LETTERS

The Problem with Patents

SHUJI NAKAMURA'S PERCEPTION THAT THE United States is the land of opportunity for inventors ("Inventor knocks Japan's system after settlement," News of the Week, D. Normile, 21 Jan., p. 337) requires some qualification. Although it is true that some inventors capitalize on the value of the intellectual property they own by patenting their inventions, the majority of inventors realize very little monetary reward. A large percentage of the scientists and engineers producing inventions with potential commercial value in the United States are employed by companies that require, as a condition of their employment, that all intellectual property rights developed using company resources must be assigned to the company for a nominal quid pro quo.

Some inventors develop their ideas, reduce them to practice, and receive patents to protect their intellectual property using their own resources. Without the ability to manufacture, market, and distribute the fruits of their labors, however, these inventors must sell their concept to a company with the ability to bring their invention to market.

> "Although it is true that some inventors capitalize on the value of the intellectual property they own by patenting their inventions, the majority of inventors realize very little monetary reward."
>
> –CRONLUND

On rare occasions, an inventor has the right balance of technical innovation and entrepreneurial skills to make a thriving business out of his or her inventions. Success in these ventures requires dedication, hard work, and shrewd business acumen.

Nakamura should consider himself fortunate that he was able to get $8 million compensation for his inventions from a Japanese for-profit company. In the United States, he might have received $1 for each of his inventions. The contributions of inventors in corporate employment are inadequately compensated. Those scientists and engineers employed by U.S. companies would work day and night with little complaint if the companies rewarded them with a reasonable fraction of the profits realized from their inventions. Talk about incentive!

MALCOLM CRONLUND
958 Meadowbrook Drive, Huntingdon Valley, PA 19006, USA.

Defining the Concept of Public Information

IN THEIR REVIEW OF INFORMATION USE BY animals in social contexts ("Public information: from nosy neighbors to cultural evolution," 23 July 2004, p. 487), É. Danchin *et al.* do an excellent job of reviewing the importance of socially acquired information in a wide taxonomic range of animals. Nevertheless, I feel that discrepancies in the use of the term "information" by Danchin *et al.* warrant attention because they are symptomatic of a broader challenge facing biology, particularly organismal biology.

With the widespread acceptance of Darwinian and neo-Darwinian reasoning in the biological sciences, information has emerged as a central analytical concept (*1*–*4*), yet there are significant inconsistencies in its use. These stem largely from a reluctance to define it explicitly when formal definitions borrowed from communication theory and physics (*5*) do not apply (*6*). To their credit, Danchin *et al.* break ranks and attempt an explicit (albeit informal) definition: "Information is anything that reduces uncertainty" (p. 487). However, this definition suffers from similar limitations in its biological applicability as more formal entropy-based concepts of information (*5*) by implying that ambiguity reduction per se is valuable (since information is presumably valuable), which is at odds with the way that informational analogies are typically made (implicitly) in organismal biology. To see why ambiguity reduction on its own is not a sufficient property of information as referred to by Danchin *et al.*, consider an extreme example: If an individual is killed by a predator (or indeed anything else), uncertainty about its future is reduced, yet by dying it does not acquire information. Other examples of this limitation to the stated definition abound in the text. Yet, the value of the Review, focused as it is on socially acquired information, hinges on such information use having special biological implications; in other words, by using this type of information, rather than, say, personally acquired information, animals behave in ecologically and evolutionarily important ways, a conclusion Danchin *et al.* persuasively sustain. This paper is thus an excellent illustration of why "pragmatic" or "semantic" concepts of information are needed in biology (*3*); information as ambiguity-reduction per se is a "syntactic," meaning-free concept (*7*) and does not capture many of the ways that researchers think about information in organismal biology.

Recently, Maynard Smith (*1*, *2*) rekindled interest in developing a biologically meaningful concept of information, emphasizing the need for an explicitly evolutionary perspective. Jablonka (*3*) subsequently took up the challenge to extend Maynard Smith's deliberations to accommodate nongenetic information, focusing on the crucial link between information and its use by emphasizing that information must have the potential to "change the state of the receiver in a… functional manner…" (p. 582). Thus, in keeping with philosophical traditions in biology, evolved entities in the form of information receivers are assigned a central role, along with their functioning from an evolutionary perspective. I feel that recent developments such as these, together with the conceptual issues they raise, deserve attention in any discussion of information use by individual organisms, such as that by Danchin *et al.* It is only by exploring such ideas explicitly, as well as developments in formal semantic-pragmatic information theory (*8*) and how animals actually use information, that progress will be made toward a scientifically useful definition of information for the biological sciences. After all, information is an integrative concept in biology that has yet to be integrated coherently.

SASHA R. X. DALL*
Department of Zoology, University of Cambridge, Downing Street, Cambridge CB2 3EJ, UK. E-mail: sashadall@iname.com
*Present address: Centre for Ecology and Conservation, University of Exeter in Cornwall, Penryn, Cornwall TR10 9EZ, UK.

References

1. J. Maynard Smith, *Q. Rev. Biol.* **74**, 395 (1999).
2. J. Maynard Smith, *Philos. Sci.* **67**, 177 (2000).
3. E. Jablonka, *Philos. Sci.* **69**, 578 (2002).
4. R. Dawkins, *A Devil's Chaplain, Reflections on Hope, Lies, Science and Love* (Houghton Mifflin, New York, 2003), pp. 91–103.
5. See, for example, C. E. Shannon, W. Weaver, *The Mathematical Theory of Communication* (Univ. of

Illinois Press, Urbana, IL, 1949).
6. See, for example, S. R. X. Dall, R. A. Johnstone, *Philos. Trans. R. Soc. London Ser. B.* **357**, 1519 (2002).
7. J. C. A. van der Lubbe, *Information Theory* (Cambridge Univ. Press, Cambridge, UK, 1997).
8. See, for example, E. D. Weinberger, *BioSystems* **66**, 105 (2002).

IN THEIR REVIEW "PUBLIC INFORMATION: from nosy neighbors to cultural evolution" (23 July 2004, p. 487), É. Danchin *et al.* illustrate convincingly that animals can use information about the behavior of other individuals in their decision-making and that such use can trigger cultural evolution. Yet, their suggested unified concept of "public information" (PI) remains somewhat vague, possibly for two reasons.

First, in their attempt to highlight the implications of PI, they expand the meaning of this term from merely describing a potential resource (a type of information) to a term that also describes a "phenomenon," and a "tool" for research (p. 490). As a result, it is not clear whether the concept of PI represents a theory, a process, or merely a potential resource. We believe that the latter, less complicated designation would in fact be more constructive. The existence of PI as a potential resource is hardly disputed, and the open issues for research are (i) the extent to which this resource is actually being used by animals and (ii) the extent to which it is being transmitted culturally across generations.

The second problem in defining PI is the authors' exclusion of information derived from animals' locations and signaling behaviors (see their fig. 1). This narrow definition may be impractical. For example, information about location may frequently be correlated with information about performance or quality (e.g., feeding site or male's position on a lek), so it seems difficult to distinguish between PI and information about location in practice. Signaling behavior, such as bird singing, in addition to containing cues for male quality, likely also provides information about male density: Is such information not PI? The exclusion of signaling comes to a real paradox when we have to deal with teaching, which is the most advanced form of information transmission in cultural evolution and which clearly involves communication: What are we to make of such intentional information transmission? Rather than viewing what we teach as nonpublic information, it would seem that there is room for considering a variety of public information sources available to animals and for using a more practical definition of PI that includes any information derived from the behavior of other individuals.

ARNON LOTEM[1] AND DAVID W. WINKLER[2]
[1]Department of Zoology, Faculty of Life Sciences, Tel-Aviv University, Tel-Aviv 69978, Israel. E-mail: lotem@post.tau.ac.il. [2]Department of Ecology and Evolutionary Biology, Cornell University, Corson Hall, Ithaca, NY 14853, USA. E-mail: dww4@cornell.edu

IN THEIR STIMULATING REVIEW "PUBLIC information: from nosy neighbors to cultural evolution" (23 July 2004, p. 487), É. Danchin *et al.* combine a sweeping survey of behavior and culture with a focused advocacy for public information's role in cultural evolution. In my reading, these elements are in tension. The examples given often go beyond the definition that public information is about the quality (rather than location) of a resource and is revealed by the performance of other individuals. Scrub jays only need to learn the location of other jays' caches to rob them, and fish do not need to observe any behavior to avoid an area containing alarm substance. These examples reveal that many interesting and important aspects of behavior may not strictly involve public information.

Although the authors couch their conclusions in terms of public information, this term is mentioned only sporadically in the second half of the Review. I found many instances where the broader terms "social information" or "inadvertent social information" could be substituted for "public information" without loss of meaning. It may be useful to discuss the relative importance of communication and inadvertent social information to cultural evolution, but it seems unnecessary and potentially counterproductive to advocate for one form of information while ignoring others.

PETER A. BEDNEKOFF
Biology Department, Eastern Michigan University, Ypsilanti, MI 48197, USA.

WE ENDORSE É. DANCHIN *ET AL.*'S EMPHASIS on public information, both as a taxonomically widespread source of adaptive behavior and as a driver of social evolution ("Public information: from nosy neighbors to cultural evolution," Review, 23 July 2004, p. 487). However, we feel it is important to stress the costs of public information and to consider why some species of vertebrates do not exploit this reservoir of knowledge. In our study of public-information use in two closely related species of sticklebacks (*1*), we found that nine-spined sticklebacks (*Pungitius pungitius*), after watching conspecific or heterospecific demonstrators feeding at two patches and then tested alone, tend to approach the former location of the richer patch. As their observational experience was restricted to the relative success of their demonstrators, and potential alternative explanations could be ruled out, we surmised that nine-spined sticklebacks were capable of public-information use. However, three-spined sticklebacks (*Gasterosteus aculeatus*), when subject to the same test, swam with equal frequency to the former locations of rich and poor patches. Why should one species and not the other rely on public information?

The answer to this conundrum comes from a mathematical analysis of the adaptive advantages of human culture. Boyd and Richerson (*2*) postulate a costly information hypothesis, which proposes an evolutionary trade-off between reliable but costly self-acquired information and potentially less reliable but cheap socially transmitted information. The relative cost of acquiring personal information varies between the two stickleback species, which determines the value of public information. Three-spines have large spines and armored body plates—robust structural defenses that allow them to sample alternative food patches directly, in relative safety. Such sampling by nine-spines, which have weaker physical defenses, would leave them vulnerable to predation and hence, in fitness terms, would be extremely costly. Consequently, nine-spines spend much of their time in refuge, from where selection seemingly has favored the ability to monitor the foraging success of others. Considerable evidence is accumulating among fish, birds, and mammals that animals will ignore public information under specific circumstances (*3*). For example, nine-spines will ignore public information if they have reliable, up-to-date personal information, yet switch to exploiting public information if their personal information is unreliable or outdated (*4*). In turn, the costs associated with public information can stimulate the collection of personal information that refreshes the cultural knowledge pool (*5*), providing the variation required for cultural evolution.

KEVIN N. LALAND,[1] ISABELLE COOLEN,[2] RACHEL KENDAL[3]
[1]School of Biology, University of St. Andrews, Bute Medical Building, Queen's Terrace, St. Andrews, Fife KY16 9TS, Scotland. [2]Institut de Recherche sur la Biologie de l'Insecte, Université de Tours, Avenue Monge, 37200 Tours, France. [3]Department of Biological Sciences, Stanford University, Stanford, CA 94305, USA.

References

1. I. Coolen, Y. van Bergen, R. L. Day, K. N. Laland, *Proc. R. Soc. London Ser. B* **270**, 2413 (2003).
2. R. Boyd, P. J. Richerson, *Culture and the Evolutionary Process* (Univ. of Chicago Press, Chicago, IL, 1985).

3. R. L. Kendal, I. Coolen, Y. van Bergen, K. N. Laland, *Adv. Study Behav.*, in press.
4. Y. van Bergen, I. Coolen, K. N. Laland, *Proc. R. Soc. London Ser. B* **271**, 957 (2004).
5. T. Kameda, D. Nakanishi, *Evol. Human Behav.* **23**, 373 (2002).

Response

THE LETTER WRITERS RAISE SEVERAL questions that provide us with the opportunity to clarify important points about public information (PI) and cultural evolution. Four major issues are raised.

What is information? We agree with Dall that a biological definition of information should be linked to the fitness consequences of having it. Our definition that information is "anything that reduces uncertainty for the observer" (our fig. 1) is set in an evolutionary context. Information thus changes the state of the receiver in a functional way: It improves fitness when a more effective response is made possible by the reduced uncertainty about current environmental conditions. A more specific definition of information is "anything that reduces uncertainty, potentially allowing a more adaptive response."

What is Public Information? While Dall questioned the definition of information generally, Lotem and Winkler and Bednekoff each question our definition of public information as information derived from the "performance of other individuals sharing similar environmental requirements." They suggest that this definition is too specific because in general use, "public" usually refers to commodities that are available to all. Our application of PI accounts for its long-term use in the literature. However, we agree with the need for a broader perspective, which is why we introduced the term inadvertent social information (ISI), which includes PI. Furthermore, Lotem and Winkler propose that PI should incorporate signaling and teaching, both of which are deliberate transmissions of information. However, it was our goal to highlight the fact that cues inadvertently produce information, while signals produce information deliberately. By viewing cues separately from signals, our aim was to explore the consequences of inadvertent information alone. We recognize the existence of interactions between cues and signals (our fig. 1), both of which, for example, contribute to culture and reputation. We also stated that cues "may be viewed in some contexts as the platform from which signals evolve." Thus, by separating cues and signals, we can better understand both in order to subsequently synthesize them.

Lotem and Winkler also criticized our unified concept of PI as being vague because we have described it as both a "tool" and a "phenomenon." Here we specify that clear definitions of phenomena are important tools that can be used in experiments. Lotem and Winkler further interpret our paper to suggest that PI can also be viewed as a resource. However, we do not state this and suggest here that it may not be useful to view information as a resource because unlike most resources, the use of information does not usually result in its depletion.

Is using PI always adaptive? Laland *et al.* note that the use of PI may sometimes be costly. Although many forms of PI use may be beneficial, we acknowledge that its benefits are by no means universal. In instances where the gathering of personal and public information are incompatible activities, animals must choose continuously which type of information to gather. When everybody is watching everybody else, there is nobody to produce PI. This frequency-dependence is akin to producer-scrounger games (*1*) where stable equilibrium mixtures of the two alternatives are expected (*2*). The paradoxical outcome of this frequency-dependence is that even though using PI could be advantageous, it spreads within a group until it does not pay any more than using personal information only (*3*). PI is used not because it provides a benefit over its alternative, but because it would be costly not to use it (*2*). The potential for such a trade-off highlights the importance of ascertaining the relative value of public versus personal information. Another potential constraint to the use of PI concerns informational cascades, which occur when public information overrides personal information such that all decisions are based on the behavior of others, irrespective of one's own personal information (*4*). Although cascades may be produced by adaptive decision-making, they can sometimes lead to incorrect responses. Thus, as Laland *et al.* underline, we expect variation in PI use across species, with that one factor explaining variation in the cost of acquiring it.

The importance of public information and its potential to trigger culture. Bednekoff questions our emphasis on PI in relation to cultural evolution. Our goal was not to advocate ignoring other contributors to cultural evolution, but rather to explain how ISI in general, and PI in particular, can be important contributors to cultural evolution. Culture can be viewed as a by-product of learning from others (*5*, *6*), and our Review shows that many major fitness-enhancing decisions do involve PI, that is, learning from others. In our fig. 3, we used the broader expression ISI to save space. However, elsewhere we made explicit that we view PI as a major component of ISI that contributes to cultural evolution.

Finally, evidence exists for the occurrence of traditions even in invertebrates (*5*). The existence of cultural processes in taxa other than vertebrates would considerably increase the potential role of culture in the evolution of life. We reiterate that evolutionary biologists should consider the possibility that cultural evolution plays a significant role in evolutionary processes and that PI may provide an important concept for studying cultural evolution in animals.

ÉTIENNE DANCHIN,[1]* LUC-ALAIN GIRALDEAU,[2] THOMAS J. VALONE,[3] RICHARD H. WAGNER[4]

[1]U.P.M.C. CNRS-UMR7625, Bât A, 7è étage, Case 237, 7 quai Saint Bernard, 75252 Paris Cédex 05, France. [2]Groupe de Recherche en Écologie Comportementale et Animale, Département des Sciences Biologiques, Université du Québec à Montréal, Case Postale 8888, Succursale Centre-Ville, Montréal, QC H3C 3P8, Canada. [3]Department of Biology, St. Louis University, St. Louis, MO 63103, USA. [4]Konrad Lorenz Institute for Ethology, Austrian Academy of Sciences, Savoyenstrasse 1a, A-1160 Vienna, Austria.

*To whom correspondence should be addressed. E-mail: edanchin@snv.jussieu.fr

References

1. L. A. Giraldeau, T. Caraco, *Social Foraging Theory, Monographs in Behavior and Ecology* (Princeton University Press, Princeton, 2000).
2. L. A. Giraldeau, T. J. Valone, J. J. Templeton, *Philos. Trans. R. Soc. B* **357**, 1559 (2002).
3. T. Kameda, D. Nakanishi, *Evol. Hum. Behav.* **24**, 242 (2003).
4. S. Bikhchandani, D. Hirshleifer, I. Welch, *J. Econ. Perspect.* **12**, 151 (1998).
5. S. Blackmore, *The Meme Machine* (Oxford Univ. Press, Oxford, 1999).
6. E. Avital, E. Jablonka, *Animal Traditions-Behavioural Inheritance in Evolution* (Cambridge Univ. Press, Cambridge, 2000).

PLOS Position on NIH Public Access Policy

THE RECENT NEWS ARTICLE "NIH WANTS public access to papers 'as soon as possible'" (J. Kaiser, News of the Week, 11 Feb., p. 825) misrepresents the Public Library of Science's position on the National Institutes of Health's new Public Access Policy. It is not the case that we are "pleased with the wording." To the contrary, our view is that the policy should have been stronger in several respects (*1*).

For one thing, to serve the public interest more effectively, the agency's language should have been to "require" or "expect" rather than "request" the deposition of NIH-funded articles in the National Library of Medicine's free-to-use Internet repository, PubMed Central. For another, the maximum allowable delay before articles' public release should have been at most 6, rather than 12 months—particularly since no publisher has presented evidence that the free availability of a fraction of its journals' articles half a year after publication would adversely affect subscription revenues.

ANDY GASS AND HELEN DOYLE

Public Library of Science, 185 Berry Street, Suite 1300, San Francisco, CA 94107, USA.

Reference

1. See www.plos.org/news/announce_nihpapolicy.html.

CORRECTIONS AND CLARIFICATIONS

News of the Week: "Unnoticed amendment bans synthesis of smallpox virus" by M. Enserink (11 Mar., p. 1540). The story stated that Peter Jahrling studied variola at the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) in Fort Detrick, Maryland. While Jahrling was employed by USAMRIID at the time, the experiments were carried out at the Centers for Disease Control and Prevention in Atlanta.

Netwatch: "Breaking down diabetes" (4 Mar., p. 1385). This item incorrectly listed the sponsors of the T1DBase. The site is is funded by the Juvenile Diabetes Research Foundation (JDRF) and is a collaboration between the JDRF/Wellcome Trust Diabetes and Inflammation Laboratory and the Institute for Systems Biology.

News of the Week: "Report puts Pasteur move on hold" by M. Enserink (4 Mar., p. 1391). The story misspelled the name of a building on the Pasteur Institute campus in Paris. The building is named Duclaux.

This Week in Science: "A tamed radical" (14 Jan., p. 177). In the 12th line, "rhenium" should instead read "rhodium."

TECHNICAL COMMENT ABSTRACTS

COMMENT ON "Grain Boundary–Mediated Plasticity in Nanocrystalline Nickel"

Mingwei Chen, Xiaoqing Yan

Shan *et al.* (Reports, 30 July 2004, p. 654) reported transmission electron microscopy observations of nanograin rotation and claimed that the plasticity of nanocrystalline nickel is mediated by this grain boundary behavior. Our analysis of Shan's results suggests that the contrast change more likely results from nanograin growth rather than plastic deformation.

Full text at www.sciencemag.org/cgi/content/full/308/5720/356c

RESPONSE TO COMMENT ON "Grain Boundary–Mediated Plasticity in Nanocrystalline Nickel"

Zhiwei Shan, E. A. Stach, J. M. K. Wiezorek, J. A. Knapp, D. M. Follstaedt, S. X. Mao

Chen and Yan propose that the contrast changes we observed likely do not result from plastic deformation. We provide specific reasons why we disagree and why their measurement approaches are inappropriate, as well as further evidence supporting our original conclusion of grain boundary–mediated deformation.

Full text at www.sciencemag.org/cgi/content/full/308/5720/356d

Published by AAAS