



The writing is on the web for science journals in print

The Internet revolution is injecting more competition into publishing and giving power back to scientists and learned societies. It presents new challenges to the guardians of the archives and could yet spell the end for many print titles.

Print versions of scientific journals will soon be history at Denmark's national Technical Knowledge Center and Library in Lyngby. It has decided to phase out print altogether, and deliver journals direct to staff desktops via the World-Wide Web.

In itself this move, expected to be increasingly followed by universities worldwide, is a revolution. But it is only one of the profound changes in scholarly publishing that are just around the corner. The very existence of research libraries as we know them is in doubt.

Their traditional roles are being eroded on every front. Publishers and new electronic services are bypassing libraries and delivering sophisticated information products direct to users. Libraries increasingly act merely as brokers to squeeze better deals from publishers.

Publishers face challenging times ahead too. The late Robert Maxwell built his empire on the lucrative business of publishing journals, many of them obscure titles read by a few. But the journals system is increasingly looking like a house of cards, and electronics is shaking the foundations.

Much evidence suggests that maintaining a plethora of high-price, low-circulation journals as the primary means of scientific communication is no longer the best way to

meet the needs of users, and that the overheads are economically unsustainable.

The ability to click from an abstract or citation to the full text of an article is prompting a shift in the way that journals are used. Scientists often care less about the journal title than the ability to track down quickly the full text of articles relevant to their interests. Increasingly, users view titles as merely part of hyperlinked 'content databases' made up of constellations of journal titles.

As a result, the competitive edge of publishers is increasingly coming to depend on their ability to muster a critical mass of attractive information through a single powerful and user-friendly interface. The boundaries created by thousands of journals appear as little more than an evolutionary vestige. The big bang of journal proliferation seems set to be followed by a big crunch.

There is growing acknowledgement that the primary role of journals will in future be to provide papers with an imprimatur of quality and to add editorial value. Their traditional role as a distribution outlet will diminish.

This is already happening in physics, where the Los Alamos e-print archives have become the primary means of communication, not just in high-energy physics but also in astrophysics, quantum physics, condensed matter theory, mathematics and computer science. Plans to create similar archives for

the biomedical sciences are receiving serious attention in the United States.

The Internet is blurring the traditional roles of creators, suppliers and distributors of scientific information, and injecting a long overdue element of competition. A shake-out of the entire scholarly publishing industry seems inevitable. "It is an interesting time. The publishers don't know which way to go, and the libraries don't either," says David Lipman, director of the US National Center for Biotechnology Information.

Serial library killer

Going fully electronic was the only way for the Danish library to continue to provide an efficient and cost-effective service, says Lars Bjoernshauge, its director. Like research libraries worldwide, it has been badly hit by the spiralling inflation of journal prices that has resulted in libraries paying more to provide users with less — the 'serials crisis'.

The US Association of Research Libraries calculates that its 114 member libraries spent 142 per cent more on journals in 1997 than ten years before, but ordered 6 per cent fewer titles. In the same year, Reed-Elsevier, one of the largest publishers, reported profits of £230 million (US\$378 million) on sales of £571 million in its scientific activities alone.

"Between 1990 and 1997, we were forced to cut 40 per cent of our subscriptions," says Bjoernshauge. The Danish library has shifted resources away from handling paper — unpacking, cataloguing and shelving journals — and fired one in seven staff. As a result, this year it expects to increase its titles by 25 per cent. "We now have more journals, less staff, and satisfied users," he says.

Just four years ago, such a move would have been unimaginable. The total number of journals, of any sort, on the web was just 306. Even 18 months ago, it would have been unthinkable, as only a few scientific journals had full text and graphics on the Internet.

The major change since then has been the arrival of traditional publishers on the web. Reed-Elsevier now has more than 1,200 journals online, Springer has 360, and Academic Press 174. A journal without a web version is now rare, and probably endangered.

The Danish action comes as no surprise to Andrew Odlyzko, a mathematician at the AT&T telecoms corporation and an expert on the economics of scholarly publishing. He has long argued that the 'journals' crisis is part of a wider crisis of identity facing research libraries, pointing out that the cost of journals is typically only one-third of a library's total staff and overhead costs.

Few other libraries are yet prepared to abandon print completely. The main obstacle to faster change is concern over how electronic materials are to be archived for posterity. Universities that have contemplated

This Briefing has been written by Declan Butler

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cancelling print subscriptions have frequently met resistance from faculty members. But a marked shift of resources from print to electronics is already under way as libraries take advantage of electronic publishing to cut overheads. And many scientists hope that electronics may bring a more fundamental reform of the economics of scholarly publishing, and a solution to the 'serials crisis'.

Many feel that publishers of high-price, small-circulation journals are making excess profits. One critic is Mark McCabe, an economist at the Georgia Institute of Technology in Atlanta, who spent seven years at the US Department of Justice's antitrust division investigating anti-competitive practices. He says the profit margins enjoyed by many publishers exceed those that would be expected in a properly competitive market.

Commercial publishers argue that they have higher costs than not-for-profit societies, whose journals are often subsidized by membership fees, and that increases in the quality and size of journals have raised prices. But McCabe maintains, for example, that it is difficult to justify the doubling of the cost of Elsevier's *Brain Research* between 1992 and 1996 to \$15,000 annually. Elsevier Science was unavailable for comment.



McCabe: keen to see more competition.

Libraries strike back

Libraries and scientists are now striking back, the ultimate goal being to return control of scholarly publishing to the non-profit societies and what they consider to be responsible publishers. Using electronic journals to achieve this is the goal of HighWire Press, a not-for-profit outfit set up in 1995 by Stanford University Libraries and Academic Information Resources to help universities and societies to publish at low cost.

Michael Keller, publisher of HighWire, says he was concerned that large companies with more money to invest would squeeze not-for-profit publishers out of the electronic journals market. He hopes that HighWire will help "correct the market", by increasing the output and quality of society journals. "This market problem has taken 40 years to come about; my guess is it will take ten to fifteen years to remedy."

HighWire now has more than 100 journals in its stable, including the *Journal of Biological Chemistry* — the world's most cited journal — *Science* and *Proceedings of the National Academy of Sciences*. Just before Christmas, Oxford University Press transferred responsibility for production and hosting of electronic versions of 160 journals to HighWire.

The Scholarly Publishing and Academic



Gateway to literature: ISI's Web of Science takes readers to the full text of more than 100 journals.

Resources Coalition (SPARC), set up in 1997 by the US Association of Research Libraries (ARL), is even more aggressive. It is underwriting the launch of journals aimed at competing head on with expensive titles, with its 114 member libraries promising to buy each of them (see *Nature* 393, 719; 1998).

SPARC has teamed up with the UK Royal Society of Chemistry to launch an electronic journal, *PhysChemComm*, that will sell at \$353 and is intended to compete with Elsevier's \$8,000 *Chemical Physics Letters*. But Elsevier complains that like is not being compared with like, and that another of its journals, *Electrochemistry Communications*, sells at \$350.

The most dramatic example of rebellion is perhaps the recent decision by Michael Rosenzweig, a researcher at the University of Arizona, to defect, along with the entire editorial board, from the Wolters Kluwer journal, *Evolutionary Ecology Research*. Rosenzweig had become disenchanted with price

increases at the journal which he established 12 years ago, and has allied with SPARC to create an alternative that will sell to institutions at around one-third of the \$777 price of the Kluwer journal.

"I think the broad support that SPARC has received speaks of a broad frustration among [researchers] with the situation and a belief that it is time to become part of the solution," says Mary Case, director of ARL.

Market distortions

The success of such electronic ventures is far from guaranteed, however. Despite enjoying library support, electronic journals face similar difficulties to those of any new journal in getting established and attracting authors.

Gregory Fu, a chemist at the Massachusetts Institute of Technology, also points out that, from a user's perspective, "unless *PhysChemComm* delivers a knock-out blow [to its competitors] it just becomes one more journal that I have to put on my list to browse; so long as the Elsevier journal has good papers I will still need to check it".

Case admits that her optimism is tempered: "If new SPARC titles can draw papers away from top expensive competitors, there should be a decrease in size or quality and eventually a decrease in price. There may be some modest effect on prices, as much due to the publicity that SPARC is generating as to the introduction of competition."

In physics, the Los Alamos e-print repository — where preprints submitted direct by

User consortia emerge as 'brokers'

In addition to efforts by scientists to create competing products, publishers face the threat of more organized action — and perhaps even a boycott — by consortia of libraries and other users intent on forcing down prices charged for electronic content.

Library consortia, established in the 1930s to cooperate in administering interlibrary loans, have over the past two years taken on a new role: squeezing better deals out of publishers for electronic licences. The movement is becoming international; the International Coalition of Library Consortia (ICOLC), set up in 1997, groups 79 library consortia in North America, as well as a growing number in other countries, including the United Kingdom, Germany and Australia.

Two dramatic examples are Ohiolink, a consortium of 74 Ohio libraries, which negotiates state-wide access and provides a common interface to users, and the new National Electronic Site Licence Initiative (NESLI), which is intended to serve Britain's entire higher education system.

NESLI was created by the Joint Information Systems Committee, a body established by Britain's higher education

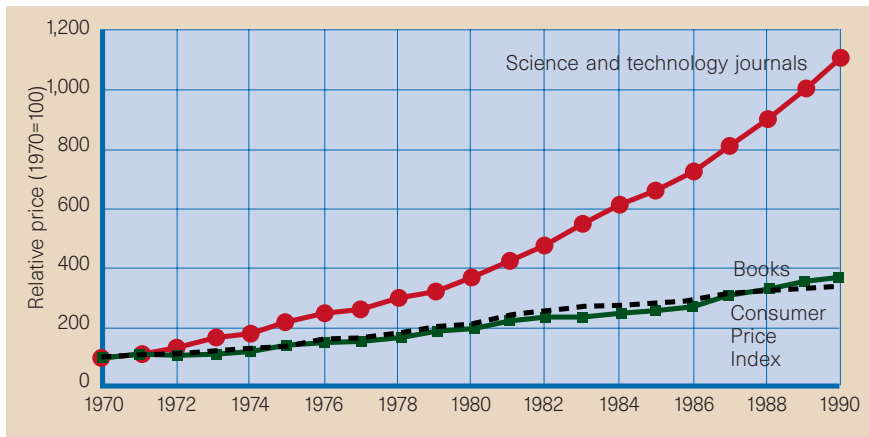
funding councils to coordinate the use of information technology by the higher education and research communities. The contract to manage NESLI has been won by a consortium led by the University of Manchester and Swets and Zeitlinger, one of the world's largest intermediaries in the distribution of scientific information. Their brief is "to lessen the financial, legal and technical barriers to the take-up of electronic journal provision... and negotiate value for money deals with publishers".

Paul Harwood, director of Swets and Zeitlinger UK, says NESLI has approached 60 publishers and will begin making electronic journals available this month. "Any [financial] impact will only be seen in subscription years after 1999," he adds.

"NESLI is an attempt to offer a complete service for the UK higher education community, from negotiation to access," says Harwood. He says the initiative will "try to bring some order to a chaotic world by offering a single service for the complex and time consuming aspects of arranging licences and access to electronic journals".

California State University has taken this approach a step further, and turned the

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Serials crisis: journal price inflation is bad news for libraries but is giving a push to web publishing.

scientists are automatically made available free — now serve tens of thousands of users worldwide and process millions of electronic transactions per month. In many fields of physics, they have supplanted journals in distributing primary literature. Yet the repository has not dented the financial health of physics journals.

Although this is partly because journals satisfy a demand for peer-reviewed collections, it also reflects what many see as distortions in the publishing market. Scientists depend on publishing for career advancement, but they do not pay directly for journals, so have no incentive to stop submitting to high-priced titles. And, as long as publishers attract good authors, libraries will come

under pressure to buy journals, some of which they cannot afford.

ARL data show that library spending per US faculty member averages \$12,000 per year. “If researchers internalized the price of journals in their budgets they would behave differently,” argues McCabe.

The lack of direct accountability of researchers for publication costs is also inhibiting one promising model of Internet publishing, based on billing authors page charges to publish, and then making the journal free. Authors have little incentive to pay page charges when they can publish elsewhere for free.

The viability of the model has been demonstrated by one electronic journal, the

Florida Entomologist, which charges authors \$45 per printed page and \$20 for each figure or table. Thomas Walker, its editor, says adoption of page charges by other professional societies would allow inexpensive journal production, while making information more widely available.

At a broader level, a grassroots movement has emerged over the past year — mainly in the United States — whose goal is to challenge the common practice whereby publishers retain copyright of articles and forbid reuse of the work elsewhere. A compromise that gives researchers greater control of their published work now seems inevitable.

Some publishers have begun relaxing the terms of copyright agreements to allow researchers to resubmit articles to other media, such as digital libraries. Several US universities, including Caltech, are contemplating achieving the same goal by requiring researchers to retain copyright over their papers and licensing them to publishers (see *Nature* 396, 293; 1998).

One-stop shopping

Whatever happens, a shake-out of the scholarly publishing market seems inevitable. In his book, *Information Rules: A Strategic Guide to the Network Economy* (McGraw-Hill, 1998), Hal Varian, an economist at the University of California at Berkeley, argues that the economics of the Internet renders unstable the traditional oligopolies achieved by economies of scale. Instead, the Internet tends to be populated by companies with temporarily dominant positions, which can be usurped almost overnight by competitors with better technologies or more attractive features.

The prospect of a few web science publishers roughly equivalent to the online bookseller Amazon.com, offering one site from which you could find the full text of articles from every journal at the click of a mouse, is not so far off.

The promise of ‘a library on the desktop’ has finally begun to become a reality over the past 12 months, and user demand for the extra capabilities of electronic journals is driving libraries inexorably towards an electronic future. “We are in a transition phase, but electronics will come to dominate because it has all the features and values,” says Mike Stout, head of electronic journals at Oxford University Press.



Power to the scientists: HighWire assists learned societies and universities to publish on the web.

tables on vendors of scientific journals and databases. Just before Christmas, it announced that, instead of negotiating individual deals, it would put out to competitive tender a contract for the building of a database to supply all its 22 campuses with 1,300 specified journals. Like Ohiolink, it also aims to provide a common database and interface to electronic journals for all its students and faculty members.

Its action is partly a response to the practice of many publishers and intermediaries of selling licences to all their electronic journals, or large bundles of them. Many libraries are concerned that as a result they will be required to pay for journals they do not want. “As the bundled database grows, there will need to be concomitant price increases,” argues Mary Case, director of the US Association of Research Libraries. “I am not convinced that such increases will be moderate.”

Case believes that it would be impossible under US law for university-based consortia to go so far as to organize a boycott of expensive journals. “Such organized activity is illegal,” she points out, as it would constitute antitrust practices.

But Mark McCabe, a former official at the US Department of Justice, says the department might grant immunity to pursue such action if libraries were to persuade it that US antitrust guidelines give companies excessive control of the publishing market.

“On occasion the department develops industry-specific guidelines that acknowledge the peculiarities of a market,” says McCabe. “Procedures exist for exceptions in areas which for public policy reasons deserve immunity”. The department’s interest in the scholarly publishing market has been aroused, he adds, and there is increasing recognition that current antitrust regulations may be poorly suited to tackling the quasi-monopoly enjoyed by some publishers.

Even without such drastic action, Case believes that much can be done by appealing to researchers: “The real success will come if authors and editors look at the titles they support, and refuse to sit on editorial boards, submit to and review papers for some of these expensive titles. This is the dramatic change that has to take place to iron out the distortions in this market.”

Demand is also being created for sophisticated new products that bear little resemblance to traditional journals. Scientists still strive to publish in brand name journals with the highest impact. But, as consumers, they tend to consult regularly only a handful of electronic journals — the ‘musts’ for their field — and some of the leading journals such as *Nature* and *Science*.

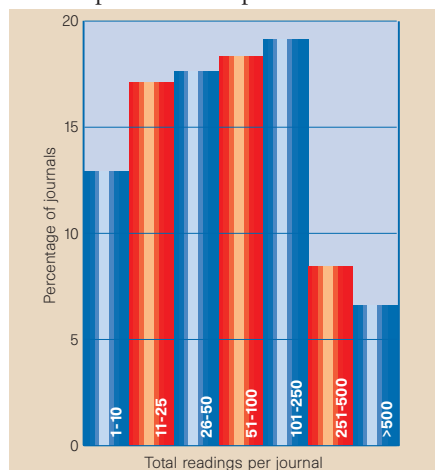
For the rest, individual titles seem less important than the scope for searching and browsing. Using facilities such as citation tracking, researchers are in effect increasingly compiling personal journals for the topics or authors of interest.

This market pressure for ‘one-stop shopping’ at a handful of sites is leading to a proliferation of intermediaries, or ‘aggregators’, which sell packages of journals and other information, and whose ambition is to become the first port of call. The competitive edge of these companies — most of which are American or British — is coming to depend on their ability to muster a critical mass of attractive information accessible through a single powerful and user-friendly interface.

The New York-based company Ovid Technologies, for example, has established itself as a leading provider of electronic material in the biomedical sciences, largely on the basis of sophisticated search software. It provides access to more than 300 journals, and is increasing its portfolio by 30 a month. Ovid was purchased last year by Wolters Kluwer for \$200 million.

Competition at the broadest level is focused on becoming the main gateway to the primary literature. The likely winners are the large abstracting and indexing services, such as the not-for-profit On-line Computer Library Center (OCLC), based in Dublin, Ohio, whose 20 million bibliographic records give it a huge competitive advantage. The Philadelphia-based Institute of Scientific Information’s (ISI) database covers 8,000 primary journals, while databases such as Medline and Embase hold millions of citations for particular disciplines.

J. ELEC. PUB.



Shelf lives: annual consultations of journals in a physical library. Less-read titles could disappear.

Preserving papers for posterity

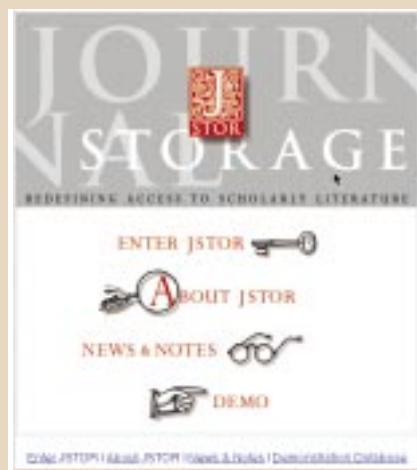
Paper, for all its drawbacks, has one big advantage over electronic media — it can last for thousands of years. The main obstacle to abandoning print journals is the worry that millions of ‘digital objects’ might be unreadable in just a few years because of hardware and software obsolescence.

The problems are mind-boggling. Compact discs only a few years old are often unreadable by new computer systems, and software codes are changing rapidly. The hyperlinked digital content of web material poses even greater problems. How can working links be maintained between text, graphics, audio and video — and who should be responsible?

Technological fixes are possible. Computers could cheaply and quickly migrate one form of software to another across entire systems. Upgrading material to run on the latest equipment is also mostly a matter of management.

But Yola de Lusenet, executive secretary of the European Commission on Preservation and Access, warns against “an unbounded belief in technological solutions”. He advocates greater attention to developing industry standards, to avoid “zillions of different formats”. The ‘millennium bug’ problem has not inspired users’ confidence in the foresight of the computer industry.

A belt and braces approach is being taken by JSTOR — for ‘Journal Storage’ — a non-



Screen saver: JSTOR is archiving back issues of print journals electronically.

profit US body set up in 1995 to archive scientific journals electronically. It scans back issues and generates both printable bitmap images of pages faithful to the original but not searchable, and text files produced using optical character recognition software, which allow searching but may contain errors. It prefers these neutral formats because they should be easier to convert to future formats.

“No single ‘best’ solution to the archiving problem will emerge,” predicts Deanne Marcum, president of the US Council on Library and Information Resources, a body

Until recently, the interest in such services was limited. Scientists could go from a citation to an abstract, but that was about it. But a flurry of deals with publishers over the past year is turning into reality the promise of being able to move rapidly and seamlessly from a citation to full text.

OCLC’s First Search is used by almost all US research libraries, for example, while ISI’s deals with publishers give users access to the full text of more than 100 journals from its web platform, the Web of Science.

In return, collaborating publishers such as HighWire Press can link citations in their journals to ‘Related Records’, an ISI feature that finds articles that have a cited reference in common with the original source article. Similarly, Britain’s Institute of Physics and other publishers are making reciprocal deals to give each other links to their journals.

Web-based communities

But central databases are just one of the many competing and complementary models emerging on the web. An equally pronounced trend away from centralization is also occurring, with a boom in sites tailored to individual communities, such as Biomednet in biology, TipTop in physics and ChemWeb in chem-

istry. Biomednet now has 300,000 registered users, including 3,000 libraries.

Many of these sites include abstracting and indexing services. The Institute of Physics offers the INSPEC physics database, for example, and Biomednet offers an enhanced version of Medline. But their unique selling point is their ‘club’ atmosphere, providing news, features, directories of laboratories and equipment suppliers, and discussion groups — not journals, but fully-fledged electronic magazines.

Taking this concept a step further, many publishers are making ‘knowledge environments’ their top priority — the bringing of a critical mass of resources, services and technology to bear on individual topics. HighWire and the American Association for the Advancement of Science expect to release a series of ‘knowledge environments’ this year. “We think there are good reasons to create deep but narrowly construed digital libraries,” says HighWire’s Michael Keller.

This is a profound shift away from the traditional journal system. Users and librarians increasingly view titles as merely part of hyperlinked ‘content databases’ made up of constellations of journals. “We are trying to get away from single journals and think

that includes the US Commission on Preservation and Access. "Only practical experience will help us make some of the hard decisions that lie ahead."

One of the biggest questions is who should be responsible. Libraries have traditionally archived journals, but specialized agencies have dominated archiving of video and audio products. Centralized national depositories may similarly be more appropriate for digital material, says Don Waters, director of the US Digital Library Federation.

But Waters believes that many of the issues are best dealt with locally by the "interested communities". Kevin Guthrie, president of JSTOR, agrees: "Individual organizations committed to archiving their material are best placed to solving their local [logistical and technical] problems."

The American Physical Society has made archiving a priority, and has digitized issues of its *Physical Review* back to 1985 at a cost of \$750,000. "I scanned in volume 1 from 1893 this morning, so now all we need to do is fill in the gap," quips editor in chief Martin Blume. Copies are kept at several libraries to guard against mishaps.

A major concern is whether commercial publishers, which increasingly archive their material, will maintain a long-term commitment. Librarians are worried that publishers will abandon costly and little used archives. Given this risk, and the

uncertainty created by possible bankruptcies or buyouts, librarians are keen that archiving should be a public service.

"Publishers may find it commercially sensible to off-load this eventually to a national archive where access could be managed according to either the terms of a licence from the publisher or under statutory requirements for legal deposit," says Graham Cornish, from the British Library. Ultimately "legislation will be needed to regulate archiving," he adds.

Questions of who is responsible for archiving are likely to be easier to resolve in Europe than in the United States, points out Marcum. Europe has national agencies for archiving information, whereas the closest US equivalent, the Library of Congress, has no national mandate for such activity.

For its part, JSTOR expects to hold complete runs of more than 100 titles in 10 to 15 disciplines by the end of this year. But Ann Okerson, associate librarian at Yale University, argues that JSTOR is unlikely to be a panacea because it is archiving only the leading journals. "These would be the last to disappear," she points out.

Guthrie accepts this criticism, but says that as a non-profit organization it had to start with journals that were likely to allow it to recover its costs through fees charged to libraries for access. "It would be great to archive more obscure titles but hard to find people willing to pay," says Guthrie.

more in terms of developing knowledge environments that integrate a number of relevant sources," says Mike Stout of Oxford University Press.

Who needs journals?

This view of the literature as one vast interwoven content database is in turn leading many to question the utility of the traditional compartmentalization of this information with thousands of journal titles.

The 'serials crisis' has provoked widespread dissatisfaction with the cost of the journal system. Some economists argue that many obscure high-priced, low-circulation journals should exist only electronically if at all, on the grounds that the costs of production in print are prohibitive.

In a typical library, half the journals are consulted no more than 50 times annually, and only 15 per cent more than 250 times, according to Carol Tenopir, an information scientist at the University of Tennessee, Knoxville, and Donald King, a consultant based in Ann Arbor, Michigan (see graph opposite).

But the cost of quality typesetting accounts for \$500 of the estimated average \$2,000 cost of producing a 20-page article,

according to Berkeley economist Hal Varian. This works out at \$5 per person if 100 people read the article, and \$50 if only ten read it.

The conclusion he draws is that, for many journals, these costs are simply not worth it and production standards should be dropped, with typesetting done by the authors. High-quality typesetting would be reserved for higher-circulation journals.

The Los Alamos e-print archives, to which authors submit formatted articles, is a working example of Varian's proposal. Andrew Odlyzko, an expert on the economics of electronic publishing, estimates that each e-print costs between \$5 and \$75 to produce, even taking into account the subsidy of \$1 million over three years that the archives receive for software development from the US National Science Foundation.

Odlyzko predicts that, while high-circulation journals will exist in print and electronic versions for the foreseeable future, the low-circulation, high-cost journals that make up the bulk of the scholarly publishing market will in future exist only electronically.

These arguments are endorsed by Michael Keller at HighWire Press. "I think that the solution to the 'journals crisis' (see page 195) lies in creating a situation where

the journals of very low circulation are entirely supplanted by electronic editions, and where the journals have got to be produced by and for the practitioners themselves."

Information overload

At a wider level, there seems to be growing acknowledgement that the main role of journals in future will be to provide research papers with a guarantee of quality and added editorial value — in terms of making the science more readable, and placing it within a wider perspective for example — while their traditional role as a distribution outlet will become less important.



Ginsparg: pioneer of physics e-prints.



Blume: 'publishers add value to papers'.

The Los Alamos physics archives created by Paul Ginsparg in 1991 now receive some 25,000 new electronic papers annually and have become the primary means of communication for physicists, tens of thousands of whom connect daily. This reality has been acknowledged by traditional journals, and the American Physical Society and several other publishers which now link their journals to the archives.

"We provide an imprimatur and a collection of articles certified as worthy of attention," says Martin Blume, editor in chief of the American Physical Society. "The individual article is not the valuable element, it is [added value put into creating] the collection."

Ironically, electronic publishing is fuelling demand for islands of filtered information in the ocean of information now available. Information overload is frequently cited by scientists as the biggest problem they face in using the web.

The Los Alamos archives have acknowledged this and have arranged with journals such as the *Journal of Artificial Intelligence Research* and the *Journal of Applied and Theoretical Mathematics* to provide peer-reviewed overlays to the unfiltered archives.

Moves are afoot to create a similar e-print archive for the biomedical sciences (see *Nature* 397, 91; 1999). The idea is being championed by Patrick Brown, a researcher at Stanford University School of Medicine, and David Lipman, director of the US National Center for Biotechnology Information, which runs PubMed and GenBank.

It is too soon to predict the prospects for Brown's initiative. But the previously antagonistic attitude of many publishers to the electronic prior publication of articles has

become more liberal over the past two years. Publishers that refuse a priori to publish articles that have been posted on e-print servers — such as the *New England Journal of Medicine* — appear increasingly isolated.

In contrast, over the past two years, *Nature*, the *Journal of Neuroscience* and several other journals have stated that posting on e-print servers does not a priori constitute prior publication, but is rather a legitimate means of communication between researchers (see *Nature* 390, 427; 1997).

The *British Medical Journal* joined their ranks this month. In an editorial, Richard Smith, its editor, argues that journals have nothing to fear from e-print servers. “Strong publication is associated with prestige, credibility, reliability, wide availability, news coverage and permanence... [scientists] want to publish both on e-print servers and in peer-reviewed journals. It’s not either/or but both.”

Brown wrote this month to major journal publishers asking them to publish “an explicit policy statement that distribution of a preprint, by means of a public electronic

preprint server or Internet site, will not influence the decision of your journal to publish a paper”. This would remove one of the major deterrents to wider use of e-print archives.

Virtual peer review

Several journals, including the *BMJ*, are experimenting with making manuscripts available on the web before they have been peer reviewed, and then subjecting them to open, online peer review.

A pilot test on one article prompted a large response from readers. Tony Delamothe, deputy editor, admits that the opinions expressed were of variable quality, but believes that they nonetheless allowed conclusions to be drawn as to whether the paper should be accepted for publication.

The stakes are high, points out Delamothe, given that, in contrast to physics, a change in publication practices could have public health consequences as information about potential treatments would be made public before being validated scientifically. But the journal is optimistic that labelling

non-peer-reviewed material may be sufficient to prevent abuse.

The journal intends to carry out further controlled experiments before changing its editorial policies. It wants especially to establish whether naming referees might affect the quality of reviewing — young referees might refrain from publicly criticizing their elders, for example, for fear of retaliation.

One idea that the *BMJ* may consider is a hybrid peer-review model that combines open online peer review and commissioned reviews. This strategy is being pursued by *Electronic Transactions in Artificial Intelligence*. It differs from conventional journals in that review and acceptance take place after the article has been published online.

The system is yielding better quality papers than conventional reviewing, claims Erik Sandewall, the journal’s editor. He adds that open online reviewing “broadens the concept of scientific publication so that the feedback and quality-control processes become integrated with the author-to-reader communication instead of being separated from it as at present”.

A less remarkable change, but one welcomed by researchers, is the practice of posting papers on the web upon acceptance, often many weeks before their appearance in print. “This is key for me; it is a tremendously good thing,” says Gregory Fu, a chemist at the Massachusetts Institute of Technology.

Electronic publishing is stimulating other innovations in the submission process. The entire editorial procedure of the *Journal of High Energy Physics* is managed by a software robot, which scans papers submitted by e-mail and assigns them to referees on the basis of key words. Authors, editors and referees have real-time access to papers throughout the editorial process.

Unfortunately for publishers and librarians, nobody has invented a software robot that can design winning strategies amid the Brownian motion of the electronic publishing business. Martin Blume of the American Physical Society sums up what many consider will be the only realistic web strategy for some time: “Experiment as much as possible, and be as fast on our feet as we can.” □

Roll over Gutenberg

Many scientists remain strongly attached to the ‘look and feel’ of the printed page, and doggedly continue to download and print web documents, rather than reading them on screen. In doing so, they are contributing to perhaps the largest, though inconspicuous, paradigm shift yet to have been brought about by electronic publishing — the shift from centralized printing to electronic distribution and local printing.

So much for visions of the paperless office. Over the past five years paper consumption has jumped 13 per cent in the United States, with 1,000 billion pages pouring out of computer printers annually.

Some publishers, such as the American Physical Society, are considering whether it might not be cheaper to stop printing low-circulation journals, and just let libraries, or whoever wants paper copies, download files and print whole issues themselves.

The US company Presspoint is already exploiting this idea to print short runs of foreign newspapers in hotels and airports. The digital printing presses required, which skip the conventional preparation of individual typeset pages on film, are becoming cheaper and more widely available. For short print runs they are as or more economical than traditional printing — and quality is the same.

But why do researchers download and print? One answer is that, although even the best monitors may look sharp, they are fuzzy, and their resolution is well below the 200 pixels per inch or so that would make reading as comfortable as on paper. Reading on screen is slower and more tiring.

The first of an expected wave of digital reading devices — or electronic books — Nuvomedia’s Rocket eBook, went on sale before Christmas at \$499. Each can hold the equivalent of a dozen novels, and offers touch sensitive, high-resolution screens.

The content of e-books will initially be restricted to special encrypted book titles downloaded from the web. But Nuvomedia, which has agreements with several major publishers, is looking at other markets. “We definitely have plans to pursue journals,” says Nuvomedia’s Robert Carter.

If Nuvomedia’s vision of scientists carrying their personal libraries around with them seems far fetched, that of E Ink, a company born at the Massachusetts Institute of Technology, appears almost science fiction. E Ink has invented an electrophoretic ink of microscopic coloured capsules that change colour when a tiny electric current is passed through them (see *Nature* 394, 253–255; 1998). Coat the ink onto paper, plug the sheet into a computer, and the sheet can produce high resolution images — black and white at present — that stay when the current is switched off.

Russ Wilcox, E Inks’ vice-president, claims the ink could be used to develop screens with four times the resolution of existing screens. The company plans to create paper books that could display any electronic text. Might researchers soon be able to download their copy of *Nature* and carry it with them on the train? “Absolutely,” says Wilcox. “Electronic ink’s light weight and low power draw make it ideal for such portable applications.”

