Steady, strong growth is expected for open-access journals

Publishing models continue evolving to accommodate government mandates. Meanwhile, publishers look to cope with article-sharing sites that affect their business.

In the more than 15 years since the advent of open-access (OA) journals, scientific publishers who once viewed them as an existential threat are now operating their own. But despite double-digit growth in OA, scientific societies and commercial publishers alike agree that the vast bulk of their publications will remain wedded to the traditional subscription model for the foreseeable future.

"Open access is much less of a contentious issue now," says H. Frederick Dylla, retired executive director of the American Institute of Physics, which publishes PHYSICS TODAY. "It's happening. It's a business model." Of more concern to publishers today is the illicit posting of papers on article-sharing services. By some estimates, such as a 2014 report prepared for the European Commission, more than half of the scientific literature from 2007 to 2012 was accessible for free online. But it's unclear how much of that content consists of papers that infringe on publishers' copyrights because they are freely accessible despite licenses that are supposed to keep them behind paywalls.

Broadly speaking, scientific publishing follows two models. Traditionally, most journals obtain their revenues from institutional subscribers, mainly universities. Outside those licenses, the journal content is located behind an online paywall. So-called gold OA journals provide their entire content for free online immediately upon publication. Their revenues are provided from fees, known as article processing charges, paid by the article authors or their institutional funders.

A second category, known as green OA, consists of nongold OA articles that are freely available in one of the following forms: An article may be made available prior to publication as a preprint. A manuscript version may be provided by the publisher so authors can post it to their websites and institutional archives at the time it is accepted for publication. Or it can be released in its final published form, known as the version of record, after a specified period, most often one year after publication (this is sometimes referred to as delayed gold OA). Most scientific papers today are or will become available in some fashion as green OA.

The extent of fully OA publishing, like that of journal publishing overall, is hard to measure. About 800 of the 11 000 or so journals included in Journal Citation Reports, the Clarivate Analytics (formerly Thomson Reuters) service that calculates the widely used journal impact factors, are gold OA. Of the 21 500 journals tracked by Scopus, an abstract and citation database, around 3500 are gold OA titles. But less exclusive indexes, such as the Directory of Open Access Journals, count more than 9300 journals published in 129 countries. Estimates of the total scientific journal population—subscription and OA—range from a low of 33 000 to a high of 60 000, depending in part on where the line is drawn between scholarly and trade journals.

The International Association of Scientific, Technical, and Medical Publishers, whose 120 members publish two-thirds of all STM journal articles, estimated annual revenues for English-language STM journal publishing at $10 billion in 2015, up from $8 billion in 2009. Delta Think, a scholarly publishing consulting firm, valued the fully OA journal market last year at $374 million, and for 2017 it forecasts growth of 12%, roughly twice the rate of growth in the overall journal market. "Going forward, we think that the open-access market will continue to grow at about 10% to 15% through 2020," says Delta Think's Dan Pollock.

Mandates and archives

The growth of OA is largely driven by dozens of governments around the globe that have mandated free access to the results of publicly funded research. In most cases, including in the US, those

CYNTHIA CUMMINGS

ACADEMIC LIBRARIES face rising subscription costs for an ever-growing number of journals. Some libraries also underwrite researchers' costs for publishing in open-access journals.

mandates require grantees to make their papers free after a one-year embargo. The same applies in the UK, where the government also sets aside funding to pay for gold OA. The European Union requires grantees of its €80 billion Horizon 2020 program to provide free access within six months of publication (see PHYSICS TODAY, March 2014, page 26).

In the US, the major federal research-funding agencies have chosen several public repositories for their sponsored research. The largest, PubMed Central (PMC), has been operated by the National Institutes of Health since 2000. In addition to NIH-funded research, PMC has been designated by NASA, NIST, the Environmental Protection Agency, the Department of Homeland Security, and other, smaller funding agencies to house their research results.

The Department of Energy, NSF, US Geological Survey, Department of Defense, Smithsonian Institution, and Department of Agriculture have chosen to link their individual repositories to the Clearinghouse for the Open Research of the United States (CHORUS) database, established by a consortium of journal publishers. As of 30 March 2017, the CHORUS repository held 327 000 articles, of which 74 000, just under 25%, were post-embargo and freely accessible.

Unlike PMC, where articles are deposited in their entirety, CHORUS directs users to the participating publishers' websites. The distinction is important for publishers, who want to attract traffic.

In response to public mandates, the majority of subscription journals now offer the option for authors to pay an article processing charge to make their articles immediately OA. That so-called hybrid model currently accounts for about 4% of published papers (see the figure on page 26). But at some future theoretical tipping point, says Ken Heideman, publications director at the American Meteorological Society (AMS), the amount of free content could outweigh the subscription-only articles and force publishers to lower their subscription rates. "If you think of the whole of your content as a piece of cheese, pretty soon the hole gets bigger and it's Swiss cheese," he says.

Some nonprofit research funders, notably the Bill & Melinda Gates Foundation and the Max Planck Society, now require gold OA publication of their sponsored research. Some organizations also may permit publication in hybrid journals.

The economics

It's clear that the subscription model remains more lucrative. Journal publishers receive, on average, about $5000 per article from subscriptions, according to industry consultant Joseph Esposito in the *Scholarly Kitchen* blog in December 2016. But article processing charges for OA journals generally are only $1000–$1500 per article.

While they contain as much as 18% of all journal content, gold OA journals and gold articles in hybrids produce just 3–6% of all publishing revenues. A smaller proportion of articles in the physical sciences, some 10–12%, are published in OA journals, Pollock says. The disparities between content and revenue probably reflect the fact that OA is still a relatively young market, with publishers discounting article processing charges, he says.

Two of the 11 AMS journals, including the flagship *Bulletin of the American Meteorological Society*, are gold OA. Heideman says physical sciences have been "dragged along" to OA by the biomedical community. "We certainly agree that open access is a good thing within the limits of our business model. But it isn't

one size fits all. We'll continue to do it incrementally."

AMS decided a year ago to make all content of its nine subscription journals freely available after a one-year embargo, regardless of funding source. It was felt to be unfair to authors not subject to mandates to have their work remain stuck behind a paywall.

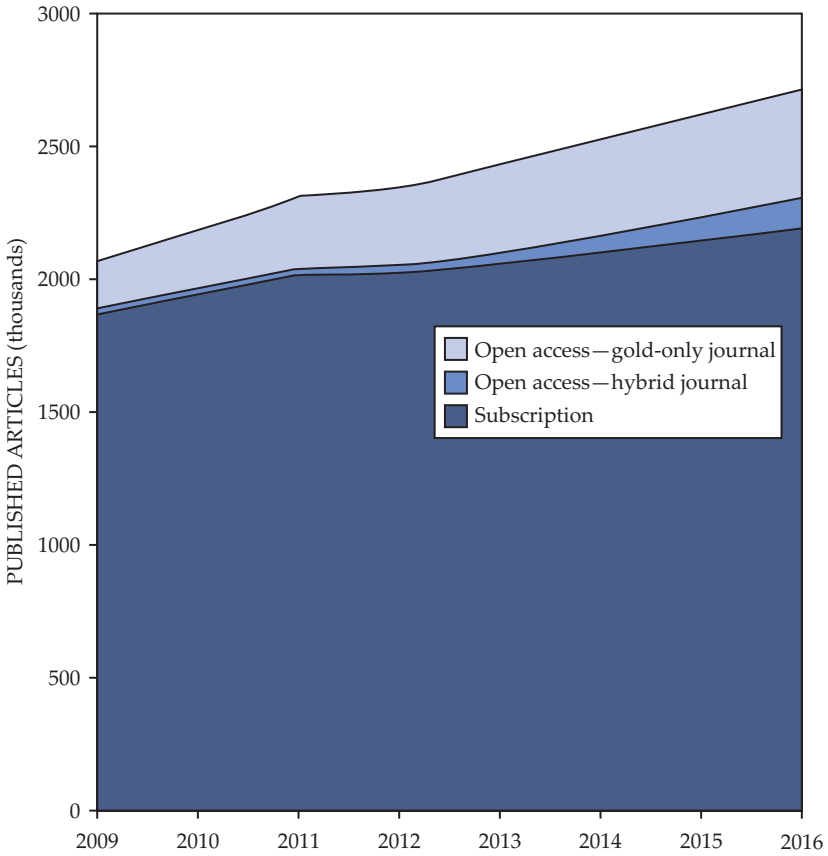
But Heideman regards the finite embargo period as an experiment, and its financial impact on AMS is uncertain. "We're banking on the fact that libraries are still going to see the value in subscribing to our content rather than waiting for a full year to get it free. We feel confident, but there are no guarantees," he says. "So far we haven't seen anything that would alarm."

With more than 200 gold OA journal titles, Elsevier is second to Springer Nature in the number of fully OA journals published. All but 200 of Elsevier's 2300 subscription journals are hybrid, and roughly 20 000 of the 420 000 articles published in Elsevier journals last year were gold OA. Elsevier policy and communications director Gemma Hersh sees gold OA continuing to grow alongside subscription. In addition, she says, "we're doing a lot of work with institutions in the US and globally to make green open access more effective and workable."

Nature Research, a component of Springer Nature and the parent company of *Nature* and its related journals, declined an interview request. However, a spokesperson said in a statement that the company offers more than 70 journals with OA options, from the multidisciplinary *Nature Communications* to highly specialized titles such as the 25 *Nature* partner journals, which are published in association with academic institutions, philanthropies, and membership organizations.

Nature Research believes the subscription model is the best way to provide sustainable and widespread access to journals with low article-acceptance rates, the spokesperson said.

OA is a particular challenge for highly selective journals such as *Science* and *Nature*, which publish fewer than 10% of submissions and thus have a considerably higher cost per article published. Jeremy Berg, editor-in-chief of *Science*, says, "A substantial part of your costs relates to processing, peer reviewing, and so on, for papers you end up not accepting." A 2013 report in *Nature* put that magazine's per-article cost at $30 000 to $40 000. For both flagship publications, advertising and income from other journals offset those high costs. Berg says there have been discussions about adopting hybrid models for *Science* and the four other Science-branded journals (a fifth, *Science Advances*, is fully OA).



NUMBERS OF SCIENTIFIC ARTICLES published in fully open-access (gold) journals and of fully open-access articles in subscription journals (hybrid) are increasing at a faster rate than are numbers of articles in subscription-only journals. Nearly all articles ultimately become freely available in some form (green open access), often after an embargo period. (Data provided by Elsevier.)

PLOS, founded by former NIH director Harold Varmus and other prominent scientists in 2001 as one of the original all-OA publishers, in 2007 created *PLOS One*, a multidisciplinary online platform. As of 30 March, *PLOS One* had published nearly 18 000 physics articles. Its "mega-journal" model differs from nearly every other journal in that research need not be novel, although it still must be sound and is peer reviewed.

After peaking at 31 500 in 2013, annual submissions to *PLOS One* fell to 22 000 last year. The decline came as other publishers started up copycats such as Nature Research's *Scientific Reports*. Some observers, including Phil Davis, a publishing consultant, have questioned PLOS's continued viability should *PLOS One* continue to shrink. And David Knutson, PLOS communications manager, acknowledges that *PLOS One* accounts for the "lion's share" of parent company revenues, which help to offset costs of PLOS's four biomedical journals. But Knutson says that the company remains in strong financial shape and that *PLOS One* today is "at the point where it's healthy and sustainable." PLOS's reported net assets were steady at $30 million from 2014 to 2015.

PLOS considers itself an advocacy organization, and Knutson notes that former CEO Peter Jerram once asserted that should it be put out of business by other OA publishers, it will have accomplished its mission.

Davis is concerned that the Trump administration's proposed cuts to research could cause a falloff in demand for OA publishing, since authors will have less funding to pay article processing charges. Some university libraries offer support for researchers to pay for publication, even as they claim to have insufficient funds to afford subscriptions

to thousands of journals. "Should they be spending $3000 on buying access to a really excellent collection of journals or pay for one paper to be published?" Davis asks.

Physicists' views

Physics-related papers have routinely been shared on the arXiv website since the 1990s. Those preprints typically are posted prior to the peer-review and editing processes that are performed by publishers. University of Maryland physicist Daniel Lathrop says posting to arXiv "satisfies our intent to have open access," and he notes that the preprint includes both figures and the basic conclusions. "It's not clear to me why you need open access in the refereed journal as long as it's the common practice" to post on arXiv, he says.

Still, Lathrop acknowledges that some fellow authors, particularly younger ones, feel strongly about OA, and their views will be considered in deciding where to submit a paper. But a more important consideration, particularly for young researchers, is the reputation and impact factor of the journal.

David Helfand, a Columbia University astrophysicist, sees OA as largely irrelevant to all but "the few people who are ideologically committed to it, who believe it's just right," and to those whose sponsors require publishing in OA journals. Helfand, a past president of the American Astronomical Society, says free public access to AAS's journal content is available through US public libraries. "The number of times this has been used in the past few years can probably be counted on your fingers," he says.

In AAS's publishing model, two-thirds of revenues are from article processing charges, with the remainder derived from subscriptions. Should funding for US science drop, Helfand worries that astronomers may submit their work to *Monthly Notices of the Royal Astronomical Society*, which has no author charges but costs institutions more than $14 000 a year.

"I don't think if AAS went gold it would change very much, because 98% of the papers are publicly available the day they are accepted, or several weeks before that" in arXiv, he says. A larger problem for public access, he thinks, is scientists' failure to write in "actual understandable English."

Helfand's and Lathrop's views are supported by author surveys. In a 2015 Nature Publishing survey of its authors, 18 000 respondents ranked an OA option 14th on a list of 17 factors driving the choice of where they submit articles.

Paul Hardaker, chief executive of the UK's Institute of Physics, which publishes more than six dozen journals, says its 2015 author survey also placed OA well down the list of considerations. "There is quite clearly a small community of strong advocates for open access, but it's not reflected in the response we've had from the broader community."

However, some view OA as an imperative. Daniel Kammen, a physicist at the University of California, Berkeley, is editor-in-chief of the decade-old OA journal *Environmental Research Letters*. Kammen says it is "absolutely the case" that all academic research should be open access, whether its funding comes from public or private sources. "The primary mission of a researcher is to be in some sense H. L. Mencken's public

intellectual," he says, which requires that both the paper and the underlying data be openly accessible. OA, he says, needs to rapidly get research results out "in a world where research is competing with tweets and Instagram and all these rapid things."

A citation advantage?

A long-standing debate has surrounded whether research will be cited more frequently in other scientific articles if it is openly available. Several studies have identified a citation advantage for such research articles. The OA advocacy organization Scholarly Publishing and Academic Resources Coalition (SPARC) maintains a scorecard of 70 citation studies, 46 of which find an advantage for OA articles. Seventeen others find no advantage, and 7 are inconclusive.

One of the more recent reviews, released in August 2016 by Science-Metrix and 1science, finds a 50% citation advantage for OA articles compared with subscription ones that aren't subsequently made open through green OA options. But a September 2016 report by Hersh and coauthor Andrew Plume claims that and other studies' methodologies are flawed, principally because of selection bias caused by a lack of randomization and control. Authors could be choosing OA journals for their most important research, for example, or researchers from elite institutions may be authoring a disproportionate share of OA articles.

By some accounts, a 2011 review by Davis is the sole randomized and controlled study to date. He concludes that while OA articles received significantly more downloads and reached a broader audience in the first year, they were cited no more frequently, nor any earlier, than subscription-access articles over the three-year study period.

Beyond open access

Publishers are trying to accommodate demand for OA while maintaining the subscription model. Last October, Springer Nature launched a content-sharing initiative to encourage "reasonable" free sharing with nonsubscribers by authors of articles in the publisher's 2300 journals, including *Nature* titles. Immediately upon publication, authors are provided shareable links to their papers, which can be viewed but not downloaded. The links can be posted anywhere, including the author's website, article-sharing sites known as scholarly collaboration networks (SCNs), and social media. Notably, an earlier year-long pilot version of the shared links program involving 50 journals resulted in no loss of institutional sales for the subscription-based journals.

Dylla sees figuring out how to deal with the SCNs as the new challenge for publishers. SCNs help scientists collaborate at all stages of their research and raise the visibility of their results, says Hersh of Elsevier, which owns Mendeley, the third largest SCN. Smaller SCNs have been around for decades. But the two largest—Berlin-based ResearchGate claims 10 million members and San Francisco-based Academia.edu boasts 50 million academic users—were founded in 2008 and are funded by venture capital.

Many articles shared on SCNs have been posted contrary to licensing agreements, intentionally or not. "They have a mixture of proper and improper content," says Dylla. Publishers seem to have reached a consensus to allow articles to be shared privately among collaborators, he says, in the same way that authors would mail reprints of articles to colleagues in the pre-electronic era. But there is a limit to how broadly a paper can be shared, and the particular version that can be shared, without jeopardizing the publishers' ability to solicit, review, produce, and archive the content, he notes.

The International Association of STM Publishers has developed voluntary principles for article sharing and operates a website, How Can I Share It, to inform researchers about which versions of articles they can properly share. "The aim is not in any way to shut down collaborations but to make sure the ecosystem works effectively," says Hersh.

To counter unauthorized content sharing, Dylla says publishers should strive to make content accessible with one-click convenience, akin to accessing movies on Netflix. "If you've got a single password, it doesn't matter if you're on a phone, iPad, or desktop, you can get to it and it comes right back to where you left off," he says. "Try that with journals." The music industry too, he adds, managed to avoid extinction from rampant piracy by working with Pandora, YouTube, and other providers to share revenues.

David Kramer