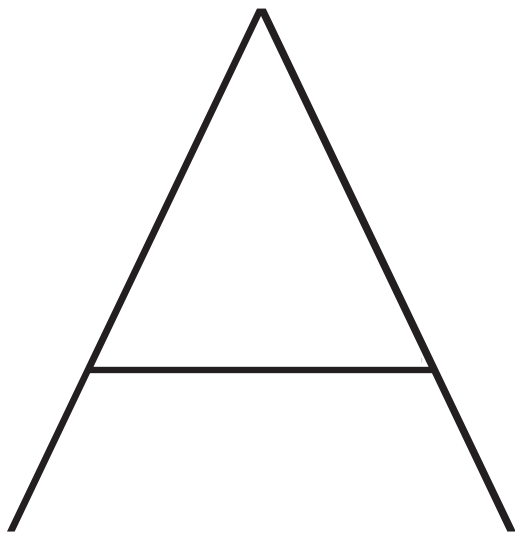


# SCIENCE 2.0: YOU SAY YOU WANT A

by **Randy Barrett** illustration by Clare Louise Mallison

The collaborative online tools people are using in other parts of their lives, such as Facebook, YouTube, and blogs, are roiling the disciplined world of scientific communication.



**SMALL GROUP OF RESEARCHERS WANTS SCIENCE to come out from behind closed doors, and they are exploiting a variety of Web-based means to help it do just that. Consider *Brain Windows*, a blog launched in 2006 by Andrew Hires to track and discuss advances in brain-imaging technol-**

**ogies. “Mostly, blogs are an easy way to communicate and distribute knowledge”—a “filtering mechanism” that can help scientists navigate their way through the blizzard of information online and find what’s important to their work, says Hires, a postdoc in Loren Looger’s lab at HHMI’s Janelia Farm Research Campus. ¶ Hires’ effort is but one small step in a quiet revolution for researchers, who have relied on traditional forms of scholarly communication—peer-reviewed journals, scientific meetings—for more**

than a century. His forebears would likely have blanched at the very prospect of free, unfettered, and seemingly instant access to proprietary information, as scientists have long been hesitant to share their thinking process with others prematurely for fear of having their ideas stolen.

Slowly, however, the culture is changing, not only through blogs but also by means of open notebooks, open publishing, and other interactive models. Those involved call it Science 2.0, an effort to harness the capabilities of the Internet to help scientists communicate better among themselves as well as to the public at large.

#### **INTO THE BLOGOSPHERE**

While many of their older counterparts remain wary, younger scientists have taken to the medium quite naturally. When Hires is not blogging himself (he posts when the spirit moves him, or research catches

his eye), he enjoys visits to other cyber sources such as *Bohemian Scientist*, *Brain Waves*, and *Neurodudes*.

Neville Sanjana, a graduate student in the lab of HHMI investigator Sebastian Seung at Massachusetts Institute of Technology (MIT), founded *Neurodudes* in 1999 along with Bayle Shanks and Stephen Larson, both at the University of California, San Diego. It started as an informal e-mail list among friends but soon became a place to share scientific concepts, news, and commentary with the world at large. It now officially focuses on the intersection of two knotty fields—neuroscience and artificial intelligence—but Sanjana is still adamant that it remain easily readable and interdisciplinary in nature. “No one should feel like it’s a formal academic journal,” he says.

Cross-pollination among research disciplines is in fact at the core of many other popular science blogs. Michael Eisen, an HHMI investigator at the University of California, Berkeley, is an avid blog reader who particularly enjoys John Hawks’ site on paleoanthropology, genetics, and evolution ([johnhawks.net/weblog/](http://johnhawks.net/weblog/)). A recent post there discussed a new sequencing of Neanderthal mitochondrial DNA. “It’s like a conduit into another whole world,” says Eisen.

Through a blog, “anyone can eavesdrop on a conversation scientists may be having,” says Matthew Nisbet, a professor of communications at American University whose research—and daily blog *Framing Science*—focus “on the intersections of science, media, and politics.” The advantage is twofold: bloggers promote improved public understanding of how science ticks; and they can present their own ideas to other researchers and get feedback. Presently, most of that data is posted only after it has been formally published elsewhere. Nisbet adds that scientists are a bit behind in the blogosphere when compared to the prevalence of political bloggers, but some science sites generate big traffic. *Pharyngula*, run by University of Minnesota biologist Paul Myers, attracts 1.5

million visitors a month. It is one of 60 or so blogs hosted by Seed Media Group's *Scienceblogs.com*.

Blogs also provide a platform for the meeting of scientific minds, says University of Iowa epidemiologist Tara Smith. Her *Aetiology* blog, where she discusses everything from AIDS issues to the anthrax attacks to fossilized dinosaur bacteria, helped her connect with Yale University neurologist Steven Novella. The two recently collaborated to publish a paper about AIDS misinformation on the Internet (propagated in large part by those who deny that HIV causes the disease) and the need for scientists to do a better job of tracking and rebutting it.

#### WHERE THE COOL PEOPLE ARE

The current extreme of collaboration via Science 2.0 is OpenWetWare.org. Begun in 2003 by Austin Che, who was then a computer science and biology graduate student at MIT, this biological-engineering Website uses the wiki model to showcase protocols and lab books: everything is open and can be edited by any of its 4,000 members.

OpenWetWare (OWW) is now overseen by Stanford University bioengineering professor Drew Endy, until recently at MIT. "I was the permissive adult who didn't say no" to the idea, he recalls, even though he didn't know much about wikis at the time: "When I did my Ph.D., I had to go to the library and collect papers."

But Endy quickly saw the power of the open online concept. OWW carries lab experiment protocols on everything from DNA precipitation to electrophoretic mobility shift assays. Particularly intriguing are the open lab notebooks that outline experiments, whether successful or not, in their entirety. It's a novel concept, and one that demands an attitude adjustment among researchers.

Harvard Medical School systems biologist Pam Silver, an early convert to OWW, has all of her experiments and protocols on the site. "I think it has made my lab members feel that they are part of a larger community of scientists who share ideas," she says, "and that their research can move forward more quickly." Silver maintains that the free-flowing interactions on OWW have contributed to her work in bioenergy and her educational efforts in systems biology. "I always encourage people to be as open as possible," she says. "No one *has* to join OpenWetWare, but that's where the cool people are."

Experimental biophysicist Steven Koch at the University of New Mexico also uses OWW, but only about 25 percent of his work is publicly available there. Although highly in favor of the OWW mission, he sees it as a work in progress and therefore not something on which he is willing to share so much information that he'd be risking his career. "Maybe tenure will allow me to," he says.

MIT biology professor Michael Laub isn't so sure either. "Somebody may have discovered some interesting gene and doesn't want to blab to the whole world about why it's interesting," he recently told *The Boston Globe* in a story about OWW. "I



Andrew Hires uses his blog, *Brain Windows*, to share articles he finds interesting on brain imaging. The blog's tagline: new tools for peering into the brain.



**Michael Eisen, a fan and originator of open-access publishing, is convinced that the scientific community is ready for Science 2.0.**

don't want my grad students to be scooped by someone else."

To those fearful of exposing their experiments to competing researchers, Endy has a simple response: No one can steal what is already public and credited on the OWW site with a time stamp. In addition, unlike Wikipedia, no anonymous edits are allowed. If a member makes a change, he or she is identified and has a responsibility to the community, Endy says.

Nevertheless, OpenWetWare is still well ahead of the scientific culture curve. "We're a multistage rocket that has only gone through stage one," he acknowledges. By the end of this year, however, Endy would like to see more projects fully represented, from initial brainstorm to conclusion. In that spirit, at his new lab at Stanford, he plans to let it all hang out on OWW.

#### **OPEN-ACCESS JOURNALS**

Meanwhile, a realignment in academic publishing is borrowing some of the strengths of blogs and

OWW and aiming for more interaction around each paper in a journal.

In April 2003, a group of leading American scientists, research funders, publishers, and librarians met at HHMI headquarters in Chevy Chase, Maryland, to discuss the future of biomedical information. The landscape was already changing, they concluded. Increasingly "out" was the traditional closed model of medical publishing controlled by a small list of rarified and expensive print journals. "In," or at least holding great promise, was a new concept called open-access publishing, which aimed to blast a hole in the status quo by making scientific studies free online to all readers.

Traditionally, print journals have been gatekeepers regarding access to new scientific information. While they usually serve their specific specialty readers quite well, the resulting stovepiping of information leaves researchers in related fields largely unaware of the new ideas and advances presented in particular journals. That

makes no sense to HHMI investigator Patrick O. Brown, a biochemistry researcher at Stanford University.

In 1998, Brown began discussing the open-access concept with Harold Varmus, then director of the National Institutes of Health (NIH), and Eisen, then a postdoc in Brown's lab. Their idea culminated in the launch of the online *Public Library of Science (PLoS)* in 2001. The free peer-reviewed site reads like a traditional academic journal, but there are two fundamental differences: the papers' authors pay \$1,300 to \$2,850 for publication, and they relinquish all publishing and distribution rights to the public as long as the work is properly cited.

"Most publishers wish open access would go away," says Brown. It won't. Major research-funding organizations, including NIH, HHMI, and the Wellcome Trust, now require their grantees to post their findings on open-access Websites such as *PLoS* or *PubMed Central* within 12 months of publication in traditional journals. Publishers are pushing back, however, and in September, the House Judiciary Committee began holding hearings on whether the federal government should be allowed to require grantees to submit accepted papers to a free archive.

Even with the recent advances in collaboration and sharing made possible with open-access publications, there is a feeling among Web-savvy scientists that more could be done. Both Eisen and Brown are working on a more interactive concept, essentially a major upgrade to *PLoS*, that would allow readers to respond

to papers and share their insights. The goal is to tap the often-efanescent thought processes of scientists as they consider the experiments of others.

“In a way, this would be a natural offshoot of what we do in our labs and offices,” says Eisen, with online papers becoming nuclei for discussion—including annotations in the margins from qualified readers. Adds Brown: “Sites like this, if they’re good,

will take over one of the most important roles that journals play—selecting and stratifying articles relevant to a particular area—while separating that role from the process of publication itself.”

#### TO OVERCOME CULTURAL BARRIERS

Another online publishing option takes selection and stratification a bit further. Launched in 2002, “Faculty of 1000 Biology” (F1000) is designed to let leading biochemists, cancer biologists, neuroscientists, and endocrinologists, among

others, help colleagues identify the most important new papers among the thousands released each year in biology and medicine. These top scientists—some 2,300 according to their Website—evaluate new papers on a numerical scale, allowing F1000 to publish an online rating, abstract, and category (one of seven) ranging from “new finding” to “technical advance” to “refutation.” In recognition that F1000 can be a great time-saver for their busy scientists, many of the world’s major research institutions subscribe to it. It has another benefit as well, says HHMI investigator Paul Sternberg at the California Institute of Technology, who serves as a section editor for the publication. “It’s especially good at highlighting papers that are obscure and bringing them to light.”

Given the obvious benefits of F1000, which also happens not to challenge the existing order, it has been the proverbial overnight success. But most manifestations of Science 2.0 largely remain obscure. The greatest roadblock to these innovations is not the established print journals themselves but an academic culture that is still inclined to value traditional publishing and that doesn’t credit scientists who share their expertise on blogs and open-access sites.

“There is still an incredible premium put on how many articles you have in *Cell*, *Science*, or *Nature*,” says Alex Palazzo, a postdoc in the Harvard Medical School lab of HHMI investigator Tom Rapoport. Palazzo runs *The Daily Transcript*, a blog dealing with technical issues in cell biology.

Advocates of Science 2.0 admit there is still resistance, but they insist that the scientific community has turned the corner on change. “The wind is at our backs,” says Eisen. ■

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### Virtual Access to the Ancients

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→ **Carey Phillips, a biology professor** at Bowdoin College, is in the process of acquiring an island to help his students recreate and study a Greek colony in its heyday 2,300 years ago. The colony actually existed, while the island will be part of Second Life—a 3-D virtual community inhabited by thousands of “avatars,” or computer representations of real people. Phillips sees Second Life as having great potential as an educational platform that capitalizes on the Internet’s connectivity. The project is funded, in part, by an HHMI grant to Bowdoin.

→ **Phillips is working with students** at Bowdoin and other universities around the globe to recreate Chersonesos, an ancient Greek outpost on the Black Sea in what is now Ukraine. “One of the basic goals,” says Phillips, “is to develop new informatics tools and approaches that allow students to integrate information across disciplines,” not unlike the process of writing one’s own blog. Moreover, “students will form teams and interact with faculty experts, within the virtual world, who serve as consultants,” as if they were all involved in an advanced collaborative form of open-access interaction.

→ **Chersonesos is a unique quirk of history.** It was burned and abandoned around A.D. 1200 and then left untouched; unlike the history of most other ancient sites, subsequent populations did not build over its foundations. And it largely escaped modern notice because it sat next to the off-limits environs of the Soviet Black Sea Fleet. Since the U.S.S.R.’s demise, however, local archeologists have unearthed thousands of artifacts, from decorated sarcophagi to mosaic floors to household items made of blue glass.

→ **Students will use geospatial data** provided by the University of Texas at Austin to rebuild the town, as well as its agricultural economic base, in Second Life. “The surrounding farmland has been cored, and we have 3,000 years’ worth of data from which to study the evolution of various cultivars based on planting practices, human impact, and cultural [and] historical events,” says Phillips.

→ **The citizens of Chersonesos also practiced** an early form of democracy. Through their avatars, students will set up a government on the island and solve problems presented by Phillips and other teachers. “We will record all the virtual chat by participants and use software developed by the military to assess the evolution of group sophistication as they interact,” Phillips says. “I will then work with a group at Amherst College to use this data to develop better educational tools within immersive virtual environments.” —R.B.