Chapter 11

Should Scientists Advocate? The Case of Promotional Metaphors in Environmental Science

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Introduction

Science holds an esteemed place in modern societies because the knowledge it provides is thought to be objective. In terms of Robert Merton's (1973) sociology of science, among other qualities scientists are supposed to be disinterested. While they produce knowledge for its own sake, it is generally assumed that the media, politicians and the public interpret scientific information and often misinterpret or misuse it. This view of the relation between science and society is commonplace, but it has been undermined by several decades of research in the fields of sociology of science and science communication (see Jasanoff, this volume). In the current era, scientists are more often asked to produce knowledge that is useful. They also have to sell their ideas and obtain funding, which melds epistemology with rhetoric. In this chapter, I attempt to capture some of the tensions scientists face as they negotiate the Scylla of absolute disinterestedness and the Charybdis of unbridled advocacy. While most of this book focuses on the role of journalists in science communication, this chapter specifically considers the role of scientists themselves in the production of ethical science communication.

My case studies concern science affiliated with biodiversity conservation, a field in which there has long been discussion about the appropriateness of advocacy. While some feel it is justified because conservation biologists have a responsibility to speak on behalf of the planet, others counter that if scientists speak out they infringe their time-honoured role as purveyors of objective information. Recently, numerous scholars have attempted to find a middle ground between these extremes (Lach et al. 2003, Wallington and Moore 2005, Kincaid et al. 2007, Lackey 2007, Noss 2007). To date, however, there has been relatively little discussion about language and metaphor specifically. One philosopher, Bryan Norton (1998: 353), has concluded that scientific language needs to be 'frankly value-laden' if it is to draw attention to critical environmental issues (see also Hull et al. 2003). Some scientists show little hesitation before entering these philosophical waters, with some condoning hyperbole (e.g., Simberloff 2006) and others seeking a more neutral, objective language (e.g., Colautti and MacIsaac 2004). We clearly require

ongoing consideration of the ethical issues surrounding the use of value-laden language in science communication.

I focus on metaphors because they are generally useful for explaining complex scientific ideas to broader audiences (Lakoff and Johnson 1980; Brown 2003). I am specifically interested in cases where environmental scientists advocate a particular view or promote a particular cause using metaphors. Such activism has significant consequences because the selection of a metaphor entrains a particular vision or expectation of how things might be. In considering such questions, we are expanding the usual epistemic evaluation of scientific metaphors into assessment of their social and environmental efficacy (Harré et al. 1999; Carolan 2006; Elliott 2009). The sociologist Dorothy Nelkin (1994) provided a precedent for this more in the case of 'promotional metaphors,' drawing on a case study of the deterministic metaphors used to represent human genetics (see also Nelkin 2001). She argued that scientists use 'evocative images, catchy titles, and often corny metaphors' (1994: 25) to attract an audience. Importantly, she concluded that because of their need to promote themselves, scientists are 'prone to overestimate the benefits of their work. But in doing so, they contribute to overblown expectations that will ultimately undermine their base of public support. Thus, in the interest of public understanding, scientists should restrain promotional tendencies that lead to oversell' (1994: 30).

While Nelkin was thus an early promoter of 'narratives of humility' (see Jasanoff, this volume), her notion of a promotional metaphor has received surprisingly little attention. Here, I rely on interviews with two scientists who have recently used promotional metaphors to illuminate their use as well as their implications. In so doing I hope to expand both the breadth and depth of Nelkin's insight. I expand her discussion into a field where advocacy is arguably more appropriate – in the interests of biodiversity conservation perhaps scientists' promotional tendencies are justified, though not without confronting a series of ethical questions. While Nelkin discussed the consequences of media interviews with scientists, I also deepen her analysis by showing how scientists use such metaphors in primary research articles. Not only the media, but also scientists themselves, use metaphors to simplify, to teach and to sell.

Case studies: 'DNA barcoding' and 'invasional meltdown'

I draw on two metaphoric case studies that have four main advantages for this analysis:

1. They derive from recent biodiversity science, so we can to some extent observe 'science-in-action' rather than historically reconstruct it;
2. They can each be traced to a specific publication and to promotion by an individual scientist;
3. Because of their social resonance, they have both been heavily cited in the scientific literature and covered extensively by the media; and

4. Scientists have debated the semantic appropriateness of each metaphor in print.

The first case study is DNA barcoding. Although the metaphor of a 'DNA barcode' has been utilized in a number of scientific contexts (Arnot et al. 1993; Leier et al. 2000), it now refers to the use of a short DNA sequence, from a standard location in the genome, to identify species. This usage can be traced to a 2003 paper by Paul Hebert et al., which led to Hebert, as the senior scientist, becoming the 'father of DNA barcoding'. Strauss (this volume) tells Hebert's story of how he came up with the metaphor. The appeal of the barcoding idea is demonstrated not only by the more than 600 citations of this paper to date,[1] but also by widespread media coverage.[2] While DNA has long been used to identify species, DNA barcoding seeks to standardize taxonomy by using one DNA sequence – potentially the shortest one possible – to differentiate among species. For many organisms, this objective appears to be met by the first 648 bases of a mitochondrial gene, COI.

Why do this? An influential conservation biologist, Daniel Janzen (2004), argues that it will lead to the taxonomic equivalent of the Star Trek tricorder (a handheld instrument for scanning alien environments). Someday, given US$ 1–2 billion in funding, people will be able to identify an animal by putting a piece of it into a handheld 'barcoder'. Not only do proponents assume that this technology will improve everyone's access to biodiversity and their appreciation of it (for an alternative view, see Larson 2007a), but it will also help scientists to inventory biodiversity and perhaps even locate new species. It may also have diverse and undeniable practical benefits, mainly related to its ability to distinguish organisms based on small fragments – for example, fish in a market, old feathers from dead waterfowl or potentially invasive species at borders (like a species' identity card). Numerous scientists have discounted barcoding technology (Ebach and Holdrege 2005; Will et al. 2005; Rubinoff 2006), including the esteemed British biologist Lord Robert May (2004), who stated, regarding the possibility that 'widgets' will allow identification of organisms within 25 years, 'I am inclined to wonder what these people had been smoking'. Nevertheless, the proposal has drawn extensive media coverage and a funding largesse. At least in this regard, barcoding has been an extremely successful metaphor (see Strauss, this volume).

The second case study concerns 'invasional meltdown', a metaphor that can be traced to a paper in the journal *Biological Invasions* by ecologist Dan Simberloff and his graduate student Betsy von Holle (1999). They attribute the metaphor both to a suggestion by a colleague, Peter Kareiva, and to familiarity with another metaphor in conservation biology, mutational meltdown, which describes how mutations may accumulate in small populations of a species at an

1 According to Web of Knowledge [Online], see http://www.isiwebofknowledge.com [accessed January March 2009].

2 See http://www.barcoding.si.edu/media.html [accessed January 2009].

increasing rate and lead to their extinction (Gabriel et al. 1993).[3] An invasional meltdown, by contrast, concerns the effect of invasive species, or species that have been introduced from one part of the world to another. The metaphor specifically refers to the 'process by which non-indigenous species facilitate one another's invasion ... potentially leading to an accelerating increase in number of introduced species and their impact' (Simberloff 2006: 912). As another ecologist describes it, a meltdown 'implies that after a certain point is reached, ordinary intercession is impossible, and a drastic state change is inevitable – whether it occurs in a toddler in the supermarket, a nuclear reactor, or an invaded ecological community' (Gurevitch 2006: 919). While this idea does not appear to have captured nearly the attention of DNA barcoding in terms of funding and media coverage, it has been featured in recent popular books on invasive species (e.g. Baskin 2002), and 'the high visibility of certain cases … has led to increasing notice in newspapers, magazines, and even political speeches' (Simberloff 2006: 916). It is part of a broader attempt by some conservation biologists and ecologists to increase public awareness, understanding and concern about the effects of invasive species (for a more detailed metaphor analysis, see Larson 2008).

To better understand how the use of these metaphors was justified, I interviewed Dan Simberloff and Paul Hebert in the winter of 2007, upon approval from the University of Waterloo Office of Research Ethics. I followed standard protocols for research interviews, but was only able to conduct one interview, lasting about one hour, with each of them. I asked a number of open-ended questions, some general to both interviews and some more specific. The interviews were recorded and transcribed and then analyzed in terms of responses to key questions and for emergent themes. Unless indicated otherwise, quotes below are taken from these interviews, though they have been slightly reworded in the interest of clarity.

Scientists and their promotional metaphors

Traditionally, metaphors in science have been considered mere rhetoric. But were these two metaphors rhetorical or did their creators take them more seriously? In fact, both scientists appear to have adopted a realist attitude towards their metaphors and begun to think in terms of them. In this respect, they could be considered what the philosopher Richard Boyd calls constitutive metaphors (see Turney, this volume), or metaphors that form 'an irreplaceable part of the linguistic machinery of a scientific theory' (1979: 360).

Hebert, for example, pointed out that the barcode metaphor is 'less of a metaphor than the "Tree of Life" … in that it relates directly to the major product lines of life – species'. The 'tree of life' is a prevalent metaphor used to describe evolutionary history (e.g. the shape of phylogenetic trees, see McInerney et al.

3 It is thus an excellent example of an intra-scientific metaphor transfer (Bono 1990).

2008), and Hebert clearly felt that it is less apt than DNA barcoding in its domain: 'I'm not sure any phylogenetic relationship looks much like an oak tree'. While it is by no means literally true to say that evolutionary history is tree-like, we can also question whether species really are product lines. Such is the power of a constitutive metaphor.

Simberloff was also a realist with regard to meltdowns:

> It's a pretty accurate metaphor … I view it almost the way we picture real meltdowns as this expanding mass of particles hitting one another and some of them are black particles and some of them are white particles and they are introduced or native, but they're all interacting. That's just the way nature is.

While he acknowledges that this is 'almost the way we picture real meltdowns', even that type of meltdown is metaphorical. More importantly, note that his description of nature invokes a black and white dichotomy between native and introduced species, despite some of the philosophical challenges this poses (see Larson 2007b). Further, there are neither good nor bad particles in a 'real meltdown' but here the metaphor is extended in order to support the idea that introduced species are necessarily bad. It is undoubtedly true that these species are interacting, but does it have to be a meltdown? In fact, the phenomenon under investigation is the development of new mutualistic (cooperative) associations between invasive species. In many respects, that could be seen as a positive development, and it is certainly a normal biological process. But this view is over-ridden by the negative valence of a meltdown.

We can also infer that these metaphors were constitutive because they were both used even before they were well-supported empirically. Hebert's paper, for example, proposed DNA barcoding prior to the resolution of certain critiques (Meyer and Paulay 2005; and see above), as Nelkin (1994) predicted for promotional metaphors. In the case of invasional meltdown, Simberloff's retrospective, six years after the term was coined, acknowledged that 'a full 'invasional meltdown' … has yet to be conclusively demonstrated' (Simberloff 2006: 912). There are still only a few well-demonstrated cases, including the interaction between yellow crazy ants and scale insects on Christmas Island. While Simberloff maintains, 'I'd be surprised if we didn't see a number of other cases within ten years,' another ecologist notes that 'the lack of evidence for its existence is certainly not for want of attention to the hypothesized phenomenon … [It] may, in fact, be uncommon' (Gurevitch 2006: 920). And yet, the term has been in use all these years, influencing people through the media and other outlets. It almost seems as though its underlying values, rather than scientific evidence, justified its use. Otherwise, the possibility would have been stated in a more muted way; we should first know whether a phenomenon occurs before calamity is announced. As Gurevitch (2006: 920) observes, 'It is alarmist, but is it unrealistically so? We cannot know until we answer the scientific questions of its generality and magnitude'.

These metaphors were constitutive for the scientists and, more importantly, potentially used ahead of the evidence, but were they actually promotional in a broader social context? With regard to barcoding, Hebert observed,

> We knew that we were heading into a campaign for serious public support for the enterprise … the initial pitch was really to the broad readership and not to members of our scientific community … I would never have titled it 'DNA barcodes' if I were writing a paper for my five scientific peers … You want to be the flavor of the day.

Interestingly, here, epistemic values related to objectivity in science were already being given less precedence than ones related to social dimensions and framing.

Accordingly, Hebert encountered problems with his scientific colleagues. He stated, 'We took a lot of heat for using that term … We had an early hit on our credibility'. Some of the attacks were 'quite violent' and he received 'incredibly inflammatory emails'. Thus, he acknowledged that

> It would have been much more dangerous for a young academician to go forward with this metaphor. I don't think a young academic would have had the allies, so they wouldn't have survived the heat. It became dangerous for people to say anything positive about barcoding because of the packing instinct that, oh God, you're as dumb as the people that promoted that idea.

Continuing with the combustion metaphors, he felt that 'fighting back against the backdraft is quite consuming', but in the end it had been worth it. He credits the metaphor as 'a big asset' and one that has been 'very useful in delivering $13 million here in Canada'. It has recently delivered much more.

In contrast, Simberloff stated that he 'didn't see [meltdown] as controversial' and thus 'never conceived of it as a risk to my career or reputation in any way'. None of his colleagues raised any issues with it. He also 'wasn't committed to people ending up believing this was one of the major forces of invasion biology'. On the other hand, he did express some desire to appeal to both public and scientific audiences:

> I wanted people to read it and think about it. I wasn't aiming at the popular domain. I never thought there'd be anything in a newspaper about it at the time. But I didn't want it to be just another paper…, just sitting there with no one bothering to read more than the abstract.

He may have been surprised at its success, for he acknowledged that 'the meltdown metaphor attracted great attention, not only among invasion and conservation biologists, but also in the popular press' (Simberloff 2006, 912, and personal communication). Though somewhat tongue-in-cheek, he attributed part of its popularity, relative to a coincident paper on the topic (Richardson et al. 2000), to

the humdrum title of the latter, 'Plant invasions – The role of mutualisms'. '[The Richardson paper is] a better review. And it's very rarely cited . I think if they had entitled theirs "meltdown," it would probably be cited ten times as much'. In fact, it has been cited over 250 times.[4]

The ethics of promotional metaphors

At this point, it is worth revisiting the question of advocacy in science. A critical issue is whether a scientist acts as a 'stealth issue advocate' (Pielke 2007), advocating a particular stance without stating it explicitly. When a scientist does so, adopting a guise of scientific neutrality to influence policy, it may diminish science's reputation and its contribution to effective policy-making (Pielke 2007; Chan 2008). Ultimately, the facts in themselves never justify conservation action, as such action always relies upon particular conservation values. The two scientists interviewed here share a concern for biodiversity and want their metaphors to contribute to its conservation. While value-laden language might assist here, 'we can minimize the mixing of facts and values by explicitly distinguishing them' and by using a term 'in ways consistent with our values …, but [noting] this value judgment when defining the term' (Chan 2008: 2). Part of the challenge, however, is that such values may be apparent to others, though not to the scientists themselves. The tension is to find enough linguistic precision for science while simultaneously selling the idea to the public through metaphoric resonance. It's a fine line; going too far the former way prevents promotion and advocacy whereas going too far the other may cause problems for scientific credibility.

As an example, both scientists encountered challenges arising from the unruliness of metaphor. Hebert initially felt that the barcoding metaphor was 'beautiful' and 'just perfect', and though it had 'serious baggage in the scientific community … it resonated immediately with the public. It drew in the unwashed masses'. But there was a flip-side, namely 'bizarre Orwellian ideas'. Some associated DNA barcoding with Craig Venter's wish 'to provide a whole genome sequence for every human being at birth for a thousand dollars', to which Hebert replied, 'We're so far from that it's not even funny'. Elsewhere, a comedian wrote, 'Why don't these darn scientists take up needlepoint and leave the world alone. Within ten years, every cardinal at my birdfeeder will have a barcode'. While this was meant to be comical, there were others who were more serious: 'you're destroying the world … you're an evil person and you should stop doing this. You're on the road to hell if you keep on. Every human will be imprinted with a barcode and you've started this'. This perfect metaphor was not perfect for all occasions.

4 According to Web of Knowledge [Online], [accessed March 2009]. Unfortunately, Web of Knowledge does not provide the number of citations of the Simberloff and Von Holle (1999) paper.

Hebert also felt that part of the problem was biologists themselves. He specifically felt that:

> there's a lot more angst among biologists than there is in some of the other more mature communities. I'm always interested in physics, which is intrinsically much more distant from the public and they seem to have an immense appetite for using terminologies that biologists would reject as being too flippant. You would pay a heavy price in biology for most of the terminology that's developed in physics. I think they're just simply secure in their science and let's just have a bit of fun with it then.

Some biologists and philosophers would consider this perspective an expression of 'physics-envy', for there are certainly many ways in which the biology he is talking about matters to us more – and very differently – than abstract physics (see Dupré 2007). Accordingly, physics may not be an appropriate model for biology.

Simberloff also acknowledged misunderstandings, but would have used the metaphor anyway as 'the press always misrepresents science'. As he states elsewhere, '[Some] writers for the lay public [have] stretched it well beyond its meaning as understood by invasion biologists' (Simberloff 2006: 912). Further, he claimed that 'loose usage in the popular press has led to a backlash' (Simberloff 2006: 916, and personal communication).

From these examples we see how scientists want precise language, but in using promotional language such as this they cannot control its interpretation. Simberloff (2006) captures this paradox in his recent review when he refers to the 'meltdown' as a 'constitutive metaphor' at one point yet as 'hyperbole' at another. There are inherent risks in metaphoric communication, in part because there are differing dynamics within science, politics, and the mass media (Weingart et al. 2000). Yet scientists repeatedly blame misinterpretations on the public, rather than their metaphor. As Simberloff (2006: 916) reports, 'it is true that martial metaphors occur in the invasion biology literature [and] such metaphors become more vivid and pervasive when the popular press reports on these subjects'. In this manner, scientists disclaim responsibility for their linguistic choices. While this is reasonable at some level, as we can't foresee every potential interpretation, is it reasonable that everyone should think of species as consumer goods or of their interactions as being like a nuclear power plant catastrophe?

It is also worth noting that we might have foreseen these interpretations. In a certain context, albeit a mistaken one from Hebert's perspective, his metaphor does seem bizarre and Orwellian. Aside from people thinking that species' barcoding might lead to individual humans being barcoded – which Hebert rightly points out makes no sense since 'all we're doing is telling you you're a human' – in a sense the control it seeks over other species is in fact quite Orwellian. It is consistent with our desire to be the Big Brothers of biodiversity (Larson 2007a).

Similarly, people can certainly interpret meltdown differently than Simberloff intends. As is often the case, however, we can see science-centrism in the

evaluation of scientific metaphors: 'There is no evidence that this hyperbole has impeded scientific understanding or caused loss of scientific credibility' (Simberloff 2006: 912). He acknowledges, however, that the term meltdown is 'certainly pejorative':

> 'Meltdown' first appeared in 1965 with reference to nuclear reactors and, in the wake of the Three Mile Island disaster, became increasingly widely used, even metaphorically, to describe processes irreversibly deteriorating, apparently at an accelerating rate – children's temper tantrums, escalating internet crashes, the 2005 University of Tennessee football team, and the like (Simberloff 2006: 916).

The fact that the term can be used in all these contexts demonstrates that it can be interpreted in diverse ways consistent with the broader social context in which it occurs. This is not an argument for using it in science. Rather the opposite. As Gurevitch (2006: 919) points out, 'scientists need to be held to a higher standard than the general public in using metaphors and concepts precisely'.

There are deeper stealth policy implications in these metaphors. Nelkin (1994: 27) observes that 'though the gene in popular culture refers to a biological construct and derives its cultural power from science, its symbolic significance rests less on scientific realities than on social meanings'. Similarly, Hebert's metaphor is implicitly a political statement because it proposes that we handle and relate to biodiversity in one way as opposed to others (Larson 2007a). It is such conscious or unconscious stealth advocacy, hiding values within scientific statements, which can lead to the discrediting of science and to policy blockage. Hebert stated that 'I actually would not mind the fact of humanity starting to think of species as important items on the store shelf of life. I mean, I really think that might be a very progressive step from the current view, which is that you can't read these things at all'. It is arguable whether we should treat species as product lines of life, but the barcoding metaphor brings that perspective in through the back door, beyond ethical scrutiny. While Hebert argues that this perspective could bring recognition to the purpose of non-human species, it is equally possible that it would devalue them. They are living beings that have an intrinsic value, in contrast to the instrumentalist view that they are there for mainly our purposes, to meet our needs as 'product lines of life'. They may be 'lines' of life, but are they products? In a broader sense, Hebert's metaphor places biodiversity within a very consumeristic context (Larson, in preparation).

Similarly, a 'meltdown' carries various associations and, from my informal discussions with people, most of them are negative. It is apocalyptic with regard to invasive species – they are bad – and it thus advocates on behalf of native ones. The metaphor is used to incite a fear of the consequences of this 'meltdown'. It draws on a prevalent 'fear-factor' approach to invasive species, one that has been drawn into question by other scholars citing empirical social data (Gobster 2005). In this sense, it is ethically suspect in a scientific context because it communicates

more than just the facts of the matter. Rather than engaging the reader in open dialogue about the dynamics and consequences of invasive species, it skips to a political statement that invasions are bad. Even if this is the way some scientists feel, there are problems with framing such political statements and personal values as scientific facts.

As Nelkin observed, promotion is a double-edged sword and scientists must somehow balance its benefits and costs to peers and funding agencies, not to mention the public more generally. Communication is a two-way street (Weber and Word 2001). Accordingly, scientists need to take greater responsibility if they are going to use metaphors to attract attention. They cannot arbitrarily raise and lower the bar – with preferred associations of a word being considered 'scientific' and others being considered naive and unscientific. Metaphors are by their nature words that operate to break down such boundaries, including the one between science and society (Bono 1990; Larson 2006). Social scholars have repeatedly shown that scientists negotiate this boundary to maintain their authority (Gieryn 1999) and metaphors provide a prime mechanism by which they do so.

In the classic case, often called the 'linear' model of science and society (Pielke 2007), scientists create objective knowledge that is then adopted (or not) by people in society 'downstream'. With the metaphors considered here, however, scientists advocate a particular view themselves, even without the media as an intermediary. They are promoting a particular way of approaching or viewing something, which is by its nature ideological; yet they are relying on their scientific authority to do the selling for them. They are advancing personal and political views in the guise of scientific language.

They also used these metaphors even before their appropriateness had been settled. This might seem unfair, as Hebert, for example, likely felt that he had enough support and his paper was published in a refereed journal. But journals are not above fanfare. Simberloff also appears comfortable working ahead of the evidence, waiting for time to prove him right. An alternative model for the development of such an idea would be to begin more slowly rather than with such a bang (see Nerlich, this volume). At a later date, when the scientific evidence was nearly incontrovertible, the public communications campaign could have begun. Metaphorically speaking, they could be more muted and increase their volume as the evidence accumulated. But this would require tremendous patience and restraint. In particular, the allure of funding and prestige would make this challenging. Hebert may be correct that the project would never have received the funding it did without the vision and the metaphor that were provided, but could he have waited longer? Perhaps not in a climate where science is conceived, more and more, as a race for funding, breakthroughs and commercial benefits (see Nerlich, this volume).

There is an additional problem with using metaphors before they are well supported. Like it or not, non-scientists are more likely to take scientific results as hard facts than many scientists. In this context, it is possible that scientists face certain problems that journalists do not. Specifically, biologists appear more

likely to take their metaphors as real, as opposed to the journalists who might be aware that they are popularizing. As these case studies have shown, biologists who coin metaphors seem to have, at some level, really adopted the metaphors they have proposed such that they recognize little distinction between metaphor and reality. While journalists may take more liberties in using novel metaphors, perhaps everyone understands that that is their role; their metaphors are not meant to correspond as closely to reality as those used by scientists. In some cases, scientific metaphors such as the ones discussed here subsequently drive the journalistic response.

Conclusion

How might scientists approach these ethical issues? How might they make decisions about the degree of advocacy to pursue? Metaphors remain with us for a long time once they are activated (see Hellsten, this volume) and it could be decades before we can assess whether their use was appropriate. I suggest that this is all the more reason to take care.

We might imagine two extremes. On the one hand, scientists could be more objective in decisions about metaphors. By weighing their contextual interpretation, they might forestall potential misinterpretations that could cause people to reject a conception they might otherwise accept. If scientists wish to use such metaphors, they might better rely on the best available knowledge rather than their intuitions (which may be wrong). It is an empirical question whether 'DNA barcoding' leads people to value organisms more or less. It is similarly an empirical question whether a 'meltdown' draws appropriate attention to invasive species.

Rather than conducting that empirical work, as a social scientist might approach it, we see assumptions masquerading as facts. In declining to assess the implications of their metaphors, Simberloff claimed 'I don't have enough expertise in psychology and sociology' and Hebert stated, 'I can't speak for the public'. But they still did so implicitly in deciding to use them. Simberloff, for example, claimed that he 'thought about all the right things', but as we've seen above he saw his metaphor as neither emotional nor controversial. He also acknowledged in the interview that he 'didn't think about' whether he might have set himself up for misinterpretation by using the metaphor he did. Just as we have social processes to assess potential new technologies, perhaps we need the same for metaphors, which instantiate a particular way of relating to the world.

One empirical angle would be to explore whether alternative, less expressive metaphors would work. Hebert discounted the alternative expression 'species-specific DNA sequence tags' as 'I'm pretty sure the public would have rolled their eyes up and gone to sleep'. He remarked, 'if we had presented it gently, nothing would have happened … To me, it's a big success, so therefore we can't have screwed up too badly'. Hebert thereby measures the success of the DNA barcoding project in terms of funding received. In modern science, that has often become the

ultimate measure of worth – though others would argue that such an enterprise is not worthy of the name of science. Indeed, at one point the US National Science Foundation rejected a funding appeal because DNA barcoding was 'not science'. Such issues merely reveal the extent to which modern science is in the business of fund-raising, with all the related issues of how this might affect objectivity. On the other hand, some scientists might feel that the risk is worth it in the interest of conserving biodiversity.

Simberloff also considered alternatives such as 'positive feedback', which was 'one of a number of boring titles'. Gurevitch (2006: 919) uses another catchy metaphor: 'Runaway positive feedbacks in a system create "snowball" effects in which a phenomenon builds on itself in an accelerating fashion, becoming unstoppable'. We have very little understanding of how people would respond to such alternatives. And even if we did, would a social marketing approach to scientific metaphors be appropriate or even possible (see Larson, in preparation)?

At the other extreme, we can turn in a very different direction than the 'objectivity' usually pursued in both the natural and social sciences. In an insightful essay on humanities and science, Lewis Thomas (1985: 155) suggests that we turn to poets, 'on whose shoulders the future rests'. At the very least, this might bring humility. We can find some evidence above that these scientists were more committed to what Jasanoff (this volume) called 'technologies of hubris' than to 'technologies of humility'. Hebert, for example, asked, 'How do you present a revolution?' Even with this intention, poets could help. Working with the social scientists alluded to above, poets – and others sensitive to the nuances of our language choices – might help us to coin better metaphors and to foresee where they might lead. This would lead to a very different form of science, one in which humanities and science were more fully blended and, with them, science and society – allowing each of us a more constructive role in decisions about which metaphors we want to shape our world.

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