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The future of scientific journals in the electronic age

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1. INTRODUCTION

Over the past decade or so, the world of publishing has entered a time of vast changes engendered by the possibilities of switching from printing on paper to electronic publishing and archiving. This transition has been complicated by the rapidly changing nature of electronic publishing and storage, which increasingly involves extensive use of the WorldWideWeb. Although only a small part of the Web is devoted to the publishing and archiving of scientific research, it is likely that the changes in the centuries – old procedures for the communication of research results to the scientific community will be profound. This paper is devoted to a discussion of these changes, their advantages and disadvantages, and of some of the possibilities for future developments, bad and good.

To begin, it is noted that any functioning system for the dissemination of research results should exhibit several features:

- The communications should be inexpensive.
- They should deliver new results quickly.
- They should be peer-reviewed for correctness and novelty.
- Research results should be archived in a stable and accessible way.
- Confidentiality should be maintained before publication. After publication, access to the report should be as wide as possible.

In the initial stages of electronic publication, important features of the current system such as anonymous refereeing, wide-spread dissemination of the results, and even questions of copyright protection and multiple publication (most often, overlapping electronic and paper) were not always properly dealt with. However, as the volume of electronic publication has increased, more

attention is being given to these issues and for the most part, they are on the way to being resolved.

The electronic age has given rise to hopes for an easy solution to a problem that has become very noticable over the past few decades in the print versions of journals in general and specifically of scientific journals. The problem is that cost for these publications have been rising rapidly, to the point where the subscriptions are beyond the budgets of many libraries and indeed, beyond the budgets of the individuals who have been purchasing journals for their private use. The most obvious consequence is that subscriptions are being cancelled. These cancellations have been mostly of marginal journals, but the trend cannot continue without beginning to cut into the hearts of research collections in university and private libraries. Thus, librarians have been searching for other ways to balance their budgets. The question is one that should be of major concern to the users of these collections.

One route that has the appearance of savings in money without seriously affecting the quality of the journal collections is offered by the possibility of electronic production, publication and delivery of research journals. If this is implemented on a large scale, it is likely to change radically the way that the scientific literature is accessed and archived.

Note that a phenomenal amount of information of all kinds has been placed on the WorldWideWeb. Estimates range from 300 to 800 million pages and interestingly, the exact number cannot be known by present technology and is even not relevant if it could be known because new material is being added at such a rate that doubling time of a couple of months is now estimated. The computer facilities needed to maintain the Web are large and expensive and will become much larger and more expensive in the future. The question of who pays for this will become more important as the system expands. The fraction of the total that is devoted to scholarly material is tiny, so that the driving forces for the future of the Web are not controlled by the authors and publishers of scholarly work. However, present publishers of scholarly material are heavily committed to make their products available via this medium and it seems that the producers and consumers of this material should have some influence on how it is done.

This paper will conclude by making some suggestions for the future system of scientific journals. One of the problems in doing this is that we are still in the early stages of the change-over. Indeed, if one looks back into the early 90's, the articles about the future of journal publishing that were appearing then are completely out-of-date now due to the changes that have occurred over the past five years or so.

2. COSTS OF THE CURRENT SYSTEM OF PAPER PUBLICATION

The issue of journal pricing is an important part of the changes that are occurring and that will occur in the near future. In any discussion of this question, we need to distinguish two groups of journals: those published by scientific societies and those of commercial for-profit publishers. Some of the distinguishing features are:

Society publications
- Non-profit
- Very low costs to members

For-profit publications
- High cost, high profit (up to 40% of subscription costs)
- Can be very large operations

With these points in mind, some relevant information concerning current print journal prices can begin with a few examples.

Table 1. Annual subscription costs

Journal Title	1992	1997	Increase
Molecular Microbiology	$548	$1615	194%
Journal of Basic Microbiology	$135	$445	230%
Applied Microbiology and Biotech	$1229	$2448	99%
Personality and Individual Differences	$464	$1029	122%
Regional Science & Urban Economics	$251	$556	125%
Journal of Medieval History	$179	$316	86%
Research in Medieval History	$135	$295	119%

Information of this kind omits one of the most important features of the present situation which is that much of the price increases are due to increases in the amount of material published per year. To see this more clearly, we will compare three publications of two large scientific societies with a group of journals published by the largest for-profit company, Elsevier. The societies are the American Physical Society, which publishes over 250,000 pages per year in 30 journals, and the American Chemical Society which publishes over 130,000 pages per year in 28 journals. The cost data are for *The Physical Review* (put out by the publishing arm of the American Physical Society and covering research in all areas of physics); two journals put out by the American

Chemical Society which are *Langmuir*, a relatively small journal concerned with surface science and colloids, and *The Journal of the American Chemical Society*, which publishes research articles of general interest to chemists; and a group of three journals in the area of surface research that are published by Elsevier (These are *Surface Science*, *Applied Surface Science* and *Surface Science Reports*.) The data in the Table below show the approximate numbers of pages published annually, which increase steadily in all cases, and the costs per page, which have been relatively stable over the six years surveyed.

Table 2. Changing size and cost per page of selected journals

Year	*Physical Review*		Elsevier-*surface*		*Langmuir* – surface		*J. Am. Chem. Soc.*	
	Pages*	Cost**	Pages*	Cost**	Pages*	Cost**	Pages*	Cost**
1992	64.0	0.08	14.0	0.36	3.3	-	11.2	0.08
1993	72.7	0.07	14.4	0.53	3.8	-	12.8	0.08
1994	79.4	0.08	14.3	0.57	4.8	-	12.3	0.10
1995	80.8	0.09	13.7	0.57	5.0	0.17	13.0	0.11
1996	78.7	-	18.9	-	6.9	-	13.2	-
1997	80.0	0.10	18.7	0.56	-	-	13.1	0.12

Blank spaces mean that the data was not available for this report
* Thousands of pages
** Dollars per page

All costs in the previous table are for institutional subscriptions which means, in essence, libraries. In 1995 the society members could subscribe to the J. Am. Chem. Soc. for a cost of $0.008 per page (U.S. surface mail), about 10% of the institutional cost. For Langmuir, the member cost was $0.013 per page (U. S. surface mail), also roughly 10% of the institutional cost. For airmail to Europe, the member costs went up to $0.026 per page.

Clearly, the costs of these societal journals to members are very low and indeed, by far the major source of income to these journals comes from the institutional subscriptions. The importance of the low-cost member subscriptions depends upon their number and some relevant data is given here for the complete set of American Chemical Society journals:

Table 3. Numbers of subscriptions, numbers of articles

Year	1992	1993	1994	1995	1996
Subscriptions*	105	101	101	97	94
Member	56	-	-	-	51
Non-member, institution	43	-	-	-	40
Non-member, personal	6	-	-	-	3
Total Articles*	14.4	15.1	15.8	16.5	18.5
Non U.S. articles	6.0	6.4	7.2	8.0	9.3

* Number in thousands

Also shown is the total number of articles and the number from non-U.S. authors (assigned somewhat arbitrarily for papers with multiple authors from different countries). Note that the number of U.S. articles remained almost constant from 1992 through 1996 (similar numbers are expected for the Physical Review). The numbers of member and institutional subscriptions are roughly equal, which means that about 90% of the subscription income comes from institutions. The breakdown of the origins of the papers in American Chemical Society journals in 1997 is: Japan, 8.9%; Canada, 4.7%; total E. U., 27.1% with Germany, 5.5%, France, 4.6%, U. K., 4.1%. In spite of the country of origin of the journal publisher and the societies that sponsor the American Chemical Society journals, it is reasonable to conclude that the journals are international when judged by the criterion of the nationality of the authors. This is just another example of the increasing internationalization of modern science. As the research reported in these and similar journals increases because of the internationalization of research support, the number of articles per year must increase and the modern research scientist will need access to this material if he/she is to remain current.

Searching the literature:

Facilities for searching the literature for the relevant previous work in a given area of research have always been an important aspect of scientific work. Such searches are greatly facilitated by the use of a computer with access to large databases of previous work since computer searches of the literature by author or by key-word can produce crucially important information. However,

the quality of such searches can be limited by incompleteness of the database, especially when it comes to older work that may not be included in a recently constructed electronic database. Other factors affecting quality include the cost of subscribing or even carrying out a single search of a database. Some of the best-known of these databases include:

Chemical Abstracts

- Covers articles, patents and proceedings in chemistry and related areas such as biochemistry and chemical physics.
- Abstracts are written by the staff; the cost to a subscriber was $13000 per year in 1992, $17000 per year in 1997.
- The number of abstracts per year was 532,000 in 1992, 717,000 in 1997. The total abstracts since the journal was started in 1902 is 17.6 million; total substances abstracted is 17.2 million.
- The more recent abstracts are on-line and can be searched electronically using
- SCIFINDER; the added cost to subscribe to this service for a Chemical Abstracts subscriber is $15,000 annually for one user, $6,000 annually for additional users.
- STN EXPRESS with DISCOVER! is personal computer software to facilitate database searching.

Other similar services include:

Medicus plus the on-line version of *Medline*:
3150 biomedical journals were indexed by these services in 1995 out of a total of about 13,000.

Physics Abstracts

Current Contents:
Publishes current Tables of Contents of selected journals; available on-line

Institute for Scientific Information:
Maintains databases from 16,000 journals, books and proceedings in science, the social sciences, arts and humanities.
Titles, authors and citations are tabulated, but abstracts are not.
Has shown that 2,000 selected journals account for 85% of the articles and 95% of the citations.
Are starting to include some electronic journals in their database, but their criteria for inclusion are the same as those for paper journals: peer review of submitted articles and high-caliber editorial boards.

This has some similarity to Current Contents, but their analyses of contents and especially citations have been used in a number of ways. Their database does not appear to be routinely available to other users.

Electronic (on-line) scientific publishing

From its beginnings less than ten years ago, the number of scientific journals available on the WorldWideWeb has grown very rapidly. These are available both by subscription to a single journal or via a central collection of electronic journals.

Examples:

- The American Chemical Society has a collection called Chem Port that includes articles and indices published in:
  All American Chemical Society journals
  All American Physical Society journals
  Academic Press journals
  Institute of Physics journals (U.K.)
  Royal Society journals (U. K.)
  Chapman and Hall journals
  Copies of these articles can be downloaded to individuals with the proper access permissions or they can be viewed directly on-screen The material can be searched electronically, but the number of back issues in the collection is presently rather limited. Pricing for the service varies from publisher to publisher within the collection; the pricing algorithms are subject to change with time.
- Elsevier Science, which publishes ~1,000 journals, has Science Direct. In 1997, this includes 650 of their journals with more being added; one can subscribe to a journal or to more than one journal or one can access individual articles. Pricing for this service was still under development in 1997.
- Other services of this nature include UNCOVER, CISTI. All require subscriptions to the service and charge for downloading. A few examples of costs in 1997 for downloading single articles:
  Experiential Family Therapy Activities, 13 pages in *J. Systematic Therapies*, cost from *UNCOVER* is $9.75.
  The Hypothalamic-Pituitary-Adrenalcortical System and Sleep in Man, 15 pages in *Advances in Neuroimmunology*, cost from Chemical Abstracts is $44.00.

Interleukin-2, Its Biology and Clinical Applications in Patients with Cancer, 13 pages in *Cancer Investigation*, cost from *CISTI* (Canada Institute for Scientific and Technical Information) is $18.00.

An example of subscription pricing for a single journal published by a scientific society is

Table 4. For *The Journal of the American Chemical Society* in 1998

Member Prices		Institutional Prices	
Print subscription	$129	Print subscription	$1865
On-line subscription	$148	On-line with one class C subnet	$1958
Print + on-line	$189	Print + on-line with the class C subnet	$2238
		On-line, site license	$3091
		Print + on-line, site license	$3525

A site license gives access to anyone in the organization within 9 km of the site (=library)

A class C subnet is a local network serving a specific department.

It is reasonable to suppose that similar pricing policies will be adopted by others, although considerable variation in prices from one publisher to another is likely.

Future Prospects

In attempting to guess how the world of scientific publishing may develop in the near future, one should begin from the currently successful system that can be summarized as:

1. Submission of a manuscript to the editorial office of a particular journal.
2. After the editor or editors select a likely referee or referees, forwarding of the manuscript to these persons for evaluation of, primarily, the correctness and novelty of the work described in the manuscript.
3. Return of the referee's or referees' comments to the journal office followed by a decision to reject, ask for revisions or accept. Transmission of this information to the author or authors.
4. In the case of revisions, steps (1) – (3) may be repeated.

Although electronic transmission of manuscripts, editorial correspondence and referee reports can speed this process, especially when overseas transmissions are involved, one must be careful not to compromise the

confidentiality of these exchanges. Furthermore, it should be noted that the slow step in all this is generally the response time of the referees who are, after all, providing their expertise at no cost in the great majority of cases. Thus, the electronic age will not cure the standard complaint by authors who feel that their manuscripts should be processed much more quickly than is the fact.

Once a manuscript is accepted, the publishers take the typescript (now nearly obsolete - word processing diskette or computer file transfer protocol (FTP) are currently more accurate descriptions) and prepare it for publication, either electronically or on paper. Ideally, these are identical in format, although electronic publication can handle color illustrations and even "movies" that are either expensive or impractical or both in a paper version.

One feature that should be emphasized here is that costs are incurred at each step in this process. These can be minimized by electronic transmission, but even this is not free – some agency is paying for the maintenance of the Web and this tends to be taken for granted by most of the scientific community.

There is no reason to believe that electronic publishing will be significantly less expensive than paper. Some costs will be moved to other agencies and some will be saved by electronic or CDROM archiving but much of the savings will be compensated by the added costs of terminals, printers, etc. that must be maintained, supplied with paper and toner for downloaded material and be replaced when they become obsolete (an all too frequent occurrence in today's computing environment.

An alternative scenario that appears to be less expensive is what might be described as a "Wild West" scientific publishing environment. This has actually been implemented in a limited way by what are called Physics E-prints. This began with a small group of high-energy physicists who were in the habit of exchanging preprints of their work by regular mail. An enterprising person at Los Alamos devoted his time and disk space on the Los Alamos computers to transform this into an electronic process. Of course, a preprint is generally understood to be a currently unrefereed research report that is circulated to a limited number of colleagues who might be able and willing to make informed comments and who would welcome advance notice of new work in this research area. When such a report is made available to the millions of people who might access it on the Web, the dimensions of the problem are materially altered and questions of copyright and publication priority that many scientists would prefer to ignore can prove to be a real problem.

Furthermore, a preprint is subject to revision and even withdrawal by its authors without notice – procedures which are anathema to an archival research collection. Formal refereeing is bypassed, which may be sustainable within a small group of well-informed workers but which may cause major problems in the scientific community at large. (Consider what might have happened if the

cold-fusion papers had appeared completely unrefereed and subject to revision or deletion at any time after their initial appearance.)

One final point to be made if an E-print scenario were to be implemented on a large scale: It also is not as cost-free as its proponents believe. Many of the actual costs are born by the agency that operates the Net and provides disk space for storing manuscripts, comments, etc.

Based on current experience, refereeing is the slowest but least expensive step in the publication process and there is no reason to believe that this will change in the future, paper or electronic. With this in mind, the question is: What are the pros and cons of electronic research publishing, as seen at the present time?

Possible disadvantages are:

1. The physical stability of electronic archives over long periods of time (such as decades) is unclear. Computer operating systems change, tapes degrade and even the hardware changes in unanticipated ways.
2. Electronic archives can be relatively inaccessible to researchers in less advanced parts of the world that are not fully into the electronic age.
3. Rapid access to the Web can be a problem. It is at present an unorganized collection of information, most of which is completely irrelevant to scholarly research. Many time-consuming processes are running on it at any moment which have the possibility of preventing or at least slowing access to other users. Users that are overseas from the U.S. must rely on satellite transmission for their access, and this can be quite slow at particular times of day. An idea that might be considered is the construction of specialized sub-Webs that would be directed towards specialized sub-areas. Resources might be assigned to a "Research Web" that would provide rapid and reliable access to its users independent of the commercial and other kinds of material that make up such a large fraction of the pages on the current Web. In any case, the question remains: Who pays for this service? How long will "free access to the Web remain and what will replace it?
4. Can one maintain the confidentiality of yet unpublished work if its draft versions are placed on the Web? Will copyright or other law be adequate to protect authors and researchers who have produced a given result and who wish to make it available to the scientific community? (Of course, these are soluble problems, but the time and costs required to do this may be considerable.) Note that copyright law already has problems with the number of copies that can be legally made of a research paper. This problem first really appeared when inexpensive copying machines first became widely available, but will be much exacerbated when downloading from the Web becomes routine. In fact, one does not even have to

download if research articles are made freely available by anyone with access to the Web and a suitable search engine.

Possible advantages:

1. An increase in the rapidity of the publication process. It should be noted that the journals of the American Chemical Society (and possibly of other publishers) are now placing articles on the WorldWideWeb as soon as proofs are corrected, thereby accelerating publication times by a month or so.
2. An increase in the speed and quality of literature searches by computer access to databanks by author, by subject or by key-word. A development which is capable of aid in this is the electronic database called JSTOR which was initiated in 1994. In it, articles in back issues of scholarly journals are being put on-line and made accessible to academic users. Currently, only articles published before 1990 are included in this database, on the reasonable assumption that the journals themselves can deal with their more recent publications. A present disadvantage is that the number of journals in this database is quite small (~120 for all areas of research), but the principle is a good one. Such activities should be supported strongly by the scientific community. The on-line posting of back abstracts by Chemical Abstracts is a useful but insufficient step in this direction.
3. For many, an increase in convenience that comes from having a terminal in one's office or in one's home that is connected to the world-wide system of journals and abstracting services.
4. A reduction in the space required for archiving. Indeed, the local archives that are presently maintained in university and industrial laboratories could be replaced by one central archive (with back-ups) so that the journal sections of scientific libraries would eventually become collections of computer terminal and printers (also, see 2 and 3).

Although it might appear that the advantages of an electronic system are outweighed by the disadvantages, that is not obvious. Many of the current disadvantages are questions and problems that should be resolvable. Certainly, speed, accessibility and convenience are major aspects of the productive usage of the enormous quantity of scientific information that has accumulated over the past century or so. Finally, it is altogether possible that completely new ways of manipulating and benefiting from this resource will make their appearance in the future. If this occurs, it is highly likely that they will be the outcome of the continuing advances in computer power.

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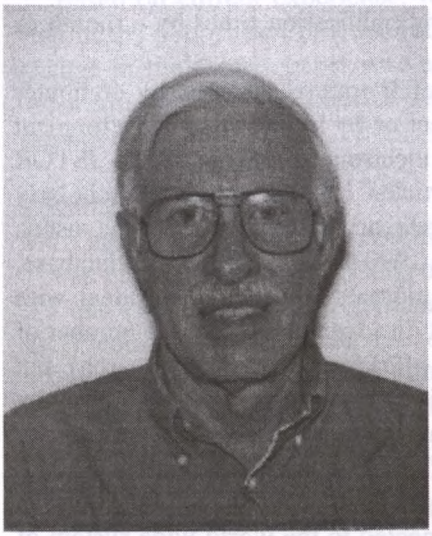
CURRICULUM VITAE



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J. Coll. Interface Sci., 1971-1974.	J. Chem. Phys., 1976-1979.
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