Viewpoint ■

Biomedicine's Electronic Publishing Paradigm Shift:
Copyright Policy and PubMed Central

BARRY P. MARKOVITZ, MD

Abstract Biomedical publishing stands at a crossroads. The traditional print, peer-reviewed, subscription journal has served science well but is now being called into question. Because of spiraling print journal costs and the worldwide acceptance of the Internet as a valid publication medium, there is a compelling opportunity to re-examine our current paradigm and future options. This report illustrates the conflicts and restrictions inherent in the current publishing model and examines how the single act of permitting authors to retain copyright of their scholarly manuscripts may preserve the quality-control function of the current journal system while allowing PubMed Central, the Internet archiving system recently proposed by the director of the National Institutes of Health, to simplify and liberate access to the world's biomedical literature.

■ **J Am Med Inform Assoc.** 2000;7:222–229.

Distribution of a scientist's research findings is a responsibility all investigators share, and the primary means of such distribution is publication in a peer-reviewed biomedical journal. Our current model of biomedical publishing mirrors the trade publishing model: Authors assign copyright to the publisher, the work is then formatted and made available for distribution to paying customers. With spiraling costs and exponential increases in published output, this paradigm is now under intense scrutiny.

The development and worldwide acceptance of the Internet and, in particular, the graphical user interface and hypertext capabilities of the World Wide Web offer an alternative to our centuries-old resource-intensive, environmentally incorrect distribution medium. Indeed, many biomedical journals are migrating to the Web with online versions—but only for their subscribers, by site license, or on a pay-per-view basis. How has this development served the biomedical community? Will this type of online access reach the widest possible audience? Why charge for online access? With the Internet, nearly anyone can "publish" their own work and avoid the need for journals altogether. Is there a way we can preserve the valued functions of biomedical journals, particularly peer review and expert commentary, yet still leverage the power of the Internet to free the biomedical literature for all to use? Harold Varmus, former Director of the National Institutes of Health (NIH), has proposed PubMed Central, a freely accessible preprint and post-publication "e-print" archive server on the Internet. Will proposals like this make journals obsolete? After all, who would pay for something they can get free?

This paper explores the issues behind these questions. The conflicts inherent in the application of the trade publication model to biomedical scientific publishing are addressed. I highlight how the scientific community—and, by extension, the governments and nations that fund it—is losing control of its own intellectual product because of unnecessary restrictions on self-distribution (before and after formal publication) and spiraling increases in journal subscription rates. A new paradigm of biomedical publishing is proposed, in which the biomedical literature is made freely available on the Internet. Liberalization of restrictive copyright policies is the linchpin on which such a change depends. Once copyright is allowed to remain with authors, the biomedical literature will be freed, and proposals like PubMed Central can and should work.

Affiliation of the author: Washington University School of Medicine, St. Louis, Missouri.

Correspondence and reprints: Barry P. Markovitz, MD, Department of Anesthesiology and Pediatrics, Washington University School of Medicine, St. Louis Children's Hospital, One Children's Place, St. Louis, MO 63110;
e-mail: ⟨markovitz@kids.wustl.edu⟩.

Received for publication: 8/18/99; accepted for publication: 12/21/99.

The "Faustian Bargain"

The print biomedical journal has served us well for hundreds of years. Until this decade, scientists needed the print journals to circulate their results, for no other distribution medium was available. We now have a high-speed, low-cost, nearly universal distribution medium that has rocketed in popularity among nearly all sectors of the developed world: the Internet. Many resources that were formerly available only in print are now available on the Web, and the advantages of the electronic medium are legion—rapid access, built-in cross-referenced hyperlinks, integrated searching, inclusion of original data, multimedia formats, and a far less expensive and environmentally friendly distribution medium. Isn't it natural to expect biomedical journals to migrate to the Web as well? To understand why the biomedical literature has not yet become entirely available online, it is worth reviewing the traditional method of biomedical publishing and the copyright considerations that govern it.

The clinical or basic scientist in biomedicine is obligated to submit his findings to a peer-reviewed journal for several reasons. The primary motivation behind scientific inquiry is the expansion of the knowledge base, and the journal is the established means of distributing and archiving this knowledge. In addition, the career development of scientists depends heavily on their record of publication. Finally, the scholarly community has generally agreed that the peer-review process, despite undergoing intermittent critical review itself, is the best mechanism we have for filtering, screening, and otherwise providing the equivalent of quality control. In any field of scientific inquiry, a hierarchy of journals exists. The most prestigious are those that are able to recruit the most talented editors, the best peer reviewers and, most important, the most influential authors. These journals function not only to distribute but also to validate a scientist's work. What price does the author pay to participate in this system? The author assigns copyright to the journal, sponsoring society, or publishing company.

Since the U.S. Copyright Protection Act of 1976 and, more globally, since the Berne Convention in 1989, authors have been automatically granted copyright privileges to the product of their intellectual labor; previously, specific notice of copyright was required (accounting in part for the nearly universal appearance of the copyright symbol, ©). Of course, the purpose of copyright is to prevent the theft or misuse of intellectual property, so without the copyright holder's permission, no one can make legal copies of the work. Why should publishers seek ownership of copyright to material they publish? Because this confers monetary advantage by granting a monopoly on distribution. Why should authors transfer copyright to publishers? The answer to this question requires a critical distinction between trade (commercial) and scholarly (scientific) publishing.

A commercial author, such as a novelist or biographer, is only too happy to transfer copyright to the publisher. The publisher sells the work (at whatever price the market will bear, since it is the sole source of the work), and the author reaps economic rewards based on actual (or projected) sales. The commercial author and publisher are fiscally aligned, for they are both seeking the widest possible audience of *paying* consumers. It is precisely in the best interests of both parties that there be a single source of legitimate copies. The scholarly or scientific author, however, reaps no such rewards and has no such restricted interest. Her objective is to seek the widest possible audience of colleagues, regardless of their ability to pay. Indeed, financial barriers to access of her work are undesirable. If the commercial author were to learn of a subversion of his contract, such that copies of his work were being distributed widely at no charge to readers, he would undoubtedly be outraged, for he is as dependent on the sale of legitimate copies of the work as is the publisher. What would the reaction of the scientist be, should she learn of a similar mechanism for the distribution of her intellectual product? No doubt she would be quite pleased to see access to her results liberated, so long as she is credited appropriately. Alas, she is bound by the same copyright agreement as the commercial author, and is forbidden to allow or encourage such "illicit" distribution. Of course, there is a method of "legally" distributing her work at no charge to potential readers: She pays the publisher for reprints to mail out to those individuals requesting a copy. No practice highlights the distinction between the two types of authors more clearly; rather than receive payment for their work, scientific authors are willing to pay extra to enable (limited) free distribution to their colleagues.

This arrangement is truly astonishing when viewed from a distance. Scientists conduct research funded through various sources, with the government (in the United States) being the largest. They turn over the results of their intellectual labor to a third party yet receive no remuneration. The journal distributes the material to several of the scientist's peers, who review it at no charge for the journal. (The free provision of peer review is a crucial point, for the editors and publishers commonly boast of the "value" of the editing and peer review that they provide. Indeed, peer review is of great "value," but the journals do not pay

for this service.) The journal then sells the material back to the scientist and her colleagues in its final form, usually in a profit-driven enterprise. The funds to pay for the journal often originate in the same sources that funded the research. The economic absurdity of this arrangement is best summarized by Morton[1]:

> There is something inherently irrational about a model that has an intelligent person giving away ownership of the fruits of intellectual labor to a commercial profit-driven enterprise in which he or she has no proprietary interest. Indeed, in many disciplines an author must actually pay on a per-page basis to have his or her work published, and then must buy back, or expect libraries to buy back, their work (or, similarly, the work of others) with all the recompense going to the journal publishing industry (and it is an industry). In my opinion, this is not an act of charity; it is one of stupidity.

In the broadest sense, the public has paid for the research; why should they be made to pay *again* to read the results?

There is one situation in which the author may not hold and the journal cannot request transfer of copyright. In the case of works of the U.S. government, all such work is decreed from inception to be part of the public domain. Direct government employees cannot hold copyright on works they create in its service. It is unclear whether a similar situation holds for those doing work *funded* by the government, but this raises an intriguing question, and perhaps points to a solution, as we shall see shortly.

The arrangement whereby the author transfers copyright (the selling of the "soul") to enable distribution (achieving "earthly rewards") is what Stevan Harnad, professor of cognitive science at the University of Southampton, calls our "Faustian bargain."[2] Why do authors accept this bargain? Until now, they had little choice if they wanted to see their work distributed. It is only now, with the widespread development and use of the Internet, that we have the opportunity to question this practice and examine the alternatives.

Ingelfinger's Legacy

If the scholarly author is prohibited, because of copyright restrictions from distributing her own work following publication (and prohibited even from using parts of it herself in future manuscripts), why can't she distribute it to colleagues prior to publication? To be sure, on a very limited scale, circulation of such "preprints" does occur, primarily to solicit opinions on the worthiness or suitability of the manuscript in preparation for publication. However, no systematic distribution has been occurring in biomedicine for the past three decades, following a simple statement in 1969 by Franz Ingelfinger, then editor of the *New England Journal of Medicine*. The Ingelfinger Rule, as it has come to be known, stating that the *NEJM* would reject any paper that had been previously published in whole or substance, was made at the time in response to publication in a pharmaceutical "throwaway" of findings due to be published in the journal. Promulgated out of economic concern that such "scoops" would threaten sales, this policy was perpetuated under the subsequent editorial leadership of Arnold Relman in the name of peer review.[3,4] Almost all biomedical journals have followed this lead, and with the exception of limited presentation at scientific meetings, scholars in biomedicine do not have the freedom to distribute their own work if they anticipate submitting it for publication. Thus, both before and after publication, scientists are severely limited in how they may distribute their findings.

Once again, the Internet's arrival makes electronic distribution of such preprints a practical and economic possibility. Lest there be any doubt as to the significance of making documents available on the Internet, the International Committee of Medical Journal Editors has recently stated that "electronic publishing (which includes the Internet) is publishing."[5] If this manuscript had been placed on line prior to publication in *JAMIA*, it would not, at least in theory, have been considered for publication.[6]

How Much is That Journal in the Window?

Biomedical journals are expensive, and their prices are continuing to rise dramatically. Scholarly libraries are facing a "serials crisis," in which rising journal prices are forcing them to cancel subscriptions, and reduced subscription rates force the publishers to raise prices to maintain income. Since 1986, the Association of Research Libraries reports member libraries spending 124 percent more to purchase 7 percent fewer journals. The prices of journals have increased exorbitantly in comparison with those of other publications or with the cost of living.[7] For example, in 1995, an institutional subscription to Reed Elsevier's *Brain Research* cost $10,181 for a year's supply of 129 issues; this year, the journal costs $15,203. The high prices of biomedical journals must be related to either organizational, printing, or distribution aspects, because the primary intellectual capital of the biomedical publishing industry is provided at no charge.

Estimates vary as to the exact savings, but it is abundantly clear that electronic publishing is significantly

less expensive than print publishing. Odlyzko[8] postulates that electronic publishing savings might be better estimated in orders of magnitudes rather than percentages. If biomedical journals had a mechanism to publish online, saving themselves and their subscribers money, what choice would they make? Many journals by now do have a Web site, but in stark contrast to the information-rich resources offered by nonbiomedical publications and media services, the full texts of articles are rarely available at no charge. The typical journal Web site offers only a table of contents and abstracts without restrictions; those with full text limit viewing to their subscribers (who may be paying a higher price now for the ''privilege'' of online access), site licensees, or those who pay or each article they view. Biomedical publishers may be justifiably concerned that their subscriber base would evaporate if they offered the content of their journals on line at no charge.

There are a few notable exceptions to this generally restrictive attitude. The *British Medical Journal* now offers the full text of each issue free on its Web site (http://www.bmj.com/). The economics of the *BMJ* may be unique, however, in that the vast majority of physicians in the United Kingdom belong to the British Medical Association, and the *BMJ* is its official publication. In other words, they have a captive audience and an assured subscriber base. *Pediatrics* offers a unique hybrid approach, with ten full-text articles appearing each month only on its Web site and no access restrictions to this section of the journal. Indeed, this section was begun three years ago with the intent of being free for only six months; with the increased access came new revenue via advertising and new print subscribers (A. Spooner, oral communication, March 1999).

There are however, some ''optical illusions'' in this world of electronic access to journals as well. For example, many journals have contracted with third parties, such as Ovid (http://www.ovid.com/) or MDConsult (http://www.mdconsult.com/) to provide packages of full-text journals to subscribers or institutions, making their full-text access *appear* free to users on a campus network. These are truly only variants of the same trade publishing paradigm, whereby an individual or institution must pay to read the material.

Electronic publication has numerous other advantages, in addition to cost reduction, compared with the print medium; these have been extensively described previously[9] and do not require further elaboration here. With the revolutionary advances in information technology and the nearly universal penetration of the Internet into both developed and developing societies, we would do well now to ask ourselves some focused questions about our publishing ''partners.'' Are they not in existence to serve us? What are we getting for our money? Are there alternative methods of publishing available now that are better, more efficient, and less expensive? More precisely, is there a way to dissociate the quality control and validation function that current journals provide from the very expensive print distribution system?

The Distillation of a Vision: PubMed Central

Several visionaries over the past decade have asked these questions and offered outlines of alternative publishing models. Among the most eloquent and prolific, Stevan Harnad has suggested that scientific societies, universities, and governments wrest back control of scholarly publication in one of several ways. (Harnad often refers to PUBLICation, emphasizing the root definition of the word.) The core of the vision of Harnad and others is simply that we cast off the trade publication model, in which the funding originates with the reader. He contends that most authors and institutions would be happy to pay ''page charges'' to have their publications made available on the Web at no cost to readers. Estimating that online publishing should cost significantly less than print, universities could easily subsidize such publications with funds saved from what they are now paying for exorbitant subscriptions.[10] This would require existing journals to retrofit their ''reader pays'' to an ''author pays'' model and all but abandon print distribution —a seemingly unlikely development. If current journals would not alter their revenue and distribution mechanisms and new e-journals were required, the transition to such a model might be murky, for scientists—or at least physicians—are notoriously resistant to change.

If we keep the ultimate goal in mind—that is, free and unfettered access to the full texts (and other formats) of the world's biomedical literature—a low-cost solution presents itself readily. Allow authors to self-archive their published work on the servers of their own institutions at their own (minimal) cost and effort. Existing journals need not change their practices, and those wishing to continue to pay for their subscriptions would continue to do so. However, the material would be ''out there'' on the Internet, undoubtedly easily retrievable with the increasingly successful search engines that scour and catalog the Internet's contents continuously. As simple as this sounds, it lacks a systematic approach. Files of different formats, unwieldy URLs, and all manner of inconsistency would probably bedevil this grassroots approach. In

other scholarly fields, calls have been made for an entirely new process of information distribution, in which the respected peer-review process was "uncoupled" from print publication.[11] Once again, however, asking authors to trust an entirely new system and migrate en masse with only the offering of more readers may not be realistic. Can biomedicine look for a model system that would suggest a solution and that could be implemented over time?

In 1991, Paul Ginsparg created an electronic archive for the physics community to distribute preprints: the Physics E-print Archive at Los Alamos National Laboratory (http://xxx.lanl.gov), supported by the National Science Foundation and the Department of Energy.[12] Receiving more than 100 submissions and 60,000 "hits" per day, this tool is now an irrevocable part of the physics community.[13] Although begun as a method to streamline their community's long-standing tradition to circulate preprints, this server also successfully archives final manuscripts that have already been published or accepted for publication in peer-reviewed journals. The American Physical Society, to whose journals many of these preprints are destined, now cooperates with the Los Alamos archive by virtue of what is arguably the most enlightened copyright policy of any scholarly journal.[14] The Society explicitly allows authors to use their own work in subsequent publications, self-archive it on the Web, and submit articles to an e-print server. The only restriction on this self-publication policy is that such Web servers must be freely accessible, without charges of any kind. Thus, the balance we seek is a reality in the discipline of physics.

Other scholarly organizations are developing online electronic journal or manuscript repositories. Stevan Harnad is developing a freely accessible author-initiated e-print archiver server for the social sciences, CogPrints.[15] SPARC, the Scholarly Publishing and Academic Resources Coalition, is a project of the Association of Research Libraries, whose goal is to foster expanded competition in scholarly communication.[16] A major initiative of SPARC, in collaboration with other societies and publishers, is BioOne, a planned full-text database of many research journals in the biological, ecological, and environmental sciences.[17]

If only an internationally respected force in biomedical research would stand up and propose some form of analogous solution. A centrally organized and maintained server system would be needed to categorize and provide a surface filter for preprints. This same organization would, ideally, archive all published manuscripts, preserving them and making them available to the biomedical community over the Internet at no charge. There would be seamless links between the extremely powerful and successful MEDLINE search engines of PubMed (http://www4.ncbi.nlm.nih.gov/PubMed/) or Internet Grateful Med (http://igm.nlm.nih.gov/) and the full texts of articles, Direct hypertext cross-links could be automatically added to each document.

Harold Varmus, former director of the National Institutes of Health, has just proposed this very solution in the form of PubMed Central.[18] He suggests that the NIH would help organize and maintain—but not control—a two-tiered, freely accessible Internet server. Unpublished manuscripts could be submitted and archived after a preliminary review by appropriate experts, not to provide true peer review but rather to prevent abuses of the system. These manuscripts would be clearly identified as unrefereed. A second tier would provide for archiving and serving of full-text (final version) papers that had been accepted for publication by peer-reviewed journals. All the advantages of electronic publishing could be realized—easier access, better integration, expanded formatting, more detailed descriptions and data availability, and faster presentation to the public.

As proposed by Varmus, the PubMed Central server would not supplant or in any way interfere with the current system of journal peer review and publication, at least in theory. In practice, when the world discovers that the same or improved information can be obtained free, subscriptions to journals will falter. If PubMed Central, and the scientific community at large, are still to depend on the peer review and quality control that journals provide, provisions will have to be made to fund this crucial aspect of biomedical publishing. This should represent only a fraction of what journals cost now. Indeed, if we were to start from scratch today to design a quality-controlled, peer-reviewed distribution system for research findings, does anyone doubt that something akin to PubMed Central would be the obvious solution?

We must then reconcile the transition process. We submit manuscripts to *Science*, the *New England Journal of Medicine*, and the *Journal of the American Medical Informatics Association* not for their glossy printed outputs but for the quality of review that the manuscripts undergo and the prestigious seal of approval that is accorded with acceptance of our work. Recall that the actual workhorses, as it were, of peer review are unpaid volunteers. But editorial duties and the technical aspects of managing the information flow of a journal do have some costs. If a method could be designed to provide adequate funds for these costs as subscriptions and access "tolls" decline with free access, then

PubMed Central could work. Harnad proposes, as a solution, that authors and their sponsoring institutions pay these costs up front (with manuscript submission or acceptance) as the equivalent of page charges, which will represent a significant savings for these institutions as they become increasingly free to let expensive subscriptions lapse. Such charges could be phased in gradually, as undoubtedly the system will take several years to evolve. As mentioned, many specialty journals already require authors to pay such page charges, particularly if special services, such as color photograph printing, are requested. In addition, and not to be overlooked, at least for a significant body of literature, is the revenue stream from advertising or industry sponsorship. With the dramatic increase in readership that free access on the Web should provide, advertising income alone might more than cover the costs of the journals, particularly with those costs significantly reduced.

The PubMed Central proposal has engendered vigorous debate.[19–21] Predictably, the editors and publishers of many established journals have raised objections, although few have been forthcoming enough to openly state the economic concern that freeing the biomedical literature might mean to their subscription revenue stream. The criticisms can be dismissed in many cases as either a misreading of the proposal or a result of the intentional vagueness of some parts of the proposal itself, for many details surely remain to be considered. A common chord among some editors' critiques is the concern of making non-peer-reviewed clinical studies freely available to the unsophisticated population of clinicians (not to mention the lay public), who are unable to interpret or filter research papers without the wise guidance of the experts via peer review and editorials.

The critics miss the point of circulating preprints and belittle clinicians' abilities to think independently. Preprints are made available primarily for colleagues in a scientific field, to improve cooperation, coordination, and communication among researchers. Since it is often difficult enough to sway clinical practice with fully refereed large clinical trials, we should have little fear that the world of practitioners will be affected at all by the availability of preprints. It is difficult enough to stay abreast of the peer-reviewed studies! With regard to the lack of editorials—an overzealous underestimation of clinicians' intelligence notwithstanding—there is no reason that editorials cannot accompany the original studies into the archive.

In an addendum to the original proposal, Dr. Varmus responds to the questions of control, relationship with existing journals, and suitability of non-peer-reviewed clinical trials, among others. He briefly discusses costs, including the effect of reduced subscription revenues on publishers and professional societies, many of whom depend on their journals' profitability to finance their other activities. Varmus reiterates the point that PubMed Central is not proposed as a superjournal and hopes that existing publications will cooperate to allow posting of accepted articles on the server. Although he plays it down, copyright is the key factor, which will determine the success of the cooperation between PubMed Central and the journals.

In fact, for PubMed Central to succeed with its two-tiered approach, two long-standing biomedical journal policies must change. To enable authors to archive their preprints in the non-refereed section, journals must abandon the Ingelfinger Rule. Recall the two principles on which this rule was promulgated and propagated—economic "scoops" and peer review. The economic issues have been noted, and peer review in this case is a non-issue, for these manuscripts would be in the clearly labeled non-refereed or non-peer-reviewed section. The most critical policy change must be copyright transfer. Once an author enters the "Faustian bargain" by assigning copyright to the publisher, he cannot be free to archive the article on PubMed Central or anywhere else. Of course, if all the world's biomedical journals simultaneously agreed now and forever to send all their completed contents to PubMed Central, then our problem would be solved. This scenario seems highly unlikely. A far simpler and cleaner break would be made by changing copyright policy outright, and the following proposal may be both necessary and sufficient.

Abolish Copyright Transfer

As representatives of the American Academy of Arts and Sciences' study on electronic communications, "The Transition from Paper," Bachrach et al. recently proposed that the U.S. government mandate, in the interests of maximal possible distribution of findings at the lowest cost, that the authors of federally supported research retain copyright of their reports.[22] Recipients of federal funds are already required to make their results public; such a policy shift would fulfill the true meaning of the word *public*. Indeed, this could simply be viewed and justified as an extension (with a twist) of the current policy for direct government employees, whose work is immediately part of the public domain; no copyright transfer can occur. If what is needed for PubMed Central to succeed is a dramatic change in copyright policy, then it is likely that such a change will occur only by such a sweeping

decree. If all federally supported scientists were prohibited from transferring copyright and, by extension, asked to use PubMed Central as a natural repository for their preprints or e-prints, then the vast bulk of the intellectual output of U.S. scientists would be freed forever. Certainly publishers should be permitted to publish the material in any format they find in their best interest, and they might rightfully request that formal citation be employed by the author in any redistribution.

Once this practice of retaining copyright by investigators receiving federal funds is established, other funding organizations will probably follow suit. In any case, since journals would no longer be able to request copyright transfer for the bulk of the manuscripts submitted to them, there would be little point in treating non-federally-funded research reports differently. Finally, to make this proposal and transition truly successful, this should be a globally accepted concept with international cooperation.

Furthermore, copyright is not an ''all or none'' entity. Copyright law actually assigns five exclusive rights to the author: to reproduce the work, to prepare derivative works, to distribute copies, to perform the work, and to display the work publicly. Scholars and scientists, for example, might assign only the first right to the publisher, retaining all others. With the digital medium, the line between reproduction of a work and distribution of copies is blurred. However, a compromise developed along these lines might enable, in effect, a non-exclusive transfer of copyright to publishers that allows authors to ''self-distribute'' their work at their discretion. This is the equivalent of the American Physics Society's policy. There is also a precedent of sorts in biomedicine: the Cochrane Collaboration (http://www.cochrane.de), an international group that promotes, organizes, and publishes systematic reviews of clinical trials, also requests a non-exclusive copyright transfer agreement from authors.

On what basis can the journal editors object to restricting access after the peer review process and quality control have been performed? Neither clinicians nor scientists sit dutifully by their mailboxes any longer, expecting to be fully enlightened by receipt of the few journals they have been able to justify in their budgets. With the power of the free Internet interfaces to MEDLINE and the global incorporation of evidence-based health care, health care professionals and researchers are becoming more and more dependent on rapid database searching and, ideally, immediate access to full-text articles on line. In whose best interest could any journal justify the position that only individuals and institutions that can pay the information can have access to it? The information was given to them freely, and assuming that a mechanism can be developed to cover the modest costs of the quality control process that the journals do provide, why shouldn't they allow self-archiving—particularly on a NIH-sponsored server—and free access? In short, for an increasing number of scientists and clinicians, rapid, seamless, and (financial) firewall-free electronic access to the biomedical literature is more important than the glossy printed page. Why should everyone be forced to subsidize this expensive distribution mechanism any longer?[23]

Conclusion

Imagine in the near future logging into PubMed from the comfort of your office, home, or patient's bedside. You search for a specific concept in MEDLINE, retrieve the citations, and with a single click of the mouse have a full-text (or video, or original data) of each original publication on PubMed Central (or on the journal's own server, once the literature is freed). The citations in each publication are hyperlinked to each other and to papers, commentaries, and guidelines that cite the manuscript you're viewing. What might the cost of this scenario entail? Your institution will be faced with the difficult decision of how to spend the money they're saving—not to mention what to do with the shelf space—from the lack of hundreds of journals arriving in the mail.

The tolls behind which publishers have hidden the world's biomedical literature are no longer justified, and they must come down. The Internet now makes it possible to distribute research findings quickly and cheaply, but we must find a mechanism to preserve the filter and quality-control functions of the current journals as we move to universal, unfettered access to the research we have all already paid to produce. The PubMed Central proposal has the potential to provide this access, and, if implemented properly, it will support (to the extent justified by markedly reduced costs) those journals whose revenue streams it will necessarily interrupt. The single act of mandating that scientific authors, funded by the U.S. government, be prohibited from transferring copyright to a third party will be the crucial action to enable this vision to proceed.

Afterword

Since the preparation of this manuscript, Marshall writes in *Science*[24] that the PubMed Central proposal has apparently changed in several ways. Initially called E-biomed and, for a brief time, E-biosci, it is

now referred to as PubMed Central to avoid a name infringement. The notion of serving preprints seemed to be fading, but appears to have been revived again in the latest description. Perhaps most notable, and most disconcerting, is that Dr. Varmus has ceded the basic proposition of a self-archiving initiative—requiring that copyright remain with the author. Publishers are now considering whether, and to what extent, they will cooperate. Marshall discusses the political dance that is evolving between publishers and the NIH, but there is no mention of what the scientists themselves want to see happen. This report makes it abundantly clear that the publishers have no ability to conceive that the intellectual property that they are bargaining with and selling is not really theirs at all. This update only confirms the need for a fundamental change in copyright policy, as the current biomedical publishing industry appears unable to think "outside the box" of the reader-pays, restricted-access, commercial publishing model.

References ■

1. Morton B. Is the journal as we know it an article of faith? An open letter to the faculty. Public-access Comput Sys Rev [online serial]. 1997;8(2). Available at: http://info.lib.uh.edu/pr/v8/n2/mort8n2.html. Accessed Aug 5, 1999.
2. Harnad, S. The post-Gutenberg galaxy: how to get there from here. Inf Soc. 1995;11:285–92. Also available at: http://cogsci.soton.ac.uk/~harnad/THES/thes.html. Accessed Aug 5, 1999.
3. Altman LK. The Ingelfinger rule, embargoes, and journal peer review, part 1. Lancet. 1996;347:1382–6.
4. Altman LK. The Ingelfinger rule, embargoes, and journal peer review, part 2. Lancet. 1996;347:1459–63.
5. International Committee of Medical Journal Editors. Policies for posting biomedical journal information on the internet. JAMA. 1997;277:808.
6. Information for Authors. J Am Med Inform Assoc. 2000;7:111–4. (cited 1999 August 5) Also available at: http://www.amia.org/pubs/jamia/authinfo.html. Accessed Feb 7, 2000.
7. Walker TJ. Free Internet access to traditional journals. Am Sci. 1998;86(5). Also available at: http://www.amsci.org/amsci/articles/98articles/walker.html. Accessed Aug 5, 1999.
8. Odlyzko AM. The economics of electronic journals. First Monday [online serial]. 1997;2(8). Available at: http://firstmonday.dk/issues/issue2_8/odlyzko/index.html. Accessed Aug 5, 1999.
9. Markovitz BP. Electronic journals: time for a new paradigm in biomedical communication. J Intensive Care Med. 1998;13:158–67.
10. Harnad S, Hemus M. All or none: no stable hybrid or halfway solutions for launching the learned periodical literature into the postGutenberg galaxy. In: Butterworth I (ed). The Impact of Electronic Publishing on the Academic Community. London, UK: Portland Press, 1997:18–27. Also available at: http://tiepac.portlandpress.co.uk/books/online/tiepac/session1/ch5.htm.
11. Buck AM, Flagan RC, Coles B. Scholar's Forum: a new model for scholarly communication. Mar 23, 1999. Available at: http://library.caltech.edu/publications/ScholarsForum/. Accessed Aug 6, 1999.
12. Taubes G. Electronic preprints point the way to "Author Empowerment." Science. 1996;271:767–8.
13. Monthly submission rates for arXiv. Available at http://xxx.lanl.gov/cgi-bin/show_monthly_submissions. Accessed Aug 10, 1999.
14. American Physical Society. Copyright transfer agreement. Available: at: ftp://aps.org/pub/jrnls/copy_trnsfr.asc. Accessed Aug 10, 1999.
15. CogPrints archive online. Available at: http://cogprints.soton.ac.uk/. Accessed Nov 10, 1999.
16. SPARC: Scholarly Publishing and Academic Resources Coalition. Available at: http://www.arl.org/sparc/. Accessed Nov 10, 1999.
17. Association of Research Libraries. Web-based forum provides unique, cost-effective access to cross-linked scientific publications previously available only in print [press release]. Jun 22, 1999. SPARC Web site. Available at: http://www.arl.org/sparc/bio1/bio1.html. Accessed Nov 10, 1999.
18. Varmus H. PubMed Central: a proposal for electronic publication in the biomedical sciences. May 5, 1999; addendum Jun 20, 1999. National Institutes of Health Web site. Available at: http://www.nih.gov/welcome/director/ebiomed/ebi.htm. Accessed Aug 6, 1999.
19. Sprent J, Fitch FW, Hogan MM for American Association of Immunologists. Comment on PubMed Central. Jun 23, 1999. National Institutes of Health Web site. Available at: http://www.nih.gov/welcome/director/ebiomed/com0627.htm#aaoi185. Accessed Aug 6, 1999.
20. Floyd E, Bloom FE. Just a minute, please. Science. 1999;285:197.
21. Relman A. The NIH "PubMed Central" Proposal: A Potential Threat to the Evaluation and Orderly Dissemination of New Clinical Studies. N Engl J Med. 1999;340:1828–9. Also available at: http://www.nejm.org/content/1999/0340/0023/1828.asp. Accessed Aug 6, 1999.
22. Bachrach S, Berry S, Blume M, et al. Who should own scientific papers? Science. 1998;281:1459–60. Also available at: http://www.sciencemag.org/cgi/content/full/281/5382/1459. Accessed Aug 5, 1999.
23. Harnad S. On-line journals and financial fire-walls. Nature. 1998;395:127–8. Also available at: http://www.cogsci.soton.ac.uk/~harnad/nature.html. Accessed Aug 10, 1999.
24. Marshall E. PubMed Central morphs to E-biosci, focus shifts to reviewed papers. Science. 1999;285:810–1.