Metaphor in Science: A Modular Teaching Unit
Brendon M. H. Larson, September 2006 (revised April 2007)

Department of Environment and Resource Studies
University of Waterloo
Waterloo, Ontario, CANADA N2L 3G1
blarson@fes.uwaterloo.ca

Introduction

An extensive body of literature in "biology studies" has shown that metaphors play a significant role in biological conceptions of the natural world. We know that metaphors shape how we think about phenomena, and that while this has benefits it also leads to a narrowing of the options and a constraining role. Furthermore, scientific metaphors are necessarily drawn from the social milieu in which scientists live, so they tend to reflect large-scale cultural assumptions. This can serve political ends; as individuals, we think we're playing individual role in society, but based on cultural assumptions we're often actually serving larger system/agenda (Winner 1986; Lewontin 1991; Keller 1995; Kay 2000).

We use some metaphors so often that they may escape critical reflection. Nonetheless, we need to draw attention to them in order to become aware of what they highlight and what they hide, of how they affect the way we relate to the world around us (Lakoff and Johnson 1980). This is particularly true for contemporary scientific metaphors, which heavily influence how many of us conceptualize reality while often containing an implicit normative or political dimension.

The following exercises are designed to help undergraduate students (or others) reflect upon scientific metaphors and their implications. In particular, they should help students to better understand the following:

- Metaphors are common in science;
- Scientific metaphors have diverse functions, both epistemic and social;
- They powerfully "frame" the way we relate to an issue/phenomenon;
- They can be interpreted in diverse ways, some of which may be unexpected;
- These interpretations can have social implications;
- It is challenging to evaluate scientific metaphors and/or to attempt to modify them, but in some cases there may be political reasons for doing so.

The following exercises introduce students to these issues through a variety of methods, including critical reading/text analysis, guided free-writing, small group discussion, and class discussion. I have not allotted/estimated times for each exercise so that they are employable in the greatest diversity of contexts.

Potential case studies

Almost any scientific paper provides an example of how metaphor is used in science, but here I list some examples from ecology, environmental science and evolutionary biology:

-balance of nature
-DNA barcoding
-ecological footprint
-ecosystem engineer
-fragmentation
-natural selection
-selfish gene
-tragedy of the commons
-war on invasive species

1. What is a metaphor?

Depending on their background, many students may not understand the concept of **metaphor**. It is even more likely that they will not know how it differs from two related concepts, **analogy** and **simile**. While the difference between these concepts is largely a matter of degree, one may to a large extent differentiate them along a continuum defining their explicitness. Analogies are often quite explicit and openly developed (often as a **model**, including mathematical models), whereas metaphors tend to be more implicit. Analogies are often of the form A is to B as C is to D, whereas metaphors more directly concern the relation between A and B. While a metaphor implicitly states that A *IS* B, a simile more openly acknowledges that A is (only) *LIKE* B, though most metaphor-makers understand that A is *NOT* (actually) B.

Exercise 1

For this introductory exercise, the instructor leads a discussion about the nature of metaphor. Ask students for a few examples of metaphor and then ask them why they are metaphors as opposed to analogies/similes. Also ensure that they understand the "source" and "target" domains of a metaphor, the former being the source of comparison for the metaphor and the latter being the new domain to which it is being applied (e.g., human engineering is the source domain that we apply to the target domain of organisms that modify ecosystems with the metaphor "ecosystem engineers").

Perhaps have a few examples on hand; for example, a google search will quickly provide examples of Shakespearean analogies, metaphors, and similes. While such examples may reinforce prior beliefs that metaphors are solely a literary phenomenon, they will also provide a segue into Exercise 2, as you can ask whether metaphors occur solely in literature or perhaps also in science. Students may already have given examples of metaphors in science.

During this exercise, use standard techniques of effective teaching, especially using a lengthy "wait time" after asking a question to give them time to formulate a response, and redirecting their responses into new questions for the class.

2. Are there metaphors in science?

For this exercise, you will introduce the students to the presence of metaphor in science through a technique known as textual analysis. For this exercise, you don't need to be overly concerned with the distinctions between metaphor/analogy discussed above. It is more important that students learn how to look at a scientific paper in this "literary" way, perhaps experiencing an "Aha!" moment.

Exercise 2

1. Choose one or a few scientific papers that utilize the metaphor(s) of interest to you as a teacher (the list above may help). It would be preferable for the class as a whole to analyze different papers, either on the same metaphor or different ones.
2. Select a short section of each paper for analysis, such as an abstract, a paragraph or a few paragraphs, or perhaps a page (at most).
3. Hand out copies of the section to the students. Students will work independently for this exercise.
4. Ask the students to read their section and to look for any metaphors, to circle them, and to note their prevalence (perhaps counting them).
5. After sufficient time, begin a class discussion on what they found. If there were different papers, ask each group of students analyzing a particular paper to speak sequentially. Guide them with questions such as the following:
    i. How common were metaphors in this paper? Were you surprised about this?
    ii. Were metaphors used more often in some papers than in others?
    iii. Were the metaphors typically single words or were they expressed more implicitly as a sequence of words?
    iv. Were the authors reflective about their use of metaphor? Or, did they seem to forget that they were using it?
    v. Can we extrapolate from this exercise to the presence of metaphors in science as a whole?
    vi. What other examples of metaphor in science can you think of?

Version 2. Choose one exemplary paper and give students different sections of the same paper (e.g., abstract, introduction, methods, results, discussion). This would motivate a comparison of how often the metaphor(s) occur in each section, perhaps leading into the next section on the different functions of metaphor in science.

Version 3. Choose instances of the metaphor in the scientific literature, popular science magazines, and in the media. Ask students to compare how metaphors are used in each case, which could again motivate the next section on the functions of metaphor in science.

3. What are the functions of scientific metaphor?
Scientific metaphors may serve multiple roles. Most philosophy of science focuses on their **epistemic** role; that is, their role in discovery and in the creation of knowledge. At times, this role may become so marked that a metaphor becomes **constitutive** of a particular area of scientific inquiry.

Despite this focus on the role of metaphor for scientific inquiry, metaphors may also serve a social function. This social function is not mutually exclusive of the epistemic virtues of a metaphor. The major role of metaphors in this domain is a **promotional** one, which helps to "sell" a particular way of organizing, understanding, and/or relating to the world. When scientists coin a new metaphor they not only have to sell it to other scientists, but also to non-scientists – especially if they want to obtain funding. Consequently, scientific metaphors may also have an aesthetic dimension as they must appeal to an audience.

Exercise 3

1. Introduce students to the method of "free-writing." [Website]
2. Ask them to write for five minutes, without stopping, to address the following question(s): What is the function of metaphor in science? What do they do? They should do so in the context of the metaphor under analysis (perhaps from the previous exercise), rather than for an abstract "metaphor in science."
3. Once they are finished, lead a class discussion to uncover what they discovered. As they speak, list some of their major ideas on the blackboard.
4. Once you've accumulated most of their ideas, ask students to think about whether there are any general categories. If so, ask them to come to the board and group items belonging to a category.
5. Conclude with a discussion of the different roles of metaphor in science, perhaps referring to some of the ideas I mentioned above. This should lead into the next exercise as students will soon realize that you can assess metaphors in different ways.

At some point in this exercise, you may want to raise broader questions:

- Is it possible to rid science of metaphor? Why or why not? Would we want to?
- If the metaphor is associated with a technology (e.g., DNA barcoding, Larson 2007): What is the relationship between "the metaphor" and "the technology? Could you have one without the other?

4. How can we assess whether or not scientific metaphors work?

The previous section should have helped your students to realize that metaphors can serve many functions and that these functions are not mutually exclusive of one another. In this exercise, they will take this to the next step to consider more specifically how they may function in these different contexts. Specifically, they will consider them in terms of both their epistemic and social dimensions.

Exercise 4

1. For each metaphor under consideration, break the students into three groups of about three students (multiples of this grouping as needed for class size). Randomly assign groups for each metaphor to either "epistemic analysis," "resonance analysis," or "social analysis."
2. Ask each group to choose a spokesperson that will present that will summarize their discussion for the class as a whole.
3. Spatially separate the groups.
4. Ask the "epistemic" group to work together to address the following questions (modified from constructivist FAR model of Venville and Treagust 1997):
    i. Is the scientific concept difficult? What ideas do they have about it?
    ii. How familiar are you with the source of the metaphor? Is it useful or obscure?
    iii. What are some similarities between the source and the target?
    iv. How is the target unlike the source?
    v. Is the metaphor useful or confusing? Does it help you understand or not?
5. Meanwhile, ask the "social" group to work together to address the following questions:
    i. Who is served by the metaphor?
    ii. Who is excluded by the metaphor?
    iii. What are its potential, broader consequences beyond "doing science?"
6. Finally, ask the "resonance" group to use the following process:
    i. Free-associate associations with the metaphor under discussion (e.g., for barcoding: supermarket, shopping, identify, etc…) and collect a list of them.
    ii. After a point of diminishing returns, discuss/elaborate key words that were mentioned.
    iii. Organize/concept map the key words to reflect upon how they might be grouped.
7. After a reasonable amount of time, ask the spokespeople to present their results/experiences.
8. As these results/points are made, lead a general discussion about the benefits/costs of this scientific metaphor, perhaps drawing on questions such as the following:
    i. Do all metaphors have benefits/costs? How can we weigh them in either the epistemic or social domain?
    ii. Do the associations found by the "resonance" group matter?
    iii. Do scientific benefits of a metaphor outweigh social costs, or vice versa? Why? Can social benefits outweigh scientific costs?

iv. How could we evaluate the overall net effect of a scientific metaphor? What sorts of evidence could we draw upon? How could you conduct research on this question?

5. Are there alternative metaphors?

The final exercise challenges students to reflect more broadly on scientific metaphors and their epistemological and ontological place.

Exercise 5

Either as a class discussion, an in-class free-writing session, or a short take-home assignment (perhaps an artistic one, such as painting or poetry), ask the students to reflect on whether there are alternative metaphors to those under discussion. Is there an "opposite" to the metaphor? Is there an alternative at all or is this the only possible one? If so, why isn't it used? If not, why not? Is it because the metaphor we have chosen has "entrenched" a particular way of seeing the phenomenon under consideration? Can they imagine relating to the phenomenon "without words?" If so, doesn't this suggest that a particular metaphor serves someone's interests? Whose might they be? Is it possible to use a democratic system to determine which scientific metaphors best meet our needs? Could new metaphors be introduced into current discussions? How?

References

Kay, L. E. (2000). Who Wrote the Book of Life? A History of the Genetic Code. Stanford, Stanford University Press.

Keller, E. F. (1995). Refiguring Life: Metaphors of Twentieth Century Biology. New York, Columbia University Press.

Lakoff, G. and M. Johnson (1980). Metaphors We Live By. Chicago, University of Chicago Press.

Larson, B. M. H. (2007). DNA barcoding: The social frontier. Frontiers in Ecology and the Environment 5: 437–442.

Lewontin, R. C. (1991). Biology as Ideology: The Doctrine of DNA. Concord, Ontario, House of Anansi Press.

Winner, L. (1986). The Whale and the Reactor: A Search for Limits in an Age of High Technology. Chicago, University of Chicago Press.