

Open Access and the Future of Scientific Publishing

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In 1665, Henry Oldenburg, publisher and prolific letter writer, changed the future of science. His legacy, the *Philosophical Transactions of the Royal Society of London*, spawned the dominant form of scientific communication for the next 3½ centuries. Robert Hooke and Isaac Newton waged intellectual battles over springs, optics, and gravity in its pages. By the late 19th century, other journals, including *Nature* and *Physical Review*, had sprung up, and as scientific progress marched along, their pages filled with articles by Albert Einstein, Marie Curie, and other scientific luminaries.

Journals hold a special place in the lives of scientists. The number of articles they publish and in what journals substantially affects the course of their entire careers—where they work, how much funding they get, and the respect of their peers. For some, articles are not just a means of communication, but the end products in and of themselves. Today, however, business pressures and emerging technologies seem likely to change everything about scientific communication—who finances it, who has access to it, even the very definition of a scientific journal.

Since their inception, these journals generally have worked the same way. Authors submit their research for publication in the most prestigious journal they can. Their colleagues, commonly three, read and review the article anonymously and recommend that the editor accept or reject the article for publication, as well as noting its strengths and weaknesses and suggesting revisions. Peer review does not certify that the results are correct; the reviewers do not replicate the experiments or analyze the data. It only means that the methodology is sound, the conclu-

sions follow the data, and the research has some degree of relevance. Once an article passes peer review, the journal publishes it months or even years later, and other scientists in that particular field eventually read it. In recent times, some journal editors have taken steps to accelerate publication, such as posting articles online before they appear in print.

Financial problems, however, have recently plagued the scientific publishing industry. Nonprofit and academic organizations used to dominate the business, but for-profit publishers entered the industry during the research boom of World War II. Today, they publish 2 million articles a year with \$8 billion in annual revenue. Most journals cost hundreds to thousands of dollars for an annual subscription, but some, like *Brain Research* and *Combustion Science and Technology*, cost nearly \$20,000 per year. That forces all but the wealthiest universities and foundations to cancel some subscriptions. Journals are expensive to produce, no matter how many subscribers they have. As the number of subscribers goes down, prices rise for the fewer institutions that must share the total cost of publication. In a vicious circle, rising prices induce even more subscribers to cancel. That circle applies to all types of journals, although the more specialized the audience, the more important the impact. If 100 libraries cancel their subscriptions to *Nature*, it barely affects this journal's bottom line; but it might be the death knell for *Colloid and Surface Science*.

The shrinking number of those with access to scientific journals angers researchers all over the world, as the ever-increasing costs of print publications shut out researchers in poorer institutions. It isn't only Third World organizations that can't keep up—many small to midsize US universities have had to pare down their subscriptions, making some of the more specialized, esoteric journals unavailable to researchers. Researchers' frustrations

climaxed in 2001, when 30,000 scientists in 180 countries signed a boycott letter calling on publishers to make their work freely available in online libraries within 6 months. They pledged not to “publish in, edit or review for, or personally subscribe to” journals that do not comply. “The current business model is unsustainable, since it is now economically and physically possible to disseminate an article worldwide at zero cost”, says Peter Suber, publisher of the *Open Access Newsletter* of the Scholarly Publishing and Academic Resources Coalition, an organization of universities and libraries that aims to raise awareness about this issue. “It's a dysfunctional system; [publishers] are racing into a brick wall”, says Suber.

Some changes have already taken place to satisfy researchers and keep traditional journals financially viable. Almost all journals published today put at least some of their articles on the Internet, retaining subscriptions by making the journals worth their high cost in the eyes of buyers. Large databases link electronic articles together, and scientists use search engines like Web of Science to gather, in a matter of minutes, the same information it previously would have taken months to find. Electronic versions of articles have quickly become indispensable to scientists. “I have journals going back for years on the shelves in my office”, says Vivian Siegel, executive director of the open-access biology journal *PLoS Biology*. “[But] if I need an article, I'll get it online. It doesn't even occur to me to read hard copies any more.”

However, that an article is online doesn't necessarily mean that all researchers who want to read it can. Most scientists are affiliated with universities or research centers and collectively subscribe to journals through their institutions' libraries. Online subscriptions are sometimes cheaper than the expensive print format, but publishers often bundle the two together, offering online subscriptions “free” to libraries that

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also purchase the print journals. In those circumstances, if scientists' research institutions can't afford the print format, they can't access electronic articles either. That hurdle is prompting scientists to search for alternative ways to develop an open-access system in which articles are available free, online, to anyone in the world.

In recent years, open-access journals have made major gains in the publishing industry. The for-profit *BioMed Central*, a general collection of over 100 more specific open-access journals, published its first article in 2000 with a novel pay-to-publish business model. *BioMed Central* makes money by charging authors or their institutions a \$1000 to \$1500 processing fee and supporting advertising on its Web site. Also in 2000, the National Institutes of Health Director Harold Varmus launched PubMed Central, a database in which publishers can deposit their articles 6 months to a year after original publication. Researchers can then search and access the database at no charge, and traditional publishers can continue to profit with their traditional business models. Over 50% of articles in medicine and health are available freely from PubMed Central, although not until well after they are initially published, which is still unsatisfactory to many researchers. In October 2003, the Public Library of Science, a nonprofit organization of scientists and physicians advocating open-access scientific communication, launched its open-access journal, *PLoS Biology*. *PLoS Biology* charges authors a \$1500 processing fee. At the end of 2003, there were 561 open-access peer-reviewed titles, less than 1% of all published articles, "but it's growing every day", says Melissa Hagemann, program officer for the Open Society Institute, which funds open-access projects.

Open-access journals benefit almost all parties involved in scientific publishing. Authors, who have never profited directly from publication of their work, gain increased visibility and prestige when more people can use the Internet to read their work. And *BioMed Central* and *PLoS Biology* have already committed to waiving

the publication fee for authors who can't afford it. Readers, primarily other researchers, benefit when they have access to more articles. Theoretically, everyone wins when scientists can communicate more efficiently—research is done faster, discovery is accelerated, and mistakes are uncovered more quickly. The public finances the bulk of American research through taxes, the argument goes, so shouldn't the public have a right to see what it's paying for? No one wins under the current system except the "extraordinarily greedy publishers . . . who charge up to 10 times as much as the nonprofits for an equivalent product", says Paul Ginsparg, professor of physics at Cornell University and developer of a pioneering large-scale database of scientific articles.

The path from the current journal system to an open-access one, however, has not been smooth. Some researchers fear that open-access journals will not implement quality control, in the form of peer review, in the same way as traditional print journals. Some members of the science-editing community wonder how thoroughly, if at all, papers in open-access journals will be edited and thus whether quality will suffer. A journal using the pay-to-publish business model might be more inclined to accept papers of questionable quality to keep up its revenue. Researchers also worry that funding scandals might be much more likely when authors finance the publication of their work. "One of the fears is that open-access journals are going to somehow dilute the seriousness of our research", says David Wood, an assistant professor of chemical engineering at Princeton University. "With free online journals, people perceive that they get what they pay for." Open-access journals will need to reconcile the peer-review process with their business models before authors, universities, and funding agencies will recognize them as acceptable venues for publication and agree to bear the burden of their cost. These solutions may use multiple peer-review stages or occur on a different time scale—or they may use a format quite different from today's standards.

Most publishers seem to agree that these

changes are indeed likely to occur within the next 10 to 15 years. Siegel predicts that 95% of all articles will be available freely through searchable databases within a decade and that open-access journals will eventually replace their traditional print counterparts. Although open-access journals will publish the bulk of day-to-day scientific research, she thinks there will always be a place for "research magazines" like *Science* and *Nature*. Those journals, with a large breadth of topics and a diverse paying audience, are taking a watchful waiting stance toward open-access publishing. "Switching to open access now would mean the demise of the journal", says Katrina Kelner, deputy editor of *Science*. "We would have to do it cautiously and in a responsible way."

Today, *PLoS* and *BioMed Central* look like online versions of traditional journals, but in the future, the whole concept of a journal may change. Scientists could simply deposit their papers in their institutional archival database. As long as they used compatible software to publish it, anyone with an Internet connection could use a Google-like search engine to find it. A "journal" might be like a virtual Good Housekeeping Seal of Approval—it would tell readers something about the topic, how it relates to the field, and, perhaps most important, its general quality, but it would have no physical meaning. Also like *PLoS* and *BioMed Central* journals, the next wave of open-access journals will probably implement peer review in the traditional way. Eventually, publishers and scientists will have to figure out how to use changing technologies to adapt to journals of the future. In the next decade or two, utilitarian search engines and high-speed connections may replace the traditional glossy pages of the venerable scientific journal.

"I foresee a true knowledge network rather than simple 'electronic publication'," says Ginsparg. "Most of the technical pieces are already in place, but the sociologic obstacles, as usual, are the most difficult to overcome." 🗨️