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EDITORIAL

"Wired" Science or Whither the Printed Page?

Electronic networks are changing the way scientists communicate and interact with each other—from the casual exchange of gossip and information to the preparation of articles and the dissemination of research results. Currently preliminary results are often available electronically as a means of rapidly bringing discoveries to the attention of colleagues; electronic mail, bulletin boards, forums, and newsgroups facilitate almost real-time discussion among researchers who may be geographically dispersed. Electronic publishing of scientific journals is not merely a hypothetical possibility, but in some cases it is already a reality; for example, the *Journal of Biological Chemistry* (http://www-jbc.stanford.edu/jbc/) and *Astrophysical Journal Letters* (http://www.aas.org/Epubs/eapjl/eapjl.html). Powerful search engines can "browse" large numbers of articles for readers quickly and efficiently, and a local printer provides readers with the pages of a favorite article for extended examination. In time electronic journal publishing may substantially replace printed scientific journals with the promise of accelerating scientific progress and making available the collected knowledge of the ages at one's fingertips.

The scientific community needs to ask some very hard questions about electronic publishing. Electronic journal publishing will certainly affect the social and economic structure of the scientific community. It raises issues that will impact scientific progress adversely if they are not resolved satisfactorily; for example, quality control, authorship, intellectual property, and archivability.

The current practices of peer-reviewed journals ensure that published results have been carefully scrutinized and provide a level of assurance of the quality of those results on which future research can be based. We must face the challenge of devising new mechanisms to ensure the same level of quality control in electronic publishing without sacrificing the advantages of rapid dissemination.

The current system rewards scientists primarily on the basis of critical judgment of authored publications in peer-reviewed journals. With increasing use of highly interactive electronic communications, the assignment of credit becomes more difficult, and we must invent ways of properly identifying and crediting scientific contributions. A closely related issue is that of intellectual property rights and the need to provide the proper incentives for investing in the scientific enterprise. Who controls the distribution of an electronic journal article that can be ported as well as altered so quickly and effortlessly?

Scientific journals serve not only to disseminate new knowledge but also to create a depository of what is known, which is traditionally collected in libraries. In moving from print publishing to electronic publishing, who will assume the responsibility of ensuring that this information can be faithfully retrieved and vouch for its authenticity?

These issues are too important to the scientific community to be left only to those who are developing the technology. The scientific community has much to gain from the new opportunities in "wired" science. Electronic publishing with its embedded hypertext and hypermedia will provide immediate access to a greater scope of information such as animated illustrations, references cited in the article, a link to relevant articles published after the present article, and optional displays of commentary by authors and readers. The static printed page may in time be a poor substitute for the electronic reporting of scientific research. New protocols will be needed to derive full benefit from these possibilities in which the new functionality of the electronic publishing medium alters the message (shades of Marshall McLuhan).

The printed page has had over 500 years to mature, whereas electronic publishing is truly in its infancy. Could we be living in an age in which electronic publishing will revolutionize the dissemination of information as Gutenberg's invention of the type mold revolutionized printing? The scientific community has developed mechanisms to use the printed page to communicate, disseminate, and archive results. We call upon this group to become involved with the complex issues outlined above so that the full potential of electronic publishing to enhance and quicken the pace of scientific progress will be realized.

Shmuel Winograd and Richard N. Zare

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