

# **Institutional Journal Costs in an Open Access Environment**

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## **Abstract**

This study investigates the potential impact of Open Access pricing on institutional journal expenditures in four subject fields at nine American colleges and universities. Three pricing models are evaluated: the Conventional Model (the current subscription model), the PLoS Open Access Model (based on the fees currently charged by the Public Library of Science), and the Equal-Revenue Open Access Model (which maintains current levels of total aggregate spending within each subject field). Because institutional disparities in publishing productivity are far greater than institutional disparities in library holdings, the shift from a subscription-based model to either Open Access model would bring dramatic cost savings for most colleges and universities. At the same time, a small number of institutions—the top research universities—would pay a far higher proportion of the total aggregate cost.

## **Introduction**

Conventional journals are noteworthy in two respects. First, they restrict access to scientific information; content is available only to subscribers. Second, they rely heavily on subscription income. In contrast, the Open Access model offers the potential for the free and widespread dissemination of scholarly work. As implemented by the Public Library of Science (PLoS), Open Access has three main characteristics: (a) content is freely accessible to the public through the internet, (b) printed copies of each journal are made available to libraries at a nominal cost, and (c) publication fees rather than subscriptions are the primary source of revenue.<sup>1</sup> Under the Open Access pricing model, authors' institutions or funding agencies pay a publication fee—generally \$600 to \$3,000—for each accepted article.

Although the benefits of Open Access publishing are well known (see, for example, Antelman, 2004; Ashling, 2003; Lawrence, 2001; and Romero, 2003), only a few authors have

considered the economic implications—in particular, the ways in which Open Access pricing might influence publishers' revenues and universities' expenditures.<sup>2</sup> For one thing, the future of Open Access depends largely on the true cost of journal publishing—on whether the publication fees currently levied by PLoS, for instance, are adequate to cover publishers' long-term expenses in a fully Open Access environment. King and Tenopir (1998) estimate that the total cost of publishing and distributing a print article is \$5,152, with only a modest cost reduction (roughly 10%) for online-only access. Most other cost estimates are somewhat lower, in the \$300 to \$4,000 range (Bot et al., 1998; King & Tenopir, 1999; Morris, 2005; Odlyzko, 1997; Tenopir & King, 1997), although others are markedly higher (Mellman, 2004). While some authors contend that Open Access publishing is less expensive than conventional publishing (Wellcome Trust, 2004), others assert that Open Access is likely to be more costly in the long run (Schwartz, 2005).<sup>3</sup>

Just as cost estimates vary, so do publication fees. PLoS charges \$1,500 per article. BioMed Central charges from \$605 to \$1,740, with an average of approximately \$820. Springer and the National Academy of Sciences charge \$3,000 and \$1,000, respectively. It is not clear whether publication fees provide the same income as subscription fees, however, since all four of these publishers have other sources of income. Springer and NAS levy subscription fees as well as publication fees, and BioMed Central publishes conventional journals in addition to their Open Access titles. PLoS receives major grants from at least five agencies, including a \$9 million grant from the Gordon and Betty Moore Foundation (Public Library of Science, 2002). Because Open Access journals are especially likely to gain the sponsorship of outside funding agencies (Kaufman-Wills Group, 2005), many survive despite their relatively low publication-fee revenue. It is uncertain whether this reliance on outside funding is sustainable or scalable, however—whether funding agencies are willing to support Open Access journals indefinitely, or to support a greater number of Open Access journals than they currently do.

Holmström (2004) was among the first authors to consider the impact of Open Access pricing on institutional journal expenditures. Discussing whether individual colleges and

universities would pay more or less in an Open Access environment, he noted that it is possible to calculate the total Open Access journal expenditure for any institution simply by multiplying the average publication fee by the number of articles published by authors from that institution. The Open Access cost can then be compared with the current subscription cost to determine how journal expenditures would change if Open Access pricing were implemented across the board.

Davis and associates (2004: 2) used a similar method to estimate Open Access journal costs for Cornell University. They report that the adoption of Open Access pricing "would not bring about cost savings for Cornell. In fact, taking into account the number of articles published by Cornell researchers each year, [the University] would likely see its serial expenditures rise significantly if the library used its current subscription funds to pay for author fees instead." Specifically, Davis and associates estimate that Cornell's annual publication fees under an Open Access model would exceed the University's current scholarly journal expenditures by approximately \$1.5 million.

Extending his analysis to the entire set of ARL institutions, Davis (2004) developed an interactive spreadsheet that can be used to estimate cost per article under the conventional subscription model. (This cost is essentially the aggregate annual subscription expenditure divided by the number of papers published by university-affiliated authors over a one-year period. It is based on the number of articles written by institutional authors—not the number of articles each institution receives through its subscriptions.) Working from the assumption that scholarly journals account for half of all library subscription expenditures, Davis concludes that 93% of ARL libraries currently pay less than \$2,500 for each article written by their faculty or students. Moreover, 73% of all ARL libraries pay less than the \$1,500 publication fee charged by PLoS. This implies, of course, that the switch to an Open Access model would increase journal costs for many ARL institutions.

The current study estimates total institutional journal costs in four subject fields at nine American colleges and universities. Cost estimates are prepared for three different pricing models: the Conventional Model, the PLoS Open Access Model, and the Equal-Revenue Open

Access Model. Although no single model is likely to prevail under real-world conditions (Schmidt et al., 2005), each is presented separately for analytical purposes.

Under the Conventional Model (the current subscription model), each institution's total journal cost is the sum of four components: single-title subscription costs, online journal collection costs, online aggregation costs, and submission/publication fees. In contrast, the PLoS Open Access Model has just two cost components: publication fees (\$1,500 per article) and print-copy charges (\$160 annually per title). Because the PLoS Model is based on the fee schedule currently in use at the Public Library of Science, the appropriateness of the model depends on the adequacy of the revenues generated by that particular fee schedule. As this analysis will show, however, the PLoS Model brings in only 15% as much revenue as the Conventional Model. For that reason, separate cost estimates have been prepared for a second Open Access model: the Equal-Revenue Model. The Equal-Revenue Model is based on a higher fee schedule which ensures that publishers' total aggregate income (from all institutions combined) is the same as that received under the Conventional Model.

The study has three goals: (1) to estimate the actual journal costs incurred by each of the nine institutions under each of the three pricing models; (2) to show how the implementation of an Open Access model would influence the distribution of total aggregate cost—the percentage of the total cost paid by each institution; and (3) to suggest which kinds of institutions (liberal arts colleges, master's institutions, research universities, etc.) would be most likely to benefit from an Open Access model.<sup>4</sup>

## **Methods**

### **Subject Fields**

Four subject fields were selected for analysis: general biology, cell biology, organic chemistry, and applied physics. Cell biology was chosen due to the relatively large number of

Open Access journals published in that area. The other three fields were chosen to provide contrast in terms of both subject (organic chemistry, applied physics) and specificity of journal content (general biology).

The cost estimates presented here include only those active journals indexed by Science Citation Index in the four subject fields: 65 general biology journals, 154 cell biology journals, 55 organic chemistry journals, and 76 applied physics journals. Science Citation Index excludes non-scholarly publications, serials that do not maintain a regular publication cycle, and journals that fail to meet certain citation-based criteria (Testa, 2004).

Altogether, 349 journals are included in the sample. (One title, FASEB Journal, is listed under both general biology and cell biology.)

## Institutions

America's Best Colleges (U.S. News & World Report, 2004) was used to compile a list of the four-year colleges and universities in each of four categories: Doctoral National Universities (248 institutions), Master's Universities (573 institutions), Bachelor's Liberal Arts Colleges (217 institutions) and Bachelor's Comprehensive Colleges (324 institutions). These categories are similar to those used by the Carnegie Foundation (McCormick, 2001). For instance, all Doctoral National Universities offer doctorates and emphasize research. Master's Universities offer a full range of master's programs but few, if any, doctoral degrees. Bachelor's Liberal Arts Colleges award at least half their degrees in the liberal arts, while Bachelor's Comprehensive Colleges do not.

Within each of the four categories, two institutions were randomly selected: one school from tier 1 (the top 25% of institutions, based on overall ranking in America's Best Colleges) and one from tier 4 (the bottom 25%). Within the Doctoral National Universities category, one additional tier-1 school was selected so that both a major research university and a smaller university would be represented in the sample.

[Table 1 about here.]

As Table 1 shows, the nine institutions represent nine distinct types of colleges and universities. These can be differentiated by institutional level (bachelor's, master's, doctoral), character (liberal arts vs. comprehensive), apparent quality (tier 1 vs. tier 4), and size (number of students, number of book volumes). While both Michigan and Brandeis are tier 1 Doctoral Universities, Michigan is much larger. Michigan is also the only institution in the sample with a medical school.

### The Conventional Model

Under the Conventional Model, the total cost of the journals in each subject field can be calculated as the sum of four components: single-title subscription costs, online journal collection costs, online aggregation costs, and submission/publication fees.

From August through October 2004, I searched the library catalogs of the nine institutions to determine whether current issues of the 349 journals in the sample were readily accessible in either print or online format to students at each college or university. Journals delayed by up to a year were counted, while those delayed by more than a year (in JSTOR, for example) were excluded.

All single-title journal subscriptions were assessed at the 2005 list price. Subscription rates were found at the web sites of the journals, or through EBSCONet or The Serials Directory in those cases where the web site gave no price information (EBSCO Information Services 2006a, 2006b). Each price accounts for the type of subscription (print-only, online-only, print-plus-online) and for any relevant characteristics of the subscribing institution (enrollment, Carnegie class, acquisitions expenditures, etc.). If two or more subscription options were available for a particular subscription type—two different kinds of print-plus-online subscriptions, for example—I chose the least expensive option consistent with the information presented in the library's catalog. All online journals were counted as subscriptions except for those noted below as collections or aggregations. A journal available at a particular institution

through multiple online interfaces was counted only once if a single subscription permitted multiple access points. For example, an Oxford journal accessible through both Oxford Journals Online and Ingenta Select was counted as a single subscription.

For journals received through two of the major online journal collections—BioOne and Project Muse—the cost of each journal was estimated as the total cost of the collection divided by the number of journals in the collection. This estimation method is based on the assumption that BioOne and Project Muse include only high-quality journals that are at least roughly comparable in value and cost.<sup>5</sup> A different estimation method was used for journals in the Elsevier ScienceDirect collection, however. Correspondence with librarians at a variety of colleges and universities suggests that few institutions are paying list price for their ScienceDirect journals. Because the terms of Elsevier license agreements are generally confidential, none of the schools under study were able to provide the details of their ScienceDirect pricing arrangements. The Elsevier license terms offered to several consortia and universities suggest that a 33% discount is not unreasonable, however. For that reason, Elsevier journals—both print and online—were assessed at two-thirds of list price. (Table 2 can be used to estimate Elsevier journal costs under alternative pricing assumptions.)

[Table 2 about here.]

For journals received through online aggregations—large full-text databases that contain the full or partial content of many different journals—the cost of each journal was estimated as 15% of the print-only list price. The aggregations assessed in this way include EBSCO Academic Search, ProQuest Research Library, Thomson Gale Expanded Academic ASAP, Wilson OmniFile Select, and 18 others.<sup>6</sup> These aggregations typically include hundreds or thousands of titles—not only scholarly journals, but popular magazines and other serials—and many of them delay the release of full-text content for up to a year after the publication of the print version. The 85% discount reflects the relatively low cost per title of these online aggregations.

Although the Conventional Model is sometimes described as a "reader pays" approach, many science journals levy publication fees in the form of page charges, publication fees, and



submission fees. Page and publication charges were assessed based on the actual number of pages and articles published by the authors at each institution. (To avoid single-year anomalies, I applied 2005 fee schedules to the average annual numbers of pages and articles published in each journal over a five year period, 1999 through 2003.) All page charges were assigned to the first author's institution, and all were assessed at the lowest possible rate—the Member Rate, for journals published by scholarly societies.<sup>7</sup>

## The PLoS Open Access Model

Under the PLoS Model, there are two kinds of costs: publication fees and print-copy charges.

To calculate publication fees, I first compiled a list of the journal articles written by the authors associated with each school. Specifically, I searched Science Citation Index for articles published from 1999 through 2003 (inclusive) by authors at the nine institutions shown in Table 1. Each search was limited to items with a document type of “article” or “note.” (This practice excludes book reviews, editorials, and similar items for which no submission fee is likely to be required.) After downloading all the items retrieved by these searches, I excluded those articles published in journals outside SCI's general biology, cell biology, organic chemistry, and applied physics categories. I also weeded out the false hits—articles whose authors had no affiliation with the nine institutions under study.

[Table 3 about here.]

The resulting five-year figures were divided by 5 to arrive at an average annual total for each institution.<sup>8</sup> Publication fees were assessed at \$1,500 per published article—the same rate charged by PLoS in 2005. Likewise, print-copy charges were assessed at \$160 per title. (Table 3 shows these calculations.) When calculating print-copy charges, I assumed that any journal received in print under the Conventional Model would also be received in print under the PLoS Open Access Model. Although Schwartz (2005) asserts that colleges libraries are

likely to cancel the print versions of many Open Access journals, the cost estimates presented here do not account for that possibility.

### The Equal-Revenue Open Access Model

As noted earlier, the Equal-Revenue Open Access Model is based on the assumption that neither commercial nor nonprofit publishers would be willing to adopt a pricing model that significantly reduces their subscription income. The PLoS Model does not meet this criterion, since it would bring a substantial reduction in revenue if implemented for all 349 journals in the fields of general biology, cell biology, organic chemistry, and applied physics. Specifically, the total revenue received from the nine institutions in the sample would decline from \$1,458,035 to \$410,820. (See Tables 2 and 3.)

The sample data do not accurately represent the full extent of the decline in revenue associated with the PLoS Model, however, since the sample does not reflect the true distribution of colleges and universities among the various institutional categories. The sample includes three doctoral institutions and two master's institutions, for example, although there are actually more than twice as many Master's Universities as Doctoral National Universities. Any aggregate revenue estimates must therefore be adjusted to reflect the actual number of institutions within each category.<sup>9</sup> The adjusted data (Table 4) reveal that for the set of all four-year colleges and universities, a wholesale switch from the Conventional Model to the PLoS model would bring an even greater decline in aggregate revenue—from \$115,590,292 to \$17,616,360.

[Table 4 about here.]

To calculate publication fees and page charges under the Equal-Revenue Model, I multiplied each PLoS-Model cost by a constant representing the Conventional-cost/PLoS-cost differential for the relevant subject field. For example, the aggregate amount paid for general biology journals under the Conventional Model is \$11,416,738. Under the PLoS Model, the total amount paid would be just \$2,691,060. (See Table 4.) The cost multiplier for general

biology is therefore 4.24, since  $\$11,416,738 / \$2,691,060 = 4.24$ .<sup>10</sup> The use of these cost multipliers ensures that the Equal-Revenue Model maintains the same total system-wide expenditure as the Conventional Model while distributing that expenditure chiefly in accordance with the publishing productivity of the faculty at each institution rather than the number of journal subscriptions held by each school.

## Results

### The Conventional Model

[Table 5 about here.]

Table 5 shows institutional journal costs under each of the three pricing models. Looking first at the Conventional Model data, we can detect three relationships that provide a context for later cost comparisons:

1. Michigan, the larger of the two Doctoral tier 1 universities, pays nearly twice as much in journal costs as any other institution in the sample. As Table 2 shows, Michigan also subscribes to more than twice as many journals as any other school. This suggests that under the Conventional Model, journal costs are more closely related to library size than to either institutional level (bachelor's, master's, doctoral) or apparent quality (tier 1 vs. tier 4).
2. Institutional level is a second major correlate of journal costs. In particular, doctoral universities spend far more than other institutions. The second numeric column of Table 5—"% of total cost borne by each school"—shows, for example, that the three doctoral universities account for 86% of the nine institutions' total expenditures on journals within these four subject areas. At the same time, however, the relationship between institutional level and journal expenditure is not linear; Master's universities spend less than either Liberal Arts or Bachelor's colleges. (Admittedly, this finding applies only to the nine

schools in this particular sample. The differences shown in Table 5 are often dramatic, however. Compare Peru State College and Grinnell College, for instance.)

3. The influence of institutional quality (tier 1 vs. tier 4) is readily apparent only within the Liberal Arts and Master's categories.

Because the field of general biology includes a number of journals that are especially suitable for undergraduate audiences (BioEssays, BioScience, Human Biology, Quarterly Review of Biology, etc.), we might expect the smaller undergraduate colleges to spend relatively more within that subject area. In fact, however, no such trend can be seen. More generally, there is no systematic variation among the four subject fields. For example, Brandeis pays a nearly identical proportion of the total aggregate journal cost in each of the four subject areas: 21% in general biology, 21% in cell biology, 23% in organic chemistry, and 22% in applied physics.

### The PLoS Open Access Model

As Table 4 shows, the total amount paid by all four-year colleges and universities under the PLoS Model is only 15% of their total aggregate expenditure under the Conventional Model. The wholesale adoption of the PLoS Model would bring a substantial reduction in publishers' subscription- and fee-based revenues. It is therefore not surprising that the PLoS Model would also dramatically reduce journal costs for all nine institutions in the sample. (See Table 5.) For instance, Michigan would pay just \$322,480 in publication fees and print-copy charges rather than \$627,013 in subscription fees and associated costs. Brandeis would pay \$48,580 rather than \$319,638, and St. Bonaventure would pay just \$1,600 rather than \$12,690.

The PLoS Model would also increase disparities in journal costs among the nine institutions in the sample. For example, the proportion of the total aggregate cost paid by Michigan would increase from 43% (under the Conventional Model) to 78%. Together, the three doctoral institutions would pay 96% of the aggregate cost rather than 86%. On the other hand, Grinnell would pay just 1% of the aggregate cost rather than 5%. As these findings

suggest, a switch from the Conventional Model to the PLoS Model would strengthen the already strong relationship between library size and journal expenditures.

Of course the real determinant of Open Access costs is not library size but publishing productivity. Among four-year colleges and universities in the United States, disparities in publishing productivity are far greater than disparities in library holdings. For this reason, any Open Access model is likely to shift journal costs from the four-year colleges to the major research universities. Within the four subject fields considered here, for example, the University of Michigan receives nearly eight times as many current journals as Grinnell. At the same time, U-M authors publish over 300 times as many articles as Grinnell authors. (See Tables 2 and 3.) In fact, four of the nine institutions had no published articles in these four subject fields from 1999 through 2003. Consequently, their PLoS costs are nothing more than their print-copy charges.

While the small sample size limits the extent to which we can generalize about particular subject areas, Table 5 does show a distinctive cost distribution for general biology. Examining the data for all four subjects combined, we can see that the six non-doctoral institutions can be expected to incur PLoS-Model costs equal to just 3 to 13% of their Conventional-Model expenditures. For general biology, however, the range is from 20 to 44%. Table 3 reveals that this disparity cannot be attributed to any systematic variation in publishing productivity. Instead, it reflects the fact that general biology journals are especially likely to be held in print by the non-doctoral institutions. Print-copy charges account for less than 18% of the total PLoS-Model cost (all four subjects combined) but for nearly a third of the total cost within the field of general biology.

### The Equal-Revenue Open Access Model

While the Equal-Revenue Model maintains total spending at Conventional-Model levels, it is based on the same cost distribution as the PLoS Model; it incorporates the same reliance on

publication fees and print-copy charges. Consequently, a small number of institutions can be expected to pay a far higher proportion of the total aggregate cost.

The University of Michigan, for example, would experience a dramatic increase in journal expenditures, from \$627,013 to \$2,115,469. (See Table 5.) Michigan is significantly larger than the other institutions in the sample, and unique among this group for its strong medical school. With regard to Open Access expenditures, however, the critical factor is the University's publishing productivity. As Table 3 shows, Michigan accounts for nearly five times as many articles as the other eight institutions combined.

Even under the Equal-Revenue assumption, seven of the other eight institutions would each pay substantially less than they currently do. In fact, all but Michigan and Brandeis would achieve journal-cost savings of at least 40% through a switch from the Conventional Model to the Equal-Revenue Model. As expected, those institutions with the lowest publishing productivity and the fewest print subscriptions would benefit the most from Open Access.

Interestingly, Brandeis is right at the break-even point, with Equal-Revenue costs almost exactly equal to current journal expenditures. (See Table 5.) Since roughly 10% of four-year institutions are larger than Brandeis, these data suggest that the vast majority of American colleges and universities—perhaps 90%—would save money under either model of Open Access pricing. This conclusion is further supported by the strong correlation ( $r^2 = 0.95$ ) between library size (number of book volumes) and Equal-Revenue cost as a percentage of Conventional-Model cost.

## **Conclusion**

Critics of the Conventional Model have claimed that mainstream journals require scholars to buy back their own research—that publishers charge authors and universities for access to the work that they themselves have created. (See, for example, Pinfield & Ayris, 2005.) When evaluated at the institutional level, this claim is false. Most colleges and universities contribute

relatively little to the scholarly literature, and the vast majority can be regarded chiefly as consumers rather than producers of research.

As a result, institutional disparities in research output are far greater than institutional disparities in library holdings. A shift from a pricing model based on subscriptions to one based on publishing productivity will therefore reduce the proportion of the total cost paid by most institutions and increase the proportion of the total cost paid by the largest research universities.

In terms of both journal accessibility and institutional cost, the PLoS Model is a clear improvement over the Conventional Model. It provides nearly universal access to journal content while reducing expenditures even at the major research universities. For all but the largest research institutions, the potential savings can be dramatic. Neither the sustainability nor the scalability of the PLoS Model has been proven, however, and these results demonstrate that publishers' revenues from subscriptions and publication fees would fall substantially if the PLoS Model were implemented.

Unlike the PLoS Model, the Equal-Revenue Model is based on the assumption that all institutions together will spend no less than under the Conventional Model. The Equal-Revenue Model is therefore likely to be regarded as more realistic by those who contend that the Open Access environment includes no mechanism that would induce publishers to accept lower revenues. (See, for example, Ewing, 2004; Mabe, 2004; Morris, 2005; and Worlock, 2004.) For the overwhelming majority of colleges and universities, a switch from the Conventional Model to the Equal-Revenue Model would dramatically increase journal access while substantially reducing costs. Within the four subject areas investigated here, a typical Master's University might increase its journal holdings tenfold while reducing its costs by 20 to 60%. (See Table 6.) At the same time, however, the largest research universities would gain only modest increases in journal access while paying substantially more than they do now.<sup>11</sup>

[Table 6 about here.]

The data presented here suggest that most universities smaller than Brandeis would pay less under the Equal-Revenue Model than under the Conventional Model. On the other hand,

universities with libraries of more than two or three million volumes would bear a far larger share of the total cost than they currently do. The success of Open Access pricing may therefore depend, at least partly, on the creation of an environment in which the largest research universities are both able and willing to pay that cost.

Further research may help address at least two limitations of the current analysis. First, in-depth evaluations of the business models adopted by both conventional and Open Access publishers might help us determine whether actual journal expenditures are more likely to follow the PLoS Model, the Equal-Revenue Model, or some other plan based on long-term, sustainable support from non-university sources. Second, studies using a wider range of institutional data may help clarify which universities would pay more (or less) in an Open Access environment. While Brandeis, with 1.1 million volumes, would experience neither an increase nor a decrease in journal expenditures under the Equal-Revenue model, Florida International—a school that is comparable in library size but not in research productivity—would achieve substantial savings.

Subsequent research might also investigate the broader cost-related implications of Open Access pricing:

1. Under the Open Access model, the financial success of each journal depends on its ability to attract authors rather than readers. As Mabe and Amin (2002) demonstrate, many authors are more interested in publishing than in reading. This suggests that for better or worse, an Open Access environment might encourage publishers to develop new journals that would not be feasible under the Conventional Model.
2. Open Access pricing is likely to shift journal costs from libraries to other parts of the university, thereby shifting authority from those who make decisions about particular journals (chiefly librarians) to those who evaluate the apparent value of particular research projects (chiefly departmental faculty and funding agencies).
3. If publishers gain additional income for every article they accept, each journal can improve its short-term financial position by accepting more articles—by increasing its acceptance rate. It is therefore possible that an Open Access environment will provide incentives for



higher acceptance rates and lower journal quality. This argument, made by Horton (2004) and others, is at least partially supported by the relatively high acceptance rates of many Open Access journals (Kaufman-Wills Group, 2005).

4. Open Access pricing may remove the market forces and legal mechanisms that make publishers responsive to the preferences of subscribers—including those mechanisms that currently ensure sustainable access to online resources (Walters, 2004). In an Open Access environment, many publishers will no longer have an immediate incentive to maintain the practices that libraries have relied upon: transparent pricing, good customer service, and responsiveness to libraries' needs when designing new products and new online interfaces.
5. Open Access pricing may lead to greater short-term volatility in institutional expenditures. This is likely to have significant implications for library collection development and acquisitions operations, especially at smaller colleges where publication rates are low.

In investigating these possibilities, it may be useful to keep in mind that most of the important decisions regarding Open Access will be made by individual authors, publishers, and universities seeking the options that best serve their own interests.<sup>12</sup> As this study demonstrates, the impact of Open Access pricing can vary substantially from one university to the next.

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## Notes

1. Although Open Access can be defined more broadly (see, for example, Chan et al., 2002; Kaufman-Wills Group, 2005; and Suber et al., 2003), this study addresses the "author pays" model that has been adopted by publishers such as the Public Library of Science (PLOS) and BioMed Central. PubMed Central, a directory and full-text journal interface sponsored by the National Institutes of Health (2005), provides free access to more than 200 Open Access journals. While nearly 70% of the journals included in PubMed Central are published by BioMed Central, PLoS and 32 other publishers are also represented.
2. Unfortunately, peer-reviewed empirical research accounts for only a small fraction of the material published on this topic. For an overview of Open Access publishing, see Bailey (2005) and Wellcome Trust (2003). Recent news and commentary can be found at several web sites (Association of Learned and Professional Society Publishers, 2006; Nature Publishing Group, 2004; Suber, 2005).
3. None of these cost estimates include the expenses associated with the acquisition, processing, storage, management, and use of scientific information. Such costs may be lower in the Open Access environment, especially if processes such as serials check-in are no longer undertaken at the institutional level (Schonfeld et al., 2004).
4. The cost estimates presented here are based on the assumption that authors' institutions—not the authors themselves—pay both subscription charges and publication fees. Of course, this does not preclude the possibility that external grant funding might be used for either purpose.
5. The price of BioOne varies with FTE enrollment; the price per journal is \$173 for Michigan, \$40 for Brandeis, and \$18 for West Virginia Wesleyan. The price of Project Muse varies by Carnegie classification; the price per journal is \$67 for Michigan, \$54 for Brandeis, \$29 for Grinnell, and \$22 for West Virginia Wesleyan.

6. The complete list includes EBSCO Academic Search Elite, EBSCO Academic Search Premier, EBSCO Business Source Elite, EBSCO Business Source Premier, EBSCO General Science Collection, EBSCO Health Source: Nursing/Academic Edition, EBSCO MAS Ultra: School Edition, EBSCO MasterFILE Select, EBSCO Professional Development Collection, EBSCO TOPICsearch, LexisNexis Academic, ProQuest ABI/INFORM Global, ProQuest Education Module, ProQuest Periodical Abstracts Research II, ProQuest Research Library, ProQuest Sciences Module, Thomson Gale Expanded Academic ASAP, Thomson Gale General Reference Center Gold, Thomson Gale Health Reference Center Academic, Thomson Gale Informe!, Thomson Gale OneFile, and Wilson OmniFile Full Text Select. I assume that the science journals represented in this study are more valuable than a simple cost-per-title calculation would suggest—specifically, that they are more valuable than most of the other journals included in these aggregations. The data shown in Table 2 can be used to construct alternative cost estimates based on different assumptions.
7. Only two journals in the sample (American Journal of Physiology: Cell Physiology and Cell Stress & Chaperones) charged submission fees in 2005. These fees were assessed based on the assumption that each published article was the result of 1.61 submissions—an assumption consistent with recent publication data (American Physiological Society, 2006).
8. In calculating costs, I assumed that all publication fees would be paid by the first author's institution. This approach is consistent with the billing practices of most journal publishers. An alternative method—allocating an equal fraction of the cost to each author—produced cost estimates nearly identical to those reported here.
9. The number of institutions in the first category, represented by Michigan, is the number with more than 4,652,000 book volumes. 4,652,000 is the average of the book-volume figures for Michigan and Brandeis.
10. The cost multipliers are 4.24 for general biology, 5.81 for cell biology, 9.50 for organic chemistry, 6.43 for applied physics, and 6.56 for all four subjects combined.
11. Table 6 is based on the assumption that an Open Access environment would provide every institution with the full text of all 349 journals in the four subject fields. The University of

Michigan would therefore gain 57 new titles in addition to the 292 it already holds—a 20% increase in the number of titles available.

12. While the behavior of individual authors is central to the success of Open Access publishing, more than 80% of scientific authors know little or nothing about Open Access journals (Nicholas & Rowlands, 2005; Nicholas et al., 2005). At the same time, however, nearly half have self-archived their work by placing it in an institutional repository, in a subject-based repository, or on a personal or institutional web site (Swan & Brown, 2005).

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TABLE 1. Institutions included in the study.

| Category            | Institution                      | Students | Book vols. |
|---------------------|----------------------------------|----------|------------|
| Doctoral tier 1     | University of Michigan—Ann Arbor | 54,600   | 8,169,000  |
| Doctoral tier 1     | Brandeis University (MA)         | 4,900    | 1,135,000  |
| Doctoral tier 4     | Florida International University | 32,700   | 1,137,000  |
| Master's tier 1     | St. Bonaventure University (NY)  | 2,300    | 285,000    |
| Master's tier 4     | Peru State College (NE)          | 1,100    | 106,000    |
| Liberal Arts tier 1 | Grinnell College (IA)            | 1,500    | 505,000    |
| Liberal Arts tier 4 | West Virginia Wesleyan College   | 1,600    | 134,000    |
| Bachelor's tier 1   | Augustana College (SD)           | 1,700    | 241,000    |
| Bachelor's tier 4   | SUNY College at Old Westbury     | 3,700    | 212,000    |

Sources: McDonough (2004); U.S. News & World Report (2004).

TABLE 2. Calculation of total annual cost under the Conventional Model.

| Institution              | Number of journals       |                        |                         |            |      |                   |                             | 2005 cost (US\$)         |                        |                         |            |      |                   |                             | Total cost |                          |
|--------------------------|--------------------------|------------------------|-------------------------|------------|------|-------------------|-----------------------------|--------------------------|------------------------|-------------------------|------------|------|-------------------|-----------------------------|------------|--------------------------|
|                          | Print+<br>online<br>subs | Print-<br>only<br>subs | Online-<br>only<br>subs | Bio<br>One | Muse | Science<br>Direct | Online<br>aggre-<br>gations | Print+<br>online<br>subs | Print-<br>only<br>subs | Online-<br>only<br>subs | Bio<br>One | Muse | Science<br>Direct | Online<br>aggre-<br>gations |            | Publi-<br>cation<br>fees |
| <b>All four subjects</b> |                          |                        |                         |            |      |                   |                             |                          |                        |                         |            |      |                   |                             |            |                          |
| Michigan                 | 141                      | 127                    | 20                      | 6          | 1    | 65                | 15                          | 259,835                  | 158,074                | 37,207                  | 1,038      | 67   | 119,203           | 392                         | 51,199     | 627,013                  |
| Brandeis                 | 43                       | 30                     | 35                      | 6          | 1    | 56                | 57                          | 102,764                  | 46,830                 | 47,525                  | 240        | 54   | 110,889           | 6,050                       | 5,287      | 319,638                  |
| Florida Intl.            | 23                       | 36                     | 56                      | 0          | 0    | 56                | 0                           | 32,061                   | 57,508                 | 101,682                 | 0          | 0    | 113,492           | 0                           | 2,496      | 307,240                  |
| St. Bonaventure          | 0                        | 10                     | 0                       | 0          | 0    | 0                 | 52                          | 0                        | 5,682                  | 0                       | 0          | 0    | 0                 | 7,008                       | 0          | 12,690                   |
| Peru State               | 0                        | 2                      | 0                       | 0          | 0    | 0                 | 24                          | 0                        | 400                    | 0                       | 0          | 0    | 0                 | 4,712                       | 0          | 5,112                    |
| Grinnell                 | 17                       | 15                     | 15                      | 0          | 1    | 0                 | 1                           | 27,139                   | 22,068                 | 21,941                  | 0          | 29   | 0                 | 389                         | 76         | 71,641                   |
| WV Wesleyan              | 3                        | 4                      | 3                       | 5          | 1    | 0                 | 1                           | 8,375                    | 1,691                  | 2,523                   | 90         | 22   | 0                 | 389                         | 0          | 13,090                   |
| Augustana                | 1                        | 9                      | 4                       | 0          | 0    | 0                 | 0                           | 2,460                    | 5,150                  | 7,416                   | 0          | 0    | 0                 | 0                           | 0          | 15,026                   |
| Old Westbury             | 0                        | 1                      | 0                       | 0          | 0    | 37                | 11                          | 0                        | 2,139                  | 0                       | 0          | 0    | 84,034            | 413                         | 0          | 86,586                   |
| All nine schools         | 228                      | 234                    | 133                     | 17         | 4    | 214               | 161                         | 432,633                  | 299,541                | 218,294                 | 1,368      | 172  | 427,618           | 19,352                      | 59,057     | 1,458,035                |
| <b>General biology</b>   |                          |                        |                         |            |      |                   |                             |                          |                        |                         |            |      |                   |                             |            |                          |
| Michigan                 | 21                       | 31                     | 4                       | 3          | 1    | 10                | 11                          | 24,859                   | 16,526                 | 5,041                   | 519        | 67   | 11,744            | 247                         | 3,952      | 62,955                   |
| Brandeis                 | 3                        | 6                      | 6                       | 3          | 1    | 9                 | 15                          | 4,848                    | 5,148                  | 6,542                   | 120        | 54   | 11,127            | 1,382                       | 216        | 29,438                   |
| Florida Intl.            | 6                        | 9                      | 8                       | 0          | 0    | 8                 | 0                           | 3,643                    | 4,902                  | 12,242                  | 0          | 0    | 9,794             | 0                           | 0          | 30,581                   |
| St. Bonaventure          | 0                        | 5                      | 0                       | 0          | 0    | 0                 | 28                          | 0                        | 1,993                  | 0                       | 0          | 0    | 0                 | 2,042                       | 0          | 4,035                    |
| Peru State               | 0                        | 2                      | 0                       | 0          | 0    | 0                 | 8                           | 0                        | 400                    | 0                       | 0          | 0    | 0                 | 791                         | 0          | 1,191                    |
| Grinnell                 | 4                        | 3                      | 1                       | 0          | 1    | 0                 | 1                           | 1,419                    | 1,260                  | 1,965                   | 0          | 29   | 0                 | 389                         | 0          | 5,062                    |
| WV Wesleyan              | 0                        | 3                      | 0                       | 3          | 1    | 0                 | 1                           | 0                        | 694                    | 0                       | 54         | 22   | 0                 | 389                         | 0          | 1,159                    |
| Augustana                | 0                        | 6                      | 0                       | 0          | 0    | 0                 | 0                           | 0                        | 2,165                  | 0                       | 0          | 0    | 0                 | 0                           | 0          | 2,165                    |
| Old Westbury             | 0                        | 0                      | 0                       | 0          | 0    | 3                 | 9                           | 0                        | 0                      | 0                       | 0          | 0    | 3,836             | 344                         | 0          | 4,180                    |
| All nine schools         | 34                       | 65                     | 19                      | 9          | 4    | 30                | 73                          | 34,769                   | 33,088                 | 25,790                  | 693        | 172  | 36,501            | 5,585                       | 4,168      | 140,767                  |
| <b>Cell biology</b>      |                          |                        |                         |            |      |                   |                             |                          |                        |                         |            |      |                   |                             |            |                          |
| Michigan                 | 68                       | 65                     | 6                       | 3          | 0    | 32                | 2                           | 115,508                  | 82,376                 | 10,415                  | 519        | 0    | 37,507            | 78                          | 27,474     | 273,877                  |
| Brandeis                 | 25                       | 5                      | 19                      | 3          | 0    | 23                | 24                          | 50,804                   | 9,531                  | 23,521                  | 120        | 0    | 28,810            | 1,997                       | 5,287      | 120,069                  |
| Florida Intl.            | 8                        | 16                     | 24                      | 0          | 0    | 27                | 0                           | 8,396                    | 22,546                 | 46,611                  | 0          | 0    | 34,525            | 0                           | 0          | 112,078                  |
| St. Bonaventure          | 0                        | 5                      | 0                       | 0          | 0    | 0                 | 12                          | 0                        | 3,689                  | 0                       | 0          | 0    | 0                 | 1,608                       | 0          | 5,297                    |
| Peru State               | 0                        | 0                      | 0                       | 0          | 0    | 0                 | 6                           | 0                        | 0                      | 0                       | 0          | 0    | 0                 | 707                         | 0          | 707                      |
| Grinnell                 | 7                        | 7                      | 4                       | 0          | 0    | 0                 | 0                           | 7,879                    | 15,631                 | 3,485                   | 0          | 0    | 0                 | 0                           | 0          | 26,995                   |
| WV Wesleyan              | 0                        | 1                      | 3                       | 2          | 0    | 0                 | 0                           | 0                        | 997                    | 2,523                   | 36         | 0    | 0                 | 0                           | 0          | 3,556                    |
| Augustana                | 0                        | 4                      | 0                       | 0          | 0    | 0                 | 0                           | 0                        | 3,727                  | 0                       | 0          | 0    | 0                 | 0                           | 0          | 3,727                    |
| Old Westbury             | 0                        | 0                      | 0                       | 0          | 0    | 15                | 1                           | 0                        | 0                      | 0                       | 0          | 0    | 21,027            | 35                          | 0          | 21,061                   |
| All nine schools         | 108                      | 103                    | 56                      | 8          | 0    | 97                | 45                          | 182,587                  | 138,497                | 86,555                  | 675        | 0    | 121,869           | 4,424                       | 32,761     | 567,366                  |

[Table 2 continues]

[Table 2, continued]

**Organic chemistry**

|                  |    |    |    |   |   |    |   |        |        |        |   |   |         |     |     |         |
|------------------|----|----|----|---|---|----|---|--------|--------|--------|---|---|---------|-----|-----|---------|
| Michigan         | 17 | 19 | 4  | 0 | 0 | 10 | 0 | 43,254 | 42,521 | 9,267  | 0 | 0 | 39,833  | 0   | 197 | 135,072 |
| Brandeis         | 6  | 14 | 4  | 0 | 0 | 10 | 2 | 18,675 | 21,110 | 9,267  | 0 | 0 | 39,833  | 641 | 0   | 89,525  |
| Florida Intl.    | 1  | 9  | 12 | 0 | 0 | 10 | 0 | 2,222  | 17,861 | 29,594 | 0 | 0 | 41,371  | 0   | 0   | 91,049  |
| St. Bonaventure  | 0  | 0  | 0  | 0 | 0 | 0  | 0 | 0      | 0      | 0      | 0 | 0 | 0       | 0   | 0   | 0       |
| Peru State       | 0  | 0  | 0  | 0 | 0 | 0  | 0 | 0      | 0      | 0      | 0 | 0 | 0       | 0   | 0   | 0       |
| Grinnell         | 2  | 4  | 5  | 0 | 0 | 0  | 0 | 6,670  | 4,062  | 8,321  | 0 | 0 | 0       | 0   | 0   | 19,053  |
| WV Wesleyan      | 1  | 0  | 0  | 0 | 0 | 0  | 0 | 2,460  | 0      | 0      | 0 | 0 | 0       | 0   | 0   | 2,460   |
| Augustana        | 1  | 0  | 4  | 0 | 0 | 0  | 0 | 2,460  | 0      | 7,416  | 0 | 0 | 0       | 0   | 0   | 9,876   |
| Old Westbury     | 0  | 1  | 0  | 0 | 0 | 8  | 0 | 0      | 2,139  | 0      | 0 | 0 | 37,745  | 0   | 0   | 39,884  |
| All nine schools | 28 | 47 | 29 | 0 | 0 | 38 | 2 | 75,741 | 87,693 | 63,865 | 0 | 0 | 158,781 | 641 | 197 | 386,918 |

**Applied physics**

|                  |    |    |    |   |   |    |    |         |        |        |   |   |         |       |        |         |
|------------------|----|----|----|---|---|----|----|---------|--------|--------|---|---|---------|-------|--------|---------|
| Michigan         | 36 | 14 | 6  | 0 | 0 | 13 | 2  | 77,012  | 18,134 | 12,484 | 0 | 0 | 30,119  | 67    | 22,714 | 160,530 |
| Brandeis         | 10 | 5  | 6  | 0 | 0 | 14 | 16 | 29,235  | 11,041 | 8,195  | 0 | 0 | 31,119  | 2,030 | 0      | 81,620  |
| Florida Intl.    | 8  | 3  | 12 | 0 | 0 | 11 | 0  | 17,800  | 12,941 | 13,235 | 0 | 0 | 27,802  | 0     | 2,496  | 74,274  |
| St. Bonaventure  | 0  | 0  | 0  | 0 | 0 | 0  | 12 | 0       | 0      | 0      | 0 | 0 | 0       | 3,358 | 0      | 3,358   |
| Peru State       | 0  | 0  | 0  | 0 | 0 | 0  | 10 | 0       | 0      | 0      | 0 | 0 | 0       | 3,214 | 0      | 3,214   |
| Grinnell         | 4  | 1  | 5  | 0 | 0 | 0  | 0  | 11,171  | 1,115  | 8,170  | 0 | 0 | 0       | 0     | 76     | 20,532  |
| WV Wesleyan      | 2  | 0  | 0  | 0 | 0 | 0  | 0  | 5,915   | 0      | 0      | 0 | 0 | 0       | 0     | 0      | 5,915   |
| Augustana        | 0  | 0  | 0  | 0 | 0 | 0  | 0  | 0       | 0      | 0      | 0 | 0 | 0       | 0     | 0      | 0       |
| Old Westbury     | 0  | 0  | 0  | 0 | 0 | 11 | 1  | 0       | 0      | 0      | 0 | 0 | 21,427  | 33    | 0      | 21,460  |
| All nine schools | 60 | 23 | 29 | 0 | 0 | 49 | 41 | 141,133 | 43,231 | 42,084 | 0 | 0 | 110,467 | 8,702 | 25,286 | 370,903 |

TABLE 3. Calculation of total annual cost under the PLoS Open Access Model.

| Institution              | Articles published per year | Print copies received | Publication fees (US\$) | Print-copy charges (US\$) | Total cost (US\$) |
|--------------------------|-----------------------------|-----------------------|-------------------------|---------------------------|-------------------|
| <b>All four subjects</b> |                             |                       |                         |                           |                   |
| Michigan                 | 186.4                       | 268                   | 279,600                 | 42,880                    | 322,480           |
| Brandeis                 | 24.6                        | 73                    | 36,900                  | 11,680                    | 48,580            |
| Florida Intl.            | 11.4                        | 59                    | 17,100                  | 9,440                     | 26,540            |
| St. Bonaventure          | 0.0                         | 10                    | 0                       | 1,600                     | 1,600             |
| Peru State               | 0.0                         | 2                     | 0                       | 320                       | 320               |
| Grinnell                 | 0.6                         | 32                    | 900                     | 5,120                     | 6,020             |
| WV Wesleyan              | 0.0                         | 7                     | 0                       | 1,120                     | 1,120             |
| Augustana                | 0.0                         | 10                    | 0                       | 1,600                     | 1,600             |
| Old Westbury             | 1.6                         | 1                     | 2,400                   | 160                       | 2,560             |
| All nine schools         | 224.6                       | 462                   | 336,900                 | 73,920                    | 410,820           |
| <b>General biology</b>   |                             |                       |                         |                           |                   |
| Michigan                 | 20.4                        | 52                    | 30,600                  | 8,320                     | 38,920            |
| Brandeis                 | 2.4                         | 9                     | 3,600                   | 1,440                     | 5,040             |
| Florida Intl.            | 0.6                         | 15                    | 900                     | 2,400                     | 3,300             |
| St. Bonaventure          | 0.0                         | 5                     | 0                       | 800                       | 800               |
| Peru State               | 0.0                         | 2                     | 0                       | 320                       | 320               |
| Grinnell                 | 0.2                         | 7                     | 300                     | 1,120                     | 1,420             |
| WV Wesleyan              | 0.0                         | 3                     | 0                       | 480                       | 480               |
| Augustana                | 0.0                         | 6                     | 0                       | 960                       | 960               |
| Old Westbury             | 0.8                         | 0                     | 1,200                   | 0                         | 1,200             |
| All nine schools         | 24.4                        | 99                    | 36,600                  | 15,840                    | 52,440            |
| <b>Cell biology</b>      |                             |                       |                         |                           |                   |
| Michigan                 | 79.2                        | 133                   | 118,800                 | 21,280                    | 140,080           |
| Brandeis                 | 13.2                        | 30                    | 19,800                  | 4,800                     | 24,600            |
| Florida Intl.            | 0.8                         | 24                    | 1,200                   | 3,840                     | 5,040             |
| St. Bonaventure          | 0.0                         | 5                     | 0                       | 800                       | 800               |
| Peru State               | 0.0                         | 0                     | 0                       | 0                         | 0                 |
| Grinnell                 | 0.0                         | 14                    | 0                       | 2,240                     | 2,240             |
| WV Wesleyan              | 0.0                         | 1                     | 0                       | 160                       | 160               |
| Augustana                | 0.0                         | 4                     | 0                       | 640                       | 640               |
| Old Westbury             | 0.8                         | 0                     | 1,200                   | 0                         | 1,200             |
| All nine schools         | 94.0                        | 211                   | 141,000                 | 33,760                    | 174,760           |
| <b>Organic chemistry</b> |                             |                       |                         |                           |                   |
| Michigan                 | 30.2                        | 36                    | 45,300                  | 5,760                     | 51,060            |
| Brandeis                 | 9.0                         | 20                    | 13,500                  | 3,200                     | 16,700            |
| Florida Intl.            | 1.6                         | 10                    | 2,400                   | 1,600                     | 4,000             |
| St. Bonaventure          | 0.0                         | 0                     | 0                       | 0                         | 0                 |
| Peru State               | 0.0                         | 0                     | 0                       | 0                         | 0                 |
| Grinnell                 | 0.2                         | 6                     | 300                     | 960                       | 1,260             |
| WV Wesleyan              | 0.0                         | 1                     | 0                       | 160                       | 160               |
| Augustana                | 0.0                         | 1                     | 0                       | 160                       | 160               |
| Old Westbury             | 0.0                         | 1                     | 0                       | 160                       | 160               |
| All nine schools         | 41.0                        | 75                    | 61,500                  | 12,000                    | 73,500            |
| <b>Applied physics</b>   |                             |                       |                         |                           |                   |
| Michigan                 | 62.2                        | 50                    | 93,300                  | 8,000                     | 101,300           |
| Brandeis                 | 0.4                         | 15                    | 600                     | 2,400                     | 3,000             |
| Florida Intl.            | 8.4                         | 11                    | 12,600                  | 1,760                     | 14,360            |
| St. Bonaventure          | 0.0                         | 0                     | 0                       | 0                         | 0                 |
| Peru State               | 0.0                         | 0                     | 0                       | 0                         | 0                 |
| Grinnell                 | 0.2                         | 5                     | 300                     | 800                       | 1,100             |
| WV Wesleyan              | 0.0                         | 2                     | 0                       | 320                       | 320               |
| Augustana                | 0.0                         | 0                     | 0                       | 0                         | 0                 |
| Old Westbury             | 0.0                         | 0                     | 0                       | 0                         | 0                 |
| All nine schools         | 71.2                        | 83                    | 106,800                 | 13,280                    | 120,080           |

TABLE 4. Aggregate distribution of cost (revenue) under the Conventional Model and the PLoS Open Access Model.

| Category                 | Representative institution | # of institutions in category | Conventional-Model Cost (US\$)       |                              | PLoS-Model Cost (US\$)               |                              |
|--------------------------|----------------------------|-------------------------------|--------------------------------------|------------------------------|--------------------------------------|------------------------------|
|                          |                            |                               | Represent. institution, from Table 2 | All institutions in category | Represent. institution, from Table 3 | All institutions in category |
| <b>All four subjects</b> |                            |                               |                                      |                              |                                      |                              |
| Doctoral tier 1          | Michigan                   | 23                            | 627,013                              | 14,421,299                   | 322,480                              | 7,417,040                    |
| Doctoral tier 1          | Brandeis                   | 101                           | 319,638                              | 32,283,438                   | 48,580                               | 4,906,580                    |
| Doctoral tier 4          | Florida Intl.              | 124                           | 307,240                              | 38,097,760                   | 26,540                               | 3,290,960                    |
| Master's tier 1          | St. Bonaventure            | 287                           | 12,690                               | 3,642,030                    | 1,600                                | 459,200                      |
| Master's tier 4          | Peru State                 | 286                           | 5,112                                | 1,462,032                    | 320                                  | 91,520                       |
| Liberal Arts tier 1      | Grinnell                   | 109                           | 71,641                               | 7,808,869                    | 6,020                                | 656,180                      |
| Liberal Arts tier 4      | WV Wesleyan                | 108                           | 13,090                               | 1,413,720                    | 1,120                                | 120,960                      |
| Bachelor's tier 1        | Augustana                  | 162                           | 15,026                               | 2,434,212                    | 1,600                                | 259,200                      |
| Bachelor's tier 4        | Old Westbury               | 162                           | 86,586                               | 14,026,932                   | 2,560                                | 414,720                      |
| All schools              | -                          | -                             | -                                    | 115,590,292                  | -                                    | 17,616,360                   |
| <b>General biology</b>   |                            |                               |                                      |                              |                                      |                              |
| Doctoral tier 1          | Michigan                   | 23                            | 62,955                               | 1,447,965                    | 38,920                               | 895,160                      |
| Doctoral tier 1          | Brandeis                   | 101                           | 29,438                               | 2,973,238                    | 5,040                                | 509,040                      |
| Doctoral tier 4          | Florida Intl.              | 124                           | 30,581                               | 3,792,044                    | 3,300                                | 409,200                      |
| Master's tier 1          | St. Bonaventure            | 287                           | 4,035                                | 1,158,045                    | 800                                  | 229,600                      |
| Master's tier 4          | Peru State                 | 286                           | 1,191                                | 340,626                      | 320                                  | 91,520                       |
| Liberal Arts tier 1      | Grinnell                   | 109                           | 5,062                                | 551,758                      | 1,420                                | 154,780                      |
| Liberal Arts tier 4      | WV Wesleyan                | 108                           | 1,159                                | 125,172                      | 480                                  | 51,840                       |
| Bachelor's tier 1        | Augustana                  | 162                           | 2,165                                | 350,730                      | 960                                  | 155,520                      |
| Bachelor's tier 4        | Old Westbury               | 162                           | 4,180                                | 677,160                      | 1,200                                | 194,400                      |
| All schools              | -                          | -                             | -                                    | 11,416,738                   | -                                    | 2,691,060                    |
| <b>Cell biology</b>      |                            |                               |                                      |                              |                                      |                              |
| Doctoral tier 1          | Michigan                   | 23                            | 273,877                              | 6,299,171                    | 140,080                              | 3,221,840                    |
| Doctoral tier 1          | Brandeis                   | 101                           | 120,069                              | 12,126,969                   | 24,600                               | 2,484,600                    |
| Doctoral tier 4          | Florida Intl.              | 124                           | 112,078                              | 13,897,672                   | 5,040                                | 624,960                      |
| Master's tier 1          | St. Bonaventure            | 287                           | 5,297                                | 1,520,239                    | 800                                  | 229,600                      |
| Master's tier 4          | Peru State                 | 286                           | 707                                  | 202,202                      | 0                                    | 0                            |
| Liberal Arts tier 1      | Grinnell                   | 109                           | 26,995                               | 2,942,455                    | 2,240                                | 244,160                      |
| Liberal Arts tier 4      | WV Wesleyan                | 108                           | 3,556                                | 384,048                      | 160                                  | 17,280                       |
| Bachelor's tier 1        | Augustana                  | 162                           | 3,727                                | 603,774                      | 640                                  | 103,680                      |
| Bachelor's tier 4        | Old Westbury               | 162                           | 21,061                               | 3,411,882                    | 1,200                                | 194,400                      |
| All schools              | -                          | -                             | -                                    | 41,388,412                   | -                                    | 7,120,520                    |
| <b>Organic chemistry</b> |                            |                               |                                      |                              |                                      |                              |
| Doctoral tier 1          | Michigan                   | 23                            | 135,072                              | 3,106,656                    | 51,060                               | 1,174,380                    |
| Doctoral tier 1          | Brandeis                   | 101                           | 89,525                               | 9,042,025                    | 16,700                               | 1,686,700                    |
| Doctoral tier 4          | Florida Intl.              | 124                           | 91,049                               | 11,290,076                   | 4,000                                | 496,000                      |
| Master's tier 1          | St. Bonaventure            | 287                           | 0                                    | 0                            | 0                                    | 0                            |
| Master's tier 4          | Peru State                 | 286                           | 0                                    | 0                            | 0                                    | 0                            |
| Liberal Arts tier 1      | Grinnell                   | 109                           | 19,053                               | 2,076,777                    | 1,260                                | 137,340                      |
| Liberal Arts tier 4      | WV Wesleyan                | 108                           | 2,460                                | 265,680                      | 160                                  | 17,280                       |
| Bachelor's tier 1        | Augustana                  | 162                           | 9,876                                | 1,599,912                    | 160                                  | 25,920                       |
| Bachelor's tier 4        | Old Westbury               | 162                           | 39,884                               | 6,461,208                    | 160                                  | 25,920                       |
| All schools              | -                          | -                             | -                                    | 33,842,334                   | -                                    | 3,563,540                    |

[Table 4 continues]

[Table 4, continued]

**Applied physics**

|                     |                 |     |         |            |         |           |
|---------------------|-----------------|-----|---------|------------|---------|-----------|
| Doctoral tier 1     | Michigan        | 23  | 160,530 | 3,692,190  | 101,300 | 2,329,900 |
| Doctoral tier 1     | Brandeis        | 101 | 81,620  | 8,243,620  | 3,000   | 303,000   |
| Doctoral tier 4     | Florida Intl.   | 124 | 74,274  | 9,209,976  | 14,360  | 1,780,640 |
| Master's tier 1     | St. Bonaventure | 287 | 3,358   | 963,746    | 0       | 0         |
| Master's tier 4     | Peru State      | 286 | 3,214   | 919,204    | 0       | 0         |
| Liberal Arts tier 1 | Grinnell        | 109 | 20,532  | 2,237,988  | 1,100   | 119,900   |
| Liberal Arts tier 4 | WV Wesleyan     | 108 | 5,915   | 638,820    | 320     | 34,560    |
| Bachelor's tier 1   | Augustana       | 162 | 0       | 0          | 0       | 0         |
| Bachelor's tier 4   | Old Westbury    | 162 | 21,460  | 3,476,520  | 0       | 0         |
| All schools         | -               | -   | -       | 29,382,064 | -       | 4,568,000 |

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TABLE 5. Institutional journal costs under three pricing models.

| Category                 | Institution     | Conventional Model              |                                      | PLoS Model                      |  |                                      | Equal-Revenue Model |  |                                      |
|--------------------------|-----------------|---------------------------------|--------------------------------------|---------------------------------|--|--------------------------------------|---------------------|--|--------------------------------------|
|                          |                 | Total cost (US\$), from Table 2 | % of total cost borne by each school | Total cost (US\$), from Table 3 | Cost as a % of Conventional Model cost | % of total cost borne by each school | Total cost (US\$)   | Cost as a % of Conventional Model cost | % of total cost borne by each school |
| <b>All four subjects</b> |                 |                                 |                                      |                                 |  |                                      |                     |  |                                      |
| Doctoral tier 1          | Michigan        | 627,013                         | 43                                   | 322,480                         | 51                                     | 78                                   | 2,115,469           | 337                                    | 78                                   |
| Doctoral tier 1          | Brandeis        | 319,638                         | 22                                   | 48,580                          | 15                                     | 12                                   | 318,685             | 100                                    | 12                                   |
| Doctoral tier 4          | Florida Intl.   | 307,240                         | 21                                   | 26,540                          | 9                                      | 6                                    | 174,102             | 57                                     | 6                                    |
| Master's tier 1          | St. Bonaventure | 12,690                          | 1                                    | 1,600                           | 13                                     | 0                                    | 10,496              | 83                                     | 0                                    |
| Master's tier 4          | Peru State      | 5,112                           | 0                                    | 320                             | 6                                      | 0                                    | 2,099               | 41                                     | 0                                    |
| Liberal Arts tier 1      | Grinnell        | 71,641                          | 5                                    | 6,020                           | 8                                      | 1                                    | 39,491              | 55                                     | 1                                    |
| Liberal Arts tier 4      | WV Wesleyan     | 13,090                          | 1                                    | 1,120                           | 9                                      | 0                                    | 7,347               | 56                                     | 0                                    |
| Bachelor's tier 1        | Augustana       | 15,026                          | 1                                    | 1,600                           | 11                                     | 0                                    | 10,496              | 70                                     | 0                                    |
| Bachelor's tier 4        | Old Westbury    | 86,586                          | 6                                    | 2,560                           | 3                                      | 1                                    | 16,794              | 19                                     | 1                                    |
| <b>General biology</b>   |                 |                                 |                                      |                                 |  |                                      |                     |  |                                      |
| Doctoral tier 1          | Michigan        | 62,955                          | 45                                   | 38,920                          | 62                                     | 74                                   | 165,021             | 262                                    | 74                                   |
| Doctoral tier 1          | Brandeis        | 29,438                          | 21                                   | 5,040                           | 17                                     | 10                                   | 21,370              | 73                                     | 10                                   |
| Doctoral tier 4          | Florida Intl.   | 30,581                          | 22                                   | 3,300                           | 11                                     | 6                                    | 13,992              | 46                                     | 6                                    |
| Master's tier 1          | St. Bonaventure | 4,035                           | 3                                    | 800                             | 20                                     | 2                                    | 3,392               | 84                                     | 2                                    |
| Master's tier 4          | Peru State      | 1,191                           | 1                                    | 320                             | 27                                     | 1                                    | 1,357               | 114                                    | 1                                    |
| Liberal Arts tier 1      | Grinnell        | 5,062                           | 4                                    | 1,420                           | 28                                     | 3                                    | 6,021               | 119                                    | 3                                    |
| Liberal Arts tier 4      | WV Wesleyan     | 1,159                           | 1                                    | 480                             | 41                                     | 1                                    | 2,035               | 176                                    | 1                                    |
| Bachelor's tier 1        | Augustana       | 2,165                           | 2                                    | 960                             | 44                                     | 2                                    | 4,070               | 188                                    | 2                                    |
| Bachelor's tier 4        | Old Westbury    | 4,180                           | 3                                    | 1,200                           | 29                                     | 2                                    | 5,088               | 122                                    | 2                                    |
| <b>Cell biology</b>      |                 |                                 |                                      |                                 |  |                                      |                     |  |                                      |
| Doctoral tier 1          | Michigan        | 273,877                         | 48                                   | 140,080                         | 51                                     | 80                                   | 813,865             | 297                                    | 80                                   |
| Doctoral tier 1          | Brandeis        | 120,069                         | 21                                   | 24,600                          | 20                                     | 14                                   | 142,926             | 119                                    | 14                                   |
| Doctoral tier 4          | Florida Intl.   | 112,078                         | 20                                   | 5,040                           | 4                                      | 3                                    | 29,282              | 26                                     | 3                                    |
| Master's tier 1          | St. Bonaventure | 5,297                           | 1                                    | 800                             | 15                                     | 0                                    | 4,648               | 88                                     | 0                                    |
| Master's tier 4          | Peru State      | 707                             | 0                                    | 0                               | 0                                      | 0                                    | 0                   | 0                                      | 0                                    |
| Liberal Arts tier 1      | Grinnell        | 26,995                          | 5                                    | 2,240                           | 8                                      | 1                                    | 13,014              | 48                                     | 1                                    |
| Liberal Arts tier 4      | WV Wesleyan     | 3,556                           | 1                                    | 160                             | 4                                      | 0                                    | 930                 | 26                                     | 0                                    |
| Bachelor's tier 1        | Augustana       | 3,727                           | 1                                    | 640                             | 17                                     | 0                                    | 3,718               | 100                                    | 0                                    |
| Bachelor's tier 4        | Old Westbury    | 21,061                          | 4                                    | 1,200                           | 6                                      | 1                                    | 6,972               | 33                                     | 1                                    |
| <b>Organic chemistry</b> |                 |                                 |                                      |                                 |  |                                      |                     |  |                                      |
| Doctoral tier 1          | Michigan        | 135,072                         | 35                                   | 51,060                          | 38                                     | 69                                   | 485,070             | 359                                    | 69                                   |
| Doctoral tier 1          | Brandeis        | 89,525                          | 23                                   | 16,700                          | 19                                     | 23                                   | 158,650             | 177                                    | 23                                   |
| Doctoral tier 4          | Florida Intl.   | 91,049                          | 24                                   | 4,000                           | 4                                      | 5                                    | 38,000              | 42                                     | 5                                    |
| Master's tier 1          | St. Bonaventure | 0                               | 0                                    | 0                               | -                                      | 0                                    | 0                   | -                                      | 0                                    |
| Master's tier 4          | Peru State      | 0                               | 0                                    | 0                               | -                                      | 0                                    | 0                   | -                                      | 0                                    |
| Liberal Arts tier 1      | Grinnell        | 19,053                          | 5                                    | 1,260                           | 7                                      | 2                                    | 11,970              | 63                                     | 2                                    |
| Liberal Arts tier 4      | WV Wesleyan     | 2,460                           | 1                                    | 160                             | 7                                      | 0                                    | 1,520               | 62                                     | 0                                    |
| Bachelor's tier 1        | Augustana       | 9,876                           | 3                                    | 160                             | 2                                      | 0                                    | 1,520               | 15                                     | 0                                    |
| Bachelor's tier 4        | Old Westbury    | 39,884                          | 10                                   | 160                             | 0                                      | 0                                    | 1,520               | 4                                      | 0                                    |

[Table 5 continues]



[Table 5, continued]

**Applied physics**

|                     |                 |         |    |         |    |    |         |     |    |
|---------------------|-----------------|---------|----|---------|----|----|---------|-----|----|
| Doctoral tier 1     | Michigan        | 160,530 | 43 | 101,300 | 63 | 84 | 651,359 | 406 | 84 |
| Doctoral tier 1     | Brandeis        | 81,620  | 22 | 3,000   | 4  | 2  | 19,290  | 24  | 2  |
| Doctoral tier 4     | Florida Intl.   | 74,274  | 20 | 14,360  | 19 | 12 | 92,335  | 124 | 12 |
| Master's tier 1     | St. Bonaventure | 3,358   | 1  | 0       | 0  | 0  | 0       | 0   | 0  |
| Master's tier 4     | Peru State      | 3,214   | 1  | 0       | 0  | 0  | 0       | 0   | 0  |
| Liberal Arts tier 1 | Grinnell        | 20,532  | 6  | 1,100   | 5  | 1  | 7,073   | 34  | 1  |
| Liberal Arts tier 4 | WV Wesleyan     | 5,915   | 2  | 320     | 5  | 0  | 2,058   | 35  | 0  |
| Bachelor's tier 1   | Augustana       | 0       | 0  | 0       | -  | 0  | 0       | -   | 0  |
| Bachelor's tier 4   | Old Westbury    | 21,460  | 6  | 0       | 0  | 0  | 0       | 0   | 0  |

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TABLE 6. Changes in journal availability and cost associated with a switch from the Conventional Model to the Equal-Revenue Model (all four subjects combined).

| Category            | Institution     | % change in<br># of titles<br>available | % change in<br>total cost,<br>from<br>Table 5 |
|---------------------|-----------------|---|---|
| Doctoral tier 1     | Michigan        | 20                                      | 237   |
| Doctoral tier 1     | Brandeis        | 72                                      | 0   |
| Doctoral tier 4     | Florida Intl.   | 112                                     | -43   |
| Master's tier 1     | St. Bonaventure | 991                                     | -17   |
| Master's tier 4     | Peru State      | 1,486                                   | -59   |
| Liberal Arts tier 1 | Grinnell        | 612                                     | -45   |
| Liberal Arts tier 4 | WV Wesleyan     | 2,227                                   | -44   |
| Bachelor's tier 1   | Augustana       | 2,227                                   | -30   |
| Bachelor's tier 4   | Old Westbury    | 676                                     | -81   |