1 Metaphors and Science

Historical Dismissal and Neglect of Metaphor by Science and Philosophy

Metaphor has traditionally been considered antithetical to science. Metaphorical speech, which is commonly associated with the creative wordplay of poetry and fiction, would seem after all to be at cross-purpose to scientists' efforts to articulate clear, rigorously precise, and objective statements of fact about reality. Aside from a tendency toward obscurity, the greater problem is that metaphorical expressions are typically false, literally speaking. Shakespeare's Juliet is not literally the sun, time does not literally flow, and the genome is not a literal blueprint, book, or program. It is principally for this reason that scientists and philosophers of science have been, until rather recently, very critical of the suggestion that metaphor might play a legitimate role in the scientific process. In the early modern period, philosophers like Francis Bacon, Thomas Hobbes, and John Locke, who were enthusiastic advocates of the new scientific approach to understanding the world so brilliantly illustrated by the likes of Hooke, Boyle, and Newton, made withering criticism of metaphor as productive of nothing but falsehood and misdirection.

Bacon cautioned against what he called four "Idols of the Mind," by which he meant habits of human speech and thought that introduced bias and distortion into our efforts to understand the world rightly. The fourth of these were the "Idols of the Marketplace," consisting of a "wrong and inappropriate application of words [that] obstructs the mind to a remarkable extent." But perhaps none expressed this attitude better (and ironically with such evocative metaphor) than Samuel Parker, a member of the Royal Society, who in 1666 described metaphors as "wanton and luxuriant phantasies climbing up into the Bed of Reason, [that] do not only defile it by unchast and illegitimate Embraces, but instead of real conceptions and notices of things impregnate the mind with nothing but Ayerie and Subventaneous Phantasmes." Metaphor is for romantic poets, not hard-nosed objective scientists. As the neuroscientist Michael Arbib and philosopher of science Mary Hesse explained, "the rise of science was accompanied by the conception of the 'ideal language' that would enable us to read off from the 'book of nature' the true science that exactly expresses reality." Eventually philosophers and even some scientists would have a change of opinion about this. But before we discuss the reasons for this reassessment, we need to clarify what metaphor is, and how it differs from simile, with which it is often confused.

What Is Metaphor?

The *Oxford English Dictionary* defines metaphor as "A figure of speech in which a word or phrase is applied to an object or action to which it is not literally applicable." There is good reason to extend the account of metaphor beyond the purely verbal to include visual metaphors, which are images (either natural or artfully constructed) that portray a thing in a way suggesting comparison with another distinct kind of thing. So metaphor involves talking about, describing, or thinking about one thing in terms typically ascribed to another quite different sort of thing. It can be quite explicit, such as when we say "Man is a wolf to man," or it may be more subtle, such as when we say "The sun sank down over the horizon." It is worth noting that what constitutes a literal application of a word or phrase will be subject to the practice of a community of speakers, and this can change over time, so that what was originally undoubtedly a metaphor – like the description of the sun sinking in the sky or the legs of a chair – may eventually be regarded as literal speech or a dead metaphor. (More will be said about this in later chapters.) In either case, whether obvious or not (live or dead), we use metaphor to say something interesting or novel about a subject by drawing an implicit comparison between two things commonly regarded as dissimilar (people and wolves or the sun and a leaky ship, for example). A metaphor usually suggests, rather than explicitly states, the features of the comparison on which one is intended to focus, so some interpretation is required on the part of the auditor. As it turns out, it is precisely because metaphors are open-ended that they can entail more comparisons than was originally intended by the speaker, which makes them powerful devices of intellectual suggestion and not just tricks for making speech pretty or entertaining.

Basically, then, metaphors allow us to compare two things in a striking and interesting fashion. When Leonard Cohen wrote the poem "A Kite is a Victim," he used metaphor to focus attention on some surprising similarities between two very dissimilar things. The poem highlights how a kite is subject to our control, by means of the string, but also puts up resistance as though it were an unwilling participant in what is for us an amusing pastime. Metaphor scholars refer to the concept of a kite here as the *target* of the metaphor (the thing to be described) and the concept of a victim as the *source* (of the ideas to be transferred to the target to make the description). The word *metaphor* actually derives from Greek, meaning "to carry over." The metaphor works by drawing on common associations we all have about victims and victimhood (the source domain) and transferring them to the concept of kites (the target domain) (Figure 1.1).

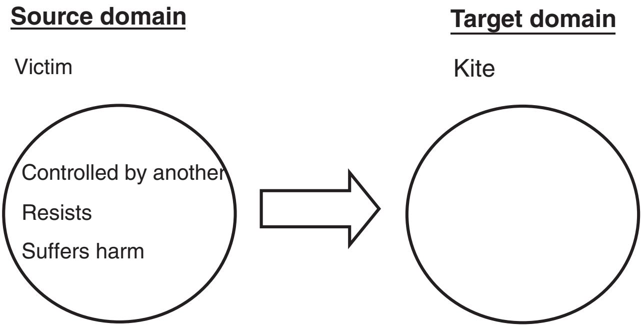

Figure 1.1 Source and target domains.

Similes also draw comparisons between things, but with the key difference that similes typically employ the words "like" or "as." For example, Cohen's song "Like a Bird on the Wire" compares his attempt to live life on his own terms ("to be free") to a variety of disparate things (including a drunk in a midnight choir and a worm on a hook). Because simile employs the terms "like" or "as," it is clear that the two things being compared are only similar in some (non-essential) properties. Metaphor, on the other hand, invites us to regard the two things as essentially identical or as two instances of the same category. A kite is not merely *similar to* or *like* a victim, the poem suggests, but actually *is* a kind of victim. And the effect is that it is difficult to look at or think about a kite in the same way after reflecting on the metaphor. The implicit assertion of identity between the relata of the source and target domains created by the metaphor explains why metaphor is such a powerful source of insight for science, as it can help us to recognize deep and non-obvious similarities and patterns between disparate things.

The Roles of Metaphor in Science

Serious attention to metaphor and its positive role in science would not occur until the early 1960s, by the philosophers Max Black and Mary Hesse. Black argued that metaphors are more than simple equivalents or substitutes for similes because the comparisons they make possible between the two domains are open-ended and, in fact, create the similarities (or lead us to "see" them to use a common lens metaphor). Saying, for instance, that "Light is a wave" is not equivalent to saying "Light is like a wave." The metaphor, he argued, is not simply a shorthand for a set of previously recognized similarities. Black also developed an insight made earlier by the philosopher I. A. Richards that the effect of a metaphor is not uni-directional, as a transfer of ideas commonly associated with the source domain to the target domain, but that our thinking about both is changed as a result of the metaphor. When we use the metaphor "Man is a wolf," the chief effect is to make humans appear wolf-like, but at the same time and to a lesser degree perhaps, wolves become more human-like. Black called this the Interaction View of metaphor. He also commented on how many scientific ideas, such as the wave theory of light or the billiard ball model of atoms, have their origins in metaphorical language. "Every metaphor," he wrote "is the tip of a submerged model."

The connection between metaphor and the construction of scientific models and theories was taken up by Mary Hesse in 1966, who argued that scientific explanation employing new theoretical language involves the metaphorical redescription of one type of object or event in terms originally appropriate to another system or domain. Much of theoretical explanation in the sciences, she pointed out, relies on analogical reasoning, whereby the scientist, upon recognizing some similarity between two separate systems, uses her knowledge of one familiar system to make inferences about another less familiar and more puzzling system. Metaphors, she noted, are an excellent facilitator of analogical reasoning. When we describe one system metaphorically in the terms appropriate to another (e.g., describing light as a wave, or gas molecules as little billiard balls) three types of analogical relations are established between the source and target domains, which she called positive, negative, and neutral (Figure 1.2).

The positive analogies are those properties that we know to be shared by the two systems; the negative analogies involve the properties we know to be present in one but not the other, and the neutral analogies are those features we do not yet know to be positive or negative – that is, either real similarities or dissimilarities. By highlighting neutral analogies between two separate systems, metaphors inspire avenues of experiment and investigation for scientists to follow. Proper scientific explanations rely on the identification of real and deep positive analogies between the two systems, typically ones that fix on underlying structural relations like physical laws. Hesse insisted that for successful science not just any metaphor will do, as those that trade on superficial similarities (say, colour or size) are unlikely to increase our understanding or ability to control events in the world.

The most influential advocates of the thesis that metaphors play an important cognitive role in how we think about and experience the world are the cognitive linguist George Lakoff and the philosopher Mark Johnson, whose 1980 book *Metaphors We Live By* introduced what is known as the conceptual metaphor theory. According to the authors, humans rely on an extensive range of metaphors drawn from a set of basic and immediate experiences to help organize and conceptualize more abstract ideas and events. So, for instance, because we associate health with standing erect (up) and illness with lying prostrate (down), we use these experiences and our descriptions of

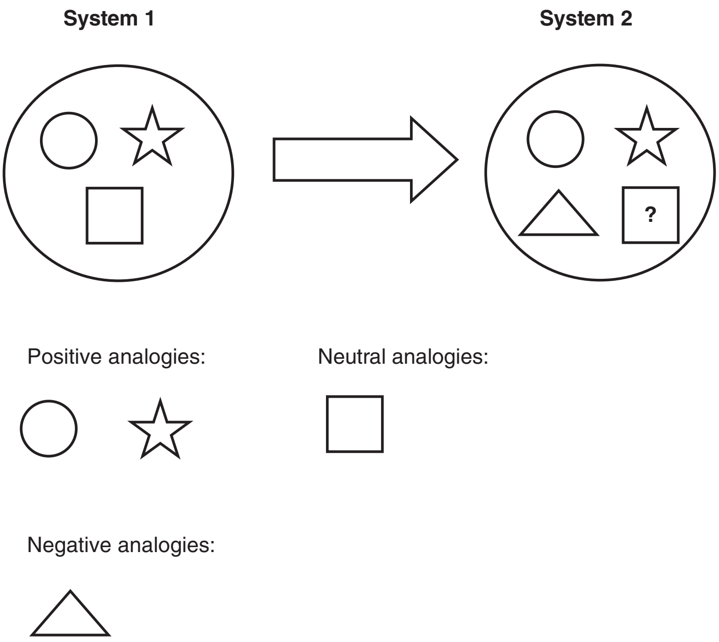

Figure 1.2 Positive, negative, and neutral analogies.

them as source domains to create and to organize our understanding of more abstract target domains, such as the concept of the future. We say, "Things are looking up!" if prospects are good. Or we describe positive economic activity as "growth" (because when a pile of objects increases in size it extends upward) or as a "healthy economy." Negative economic activity is described as "sluggish," "in recession," "depression," or an "economic slump," all suggestive of the lack of activity and uprightness associated with illness. We describe and think about the future and life generally as a journey: "No one knows where the future leads or what's on the road ahead, and sometimes there will be obstacles and crossroads at which you will have to make tough decisions, etc."

One of their most interesting assertions is that not only are metaphors not inconsequential *façons de parler* but essential components of how we describe and make sense of the world, they also, as the title of their book proclaims, shape the very way we live and experience the world. Because we employ the conceptual metaphor "life is a journey," we actually experience it that way, and at least among most members of the Western world, we experience the future as though it were spatially situated in front of us and the past behind us, and think of ourselves as travelling toward it as if it were a destination.

So far we have seen that metaphors play at least two important roles in science: (1) a *heuristic* role, suggesting analogical models or hypotheses to be explored in order to discover important unifying similarities or patterns in nature (functioning in what philosophers of science have traditionally called *the context of discovery* where creativity is all that matters and "anything goes"); and (2) a *cognitive* role in the development of explanations that increase our understanding of nature and its mechanisms (functioning in *the context of justification*, where logic, experiment, and careful attention to evidence and its interpretation are supposed to rule). To this list we may add a third role: (3) as a *pedagogical* or *rhetorical* device in the communication between scientists and non-scientists and students. This is the function most frequently and grudgingly conceded to metaphor by those who wish to defend the image of science as the purely objective and factual account of how the world really is. Sure, these people will say, scientists engage in metaphor, but that's only to dumb down the highly technical and difficult jargon-laden language that they use to make sense of the world. They do this so that non-scientists and students can get some basic understanding of what the scientists are *really* saying and thinking when they are in the lab or actually doing the science.

It is unquestionably true that scientists and science journalists do employ all kinds of creative metaphors for the strictly rhetorical purpose of helping them communicate difficult and unfamiliar ideas to an audience of non-scientists. But as we shall see throughout this book, the heuristic and cognitive roles metaphors play in science cannot be denied without grossly mischaracterizing the actual process of scientific practice and the ultimate product – namely the knowledge, theory, explanation, and understanding that science provides. In later chapters. I will suggest a fourth role metaphors play in science: (4) as technological instruments that assist scientists in manipulating and bringing about real material change to the objects of their study.

The Social and Linguistic Nature of Science

Science is an activity carried out by humans in their attempt to understand the world: what kinds of things there are in it, what they are made of, and how they work. The humans attempting to make sense of the world by means of the scientific process are always doing so from within particular cultural, social, political, economic, and linguistic communities and contexts. And these contexts themselves are always undergoing historical change, which significantly shapes the account of the world scientists produce, despite their best attempts to escape these biasing influences so as to attain as objective a picture of reality as possible. The history of science brilliantly illustrates the bi-directional and mutually constructive interaction that takes place between science and society. One reason to believe that the human stamp on the scientific product (its knowledge and theoretical explanation of reality) is unavoidable, is that some sort of language is a necessary component or tool for science to proceed at all. Whether that language is natural (Latin, English, Mandarin Chinese, Hindustani, etc.) or formal-mathematical, we humans must supply it. Nature has no language of its own (either objective or subjective), and it cannot tell us what terms to use to describe it. It is up to us to create the vocabulary and the rules of grammar with which we attempt to capture an understanding of nature that is empirically adequate (describing things as they appear to us) and useful for our purposes of surviving and thriving at the very least, and objectively true (describing things as they really are) in the best and most ambitious scenario.

A careful reading of the history of science shows that finding the right words or concepts to describe the natural world is often one of the most difficult and crucial tasks. Consider the efforts of early physicists like Descartes, Kepler, Galileo, Leibniz, Newton, and others to find the right way to describe motion (quantity of motion, inertia, vis insita, vis viva, force, momentum, kinetic energy, etc.). Metaphor is one way that scientists can identify useful terms and concepts for picking out important natural phenomena or features of what would otherwise be, in William James' description, "one great blooming, buzzing confusion." Metaphor helps us to fill in gaps in our current vocabulary (a function known as *catachresis*) by borrowing terms already in circulation and putting them to work in new contexts, rather than having to create entirely new technical terms and jargon with which we have no prior familiarity or understanding. In this way, metaphors can be *theory-constitutive*, to use the philosopher of science Richard Boyd's term, providing scientists a means of identifying and referring to a novel phenomenon, and to develop some theoretical understanding about it. And as an extra bonus, by facilitating analogical reasoning metaphor allows us to weave together different aspects of our experience and understanding of the world into a unified pattern rather than a series of disjointed and entirely separate accounts. On occasion, as Thomas Kuhn argued, the introduction of novel metaphors provides the impetus for revolutionary paradigm shifts that disrupt the continuity of scientific thought, such as when Descartes and other early modern thinkers started to view the universe and living bodies as machines. Either way, there has been increasing recognition, even by scientists themselves, of metaphor's importance in the scientific process.

Metaphors as Perspectives, Filters, Lenses, Tools, and Maps

It is common practice to describe metaphor's role in science in metaphorical terms – that is, to engage in meta-metaphor. For instance, it is commonly said that metaphor allows us to *see* things from a *particular perspective*, that it acts like a *filter* or *lens* through which we see the world, with certain features highlighted or magnified, that it is a cognitive *tool* or *instrument* with which we can conceptually dissect or reconstruct things. But as valuable a tool or lens as they may be, as with any instrument, it is important to use the right tool for the job. A hammer is great for driving nails, but it is no substitute for a saw or pair of pliers. Likewise, a novel perspective may show us very interesting things we might not otherwise see, but to observe the world from one perspective alone is a form of bias. It is little surprise, therefore, that much of the discussion about metaphors in science concerns their potentially negative effects. Two representative quotations (the first from evolutionary geneticist John Avise, the second from ecologists Christoff Kueffer and Brendon Larson) will suffice to capture the sentiment:

> The hope for any metaphor in science is that it may bring otherwise unfamiliar subjects to life, make connections not otherwise apparent, and stimulate fruitful inquiry. A danger is that a metaphor can restrict rather than expand research horizons.
>
> The problem . . . is not so much that a metaphor is wrong but that it is misleading: It encourages the interpretation of a partial view as the whole truth or the attribution of too much importance to the view provided by one metaphor as opposed to the different insights provided by a plurality of them.

It is important to recognize that every metaphor provides at best a *partial* and *selective* perspective on reality, and that it may be important to adopt several different metaphors if we want a more complete (more objective) understanding; just as we typically attempt to view an object, like a statue, or an issue of debate *metaphorically* "from all sides." We can think of metaphors as providing a path or map forward, through a tangled jungle of unfamiliar territory (to use yet another meta-metaphor), but like any map they may not lead us to where we ultimately want to go; and if we do not exercise due caution, we can be easily misled by them.

Metaphor's Broader Impact Beyond Science

In the chapters to follow, we will look closely at examples of metaphors that have been highly conducive to advancement in various branches of the life sciences, some that have been less so, some that are a mix, and some about which the jury is still out. We will also consider the equally important question of the impact that metaphors can have on broader society via science communication, or their rhetorical-persuasive effects. As the population geneticist Richard Lewontin has said, in addition to helping us to understand the world and to manipulate it to our advantage, through the accounts it gives of the way things are, science also works to *legitimate* and support various political, economic, and social ideologies. Because metaphors work by drawing on common beliefs and attitudes associated with a source domain, implicit values and value judgments can also be transferred to the target concept, but often implicitly and therefore escaping critical scrutiny. Empirical studies indicate