

TheScientist

AUGUST 2012 | WWW.THE-SCIENTIST.COM

EXPLORING LIFE, INSPIRING INNOVATION

DEBATING THE FUTURE OF SCIENCE PUBLISHING

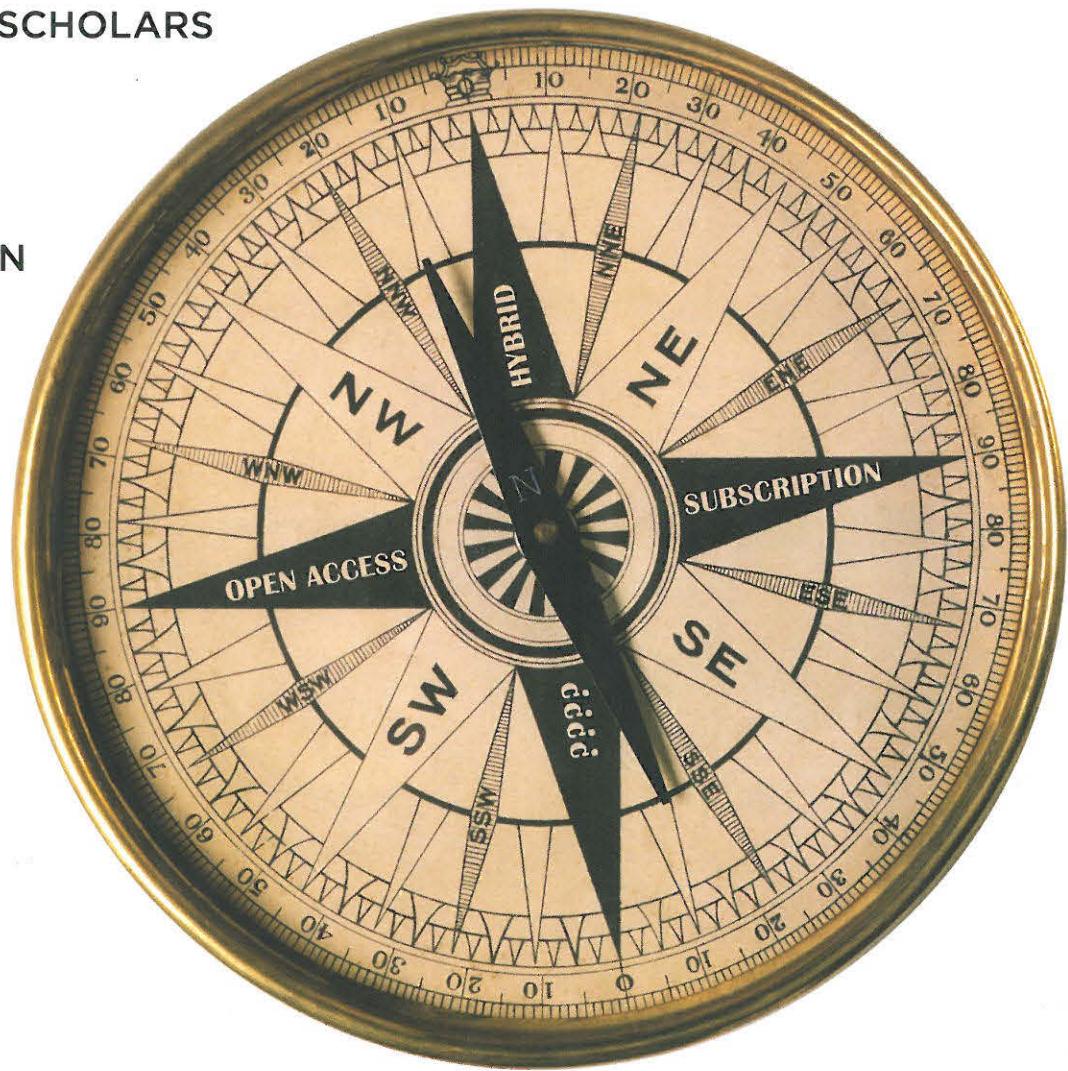
PUBLISHERS AND SCHOLARS
CHART A PATH

ORGANS FOR
TRANSPLANTATION

BEST PLACES
TO WORK
IN ACADEMIA

MASS SPEC
FOR STUDYING
OMICS

PLUS
BALANCING LIFE
AND RESEARCH



Survival of the Fittest (to print)

Science publishing is locked in an evolutionary arms race as it edges further into the digital age.

BY MARY BETH ABERLIN

What's black and white and 'read' all over?" "A blushing zebra!" we'd always shout as kids, even when we knew the right answer: "a newspaper."

But in the years since I first heard this punning riddle, the rise of the Internet has put a new face on the dissemination of information, challenging both researchers and publishers to find the best way to communicate scientific findings swiftly, cheaply, and effectively. No longer is there a black-and-white way of publishing scientific papers, especially those intended to be read all over.

Novel publishing platforms are being developed and launched at dizzying rates. As we go to press, and within less than a week of each other, both BioMed Central and F1000 announced the launch of new open-access (OA) journals. (The two companies are the brainchildren of Vitek Tracz, former owner of *The Scientist*.) One of the pioneers of open-access publishing, BioMed Central (now owned by Springer) opened shop in 2000 and currently publishes 240 peer-reviewed, OA journals. On July 12, it added *GigaScience*, an OA and open-data journal published in collaboration with BGI (formerly the Beijing Genomics Institute) that is devoted to "research that uses or produces 'big data'" and "integrates manuscript publication with complete data hosting, and analyses tool incorporation." One article reportedly contains 84 gigabytes of data!

The following day, *F1000 Research* initiated a soft launch, publishing the first of three articles released over 4 days, with a formal launch planned for later this year. But the editorial process of this OA journal is very different. *F1000 Research* offers immediate publication "after a rapid initial check by the in-house editorial team," with peer review to be conducted post-publication—"fast, formal, and completely open."

Also planning to accept submissions this September is the OA journal *PeerJ*, whose cofounder Peter Binfield is the former publisher of *PLoS ONE*. While *PeerJ* will publish peer-reviewed biological and medical articles, it will not charge authors on a per-article basis, but rather offers three-tiered, lifetime membership for a fee based on the number

No longer is there a black-and-white way of publishing scientific papers, especially those intended to be read all over.

of articles an author publishes—fees substantially lower than those charged by other OA journals. The other factor that differentiates *PeerJ* from all the other new kids on the block is that articles submitted for publication will not be rated for impact.

Billed as being published by scientists for scientists and launching this winter, *eLife* will publish *only* high-impact articles, which it began accepting on June 21. Initially the journal will not be charging authors. University of California, Berkeley, biologist and former editor-in-chief of *Proceedings of the National Academy of Sciences* Randy Schekman will be the journal's top editor.

Schekman is one of 12 researchers, information scientists, and publishers who debate how increasingly complex and data-heavy scientific research should be presented in "Whither Science Publishing?" on page 32. Yes or no to peer review? Who should pay to publish? When to go open access? Two complementary Critic at Large columns examine predatory publishers (page 22) and the need to set transparency standards (page 24).

This month's magazine also contains a progress report, "Replacement Parts," on two very different methods for addressing the huge shortage of organs suitable for transplanting into humans: xenotransplantation from genetically engineered pigs, and the use of artificial or decellularized scaffolds seeded with a patient's own cells and grown in the laboratory (page 26). You will also find the perennially popular Best Places to Work in Academia—our 10th annual survey.

It's not black and white, but this issue is one to be read all over. ■

Editor-in-Chief
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Predatory Publishing

Overzealous open-access advocates are creating an exploitative environment, threatening the credibility of scholarly publishing.

BY JEFFREY BEALL

A great upheaval is occurring in scholarly publishing. Over the past 10 years, researchers, academics, and academic librarians have been promoting open-access publishing, and we are just now beginning to see the results of their advocacy, which unfortunately are way below expectations.

One result is that the open-access movement is producing an almost boom-town-like increase in the number of scholarly open-access publishers, fostered by a very low barrier to entrance into the learned publishing industry. To become a scholarly publisher, all you need now is a computer, a website, and the ability to create unique journal titles.

Bolstering this trend is the so-called “gold open-access” model, in which publishing is supported not by subscription fees but by author fees. An example of a gold open-access journal is *The Scientific World Journal*, currently published by Cairo-based Hindawi Publishing Corporation. This megajournal covers virtually all scientific fields and imposes an article processing charge of \$1,000 for each accepted article. Similarly, the better-known *Public Library of Science (PLoS)* journals charge authors anywhere from \$1,350 to \$2,900 to publish, with a discount if the researcher is affiliated with a university that is an institutional member.

This increase in the number of open-access journals has major implications for scholarly publishing. Authors become the publishers’ customers, an arrangement that creates a conflict of interest: the more papers a publisher accepts, the more revenue it earns.

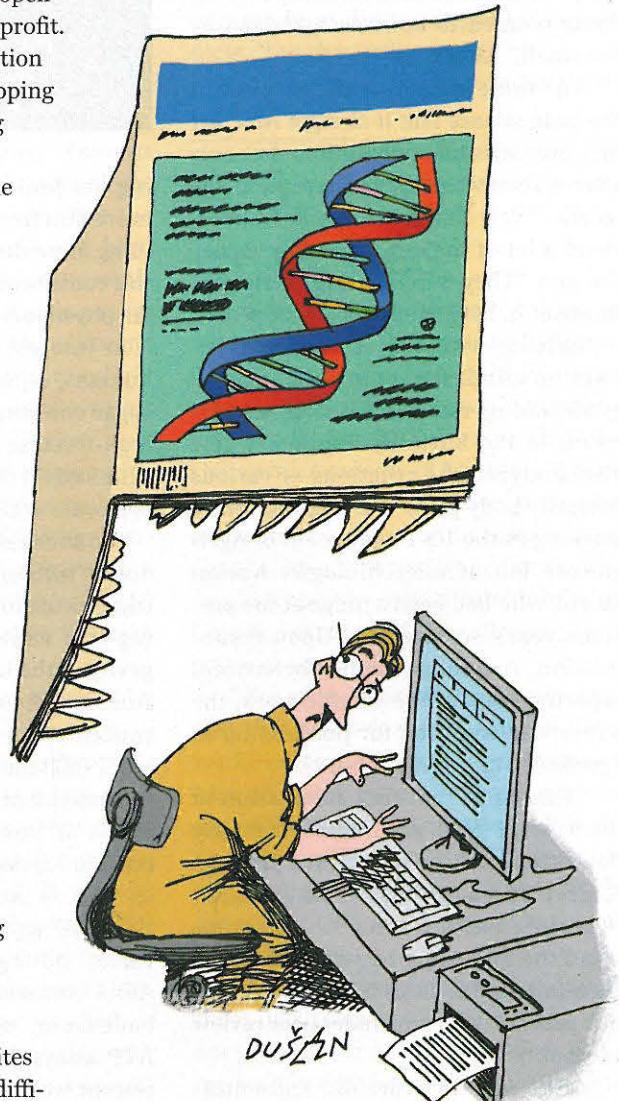
Not surprisingly, acceptance rates at gold open-access journals are skyrocketing, and article peer review is decreasing.

Scholarly communication is now flooded with hundreds of thousands of new, second-rate articles each year, burdening conscientious researchers who have to sort through them all, filtering out the unworthy ones.

Exploiting the trend is an increasing number of what I define as “predatory” publishers—those that unprofessionally exploit the gold open-access model for their own profit. These publishers use deception to appear legitimate, entrapping researchers into submitting their work and then charging them to publish it. Some prey especially on junior faculty and graduate students, bombarding them with spam e-mail solicitations. Harvesting data from legitimate publishers’ websites, they send personalized spam, enticing researchers by praising their earlier works and inviting them to submit a new manuscript. Many of these bogus publishers falsely claim to enforce stringent peer review, but it appears they routinely publish article manuscripts upon receipt of the author fee. Some have added names to their editorial boards without first getting permission from the scientists they list, among other unethical practices.

These publishers’ websites look legitimate, making it diffi-

cult to separate the professional from the unethical. Unfortunately, many scientists have been fooled. Dozens have asked me for a measure for determining legitimacy, but there is very little that can be measured directly. The only real measure is the publisher’s intent, which is hard or impossible to discern.



**Predatory publishers
use deception to appear
legitimate, entrapping
researchers into submitting
their work and then
charging them to publish it.**

The implications for tenure and promotion are significant. Previously, traditional publishers played a validation role: if an article appeared in a journal of a respected publisher, generally everyone accepted it as quality work worthy of publication. Now, predatory publishers assign lofty titles to their journals, making the task of judging a tenure candidate's list of publications much more complicated. Sadly, a few academics are gaming the new system, exploiting the scholarly vanity press to buy prestige.

Predatory open-access publishers threaten to erase the line that divides science from nonscience. By accepting pseudoscientific articles that outwardly appear legitimate but whose methodologies are unsound, bogus publishers gratuitously confer the imprimatur of science. As this trend continues, we may lose the ability to easily separate the real science from the fake.

The problems these predatory publishers cause have been worsened by several of the players in the open-access movement. Many academic librarians and other open-access advocates have promoted open-access scholarly publishing across the board, without limiting their promotion to the few worthy open-access publishers, thus creating a more fertile ground for predatory publishers. Librarians and open-access advocates have also spent much time and effort denouncing—and even cyberbullying—traditional scholarly publishers, a practice that regrettably has further enabled the growth of illegitimate open-access publishers. Some even insist on open-access mandates, rules that would require researchers to publish all their work in open-access venues, thereby depriving them of the freedom to publish in the venue of their choosing and serv-

ing to further energize the exploitative open-access publishers.

Open-access enthusiasts are too quick to dismiss traditional scholarly publishers. They have overly politicized scholarly communication, applying their anticorporate beliefs and tactics to learned publishing. Many have abandoned objectivity; instead of seeking the best model for scholarly communication, they seek only the *au courant* one that fits their narrow beliefs.

Many open-access advocates fail to understand or recognize the value that high-quality publishing adds to scholarly content. One of these values is digital preservation, or the long-term maintenance of journal articles and other research output. Most of the new open-access publishers have no long-term preservation strategies, instead choosing to operate in the moment. Furthermore, some open-access publishers now bypass the copyediting process. In addition to deteriorating article quality, these practices perpetuate the problem of increasing plagiarism, as these journals rarely use the available tools that can detect overlap between submitted and published works.

Thus, while open-access publishing has some obvious advantages—namely making scientific research freely available to all that seek it—there are many other factors to be considered. (For a more complete discussion of these considerations, see “Whither Science Publishing” on page 32.) A publication model that has authors rather than readers as its customers is still unproven and risky in the long term. Scholarly communication needs more unbiased analysis and less ideology. The publishing model that we bequeath to the next generation of researchers needs to be the best one, and not necessarily the ideologically correct one.

Jeffrey Beall is a metadata librarian at the University of Colorado Denver's Auraria Library. Read more about scholarly open-access publishing on his blog, Scholarly Open Access (scholarlyoa.com).

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Bring On the Transparency Index

Grading journals on how well they share information with readers will help deliver accountability to an industry that often lacks it.

BY ADAM MARCUS AND IVAN ORANSKY

Scientists are universally familiar with the Impact Factor, even if they're often frustrated with how it can be manipulated and misused. More recently, Ferric Fang and Arturo Casadevall have introduced the idea of the Retraction Index, a measure of how many papers journals retract for every 1,000 they publish. As science journalists who have spent the last 2 years closely monitoring retractions, we think this is a great idea.

Last year, in a post on our blog *Retraction Watch*, we recommended that journals publicize their Retraction Indices just as they trumpet their Impact Factors. It's unlikely many will take us up on the suggestion, but we'll go once more into the breach anyway and suggest another metric of journal performance: the Transparency Index.

Regardless of what metric scientists use to rank journals, one of the reasons they read the top-ranked journals is their sense that the information is reliable. We believe, and we're not alone here, that journals become more trustworthy when they are open about not only their successes, but also their failures.

We understand—in theory, at least—why some journals and editors might be reluctant to share the details of a retraction with their readers. Sometimes the problems involve shoddy reviews, failure to check a manuscript for evidence of plagiarism or duplicate publication, or other avoidable mistakes.

But lack of transparency serves only to reinforce a sense of incompetence. Journals and editors willing to pull aside the curtain to show readers what went wrong with a particular article or group of articles send the messages that 1) they care about conveying truth to their audiences;

WHAT SORT OF FACTORS MIGHT GO INTO THE TRANSPARENCY INDEX?

In no particular order:

- The journal's review protocol, including whether or not its articles are peer-reviewed, the typical number of reviewers, time for review, manuscript acceptance rate, and details of the appeals process
- Names and expertise of editorial board members, including whether or not they know they're on the board (that last part shouldn't be controversial, but we've spoken to a number of alleged editorial board members who are surprised to hear about such appointments. The publishers of many of those journals show up on University of Colorado Denver librarian Jeffrey Beall's List of Predatory, Open-Access Publishers. Read his Critic at Large, "Predatory Publishing," on page 22.)
- How authors are asked to disclose conflicts of interest, and the threshold for sharing those conflicts with readers
- Contact information for the journal's editor-in-chief, including an e-mail account that someone actually reads
- Costs, not only for authors, but for readers. How much does it cost someone without a subscription (personal or institutional) to read a paper?
- Whether the journal requires that underlying data are made available
- Whether the journal uses plagiarism detection software and reviews figures for evidence of image manipulation
- The journal's mechanism for dealing with allegations of errors or misconduct, including whether it investigates such allegations from anonymous whistle-blowers
- Whether corrections and retraction notices are as clear as possible, conforming to accepted publishing ethics guidelines such as those from the Committee on Publication Ethics (COPE) or the International Committee of Medical Journal Editors (ICMJE)

2) they are committed to producing a high-quality publication; and 3) potential fraudsters are not welcome in their pages.

Our hope is to turn the above criteria into a numerical metric that can give authors and readers a sense of a journal's transparency. How much can they trust what's in its pages? Help us refine the Transparency Index at retractionwatch.com.

wordpress.com/transparencyindex. The number, however, will just be an indicator. Scientists' judgment will still be the most important factor.

Ivan Oransky is former deputy editor of The Scientist. He and Adam Marcus are cofounders of Retraction Watch: retractionwatch.com.

Whither Science Publishing?

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Contributors to this article were not privy to each other's responses.

As we stand on the brink of a new scientific age, how researchers should best communicate their findings and innovations is hotly debated in the publishing trenches.

Scholarly publishing is, and always has been, an adaptable beast. What started as the hand-scribed musings of ancient philosophers evolved into the printed manuscripts of wealthy gentlemen-scientists observing nature or conducting experiments using their own pounds sterling. These "natural philosophers" formed the Royal Society of London for Improving Natural Knowledge in the mid-17th century and published their work in the *Philosophical Transactions of the Royal Society*, the first journal devoted entirely to science and one that continues to publish biweekly issues to this day.

Over the intervening centuries, academic publishing has morphed into a sprawling international industry that, on the one hand, rakes in revenues of more than \$19 billion in its scientific, technical, and medical segment alone, according to one 2008 analysis (*Electronic Journal of Academic and Special Librarianship*, 9, ISSN 1704-8532, 2008). On the other hand, a constellation of open-access (OA) publishers, producing nearly 8,000 OA journals (according to statistics kept by the Directory of Open Access Journals) has grown up, paralleling the rise of the Internet as the primary mode of gathering, communicating, and sharing information both inside and outside the scientific community.

Today, researchers stand on the brink of a new age in scholarly publishing. Never before has science been so inundated with new findings, or have technical advances generated such mountains of data. Innovations sprout from labs the world over as humanity's understanding of our universe grows. But that growth is only as robust as the system used to share disparate bits of knowledge, test and challenge reported advances, and remotely collaborate in scientific efforts.

To keep up with the blistering pace of scientific and technological advances, publishers are getting creative. In recent years, new concepts such as post-publication peer review, all-scientist editorial teams, lifetime publishing privilege fees, and funder-supported open access have entered the publishing consciousness.

But open access and other newer publishing modalities are still dwarfed by the traditional subscription-based model. Will open access eventually become the dominant mode of publishing science? Are there unseen challenges that await such a dramatic shift? Are there ways to improve the traditional system of peer review, a practice introduced nearly 350 years ago to vet articles published in the *Philosophical Transactions of the Royal Society*?

The Scientist asked these questions and more of publishers, researchers, information scientists, and others to get a sense of where scientific publishing stands today, and where it's going. Here's what they had to say.

—Bob Grant

WHAT ARE THE MAIN PROBLEMS WITH THE EXISTING SYSTEM FOR PUBLISHING SCIENTIFIC RESEARCH?

MICHAEL EISEN

Everything.

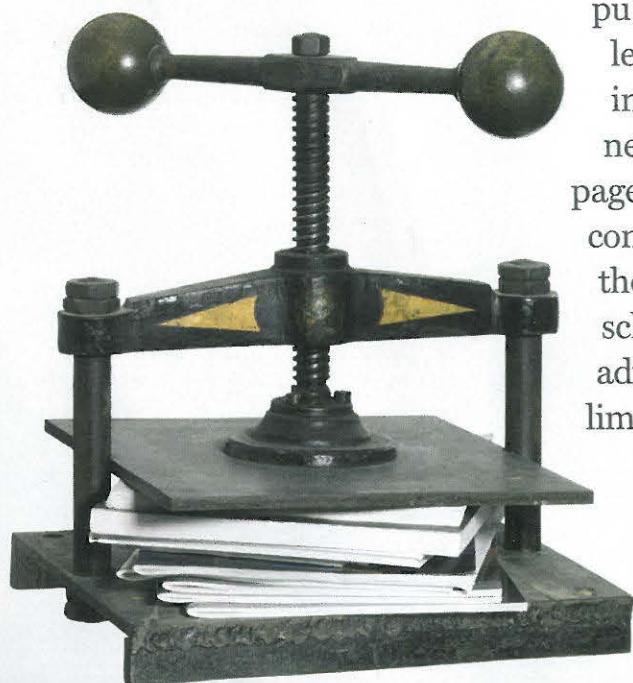
The question should be: "What isn't a problem with the existing system of scientific publishing?" Every major aspect of the traditional journal system scientists use to communicate with each other was developed for a world in which information was disseminated in printed journals. And every single major aspect of this system—the format of papers, the structure of peer review, the subscription-based business model, and even the very existence of journals—has been rendered obsolete by the rise of the Internet. Because of our continued unwillingness as a community to face up to the challenge of reforming scientific communication, we are left with a system that is slow, capricious, and intrusive; produces papers in an archaic format that limits the conveyance of data and ideas; costs an obscene amount of money; and provides access to a small fraction of the people who are interested in and could benefit from the most up-to-date scientific discoveries.

If the entire publishing industry disappeared tomorrow, science would be immeasurably better off. It might take us a few weeks to recover and build a new system optimized for modern science and electronic communication. But if we did it right, it would not retain any features of the current system.

RANDY SCHEKMAN AND MARK PATTERSON

The current system fails to take advantage of the potential created by technology to advance scientific discourse and accelerate the pace of discovery.

For example, print-oriented approaches restrict the publication of full-length, data-rich articles in magazines that necessarily have limited page space. And the most competitive journals—those that young scholars seek for career advancement—artificially limit the fraction of papers that are accepted. These limits have no place in the online environment.



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PATRICK TAYLOR

I think there are three major problems. Most notoriously, access is limited and primarily unidirectional, meaning that articles land in readers' laps, like an unalterable consumable product, rather than with the dialogue of 17th-century Royal Society proceedings or a vivacious contemporary conference.

Secondly, systems of validation in both open-source and proprietary publication systems are quite weak. That is partly because of the inherent limitations of any review as currently done, and partly because of biases that we seem unable, as yet, to sufficiently control.

Third, and most fundamentally, research publication is still mainly considered apart from the larger public ecosystem in which understandable and valid discoveries, engagement and public support for knowledge, and scientific methods are all intertwined. It's that decontextualization that leads to narrow discussions about business models for publication, or to benchmarking problems as lapses from a recent status quo, rather than asking ourselves: What would a robust, imaginative, future device for encouraging pertinent inquiry, and validating and disseminating scientific knowledge to peers, policy-makers, and public, optimally look like?

ALICIA WISE

It is no surprise to any of us that unfortunately there is an affordability crisis in libraries. This is a huge challenge that impacts on all stakeholders—authors, funders, libraries, publishers, researchers, and universities—and one that is in all our interests to solve.

ARE THERE PROBLEMS WITH THE EXISTING PEER-REVIEW SYSTEM?

PATRICK TAYLOR

Sometimes peer review is stellar and insightful—there are peer reviewers I wish I could have given co-authorship or sent flowers to!—and sometimes quixotic.

More fundamentally, peer review is inherently limited, unless one has access to underlying raw data, and some greater sense of the lineage of scientific choices than is reflected in a manuscript. Think back on the world-shaking Hwang claims a few years ago that somatic cell nuclear transfer had been achieved in human beings, and the review finally required to establish falsification and to uncover the ethical issues with human egg donations.

I believe that without fundamental changes in data access, like widely pooled data, and iterative collective examination of aims and methods, peer review can never do all we ask it to do, which is to compare and validate approaches, data, results, and directions, in themselves and as stepping stones to further scientific work and informed policy-making.

STUART TAYLOR

It is not perfect, but the system has worked well for 350 years. The best work has been published. Occasional mistakes have made it through the process, but the self-correcting elements of the system, such as post-publication criticism, have put them right in the end.

RANDY SCHEKMAN
AND MARK PATTERSON

The process is slow and cumbersome, and often involves multiple rounds of revision and review, demands for additional experiments, and frequent rejection and resubmission to multiple journals.

JOHN VAUGHN

The peer-review system has never been viewed as a flawless system but continues to be widely and appropriately regarded as an indispensable component of the translation of research results into trusted new knowledge. It is the most effective way that has been devised to bring expertise and judgment to the evaluation of reports of scientific research. As a human process that engages multiple perspectives in the evaluation of complex content, peer review is not impervious to error or bias, but government agencies, publishers, universities, and scientists continue to review and refine the peer-review process to assure the highest levels of impartiality, transparency, and integrity.

DONALD KING

While there are still many flaws in the review process, such as delays, use of “old boy networks,” etc., I believe it is an important component of scholarly publishing. On balance, I believe the benefits outweigh the problems.

MICHAEL EISEN

Peer review as practiced in 21st-century biomedical research poisons science. It is conservative, cumbersome, capricious, and intrusive. It slows down the communication of new ideas and discoveries, while failing to accomplish most of what it purports to do. And, worst of all, the mythical veneer of peer review has created the perception that a handful of journals stand as gatekeepers of success in science, ceding undue power to them, and thereby stifling innovation in scientific communication.

Among the problems that need to be addressed is the unreasonable amount of time the process takes. In my experience, the first round of review rarely takes less than a month, and often takes a lot longer, with papers sitting on reviewers' desks the primary rate-limiting step. But even more time-consuming is what happens after the initial round of review, when papers have to be rewritten, often with new data collected and analyses done. For typical papers from my lab, it takes 6 to 9 months from initial submission to publication.

The scientific enterprise is all about building on the results of others—but this can't be done if the results of others are languishing in the hands of reviewers, or suffering through multiple rounds of peer review. There can be little doubt that this delay slows down scientific discovery and the introduction to the public of new ways to diagnose and treat disease.

IS OPEN-ACCESS PUBLISHING THE WAVE OF THE FUTURE? WHAT PROBLEMS PLAGUE OPEN-ACCESS PUBLISHING AS PRACTICED NOW?

JOHN VAUGHN

Open-access publishing is the wave of the future in many disciplines for the simple reason that it is so beneficial to the conduct of research in those disciplines. If the costs of publishing can be fully met at the front end of the process, through author payments or by other means, the extraordinary advances in digital technology and online dissemination make it possible for the final published article to be immediately freely available to all. Thus, scientists will have quicker access to research results, and the broader public will have access to content that many otherwise could access only with difficulty or not at all. Open-access publishing is especially beneficial to the scientific enterprises of developing countries that lack the financial resources and structures to effectively access subscription-based scientific literature.

BRIAN SCANLAN

If we are to continue to have high-quality scientific and scholarly journals, we must continue to have and to strengthen the existing systems of peer review, content preparation, and discoverability. The cost of peer review is high because, on average, fewer than 50 percent of articles are published (the most selective journals reject 90–95 percent of submissions). Subscription fees pay for our work to validate an author's contribution, as well as to judge its significance, clarity, and originality. Our [Thieme Medical Publishers'] content-preparation process, which includes language editing, measurement standardization, and coding, is particularly important because of the increasing surge of research reports by non-native speakers of English, especially in Asia. Commercial and large-scale society publishers are in the best position to complete these necessary tasks in an efficient manner.

MARTIN FRANK

Not unless funding agencies or universities are able to provide the author payment charges independent of research dollars. Many funding agencies are telling their grantees to pay for publication from their grants. This will further diminish the resources available to an investigator to do research at a time of constricting budgets. Will the universities be willing to transfer some or all of the funds going to libraries to a fund to pay for publication, especially for publications that arise after the investigator's grant expires? Will universities decide where a faculty member should publish by directing them to OA journals with lower article-processing charges because of budgetary problems at the institution?

Additionally, there is concern about the quality of peer review for these journals and concerns that they will be publishing articles of minimal value. In time, such journals will be recognized and eliminated as viable venues for publication, but in the meantime they are sucking up funds that can be better used for research. They are also serving as venues for the publication of low-quality articles that would traditionally be buried in a file drawer because the research had little value for the community. These OA journals are becoming vanity journals, designed to provide a venue for research. (See "Predatory Publishing" on page 22.)

MICHAEL EISEN

Yes, if by open access you mean that all scientific publications are made immediately freely available. There are many different ways to support such a system financially: per-article publication fees, such as used by PLoS and BMC, and direct subsidies from funders, as will be done by eLife, are two currently in use.

ALICIA WISE

Open-access publishing has been with us for a decade now, so it's a growing part of the current publishing landscape. Without doubt it will continue to grow, but it is growing from still quite a small base.

I do think it is possible for scholarly publishing to be entirely open access, but I am more skeptical that the foundations currently in place would enable this to happen and the system to remain sustainable. My concern is that without adequate funding and sustainable policies in place, and cooperation amongst stakeholders, a rush to a fully open-access publishing world would be a race to the bottom in terms of quality.

Some of the established mixed-model publishers, including Elsevier, are a bit late to the open-access publishing party and need to establish a credible track record. I'm encouraged by the terrific success we've had with *Cell Reports* and some of our other open-access titles, and so I feel confident that we'll get there quickly. Authors or their institutions may also sponsor open access to a refereed article in more than 1,200 of Elsevier's peer-reviewed journals, including *The American Journal of Human Genetics*, *Neuron*, and *Cell*. What keeps me up at night? The scale of investments we are making to transform our back-office systems to be OA ready—how on earth will smaller publishers possibly afford to do this?!

IS THERE AN AS-YET-UNTRIED ALTERNATIVE TO SUBSCRIPTION-BASED OR OPEN-ACCESS PUBLISHING?

RANDY SCHEKMAN
AND MARK PATTERSON

Open access is the future of science communication and necessary to advance the pace of research in the digital age. However, while authors continue to submit work to established subscription journals, there is insufficient incentive in the short-term for incumbent publishers to convert subscription journals to open access. High-quality open-access journals have now been established, and new mechanisms for research assessment are also emerging which could rapidly expand open-access publishing and disrupt the traditional subscription journals market.

JOHN VAUGHN

Another emerging option is hybrid journals, which are subscription-based journals in which authors have the option of paying a fee for open-access publishing of their articles.

STUART TAYLOR

The web offers many opportunities for self-publishing which have never existed before, so it is now perfectly possible for scientists to simply upload all their methods, data, and conclusions via a blog or one of the other social media routes. However, the burden of quality control would then shift to the reader community rather than being concentrated into a far smaller number of journal editorial boards. This would be much more time-consuming for the reader and would probably be less effective than the present system at sorting the good from the bad.

ALICIA WISE

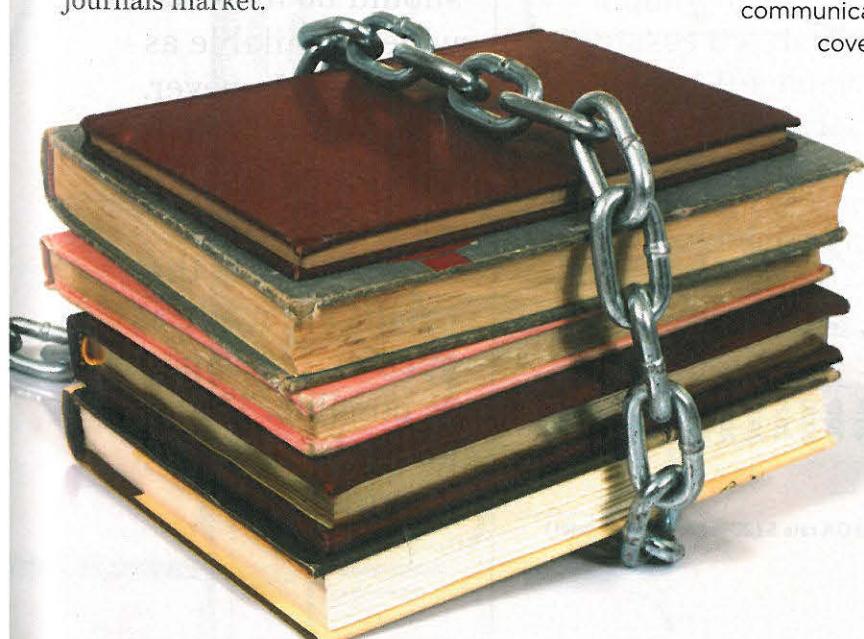
There are many additional revenue streams, or business models, in the mix already, and I believe there will continue to be a mix of models. So, for example, some academic journals carry advertising. There is also a thriving secondary rights revenue stream for most titles. Societies, and others, sponsor issues and journals. And publishers have diversified their product and service base well beyond journals.

MICHAEL EISEN

Yes. Several: direct subsidies to publishers (*à la eLife*) and doing away with publishers entirely and using a system based completely on something like arXiv.org [a seminal open-access archive used to share research in the fields of mathematics, physics, and computer science].

SUSAN KING

No. The value-add that publishers provide through services like supporting peer review; enhancing the global accessibility of scholarly communication in standardized formats; enabling the discovery of knowledge through innovative web-based platforms, tools, and interlinked content; protecting the integrity and reliability of the scholarly record; and preserving the scholarly record for future generations have costs that must be paid for in some way. Both subscription and open-access publishing seek to recover the costs of this ongoing investment from those who benefit from it. It has been argued that even projects such as *eLife*, which do not plan to charge initially, constitute a form of prepaid gold open access (see “Flavors of Open Access” on page 41), with its sponsors prepaying the fees that the project eventually expects to incur.



PUBLISHING BY THE NUMBERS

By Donald King

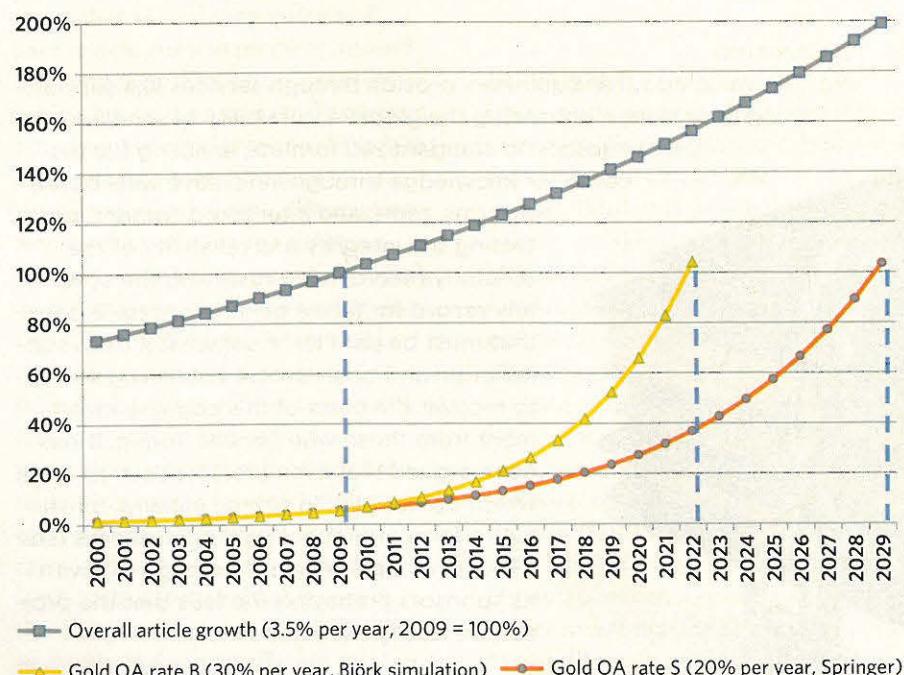
In 2008, there were 5.5 million scientists and engineers occupied in science-related industries. They published more than 200,000 articles that year. While large universities employed only 7.1 percent of scientists (a high proportion of whom are PhDs), they published more than three-quarters of all scientific articles.

Workplace	Employment (%)	Articles Published (%)
For-profit business	45.0	5.8
Nonprofit organization	18.4	11.0
Government	9.4	7.0
4-Year university	7.1	76.1
2-Year university	0.6	—
Pre-college	13.5	—
Self-employed	6.1	—
(Small organization with fewer than 100 employees)	11.6	—

*Data based on *Science and Engineering Indicators: 2012*

HOW QUICKLY WILL OA BECOME THE NORM?

Two different projections for the growth of gold open-access articles published in scientific journals are shown below. The yellow line represents a projected growth of 30 percent per year for both ISI and non-ISI journals, as calculated by M. Lassko et al. (*PLoS ONE*, 6:e20961, 2011), and reaches 100 percent gold OA in 2022. The orange curve, based on a projection of 20 percent growth in gold-OA articles calculated by scientific publisher Springer, predicts 100 percent gold OA articles in ISI journals by 2029. (Graph reprinted from R. Poynder, "Open Access by Numbers," *Open and Shut*, poynder.blogspot.com/2011/06/open-access-by-numbers.html, June 19, 2011.)



SHOULD THE SOURCE OF FUNDING FOR SCIENTIFIC RESEARCH DETERMINE HOW MANUSCRIPTS ARISING FROM THAT WORK ARE PUBLISHED?

MARTIN FRANK

It is inappropriate for funders to dictate business models for publishers.

STUART TAYLOR

There is an argument that research funded from the public purse should be made as widely available as possible. However, the guiding principle should not be about what the funder wants but that the results are made as open and transparent as possible. That is how science makes progress.

PATRICK TAYLOR

I think that work funded by the public ought to be as free as possible from any encumbrance whatsoever on access or exploitation of its contents, whether by laypeople, journalists, peers, or policy-makers. Public science requires public access, and publicly engaged science, with data and methods fully exposed in an open field of play for scientists and the community alike. Over time, experience has made me definite and unequivocal on this issue: I do not believe public money should support private fiefdoms, whether the fief is held by a crown prince of publication, a lord among lab heads, or an inventor among investigators. Knowledge is to be shared, and played with in the sunlight. It's the only way it grows.

CAROL TENOPIR

If funding agencies require open-access publishing of results and/or data (either immediately or with an embargo), they should also allow or provide the payments for any associated author fees.

MICHAEL EISEN

Absolutely. Funders have a vested interest in ensuring that their work is as valuable as possible, and, given how important scientific communication is, funders have every right—even a responsibility—to dictate the terms under which work they fund is published.

BRIAN SCANLAN

It's crucial for the freedom of scientific inquiry that the author makes the decision about the number of articles that arise from the research being conducted and where it should be published.

SUSAN KING

No. The ability of authors to choose the appropriate journal ensures competition among journal publishers to offer the best service to authors and maintain academic freedom.

**RANDY SCHEKMAN
AND MARK PATTERSON**

If an organization is funding research as a public good, then the work should (and can) be made open access. In many fields, including the life and biomedical sciences, it also makes sense for the costs associated with the communication of research to be considered one of the costs of the research itself, leading to a model whereby research grants include expenses for publication fees in open-access journals.

ALICIA WISE

Funders can play a powerful role by creating the enabling mechanisms, and in particular creating the funding streams to support gold open-access publishing. However, I strongly believe that they should not decide where articles get published. This is the choice of authors, who need freedom and flexibility to decide where to publish in order to effectively communicate their research and advance their discipline.

IF YOU COULD CHANGE ONE THING ABOUT HOW SCIENTIFIC RESEARCH IS PUBLISHED RIGHT NOW, WHAT WOULD IT BE?

MICHAEL EISEN

Every paper would be freely and openly available from the moment of publication.

No journals. Scientists effectively blogging about their research whenever they want to share it, producing rich works that combine narratives, methods, ideas, and conclusions, along with embedded data, figures, and other essential information.

ALICIA WISE

If I could change one thing overnight it would be to create a place where all stakeholders—authors, funders, librarians, publishers, researchers, universities—would come together to proactively work on practical solutions to the big issues, such as how to deliver universal access to quality scientific publications, and all the little inconveniences.

JOHN VAUGHN

The one discrete change that could be implemented in the existing system would be to focus pricing policies on the public purposes of scholarly publishing, setting prices based on costs rather than income generation. Many publishers do this; all should.

RANDY SCHEKMAN AND MARK PATTERSON

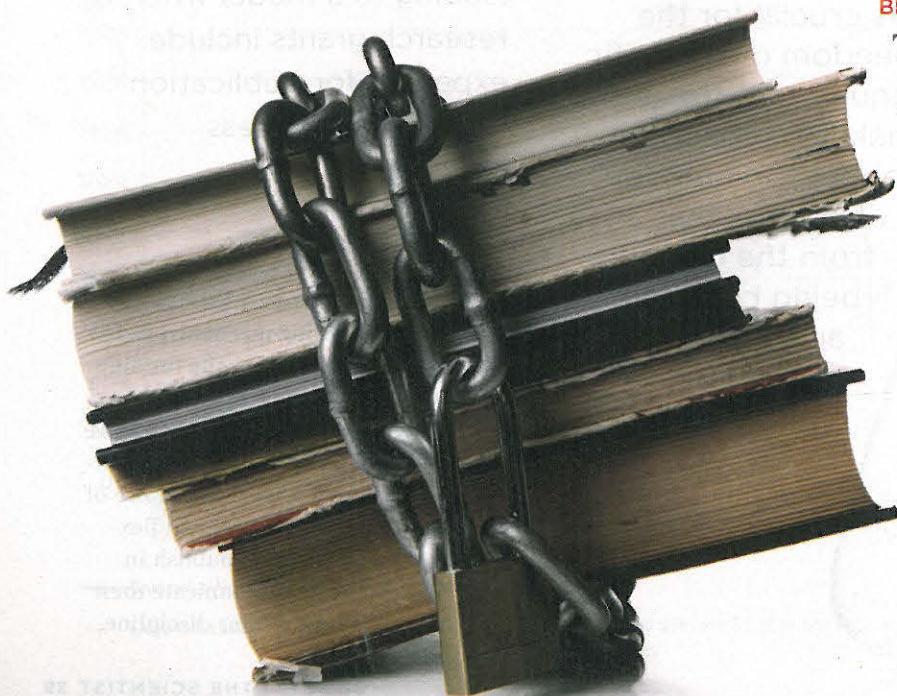
Create a credible alternative to the journal impact factor for research assessment. The impact factor is a very strong motivating force for author decisions about where to publish their work; it's a barrier to innovation, including open access. (See "Bring on the Transparency Index" on page 24.)

SUSAN KING

Implementation of a systematic US government-wide policy ensuring public access to research reports produced by researchers who receive federal funding, as required by Federal Acquisition Regulations. The government already receives research reports for the researchers it funds. Agencies including the Department of Energy and the National Science Foundation have extensive Web portals that provide searchable public access to their unclassified reports. To meet the demand for public access to federally funded research results, all the US government has to do is make all research reports publicly available. No new system is required.

BRIAN SCANLAN

The most immediate change that should be made is for librarians to have the courage to break up the big deals [in which journal subscriptions are grouped by publishers]. The big deals are a stranglehold on institutional budgets, reduce competition, support poor-performing journals, and hurt the smaller publishers.



FLAVORS OF OPEN ACCESS

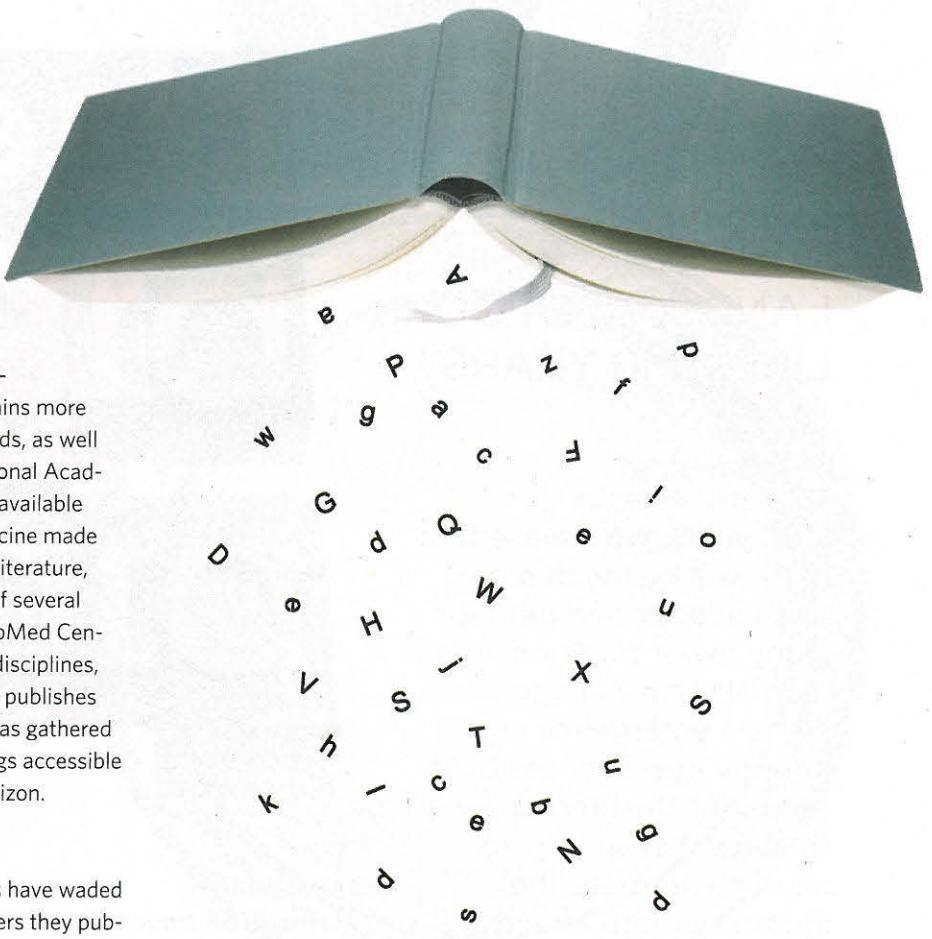
Open-access science journals are relatively new to the publishing landscape. The modern open-access movement started in 1991 with the establishment of arXiv.org, the first free scientific online archive. Researchers self-archive their papers on the site, which now contains more than 760,000 "e-prints" from a variety of physics subfields, as well as mathematics and computer science. In 1994, the National Academies Press made full-text versions of their books freely available on the Web, and in 1997 the US National Library of Medicine made Medline, a comprehensive index of biomedical research literature, freely accessible via PubMed. The 2000s saw the birth of several open-access science publishers, such as the for-profit BioMed Central, which publishes more than 200 titles in an array of disciplines, and the nonprofit Public Library of Science (PLoS), which publishes seven journals. As the modern open-access movement has gathered steam, a few different models for making research findings accessible to the public have evolved, with perhaps more on the horizon.

HYBRID OPEN ACCESS

- Many traditional subscription-based science publishers have waded into the open-access realm by making some of the papers they publish freely accessible to the public, giving authors the choice to pay a publication fee to make their articles open access.
- Examples of hybrid-OA publishers include:
 - Royal Society
 - Wiley-Blackwell
 - Springer
 - Nature Publishing Group
 - Elsevier

GREEN OPEN ACCESS

- Green OA is the original form of open-access publishing in the modern era.
- Authors publish in a journal of their choosing and then (sometimes after an embargo period) self-archive manuscripts in databases that may be accessible by the public or by colleagues at their institution or beyond.
- Fees associated with green-OA publishing are typically minimal, as access to information is granted via self-archiving.
- Immediate self-archiving and public access is typically encouraged by publishers who champion green OA.
- Papers deposited in green-OA repositories are not necessarily peer-reviewed. Preprints of articles not yet accepted for publication may be self-archived, as well as theses and dissertations, course materials, reports on work in progress, and other documents.
- Examples of green-OA repositories include:
 - arXiv.org
 - DASH (at Harvard University)
 - PubMed



GOLD OPEN ACCESS

- Gold OA refers to entire journals that publish manuscripts that will be made freely accessible to the public.
- Authors typically pay a fee to publish their work in gold-OA journals. (The 2011–2012 fee to publish an article in *PLoS Biology* is \$2,900.)
- Gold-OA publishers typically make their manuscripts immediately accessible to the public.
- Articles appearing in gold-OA journals are typically peer-reviewed.
- Examples of gold-OA journals include:
 - *PLoS ONE*
 - *PeerJ* (slated to commence publication at the end of this year)
 - *BMC Biology*
 - *eLife* (slated to commence publication later this year)

DELAYED OPEN ACCESS

- Delayed OA refers to a policy at some subscription-based journals to allow authors to self-archive published papers after a predetermined embargo period.
- This form of OA is often derided by OA advocates, as it does not allow for *immediate* public access to information.
- Examples of delayed-OA journals include:
 - *Molecular Biology of the Cell* (one-month embargo)
 - *Journal of the Physical Society of Japan* (15-year embargo)

—Bob Grant

WHAT WILL THE SCHOLARLY PUBLISHING LANDSCAPE LOOK LIKE IN 10 YEARS?

RANDY SCHEKMAN
AND MARK PATTERSON

In 10 years, we believe that there will be much more open access, and perhaps many fewer traditional journals. We will also see the emergence of entirely new services built on top of the literature to allow researchers to navigate and use the literature more effectively. Journal articles might also be complemented by new channels for the communication of new results and ideas, and these new channels could be included in the assessment of research and researchers.

JOHN VAUGHN

I don't know what the scholarly publishing landscape will look like in 10 years, but that landscape will most effectively accommodate the needs of the scholarly community if it is shaped by voluntary, good-faith collaborations by all stakeholders working toward a shared goal of providing the broadest, most effective—and most cost-effective—access to the results of authoritative research and scholarship. Many such collaborative projects are underway, which leaves me optimistic about scholarly publishing's future landscape.

CAROL TENOPIR

There will continue to be a mix of open-access (author-pays or subsidized) and subscription-based journals for the next 10 years, with a gradual switch to open-access models. Data sets behind scientific research will also become increasingly available, as systems of deposit and citation become commonplace. Print-on-paper issues will be almost totally phased out.



BRIAN SCANLAN

I believe over the next 10 years we will see an increase in the hybrid subscription-based/author-pays model. Because of publishers' innovative and ongoing investments in electronic publishing, we are enabling greater access to research at ever-decreasing costs. What will interfere with this trend are unfunded, one-size-fits-all governmental mandates. What will support this trend is continuing collaboration between funding agencies, scientists, publishers, libraries, and other stakeholders.