PERSPECTIVES

The Open Access Initiative in Scientific and Biomedical Publishing: Fourth in the Series on Editorship

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• PURPOSE: To provide basic information about the Open Access concept and its historical development, define the benefits and challenges inherent in this new model, and identify the value of the traditional print model and its movement towards more open access.
• DESIGN: Review of current information on the subject from numerous sources.
• METHODS: Medline search and Internet search engines on the topic of Open Access Publishing.
• RESULTS: The Open Access initiative derives from several premises: medical libraries can no longer afford journal subscriptions; society benefits from the open exchange of ideas; society has in large part already paid for this research; the Internet provides an available venue. The traditional journal publishers model, however, has functioned well over many years with a robust peer review system and increasing Internet digital components permitting search and cross referencing, including elements of the Open Access model.
• CONCLUSIONS: It will be difficult to maintain the costs of both the traditional journal system and the fully implemented Open Access model. Any decisions that are made must ensure that the archive of prior medical knowledge is not lost, that financial barriers do not restrict publication, and that research continues to be available to those who need it, in the media that they prefer. (Am J Ophthalmol 2005;139:156-167. © 2005 by Elsevier Inc. All rights reserved.)

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SCHOLARLY COMMUNICATION AND BIOMEDICAL LIbraries are at a crossroads, with both for-profit and not-for-profit publishers threatened by the technological capabilities inherent in the electronic storage and retrieval of information on the Internet. The concept of Open Access publishing is emerging to counteract increases in traditional journal costs and delays in publication.[1] Open Access is a publishing model in which journal content is accessed free on the Internet by any reader from the moment of publication, or at least within months. The model uses a different financial model than traditional journals in that they plan to recoup some of their costs by charging authors a fee; parenthetically, this makes such manuscripts "advertisements" under United States law. The premise of the Open Access initiative is that society benefits from the open exchange of ideas and that access to copyrighted or non-copyrighted materials inspires creativity and facilitates the development of new knowledge. Open access does not apply to materials for which the authors expect to generate revenue, for example, most textbooks.

A conflict has developed between the traditional print journal and the Open Access advocates since the model affects publishing businesses, journals, academic institutions, government, researchers, and the reading public. The mutual success of traditional print and Open Access may not be possible because of the costs of both systems. Yet, the survival of archives that deliver, store, and allow retrieval of all past science and medical information is critical.[2] Political forces in the United States Congress and the United Kingdom House of Commons are already seeking to regulate this movement because of the potentially widespread effect on the public.

The Open Access initiative seeks to provide access to scientific research including peer-reviewed journal articles, preprints, preliminary findings, and data sets, without financial, legal, or technical barriers.[3] Electronic publishing takes advantage of unique Web capabilities such as easy transfer of documents, direct communication between writer and reader, and data manipulation in new ways,

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TABLE 1. Web Links to Related Materials About Open Access Initiatives*

PubMed Central	http://www.pubmedcentral.gov
Public Library of Science	http://www.plos.org
BioMed Central	http://www.biomedcentral.com/
Open Access Now	*http://www.biomedcentral.com/openaccess/*
Biomed Central Ophthalmology Journals	http://www.biomedcentral.com/bmcophthalmol/
Budapest Open Access Initiative	http://www.soros.org/openaccess/read.shtml
Scholarly Publishing and Academic Research Coalition	http://www.arl.org/sparc
SPARC Gaining Independence Manual	http://www.arl.org/sparc/GI/toc/index.html
World Summit on the Information Society	http://www.itu.lnt/wsis/
Directory of Open Access Journals	http://www.doaj.org
CrossRef	http://www.crossref.org
Health InterNetwork Access to Research Initiative	http://www.healthinternetwork.org/index.php
Washington, D.C., Principles for Free Access to Science	http://www.dcprinciples.org/
Open Access News Blog	http://www.earlham.edu/~peters/fos/fosblog.html
Berlin Declaration on Open Access to Knowledge	http://www.zim.mpg.de/openaccess-berlin/
Bethesda Statement on Open Access Publishing	http://www.earlham.edu/%7Epeters/fos/bethesda.htm
Wellcome Trust Economic Analysis	http://www.wellcome.ac.uk/en/1/awtpubrepeas.html
Open Citation Project	http://opcit.eprints.org/explorearchives.shtml
Open Archives Initiative	http://www.openarchives.org/

*All accessed October 1, 2004.

such as three-dimensional objects, moving images, and hypertext links to related research materials.[1] Search, retrieval, and integration of information are improved; printing, binding, and distribution costs are reduced. Rapid exchange of information among participants creates the potential to expedite the development of ideas. Open Access operates within the current legal framework of copyright law.[4] Authors can transfer the right for publishers to post the work freely on the Web or retain the right to post their own work on institutional or discipline-oriented servers. Authors do, however, retain control over the integrity of their work and have the right to be properly acknowledged and cited. As with print journals, open access journals can be peer-reviewed, indexed, and cited; some have print counterparts available on a subscription basis. Despite these similarities, Open Access differs from traditional print publishing in terms of its financial infrastructure. Under this model, authors and institutional or research-funding agencies are asked to provide the fees for dissemination of scientific information as opposed to the traditional library subscription model.[5]

This perspective will provide basic information about the Open Access concept and its historical development, define the benefits and challenges inherent in this new model, and identify the value of the traditional print model and its movement towards more open access.

• **HISTORY OF THE OPEN ACCESS INITIATIVE:** The Open Access concept is not without precedent. With the advent of the Internet, relationships for the dissemination of scientific information developed in several fields of science. Anton recounts a successful form of alternative scientific communication in the physics e-print archive.[1] This archive was created as an experiment among high-energy particle physicists in order to circumvent perceived problems of publishing in research journals. The concept became the primary means of distributing research in physics, pure mathematics, and nonlinear sciences. The physics e-print archive serves as a model of exchange of scientific information, receiving two million visits each week (most from outside the United States). The archive is supported by half a million dollars each year from the National Science Foundation, Department of Energy, and Cornell University. Access to the server is free and includes the full text of e-prints, reports of the most recent developments, and research in these fields. Submissions are processed, archived, indexed automatically, and made available by e-mail and through the Internet. Subscribers are automatically e-mailed abstracts of new submissions through an unstaffed, unsupported system. Earlier drafts of submissions are usually replaced by edited versions. In this model, the electronic e-prints represent the "raw literature" (First Publication) and final publication of articles provides the value-added services (Definitive Publication).[6] Physicists readily accepted this model because they had been distributing preprints in paper format for years and electronic distribution made the process much more efficient.

Another open access format is PubMed Central, a digital archive of life sciences journal literature developed, managed, and supported by the National Center for Biotechnology Information at the United States National Library of Medicine. PubMed Central is not a journal publisher but archives complete journal articles provided

TABLE 2. Timeline of Significant Events In the Open Access Initiative

September 1997
Presenting to the third International Congress of Peer Review on Biomedical Publication in Prague, Stevan Harnad begins advocating for free, virtually instantaneous access to biomedical literature and for authors to self-archive their work.
June 1998
The Association for Research Libraries (ARL) creates the Scholarly Publishing and Academic Research Coalition (SPARC) in response to the crisis in scholarly publishing.
February 2000
PubMed Central launches with content from *Proceedings of the National Academy of Sciences* and *Molecular Biology of the Cell.*
October 2000
Scientists begin circulating an open letter in support of a "Public Library of Science." By mid-2002, approximately 31,000 scientists in 182 countries had signed this letter.
January 2001
SPARC launches "Declaring Independence" initiative, encouraging scientists to distance themselves from commercial publishers, that is, publishers who do not serve the changing needs of the scientific community.
February 2002
The Budapest Open Access Initiative produces a statement of principle, strategy, and commitment to making research articles in all academic fields publicly available on the Internet and encourages the principles of PubMed Central. The initiative recommends complementary use of self-archiving in institutional/disciplinary repositories and open access journals.
March 2002
The National Institutes of Health issues a Draft Statement on Sharing Research Data stating that NIH support for studies should include the expectation of timely release and sharing among researchers of final research data.
December 2002
The Public Library of Science receives a $9 million grant from the Gordon and Betty Moore Foundation for open access publishing and announces its first two open access journals. This initiative arose from the failure of the library's original mission to persuade major publishers to convert existing subscription journals to open access.
March 2003
The National Health Service in the United Kingdom announces a membership deal with BioMed Central.
June 2003
The Joint Information Systems Committee (a committee of United Kingdom further and higher education funding bodies) buys institutional memberships of BioMed Central for all 180 universities in the United Kingdom. The Bethesda Statement on Open Access Publishing makes suggestions as to what institutions, funding agencies, libraries, publishers, and scientists can do to bring open access to fruition. Martin Sabo introduces the Public Access to Science Act into Congress, which would exclude from copyright protection works resulting from scientific research substantially funded by the United States government.
September 2003
Howard Hughes Medical Institute tells grantees that the institute will cover article-processing charges for open access.
October 2003
PLoS Biology, the first open access journal from the Public Library of Science, launches. Two scientists at the University of California San Francisco call for a boycott of six molecular biology journals, accusing the publisher of charging exorbitant fees for access. Major German research organizations and many other international research centers sign the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities in the same spirit as the Bethesda Declaration and the Budapest Initiative. The Wellcome Trust publishes a position statement in support of open access publishing. Financial analysts at BNP Paribas and Citigroup Smith Barney independently conclude that the business model of open access publishing is viable and is likely to put pressure on commercial publishers.
December 2003
The World Summit on the Information Society, co-sponsored by the United Nations and the International Telecommunications Union, adopts a Declaration of Principles and Plan of Action endorsing the principles of open access. The Science and Technology Committee of the United Kingdom House of Commons announces an inquiry into journal access within the scientific community, with particular reference to price and availability. The Joint Information Systems Committee announces a £150,000 funding program to help publishers make journals freely available on the Internet using open access models.
February 2004
The government of the United Kingdom convenes the UK House of Commons Select Committee for Science and Technology to consider mandating that research results obtained from publicly funded medical research (most urgently those from clinical trials) be published under open access rules.
March 2004
A coalition of 48 nonprofit publishers, including the American College of Physicians and the American Academy of Pediatrics, issues the Washington D.C. Principles for Free Access to Science, pledging free, worldwide access immediately or within months of publication of their journals and a commitment to innovative and independent publishing practices.

TABLE 2. Timeline of Significant Events in the Open Access Initiative *(Continued)*

April 2004
The Public Library of Science's second journal, *PLoS Medicine,* begins accepting submissions for its inaugural issue, slated for Fall 2004.
July 2004
The Appropriations Committee of the U.S. Congress recommends requiring free access to papers based on research financed by the National Institutes of Health. The Science and Technology Committee of the UK's House of Commons endorses open access to research results and criticizes the scientific-publishing industry for the escalating prices of its journals. The committee stops short of requiring open access to research papers but it encourages depositing published papers into online archives and publishing scientific journals using author-pays business models.

to it by journal publishers. Access to PubMed Central is free and unrestricted, and publisher participation in PubMed Central is voluntary. While subscription and open access journals can deposit their materials at any time, PubMed Central has had limited publisher participation since it began in February 2000. PubMed Central recently made concessions to encourage greater participation, such as not requiring material to be viewable from its site; hyperlinks are provided from article abstracts directly to publisher sites containing the original material.

PubMed Central was originally conceived with a design similar to the physics model discussed above with no requirement for peer review. Opponents argued that under that model, misleading or inaccurate biomedical literature would be available; multiple versions of articles would lead to confusion, particularly on the part of healthcare consumers; ownership of the work would be in doubt; and journals might not publish work when earlier versions had been published on the Web.[7,8] The prestigious journal Proceedings of the National Academy of Sciences (PNAS) was among the first to sign on with PubMed Central but only after PubMed Central agreed to alter the model to accept strictly peer-reviewed materials. Publishers' copyright provision on commercial use of published material remains intact and journals are providing content free, but only after a delay that will protect the subscription base of individual journals. In the case of PNAS, the delay is six months. PubMed Central now costs about $2.5 million a year and contains papers from about 150 journals. It is estimated that it would cost $50 million to post full-text articles for all 4500 journals in MEDLINE. In the fall of 2000, scientists began circulating an open letter in support of a "Public Library of Science." This letter advocated public ownership of the scientific record, and signatories pledged they would publish in, edit or review for, and personally subscribe to only those journals that make their work available through PubMed Central or another server. By mid-2002, approximately 31,000 scientists in 182 countries had signed this letter. However, there has been minimal impact; only a handful of journals have agreed to archive their articles in PubMed Central and only a few researchers have boycotted the non-participating journals.

Following this, Dr. Harold Varmus, Nobel laureate and former director of the NIH, formed a private open access venture named the Public Library of Science (PLoS) with considerable initial financial backing.[9] In December 2002, The PLoS announced a series of open access journals to compete directly with commercial publications. The first of these, *PLoS Biology*, was launched in October 2003 and is freely available on the Internet. The organization's second journal, *PLoS Medicine*, started in October 2004. Authors are charged a fee ($1500, or whatever they can afford to pay) for each manuscript published in order to cover the costs of processing the articles (peer review and technical editing) and electronic distribution. It intends to maintain high editorial and production standards. Articles are freely available from the PLoS website as well as from PubMed Central. *PLoS Biology* will also have a print version available for about $160 per year.

Similarly, BioMed Central, an independent commercial publisher in the United Kingdom, uses the Open Access model for its own online journals of peer-reviewed biomedical research. The original research journal articles published by BioMed Central are immediately and permanently available online without charge or other barriers to access. BioMed Central supports itself with a combination of author fees and membership fees. BioMed Central also earns money through advertising and subscriptions to value-added features, including reviews, commentaries, navigation, and interpretation tools. Processing fees, normally $500, are waived for authors from developing countries or in cases of hardship, and authors maintain copyright and editorial control of their manuscript. BioMed Central now publishes more than 100 open access journals covering many aspects of biology and medicine, including ophthalmology. The Joint Information Systems Committee (a committee of United Kingdom higher education funding bodies) provides funding for institutional memberships to BioMed Central for 180 universities in the United Kingdom.

Recently, the level of debate about the concept of open access publishing has increased markedly throughout the world (see Table 1 and Table 2). Beginning with a presentation in 1997 to the International Congress of Peer

Review on Biomedical Publication in Prague, Stevan Harnad of the United Kingdom has been a strong proponent of the premise that the biomedical literature should be free of charge and virtually instantaneous and that authors should self-archive their work.[10,11]

In 1998, the Association for Research Libraries (ARL) created the Scholarly Publishing and Academic Research Coalition (SPARC) in response to the crisis in medical libraries (summarized below).[12] The goals of the coalition are directed at the large issues in scholarly publishing: to bring down the cost of the production and distribution of scholarly journals; address copyright and fair use issues; and use technology to improve the process of scholarly communication. SPARC aims to create a more competitive scholarly communication marketplace, where the cost of journal acquisition and use is reduced, and to reward publishers who are responsive to customers' needs. A particular focus of SPARC is to partner with scientific societies and create an alliance of universities, research libraries, and organizations. SPARC serves as a catalyst for action, striving to create systems that expand information dissemination and use in a digital environment while responding to the needs of scholars and academe. In January 2001, SPARC launched an initiative "Declaring Independence" from commercial publishers, that is, publishers who do not serve the changing needs of the scientific community. It further offers detailed suggestions for creating alternatives to expensive scientific journals, including a "how-to" manual.

The Budapest Open Access Initiative produced a statement of principle, strategy, and commitment to making research articles in all academic fields publicly available on the Internet and encouraged the principles of PubMed Central.[13] These scientists believe that information from multiple sources stored in a common format within central repositories can substantially enhance their ability to search across collections, manipulate data, and develop tools to integrate the literature with a variety of other information resources. This initiative recommended complementary use of self-archiving in institutional/disciplinary repositories and open access journals.

In early 2002, the NIH issued a Draft Statement on Sharing Research Data stating that NIH support for studies should include the expectation of timely release and sharing among researchers of final research data.[14] In June 2003, the Bethesda Statement on Open Access Publishing made suggestions as to what institutions, funding agencies, libraries, publishers, and scientists should do to bring open access to fruition.[15]

In October 2003, major German research organizations and many other international research centers signed the Berlin Declaration on Open Access to Knowledge in the Sciences and Humanities[16,17] in the same spirit as the Bethesda Declaration and the Budapest Initiative.[13,15] The Berlin Declaration advocated the free use of the Internet for scientific communication and publishing, mechanisms to evaluate and maintain quality assurance in the process, the recognition of an Internet publication in academic promotion, and resolution of the financial and legal roadblocks.[17]

In December 2003, the World Summit on the Information Society, co-sponsored by the United Nations and the International Telecommunications Union, adopted a Declaration of Principles and Plan of Action endorsing the principles of open access. The NIH, the Howard Hughes Medical Institute, the Wellcome Trust, and Germany's main research agencies have agreed to cover the author costs of open access publishing for research that they sponsor.[18] Since 1995, more than 100 society and university nonprofit publishers have been working with Stanford University's HighWire Press to transform traditional print journals into enduring, dynamic online journals. In March 2004, a coalition of 48 nonprofit publishers, including the American College of Physicians and the American Academy of Pediatrics, issued the Washington D.C. Principles for Free Access to Science,[19] pledging free, worldwide access immediately or within months of publication of their journals and a commitment to innovative and independent publishing practices. They specifically supported the following forms of free access in their own journals: selected important articles would be free online from the time of publication; the full text of journals would be freely available worldwide either immediately or within months of publication; the content of their journals would be available free to scientists working in many low-income nations; articles would be made available free online through reference linking between these journals; and content would be available for indexing by major search engines. There are more than 1100 open access journals listed on the Directory of Open Access Journals[20] (Table 3). BioMed Central produces *Open Access Now*, a newsletter designed to update life sciences researchers on the revolution in publishing and distribution of research. The logo of *Open Access Now* is a caged bird flying free.[21]

• **DIFFERING VIEWPOINTS ON THE OPEN ACCESS MODEL:** At a time of information explosion, does more information need to be widely available? Dr. Halsted articulated a cautious approach to the Open Access model.[22] Although immediate open access to all scientific content serves both scientists and the public, instant access to newly published data may further confuse the public, especially when health decisions must be made. The average consumer does not have the skills to discern good science from bad science or to distinguish an inadequately controlled drug trial from a well-controlled one.[23,24] The "Public Library of Science" initiative recommended that scientific publishers turn over their contents to the public six months after publication and asked scientists to boycott those journals that do not agree to these demands.[25] The emergence of the Public Library of Science (PLoS) as a private, nonprofit organization is an indication that this

TABLE 3. Open Access Ophthalmology Journals*

Archivos de la Sociedad Espanola de Oftalmologia	http://scielo.isciil.es:90/scielo.php?script=sci_serial&pid=0365-6691&lng=en&nrm=Iso
Arquivos Brasileiros de Oftalmologia	http://www.sclelo.br/sclelo.php?script=sci_serial&pid=0004-2749&lng=en&nrm=iso
BMC Ophthalmology	http://www.biomedcentral.com/1471–2415/
	http://pubmedcentral.com/tocrender.fcgi?action=archive&journal=52
British Journal of Ophthalmology	http://bjo.bmjjournals.com/
Bulletin de la Societe Belge d'Ophthalmologia	http://www.ophthalmologia.be/plugins/publications/show_publications.php?pca_id=7
Digital Journal of Ophthalmology	http://www.djo.harvard.edu/
Internet Journal of Ophthalmology & Visual Science	http://www.ispub.com/ostia/index.php?xmlFilePath=journals/ijovs/front.xml
Journal of Vision	http://journalofvision.org/4/9/
OSL - Oftalmologica Santa Lucia	http://www.hospitalsantalucia.com.ar/osl/osl.htm
Review of Ophthalmology	http://www.revophth.com/
Revista Cubana de Oftalmologia	http://bvs.sld.cu/revistas/oft/indice.html

*All accessed October 1, 2004. Note: Several other ophthalmology journals have components of Open Access.

strategy did not work. The Open Access initiative does not take into consideration that some journals may be less able to afford to participate. Scientists starting their careers, non-United States scientists, or scientists employed by the United States government or foundations that do not provide publication costs would be excluded from institutional support for this publication fee.[22] Halsted cautions that the Open Access model could essentially terminate the hundreds of nonprofit scientific journals that depend on individual and institutional journal subscriptions for their financial solvency.[22] Smaller open access journals are threatened because of their inability to compete with the financial backing of PLoS.[26] If the financial burden of author fees falls to the universities and departments, how will they decide which faculty and areas of research are supported?[27] Universities must also consider the potential long-term impact of this open access movement since it might actually make journals more expensive for them as they pay author fees for open access publications while still subscribing to traditional journals. Another concern that will undoubtedly affect open access articles more frequently is the problem of Internet references that are no longer retrievable after an article is published.[28] Even high impact journals such as the New England Journal of Medicine, Science, and JAMA have up to 21% of their Internet references within published articles no longer retrievable within 27 months after publication. The traditional copyright system has seemingly worked to protect the integrity of published scientific information. The high publication costs of scientific journals, especially non-Society journals, are used to support the methodical stages of scientific peer review, copy editing, and publication of print and online versions. Free cross-referencing to other online journals is another cost that publishers bear or must consider. Although most editors of print journals do not have access to the data, at least one journal has estimated its publishing cost—by dividing the annual expenses of scientific editing and production management by the annual number of pages published—at $435 per page, or roughly $2500 per five-page printed article.[22] The American Association for the Advancement of Science would have to charge $10,000 per paper in *Science* because of the expenses attendant to its 90 percent rejection rate and the journal's news and reviews sections.[29] If the goal is to create open access journals that can compete or compare with elite journals in content, these open access journals must be prepared for high rejection rates and support the costly peer-review and editorial process. It is likely to cost much more than $1500 per accepted article. Some funding agencies will participate in this increased cost, but then the process may become elitist and biased again.[18]

Anton points out that while the numbers of scholarly articles and publications have increased markedly, so also have the costs of scientific journals.[1] Many libraries have canceled journal subscriptions, decreased access and forgone book purchases.[30] Science journals account for approximately 29 percent of the total number of serials, but their subscriptions consume 65 percent of a university library's serials budget.[31,32] Science journals are more expensive to produce because of color diagrams and/or high quality photographs. Newer journals tend to be more specialized and have smaller subscription bases, leading again to higher costs. Research libraries, as repositories of scientific knowledge, and librarians, as organizers and providers of access to this knowledge, are as central to scientific communication and progress as continuous and complete archives. Yet, research libraries are no longer able to provide full archives to critical scientific information, and the system of scientific communication is perilously close to collapse.[1] Universities, colleges, and the government continue to provide intellectual property to commercial publishers and professional societies, purchasing it back at ever-higher prices.

Morgan Stanley has calculated that Global Science, Technology, and Medical (STM) publishing is a seven billion dollar a year industry, and that scientific journals have been the fastest-growing media sub-sector of the past 15 years.[33] This has been exacerbated even further by a number of major mergers, resulting in some increases in subscription rates.[34] The Association of Research Libraries (ARL) statistics indicate that between 1986 and 2001, journal expenditures among member institutions increased 210 percent, the number of serials purchased decreased by 5 percent, and the unit cost of journals increased 215 percent.[32] Between 1996 and 2000, the average price of a commercially produced scientific journal increased almost 45 percent.[35] A different report indicated that between 1986 and 2002, expenditures for journals in research libraries increased by 227 percent but the number of serials purchased with these resources only increased by 9 percent.[36] Weaker commercial publishers and non-profit publishers or society publishers bear the brunt of library budget cuts; major publishers tend to outperform the market as libraries trim peripheral, smaller suppliers who can't bundle journals as effectively as the publishing giants.[33] The Association of Research Libraries outlined several financial considerations in developing an open access model.[4] The federal government spent close to $50 billion on non-defense related research and development in 2002. The government depends on the dissemination of the research results to stimulate economic, scientific, medical, and environmental development. Yet book purchases by libraries declined by 9 percent between 1986 and 2001 as they sought to sustain journal collections. Based on 1986 purchasing levels, the typical research library has foregone purchasing 90,000 monographs over the past 15 years. The model has changed from the purchase of physical copies to negotiating licenses for electronic access. Multiple-year licenses to large bundles of content precluding cancellation will force libraries to stop carrying titles from smaller publishers to cover price increases of the bundles. A lack of corrective market forces has permitted large companies to reap high profits from publishing science journals.[4] In 2001, a major publisher's scientific, technical and medical division's operating profit was 34 percent, while its legal division's operating profit was 20 percent, business division's was 15 percent, and education's was 23 percent. Mergers exacerbate substantial subscription price increases of journals owned by merging companies. While there were 13 major STM publishers in 1998, only seven remained by the end of 2002.

In October 2003, two scientists at the University of California, San Francisco called for a boycott of six molecular biology journals, accusing the publisher Elsevier of charging exorbitant fees for access. The academic senate at the University of California, Santa Cruz called on tenured members to no longer submit papers, to refuse to referee submissions, and to give up editorial posts at that publisher's journals until prices dropped. Although the boycott was not effective, a major initiative to improve the publishing system followed, and a subscription arrangement was finally reached with the University of California.

On the basis of an economic analysis, the United Kingdom's leading biomedical research charity, the Wellcome Trust, concluded that open access publishing would better serve the interests of scientists and the public.[37] However, a Morgan Stanley financial report also acknowledged that the publishers with the biggest online portfolios may drive many of the smaller commercial and society publishers out of business.[33,38] Morgan Stanley's report suggested that publishers are crafting licensing agreements that lock libraries into subscriptions to lower-use, more marginal titles in order to ensure access to prestigious, high-use titles. Two of the largest science, technology, and medicine publishers account for 60 percent of the University of California's shared digital journals but only 33 percent of e-journal use.[39] This portfolio pricing obscures journal prices and reduces competition among individual titles from different publishers, contributing to the monopolistic trend of the market. The open access model shifts the high costs of publishing to researchers and research grant money. Open access has, in essence, been accepted and adopted by funding bodies as diverse as the Howard Hughes Medical Institute, the Wellcome Trust, the Max Planck Society, the German Research Council (DFG), the French Scientific Research Council (CNRS), the French National Medical Research Institute (INSERM), and the NIH. Some 2000 Scientific, Technical, and Medical (STM) publishers annually produce and circulate 1.2 million peer-reviewed articles selected for their quality. Publishers organize, establish, manage, produce and disseminate journals; define new disciplines; and establish and actively manage editorial boards while investing in new technologies to make research more accessible. The substantial investments that STM publishers have made in electronic technologies continue to deliver productivity improvements. More users than ever gain quicker and easier access to more content at lower per-article costs for the institutions that serve them. In a document submitted to the hearings of United Kingdom House of Commons Select Committee for Science and Technology in February 2004, Elsevier, the publisher of hundreds of journals including both *Ophthalmology* and the *American Journal of Ophthalmology*, articulated the publisher's viewpoint about the successes of the traditional publishing models in the United Kingdom.[40,41] Other publishers, including Blackwell Publishing, Taylor & Francis, and Nature Publishing Group, also made reports to the committee expressing the publisher's perspective.

After investing approximately £200 million to date in its *ScienceDirect* electronic distribution platform and in other programs (for example, digitization of archived journals), Elsevier noted increased productivity in its electronic initiatives' access, usage and functionality within the United Kingdom.[41] All United Kingdom higher education

institutions engaging in science and medical research have access to nearly all Elsevier journals that pertain to their research programs; 97 percent of United Kingdom researchers have direct access, on average, to 90 percent of Elsevier journals under license of their host institution. United Kingdom citizens also have access to all Elsevier journals and articles either directly through their local libraries or via inter-library loan agreements. From 2001 to 2003, the number of United Kingdom researchers downloading Elsevier's electronic articles at least once per month more than doubled from 145,000 to 360,000, while the number of Elsevier articles downloaded tripled from 4.4 million to 13.3 million (how a download is related to actual usage is unclear). More than 820,000 United Kingdom researchers use *ScienceDirect* regularly. These increases in breadth and frequency of use reflect the benefits to users, who can access a highly expanded range of articles on campus or remotely at any time and with greater efficiency. *ScienceDirect* allows users to perform complex searches and retrieve full text articles, link to other articles cited, export content to local databases and citation management software, and receive alerts when new journal issues are released. In the case of Elsevier, the average cost for a retrieved article for United Kingdom users of *ScienceDirect* has fallen from £4.57 to £1.69 since 2001, a reduction of 63 percent.

Elsevier cautions that the author-paid Open Access model risks undermining public trust in the integrity and quality of scientific publications, whereas the subscription model ensures high-quality, independent peer review and prevents commercial interests from influencing decisions to publish.[41] Elsevier maintains that the Open Access business model has not proven its financial viability and that costs have to be covered by foundation, university, and government subsidies. While it is conceivable that mean costs per article may fall as electronic-only publishers gain scale (currently less than 1 percent of articles are open access), Open Access publishers are unlikely to cover production costs with revenues of $1500 per article, assuming they provide similar levels of quality, peer review, proof reading, copy editing, graphic design, and layout and web functionality and accessibility as researchers receive today with traditional journals. Open access publishers would almost certainly not be able to invest in technological innovation to any substantial extent or in emerging areas of science.

For universal access to be a reality, publishers must continue to make articles available in multiple formats. Print is still used by many to gain knowledge about scientific and medical research. To rely on the Internet alone for distribution, as most open access journals do, risks reducing levels of access among these beneficiaries. In fact, only 11 percent of the world's population uses the Internet.

The recent period of rapid, intense innovation in STM publishing seems far from over. The publishers expect the benefits in productivity for users (that is access, usage, functionality, and lower unit costs for customers) to continue. All publishers must continue to innovate, observe the impact of Open Access, and assess how effectively such initiatives serve the needs of scientific and research communities. As developments bring demonstrable and sustainable improvements for those communities, publishers must adapt and invest accordingly. Elsevier concluded that the United Kingdom government should continue to allow the market dynamics of this global industry to drive innovation and determine which publishing models can best serve the needs of the scientific and medical research communities.

Electronic publishing has increased the need to monitor quality more closely and to ensure attribution of authorship as it moves on the Internet. Traditional publishers have been effective in minimizing the risks of scientific fraud and malpractice through their organizational and oversight roles in editorial offices, peer review, and independent guardianship of the scientific record. This critical control reduces the ability of commercial interests to influence decisions to publish. The subscription-based model favors more rejections, which seems important in clinical medicine, where the risks associated with publishing substandard material are substantial.

Many scientific journals are published by or on behalf of societies that have a special need, audience, and cost structure. Their role and views are undervalued in the current debate on Open Access. Even if a journal decides that open access is a goal, there are large financial and stability costs during the intermediate states to this new model. If an open access system fails for a specific journal, the journal will also likely cease to exist. Publishers such as Elsevier have been working in consultation with their editorial boards on models to achieve the widest possible access to and visibility of their journals.[25] Publishers are creating agreements with library consortia for electronic access to its journals but should develop a payment schedule that is responsive to an institution's means and degree of access. Most peer-reviewed scientific research is abstracted and indexed by secondary information services with metadata and summary abstracts of findings available online, often free of charge. Licensing arrangements with library consortia worldwide have broadened cost-effective access. Commercial publishers provide start-up grants and loans for a wide range of industry activities to improve scientific communication. Publishers pushed for the expansion of reference interlinking through the application of digital object identifier (DOI) technology. The widespread participation of 225 member publishers in the nonprofit organization CrossRef has resulted in an extensive network of interconnected scientific information. Commercial publishers operate under a self-sustaining business model that allows these beneficial investments. Elsevier assures electronic versions of journals are stored and will be retrievable with independent third party archival entities in redundant locations. More than 30

TABLE 4. Links to the United Kingdom House of Commons Science and Technology Committee Hearing on Open Access Publishing*

Science and Technology Committee	http://www.parliament.uk/parliamentary_committees/science_and_technology_committee.cfm
The Inquiry	http://www.parliament.uk/parliamentary_committees/science_and_technology_committee/scitech111203a.cfm
BioMed Central Submission	http://www.biomedcentral.com/openaccess/inquiry/bmcsubmission.PDF
Elsevier Submission	http://www.elsevier.com/authored_news/corporate/images/UK_STC_FINAL_SUBMISSION.pdf
Oxford University Press Submission	http://www3.oup.co.uk/jnls/2004/03/08/index.html
Public Library of Science Submission	http://www.plos.org/downloads/HCEvidencefromPLoS.pdf
Wellcome Trust Statement	http://www.wellcome.ac.uk/doc%5Fwtd002766.html
Transcript of Oral Evidence Session 1	http://www.publications.parliament.uk/pa/cm200304/cmselect/cmsctech/uc399-i/uc39902.htm
Transcript of Oral Evidence Session 2	http://www.publications.parliament.uk/pa/cm200304/cmselect/cmsctech/uc399-ii/uc39902.htm

*All accessed October 1, 2004.

leading biomedical publishers have made the content of more than 2000 journals available online free to clinical investigators at institutions from more than 100 developing countries through an arrangement between the publishers and the Health InterNetwork Access to Research Initiative, a project undertaken in collaboration with World Health Organization (WHO).

Since obtaining the benefits of open access requires additional stimuli for development and growth, the proponents of Open Access are actively seeking government intervention in the Open Access initiative. Several petitions are before various governments that are appropriately entering into the fray. "Public Access to Science," a bill before the United States House of Representatives states that any federal department or agency that enters into funding agreements for research should develop and support mechanisms for making the published results of the research freely and easily available to the scientific community, private sector, physicians, and the public.[42] The bill would place all published work that is "substantially funded" by agencies of the United States government beyond the reach of copyright protection so that it will be freely available. This concept seems to contradict Article I, Section 8, of the Constitution, which gives Congress the responsibility to promote the progress of science and the useful arts by securing, for limited times, authors' and inventors' exclusive right to their respective writings and discoveries.[22] Because scientific discoveries by United States government employees are considered "works for hire" and are not protected by copyright, this bill would simply broaden the definition of "works for hire" to include any scientific discovery supported by United States government fund. In July 2004, the Appropriations Committee of the United States Congress recommended requiring free access to papers based on research financed by the NIH.[43] The government of the United Kingdom convened the United Kingdom House of Commons Select Committee for Science and Technology on February 12, 2004, to consider a petition to mandate that research results obtained from publicly funded medical research be published under Open Access rules.[44] (Table 4). This petition did not intend to restrict publication to open access journals, but would require any journal publishing such research findings to accept the Open Access rules for the article in question. In July 2004, the Science and Technology Committee of Britain's House of Commons endorsed open access to research results and criticized the scientific-publishing industry for the escalating prices of its journals.[45] The British committee stopped short of requiring open access to research papers but it encouraged two ways of making articles freely available: depositing published papers into online archives and publishing scientific journals using author-pays business models. The report outlined several concerns about the author-pays model, including its possibly detrimental effects on scientific societies that rely on subscription fees to survive and the concern that peer-review standards might decline, since the more papers an author-pays journal publishes, the more money it makes. In the document to the United Kingdom House of Commons Select Committee for Science and Technology in February 2004, Elsevier countered with some concerns about government intervention.[41] Ongoing innovations in science and advances in publishing technologies seem to contribute to a dynamic and healthy marketplace.

• **EVOLUTION OF THE TRADITIONAL JOURNAL-LIBRARY MODEL:** Publishers of traditional journals provide value through editing, typesetting, printing, distribution, provision of standards, and archiving.[29] The publisher creates a peer-reviewed, indexed product and sells the content back as a subscription to readers, institutions, or

academic societies, which may provide subscriptions as a membership benefit. In addition, publishers sell online journals, monographs, audio/visual products, and data sets to libraries. Libraries organize and preserve the historical scholarly record and provide access to other scholars. In the current model, institutional subscribers (libraries) pay premium prices for subscriptions compared to individual subscribers. The cost of the subscriptions is increasing while most library budgets are stable or shrinking. Moreover, libraries are required to maintain the same content in multiple formats, while publishers sell the same content in different formats with a negligible additional cost for that different format. This marketing device has no direct parallel in markets for ordinary commodities, yet it recognizes the reality that so many people depend on this medical knowledge. Unfortunately, the prohibitive costs of this model have led many libraries to cancel journal subscriptions and decrease access.[30]

Publishers have already responded to some of the issues raised by the Open Access initiative. Many subscription journals are already operating a mixed publishing model, allowing some papers to be published under Open Access rules. There are many versions of access that fall short of complete open access. The Journal of the American Medical Association will allow open access for articles older than six months and younger than five years. Journal of Cell Science (JCS) is a print subscription publication with an online offspring that is free to subscribers and becomes free to the public in six months.[46] JCS is now adopting a hybrid approach wherein authors can choose to pay a publication charge for open access or have an article published in the normal way at no cost. Initially, the publication charge for open access will be subsidized by the society at the introductory rate of $800. Its sustainability as a business model remains unproven; therefore there is a good case for not completely abandoning current subscription-based models.[47]

Although many wish information, especially on the Internet, to be free, it is more important that it is valuable in order to be transformed into knowledge.[48] Peer-reviewed publications, though expensive, transform unpublished data into information valuable to the author and the scientific community. While dissemination through informal communications, such as conferences and circulation of drafts and preprints, are important to scientific exchange, the tradition is to present completed research formally in a print, peer-reviewed journal.[1] In the academic setting, publication in a peer-reviewed traditional journal with editorial quality, impact, reliability, and a large audience gives recognition to the author or institution, helps in future acquisition of funding, and assists in career advancement. In exchange for orchestrating the process of peer review and publication, the publisher derives sale value from the copyright or publishing rights transferred for the authored work. The typical author of a journal research paper willingly assigns such rights in order to communicate the work to his or her peers and to thereby achieve maximum use value for the author, institution, and scientific community.

Most people find it difficult to read medical literature for prolonged time on the Internet. eBooks have certainly not been a huge success. However, for short information, the Internet provides a quick source. If the open access initiative is successful, print journals may be delegated to libraries only and most people will not sit down with a whole journal issue as they have done in the past.

Whether the author-pay model will erode the quality of the research or lead to conflict of interest, and whether journals could survive financially under a new system are matters at issue. The issue also revolves around who should own and control the intellectual property of research. Is it the scientists who produce it, the universities who promote research, the taxpayers who support universities and grant-funding agencies, or the publishers who provide value-added services?[49,50] Further dialog, experimentation, and competition is warranted, but all scientists and clinicians must realize that the existing subscription-based business model has worked well for many years and should not be abandoned until another form of communication is vetted and successful. It would be tragedy to lose the archive and retrieval mechanisms that we have enjoyed in the past. Unfortunately, there do not seem to be enough resources to support both systems simultaneously.

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