If Research Libraries and Funders Finance Open Access: Moving beyond Subscriptions and APCs

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Following the examples of SCOAP3, in which libraries fund open access, and eLife, in which funding agencies have begun to directly fund open access scholarly publishing, this study presents an analysis of how creatively combining these two models might provide a means to move toward universal open access (without APCs). This study calculates the publishing costs for the funders that sponsor the research and for the libraries that cover unsponsored articles for two nonprofit biomedical publishers, eLife and PLOS, and the nonprofit journal aggregator BioOne. These entities represent a mix of publishing revenue models, including funder sponsorship, article processing charges (APC), and subscription fees. Using PubMed filtering and manual-sampling strategies, as well as publicly available publisher revenue data, the study found that, in 2015, 86 percent of the articles in eLife and PLOS acknowledge funder support, as do 76 percent of the articles in the largely subscription journals of BioOne. Such findings can inform libraries and funding agencies, as well as publishers, in their consideration of a direct-payment open access model, as the study (a) demonstrates the cost breakdown for funder and library support for open access among this sample of X articles; (b) posits how publishing data-management organizations such as Crossref and ORCID can facilitate such a model of funder and library per-article open access payments; and (c) proposes ways in which such a model offers a more efficient, equitable, and scalable approach to open access across the disciplines than the prevailing APC model, which originated with biomedical publishing.

Introduction

Open access to research and scholarship has reached both a tipping point and, for research and college libraries, something of an impasse. The proportion of the recent literature that is now open access is approaching 50 percent, to judge from a number of studies.[1] In addition, the major funding agencies have open access policies in place on a global scale, while the large corporate publishers have a growing number of open access journals and hybrid options. While these are encouraging developments, that portion of the literature that is open access consists of not only published versions but final drafts and rogue copies, which, combined with open-access policy embargo periods, means that the libraries need to continue purchasing subscriptions for material that may or may not be open. In addition, the spread of the "article processing charges" (APC)

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model of open access, which began in the grant-rich field of biomedical research, does not bode well for open access in the social sciences and humanities.[2] And while by 2014, 50 libraries in North America had set up APC funds for their faculty members to use, according to a recent study, libraries at research-intensive universities will not have the capacity to support this model without the support of granting agencies.[3] At the same time, the APC appears subject to the same aggressive pricing strategies that have historically beset journal subscription fees, with authors not proving a particularly efficient market force in setting prices.[4]

More than one promising variation, however, has appeared to the APC open access model, divided between library and research-funder approaches to underwriting open access publishing costs. On the library side, SCOAP3 (Sponsoring Consortium for Open Access Publishing in Particle Physics) has assembled 3,000 research libraries in 44 countries that collectively pay the equivalent of an APC for all of the articles published in eleven physics journals, based on their country's share of publishing activity.[5] Outside the sciences, the Open Library of the Humanities is able to provide 20 open access journals through the direct support of some 200 libraries, while Knowledge Unlatched has been able to arrange for the publication of 500 open access books through the support of 500 libraries.

The research funding agencies have also become involved in directly paying for open access publishing as well. A prime instance is eLife, which is a multimillion-dollar creation of Wellcome Trust, Howard Hughes Medical Institute, and the Max Planck Society (with more on this journal below, as it is a subject of this study). In 2016, through a different form of funder intervention, the Gates Foundation launched its Chronos platform, which in its first year has paid the authors' APCs for more than a thousand Gates-sponsored research articles directly to the publishers of 26,000 journals with open access options.[6]

To have libraries and funders investing directly in open access by making arrangements to pay publishers directly to open their journals suggests a new path for increasing access to research. In what follows, we propose a variation on this model, by combining the efforts of libraries and funders in paying publishers for open access. This study uses the 2015 publishing output and costs for eLife, PLOS, and BioOne to demonstrate the workings of an economic model in which the funding agencies pay the publishers for the publication of the research they have sponsored, while the libraries pay the publishers for the remaining publishing costs of the articles that do not have such sponsorship. We have chosen the biomedical field to do an initial demonstration of this model because it is where the open access APC was introduced into publishing by BioMed Central in 2000 (based on an earlier tradition of page charges). As this successful open access financial model spreads among publishers today, we want to demonstrate an alternative that offers a number of advantages to all scholars, libraries, and publishers. While in the biomedical field, as we demonstrate below, the proportion of publishing costs paid by funders will be considerably higher than the costs paid by libraries (for the unsponsored articles), most disciplines have some form of research sponsorship. However, we recognize that in the humanities and social sciences the libraries would pay the larger share but rarely, if at all, the entire publishing costs for open access.

Method

This study uses publishing data from three sources: eLife, PLOS, and BioOne. eLife and PLOS are journal publishers, while BioOne is a journal aggregator. All three are nonprofit organizations, which in 2015 were responsible for a total of 198 journals. These organizations were

selected because of (a) their mix of subscription and open access titles; (b) their nonprofit pursuit of a public good (which involves posting of IRS Form 990 statements of publishing revenue); (c) the involvement of funders and libraries in their origins; and (d) their record of leadership and innovation in scholarly publishing. What follows is a brief description of each.

1. eLife was formed in 2012, when the Wellcome Trust, Howard Hughes Medical Institute (HHMI), and Max Planck Society came together to initially pledge $26 million and later an additional $35 million to creating a new innovative open access journal.[7] The journal quickly established itself as a leading source of research, as well as providing others with open source publishing infrastructure, as part of its contribution. Although eLife added an APC of $2,500 in 2017, it remains a particularly striking example of a cooperative publishing venture among funders and a research institute, which influenced the thinking behind the model presented here.[8]
2. PLOS is another publisher that, in its origins, brings the funders into the publishing picture. One of PLOS' three founders, Harold Varmus, was director of NIH from 1993 to 1999, during which time he pursued greater public access for biomedical literature. After considerable pushback from the publishing industry, PubMed Central was established by the NIH in 2000 as an open access repository for voluntary submissions, demonstrating the funder's direct investment in broadening access to and advancing the quality of scholarly communication, principally through National Center for Biotechnology Information. That same year, Varmus joined with Pat Brown and Michael Eisen to form the Public Library of Science (PLOS), launching PLOS Biology in 2003, to which an additional six journals have been added since, all relying on an APC to finance open access.
3. BioOne was founded in 1999, according to its website, "by both library and publisher interests to address the inequities posed by commercial journal publishing." In 2015, it was the home of 190 journal or book series (which are treated as journals for purposes of this study) from 140 scholarly societies in the field of biology. BioOne is a secondary or ancillary publisher offering a publishing platform, which offers exclusive online access to 45 percent of their journals. While 1,500 institutions subscribe to BioOne Complete, a small but growing proportion of titles are open access, including 13 titles in 2015, of which only seven charged an APC. BioOne has a nonexclusive publishing agreement with the professional or scholarly societies, which are free to enter into other publishing arrangements (with JSTOR, for example). The societies also sell additional subscriptions (outside the BioOne collection) with a little more than half of the journals.

The eLife and PLOS content is indexed in PubMed, a service of the National Institutes of Health (NIH). Only 23 of 190 BioOne titles are indexed in PubMed because many of its biology journals fall outside the scope of PubMed. For eLife, PLOS, and 23 BioOne titles, PubMed was used to identify the research sponsorship of articles that appeared in 2015. This was done by applying the "journal article" and 2015 filters to ensure a count that included articles and not editorials, letters, and the like. Further filters were applied to identify articles that listed "NIH grant number," "Howard Hughes grant number," and/or "Wellcome grant number" (as the three substantial biomedical research funders of particular interest to this study), as well as "Research Support: U.S. Gov't" and "Research Support: Non-U.S. Gov't." With the 167 BioOne journals that were not indexed in PubMed (or had 10 or fewer articles indexed), the funders were determined by manually searching a random sample of 350 articles from 20 of the journals.

Examples of U.S. government support for these research articles, in addition to the NIH, include the U.S. Agency for International Development, U.S. Centers for Disease Control and Prevention, National Science Foundation, the President's Emergency Plan for AIDS Relief, and U.S. Department of Veterans Affairs. The non-U.S. government category of research support involves thousands of funders beyond HHMI and Wellcome Trust (see table 1).

TABLE 1
Examples of Organizations Included under PubMed's "Non-U.S. Gov't" Funder Category

American Asthma Foundation	J. David Gladstone Institutes
Andrew W. Mellon Foundation	Janssen Pharmaceuticals Inc.
Australian Commercial-Ready Proof of Concept Grants	Korean Ministry of Health and Welfare
Department of Health (UK)	Investissement d'Avenir (France)
Bill & Melinda Gates Foundation	Rosetrees Trust
Bristol-Myers Squibb	Royal Society
European Centre for Disease Prevention and Control	Sandler Foundation
European Community Marie Curie Actions	South African Medical Research Council
Fundación Ramón Areces (Spain)	ViiV Healthcare
Heart and Stroke Foundation (Canada)	William and Flora Hewlett Foundation

While we imagine that the actual governance of the financial arrangements will take place cooperatively among the stakeholders and will evolve and be refined over time, for the purposes of this study, and in light of a proportion of the articles having more than one study, we decided that each funder would pay a share of the publisher's 2015 revenue (which we are treating as the publishing costs of the article) proportionate to the number of articles that credited the funder. This means that, if the NIH funded the research behind 100 articles, with HHMI also funding 50 of them, then the publishing costs of those 100 articles are divided among the 150 funding credits or acknowledgements included in the 100 articles. If the 100 articles were published in *PLOS Medicine*, which charged a $2,900 APC for each article in 2015, the total publishing cost would be $290,000; the NIH would be invoiced for 100 articles at $1,934 each ($290,000 divided by 150), just as HHM would be invoiced for 50 articles at $1,934 each.

Also for the purposes of this study, we are assuming that the number of libraries participating in this model matches the number of BioOne's current subscription count of 1,500 "academic libraries, research institutions, governmental bodies, NGOs and corporations," according to its website (as of May 1, 2017). The libraries that are currently paying for subscription access to the BioOne collection are likely willing, in the spirit of the 3,000 SCOAP3 libraries (many of which are likely BioOne subscribers), to pay publishers directly for the open access publishing costs of the unsponsored articles from among this set of journals.

It should also be noted that the ability of libraries and funders to enter into this sort of direct-pay model of open access would be facilitated by the growth of the publishing industry organizations, Crossref and ORCID. Crossref has 3,600 scholarly publisher-members representing 40,000 journals for which it collects bibliometric metadata, while its Open Funder Registry lists some 10,000 research funders.[9] ORCID provides a growing registry of what is currently 3.5 million researchers, along with information on their universities, as well as the

authors' funders. As both of these organizations have automated the acquisition of journal article data and metadata, their services could be extended to (a) verify, with the initial article submission process, that the appropriate journals, grants, and grant holders are involved and (b) invoice on publication the appropriate funders or library collective for publication costs.

Results

eLife

In 2015, eLife published 956 articles, according to PubMed, with 86 percent of them crediting one or more sponsors. The NIH was identified by 39 percent of the articles, HHMI by 10 percent, and Wellcome Trust by 7 percent (see table 2). In addition to these three funders, other unspecified US government agencies account for 3 percent of the sponsored articles and non–U.S. government funders for 43 percent of the credits.

TABLE 2
eLife Articles by Sponsor with Proposed Expense Share for 2015

	Articles	Expense Share
Sponsored articles	821 (86%)	$4,678,961
Unsponsored articles	135 (14%)	$769,379
Total articles	**956 (100%)**	**$5,448,340**
Article sponsorship (n = 821)		
NIH	464 (39%)	$1,809,198
Other US gov't funders	32 (3%)	$124,772
HHMI	114 (10%)	$444,501
Wellcome Trust	79 (7%)	$308,032
Other non-US gov't funders	511 (43%)	$1,992,458
Total	**1,200 (100%)**	**$4,678,961**

The publishing expenses were calculated using eLife's reported costs at $5,600 an article in 2015.[10] The funders' share was calculated by dividing the costs of the 821 articles by the proportion of articles for which the funder is credited (see table 2). It should be noted that eLife's reported cost of $5,600 does not take into account expenses associated with developing the platform and other technical innovations, such as the Lens article-display technology (released as open source software), with costs of these developments placed at around two million dollars annually.[11] These development costs do not figure into these calculations; they seem appropriately assigned to eLife's original endowment. Funder support for technical innovation will play an important role in this model's scalability, as well as in its technical contributions (such as eLife's open source Lens, which lays out articles in very readable online form) that improve scholarly publishing.[12]

Given that there are at least 1,200 funders or funder category credits listed in the 821 eLife articles with a sponsor, each funder will be invoiced, under this model, for $3,899 out of the $5,600 publishing costs for each article (see table 3). The actual figure paid by the funder may be less than $3,899, given that the number of articles identified with "US gov't" (3 percent) and "non-US gov't" (43 percent) may have more than one sponsor in those categories, who then also be sharing the cost of the article.

As for the 135 articles that did not have a sponsor, representing 14 percent of eLife's 2015 output, their publishing costs will be covered in this model by the research library community. With 1,500 institutions in place, based on our use of the BioOne community of libraries, this works out to a charge of $513 per library, or $3.80 per article. It may well seem odd to ask libraries to start paying for open access articles from eLife, but the libraries will experience savings with subscription content, which is a larger proportion of the literature, when the funders cover their share of the sponsored articles published.

With its introduction of an APC in 2017, eLife has recognized the need for a sustainability model that is shared by more funders (through research grants used for APCs) than the three original funders who directly supported its operations. The model proposed here offers another means of rationalizing a broader and more precisely calculated form of support from among the funders who sponsor the work that appears in the journal.

TABLE 3
Existing and Projected eLife Publishing and Expense Structure for 2015

	eLife
Journals	1
Articles	956
Cost/article	$5,699[a]
Total cost	$5,448,340
Projected	
Funder article credits	1,200
Funders' share	$4,678,961
Funder fee/article	$3,899
Unsponsored articles	135 (14%)
Libraries' share	$769,379
Individual library share	$513
Library fee/article	$3.80

[a]Expense reported by eLife for 2015.

PLOS

Six of the PLOS journals are squarely in the field of biomedical research, while the seventh, *PLOS One*, the original "mega-journal" (with more than 28,000 articles in 2015), reaching across the sciences and beyond (see table 4).[13]

TABLE 4
PLOS Article Processing Charges (APC) by Journal (2015)

Journal	APC
PLOS Medicine	$2,900
PLOS Biology	$2,900
PLOS Computational Biology	$2,250
PLOS Pathogens	$2,250
PLOS Genetics	$2,250
PLOS Neglected Tropical Diseases	$2,250
PLOS One	$1,495

In 2015, the NIH was credited by 38 percent of the sponsored articles in *PLOS Pathogens* and *PLOS Genetics*, both of which had well over 90 percent of their articles funded, as did *PLOS Computational Biology* (see table 5). Despite its relatively unrestricted research focus, 14 percent of its sponsored articles in *PLOS One* acknowledged NIH support, with 85 percent identifying a funder of some sort; it also had a high level of participation, relative to the other journals in this study, from non-U.S. government funders (70%). Even with the lower APC, these figures suggest that *PLOS One* attracts studies with funding from the broader range of sciences.

Under the proposed model, the non-U.S. government funders (other than HHMI and Wellcome Trust, which are treated separately) who provided support for articles in these journals will collectively pick up the publishing expenses associated with 78 percent of the articles that PLOS published in 2015 (see table 6). PLOS's revenue of $42,274,910 (from its

TABLE 5
Distribution of Articles by Journal and Funders for PLOS Journals in 2015

	Medicine	*Biology*	*Comp. Bio.*	*Pathogens*	*Genetics*	*N. Trop. D.*	*One*
Sponsored articles	109 (84%)	192 (72%)	581 (94%)	665 (94%)	747 (96%)	688 (85%)	24,219 (85%)
Unsponsored articles	21 (16%)	74 (28%)	35 (6%)	43 (6%)	34 (4%)	123 (15%)	4,118 (15%)
Total articles	**130 (100%)**	**266 (100%)**	**616 (100%)**	**708 (100%)**	**781 (100%)**	**811 (100%)**	**28,337 (100%)**
Article sponsorship							
NIH	40 (28%)	76 (30%)	216 (29%)	343 (38%)	381 (38%)	163 (20%)	3,838 (14%)
Other US gov't	6 (4%)	16 (6%)	53 (7%)	21 (2%)	30 (3%)	36 (4%)	775 (3%)
HHMI	4 (3%)	5 (2%)	6 (1%)	23 (3%)	27 (3%)	0 (0%)	73 (0.5%)
Wellcome Trust	27 (19%)	18 (7%)	439 (3%)	61 (7%)	44 (4%)	86 (11%)	322 (2%)
Other non-US gov't	68 (47%)	139 (55%)	427 (59%)	453 (50%)	534 (53%)	526 (65%)	21,679 (78%)
Total	**145 (100%)**	**254 (100%)**	**739 (100%)**	**901 (100%)**	**1,016 (100%)**	**811 (100%)**	**26,687 (100%)**

2015 tax form) resulted from publishing 31,656 articles that year. This amounts to an average revenue of $1,335 per article (see table 7). While $1,335 is less than PLOS's lowest APC rate of $1,495 (for *PLOS One*), PLOS did not collect an APC on 5 percent of its articles, which were granted a waiver (referred to by PLOS as "support provided to authors" due to hardship, location, lack of grants, or other circumstances), while other items may have been published without an APC as well.

The funders' contribution for sponsored articles would be no more than $1,189 per article, and likely less than that, given some articles having multiple funders in the U.S. government and non–U.S. government categories. The libraries' share for unsponsored articles in the seven

TABLE 6
PLOS Articles by Sponsoring Funder with Proposed Distribution of Expenses for 2015

	All 7 PLOS Journals	**Expense Share**
Sponsored articles	27,207 (86%)	$36,333,649
Unsponsored articles	4,449 (14%)	$5,941,261
Total articles	**31,656 (100%)**	**$42,274,910**
Article sponsorship (n = 27,207)		
NIH	5,059 (17%)	$6,014,776
Other US gov't	937 (3%)	$1,114,387
HHMI	138 (0.5%)	$164,205
Wellcome Trust	584 (2%)	$693,772
Other non-US gov't	23,841 (78%)	$28,346,509
Total	**30,559 (100%)**	**$36,333,649**

TABLE 7
Existing and Projected PLOS Revenue and Expense Structure for 2015

	PLOS
Journals	7
Articles	31,656
Revenue/article	$1,335
Revenue total	$42,274,910[a]
Projected	
Funder article credits	30,559
Funders' share	$36,333,649
Funder fee/article	$1,189
Unsponsored articles	4,449 (14%)
Libraries' share	$5,941,261
Individual library share	$3,961
Library fee/article	$0.89

[a] IRS Form 990, 2015, publication income.

journals is $5,941,261, which works out to $3,961 per library annually among the assumed community of 1,500 institutions and $0.89 per article (see table 7).

BioOne

As a journal aggregator, rather than a publisher, BioOne brings a certain complexity to this study. What it offers, in return, is the example of a publishing organization in which (a) libraries played a formative role and continue to constitute a sizable community of support by subscribing to the complete set of biology journals; (b) small societies enter into an agreement with a nonprofit to increase their journal distribution and income; (c) the proposed model applies to broader field of biology beyond the biomedical area; and (d) there can be found a potential organizing body for coordinating scholarly society involvement in this model.

To calculate the publishing costs for the journals in BioOne, we needed to assemble revenue data for the societies, in addition to the revenue for BioOne. We were able to do this for fourteen of the American societies belonging to BioOne in 2015 that were large enough to be required to file a IRS 990 form (in contrast to those with lower revenue levels, such as the Kansas Entomological Society, or those located outside the United States such as the East African Natural History Society) (see table 8). These 14 societies accounted for 21 journals, or 20 percent of the articles in BioOne; they published an average of 101 articles per journal in 2015, compared to an overall BioOne average of 56 articles per journal.[14]

TABLE 8
Fourteen Societies (21 Journals) with BioOne with Articles and Revenue in 2015

Scholarly Society	Articles Published	Publishing Revenue	Revenue/ Article
American Assoc. of Avian Pathologists	86	$155,739	$1,811
American Association of Zoo Veterinarians	159	$187,015	$1,176
American Fisheries Soc. (5 titles)[a]	394	$867,995	$2,203
American Malacological Society[b]	15	$15,240	$1,016
American Society of Mammalogists (2 titles)	141	$150,000[c]	$1,064
American Society of Parasitologists	142	$78,182	$551
Eagle Hill Institute (3 titles)	227	$306,246	$1,349
Florida Entomological Society[d]	163	$47,106	$289
National Association of Biology Teachers[b]	89	$234,084	$2,630
National Shellfisheries Association	103	$157,747	$1,532
Radiation Research Society	147	$407,953	$2,775
Society for Freshwater Science[d]	128	$178,649	$1,396
Society for the Study of Reproduction	280	$790,473	$2,823
Waterbirds Society[b]	52	$48,457	$932
Averages	**101/journal**	**$258,920**	**$1,539**

[a] Does not include revenue of its publishing partner Taylor & Francis.
[b] Journal offered exclusively online with BioOne.
[c] 2014 is most recent year available for IRS 990 Form.
[d] Publishes an open access journal.

The 14 societies had an average annual revenue of $1,539 per article, which includes the royalty payments from BioOne. The revenue associated with a published article for the societies differed significantly from $289 per article for the open access *Florida Entomological Society Journal* to $2,823 per article for *Radiation Research*, almost a tenfold factor.[15] In addition to the $1,539 per article that the societies collected in revenue, BioOne retained the equivalent of $606 per article. Thus, the total that the funders and libraries would have to cover in publishing costs for open access would be ($1,539 + $606) = $2,145 per article (see table 9).

TABLE 9
BioOne and Society Total and Average Royalties and Revenue Levels for 2015

	BioOne + Societies
Journals	190
Articles	10,754
BioOne revenue	$10,675,768[a]
Share paid to societies as royalties	$4,157,761
BioOne's after-royalties revenue	$6,518,007
BioOne after-royalties revenue/article	$606
Society revenue/article[b]	$1,539
Total revenue/article	**$2,145**

[a] IRS Form 990, 2015, publication income.
[b] Includes BioOne royalties and other revenue sources, such as additional subscriptions, discounted by 25 percent from amount reported in Table 8 because the revenue is only available for the larger societies.

The 23 BioOne journals that were indexed in PubMed had levels of article sponsorship similar to the 167 journals that were not included in PubMed, although both sets had a somewhat lower level of sponsorship than other journals in this study, with Wellcome Trust and HHMI sponsorship so rare that it warranted omitting their counts in this case (see table 10).

TABLE 10
Article Sponsorship for BioOne Journals, by PubMed Indexing, for 2015

	PubMed Indexed	Not in PubMed	Total	Revenue Share
Journals	23	167	190	190
Sponsored articles	2,437 (72%)	5,694 (77%)	8,132 (76%)	$17,443,969
Unsponsored articles	936 (28%)	1,687 (23%)	2,623 (24%)	$5,626,846
Articles published	**3,373 (100%)**	**7,381 (100%)**	**10,755 (100%)**	**$23,070,815**
Article sponsorships (n = 8,132)				
NIH	294 (11%)	42 (0.6%)	336 (4%)	$613,582
Other US gov't	412 (15%)	2,531 (37%)	2,943 (31%)	$5,370,807
Non-US gov't	2,082 (75%)	4,197 (62%)	6,279 (66%)	$11,459,580
Total	**2,788 (100%)**	**6,770 (100%)**	**9,557 (100%)**	**$17,443,969**

With the BioOne collection, the funders will cover the publishing costs of 76 percent of the articles, paying $2,145 for each article that credits their sponsorship, while the libraries will cover the remaining 24 percent of the articles at the same rate, which amounts to 2,623 unsponsored articles with each of the 1,500 libraries paying $3,078 to cover the costs (see table 11).

TABLE 11
Projection of Funder and Library Share of Expenses for BioOne and Its Member Societies for 2015

	BioOne + Societies
Funder article credits	9,557
Funders' total cost	$17,443,969 (76%)
Funder cost/article	$1,825
Unsponsored articles	2,623
Libraries' total cost	$5,626,846 (24%)
Individual library cost	$3,751
Library cost/article	$1.43

Discussion

Under the model proposed here, the funders and libraries are together paying the publishing costs for open access to this literature, with those costs treated, for the purposes of this study, as equivalent to the revenue-per-article that eLife, PLOS, and BioOne received in 2015 (see table 12). To consider the funders side of this model first of all, within the scope of this demonstration study, the publishing expenses for 84 percent of the articles offered by eLife, PLOS, and BioOne will be invoiced to the funders of the research, with each funder paying proportionately for the number of articles that credit its support. The NIH would pay the publishing costs for the largest proportion of articles, given its sponsorship of the research in 12 percent of the studies. But then, in addition to advancing its long-time goal of universal open access to the biomedical literature, dating back to Harold Varmus' tenure at the head of the organization (1993–1999), the NIH could use its purchasing power to work with publishers on improving (a) article metadata for more efficient indexing in PubMed; (b) research data sets for NCBI repositories; and (c) reporting standards for clinical trials on matters such as power calculations, primary outcomes, allocation concealment, and attrition.[16] "Experience has shown," NIH currently advises publishers, "that this integration of information resources leads users to new knowledge and stimulates scientific discovery."[17]

TABLE 12
Funder and Library Share of Open Access Publishing Expenses for 2015

	eLife	PLOS	BioOne + Societies	Total/Average[a]
Journals	1	7	190	198
Total articles	956	31,655	10,755	43,366
Funder fee/article	$4,081	$1,189	$1,825	$1,329
Funder proportion	86%	86%	76%	84%
NIH share of all articles	33%	14%	3%	12%
Other US gov't	2%	3%	23%	8%
HHMI	8%	0.4%	—	0.5%
Wellcome Trust	6%	2%	—	1%
Other non-US gov't	37%	67%	50%	62%
Library proportion	14%	14%	24%	17%
Library fee/article	$3.80	$0.89	$1.43	$1.09
Library payment	$513	$3,961	$3,751	$8,225

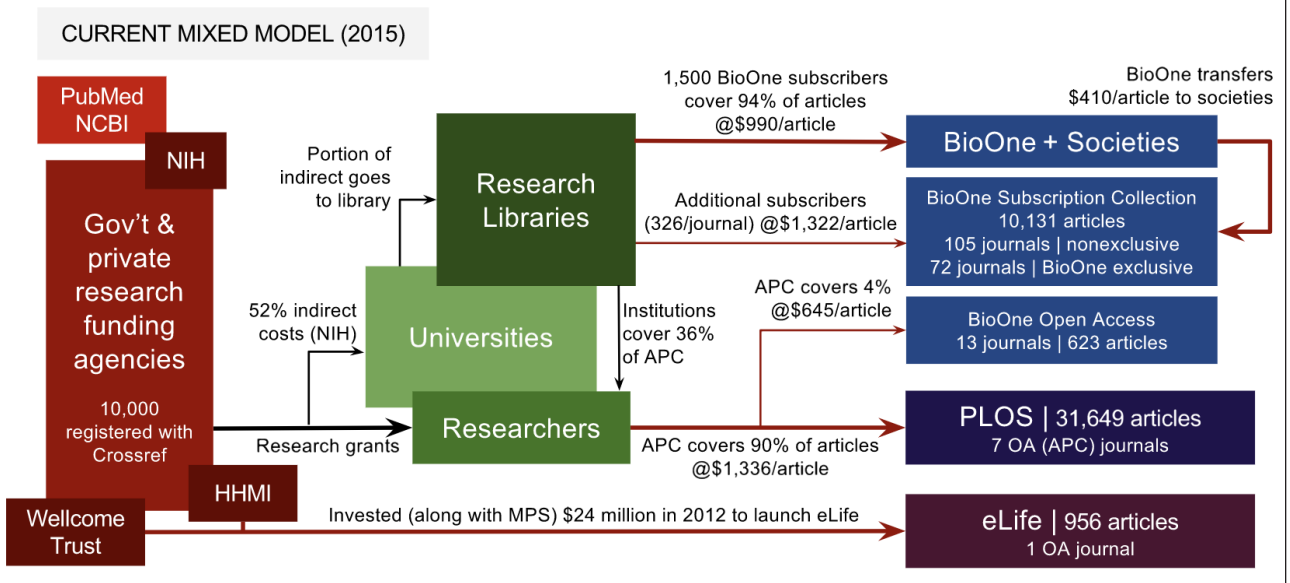
[a] Weighted average

In this study, the projected 1,500 libraries picked up 17 percent of publishing costs, with each library paying $7,843 to cover the unsponsored articles in eLife, PLOS, and BioOne in 2015. This is roughly 10 percent higher than the 2015 BioOne Collection subscription fee that the libraries paid in 2015, which we estimate to average out at $7,117. That is, in applying the proposed model to this sample of journals, in which the majority of articles are already open access, the libraries' share is 10 percent higher than they are currently paying in subscription costs to BioOne. Yet, if this direct-pay model of open access were to be extended to other publishers and fields—in which the vast majority of journals currently use an exclusive subscription model—the effect of the funders' direct contribution to the publishers for all articles they have sponsored will reduce the libraries' overall outlay.

The figures presented here represent considerable differences in per-article revenues. This points to how the proposed model both *caters* to current differences in publisher revenue (as it has funders and libraries match current revenue figures as its starting point) and *exposes* the extent of those differences in per-article revenues. This could provide a basis for funders, libraries, and publishers to discuss differences in expenses and value in light of submission and rejection rates, editorial services, and publishing innovations. Ideally, such discussions will be about the value of improving scholarly publishing standards for all journals as a justification for any price increases in subscribing to open access.

As things stand today, biomedical research funders are underwriting the publishing costs of the research through a complex array of indirect strategies that involve funder sponsorship, plus the recent addition of APCs, in the case of eLife; funder and (limited) library support for APCs with PLOS; and mainly library subscription fees, with some APCs, when it comes to the journals with BioOne (see figure 1).

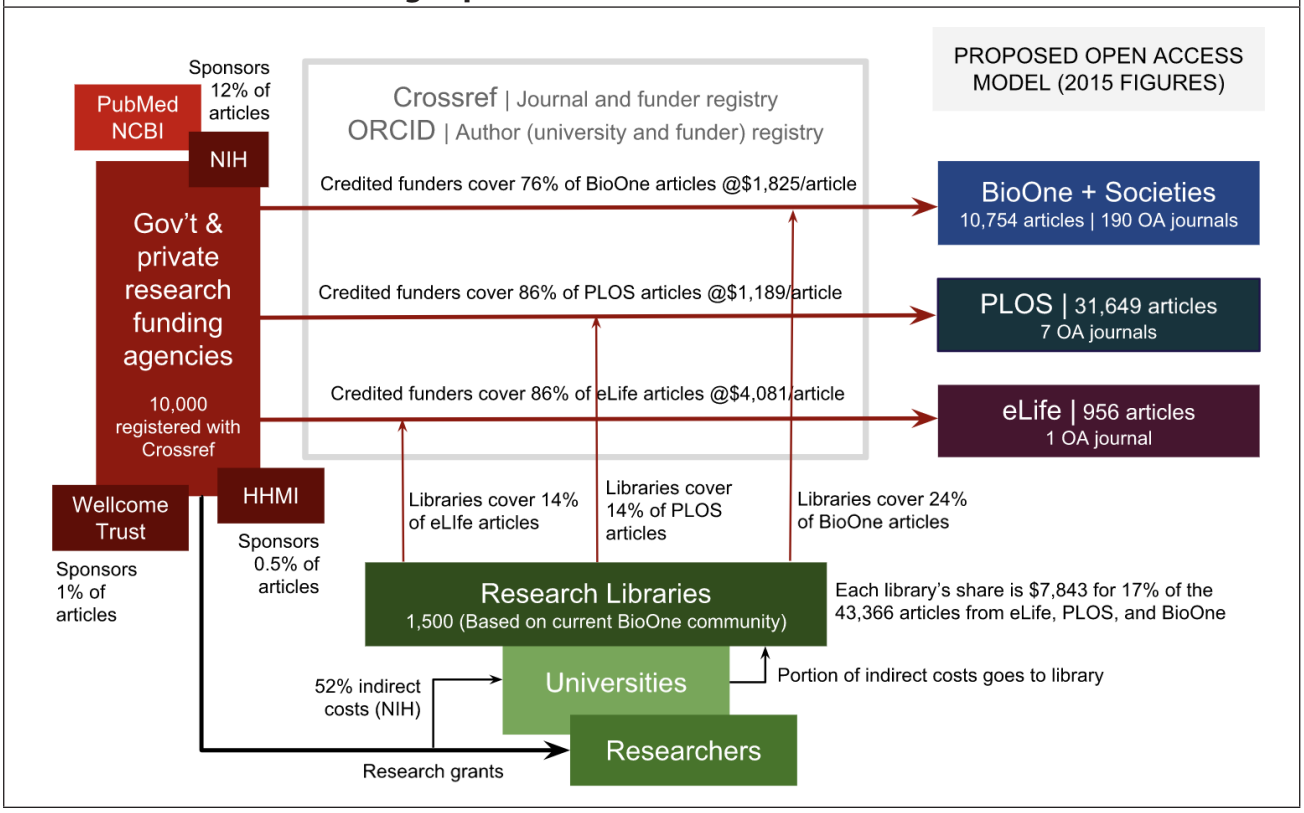
FIGURE 1
The Current Mixed Biomedical and Biology Publishing Model, Based on Subscriptions, APC, and Sponsorship, for eLife, PLOS, and BioOne for 2015



Note: Summary of calculations in paper with exception of BioOne's "additional subscribers," which is included in study's data set (https://doi.org/10.6084/m9.figshare.5965474.v2).

The alternative model proposed here has libraries and funders directly involved in a more transparent and efficient approach to moving journal publishing toward universal open access (see figure 2).

FIGURE 2
Proposed Biomedical and Biology Publishing Model Based on Funder and Library Support for Publishing Expenses for eLife, PLOS, and BioOne for 2015



As for how to initiate such a model in scholarly publishing, the Gates Foundation might be regarded as currently conducting a funder-side pilot study of what we are proposing with the 26,000 journals that form part of its Chronos program, while SCOAP3 has demonstrated how twice the number of libraries considered in these calculations can agree to subscribe to open access for a set of journals. Both are pursuing open access as if it was the role and in the interest of the funder and library to pay the publishers directly for making this work publicly available. What we are proposing is creating a combined and coordinated approach between funder and library, given their shared goal. This can be done through a platform such as Chronos, but we also believe that the Crossref and ORCID systems are in a better position with their publisher, article, funder, and author data. The modifications needed to make this work, along with other initial transition costs for this mode, could well be supported by those foundations (such as Sloan, Arnold, Robert Wood Johnson, and Mellon) that have been underwriting just such open source and open access infrastructure development for scholarly communication.

The goal of such modified systems will be to (a) provide more precise and detailed reporting for funders and indexing for researchers and the public; (b) achieve greater efficiency in publishing transaction costs after the initial transition costs of setting up automated systems; (c) ensure that publishers have the ability to innovate and improve editorial services (which

is already a part of eLife's contribution both in methods and in open source tools); and (d) place a check on a history of monopolistic price increases by treating scholarly publishing as a market for publishing services rather than a set of intellectual assets for extracting rents.[18]

Limits to this Model

Reasons abound for cautionary notes on proposing such a model. While we presume this to be a model that can work across the disciplines, we choose to offer an initial demonstration with the biomedical field (with some biology), which is decidedly a limit given that this field is grant-rich and has a successful open access approach with APCs. We decided that APC open access needed to be addressed, as it does not bode well for other disciplines or regions, while the biomedical field and funders have been among the leaders in open access. Still, we can offer a brief humanities example here. If 5 percent of the National Endowment of the Humanities' research grant budget (of $17 million in 2015) went to open access publishing costs, under a model like ours, then $850,000 would be paid to publishers for NEH-sponsored articles from the 264 grants issued in 2015.[19] As a result, the libraries would collectively pay $850,000 less for open access publishing in the humanities (than they are currently paying for subscriptions), which works out to a reduction of $567 per library (with the participation of 1,500 libraries, as discussed above, for the purposes of this study). This is to leave aside, for the moment, the humanities penchant for book publication, for which Knowledge Unlatched has an open access model that builds much as our model does on library payment. With only a small fraction of humanities studies having grants on any kind, the libraries would be devoting most, but not all, of their previous humanities subscription allocations to supporting the open access publishing costs of those same journals. While even a 5 percent reduction in NEH grants would understandably be of concern to humanities scholars, the NEH has a broad scope of public programs to which this move to open access would contribute in ways that may be able to be supported by other funds than from the grants to scholars.

A second and related limit to this model is that it starts with publishers' existing pricing structures in calculating publishing costs for open access. Some find this an unacceptable limit to our model, given the profit margins currently being extracted from scholarly publishing by some publishers.[20] We hold that the best hope for changing what is unsustainable about the current combination of subscriptions and APCs is to start with current pricing, in good faith, to then establish the means for funders, libraries, and publishers to negotiate a new set of arrangements based on paying for publishing services rather than for access to content. This might lead, in turn, to a rationalizing of article costs, while continuing to improve publishing standards (given the current considerable discrepancies even within publishing communities, as noted with table 11). Many considerations will need to figure into these deliberations among public and private, nonprofit and commercial operations, not least of which will be the researcher rights to publish were they to think it best for the work and field. Still, one can see the use of fair pricing and transparency incentives, as well as spending caps, following SCOAP3's example.[21] Other strategies could be drawn from the literature on U.S. Medicare and Medicaid struggles with centralized purchasing programs.[22]

A further concern is that this model, as it enables funders to reduce their grants to researchers by the amount that the funders are paying publishers, will reduce the indirect-costs payments that universities receive from funders, some part of which makes its way to the libraries.[23] This could be seen to reduce whatever savings the libraries would experience from

funders bearing a greater portion of publishing costs. The intent of this model, however, is not to create windfalls for libraries, nor has this prospect been the motivation, in our experience, behind library support for open access.

Finally, the model of open access proposed here is vulnerable to free-rider issues. Once the journals are open access, will the libraries continue to cover the costs of unsponsored articles? This will need to be addressed through an active recruitment and retention plan, inspired by the example of SCOAP3 in which 3,000 libraries remain part of the collective, although limited to 40 participating countries and based on the country's level of physics publishing, as a matter of equity. Still, participation in this model is not be taken for granted (much as libraries cancel journal subscriptions), with an ongoing need to demonstrate the value of open access to research and scholarship creating a public good supported by research libraries and funders.

Conclusion

Three-and-a-half centuries before the 2001 World Social Forum in Porto Alegre adopted "another world is possible" as its motto, Descartes' asked his readers in *The World or Treatise on Light* to "allow your thought to wander beyond this world to view another world—a wholly new one which I shall bring into being before your mind in imaginary spaces."[24] The world that Descartes went on to describe was not really "another world" but a new perspective on the present one. Just so, what we have set out here may seem to be an imaginary world, while it is, in fact, building on existing online publishing systems, journal and funder databases, and current funder involvement in scholarly publishing. It is the world that particle physicists have already created for their journals with library support; that research funders are building with new publishing processes and new relationships with publishers; and that publishers are embracing with their open access options. It is the world that this paper has attempted to demonstrate can be extended across the board of scholarly inquiry by further rationalizing and extending the open circulation of this public good. Open access is, after all, a concept to which funders and libraries already wholeheartedly subscribe, as do the biggest of publishers.[25]

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