one since it allows one to transfer directly to another theory all the algebraic tools constructed for one theory, but it also constitutes a method of discovery. However, he did not deny the role of models in inspiring discoveries, because discoveries do not obey any fixed laws. He says: No doctrine is so foolish that it cannot be so that it cannot one day give rise to novel and fortunate ideas. Astrology, which determines fate, also played its part in the development of the principles of celestial mechanics.

Nagel later also explored the place of metaphors, analogies, and models in scientific cognition[1], and he noticed that their common feature was the reduction of the unfamiliar to the already familiar. He made the following observations about metaphor:

The widespread use of metaphors, whether rigid or vibrant, is a powerful testimony to the profound human gift of discovering similarities between new experiences and familiar facts, so that the new is mastered by being subsumed under already established features. In any case, people do tend to use familiar systems of relations as models by which to intellectually assimilate initially unfamiliar fields of experience.

However, Nagel also understands that in the vast majority of cases the use of metaphor is not a conscious and deliberate process. Without a careful collation of expressions, the similarity between something new and something old is often understood only vaguely, and in addition the limits of the limited nature of this perceived similarity attracts little attention. Thus, it is easy to make serious mistakes when extending familiar concepts to new subjects based on unanalyzed similarities. Even so, he fully acknowledges the discovery-aiding value of metaphor: understanding even vague similarities between the old and the new is often the starting point for important intellectual progress. As reflection becomes critically self-aware, this understanding can perhaps evolve into carefully formulated analogies and hypotheses that can serve as effective tools for systematic research.

In Nagel's view, the history of theoretical science provides a wealth of examples of the influence of analogies on the formation of theoretical ideas. A number of distinguished scientists have quite explicitly affirmed the significant role played by models in the construction of new theories: models serve both as a guide for building the fundamental premises of a theory and as a source of inspiration for extending its application. In addition to its illuminating value in the construction and application of theories, the model contributes to the acquisition of a wide range of descriptive systems. A theory expressed according to a familiar model resembles in some important respects those theories or laws that are thought to apply to the model itself, so that the new theory not only assimilates what is already familiar, but can often be seen as an extension and generalization of the old theory that originally had a more limited application. From this perspective, analogies between old and new theories are not only an aid to the development of new theories, but also a much-needed effort by many scientists to obtain something that is unspoken in the construction of explanatory systems. Of course, he also warns that the formulation of a theory according to a model is not without its dangers, and that a model can be both a potential intellectual trap and a priceless intellectual tool. The main danger is twofold: a model (especially a substantive model) may be mistakenly thought to have a non-essential feature that constitutes an essential feature of the theory it contains, and the model may be confused with the theory itself.

Nagel, like Mach and Duhem, sees Maxwell as a master of the use of analogies and models. Maxwell said, "By analogy in physics I mean a partial similarity between the laws of one science and those of another, so that one of the two sciences may be used to elucidate the other." Maxwell believed that the similarity in mathematical form between some laws for different subjects was useful "in stimulating suitable mathematical ideas. He developed his mathematical representation of electrical phenomena precisely by using this analogy, and it was for this purpose that he adopted as a model a mathematical analysis of fluid motion that included compression. Based on examples and on Maxwell's insights, Nagel divided analogies into two main types: "substantive" analogies and "formal" analogies. In the first type of analogy, a system consisting of elements with certain known properties (assuming that these elements are connected in some known way articulated by a set of laws of the system) is seen as a model for the theoretical construction of a second system. This second system can differ from the original one only in that it contains a broader set of elements, but everything in that system has properties exactly similar to those in the model; or, the second system can differ from the original one in a more radical way, because the elements that make up that system have properties that cannot be found in the model (or in any case are not mentioned in the laws elaborated for the

model). The use of this type of analogy is exemplified by the various atomistic theories of matter. In the second type of analogy, the formal analogy, the system that serves as a model for constructing a theory is some familiar abstract relational structure, rather than, as in the substantive analogy, a set of elements that can be visualized in more or less familiar relationships with each other. In fact, Maxwell has long classified it this way: the substantive analogy treats the system of elements with known properties as a model, and the formal analogy makes use of the structure of abstract relations.[1] This dichotomy has also been called the pictorial model and the symbolic model.

3. Why metaphors are essential in scientific cognition

Most of the scientists and philosophers of science involved above do not make a distinction, at least not a clear one, between metaphor, analogy, and model, and indeed it is difficult to distinguish between them. However, we can affirm that:

Metaphors, analogies, and models are much more alike than they are different from each other. They are all based on the concrete or abstract similarity of different things or relations, establishing a comparative or corresponding pattern between different empirical or conceptual worlds, thus building an invisible bridge between them, so as to smoothly transition from the known, familiar existence and situation to the unknown, unfamiliar existence and situation, with the purpose of grasping and understanding the latter. Analogies and models are non-logical or non-strictly logical tools of reasoning, no matter what type they belong to, and no matter when and where they come from, their essence is comparative, comparative, comparative, comparative, and also schematic, symbolic, allegorical, and metaphorical, in a word, "metaphorical". Therefore, there is nothing wrong to include analogy and model in the big pocket of metaphor, and they can be regarded as special expressions of metaphor.

Metaphor is indeed indispensable in scientific cognition or scientific invention. It is true, as Habermas says: "In philosophy and the humanities, the presupposed content of a proposition cannot be separated from the rhetorical form of its expression. And, even in physics, theory is not free from the rhetorical device of metaphor. The rhetorical device of metaphor is particularly necessary to make new modes, new ways of looking at things, and new contingencies seem plausible (with intuitive recourse to the presuppositions of everyday language). No creative breakthrough in empirically proven desirable forms of knowledge and scientific habits is possible without a linguistic breakthrough: the connection is unmistakable."[1] Here, we have to ask, how did this situation happen?

From an ontological point of view, as Bacon says: "The subtleties of nature are so much higher than those of the senses and the understanding that all the contemplations, speculations, interpretations, etc., in which men are absorbed, 'as if they were in a fuss', are like the blind men's dark senses, and are far from the subject."[2] What is more, the "self-existent" is on the other side of the phenomenon; the reality is not presented to us directly, there is a "veil of appearance" between the objective reality and the cognitive subject; moreover, the reality is often shown to us not as it is, but as a relation between them (this is what Pangal's relational positivism is about.), and it is this relation that is grasped metaphorically rather than the referent, i. e., the entity. We are like the prisoner in Plato's cave, seeing only a shadow of the reality, or even a shadow of the shadow. In the macrocosm, the situation is perhaps a little better. For the microcosm and the cosmovision, we simply cannot face the reality or even face the phenomena, not to mention the littoscopic and the bulgoscopic. However, the human nature of seeking knowledge and truth cannot make us stay in ignorance with peace of mind, and we cannot even be satisfied with knowing what is true, but always try to know what's going on. Since there is no straight path to follow, people are forced to use metaphors as a crutch to follow the paths and twists and turns toward their ideal and longed-for destinations.

At this point, the scientist, like the cultural researcher, is diving into a sea of fluid metaphors, not an ocean of absolute "truths".

From the epistemological point of view, due to the anthropological limitations of the human organism and senses, people cannot reflect the world like a mirror or even a stereoscope, much less have the view of God's eyes to see the reality. In the process of cognition, what one perceives is not the object itself or all the information of the object, but the appearance of the object to us or a very small amount of its information, which is the elementary sensory givens, because there is a curtain of appearance mediated between the cognitive subject and the external world. Even this minimal sensory information is assimilated and shaped by our cognitive schema, including the role of metaphorical concepts--the intrinsic influence of society and culture on science is thus evident. What is more, there are no empirical or logical channels that allow reason to grasp the real directly through the curtain of appearance. In this case, our thinking must try to "leap" from the subject to the object in order to understand the real as much as possible, when only the super-empirical and super-logical metaphor, the wings of imagination, can make the human mind soar and thus achieve some degree of leap. Moreover, human cognition is always based on existing knowledge, starting from what one knows well, which coincides with the route of metaphorical cognition. Moreover, as the English poet Eliot said, metaphor is not a writing technique, but an effective way of thinking: "This way of thinking is raised to a certain height to produce great poets, great saints and mystics." This is because metaphor is the establishment of reciprocity between different existences, different worlds of experience, and therefore the metaphorical way of thinking is not a continuous state in time, but a state of simultaneity or a form of space. The language and way of thinking of metaphor both utilize and deny time, establishing a permanent form of simultaneity and space, i. e., establishing eternity. Metaphor is associated with space, while the narrative language of linear logic is associated with time.

From a methodological point of view, special forms of expression of metaphors such as analogies and models have long been entered into the textbooks of philosophy of science and scientific methodology as formal scientific methods. More importantly, in the period of conventional science, scientists were guided by paradigms to solve mysteries; in the period of scientific crisis and revolution, in the face of a series of anomalies, the old paradigms were useless as tools, and the traditional inductive and deductive methods were useless, because scientific inventions never followed ready-made methods, and scientific inventions were also inventions of methods. In this extraordinary period, it is a good time and a wide world for imagination or figurative thinking to run wild. Imagination is the source of the evolution of knowledge, and it is the source of "the desire to sweep the world, to encompass the universe, to encompass the four seas, and to swallow the eight deserts". It is important to know that metaphor is the central issue in the change of scientific theories, and the paradigm change contains a fundamental revision or innovation of metaphor. What's more, new basic concepts and fundamental principles are often not directly or immediately put to experimental test when they are proposed, or even impossible to test, and without metaphors, analogies, and models, wouldn't we be unable to move an inch?

From the point of view of linguistics and philosophy of language. In the first place, as Cahill deeply examines, language and myth originate simultaneously; they are two different offspring from the same mother root, two different forms drawn from the same impulse to symbolic representation, and they arise from the same basic mental activity, the condensation and sublimation of simple sensory experience. However different the two may be in content, the form of the mental concept works in both equally: this is the form that may be called metaphorical thinking, for the true underlying metaphor is the condition under which the mythical and linguistic concept itself is expressed. There must have been a time in human history when any thought that went beyond everyday life had to be expressed by means of metaphor. Cahill says:

If we track the metaphors of language and myth until we find their common roots, if we look for them in the process of aggregation or "intensification" of the unique sensory experiences that underlie all language and mythic-religious expressions, then the meaning of language and mythic metaphors will each be revealed and the spiritual forces embodied in them can be properly understood.

Here, both language and mythology are permeated and governed by the same basic principle, namely, the principle of "pars pro toto, " which is no wonder that ancient rhetoric used it as a major type of metaphor. Under this principle, the part becomes not only the whole but also the whole. By virtue of the so-called "reciprocity" principle, entities that appear to be completely different in direct sensory perception or from the point of view of logical classification can be seen as similar in language, so that every statement about any one of them can be transferred or applied to another. can be transferred to or applied to another entity.[1] The typical features and specific operations of these ancient metaphors have been passed down from generation to generation and still survive in modern language and mindsets.

Second, "language, to its very nature and essence, is metaphorical; it cannot describe things directly, but resorts to indirect ways of describing them, to the ambiguous and ambiguous ton of words. "[2] Thus, the relationship of meaning between words is an intertwined metaphorical web, and words are the knots of this web of meaning, each word being elaborated in terms of the others. Whether it is a hilltop, a mountainside, or a foothill in everyday language describing external objects, or a heart, a tide, or a chill in the heart, it is all metaphorical. This is true even in scientific language, such as force, work, atoms, and black holes in physics, and the struggle for survival, evolution, genes, and cloning in biology. In particular, the basic concepts in science are so abstract and so far, removed from direct experience that they cannot be expressed at all without the help of metaphors. Metaphors evoke changes in similarity relations in people's minds, establishing a certain pattern of similarity with words, and thus constructing a structure of the world that is isomorphic to the structure of the lexicon. This also shows that the basis of metaphor lies in the isomorphism or similarity of human thought, language and nature. Thus, for science, metaphorical language is not purely a "prison" for understanding, but also a valuable "toolbox". "The cultural character of scientific language allows cultures to use their own familiar metaphors and models to explore different aspects of natural regularity; they adopt the standpoint of their cultural heritage in order to 'observe nature' in a distinctive way - while this is a characteristic of science…… ". Again, Wittgenstein has said, "All that can be thought can be thought clearly. All that can be said can be said clearly." "Philosophy is to consist in the clear representation of the sayable in order to mean the unsayable."[1] How is this not the case in science? This requires the use of metaphors, from the clear expression of the speakable (the literal meaning of a word we already know) to the meaning of the unspeakable (suggesting the similarity with the mysterious real), in order to evoke mental reflections and endless associations in the speaker and the listener. Thus, the real is approached and partially grasped in a metaphorical way, leaving room for a deeper understanding of the real. As a result, it follows that metaphor is not strictly logical and purely rational, but a matter of psychology and of the development of the human mind. Because of this, there is considerable concern in contemporary philosophy of mind and philosophy of language about the nature of metaphor and its use in everyday life and even in various sciences and disciplines.

The British sociologist of science Barry Barnes (Bany Barnes) has given a masterful exposition of the metaphorical nature of thought, culture, and the use, function, and meaning and importance of metaphor in science and culture, which we might quote as the concluding term of this paper: A theory is a metaphor that people create to make sense of new, puzzling, or anomalous phenomena based on existing culture that we are familiar with and has been well treated, or on newly created statements or models that our existing cultural resources enable us to comprehend and grasp.

He adds, "All research traditions generally develop their beliefs and cultures through the use of metaphor; long-term cultural change is metaphorical expansion or metaphorical variation." "Models, metaphors, and paradigms are of fundamental importance in the process of scientific change." "The main path of cultural change is blazed by scientists committed to using, expanding and developing a particular metaphor as much as possible. The key forms of the ideas and arguments devised are metaphorical and metaphorical." "To account for the metaphorical nature of thought is to account for the cultural constraints on the qualities of thought.