Mirror neurons have received quite a bit of attention since they were discovered in the 1990s. First found in macaques, these are nerve cells which fire both when the animal moves and when it sees another individual move in a similar way. These cells and their functioning are obviously fascinating because they suggest that the brain relates its own actions with those of others. But Antonio Damasio and Kaspar Meyer (2008) warn that “perhaps the name was too evocative for the finding’s own good. It seems to have tempted people into thinking of these neurons as tiny, miraculous mirrors that allow us to understand each other, diverting attention from the search for how they work” (p. 167).

What Damasio and Meyer appear to be cautioning about here are the dangers of metaphorical thinking. There seems to be a lot of that going around lately. The science writer Natalie Angier (2008) has an essay on what she terms “biobigotry,” something she freely admits being prey to. She describes the loathing she felt when she looked out to see cowbirds at her bird feeder and thought: “Hey, you parasites, get your beaks off my seed!” (p. D1). These “freeloaders” were taking food away from “hard-working” birds like cardinals and woodpeckers. Angier confesses that she is using metaphorical language to make very human value judgments about other species, a form of anthropomorphism, something many biologists try to avoid. Angier’s immediate and visceral response to cowbirds shows how difficult this is to do. We are metaphorical creatures; we think in comparisons, and we just can’t seem to stop ourselves.

Before I get more deeply into metaphors, I should mention other types of comparisons, namely similes and analogies. Like a metaphor, a simile is a literary device, a figure of speech. The difference between them is that a simile uses “like” or “as,” while a metaphor doesn’t. When I took literature, where I originally learned all this, I saw the difference as merely nitpicking; adding a little word didn’t seem to make much difference. However, this simply shows my literary naiveté. “My love is like a rose” has a lot less emotional power than “my love is a rose;” just as saying that a neuron is like a mirror doesn’t carry the weight of saying that a neuron is a mirror. As for an analogy, it is even more direct and less dramatic; it refers to cases where the comparison is between two things that are more fundamentally similar, such as referring to both pollen and sperm as male.

Over the past 30 years or so, literary theorists and linguists have significantly rethought the importance of metaphors (Lakoff & Johnson, 1980). They used to be considered literary figures of speech and mainly in the realm of poetry and are now seen as fundamental to the way the human mind works. We can only learn about new things we encounter by comparing them to what we already know. Cowbirds deposit their eggs into the nests of other bird species which then raise the “freeloaders,” so just like a tapeworm, the quintessential parasite, a cowbird drains food away from its host species. “Freeloader” makes it very clear to one who hasn’t encountered cowbirds before, what to think of them: Cowbirds are obviously not good avian “citizens.” This highlights that there are value judgments associated with metaphors used in describing animals, a topic that has received attention from conservation psychologists, people who study the relationship between human emotional responses to organisms and their attitudes to environmental issues.

**Interaction View**

To appreciate what’s going on in metaphorical language, it’s helpful to examine the work of Max Black, a philosopher who developed the interaction view of metaphor in the 1950s. In the metaphor “The cowbird is a freeloader,” “cowbird” is the principal subject and “freeloader” the subordinate subject, according to Black’s (1954) analysis. He argues that something is learned about the principal subject by comparing it to the subordinate one. The connotations or associated meanings of the subordinate subject are used to describe the principal subject, and since there may be many such associated meanings, full exploration of the metaphor can greatly enrich understanding of the principal subject. Calling a cowbird a freeloader casts on the bird a host of negative human valuations—scrounger, bloodsucker, sponge—which are all metaphors themselves. Using a metaphor plunges a term into a whole web of other terms.

While emphasizing some characteristics of the principal subject, a metaphor also hides others because of what Black calls filtering: the only ideas passing through the filter are those which are similar for the two subjects. A cowbird is a free living organism, a fact not highlighted in the freeloader metaphor; that cowbirds spend most of their lives without assistance from their host species gets diminished attention. Douwe Draaisma (2001) describes this very aptly—and metaphorically: “Metaphor, particularly the powerful ones . . . lay the tracks for our trains of associations” (p. 153). As a final note on his perspective, Black’s approach is called an interaction view of metaphor because perceptions of both subjects in a metaphor are changed by their juxtapositioning; the subordinate subject is also seen in a different light because of the emphasis on the characteristics it shares with the principal subject. Calling a cowbird a freeloader can actually make this term seem a little less negative by relating it to a group of animals that are seen almost as paragons of free living, flying off toward the horizon. There are other metaphor theorists, but I like Black’s ideas because they make sense to me. They seem to describe what really goes on with the way we use metaphors, both in science and in daily life. However, I am definitely not a literary expert so my analysis here is crude at best; I just want to get the idea across that metaphors do play a role in science.

**Questionable Metaphors**

A point on which many linguists agree is that over time, a metaphor may become used so much that its metaphorical aspects tend to fade, in other words, the primary and subordinates almost become synonyms. The biologist Joan Herbers (2006) describes an example of this phenomenon in her essay, “The Loaded Language of Science.” She studies slavemaking ants and has been taken aback on several occasions when people criticized her use of this term because of its racial connotations, or as Black would say, associated meanings. To Herbers, “slavemaking” is not a racially charged word. For 200 years it has been used to describe a particular form
of ant behavior; the technical term is dulosis, from the Greek word for slave, *doulos*. As Herbers notes: “I did not invent this jargon, but I have certainly used it without thinking” (a sure sign of a metaphor that has lost its shine). She goes on: “Given its long history of usage, and by no less august a figure than Charles Darwin himself, what is the problem? I posed that question to a colleague who specializes in rhetorical studies of (human) slave narratives of the 18th and 19th centuries. She responded crisply: ‘We should be able to study ants without being reminded of race, for crying out loud’” (p. B5).

In other words, a scientist’s choice of words does matter. Despite how commonplace a term has become, how cleansed of its metaphorical meanings it seems to be, it is still subtly but surely having an influence. After this conversation, Herbers became more sensitive to the ways her words affect the scientific message she is presenting. She now sees that jargon like slavemaking ants may make her research less attractive to people of color. Also, as Herbers examined this metaphor more carefully, she realized that it was not even very effective scientifically. Individuals of one ant species captured by another aren’t technically slaves at all, because human slaves can live in bondage for many generations, while ant slaves don’t reproduce. The captors or “slave owners” have to keep replenishing their stock.

When Herbers brings this topic up with her colleagues in entomology, most don’t see it as an issue. They continue to argue that the term has been used for so long that it has become innocuous. She counters by citing a case where a questionable metaphor has disappeared from a biological field. Up to the early 1980s, behavioral ecologists often described “rape” cases in some animal species where males forced copulation on females. When feminists criticized the term, “forced copulation” came to be used and the loaded word “rape” faded from this literature. I think “loaded” can be seen as suggesting that rape carries with it many associated meanings, as the word slave does, and though the metaphor has become worn and familiar with use, those meanings still lurk, poisoning the scientific atmosphere.

Some metaphors are criticized, not for their social connotations, but because they may mislead scientific inquiry. That’s the argument Martin Chew and Manfred Laubichler (2003) make in their analysis of the term “natural enemies.” In part, their criticism has the same basis as Angier’s: We are imputing human characteristics to other species, and we are judging the behavior of other species as we would judge members of our own species. Chew and Laubichler note that in the ecological literature, this phrase “refers to relationships that can be more precisely described as herbivory, predation, parasitism, parasitoidy, or pathogen infection. Therefore, it is hard to see what the persistent use of the term natural enemies technically contributes to any ecological discussion” (p. 53). They go on to argue that ecologists seem to use the term for its “rhetorical power” in getting the message across. Well, this appears to be the case with most metaphors. Let’s face it, “natural enemies” says a lot more to the average person, and to most biologists, than does “parasitoid.” As does Herbers, these authors make an important point about metaphor and their analysis is superb because they carefully examine both the pros and cons of this figurative language in biology. But both these essays, while questioning the use of metaphors in science, also illustrate why figures of speech continue to be used: They make ideas more approachable, they bring abstract and foreign ideas into the realm of the familiar, and they utilize the power of language to create memorable images.

A More Positive View

I seem to have come down hard against metaphors, but now I want to look at the other side of the coin, so to speak. Because metaphors are so essential to the way we communicate ideas to each other, it’s not surprising that metaphors are important to scientific inquiry, and they are important in two ways. First, they help scientists to communicate their ideas to others. Take the leucine zipper protein structure (Landschulz et al., 1988). This is where two alpha helices run parallel to each other, and in both, every seventh residue is a leucine; this means that the leucine on one helix is attracted to the leucine on the other helix every second helical turn. I hope you can picture in your mind something of what this looks like, because that’s the whole idea of the metaphor, to create a mental image. As with all metaphors, you have to keep in mind that this describes a similarity, not identity. The structure does not act like a zipper, doesn’t open and close like one; it retains its long narrow form so it can fit into the major groove of a DNA double helix, and then the two helices pivot in relation to each other like a “scissors” (Vinson et al., 1989).

The second function of scientific metaphors is to actually further inquiry. Along with many other topics in biology, Charles Darwin’s work provides a good example here. In 1837 as he was groping toward his theory of natural selection, he sketched tree diagrams in his notebook on species change. These trees represent how species arose over time by dividing or branching. In a study of scientific creativity, the psychologist Howard Gruber (1974) traces how these sketches relate to Darwin’s developing ideas on the origin of species. Darwin toys with the idea of monads, one-celled organisms from which life arose and which were then directly changed by the environment, so that one type of cell could branch into two types and eventually into many. He realized that the disappearance of many of these species or branches would lead to the kinds of patterns seen on Earth today, with most of the intermediates between species missing.

Darwin eventually gave up on the monad idea, but the tree image stuck and reappeared in a more developed form several pages further on in the notebook. This later drawing has been reproduced often this year as we celebrate Darwin’s 200 birthday; it is a more complex tree diagram, with many of the branches capped with a short line to indicate extinction. Important to the significance of this image is what proceeds it. Darwin begins the page with the words: “I think.” In this diagram Darwin is, indeed, thinking visually, attempting to make sense of vague ideas running around in his mind by representing them not in words, but in an image.
a metaphorical image. The words will come later, to explicate the image, just as later still he will use words and a diagram to describe this central idea in *The Origin of Species*, which was published 150 years ago this year.

**Poetry**

Roald Hoffmann (2006), a chemist and poet, sees a connection between scientific inquiry and explaining science to others: “When scientists themselves write for a general audience, their research is likely to improve. Why? Because writing sets free the oft-suppressed metaphor” (p. 406). He argues that scientists tend to stay away from using metaphors in their technical papers, for just the reasons Chew and Laubichler raise: Metaphors can mislead and aren’t precise enough. On the other hand, Hoffmann sees writing for the public as fundamentally pedagogical; the author is attempting to communicate scientific ideas just as in a research paper, but to an audience that doesn’t have as much knowledge of the field. How do we explain something new?—By comparing it to the familiar, by metaphor.

Hoffmann adds that something more is needed: This metaphor has to be put in context, in a narrative. Just setting these words down on paper makes me think of the two best teachers of biology I ever had. Whenever I’m asked to describe why they were so good, I always say that they told stories, they wove the concepts and information of a lesson into an unfolding narrative, metaphors and all. And that’s how Hoffmann teaches as well, both in his classes and in his writing. He’s convinced that he became a better researcher because he had to teach undergraduate courses and because he chose to write for the public.

I don’t think it’s a coincidence that Hoffmann, a Nobel Prize winner who has been very successful as a researcher, teacher, and essayist, has also published three books of poetry. When he writes of metaphor, he is viewing it from both sides of the science/literature divide. Robert Root-Bernstein (1989) contends that while the types of truth dealt with in science and poetry may be different, the process of mental metaphor-making is essentially the same, and that the skill a scientist develops in creating poems can assist in making science as well. Poetry comes from a very deep place in the mind, from almost beyond mind, where body and soul fuse. Getting to that place isn’t easy, and it’s even more difficult to remain there long enough to explore it. But this is the same deep place where the ideas of science arise, so familiarity with it as a poet can make it more accessible to the scientist as well, as seems to be the case for Hoffmann.

**Visual Metaphors & Maps**

Poets have also been aware of the metaphorical richness of science. Toby Lichtig (2008) notes that Samuel Taylor Coleridge went to Humphrey Davy’s public chemistry lectures in order to build up his stock of metaphors. From examples like this, I think it can be argued that metaphor is a wonderful glue that binds all forms of human knowledge and creativity together. Some of the best such adhesive is provided by visual metaphors, for example, the tree image that Darwin found so powerful and fruitful. Felice Frankel, who specializes in presenting scientific ideas visually and is Director of the Picturing to Learn Project (http://www.picturingtolearn.org/), considers visual metaphors particularly helpful ways to deepen understanding. Frankel (2006) uses as an example, an illustration created by Viktor Koen to accompany an article about complex systems, about the whole being greater than the sum of its parts. Koen took a photo of a clock mechanism and an image of the interior of a halved apple, and created an illustration with the clock embedded in the apple’s flesh—the clock representing parts and the apple the whole. A very clever image and one that
helped Koen himself better understand the point of the article on emergence of complexity.

Maps are a particularly fertile source of visual metaphors, as the idea of genetic maps indicates. It has also become common to “map” knowledge, and this is the theme of a project called Places and Spaces: Mapping Science, which included a 2007 exhibit at the New York Hall of Science (http://www.scimaps.org). Historical maps presenting geography from the world as a whole to specific areas, such as Jan Lannsion’s 1642 map of the New World, were shown in juxtaposition to concept maps of such things as technology integration into education and domain maps which organize knowledge in a number of fascinating ways. There is one on the historical development of DNA science (http://www.scimaps.org/dev/map_detail.php?map_id=139) and another on the structure of science as a map of interrelationships among disciplines (http://www.scimaps.org/dev/map_detail.php?map_id=48).

The Places and Spaces Web site provides links to all the maps in the exhibit. Really studying them would provide a good education in visual literacy and, as far as the domain maps are concerned, a different view of what knowledge is and how different kinds of learning relate to each other. This is a good example of what a rich metaphor can do when explored in creative ways. Thinking of knowledge as a map, as occupying space, brings up all kinds of associated ideas, such as how much space to assign to discipline: How do you measure the area? Some of these maps use the number of citations in scholarly journals, others use the results of Google searches or the number of blogs on a topic.

A visit to the Information Aesthetics Web site (http://infoesthetics.com/) will provide you with some of the latest visual metaphors for information. Many of these are based on complex visualization computer programs and some seem much more useful than others. One of the most fascinating to me is Worldmapper (http://www.sasi.group.shef.ac.uk/worldmapper/index.html) where the size of countries and continents are presented relative to different data sets. For example, a map of endangered plant species makes South America huge and Europe small (http://www.sasi.group.shef.ac.uk/worldmapper/display.php?selected=271), while mapping public health spending has the opposite effect (http://www.sasi.group.shef.ac.uk/worldmapper/display.php?selected=213).

At Information Aesthetics, there are other visualizations that are definitely less compelling, such as one of wallpaper representing spam e-mail subjects, which is billed as a way to make something aesthetically pleasing out of e-mail junk (http://infoesthetics.com/archives/2009/05/spamghetto_junk_mail_wall_covering.html). This and other programs are based on software that images social networks, one of the most powerful visualization trends at the moment. Here is a metaphor that began within electronics, spread to computers and brain research which have been metaphorically linked for years, and now infects every aspect of life. Social networks are ways of making visual something that we usually take for granted, the fact that no person is an island. But I have to stop myself here, or I will be mentioning Facebook and its academic semi-equivalent, Academia.edu. It really is amazing where a metaphor will take you.

Before closing, I want to get back to map metaphors, but ones found in books rather than Web sites. I’ve recently gotten two map treasure troves that couldn’t be more different from each other. One is The Nature of Maps: Cartographic Constructions of the Natural World (Wood & Fels, 2008). This is a very serious study of geographical maps by long-time students of the field. They do not so much treat maps as metaphors, but rather explain how maps present varying metaphors for nature: such as nature as cornucopia, as threat, and as mystery. This volume is full of images but it is hardly a coffee-table book. Instead it is a thought-provoking study of how mapmakers make meaning.

The other book is less serious, though it too will get you to think about maps, and metaphors, differently. It is Katharine Harmon’s (2004) You Are Here: Personal Geographies and other Maps of the Imagination. Here the metaphorical leaps are spectacular. There is a map of lovemaking which blends topography and anatomy and a London Underground map where each line has “stops” named for a different group—one for saints, another for philosophers. These are fun to look at, but they also got me thinking about precisely what a map is, how every map has assumptions behind it, and how all maps have to be “read,” they are not often understandable at first glance. The real London Underground map is considered a model of clarity, but to make effective use of it, you have to realize that it doesn’t represent distances accurately, and the train paths are straightened out. What it does provide is relational information on how the different lines hook up to each other and the proper order of the stations on each line—the really vital things for a traveler to know.

I have, metaphorically, come a long way in this column, from monkeys and mirrors to subway maps. But that’s the beauty of metaphors, they force us to travel mentally, to make new connections, and to understand the world around us a little, or a lot, differently. They are essential tools in teaching, and in research, and despite the difficulties they sometimes pose, we cannot, literally, live without them.

References

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