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Global Changes in Scholarly Communication

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Introduction

For more than a decade, the cost of print and electronic journals, particularly in the sciences, has increased rapidly at the same time that the amount of research being reported via published articles has grown exponentially. With academic libraries being less and less able to purchase the journals needed for their communities, the use of the term *scholarly communication* has evolved to illustrate the breakdown of the process of traditional scholarly publication; that is, as a means to disseminate research results, the present system of scholarly communication can no longer meet the needs of the scholarly community at large.

When looking closely at the term scholarly communication, it has a somewhat broader meaning than publication, as it also includes the processes by which scholars communicate with one another as they create new knowledge and by which they measure its worth with colleagues prior to making a formal article available to the broader community. For the purposes of this paper we are dividing the scholarly communication process into three distinct aspects: 1) the process of conducting research, developing ideas, and communicating informally with other scholars and scientists; 2) the process of preparing, shaping, and communicating to a group of colleagues what will become formal research results; and 3) the ultimate formal product that is distributed to libraries and others in print or electronically. In addition to describing each of these aspects, we will illustrate some of the changes which are destabilizing longstanding traditions.

The publicity surrounding the cost of the final product has come about because librarians in effect stand at the end of an assembly line holding an item, that in a growing number of cases, we simply can't afford to buy. At first blush, the assembly line where the product itself is created appears to function in a *business as usual* mode: humanities scholars mostly remain solitary researchers as they accomplish their work and physical scientists work together as they have for decades while conducting research; traditional peer review continues per the traditions of each disciplinary group, and applications for tenure and promotion are reviewed by academic committees using standards that can be more than a century old.

For some time, much of the academic world has been perplexed as to why librarians are creating such a fuss about the price of journals. Many faculty are only vaguely aware that library budgets have shrunk in buying power, and some express frustration with the amount of funding given to building complex information technology environments at their campuses instead of allocating it to meet their direct needs, including books and journals in their fields. Under what is still on the surface a relatively stable environment

for teaching, learning, and scholarship, seismic changes are actually occurring that are affecting each stage of the scholarly communication process. Springing up wildly and seemingly from nowhere are "sudden" changes that are ensuing from the increasing use of sophisticated digital technology by scholars and scientists. Massive and profound changes are occurring that are not only affecting teaching, learning, research, and administrative processes, but which are reshaping the academy itself.[1]

This paper will address some of the strategic issues that relate to the traditional system of scholarly communication by looking at changes in informal and formal communication between scholars and scientists and at emerging spaces that scholars are using to conduct and to disseminate the results of their research.

Beginning at the End: The Product

The extreme price hikes that have occurred over the past decade for journals, especially those in science, technology, and medicine (STM), are often described as a "serials crisis." This worrisome situation has had the effect of limiting the number of monographs that libraries could purchase as we diverted a growing percentage of our acquisition budgets to science serials and away from books. The price increases have been well-documented by the Association of Research Libraries (ARL): the unit cost paid by research libraries for serials increased by 226 percent between 1986 and 2000, while the consumer price index increased by only 57 percent.[2] Coupled with decreasing annual increments and one-time infusions to library budgets as universities have had to make other large financial commitments, including the allocation of substantial funds for building information technology infrastructures, university libraries have lost significant purchasing power. Mary Case, Director of the Office for Scholarly Programs at ARL, describes the effect on libraries[3]:

> Even though the typical research library spent almost 3 times more on serials in 2000 than in 1986, the number of serial titles purchased declined by 7%. Even more dramatically, as libraries diverted resources to support journal subscriptions, book purchases declined by 17%. Based on 1986 acquisition levels, this figure represents over 6,000 monograph volumes a year not purchased by the typical research library. With such a drastic erosion in the market for books, publishers had no choice but to raise prices. By 2000, the unit cost of books had increased 66% over 1986 costs.

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[1] These changes were predicted in 1998 by Hawkins and Battin in their book, *The Mirage of Continuity: Reconfiguring Academic Information Resources for the 21st Century* (Washington DC: Council on Library and Information Resources, 1998), 290 pp.; Duderstadt, Atkins, and Van Houweling have recently written on the same topic: *Higher Education in the Digital Age: Technology Issues and Strategies for American Colleges and Universities* (Westport: Greenwood Publishing, 2002), 304 pp.

[2] The Association for Research Libraries is a membership organization of 114 large research libraries in the United States and Canada. For more information, see http://www.arl.org/stats/index.html and http://fisher.lib.virginia.edu/arl/index.html.

[3] Mary M. Case, "Igniting Change in Scholarly Communication: SPARC, Its Past, Present, and Future," *Advances in Librarianship*, 26 (2002): 3. Available at: http://www.arl.org/sparc/SPARC_Advances.pdf.

Within these two interlocked pricing spirals, the most dramatic increases have occurred in STM journals that are produced by commercial firms. As Case states, "Data consistently show that the cost-per-unit of content, the cost-per-citation, and the cost-per-use of commercially produced journals are higher than those of journals produced by society and not-for-profit organizations."[4]

Librarians have been placed in a position of defending the purchase or licensing of expensive journals for science faculty over books and journals for the humanities faculty, even as science faculty also continue to receive a much greater share of governmental grant support than do their humanities colleagues. This situation, which initially appeared to some to be a library's poor management of existing funds or its ineffective lobbying for additional library funding from the university, was actually a logical and perhaps predictable next step within a much more complex environment that has evolved in the field of scientific research publication for more than a decade. Librarians, who have been described more than once as whiners, actually have a relatively minor role in a complex drama being played for power and profit by international commercial firms, with sometimes unknowing support from faculty members seeking promotion, tenure, and the confirmation of status in their fields. And, this faculty role has not been undertaken with malice toward libraries; rather, faculty are participants in the complex social and intellectual process that has worked for more than a century to make scientific research available to the community. To understand the process, we need to understand the history and the ingredients that led first to success and now to a growing and urgent need for disruption and change.

Jean-Claude Guédon, historian of science and professor of comparative literature at the Université de Montreal, has written a definitive and elegant explanation of "how we got to where we are today." [5] It all began, Guédon writes, with Henry Oldenburg, who created a journal called *Philosophical Transactions of the Royal Society of London* (*Phil Trans* for short) in 1665. Oldenburg's aim was to document and distribute original contributions to knowledge. As Guédon notes, "In particular, it [*Phil Trans*] introduced clarity and transparency in the process of establishing innovative claims in natural philosophy, and as a result, it began to play a role not unlike that of a patent office for scientific ideas."[6] In other words, publication in this journal not only dispersed scientific ideas to the world at large, but it provided, in effect, a record of who introduced what new knowledge and when. Critical to Oldenburg's strategy was being able to attract the best authors from England and Europe.[7]

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[4] Ibid., p. 4.

[5] Jean-Claude Guédon, "In Oldenburg's Long Shadow: Librarians, Research Scientists, Publishers, and the Control of Scientific Publishing," (Washington, DC: The Association of Research Libraries, 2002). Available at: http://www.arl.org/arl/proceedings/138/guedon.html.

[6] Ibid., p. 5.

[7] There were many reasons that Oldenburg did not achieve his goal of placing all knowledge of the natural sciences in his journal for distribution to the community at large. Guédon notes that the roles of writers, printers, and bookstore owners were still being explored in the 17th century, much as the relationship between Internet service providers, networks, authors, and users are still evolving today.

The purpose of a scholarly journal is not only to disseminate information to the community, but in its present configuration it also provides quality control, a trusted archive, and author recognition.[8] But throughout the history of scientific publication, profit has also been an ingredient. And, as Guédon describes, the scientist/scholar can take either of two roles. The first, as a scholar/faculty member seeking published research of others or his/her own published research, the faculty member can complain loudly about how inequitably the library's acquisitions budget has been spent and particularly about any serials cancellations in his/her field. The second role, which is considerably nobler, is one that s/he assumes as author. Ignoring any economic considerations, s/he cares about the visibility of the journal, its authority, prestige, and its so-called impact factor. That the journal where the article appears is enormously expensive is possibly a factor that even increases its prestige.

In the traditional process of publication, a completed article, as opposed to a pre-print, is necessary because the article needs to be validated through peer review and its ownership recognized. As an author is footnoted by others, the quality of the journal cited helps to build the reputation of the author. But the location of the article in a distinguished journal is paramount because it helps to "brand" the author by linking his/her name and work to that journal. Guédon compares being published in the most prestigious journals to being on prime time television as opposed to the local news. The author is placed in an exclusive "club" of the very best researchers and his/her ability to get grants, tenure, and promotion is enhanced.

Another player in journal publishing is the editor, whose role is a gatekeeper, according to Guédon. "Silently, the journal's editor…has come to occupy the role of guardian of truth and reality or, in other words, the role of a high priest."[9] The editor also gains prestige when the journal that he/she edits is referenced repeatedly and as the journal gains a reputation for being a major contributor to the record of science. When one understands the Janus-like role of scientists and scholars in the publishing process, the librarian, who plays a walk-on part and who sits well below the faculty in the university hierarchy, is relegated to a reactionary role.

There are ingredients that are causing this stable, albeit imperfect, system to begin to come apart. Several components that keep the process together have begun to fragment. The first weakening began with the explosion in the amount of research that came about after the Second World War. Until World War II, most scholarly publishing was supported by not-for-profit scholarly societies. The rapid growth of research in universities after the war resulted in more articles than could be handled by the existing societies. Impatient authors, who wanted to see the results of their research published more quickly, turned to commercial journals which previously had no or little interest in articles which they believed held no hope of profit.

Guédon argues that there are two other issues: 1) the concept of *core journals* evolved, and 2) the *Science Citation Index (SCI)* began to be published in 1961. With limited

[8] Fytton Rowland, "Print Journals: Fit for the Future?," *Ariadne: The Web Version* 7 (January 1997), p. 1
[9] Guédon, p. 17.

budgets, we librarians have always wanted to find a way to buy only what is needed by our constituencies. We proceeded to identify and codify the critical serials for each discipline, believing we could satisfy most needs of our local research scientists through what were subsequently called *core collections*. In the print world this was a fairly reasonable approach because each library needed to collect virtually the same volumes. When the Institute of Scientific Information (ISI) published the SCI, it enabled one to trace citations for articles across all science journals. From this feature came the "impact factor," that is, the number of times an article is cited directly relates to its importance in the field. As we have already noted, it is the journal itself, not the individual articles, that gain status from being cited because it is the journal's impact that brands the scientist. By making the journal the most important element in publication, Guédon argues, researchers seek the "visibility, prestige, and authority (and improved institutional ranking) in these publications." And further, by limiting the citation analysis to a core of journals, the SCI made these journals elite. This argument is important because it sets the stage for why the ensuing price increases could occur.

It is likely that the entry of commercial firms into scientific journal publishing probably produced some healthy competition between the groups at first. But once the core journals had been defined by libraries and the SCI data became integral to the prestige of these journals, librarians had no choice but to purchase the core journals, and we did. The stage was now set for dramatic price increases within a closed market and for the ensuing mergers where publishers have attempted to increase their profits by buying other companies which shared the market.

In its attempt to capture the lucrative science market, the commercial publishing world buys and sells firms regularly. It is well known that Reed-Elsevier now publishes about 20 percent of the core science publications available commercially. In May 2003, the German conglomerate Bertelsmann announced that, subject to regulatory approval, it was selling its Bertelsmann Springer science publishing operations to the British private equity firms Cinven and Candover for just over 1 billion euros.[10] (Bertelsmann is selling Springer to reduce its debt load.) If successful, this acquisition would place Cinven and Candover, which acquired Kluwer Academic Publishers in 2002 for over 600 million euros, second only to Reed Elsevier in market share. Cinven and Candover would publish nearly 1,500 journals and about 5,000 books annually.

With the introduction of electronic versions of articles, journal publication has become even more complicated. Instead of placing the electronic article within the framework of copyright law, the first experiment (Elsevier's TULIP[11]) made the articles available as materials licensed, rather than purchased by the libraries, and this model is now the norm. An exciting project from the view point of what digital technology could deliver, TULIP also set up a new role for the library, one of an access point, rather than an owner of intellectual products. As the number of electronic journals grew, librarians became

[10] See http://www.bertelsmann.com/documents/en/BSpringer_e.pdf.

[11] TULIP (The University Licensing Program) was a collaborative project (1991-1995) of Elsevier Science and nine American universities to test systems for networked delivery to and use of journals at the user's desktop. For more information, see http://www.elsevier.nl/homepage/about/resproj/trmenu.htm.

deeply immersed in a new and highly complex world where we seek to cut the best licensing contracts for our constituencies.

And, while we librarians still seek to bring our own faculty and students what they need when negotiating licensing contracts, we have found most of the time that larger contracts and bigger constituencies bring better deals. A state-wide consortia, such as OhioLINK in the U.S. with 450,000 full-time equivalent users, is able to negotiate the price of products more effectively. The Canadian National Site Licensing Project has also achieved some success, and licensing contracts for entire countries are common in Europe and the Far East.

As users come to rely on a certain scale of electronic resources negotiated for substantial savings in the first round of negotiations, librarians fear that it will become more difficult to negotiate effectively the second and third time around because our users will have come to rely on the products. In addition, there are other elements when one commits to what is now called the Big Deal[12] as described by Ken Frazier, Guédon and others. With a high percentage of a library's or consortium's budget being spent to fund resources from one publisher, there is a danger that subscriptions from other publishers will be cancelled to the detriment of what competition there is left standing.

In addition, the Big Deal publisher (Elsevier, at this point) ends up dominating the users' space. With the ease of finding so many articles online, users rely on what is available. If Elsevier dominates, more Elsevier articles will be read and cited. Guédon notes that Elsevier, with about a 20 percent share of the entire scientific market, accounts for 68.4 percent of the articles downloaded in OhioLINK. Recalling the impact factor, Elsevier journals cited then get added to the impact and the reputation of the journal goes up.

Guédon speaks to several other critical issues in licensing:

1. Publishers, for the most part, have not guaranteed permanent access to their products. For research universities, it is imperative that the record of scholarship continues to exist;
2. Librarians now provide restricted and temporary access within a licensing environment, rather than through copyright laws; with the growth of sophisticated e-commerce, publishers could begin to give individuals direct access to articles for a price instead of selling access through libraries.
3. All contracts negotiated by a publisher are known to that publisher; on the other hand, negotiated contracts are usually not shared among libraries, thereby making an individual library's negotiating position weaker than that of the publisher;
4. User statistics are known to publishers but not always to librarians. (In addition to using statistics to monitor market impact, publishers also can know specifically what articles a person is reading; when known, such

[12] Kenneth Frazier, "The Librarians' Dilemma: Contemplating the Costs of the 'Big Deal,'" *D-Lib Magazine* 7:3 (March 2001): 1-8. Available at: http://www.dlib.org/dlib/march01/frazier/03frazier.html.

information is virtually never revealed by librarians except under special and defined legal circumstances. Publishers have not made that commitment.)

So, has the genteel world that we used to imagine ended? Yes! Moreover, there is near consensus by university librarians and administrators that the current system of scholarly communication in the sense of publication is not sustainable. Fortunately, the very growth of digital technology that has helped to produce the problematic situation that we have just described is also helping scholars and librarians to explore new directions. The sophistication and accessibility of digital tools is enabling all sorts of creative efforts to flower that may eventually lead to a new system of scholarly communication.

In the late 1980's, the Association of Research Libraries conducted a number of studies that documented trends in subscription prices and publisher costs, which Mary Case describes in a recent article.[13] Over the next several years, ARL conversed extensively with any number of stakeholders, including university administrators, librarians, societies, university presses, and others. The idea of stimulating competition was a thread in most of these discussions, but no single idea was put forward for action. At a remarkably unusual ARL membership meeting in 1996, Ken Frazier, Library Director at the University of Wisconsin, Madison, spoke vigorously for action. He proposed that 100 libraries contribute $10,000, a total of $1 million, to create ten new electronic journals that would compete with established and expensive scientific and technical journals. Within a month or so, a working group was formed to develop an action plan, and by October 1997, the project was named the Scholarly Publishing & Academic Resources Coalition or SPARC. With substantial contributions in hand, SPARC sought to partner with prestigious scholarly societies and university presses to develop new journals. Because these publishers needed ongoing subscriptions, libraries also committed themselves to purchasing the new journals.

The first journal, published in partnership with the American Chemical Society, was called *Organic Chemistry* and was meant to compete directly with *Tetrahedron Letters*, an Elsevier Science title that cost $8,000 U.S. annually at that time. Shortly after, SPARC signed agreements with the Royal Society of Chemistry and with Michael Rosenzweig, who left a journal he helped to create to begin another with SPARC. The publicity surrounding Dr. Rosenzweig was helpful to raising the consciousness of other scholar-editors.[14]

SPARC offers grants for digital experiments that work toward changing scientific publishing, and it created a new program called *BioOne* in 1999 which seeks to build an electronic aggregation of leading research journals in the geological, ecological and environmental sciences, journals then published in print by the member societies of the American Institute of Biological Sciences. In 2002, 40 journals from 29 societies became available to some 328 subscribing institutions.

[13] Mary M. Case, "Igniting Change in Scholarly Communication," p. 1-26 passim.
[14] Ibid., p. 9.

Although SPARC has been criticized for adding to the plethora of scientific journals, it is clear that its journals are making some difference. In 2002, the SPARC journal, *Organic Letters*, surpassed its main commercial competitor, *Tetrahedron Letters*, in impact factor. The Wolters Kluwer publication, *Evolutionary Ecology*, reduced its price and number of issues per year because of competition from the SPARC journal, *Evolutionary Ecology Research*.

Since its inception, SPARC has grown to 200 full, consortia, and supporting members that include international library association membership. In 2001 SPARC expanded its operations to Europe by founding SPARC Europe. SPARC Europe has introduced advocacy initiatives tailored to European research and library communities, and there is growing interest in Japan, which has prompted exploration of a SPARC Asia.

Is SPARC the complete answer to the high prices that commercial publishers charge? Absolutely not. But its small successes have been important and are making a difference, especially as its work becomes better known within the academy. SPARC's support of the Open Archives Initiative (OAI), which seeks to develop standards that will enable institutional and disciplinary e-archives to be linked, is an important new direction and will encourage and facilitate the creation of discipline- and institutional- based repositories. In fact, Guédon argues strongly that OAI is presently the one viable solution for scholarly publishing, although others disagree with this premise.[15] He believes that OAI has the potential for librarians and scholars to return publishing to the academy in the sense that freely distributed information and knowledge will lead to better research results and hopefully to the betterment of humankind.

In fact, the promise of building repositories with freely available articles follows any number of community proposals, which usually aim to offer articles for free after a limited time or even immediately, if the research was conducted using government funding already contributed through taxation.[16] Before looking at potential solutions, however, we need to look first at the complex environment that comprises the scholarly communication process.

Midway: The Process of Shaping Research into a Finished Product

In July 1998, Myles Brand, then president of Indiana University (United States), convened a university committee on scholarly communication and charged it to look at the national efforts afoot that were seeking to change the environment and to plan a course of action that would be undertaken at Indiana University. It was no surprise that

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[15] Clifford A. Lynch, "Institutional Repositories: Essential Infrastructure for Scholarship in the Digital Age," *ARL: A Bimonthly Report on Research Library Issues and Actions* 226 (February 2003): 1-7. Available at: http://www.arl.org/newsltr/226/ir.html. See also, Edward J. Valauskas, "Waiting for Thomas Kuhn: First Monday and the Evolution of Electronic Journals," *First Monday* 2:12 (December 1997): 1-12. Available at: http://www.firstmonday.dk/issues/issue2_12/valauskas/.

[16] Mary M. Case, "Principles for Emerging Systems of Scholarly Publishing," *ARL: A Bimonthly Report on Research Library Issues and Actions* 210 (June 2000): 1-7. Available at: http://www.arl.org/newsltr/210/principles.html. See also http://www.arl.org/info/frn/gov/pubscience.html and http://www.arl.org/sparc/core/index.asp?page=f59.

one of the committee's charges was to analyze the impact of high prices on library acquisitions and to develop policy changes to maximize access by faculty to the materials they need.

The committee was co-chaired by this author (dean of the libraries) and the chair of the Chemistry Department. It included two other librarians who were collections and reference experts, and representatives from philosophy, history, law, business, library and information science, psychology, geology, physiology and biophysics, and mathematics. The director of the university press and a copyright lawyer also participated.

After considerable discussion about the process by which articles are published, the committee decided it would review the communication processes that are involved when an author initially begins to create what will become a publication and to move through the peer review process. Because the committee did not have enough time to look intensely at all the disciplines, the group agreed to use its own expertise to present and discuss communications practices in two areas in the sciences (chemistry and mathematics), two in the humanities (history and philosophy), and in two professions, law and business.

Before the faculty members began their presentations, it was clear that most committee members believed they would be listening to a redundant one-size fits all description of peer review and other informal communication. This assumption fell apart immediately as it became clear that none of the faculty members knew anything about disciplines other than their own. Each had assumed wrongly that other disciplines functioned as theirs did.

Overall, each committee member knew at the outset that faculty in the humanities published books and science faculty produced articles. They also knew that monographs were critical for obtaining tenure and promotion in many areas of the humanities and that books were increasing in price at a slower rate than were journals. A few realized that because of the need to fund expensive journals, particularly in the sciences, fewer monographs were being purchased by the libraries for humanities faculty. They learned, however, that in some areas of the humanities, such as philosophy, monographs play a much smaller role than do journals.

In business, journal articles are the main outlet for research results. Monographs and conference proceedings are of secondary importance. Both association and commercial journals are important. Association journals are significantly cheaper than commercial journals and electronic versions of journals and working papers are becoming more common.

The field of law is radically different from both the humanities and the sciences. Articles are generally not peer-reviewed, but are most often reviewed by students who edit the law journals. The journals are inexpensive and largely subsidized by the universities which publish them; commercial journals are not the most prestigious, but institution-

sponsored law journals are, and their importance generally comes from the ranking of the law school that sponsors them.

When a committee member described the kinds of publications that are important in his/her field, the others were surprised. Most of the literature and rhetoric that describes the so-called crisis in scholarly communication in no way captures the distinct and fine differences in the way scholars in different disciplines work. The professor describing processes in history brought with him an example of a book in case his scientist colleagues had forgotten what one looked like!

Even more fascinating were the reactions to how faculty in different disciplines communicate with one another as they began to draft ideas. In some cases, history being one, other colleagues except for a trusted *invisible college*,[17] do not regularly read and criticize another colleague's ideas. Even the sciences vary in how much they communicate and how widely. High-energy physicists, with their need for expensive equipment, have traditionally communicated through pre-prints and multi-layered conversations, even before electronic pre-print servers and e-mail. Chemistry, perhaps because of its close association with business and the need to patent results, does not communicate broadly within the profession.

Even peer review, a fairly homogeneous process, except for law as noted above, had disciplinary variations: in some disciplines authors know who their reviewers are and in others the reviewers remain unknown (blind review). Committee members were actually shocked at the different practices that had evolved over the years. While the variations in practices may have been known to a few on the committee, possibly the copyright lawyer and the librarians, most members of the committee were surprised by how widely the norms of scholarly communication and the markets for scholarly materials differ among the disciplines. As a result of the wide divergence, the committee ended up believing that it was unlikely that any single solution would emerge to address the wide range of issues connected with scholarly communication. Put bluntly, they found no "magic bullet" that would correct the present system of price increases for scholarly publications.

Tony Becher has called the various disciplines *tribes*.[18] The *Oxford Encyclopedic English Dictionary* defines a tribe as a group of families or communities, linked by social, economic, religious, or blood ties, and usually having a common culture and dialect and a recognized leader.[19] Implicit in Becher's use of the word *tribes* to describe the different disciplines is the notion that even though each group is similar, i.e., all are scholars or scientists, the traditions and rules that govern a tribe's work processes have evolved over a period of time and are different from other tribes. These processes were stable before electronic publication began to emerge and are still, with some exceptions, stable today.

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[17] A trusted community of scholars, who share an interest in a common subject or discipline and who communicate informally and often privately.

[18] Tony Becher, *Academic Tribes and Territories: Intellectual Enquiry and the Cultures of Discipline*, (Milton Keynes: Open University Press, 1989), 200 pp.

[19] Judy Pearsall and Bill Trumble, eds., *The Oxford Encyclopedic English Dictionary*, (New York: Oxford University Press, 1995), p. 1537.

Furthermore, there would be no reason for tribes to explore practices of other tribes because each tribe is fairly independent. An American university's promotion and tenure process begins in a discipline-centered department which, as one tribe, makes its processes and values a part of the collegial environment. Other considerations come up as the tenure and promotion folders are forwarded to the university promotion and tenure committee and the provost. But even when particular tribal customs and values are questioned by the university committee or provost, as far as we can tell, the procedures and values do not need to be defended, but simply explained by tribal representatives.

As for the President's Committee on Scholarly Communication, its six long sessions were incredibly illuminating to the diverse group (and especially to the librarians), but plans to educate colleagues through a series of seminars were never realized, we believe, because each faculty member wanted to get back to the focused work of the discipline with its many pressing issues and duties. The overview the committee members gained was impressive, but their interest in the overview was far superceded by a consuming interest in their own areas. It was also clear that the underlying differences in how each discipline works are complex and so are faculty members' relationships with publishers of their work. With no clear path toward victory, the committee never made a final report.

At the point the committee discussed the sciences, we invited Rob Kling, an Indiana University faculty member, to discuss his extensive research in disciplinary differences.[20] Rob concluded that "communicative plurality and communicative heterogeneity are durable features of the scholarly landscape, and that we are likely to see field differences in the use of and meaning ascribed to communications forums persist, even as overall use of electronic communications technologies both in science and in society as a whole increases."[21] In his work, he describes the differences in how three scientific fields: high-energy physics, molecular biology, and information systems are using and shaping "electronic media."

The first field, high-energy physics, works on a small number of projects that last for two to three years or longer. The scientists, whose very expensive projects are supported by grants of hundreds of millions of dollars, use expensive equipment. Multi-institutional collaborations that can involve hundreds of scientists and more than two dozen institutions have long been common because of the nature and expense of this research. A new $1 billion project, the ATLAS experiment, will begin in 2007 and will include nearly 2,000 physicists from more than 150 universities and laboratories in 34 countries. The project's locus is the CERN laboratory, the European Center for Nuclear Research, in

[20] Before his untimely death in May 2003, Rob Kling was a professor in the Indiana University School of Library and Information Science and the director of the Center for Social Informatics. The following pages rely on two of Rob's publications, the first a working paper: Rob Kling, "Not Just a Matter of Time: Field Differences and the Shaping of Electronic Media in Supporting Scientific Communication," a CSI Working Paper No. WP-99-02, http://www.slis.indiana.edu/CSI/WP/wp99_02B.html, and second, the published article, "Scholarly Communication and the Continuum of Electronic Publishing," by Rob Kling and Geoffrey McKim, *Journal of the American Society for Information Science*, v. 5, no. 7, 1999, http://xxx.lanl.gov/ftp/cs/papers/9903/9903015.pdf.

[21] Kling, "Not Just a Matter of Time," p. 2.

Switzerland, and it is funded by the National Science Foundation (U.S.) and the Department of Energy (U.S.)[22]

It is not surprising that physicists have led the sciences in the use of electronic media because they have a strong need to communicate and have done so through various means, including pre-prints, before they used electronic communication. The working paper has long been a main source of communication between scientists, and since the 1970s physicists submitted their papers to clearinghouses which then redistributed them to researchers who requested them. Kling notes that even though the Los Alamos e-print server (now called arXiv and located at Cornell University) has become the most famous there are approximately 11 others, including the CERN preprint server, DESY preprints, and one from the American Physical Society.[23] For purposes of archiving and for "prestige and reward allocation" the electronic preprints are also formally published, but the article is usually also available electronically on a pre-print server.

Molecular biology is the second area Kling describes. Here the biologists also circulate preprints, but only within small so-called invisible colleges. Preprint servers do not play a significant role in communication as they do in high-energy physics. But, Kling points out that the field of biology does use shared databases and data sets in its research. The Protein Data Bank, a repository of experimentally determined three-dimensional structures of biological macromolecules; Flybase, a database that maps the genetics of Drosophila (the fruit fly) and into which biologists submit genomic data; and AceDB (A C. Elegans Data Base) which studies Nematode worms, are three examples. Moreover, adding data to these shared knowledge databanks is sometimes required before the researcher publishes an article. "The 'accession number,' a unique number identifying a dataset submitted to one of these databases, is then published along with an article in a paper journal, allowing readers to obtain research data almost instantly, if desired."[24] These digital corpora, Kling notes, are critical to the communications system in molecular biology, but they operate synergistically with print journals.

Information systems is the third discipline Kling describes. A new field, it seeks to decide which activities in an organization need to be computerized, how they should be computerized and evaluated, and how people use systems. Its roots lie in data processing, accounting, management science, and organizational behavior. Kling describes the development of ISWORLD, a Web-based collection of various resources, as follows:

> Eight scholarly societies are listed as co-founders and the top-level site is sponsored by MIS Quarterly, the top-impact journal in the field. Information systems scholars act as section editors for the many sub-pages of the site and the result is in an extensive, distributed but centrally accessible digital disciplinary corpus. The research sections contain links to tutorials, software, field overviews,

[22] See http://pdg.lbl.gov/atlas/atlas.html.
[23] arXiv (formerly Los Alamos National Lab Physics Preprint Server): http://arxiv.org/; CERN: http://preprints.cern.ch/, DESY: ftp://ftp.desy.de/pub/preprints/; and the American Physical Society: http://publish.aps.org/eprint/.
[24] Kling, "Not Just a Matter of Time," p. 4.

and so on (http://www.isworld.org/isworld/isworldtext.html#research). However, unlike the E-Print Server at LANL, ISWORLD is not a repository for the full text of working papers that have yet to be refereed for conferences or journals. However, a small fraction of information systems faculty do post some of their working papers on their own web sites or in the report series of a research center at their universities. ISWORLD also manages several associated electronic discussion lists which information systems scholars use for making inquiries about research topics and teaching materials, as well as conference announcements and other publishing opportunities.

Within these three disciplines, high-energy physics alone uses e-print servers; information systems alone communicates through "pure" electronic journals; molecular biology and information systems build digital disciplinary corpora, but high-energy physics does not; information systems alone produces shared digital libraries; and all three publish additional data or enhancements in paper-electronic journals, high-energy physics and molecular biology in *Science Online* and information systems in the *MIS Quarterly*.

The complexities and traditions in each discipline even in the sciences, Kling argues, are driving their use of information technology differently in all aspects of research, communication, and publication. He disagrees heartily with the notion that all disciplines will use technology and communication practices common in high-energy physics. Stevan Harnad, Andrew Odlyzko, and Paul Ginsparg[25] are probably the best known promoters of what Kling calls the electronic publishing reform movement. All believe that electronic scholarly communication is better than communication via print. They describe it as being less expensive and faster and having easier access. They claim that the push toward total electronic communication is inevitable. Though this may be true, by advocating a single model as appropriate for all scholarly communities and by dominating the press about scholarly communication, the heterogeneity of the disciplines that actually is driving different solutions suitable to long-standing disciplinary practices is lost in discourse on this topic, particularly by libraries and university administrations.[26]

By ignoring the complexities embedded in the disciplines, there is a danger that librarians and university administrators might use limited funding toward solutions that may appear obvious at first but actually are unworkable and engage in frustrating dialogs with

[25] Stevan Harnad is a Professor of Cognitive Science at Southampton University and the founder of the CogPrints Electronic Preprint Archive in the Cognitive Sciences, http://www.ecs.soton.ac.uk/~harnad/; Andrew Odlyzko is Director of the interdisciplinary Digital Technology Center and is an Assistant Vice President for Research at the University of Minnesota, http://www.dtc.umn.edu/~odlyzko/; Paul Ginsparg is a Professor of Physics and Computing and Information Science at Cornell University. He developed the Los Alamos National Labs Physics e-Print Server, now located at Cornell University, http://xxx.arXiv.cornell.edu.

[26] In his article "Waiting for Thomas Kuhn: First Monday and the Evolution of Electronic Journals," Valauskas argues the same points as does Kling.

publishers because they believe that the scholarly world is moving in one direction lock step.[27]

Starting at the Beginning: Conducting Research

Massive and complex changes are occuring in how scholars conduct their research, mostly in the sciences, but also in the humanities, due to a small number of intrepid humanists who are pursuing the use of technology far beyond the publication of research in electronic format instead of or along with the print publication. Perhaps the best place to begin is the report of the National Science Foundation (NSF) Blue-Ribbon Advisory Panel on Cyberinfrastructure which itself links to similar efforts in Great Britain and the European Union.[28] These changes will eventually transform the research community, scholarly communication, and the role of the research library.

The NSF Blue-Ribbon Advisory Panel, which was chaired by Dan Atkins, an engineer and founding dean of the School of Information at the University of Michigan in Ann Arbor (U.S.), was charged "to inventory and explore current trends and to make strategic recommendations on the nature and form of programs that NSF should take in response to them."[29] The report uses the term *infrastructure* in the broadest sense – the structural foundations of a society or its economic foundations, including roads, bridges, sewers, telephone lines, power grids, etc. and adds the prefix *cyber* to refer to the growing distributed computer, information and communication technology. "If *infrastructure* is required for an *industrial* economy, then we could say that *cyberinfrastructure* is required for a *knowledge* economy."[30]

The technologies supporting a cyberinfrastructure are the "integrated electro-optical components of computation, storage, and communication that continue to advance in raw capacity at exponential rates."[31] They also include enabling hardware, software, instruments, algorithms, data, information, services, social practices, disciplines, and communities of practices, communications, institutions, and personnel. Put another way, there are two overall ingredients: the layers of enabling technology and the complex social practices of the people who use the technology. Atkins' team was concerned about

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[27] Several years ago there was a growing public dialog among university presidents to "take back" the scholarly articles that they said American university professors had written while being supported by university funds and in many cases by government grants. Implicit in this argument was their belief that most articles were written by American professors. Representatives from six scientific publishers who spoke with university librarians from 12 major Midwest universities in the U.S. (The Committee on Institutional Cooperation), however, told the group that more than 60 percent of their authors were not faculty members at U.S. universities but were located throughout the rest of the world. We mention this because librarians and others have the responsibility to help presidents shape their strategies. And, unless we understand these complex issues ourselves, we cannot harness the power of our administrators to help us.

[28] Daniel E. Atkins, et al., "Revolutionizing Science and Engineering through Cyberinfrastructure: Report of the National Science Foundation Blue-Ribbon Advisory Panel on Cyberinfrastructure," (January 2003): 1-84. Available at: http://www.communitytechnology.org/nsf_ci_report/report.pdf.

[29] Ibid., p. 5.

[30] Ibid., p. 5.

[31] Ibid., p. 5.

building the required technology infrastructure, but also about redundant activities resulting from lack of communication between disciplines and a lack of understanding of the social and cultural practices of various disciplines, both of which could prevent full use of technology that he contends will help humankind and the planet Earth to survive and prosper.

The report mentions collaboratories, co-laboratories, grid community/networks, virtual science communities and e-science communities with examples such as the Network for Earthquake Engineering Simulation (NEES), the National Virtual Observatory (NVO), the National Ecological Observatory network (NEON) , the National Science Digital Library NSDL), the Grid Physics Network (GriPhyN), and the Space Physics and Aeronomy Research Collaboratory (SPARC) as examples of *building out* broader scientific applications and *building up* function and performance. Atkins uses these examples as efforts that push toward the future. For the purpose of this discussion, the social aspects of these efforts are more important than are the technical aspects.

The report emphasizes the need for comprehensive libraries of digital objects and for curators who will organize and preserve them. It also emphasizes that efforts should transcend individual agencies and institutions and be international in scope. Because of the growth of the cyberinfrastructure, scientists have been able virtually to revolutionize their research through the use of digital data and networks. Simulation and modeling have been added to the more classic theoretical/analytical and experimental/observational approach in such fields as scientific and engineering research, including the biological, chemical, social, and environmental sciences, medicine, and nanotechnology. In all these fields data has been collected and is available online. Modern genome research is probably the most well-known example, but astronomical research is also being redefined. The report notes that scientific publication is now almost totally online, that publications are beginning to incorporate rich media (hypertext, video, photographic images), and complex data sets are being visualized in new ways that will lead to a better understanding of their meaning. The report also states that researchers could not do without e-mail and the Web.

Within this growing environment, the report lists some serious concerns:

- Researchers in different fields may adopt different formats and representation of key information that will be impossible to combine or reconcile
- The lack of systematic archiving and curation of data, gathered at great expense, is endangering its long-term existence
- Incompatible tools among the disciplines will serve to continue to isolate scientific communities
- Groups who are building their own software are unaware of comparable needs elsewhere
- Forthcoming changes in computing and applications could render some projects obsolete before they are completed
- If the sociological and culture barriers to technology adoption are not addressed, large investments in technology may be wasted.

The issues above address an overall need to coordinate change and to educate and influence the various communities to adopt new ways of working. In this sense, the research process, the first step in scholarly communication, as we have defined it, is the appropriate place to begin and to influence other informal communication and eventual publication in whatever format. As we have seen, however, the traditions within each discipline have worked for many years; modifying these processes will take time for the disciplines to adopt new technology and to make use of it in concert with their own practices. The prospect of fully employing technology and conducting research in comprehensive digital environments that are interactive and that have high levels of computational, storage and data transfer may push changes that could not have happened before.

This report also emphasizes the need for the research community to find "trusted and enduring organizations" to preserve and make available scientific data. As research libraries experience the move of many serials and some monographs to digital only – or digital and electronic – we need a dialog that expands from preserving e-publications to our potential responsibility for preserving other scholarly and research output. In one sense, the growing discussion of institutional repositories allows us to expand our own traditional thinking. In our older archival role, we collected scholarly products—the ultimate formal article that serves as the copy of record. Institutional repositories allow us to work with more informal products, to serve the needs of some of our cutting-edge faculty, and to work interactively with all faculty on more than simply purchasing or licensing formal scholarly products.

Clifford Lynch notes that the development of institutional repositories is now possible for several reasons: online storage costs have dropped considerably; standards such as open archives metadata harvesting protocol are now being adopted; and digital preservation, the most talked about ingredient in digital publishing, has advanced to the point where we can test technical approaches.[32] As for the content, Lynch observes that "a mature and fully realized institutional repository will contain the intellectual works of faculty and students—both research and teaching materials—and also documentation of the activities of the institution itself in the form of records of events and performances and of the ongoing intellectual life of the institution. It will also house experimental and observational data captured by members of the institution that support their scholarly activities."[33]

In addition to describing the challenges of creating an institutional repository and the long-term commitment needed by the sponsoring organization, he argues that a repository is *not* a substitute for formal publication. To illustrate his point, he distinguishes between the terms *scholarly communication* and *scholarly publishing.* In Lynch's view, an institutional repository's purpose is to preserve and disseminate scholarly communication, rather than publication. In other words, he does not believe that the repository is the vehicle that will change the publishing part of the scholarly

[32] Lynch, p. 1.
[33] Ibid., p. 2.

communication process. Instead, he sees it working synergistically with formal scholarly publishing, much as some disciplines work with pre-prints that are simultaneously published and informally distributed. Also, the data that are now accepted in conjunction with a formal article in the sciences, could be preserved in an institutional repository, another example of extending existing publishing practices.

Overall, Lynch believes that institutional repositories can 1) facilitate access to traditional scholarly content; 2) feed into disciplinary repositories directly; 3) encourage the exploration and adoption of new forms of scholarly communication that exploit the digital medium in different ways, and 4) support "new practices of scholarship that emphasize data as an integral part of the record and discourse of scholarship."[34]

Lynch cites the NSF Blue Ribbon report and notes that its implications are applicable both to scientific *and* humanities research. An interdisciplinary conference, *Transforming Disciplines: Computer Science and the Humanities*, held in Washington, DC in January 2003, helped to illuminate some of the current groundbreaking computer projects in the humanities.[35] Its goal was for computer scientists and humanities computing practitioners to review current needs and policy issues and to identify areas of research that would benefit from cross-disciplinary applications conducive to new discovery and long-term collaboration between the humanities and engineering sciences.

Linking engineering to the humanities, keynote speaker William Wulf (National Academy of Engineering) stated that he believed that the computer can do the same thing for the humanities that it has done for the sciences. He described the profound changes occurring in the scientific method from the practice of simulation. Instead of waiting for two galaxies to collide and observing the results, the results can be observed through computational simulation.

Other humanities scholars who spoke, illustrated how they are building data and using it to draw conclusions. They included:

> 1) Gregory Crane, a professor at Tufts University who is dissecting languages to find patterns/data that will lead to discovery and conclusions. See http://www.perseus.tufts.edu and http://www.darpa.mil/iao/TIDES.htm;
>
> 2) Douglas Greenberg, who directs the project, "Indexing Memory: The Shoah Foundation Archive of Holocaust Testimony." The Shoah Visual History

[34] Michael Day's article, "Prospects for institutional e-print repositories in the United Kingdom," *Resource Discovery Network*, ePrints UK supporting study 1 (May 2003): 1-18, includes a discussion of potential impediments to repositories that include the traditional assignment of copyright to publishers rather than to institutions; peer-review; quality control; and long-term preservation. Most important, however, are the cultural differences between subject disciplines. At this point, Day writes, many academics and researchers are not certain of the role of repositories. He quotes Andrew Odlysko who in turn wrote, ". . .while scholars may be intellectually adventurous, they tend to be conservative in their work habits." Available at: http://www.rdn.ac.uk/projects/eprints-uk/docs/studies/impact/.

[35] Mary Davidson and Suzanne Thorin, "Informal Notes from the Interdisciplinary Conference Transforming Disciplines: Computer Science and the Humanities," Sponsored by the National Initiative for Networked Cultural Heritage (Washington, DC, 2003). [unpublished]

Foundation has collected on digital tape 52,000 testimonies, the average being 2-3 hours in length. The completed project, which will comprise 180 terabytes, offers ample challenges for effective indexing and storage, but the size of the database also potentially opens up prospects for codifying aspects of human behavior. See http://www.vhf.org/index.htm;

3) Steven Murray, professor at Columbia University, who spoke on generating humanistic knowledge through the media and who illustrated through a video based on computer modeling, which was in turn derived from other manual measurements and analysis, that illustrates how a cathedral at Amiens, France was constructed. He also showed us how computer modeling is illuminating aspects of Gothic cathedral architecture throughout France. See http://www.mcah.columbia.edu; and

4) Will Thomas, professor at the University of Virginia (U.S.), who spoke on the differences slavery made in two communities, one located in the north and the other in the south. He described his fully electronic journal "article" that is being reviewed by the journal, *The American Historical Review* and is based on research conducted in the Valley of the Shadow project. Using data from this project, he aims to present a scholarly argument as to what caused the Civil War in the mid-19th century. The contextual material is separate, yet connected, as is the evidence and data. Other scholars will be able to enter a dialog within the article. This new format is being developed not only in the field of history but in other parts of the academic community and also in the entertainment field where the user can interact and even control the ending of a story. See http://valley.vcdh.virginia.edu/.[36]

In the discussions that followed, it was clear that the vast majority of humanities scholars at universities are not yet working in new media. Those who do usually work in centers or institutes and their work is often misunderstood by colleagues. The use of data by humanists brings up the question of sharing data, a practice common in most of the sciences but not in the humanities. The humanities are now using technology in a way that incorporates long-held practices, but as the potential of better research through the effective use of digital technology is realized, traditional practices may change. At this point, progress is not exponential.

Conclusion

[36] Three other interesting examples are: 1) The Physics of Scale Project in the History of Recent Science and Technology (http://hrst.mit.edu) at the Dibner Institute (http://dibinst.mit.edu/); 2) the work of the Center for History and New Media, George Mason University (http://chnm.gmu.edu); and 3) the William Blake Archive, Monuments and Dust, and the Complete Writings and Pictures of Dante Gabriel Rossetti: A Hypermedia Research Archive, projects of The Institute for Advanced Technology in the Humanities, University of Virginia, U.S. (www.iath.virginia.edu). These examples are described in "New-Model Scholarship: How will it Survive?" by Abby Smith, *Council on Library and Information Resources* (March 2003): 1-49. Available at: http://www.clir.org/pubs/reports/pub114/contents.html.

Because the overall shape of the traditional system of scholarly communication is similar among all the disciplines, some have assumed that the entire process of research and communication is uniform throughout. The dominating rhetoric among some scientists is evangelical in its desire to transform scholarly communication through a single electronic approach. Taking that very interesting and compelling viewpoint and broadening it to include all the scientific, social sciences, and humanities disciplines has resulted in a picture being drawn that is too simple, given the heterogeneity of the various disciplines. The library profession is only now growing in its knowledge of scholarly communication processes and beginning to be able to understand the similarities and differences. This understanding is vitally important for at least two reasons:

First, academic librarians and particularly library directors, whose knowledge should span the disciplines, can only be effective communicators with our administrations if our knowledge of the disciplines is deeply rooted. We have already seen that faculty members are profoundly (and narrowly in the best sense of the word) involved in a particular discipline or a sub-discipline. Even those who are interdisciplinary in scope, focus intensely on the particular subject areas and their relationships. In any case, a scholar's job normally is not to understand practices in other disciplines, but to relate subjects, develop ideas, and publish them. Up to this point, the academic library profession has not deeply explored the dimensions of changes in scholarly communication beyond rapidly escalating prices for journals and the effects of mergers of the conglomerates that publish significant academic output. Both of these troubling practices are important, however, and we have already described how the pricing situation evolved.

But to take only the pricing issues into account and not to understand that each discipline is different in its practices, we have perhaps proposed simplistic solutions to our university presidents and provosts and may have placed them in the position of advocating unworkable solutions. A good comparison exists in the world of digital libraries. When libraries first began to develop digital libraries, staff looked for what is called in digital parlance, the *killer application (killer app)*, the overall solution that would obviate the need for slow and painful progress. As digital librarians grew more sophisticated, both in experience and expertise, the *killer app* idea was left behind.[37] The same is true in the changes that are occurring in scholarly communication. While there are some dramatic changes occurring, those changes are not transforming scholarly communication in the same way or at the same pace.

Second, in reshaping the role of the library to accommodate and support change, it is equally important to understand how each facet of the scholarly community works. We have seen that some communities are comfortable with pre-prints and others are not. Some scholars work alone and others in groups. Some are constructing data sets together to analyze as a community. There is even some use of and interest in data sets in the humanities. But each group is using technology a little differently and at a different pace.

[37] Daniel Greenstein and Suzanne E. Thorin, "The Digital Library: A Biography," *Digital Library Federation and Council on Library and Information Resources* (September 2002), p. 10.

Most important, each group is working with technology within the framework of its own traditions.

As we look at how our libraries are organized to support the changes that are occurring, our understanding of what the changes are is vitally important. While our old print library system was not a simple one, we knew who we were and what our job was. Scholars and scientists came to us to find and to use books and journals they needed. Our responsibility was to acquire, catalog, and preserve those materials and to make them accessible to our communities. The physical arrangements in our libraries reflected these purposes. Now, we find that scientists are creating complex online communities where they share research, conversation and ideas, build datasets, and publish. Humanities scholars come to the library less often because they now have online journals and in some cases publishing processes which are close to being completely online.

If we can understand and grapple effectively with the changes occurring now and in the next few years, we have the opportunity to move our relationship with faculty from one of facilitator to one of partnership, and this is unprecedented. Interestingly, one of our traditional roles, that of archivist, is being explored in the digital environment.[38] But not only do we have the potential to have a major role in digitally preserving electronic journals, we also have the opportunity to be a part of archival solutions for more informal scholarly communication through institutional repositories. To build an effective repository, however, we must build new relationships with the faculty.

In addition, many of us are digitizing important historical collections. Not only are we digitizing text, but a growing body of photographs, film, and audio. With the growth of the Internet, we are beginning to understand that we must create for our users a more coherent digital environment that includes the materials our own libraries digitize, our online catalogs, as well as materials available globally through the Web. Many of us are exploring the technical and cultural challenges of being able to search across numbers of digital resources and pulling out those materials needed in a particular field. Some of us are also finding that scholars are suddenly locating materials online that they had not explored before because those materials had been "classified" in another discipline. With so much available to them, scholars are now beginning to expect that they will be able to move these digital materials into their own digital surroundings, and modify them for use in their research and teaching. As we work with scholars and scientists, if becomes imperative that we know how they work in order to shape our access tools into effective mechanisms for delivery.

The number of simultaneous developments occurring presently in the way scholars and scientists work and communicate will eventually result in a greatly modified or even new system of scholarly communication, one that will sustain itself in a digital environment. At this point it is difficult to understand completely what the role an academic library will be, that is, how libraries (and librarians) will be involved in the new system. We do know, however, that the days of an academic library standing alone are gone, and those

[38] LOCKSS (Lots Of Copies Keep Stuff Safe) is a prototype of a system to preserve access to scientific journals published on the Web. For more information, see http://www.rlg.org/events/pres-2000/reich.html.

of us responsible for managing staff and those librarians who understand these changes, need to work effectively together to build a completely new environment, one that is fraught with challenges, but one that will transform libraries in synchronization with the evolution of scholarly communication.

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Bibliography

Atkins, Daniel E., Kelvin K. Droegemeier, Stuart I. Feldman, Hector Garcia-Molina, Michael L. Klein, Paul Messina, David G. Messerschmitt, Jeremiah P. Ostriker, and Margaret H. Wright. "Revolutionizing Science and Engineering through Cyberinfrastructure: Report of the National Science Foundation Blue-Ribbon Advisory Panel on Cyberinfrastructure" (January 2003): 1-84. http://www.communitytechnology.org/nsf_ci_report/report.pdf.

Becher, Tony. *Academic Tribes and Territories: Intellectual Enquiry and the Cultures of Discipline*/ Milton Keynes: Open University Press, 1989.

Case, Mary M. "Igniting Change in Scholarly Communication: SPARC, It's Past, Present, and Future." *Advances in Librarianship*. New York: Academic Press 26 (2002): 1-26. http://www.arl.org/sparc/SPARC_Advances.pdf.

Case, Mary M. "Principles for Emerging Systems of Scholarly Publishing." *ARL: A Bimonthly Report on Research Library Issues and Actions* 210 (June 2000): 1-7. http://www.arl.org/newsltr/210/principles.html.

Davidson, Mary and Suzanne Thorin. "Informal Notes from the Interdisciplinary Conference Transforming Disciplines: Computer Science and the Humanities." Sponsored by the National Initiative for Networked Cultural Heritage (Washington, DC, 2003). [unpublished]

Day, Michael. "Prospects for institutional e-print repositories in the United Kingdom." *Resource Discovery Network*. ePrints UK supporting study 1 (May 2003): 1-18.

Duderstadt, James J., Daniel E. Atkins, and Douglas Van Houweling. *Higher Education in the Digital Age: Technology Issues and Strategies for American Colleges and Universities*. Westport: Greenwood Publishing, 2002.

Frazier, Kenneth. "The Librarians' Dilemma: Contemplating the Costs of the 'Big Deal.'" *D-Lib Magazine* 7:3 (March 2001): 1-8. http://www.dlib.org/dlib/march01/frazier/03frazier.html.

Greenstein, Daniel and Suzanne E. Thorin. "The Digital Library: A Biography," *Digital Library Federation and Council on Library and Information Resources* (September 2002).

Guédon, Jean-Claude. "In Oldenburg's Long Shadow: Librarians, Research Scientists, Publishers, and the Control of Scientific Publishing." Washington, DC: The Association of Research Libraries, 2002. http://www.arl.org/arl/proceedings/138/guedon.html.

Hawkins, Brian L. and Patricia Battin. *The Mirage of Continuity: Reconfiguring Academic Information Resources for the 21st Century*. Washington, DC: Council on Library Information Resources, 1998.

Kling, Rob. "Not Just a Matter of Time: Field Differences and the Shaping of Electronic Media in Supporting Scientific Communication." CSI Working Paper No. WP-99-02. http://www.slis.indiana.edu/CSI/WP/wp99_02B.html.

Kling, Rob and Geoffrey McKim. "Scholarly Communication and the Continuum of Electronic Publishing." *Journal of the American Society for Information Science* 5:7 (March 1999). http://xxx.lanl.gov/ftp/cs/papers/9903/9903015.pdf.

Lynch, Clifford A. "Institutional Repositories: Essential Infrastructure for Scholarship in the Digital Age." *ARL: A Bimonthly Report on Research Library Issues and Actions* 226 (February 2003): 1-7. http://www.arl.org/newsltr/226/ir.html.

Pearsall, Judy and Bill Trumble, eds. *The Oxford Encyclopedic English Dictionary*. New York: Oxford University Press, 1995.

Rowland, Fytton. "Print Journals: Fit for the Future?." *Ariadne: The Web Version* 7 (January 1997): 1-5.

Smith, Abby. "New-Model Scholarship: How will it Survive?" *Council on Library and Information Resources* (March 2003): 1-49. http://www.clir.org/pubs/reports/pub114/contents.html.

Valauskas, Edward J. "Waiting for Thomas Kuhn: First Monday and the Evolution of Electronic Journals." *First Monday* 2:12 (December 1997): 1-12. http://www.firstmonday.dk/issues/issue2_12/valauskas/.