Open Access Scientific Publishing and the Developing World

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ABSTRACT

Responding to rapid and steep increases in the cost of scientific journals, a growing number of scholars and librarians have advocated "open access" (OA) to the scientific literature. OA publishing models are having a significant impact on the dissemination of scientific information. Despite the success of these initiatives, their impact on researchers in the developing world is uncertain. This article analyses major OA approaches adopted in the industrialized world (so-called Green OA, Gold OA, and OA mandates, as well as non-OA information philanthropy) as they relate to the consumption and production of research in the developing world. The article concludes that while the *consumption* of scientific literature by developing world researchers is likely to be significantly enhanced through such programs, promoting the *production* of research in the developing world requires additional measures. These could include the introduction of better South-focused journal indexing systems that identify high-quality journals published in the developing world, coupled with the adjustment of academic norms to reward publication in such journals. Financial models must also be developed to decrease the reliance by institutions in the developing world on information philanthropy and to level the playing field between OA journals in industrialized and developing countries.

Introduction

Sociologist Robert K. Merton is perhaps best remembered for identifying the norms that characterize the practice of modern science. Among these norms is the willingness of scientists to share knowledge with one another.[1] Such sharing is critical to the advance of science and to the independent verification of scientific claims. The many benefits of scientific research—improvements to health, agriculture, infrastructure, and industry—also flow from the ability of scientists to share and build upon each other's discoveries. But despite the importance of sharing scientific

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information, the ability of scientists to access knowledge relevant to their fields remains under pressure. Since the beginning of modern science, the majority of scientific findings have been published in specialized journals. Journals select articles for publication using a system of peer review where researchers evaluate the submissions of their peers based on the submissions' scientific merit, originality, significance, and, in some cases, the reputation of the authors.

Different estimates place the current number of peer-reviewed scientific journals between 16,000[2] and 24,000, yielding between 1.2 and 1.6 million articles per year. Yet the most selective and prestigious journals can publish only a fraction of the thousands of articles submitted to them each year.

In the traditional scientific publishing model, neither authors nor reviewers are compensated. Libraries that wish to make a journal's content available to its users pay substantial subscription fees. Due in large part to the growing role of commercial publishers in an industry formerly occupied by learned societies and university presses, between 1975 and 1995 the price of scientific journals spiralled upward at rates far in excess of inflation.[3] The cost of subscribing to multiple journals, particularly in specialized technical areas,[4] became prohibitive to all but the largest institutions. The result was a significant reduction in subscriptions by academic libraries, not to mention headlines such as "Libraries Stunned by Journal Price Increases."[5] This phenomenon has been termed the "serials crisis."

The impact of the crisis was pronounced in the developing world.[6] In his 2006 book *The Access Principle*, John Willinsky poignantly recounts the experience of the Kenya Medical Research Institute (KEMRI), a leading East African research centre, which by 2000 could only afford to subscribe to five scientific journals, none of which focused on tropical diseases or KEMRI's other primary areas of research.[7] Ironically, at that time, KEMRI was among the more fortunate institutions in the developing world. According to a World Health Organization (WHO) study conducted in 2001, 56 per cent of research institutions in very low-income countries had *no* subscriptions to international scientific journals and 21 per cent averaged only two such subscriptions. Even in the next income tier, 34 per cent had no subscriptions, and a further 34 per cent had between two and five.[8] Today, governments in some middle-income developing nations are helping local institutions fund journal subscriptions via centralized procurement houses. Government strategies vary, however. While some governments provide a limited number of journal subscriptions to a broad range of public universities, others focus only on what are seen as top local institutions. Even in countries that could afford to fund local institutional subscriptions, such support is sometimes lacking, in part due to historical suspicion of the Western research establishment.[9] Thus, the serials crisis continues to be felt at all levels and types of institutions in the developing world.

The Global Call for Open Access

One response to the serials crisis has been the rise of a vocal and influential "open access" (OA) movement among scholars and librarians. This movement in scientific publishing is linked to the rise of the Internet in the 1990s, when it became widely apparent that research could be shared online at low cost and great speed. In 2000, Harold Varmus, the Nobel-winning Director of the US National Cancer Institute, and other prominent scientists formed the Public Library of Science (PLoS), a coalition dedicated to improving public access to biomedical literature. The PLoS circulated an open letter, eventually signed by 34,000 scientists in 180 countries, urging publishers to make "the full contents of the published record of research and scholarly discourse in medicine and the life sciences" publicly available within six months of initial publication.[10]

The OA movement gained further momentum in 2001 when a group sponsored by George Soros's Open Society Institute met in Budapest to develop recommendations for expanding open access to peer-reviewed scientific literature. The resulting Budapest Initiative, released in February 2002, calls for self-archiving of journal articles by scholars and for a "new generation" of OA journals, disseminated as widely as possible.[11] The lofty goal of the Budapest summit was no less than "building a future in which research and education in every part of the world are that much more free to flourish." Similar calls followed from Bethesda, Maryland in June 2003 and Berlin in October the same year.[12] The three declarations—Budapest, Bethesda, and Berlin—known as the "Three Bs," received wide support from the international scientific and academic communities. Though they differ in detail, all three call for the free, online accessibility of scientific literature and the elimination of restrictions on its reproduction.

The OA initiatives culminating in the Three Bs were led largely by scientists, archivists, and advocates in Europe and North America. At the same time, similar concerns were being voiced by representatives of developing countries within the broader "Access to Knowledge" (A2K) movement. The A2K agenda, which shares an intellectual heritage with the more mature "Access to Medicines" movement, was first articulated in 2003 by a group of activists, non-governmental organizations, and developing world delegates to the World Intellectual Property Organization (WIPO).[13] Early A2K discussions concerned primarily the availability of educational materials and learning tools. The agenda has since grown to encompass a diverse range of issues surrounding the accessibility to the developing world of technological, cultural, and educational resources produced in the industrialized world. Access to scientific literature emerged as a key component of the A2K movement. The Declaration of Principles of the World Summit on the Information Society, a meeting convened by the United Nations in December 2003, included as a key principle "equal access to all scientific knowledge and the creation and dissemination of scientific and technical information, including open access initiatives for scientific publishing."[14] Similar sentiments were expressed in the WIPO Development Agenda[15] and a proposed (but still unsuccessful) A2K Treaty.[16] The Pan-American Health Organization and Latin American and Caribbean Centre on Health Sciences Information led a coalition of the South, which met in Salvador, Brazil in 2005 to urge that access to scientific literature be considered a "universal right."[17] Calls for global open access to scientific information continue, including, most recently, in the Washington Declaration on Intellectual Property and the Public Interest. This declaration, developed by an international coalition of experts at the Global Congress on Intellectual Property and the Public Interest held at American University in August 2011, echoes the themes of the Three Bs declarations while speaking more broadly to mitigating the global trend toward intellectual property "maximization."[18]

Modes of Open Access Publication

Calls for OA have not gone unheeded, and numerous initiatives have emerged. These range from government mandates to university policies to innovative publishing models. Below is a summary of the principal modes of OA publication for scientific literature.

Self-Archiving—The Green Route

Before the advent of the Internet, researchers circulated their published articles to colleagues by mail or fax. The Internet has made the practice of sharing faster and more efficient. Many faculty members post copies of their work, both pre-publication and post-publication, on their departmental or institutional web pages, making it available to all without charge. This practice is termed "self-archiving," or the "Green" route to OA. One study found that in 2008 approximately 12 per cent of the published scientific literature was available through Green OA archives.[19] While this figure demonstrates impressive gains seen by OA advocates, it is still a small percentage of the overall body of scientific literature.

Though self-archiving enjoys the virtues of convenience and speed, it is not without limits. It relies on the technical capabilities and idiosyncrasies of the author's home institution, lacks indexing across different institutional repositories, and suffers dislocation when authors move from one institution to another. Some disciplines have launched centralized archiving services such as arXiv.org (physics and mathematics) and SSRN (social sciences, economics, and law). These services generally allow free submission of articles, some limited indexing, and free access to all users. They are typically supported by volunteer efforts, institutional grants, or charitable contributions. In addition, numerous software tools now exist to enable self-archiving and tagging of documents so that they can be easily searched and indexed.[20]

Perhaps the most serious challenge to self-archiving (whether institutional or centralized) is presented by copyright law. Even though scientific facts and conclusions are not themselves copyrightable, the articles (including text, diagrams, and illustrations) in which they appear are subject to copyright protection. Because scientific publishers typically require authors to assign them the copyright of articles, authors have traditionally been constrained from disseminating their published work outside the publisher's established channels. An author who wishes to post a copy of a published article on his or her web site cannot do so without the permission of the publisher. In response to this situation, a number of prominent research universities, in conjunction with groups such as the Association of College and Research Libraries (ACRL) and the Scholarly Publishing and Academic Resources Coalition (SPARC), began in 2005 to encourage researchers to use "author addenda" in their publishing contracts.[21] These addenda typically reserve an author's right to publish her work on an institutional web site or other OA repository following journal publication. Like the riders to a real estate purchase agreement, author addenda require the agreement of both parties. Publishers must acquiesce to such addenda for them to be meaningful. Large institutions that subscribe to numerous publications have proven to possess sufficient leverage to persuade publishers to permit such archiving. Self-archiving of pre-print versions of articles after the expiration of an agreed embargo period is now permitted by a growing number of commercial publishers.[22] But this is more difficult for smaller institutions, or for institutions and publishers in the developing world.

Open Access Journals—The Gold Route

Green OA hopes to mitigate the copyright-based access limitations imposed by proprietary journals. An alternative OA approach bypasses limited-access journals by making published literature open from the outset. This approach is enabled by a relatively new category of OA journals, primarily in the biomedical sciences, that support themselves not by charging readers, but by charging authors who publish in them.[23] This model is known as the "Gold" route to OA. According to one recent study, approximately 8.5 per cent of articles published in 2008 were openly available from the publisher.[24]

The first significant Gold OA publishing venue was launched in 2000 by for-profit publisher BioMed Central, today part of the Springer publishing group. BioMed Central publishes more than 220 OA journals across biomedical science. In 2003 the PLoS launched its first OA journal, *PLoS Biology*, with financial backing from the Gordon and Betty Moore Foundation. PLoS has since achieved significant recognition. Its flagship journal *PLoS ONE* published 6,749 papers in 2010, more than any other scientific journal.[25] Publication fees for PLoS journals range from US$1,350 (for *PLoS ONE*) to $2,900 (*PLoS Biology* and *PLoS Medicine*).[26] Increasing numbers of funding agencies have committed to pay OA publication fees for research that they support.[27]

In addition to journals that began as OA vehicles ("born OA" journals), a number of proprietary journals have converted to Gold OA formats. Other proprietary journals now offer authors an option to choose whether to publish in the traditional manner, where the author is not charged, but access to the article is granted only to paying subscribers, or under a Gold OA model, where the author pays and access is free. Gold OA journals have grown steadily over the past decade and show signs of financial sustainability. One study found that in 2009 nearly 200,000 peer-reviewed articles were published in 4,769 Gold OA journals, representing between 6 and 8 per cent of the total peer-reviewed scientific literature published that year.[28] OA journals have thus seen impressive gains in just a decade, even as the large majority of peer-reviewed scientific output continues to appear in commercial, limited-access journals.

Time-Delayed Open Access

The scientific publishing industry has not uniformly opposed OA initiatives and a few publishers have even embraced them. Journals such as the *New England Journal of Medicine* (*NEJM*) and *Molecular Biology of the Cell* (*MBC*) voluntarily make their contents publicly available after a waiting period (six months for *NEJM*, two months for *MBC*).[29] The theory behind such delayed-release programs is that institutions will continue to subscribe to journals in order to ensure that their researchers have access to the most current literature, even if content is eventually made publicly accessible. Though seemingly successful, such delayed-release programs have been adopted primarily in journals published by learned societies, rather than commercial publishers. This is the case with both *NEJM* and *MBC*,[30] whose publishers serve their members through multiple channels, of which journal publication is only one. The largest publishers of scientific journals, Reed Elsevier (approximately 1,800 titles), Taylor and Francis (more than 1,000 titles), and Springer Verlag (more than 500 titles), which as of 2006 collectively controlled 60 per cent of scientific research content, are commercial interests with significant subscription and reprint revenues at stake.[31] These organizations have not, by and large, engaged in any large-scale adoption of OA models, the notable exception being Springer's acquisition in 2008 of BioMed Central, the largest Gold OA publisher.

Institutional Mandates

Both Green and Gold routes to OA are largely voluntary. Authors choose to make their work openly accessible, by either self-archiving or submitting it to an OA journal. Beginning in 2008, however, several prominent research universities including Harvard University, the Massachusetts Institute of Technology, and University College London began to implement policies arising from their frustration with commercial publishers' unwillingness to allow self-archiving. These policies typically *mandate* that faculty members deposit research publications in OA databases, whether or not the work has previously been published commercially, within some defined period after initial publication.[32] Institutional mandates give scholars at these institutions a strong incentive to submit their work to journals that permit self-archiving or other OA releases, and consequently encourage commercial journals to permit such access. By the end of 2011 more than 150 institutions worldwide had implemented mandatory OA policies,[33] and self-archiving is now permitted by a growing number of commercial publishers.[34] The use of time delays before published content is granted OA status has facilitated negotiation and agreement on this difficult issue.[35]

Funder Mandates and Repositories

Closely related to institutional OA mandates are requirements that have been implemented by funders of scientific research, both governmental and non-governmental. Non-governmental research foundations such as the Wellcome Trust in the United Kingdom, the Howard Hughes Medical Institute and the MacArthur Foundation in the United States, and nearly fifty other funding bodies throughout the world have implemented requirements for OA release of published research.[36] These mandates typically provide that if research is financially supported by the funder, the researcher must deposit any resulting scholarly articles in an OA repository, though how exactly this requirement is met is often left to the individual researcher.

A more contentious debate surrounds the publication of government-funded scientific research, which represents a large portion of academic research globally. By one estimate, research funded by the US National Institutes of Health (NIH), with an annual research budget of more than $30 billion, produces approximately 60,000 scientific papers per year.[37] From 2003, a growing number of scientists, archivists, and policy makers began to argue that it was inappropriate for taxpayer-funded research to inure solely to the financial benefit of publishers, and that the public should be granted free access to taxpayer-funded research. Accordingly, in June 2004 the US House Appropriations Committee instructed NIH to make all scientific publications generated by NIH-funded research available online. After considering more than a thousand responses received during a sixty day public comment period, NIH adopted a policy[38] that encouraged, but did not require, investigators to place the full text of their published articles in the National Library of Medicine's publicly-accessible PubMed Central archive within six months of publication.[39] With little direct incentive to comply, scientists did not submit their articles to PubMed Central in large quantities.[40] In 2007 Congress directed NIH to revise its policy to *require* OA publication of NIH-funded papers. The revised policy went into effect in 2008.[41] All publications arising out of NIH-funded research must be submitted to PubMed Central within a year of publication. As of December 2011, the PubMed Central repository held approximately 2.3 million articles relating to the biomedical sciences. Similar OA mandates have been enacted by the European Research Council, the UK Medical Research Council, and numerous other funding agencies. Though government OA mandates such as the NIH policy have been opposed by the commercial publishing industry,[42] legal challenges have not been successful in overturning them.

Open Access and the Developing World

Since the Budapest Initiative, concerns regarding the availability of scientific literature to researchers in the developing world have formed an integral part of the OA debate. Recalling the crippling subscription reductions experienced during the serials crisis, commentators agree that OA models are likely to benefit researchers in the developing world.[43]

Yet, as shown in the preceding sections, there are numerous divergent models by which OA publishing is being implemented. Which of these OA models are most likely to benefit, or least likely to disadvantage, researchers in the developing world? Are the needs of developing world researchers in the developing world the same as, or somehow any different from the needs of researchers in the industrialized world?

The State of Science Publishing in the Developing World

To address these questions, it is useful to unpack some assumptions underlying the discourse on science in the developing world.[44] In the industrialized world, scientists generally fill two complementary roles: as *consumers* and as *producers* of information. Scientists as consumers read journal articles to keep abreast of developments in their fields. They use this reading for a variety of purposes, in educating students, in developing and using technology, and in formulating their own research programmes. Depending on the institution, the emphasis placed on each purpose will vary.

In the developing world, the relative weight placed on teaching, technological capacity, and research productivity is likely to vary even more. Some countries that are considered "developing" according to average income, such as South Africa, Brazil, India, and China, have prestigious research institutions, whose faculties publish in well-regarded journals, and collaborate with researchers around the world. Other developing countries, including most countries in sub-Saharan Africa, the Middle East, Southeast Asia, the Caribbean, and Latin America, are a different story. There are many statistics and studies attesting to the modest levels of scientific output from the lowest income countries.[45] David King's frequently cited 2004 study of global scientific literature is telling.[46] Of all articles published between 1997 and 2001 in scientific journals indexed by Thomson ISI (approximately 8,000 journals, in 36 languages), roughly 35 per cent included authors based in the United States, 37 per cent in the European Union, 9 per cent in Japan, 5 per cent in Canada, and 3 per cent in each of Russia, Australia, and China. The only other developing countries to appear on the list were India (2 per cent), Poland (1 per cent), Brazil (1 per cent), South Africa (0.5 per cent), and Iran (0.13 per cent).

Similarly skewed figures exist with respect to the number of journals published in the developing world. A 2004 study reviewed the 43,500 peer-reviewed scientific journals found in Ulrich's Periodicals Directory and found only 327 journals published in the 47 countries of sub-Saharan Africa (0.75 per cent).[47] Willinsky offers various explanations for the lack of research publication in the developing world.[48] These include the small number of locally-published journals, the lower prestige and recognition of those local journals that do exist, the exclusion of those journals from internationally recognized indexes, the difficulty researchers from the developing world have getting work accepted by international journals,[49] and perceived peer reviewer bias against developing world authors. Other factors militating against developing world researchers include difficulties writing in English (the language of most international scientific publications), lack of editorial support, and lack of experience preparing manuscripts.[50]

These findings suggest that, at least on an international scale, researchers in developing countries remain primarily *consumers* of scientific information. They use scientific journals primarily for educational purposes and to implement the latest technological advances—in fields such as medicine, public health, agriculture, and hydrology. Their actual production of scientific information lags far behind the industrialized world. Even in their capacity as consumers, the situation of developing world researchers is complex. Observers in the industrialized world, accustomed to high-speed Internet access, often overlook the low rates of broadband penetration in much of the developing world.[51] Many functions associated with electronic access to literature, from searching to downloading articles, are slower and less reliable.

A second factor is the coverage of the literature available in the developing world. In OA discussions, emphasis is usually placed on the biomedical sciences, as it is generally believed in the industrialized world that advances in medicine, biochemistry, and public health are likely to improve life in the developing world. Biomedical issues have been a staple of the development agenda for years in connection with the Access to Medicines movement, and thus form a natural extension in the context of OA. Next in line are other scientific fields with clear applicability to challenges faced by the developing world: engineering, climatology, agriculture, renewable energy, population science, infrastructure development, and the like.

Observers have also cited such fields as anthropology, paleontology, archeology, and geology as important, given the resources found in many developing countries. But how pressing is the need for the latest literature on mathematical theory, high energy physics, or planetary science, fields that are the subject of significant investigation in the industrialized world but have little direct bearing on developing world issues? Is the ultimate goal of expanding developing world access to scientific literature primarily *utilitarian*, in which case the value of a body of literature should be measured in terms of improving human health, economic development, and other tangible metrics, or based on an inherent *right* of all individuals to access the fruits of scientific research and participate in the global intellectual community? Should all fields of knowledge be valued equally?[52] Answers to these questions will affect strategies for implementing OA programmes.

The Costs of Information Philanthropy

There is one additional and significant difference between the situations of researchers in the developing and industrialized worlds. Partially as a result of calls for global OA, a handful of programmes have been implemented by philanthropic organizations in conjunction with scientific publishers to provide researchers in the developing world with free or significantly discounted access to paid journals. These programmes exist independently and, some would argue, in defiance of OA publication. For example, in 2002 the WHO launched the Health InterNetwork for Access to Research (HINARI), a program which saw six major commercial publishers offer academic and government researchers in developing countries free or heavily discounted online access to 1,500 journals in fields relevant to public health and medicine.[53] Today the programme has expanded to include 160 publishers and more than 8,000 journals. A sister programme, Access to Global Online Research in Agriculture (AGORA), was established in 2003 by the Food and Agriculture Organization of the United Nations (FAO). It makes 1,900 journals in agricultural science available to eligible researchers.[54]

Online Access to Research in the Environment (OARE)[55] is a joint project of the United Nations Environment Programme (UNEP) and Yale University, supported by the MacArthur Foundation and other donors. It makes 4,150 environmental science journals from 350 publishers available to researchers in developing countries. HINARI, AGORA, and OARE are grouped under the banner "Research4Life."[56] Smaller and more focused programmes also exist. One example is the electronic Journals Delivery Service (eJDS) managed by the International Center for Theoretical Physics in Trieste, Italy, which distributes free copies of physics and mathematics articles to researchers in developing countries. A somewhat different approach is taken by the Programme for the Enhancement of Research Information (PERii), coordinated by the International Network for the Availability of Scientific Publications (INASP).[57] PERii works with more than fifty scientific publishers to make online content from 38,000 journals available to participants in the developing world with significant discounts (generally 90 to 98 per cent). PERii also seeks to educate institutions, libraries, and researchers in the developing world about the scientific publishing industry, and claims over 1,300 registered research institutions. The collective impact of these philanthropic programmes is sizeable. A recent survey of African research libraries finds that they can now access on average 11,000 international online journals, a far cry from the single-digit figures seen a decade ago.[58]

While philanthropic programmes have undeniably expanded access to publications that would otherwise be inaccessible, commentators have questioned their overall usefulness and sustainability. Most obviously, any programme based on philanthropic support depends on the continuing generosity of donors (in this case, scientific publishers). While many of the largest commercial publishers participate in such programmes, they are not perpetually committed. Corporate philanthropy is funded largely by a corporation's paying customers. To the extent that pricing pressure from subscribers increases, publishers' willingness to "give away" content may decline.[59]

More fundamentally, Leslie Chan and Sely Costa question whether content from leading Western journals, even in the biomedical field, is sufficiently relevant to research and practice in developing countries, where disease vectors, medical practices, crop varieties, and genetic factors differ substantially from those in the industrialized world.[60] To make scientific advances useful to the developing world, research relevant to the developing world must be published. Other authors, including Eve Gray and Smith Esseh, argue that the free availability of so much international scientific content may actually hinder the development of local knowledge and the growth of local scholarly publications.[61] Y.Z. Ya'u even refers to the developing world's growing reliance on imported knowledge as a "resurgence of imperialism ... represented by knowledge dependence."[62]

Theory aside, serious questions exist regarding the actual use of this abundance of international literature, and answers appear to vary based on whether the question is posed to libraries or researchers. For example, a recent study of junior-level public health researchers in Asia, Africa and South America found that nearly one-third of respondents preferred printed, hard-copy periodicals over electronic resources, and more than half expressed dissatisfaction with the accessibility of both print and online resources at their institutions.[63] While statistics compiled by Elsevier on behalf of Research4Life indicate increases in research output by scientists in the developing world since the initiation of the HINARI, AGORA and OARE programmes,[64] the methodology and reliability of these claims has been questioned.[65]

Finally, one must consider the effect on research of the underlying humanitarian goals of the philanthropic support of knowledge access: curing disease, ending hunger, improving quality of life, building infrastructure, and enabling economic development. While these goals are laudable, they fail to encompass the whole of the scientific enterprise. It would be hard to justify the study of gravitational fields or string theory under the banner of "Research4Life." In this way, humanitarian efforts can be constraining. Researchers in the developing world should not be required to allow the judgment of well-meaning donors to circumscribe the boundaries of their scientific curiosity.

The Green Route and the Developing World

Leslie Chan, one of the original Budapest Initiative signatories and a leading advocate for OA, has suggested that the self-archiving "Green" route is "the key to a rapid advance in scientific growth throughout the world."[66] Among the benefits of Green OA are its ability to make otherwise inaccessible literature available in the developing world (so-called North-South knowledge transfer) and to make research from developing countries broadly available to the international community (South-North and South-South knowledge transfer). It is useful to consider these two points in the context of the inbound (consumer) and outbound (producer) character of developing world science.

With respect to researchers in the developing world as *consumers* of knowledge, it is hard to dispute Chan's logic. To the extent that scientific articles published in commercial journals (still the favoured route for publication) are made available by their authors on institutional web sites or collective archiving services, scientists everywhere stand to benefit. Assuming institutions can agree with publishers on copyright, continued Green OA archiving by researchers in the industrialized world will benefit researchers in the developing world (i.e., North-South transfers).

It is less clear that self-archiving will meaningfully increase research output by scientists in the developing world, or make their work more visible to (or respected by) scientists in the industrialized world (i.e., South-North transfers). Two kinds of articles can be self-archived: articles published in established journals (in which case the self-archiving establishes an alternative, often free, means of access), and all other work, including work published in less known local journals, together with unpublished white papers, reports, theses, and pieces that otherwise do not appear in the established literature. To the extent that researchers in the developing world publish through traditional, mainstream channels, their work is already available to the same extent as that of their colleagues in the industrialized world, and self-archiving serves the same function as self-archiving by those colleagues: it makes published work available through an alternative, free mechanism. This is a positive outcome, but it represents only a small percentage of the research output of the developing world, where researchers experience significant difficulty placing their work in highly-ranked international journals.

The greater benefit sought by Green OA advocates is the wider dissemination of the other work produced in the developing world. Self-archiving seems an imperfect solution. Making work available on the Internet indeed results in global accessibility. Search engines such as Google Scholar will index it and enable it to be downloaded. But is it likely that this work will be read and cited more frequently simply because it is available? The traditional peer-reviewed journal publishing system, imperfect as it is, serves a valuable credentialing role. It assures the reader that articles have met minimum criteria of value. Unmediated self-archived articles lack this "seal of approval" and will less likely gain the trust and attention of the international scientific community. Self-archiving may also undermine the ability of new journals from developing countries to gain respect and develop an international following, as a proliferation of unmediated self-archived articles may drive "serious" scientists more firmly into the arms of the international publishing establishment.

Green OA self-archiving also suffers practical impediments. Self-archiving is typically implemented by individual institutions on their own web sites. This system has proven to work well for major American and European research institutions, with robust network infrastructures, backup mechanisms, and high-speed broadband connections. The picture is different at many resource-strapped institutions in the developing world.[67] Access to a researcher's work depend on the functioning of patchy connections and homespun networks. I experienced the effect of such difficulties while researching this article. Using Google Scholar, I found an article about citations to geology journals in South America. When I attempted to access the article I found that the domain name for the web site on which it was archived had expired and reverted back to the domain registrar. The article was, for all practical purposes, lost to the world. One solution to the institutional infrastructure problem are collective archiving services such as arXiv.org and SSRN. Here, a centralized, often grant-supported external service handles the archiving. The scope of these services is still limited (arXiv.org covers primarily physics and mathematics). Moreover, because they do not provide selection, quality-control, or peer review, they are not seen as substitutes for journal publication (though they often do host articles that have been published in journals).

Another significant hurdle for Green OA arises in connection with scientific data. Results reported in scientific articles must be distinguished from the experimental and observational data generated by research and upon which published results are based. A journal article typically includes a brief presentation of findings, often in summary or tabular fashion, together with the scientist's analysis and conclusions. The data reported in a journal article are typically only a fraction of the "raw" data.[68] However, in order for other scientists to fully evaluate an article's claims, they often need to see the full data set. When and how data sets should be made available to the scientific community is debated.[69] Particularly in the biological sciences, funding agencies can require that data be deposited in publicly administered databases such as NIH's GenBank and dbGaP repositories. In other cases, scientific journals require the deposit of data supporting assertions made in published articles and sometimes maintain data repositories themselves.[70] Whether and how self-archived articles ought to make data available is unclear. Ensuring access to data places significant additional demands on local IT infrastructures far beyond those involved in archiving text files of articles.

The Gold Route and the Developing World

As in the industrialized world, the Gold (author-pays) OA route has been advanced as an alternative or complement to Green OA self-archiving in the developing world. Under a Gold OA model, articles are selected and published through a traditional peer-review system, then made freely available. Journal costs, particularly in the biosciences, are often covered by fees levied on authors, generally in the range of $1,000 to $3,500. As consumers of research, scholars in the developing world clearly benefit from the free accessibility of OA journals. In this respect, they are situated no differently than scholars in the industrialized world.

The situation becomes more complex when considering the effect of Gold OA on the production and recognition of research. Studies show that placement of articles in OA journals substantially increases the visibility and citation of articles by authors in the developing world.[71] But these statistics do not reveal how widely researchers in the developing world use Gold OA publishing routes. Author fees present significant obstacles. This being said, many OA publishers waive or heavily discount author fees for researchers in low-income countries. BioMed Central, the publisher of more than 220 OA journals, waives fees for all authors in World Bank low-income or lower-middle-income countries, some 90 countries, including Egypt and Nigeria, a group which nevertheless excludes scientifically productive nations such as India, China, Brazil, Iran, and South Africa.[72]

Assuming that such fee waivers remain, this situation might seem suited to greater research publication, at least in very poor countries. But problems arise when locally-produced OA journals are added to the picture. Like OA journals based in the industrialized world, these journals need to meet costs associated with publication, editing, and peer review. Yet these journals cannot depend on income from a steady stream of researchers in the industrialized world. Their authors are likely to be from the developing world. As such, these journals cannot afford to waive fees, as this would eliminate most of their income. Absent some other means of support (through grants or governmental subsidy), Gold OA journals in the developing world face a perverse competitive challenge from journals in the industrialized world when soliciting quality contributions from developing world authors.[73]

Some OA journals in the developing world take a different approach. Hindawi Publishing, based in Cairo, publishes more than 300 OA journals, ranging from *Advances in Power Electronics* to *Oxidative Medicine* and *Cellular Longevity*.[74] Though Hindawi is based in Egypt, it does not cater to Egyptian or developing country audiences. Its journals are mainstream publications that compete with the likes of BioMed Central and PLoS. Hindawi's decision to operate out of Cairo is based on the low cost base and educated workforce.[75] Journals such as Hindawi's contribute to the national economies of their host countries, but do not achieve the development goals ascribed to OA publishing in the developing world. They are international journals that outsource their labour.

To observers of the OA movement, the above reservations may seem misplaced, or at least incongruous. First, many "open access" journals in the developing world do *not* charge author fees, effectively mooting the Gold OA author-pays debate. In some cases high-quality OA journals are operated on a volunteer basis by dedicated researchers. In other cases, journals may be more akin to self-archiving sites, without significant selection, editorial, or peer-review functions. Such efforts provide a service to the community, but are not substitutes for full-fledged journals. Some OA journals are subsidized or fully funded by government programmes, academic institutions, professional societies, or charitable donations. None of these examples, however, eliminate the need for commercially-viable, peer-reviewed OA journals in the developing world. Volunteer and subsidised activity cannot be relied on as long-term solutions for a robust and globally-respected publishing industry.

Second, all indications point to significant growth in the number of OA journals in the developing world. A quick review of the Directory of Open Access Journals (DOAJ), operated by Lund University in Sweden,[76] shows that after the United States (with 1,333 OA journals), the country with the next greatest number of OA journals is Brazil, with 656. India ranks fifth with 372 journals, Turkey tenth with 177, and Colombia, Poland, Egypt, Chile, Iran, Argentina, and Mexico all appear in the top twenty (ranking above technology powerhouses South Korea, Sweden, Finland, the Netherlands, Switzerland, and even Japan). Moreover, numerous well-regarded aggregators of developing world OA journals now exist, including the South American *Scientific Electronic Library Online* (SciELO) funded, in part, by the Brazilian government,[77] the pan-African *African Journals OnLine* (AJOL),[78] and Bioline International, which offers peer-reviewed journals from sixteen developing countries in Asia, Africa, and South America.[79] These facts might indicate that OA publishing has been a great success in the developing world. Yet the full picture is different.

Unlike the more traditional indices of scientific literature (Thomson ISI, Ulrich's Periodicals Directory, Scopus), DOAJ statistics are self-reported. Journals in DOAJ need not be peer-reviewed, nor demonstrate continuing viability. Recent studies of the OA journal literature find that the large majority of long-lived, frequently-cited journals are still published in "scientifically-advanced" countries.[80] While OA journals appear to be proliferating in the developing world faster than in the industrialized world, it is not clear that they are having a sizeable impact on scientific practice in either theatre.

Mandates and the Developing World

One of the largest repositories of full-text biomedical literature is PubMed Central, managed by the US National Library of Medicine. As discussed earlier, all NIH-funded publications must be deposited into PubMed Central within a year of publication. Non-NIH funded literature may also be deposited in PubMed Central, and a number of non-US funders such as the Wellcome Trust encourage the use of this repository to satisfy their own OA requirements. Clearly the 2.3 million articles freely available in PubMed Central—and the increasing number of other funder OA mandates in the industrialized world—can benefit researchers in the developing world as consumers of content.

Nevertheless, researchers in the developing world should be wary of reliance on government-mandated information philanthropy. Just as commercial publishers might discontinue subscription discount programs, so could the governments of the United States and other industrialized nations seek to limit access to the information resources funded by their citizens. A system where articles in PubMed Central could be downloaded only by individuals with a US account, or using a verified .edu domain, is not hard to envision.

Moreover, mandates by funders in the industrialized world are likely to have little effect on the *production* of scientific output in the developing world, where few researchers are supported by the NIH or by other industrial world funders. Researchers in the developing world are left, then, without the "stick" of OA mandates when negotiating the publication of their work with commercial publishers. This begs the question of whether governments in the developing world should follow the lead of the United States and the European Commission and impose mandatory OA policies on research produced with their backing. This suggestion was put forward in a draft National Open Access Policy for Developing Countries adopted by delegates at a 2006 meeting hosted by the Indian Institute of Science in Bangalore.[81]

The move toward NIH-like pronouncements by developing world governments, while defensible, could be risky. US trade negotiators take a dim view of governments that seek to erode copyright and similar intellectual property protections. In the context of biomedical research, one has only to recall the vehement Access to Medicines debate and the "compulsory licensing" terms of the so-called Trade-Related Aspects of Intellectual Property Rights (TRIPS) Agreement[82] and subsequent Doha Declaration to envision potential objections to strong OA policies by countries invested with publishing interests. Commercial interests have continued to protest the NIH policy, and to push for revoking it through counter-legislation in the United States.[83] In the realm of copyright law, the recent international Anti-Counterfeiting Trade Agreement (ACTA) sponsored by the United States demonstrates a trend toward greater enforcement of proprietary rights and limitations of user flexibility.[84] ACTA, ostensibly drafted to prevent global media piracy, has been criticized as negatively impacting A2K in developing countries.[85] The effect of the treaty on OA mandates can easily be imagined. One publisher recently referred to the NIH OA policy as nothing less than "a means for facilitating international piracy."[86]

Other OA mandates in the developing world that do not directly impinge on intellectual property rights may be less controversial internationally, but may generate controversy within local scientific communities. The Bangalore draft policy described above encourages researchers in developing countries to publish in OA journals. While such statements of encouragement have been of limited effectiveness, more mandatory policies have also been discussed. Such policies run the risk of alienating the very researchers that they are trying to empower. As explained by Padmanabhan Balaram, Director of the Indian Institute of Technology, scientists in the developing world wish to publish in prestigious venues, with the greatest likely readership. Artificially forcing them to publish in OA journals of lesser impact could be resented and resisted, as it would be in the industrialized world.[87]

Given the challenges faced by researchers in the developing world, is OA publishing likely to advance their scientific work in a meaningful way? The answer is almost certainly "Yes," though not without effort, and not without adjustments to traditional ways of thinking about scientific research and publishing.

Many commentators have identified the need for more and better South-focused scientific journals. While recent years have seen an increase in the numbers of online OA journals in such developing countries as Brazil, Egypt, and India, most such journals are not indexed by international bodies and have low or non-existent impact factors. It is not surprising that the best scientists in the developing world submit their work to recognized international journals. Career advancement, peer recognition, and overall status in the scientific community are shaped by the reputation of the journals in which a scientist publishes. It is not surprising that scientists publishing in lesser-known OA journals in the developing world fail to gain international recognition. Of the millions of articles published each year, an individual can only read a small fraction, and many scientists use measures such as journal impact factor, reputation, and personal experience as proxies for quality. Thus, while raw materials for improving the scope, reach, and impact of developing world science already exist in the form of Green and Gold OA systems, they have not yet had the impact one might hope to see.

How might this situation be improved? There are, of course, no panaceas for a problem that is entwined with so many issues of North-South interaction. However, a few measures might begin to address these challenges. First, better systems to differentiate among developing world OA journals on the basis of quality could be implemented. As in the North, not all journals in the South are created equal. Some will falter, some will disappear, some will remain amateur efforts without solid peer review or selection criteria, and some will function primarily as vehicles for the self-archiving of content by researchers. All of these efforts should be encouraged, fostered and applauded. However, there is also value in identifying the leading developing world journals, which stand on a par with journals in the industrialized world. Current indexing systems and impact ratings overlook many deserving developing world journals for reasons historical, cultural, and logistical.

Eventually, the best developing world journals may receive their deserved place in existing indexes. Until that happens the scientific community should call for the development of a selective South-focused journal index that includes, for example, the top 10 to 20 per cent of journals published in developing countries, or with developing country issues as their focus. Such rankings might be based on journal longevity, consistency of output, composition of editorial board, composition of peer review panels, citations, and readership. The availability of such a "South-Elite" OA journal index could encourage existing international indexes to include developing world journals, and persuade leading researchers in the developing world to view publication in such journals as desirable.[88]

Second, leading universities and research institutions in the developing world can support locally-published journals, not only financially, but also through formal and informal recognition of researchers publishing in such journals. Whether in Boston or Bogota, university departments are comprised of individuals, and departmental leadership is comprised of successful individuals in their fields. Traditional metrics of academic achievement include publication in prestigious, internationally recognized journals. It is not surprising that promising junior faculty in the developing world are encouraged by their institutions and mentors to publish in international journals. To the extent that tenure and review committees at leading institutions in the developing world instead promote publication in South-focused journals, the reputation of such journals would further be enhanced, within the developing world and beyond.

Third, developing world researchers should pay greater attention to research emanating from the rest of the developing world. One recent study shows that citations to papers written by South African authors fall well below global citation averages, even in fields where South African researchers are extremely productive.[89] The South African results compare unfavourably to those in Kenya, in which researchers collaborate regularly with non-Africans but primarily as representatives of "field sites" rather than as independent investigators.[90] Another recent study found that researchers from sub-Saharan Africa were far more likely to collaborate with non-Africans than with each other.[91] These results suggest that researchers in the developing world look to the industrialized world for collaboration and information. For scientific production in the developing world to improve and gain recognition, researchers in the developing world must engage each other's work, and forge their own collaborations with each other.

Finally, financial models must be developed to decrease reliance on information philanthropy, which distorts information markets and influences behaviour in counterintuitive ways. Fee waivers for Gold OA author-pays journals are meant to help authors in developing countries, but often do not apply to the most scientifically productive of such countries. Moreover, fee waivers create challenging competitive pressures for locally-produced OA journals, lacking the base of paying authors of Gold OA journals in the industrialized world. One solution would be to eliminate fee waivers and ask OA and commercial publishers in the industrialized world to contribute to a fund to support the Gold OA author fees of qualified developing world researchers. Funds would be paid to whichever OA journal accepted a developing world researcher's work. This system would level the playing field between OA journals in the developing and industrialized worlds, while enabling developing world researchers to publish in relevant and high quality OA journals, regardless of fees.

OA models have brought about significant changes in the world of scientific publication and knowledge dissemination. While such models have already had a positive impact on researchers in the developing world, more can be done to fulfil the promise of OA publishing for the global consumption and production of scientific research. ■

Notes

1 Robert K. Merton, "The Normative Structure of Science," in *The Sociology of Science*, ed., Norman W. Storer (Chicago: University of Chicago Press, 1973), 267–278.

2 *The Economist*, "Access All Areas," August 5, 2004.

3 European Commission, *Study on the Economic and Technical Evolution of the Scientific Publication Markets in Europe: Final Report*, January 2006, 23. This period of sustained price increases has been termed the "serials crisis."

4 According to one study, the average subscription to commercially-published journals in the field of economics in 2001 cost over $1,600. Theodore C. Bergstrom, "Free Labor for Costly Journals?" *Journal of Economic Perspectives* (Fall 2001): 183. Specialist publications, particularly in the medical literature, can cost in the range of $20,000 per year. Pamela Burdman, "A Quiet Revolt Puts Costly Journals on Web," *New York Times*, June 26, 2004.

5 "Libraries Stunned by Journal Price Increases," *Science* 236, no. 4804 (1987): 908.

6 The term "developing world" is a fraught one. This article does not delve into the various metrics by which the developmental status of a country may be judged, but rather uses the term with intentional imprecision to denote the many countries that are not generally viewed as leaders in the scientific community.

7 John Willinsky, *The Access Principle: The Case for Open Access to Research and Scholarship* (Cambridge, MA: The MIT Press, 2006), ix and 93–94.

8 Barbara Aronson, "Improving Online Access to Medical Information for Low-Income Countries," *New England Journal of Medicine* 350, no. 10 (2004), 966–968.

9 See generally Mahmood Mamdani, *Scholars in the Marketplace: The Dilemmas of*

Neo-Liberal Reform at Makerere University, 1989–2005 (Dakar: Council for the Development of Social Science Research in Africa, 2007).

[10] The text of the PLoS 2001 letter can be found at http://www.plos.org/about/what-is-plos/early-history/.

[11] The statement of the Budapest Initiative can be found at http://www.soros.org/openaccess/read.

[12] The Bethesda Statement on Open Access Publishing offers "concrete steps" that scientists, publishers, libraries, and funding agencies can take to "promote the rapid and efficient transition to open access publishing." It can be found at http://www.earlham.edu/fflpeters/fos/bethesda.htm. The Berlin Declaration on Open access to Knowledge in the Sciences and Humanities offers several conditions and definitions further elaborating the path toward an OA regime in scientific publishing. It can be found at http://oa.mpg.de/berlin-prozess/berliner-erklarung/.

[13] Ahmed Abdel Latif, "The Emergence of the A2K Movement: Reminiscences and Reflections of a Developing-Country Delegate," in *Access to Knowledge in the Age of Intellectual Property*, eds., Gaëlle Krikorian and Amy Kapeczynski (New York: Zone Books, 2010), 99 and 109–112.

[14] World Summit on the Information Society, *Declaration of Principles*, Art. 28, December 12, 2003, http://www.itu.int/wsis/docs/geneva/official/dop.html.

[15] World Intellectual Property Organization, *The 45 Adopted Recommendations under the WIPO Development Agenda*, 2007, http://www.wipo.int/export/sites/www/ip-development/en/agenda/recommendations.pdf.

[16] The text of the proposed A2K Treaty (draft of May 9, 2005) can be found at http://www.cptech.org/a2k/a2k—treaty—may9.pdf. A good discussion of the proposed treaty terms and of the relevant negotiations is contained in David W. Opderbeck, "The Penguin's Paradox: The Political Economy of International Intellectual Property and the Paradox of Open Intellectual Property Models," *Stanford Law and Policy Review* 18, no. 1 (2007): 114–116.

[17] International Seminar: Open Access for Developing Countries, *Salvador Declaration on Open Access: The Developing World Perspective*, September 21–22, 2005, http://www.icml9.org/meetings/openaccess/public/documents/declaration.htm.

[18] Washington Declaration on Intellectual Property and the Public Interest, August 27, 2011, http://infojustice.org/washington-declaration.

[19] Bo-Christer Björk et al., "Open Access to the Scientific Journal Literature: Situation 2009," *PLoS ONE* 5, no. 6 (2010).

[20] Willinsky, *Access Principle*, App. F.

[21] See SPARC, *Author Rights: Using the SPARC Author Addendum to Secure Your Rights as the Author of a Journal Article*, http://www.arl.org/sparc/author/addendum.shtml.

[22] The RoMEO database hosted by the University of Nottingham lists 217 publishers that automatically allow institutional self-archiving of articles, and 58 more that allow self-archiving after the expiration of an embargo period. See http://www.sherpa.ac.uk/romeo/PDFandIR.php?la=en (accessed December 4, 2011).

[23] Not all OA journals charge author fees. Some are operated on a volunteer basis by interested researchers or receive support in government subsidies or charitable contributions. For the purposes of this article, I discuss the "Gold OA" model as an author-pays model. Reliance on volunteer efforts and subsidy and charitable contributions involve uncertainties that make them less reliable models for long-term sustainability.

[24] See Björk et al., "Open Access."

[25] John Whitfield, "Open Access Comes of Age," *Nature* 474, no. 428 (2011): 428

[26] PLoS, Publication Fees for PLoS Journals, http://www.plos.org/journals/pubfees.php (accessed July 4, 2010).

[27] Declan Butler, "US Seeks to Make Science Free for All," *Nature* 464 (2010): 822–823. A group of major research universities and institutes, including Harvard University, the Massachusetts Institute of Technology, Dartmouth College, Cornell University, the University of California, Berkeley, Columbia University, the University of Ottawa, and the Memorial Sloan-Kettering Cancer Center, have formed a group called the Compact for Open-Access Publishing Equity to advocate for greater payment of OA publication fees by research funders. See http://www.oacompact.org/compact/.

[28] Mikael Laaski et al., "The Development of Open Access Journal Publishing from 1993 to 2009," *PLoS ONE* 6, no. 6 (2011). Significantly higher figures for OA journals are reflected in the online Directory of Open Access Journals (www.doaj.org), which lists more than 7,300 OA journals in 117 countries. However, these figures rely on self-reporting, do not account for discontinued or merged journals, and do not require that journals be peer reviewed.

[29] Willinsky, *Access Principle*, 68.

[30] *NEJM* is published by the Massachusetts Medical Society and *MBC* by the American Society for Cell Biology.

[31] Willinsky, *Access Principle*, 18.

[32] See Eric Priest, "Copyright, Scholarship, Authorial Autonomy, and the 'Harvard' Open Access Mandate," *Northwestern Journal of Law, Science and Technology* (forthcoming 2012); John Timmer, "MIT to Make All Faculty Publications Open Access," *Ars Technica*, March 24, 2009, and "Open-Access Publishing Gains Another Convert," *Nature* 459 (2009): 627.

[33] ROARMAP Registry of Open Access Repositories Mandatory Archiving Policies, http://roarmap.eprints.org/.

[34] RoMEO database, University of Nottingham, http://www.sherpa.ac.uk/romeo/PDFandIR.php?la=en (accessed December 4, 2011).

[35] Jorge L. Contreras, "Prepublication Data Release, Latency, and Genome Commons," *Science* 329, no. 5990 (2010): 393; Jorge L. Contreras, "Data Sharing, Latency Variables and Science Commons," *Berkeley Technology Law Journal* 25, no. 4 (2010): 1601.

[36] ROARMAP.

[37] Willinsky, *Access Principle*, 2.

[38] Policy on Enhancing Public Access to Archived Publications Resulting from NIH-Funded Research, NOTOD 05-022, February 3, 2005, http://grants.nih.gov/grants/guide/notice-files/NOT-OD-05-022.html.

[39] United States National Library of Medicine, http://www.ncbi.nlm.nih.gov/pmc/.

[40] According to a 2006 progress report from NIH to Congress, the compliance rate with NIH's voluntary policy was 3.8 per cent. Peter Suber, "NIH Report to Congress," *Open Access News*, February 16, 2006, http://www.earlham.edu/fflpeters/fos/2006/02/nih-report-to-congress.html.

[41] NIH, Revised Policy on Enhancing Public Access to Archived Publications Resulting from NIH-Funded Research, NOT-OD-08-033, April 7, 2008, implementing Division G, Title II, Section 218 of PL 110-161 (Consolidated Appropriations Act, 2008).

[42] The proposed Research Works Act (H.R. 3699) (2011) was introduced in the U.S. House by Representatives by Rep. Darrell Issa (R-CA) and Rep. Carolyn Maloney (D-NY) on December 16, 2011. This act would have prohibited any federal agency from requiring the author of a federally-funded article to distribute, make available, or offer or disseminate it through the Internet or other electronic network. The bill has since been withdrawn. The earlier Fair Copyright in Research Works Act, H.R. 801 (2009) would have prohibited federal agencies from adopting open access publication policies.

[43] In contrast, Jutta Haider notes two apparently contradictory discourses embodied in the OA dialog: that of modern Western scientific superiority and dominance, and that of openness, collaboration, and participation. She casts doubt on the moral authority of Western reformers seeking to bring OA publishing to the developing world. Jutta Haider, "Of the Rich and the Poor and Other Curious Minds: On Open Access and 'Development,'" *ASLIB Proceedings* 59, nos. 4–5 (2007). See also Ulrich Herb, "Sociological Implications of Scientific Publishing: Open Access, Science, Society, Democracy and the Digital Divide," *First Monday* 15, no. 2 (2010).

[44] While the focus of this article is on the natural and biomedical sciences, the situation in the developing world is not dramatically different in the social sciences. See International Social Science Council, *World Social Science Report 2010—Knowledge Divides* (UNESCO Publishing: 2011), http://www.unesco.org/shr/wssr.

[45] See, for example, B.M. Gupta, S.M. Dhawan, and R.P. Guptaw, "Indicators of S&T Publications Output: Developed versus Developing Countries," *DESIDOC Journal of Library and Information Technology* 27, no. 1 (2007): 5–16, offering an overview of this literature.

[46] David A. King, "The Scientific Impact of Nations," *Nature* 430 (2004): 311.

[47] Samuel Kwaku Smith Esseh, "Strengthening Scholarly Publishing in Africa: Assessing the Potential of Online Systems" (doctoral thesis, University of British Columbia, April 2011), https://circle.ubc.ca/bitstream/handle/2429/34184/ubc—2011—spring—esseh—samuel.pdf?sequence=1.

[48] Willinsky, *Access Principle*, 103–07.

[49] Some have attributed this difficulty to bias and, occasionally, racism. See Zoe Corbyn, "A Threat to Scientific Communication," *Times Higher Education*, August 13, 2009.

[50] Joanna Adcock and Edward Fottrell, "The North-South Information Highway: Case Studies of Publication Access Among Health Researchers in Resource-Poor Countries," *Global Health Action*, November 13, 2008.

[51] International Telecommunications Union, *Measuring the Information Society* (Geneva: ITU: 2011).

[52] Note that the utilitarian and rights-based approaches are not mutually exclusive, and neither has been co-opted entirely by advocates from either the industrialized or developing world. See the Salvador Declaration, which blends both approaches in its pronouncements, "Scientific and technological research is essential for social and economic development" and "It is important that access be considered as a universal right".

[53] WHO, About HINARI, http://www.who.int/hinari/about/en/ (accessed December 3, 2011).

[54] FAO, About AGORA, http://www.aginternetwork.org/en/about—agora/ (accessed December 3, 2011).

[55] Online Access to Research in the Environment, About OARE, http://www.oaresciences.org/about/en/index.html.

[56] Research for Life, www.research4life.org (accessed March 20, 2012).

[57] INASP, *PERii: Information Delivery*, http://www.inasp.info/file/ea36e1cc2424ebadbe73d076d430faa7/perii-information-delivery.html.

[58] Smith Esseh, "Strengthening Scholarly Publishing," 292.

[59] At least one of the major publishers supporting the Research4Life programs, Elsevier, has publicly committed to continue to support these efforts through 2015. Francis Cox, "Bridging the Information (Philanthropy) Gap," *Elsevier Editors' Update*, May 2009, http://www.elsevier.com/wps/find/editorsinfo.editors/editors—update/issue26e.

[60] Leslie Chan and Sely Costa, "Participation in the Global Knowledge Commons: Challenges and Opportunities for Research Dissemination in Developing Countries," *New Library World* 106 (2005): 141 and 146.

[61] Eve Gray, *Achieving Research Impact for Development: A Critique of Research Dissemination Policy in South Africa* (2007), 6–7; Smith Esseh, "Strengthening Scholarly Publishing," 56–57.

[62] Y.Z. Ya'u, "The New Imperialism & Africa in the Global Electronic Village," *Review of African Political Economy* 31, no. 99 (2004): 11.

[63] Adcock & Fottrell, "The North-South Information Highway."

[64] Elsevier, "Research Output in Developing Countries Reveals 194% increase in Five Years," July 2, 2009, http://www.elsevier.com/wps/find/authored—newsitem.cws—home/companynews05—01269).

[65] Philip M. Davis and William H. Walters, "The Impact of Free Access to the Scientific Literature: A Review of Recent Research," *Journal of the Medical Libraries Association* 99, no. 2 (July 2011). The authors criticize the report of these findings, which "did not provide information on the methods used to reach that conclusion, and no attempt was made to control for potentially important confounding factors, such as country wealth, national expenditures on research and development, number of active scientists, emergence of research centers in high-impact fields such as medicine, or improvements in library and information technology infrastructures. The authors also provided no data on the number of articles published in each country, as even modest increases in article publication in countries with historically low output can result in high percentage increases. In the absence of more detailed information, the Research4Life results should be considered speculative at this point."

[66] Leslie Chan, Barbara Kirsop, and Subbian Arunachalam, "Open Access Archiving: The Fast Track to Building Research Capacity in Developing Countries," *Science & Development Network* (November 2005).

[67] Willinsky, *Access Principle*, 96–97.

[68] For example, the full genomic sequence of an organism might require hundreds or thousands of pages to print, whereas most journal articles are in the range of ten printed pages or less.

[69] See, e.g., Jorge L. Contreras, "Prepublication Data Release, Latency, and Genome Commons," 329 *Science* 393 (2010)

[70] US National Research Council, *Sharing Publication-Related Data and Materials: Responsibilities of Authorship in the Life Sciences* 32 (2003).

[71] James A. Evans and Jacob Reimer, "Open Access and Global Participation in Science," *Science* 323 (2009): 1025.

[72] BioMed Central, *Open Access Waiver Fund*, http://www.biomedcentral.com/authors/oawaiverfund (accessed December 4, 2011).

[73] See BioMed Central Blog, "The Blossoming of Open Access in Africa", November 7, 2011, http://blogs.openaccesscentral.com/blogs/bmcblog/entry/the—blossoming—of—open—access (accessed December 4, 2011)

[74] Hindawi Publishing Corporation, http://www.hindawi.com/ (accessed March 20, 2012).

[75] Nancy L. Maron, *Hindawi Publishing Corporation: The Open Access Contributor Pays Model*, Ithaka Case Studies in Sustainability, 2009, http://www.ithaka.org/ithaka-s-r/research/ithaka-case-studies-in-sustainability/case-studies/SCA—BMS—CaseStudy—Hindawi.pdf.

[76] Directory of Open Access Journals, "Open Access Journals by Country," http://www.doaj.org/doaj?func=byCountry&uiLanguage=en (accessed December 4, 2011).

[77] *Scientific Electronic Library Online*, http://www.scielo.org/php/level.php?lang=en&component=42&item=1 (accessed March 20, 2012)

[78] *African Journals Online*, http://www.ajol.info/ (accessed March 20, 2012).

[79] *Bioline International*, http://www.bioline.org.br (accessed March 20, 2012).

[80] Hajar Sotudeh and Abbas Horri, "Countries Positioning in Open Access Journal System: An Investigation of Citation Distribution Patterns," *Scientometrics* 81, no. 1 (2009); Sheikh Mohannad Shafi and Mohammad Haneef Bhat, "The Impact of Open Access Contributions: Developed and Developing World Perspectives," *Digital Publishing and Mobile Technologies*, 15th International Conference on Electronic Publishing, June 22–24, 2011.

[81] Workshop on Electronic Publishing and Open Access, "A National Open access Policy for Developing Countries" (November 2–3, 2006), http://www.ncsi.iisc.ernet.in/OAworkshop2006/pdfs/NationalOAPolicyDCs.pdf.

[82] Agreement on Trade-Related Aspects of Intellectual Property Rights, April 15, 1994; Marrakesh Agreement Establishing the World Trade Organization, Annex 1C, 108 Stat. 4809, 1869 U.N.T.S. 299.

[83] Research Works Act (H.R. 3699)

[84] See Brook K. Baker, "ACTA—Risks of Third Party Enforcement for Access to Medicines," *American University International Law Review* 26, no. 3 (2011): 579.

[85] Andrew Rens, "Collateral Damage: The Impact of ACTA and the Enforcement Agenda on the World's Poorest People," *American University International Law Review* 26, no. 3 (2011): 783.

[86] Butler, "US Seeks to Make Science Free," 822.

[87] Center for Internet and Society, "Professor Balaram Talks Open Access," November 15, 2011, http://www.cis-india.org/openness/professor-balaram-talks-open-access.

[88] Some might argue that journal indexing systems are becoming obsolete as article-level citations and statistics become more prevalent. However, fairly or unfairly, it remains that in many scientific disciplines publication in an indexed journal serves as a proxy for the quality and significance of an article, with implications for a researcher's career and ability to secure funding.

[89] Mohammed Jeenah and Anastassios Pouris, "South African Research in the Context of Africa and Globally," *South African Journal of Science* 104 (September/October 2008): 351.

[90] Ibid., 354.

[91] Omwoyo Bosire Onyancha and Jan Resenga Maluleka, "Knowledge Production through Collaborative Research in Sub-Saharan Africa: How Much Do Countries Contribute to Each Other's Knowledge Output and Citation Impact?" *Scientometrics* 87, no. 2 (January 2011).