

Incorporating the Internet

The Internet's ubiquity in the everyday lives of biomedical scientists has permanently altered the doing of science. From the ordering of reagents to online web broadcasting of meetings to the publishing and reading of papers, a scientist's work is enhanced by Internet functionality. How the information that scientists generate, validate and publish is handled has also been changing. The integration of the online world with the archiving and retrieval needs of scientists is now a topic of intense discussion. Publishing is entering an exciting era and decisions made today will have long-term ramifications.

As long as people have been curious, natural phenomena have yielded to our prying. And for almost as long, investigators have turned to their peers for consultation and validation. From the founding of the Royal Society in 1660, science has been propelled by the exchange of information and ideas through oral presentations augmented by publications—by 1665 they launched *Philosophical Transactions*. The original reasons for formalizing publishing are as valid today as they were 350 years ago. The first—that a record of the precise experiments and conclusions is needed for independent repetition and analysis—forms the bedrock of modern investigations. Another major role is to communicate experimental details to scientific colleagues. The third argument in favor of formal publication is a byproduct of the independent peer review provided by most publishers within the last 50 years: publication helps establish a scientist's reputation. Knowledgeable peer review reduces the likelihood that technically faulty data or ill-conceived conclusions will be published. The momentum of scientific progress depends on the competition for reputation by its practitioners—reputations validated by the third-party peer-review mechanisms of formal publishing.

Scientific publishing recently has been attempting to mesh the needs and expectations of biomedical investigators with the global reach of the Internet. The flexibility of the web allows scientific publication to assume many forms. 'Self-publishing' has not turned out to be a preferred method, however. Personal and departmental websites are not designed for archiving, so manuscript availability may come and go, wreaking havoc on access and the scientific record as a whole. In addition, without independent peer review, the value of a paper would be difficult to ascertain quickly; at present a paper's quality is judged (rightly or wrongly) to be correlated with the reputation of the journal in which it is published.

The Internet has spawned better models for the dissemination of scientific information. In 1989, 4 years before the introduction of Mosaic (the first Web browser with a graphical interface), the publisher of *Science* and the Online Computer Library Center initiated a collaboration to produce a digital-only journal; in 1992 the first issue of the *Online Journal of Current Clinical Trials* went live. From this beginning, we now have biomedical journals available in both paper

and electronic form. Many journals, including *Nature*, are also converting their older print-only issues to digital format for archiving on websites. Some newer publishers, such as the Public Library of Science (PLOS), use the Internet as their primary distribution medium and offer print secondarily, for an additional fee. Successful technological integration is evident in the now common online submission and review systems; deep-linking into sequence and microarray databases; and the development of novel new web tools, through such partnerships as that of the Nature Publishing Group (NPG) and the Alliance for Cell Signaling.

Some of the current areas of exploration are accessibility and payment models. Traditionally journals were paid for by subscribers and/or authors (page charges). With the advent of a reliable Internet, the subscription model added a new category, the 'site license', where publishers provide electronic versions of their journals to entire universities and institutes (current NPG licenses cost on average less than \$3 per desktop per year). To ensure equitable global access, many publishers (including NPG) also make their sites available at no cost to developing countries through the United Nations' HINARI and AGORA programs. As for the 'author-pay' model, some publishers, such as BioMed Central and PLOS, rely on author fees to support online publication, but in a new twist, make the journal free for anyone with access to the Internet.

The altruistic aspects of these models appeal to many scientists. However, nothing is truly free and trade-offs are a reality. Developing technologically sophisticated ways to serve scientific information while continuing to ensure a journal's integrity and stability is neither easy nor cheap. As journals turn to the web, traditional revenue streams such as print advertising diminish, and new ones need to be found to fund development. In uncertain economic times, subscription-based publishers are seeking to provide as much content and access at as low a cost as possible that still allows them to fulfill their responsibilities. Publishers of the newer author-pay journals have additional challenges as they strive for financial self-sufficiency while trying to avoid the potential publishing conflict-of-interest wherein editors in lean times may feel pressure from publishers to accept more papers (and thereby increase revenues). It is also not clear that current author charges are adequate to support the model, a variable that introduces additional economic and legacy uncertainties. As scientists and publishers experiment with author-pay models, funding agencies and institutions will be reexamining library budgets and the proportion of research grants devoted to publication fees and subscriptions. These issues and others need to be dealt with head-on. As we traverse this new landscape, authors' needs and publishers' responsibilities must serve as the guideposts for the community as we navigate this continually changing terrain.