

not reduce the access to the full record. For those dependent upon indexing services, access to the "deposited" information is generally lost. This is due to the great increase in cost and interruption of workflow which result when indexing services try to routinely obtain copies of the deposited information. The tendency of each primary publisher to establish his own depository amounts to dividing each publication into a publication pair consisting of a formal journal for which routine subscriptions are easily available, and informal copies of deposited material for which subscriptions are unavailable. Control and coalescence of the many separate depositories would be of great value to indexing services.

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The Primary Journal: Past, Present, and Future*

ARTHUR HERSCHMAN

Information Division, American Institute of Physics, New York, N. Y. 10017

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The historical role of the primary journal as a social institution of science, as well as a communication medium, is discussed, with particular reference to its function as the official public scientific record and the prime mechanism for rewarding the performance of research. The impact of various proposed changes in the role of the journal on these traditional functions is also considered, and predictions are made as to its possible future state in a more computerized world.

Since its inception in 1665, the modern scientific journal has evidenced a startling growth (Price,^{1,2} Figure 1). It began with a precursor stage, which seems to be common to most social institutions,^{1,2} went through a period of exponential growth, and finally shows signs of saturation,³ itself the precursor of either stagnation as an institution or transformation into a new institution.^{1,2} In order to understand the nature of this social institution called the scientific journal, let us look at its functions (Table I). There are three which are important: The journal is a means for recording information—the official public record; it is a means for disseminating information—a communications medium; however, it is also a means for conveying prestige and recognition—in short, a social institution.

RECORDING INFORMATION—OFFICIAL PUBLIC RECORD

These three functions are now, and have been from the beginning, completely intertwined. To see this, let us look into them in greater detail. The recording function has several parts: that of a formal means of control of quality through the editor-referee system⁴ (the "gatekeepers," according to Price^{1,2}), and its obverse—

the formal means for validating the author's work to him. It supplies an archive, with all of its implications as an educational and historical resource. As a public archive, it is the resource for scientific scholarship out of which come such distillates as compilations and reviews. It is just this combination of the public archive, the formal validation procedure, and the consensus-forming mechanisms culminating in scientific scholarship which, as Ziman⁵ has shown, transform mere opinion into what we call scientific knowledge. From the point of view of society, this recording function is of great importance. The last, but very important, aspect of this function is the use of the journal for establishing priority, which, as Merton⁷ has shown, is an essential factor in the complex motivation procedures for science.

DISSEMINATING INFORMATION—COMMUNICATIONS MEDIUM

The second function is that of disseminating information. Here also there are several parts. It is a means for communicating scientific information, including tentative information—in order to solicit comment, initiate scientific dialogue; it is a means for disseminating information of interest to scientists: pedagogical, historical, news

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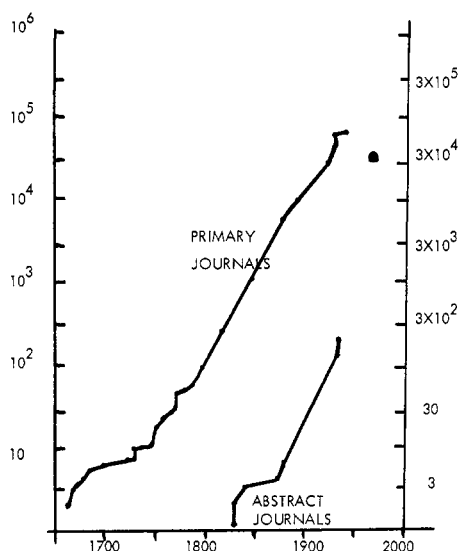


Figure 1. Increase in the world's total number of scientific journals

Table I. Functions of Scientific Journals

1. Recording information (official public record)
 - a. Control of quality (formal validation)
Editor/referee (new; correct; non-trivial; appropriate; intelligible; referenced)
 - b. Storing of information (scientific archive)
Educational and historical resource
Archive for scientific scholarship (data compilations; reviews)
 - c. Establishment of priority (prime motivation)
Support for claims; patents
2. Disseminating information (communication medium)
 - a. Scientific information
Tentative information (scientific dialogue)
 - b. Pedagogical and historical information
 - c. Information about science
Scientist and institutions (news)
Equipment and facilities (new, advertising)
 - d. Contents of literature (information retrieval)
Scanning journals
Secondary journals
3. Conveying prestige and recognition (social institution)
 - a. For authors (prime reward)
Career advancement
Visible progeny
 - b. For institutions (status)
Evaluation of personnel and programs
 - c. For editors and referees (primary reward)
Visible progeny
 - d. For subscribers (visible credentials)
 - e. For publishers (prestige and profit)

of several types, etc. In addition, the scientific journal is a device for information retrieval, in that tables of contents may be scanned. Studies have shown that this is the most important way in which scientists obtain information.⁸⁻⁹ In this last regard, there has developed a subordinate institution organized around abstract journals and current awareness journals (the growth of these secondary journals is shown in Figure 1), with its own momentum and structure. It is in the role of a disseminator

of information that the primary journal is most vulnerable, and where most of the suggestions for change have been directed. In particular, most of the criticism has been made¹¹ in the area of long delay times in the publication process.¹⁰ The implications of this for the journal as an institution will be discussed in more detail later.

CONVEYING PRESTIGE AND RECOGNITION—SOCIAL INSTITUTION

This brings us to the third function, that of conveying prestige and recognition. We have all chuckled over "publish or perish," but have we really looked into its more serious side? It is true that our institutions use this visible means of weighing ourselves and our programs, but the obverse of this, the recognition which we and they gain from publications, is the coin of our realm; it is our reassurance that our life's work is meaningful, as judged by ourselves and by our peers.⁷ This recognition, taken together with our need to believe that our intellectual effort was original (priority), has been formally validated, and is publicly known as our own (dissemination), is the social mechanism by which the community encourages us to be scientists. Our ideas are our property rights, and it is an important contribution of the primary journal as an institution that it has been able to combine publication (the rendering public) of these ideas with the safeguard of priority—largely through its potential speed of publication, its wide circulations, and the activity of the "gatekeepers" in checking for adequate referencing to earlier work.

The importance of speed was apparent from the beginning; witness the following remark from Henry Oldenburg, the first editor of one of the original journals, *Philosophical Transactions*,⁷ in assuring Robert Boyle that he would best protect Boyle's priority rights through prompt publication: "They [your papers] are now very safe, and will be within this week in print, as [the printer] Mr. Crook assureth, who will also take care of keeping ym unexposed to ye eye of a Philosophical Robber [plagiarist]." In part, the failure of journals to maintain rapid publication schedules has had as much, if not more, impact on the priority-recognition aspect of the institution as on its dissemination aspect.

That this is the case today can best be seen from the experience of *Physical Review Letters*, a journal conceived by Samuel A. Goudsmit, its original editor, and presently Editor-in-Chief of the American Physical Society, as a means for rapidly disseminating new ideas in physics. This "urgency" of the idea in a potential paper is an explicit criterion which the referee is asked to judge. However, as can be seen from Goudsmit's many editorials, the popularity of his journal for authors is due largely to the sureness with which they can stake claims.

Prestige and recognition are also important considerations for editors and referees, in that it is the tangible (visible) quality of the product of their labors which is their primary reward. The visible nature of this product is also important for the subscribers—how many of us cover our walls with journals, rather than diplomas, as a symbol of our professional credentials. This same phenomenon, augmented by a more financial consideration, is also the reason for commercial publishers to undertake

their task. In physics, about an equal number undertake the publication of research for reasons of prestige, profit, or national purpose—depending largely on which environment they find themselves in.

TYPES AND QUALITIES OF JOURNALS

Let me summarize this argument as follows: The journal as a social institution has grown tremendously in the last three centuries from its earliest years onward.¹² The scientific journal has also proliferated as to type (Table II), with the different types—primary, secondary, and what has been called tertiary—each taking on various of the characteristics discussed earlier, but in all cases contributing to the positive, socially valuable, qualities of the institution.

The qualities have been brought together in Table III. The importance of the priority and recognition quality has already been mentioned; it is discussed at length by Merton.⁷ The importance of the quality control aspect (Price's "Gatekeeper") is discussed at length by Pasternack.⁴ The implication of the public nature of the archive for knowledge has also been mentioned, and is the prime subject of Ziman's book.⁵ And we have indicated that the journal is still the way in which most people obtain information,^{8,9} although most suggestions for journal change relate to its role as a dissemination mechanism. Let us look at some of these suggested techniques (summarized in Table IV).

SUGGESTED TECHNIQUES FOR IMPROVING MEETINGS

The first group of techniques, relating to scientific meetings, has very little to do with the present subject—

Table II. Types of Scientific Journals

1. Primary
 - a. Archival
 - b. Express (letters)
 - c. Comment
 - d. News (science, science policy, scientist, and institutions)
2. Secondary
 - a. Abstract and index
 - b. Current awareness (titles)
 - c. Bibliography
3. Tertiary
 - a. Compilations (handbooks)
 - b. Review (critical; expository)
 - c. Pedagogical
 - d. Historical
 - e. General

Table III. Values of the Journal as a Social Institution

1. For authors—priority and recognition (discussed by Robert K. Merton⁷)
2. For the scientific community—quality control of input (discussed by Simon Pasternack⁴)
3. For society—public archive open to scholarship (discussed by John M. Ziman⁵)
4. For subscribers—the best way to obtain information (discussed by many, pro and con)

Table IV. New Techniques for Information Dissemination

1. Relating to scientific meetings
 - a. Expanded abstracts
 - b. Video coverage
 - c. Small-group meetings
2. Relating to publications
 - a. Distribution of preprints
 - b. Selective notification
 - c. Selective dissemination
 - d. Generation and distribution of separates
 - e. Central manuscript depository (alerting services, selective dissemination)
3. Relating to information centers
 - a. On-line access
 - b. Referral (switching) service
 - c. Reference service
 - d. Review-writing center

meetings have an even larger history than do journals, and the two institutions have coexisted with only perfunctory overlap for the entire history of the latter. The only points of interest to us now relate to the journal dissemination of expanded abstracts as a means of better communicating the nature of the meetings^{13,14} and the use of the relatively small special-interest conference as a possible means of soliciting the writing of review articles.¹⁵ The former is in the traditional line of journal services, but the latter could likely be an important mechanism for improving what is widely conceived of as being another of the weaker links in the edifice.¹⁶⁻¹⁸

SUGGESTED TECHNIQUES FOR IMPROVING DISSEMINATION

The second group of techniques, dissemination of publications, is directly related to our problem. The distributions of preprints has been widely debated^{11,19} and studied,^{8,9} however, none of the proposals made for formalizing this distribution has made adequate allowances for the economic considerations involved or for the impact of this new institution on the values previously discussed. The major justification given by its proponents is the acceleration of communication—explicitly for dissemination and implicitly for priority claims. We have noted that the now-traditional slowness of journal publication has become another of its main failings. However, even though this procedure of centrally distributing unrefereed and unedited material to all subscribers will undoubtedly increase the speed of transmission of preprints to the subscribers (Table III, quality four—obtaining information), the practice is of questionable value for priority, although of more value for recognition, since the distribution lacks the requisite formal nature (quality one). Preprint distribution is also clearly detrimental to quality control (quality two) and to the concept of the public archive (quality three), since the structure is of the same quasi-public—i.e., not readily obtainable—nature as the report literature.

The technique of selective notification—automatically notifying subscribers of the existence of articles which should be of interest to them—and selective dissemination—actually sending the subscribers articles of interest—have been discussed by many authors.²⁰⁻²² In

its first form, selective notification is entirely compatible with journal structure and, in fact, improves operations. In its second form, selective dissemination does affect the journal structure—particularly in the area of individual subscriptions. However, most journals do not utilize individual subscriptions as an important revenue source,¹⁰ and as long as there is a standard library edition of the journal, the intangible qualities which would affect the editor-referee satisfaction remain relatively undisturbed,^{5,6} and quality two (Quality Control), the only one which was vulnerable, remains intact. Since selective dissemination greatly improves quality four (availability of information), it is clearly a positive innovation to the social system.

The concept of the distribution of separates only has another characteristic, however; here there is no library edition of the journal, and library storage would be a nightmare²³—a separate is printed and distributed as a set of individual articles. Not only are the intangibles of the editor-referee system seriously threatened by this (how many would still be willing to serve?), it is decidedly uneconomic^{24,25} to individuals at present, despite the protestations of its proponents.²⁶ Dissemination of separates is also of unproven practicality, with present facilities in a large-scale enterprise, since the potential routing ability is open to question. In this sense, it may deteriorate quality three, the public nature of the file. Because of this, the distribution of separates only, without the existence of the complete journal in libraries, could be detrimental.

An important variant on SDI coupled with distribution of separates is the servicing of group needs.²⁷ Here the existing journals would be published for archival use in libraries, but articles would be repackaged according to the interests of definable working groups. In physics, such groups seem to have membership ranging between 300 and 3000, averaging about 1000, and there are probably about 30 which can be defined easily. Such groups have well-defined profiles of interest, greatly facilitating the routing of articles to them. Also, recent developments in photocomposition imply the economic feasibility of this process. There are other variants on this process, using microcopy as a backup, which may also prove feasible if user interest in microcopy can be stimulated.

The most serious threat to the institution of journals and to its values as enumerated is the idea of a central manuscript depository²⁸⁻³⁰ in which all manuscripts, unedited and unrefereed, are deposited and then made available to all interested parties, by either an announcement bulletin, selective notification, or selective dissemination. In any of these several forms, it would rapidly debase quality (quality two) to the negligible;^{5,6} none of the distribution forms, with present knowledge, is adequate to insure the manuscript being public (destroying quality three); it is questionable, indeed, if debasing the literature, even if flow could be improved, improves the transmission of information (quality four); and again, the informal and quasi-public nature of the depository protects priority and conveys recognition only in the most legalistic sense (quality one).

Although I have deliberately taken the most negative view of this proposal in its usual form at this time, I will return to it later on, in an entirely different form, in a more positive spirit.

OTHER SUGGESTED TECHNIQUES

The techniques involved in the third group, information centers, like those in the first, scientific meetings, do not directly impinge on the journal as an institution, and are compatible with it. On-line access to bibliographic store is an improvement on retrieval techniques, although rather expensive at this time. Referral (informing the client where he may find what he wants) and reference (giving him the answer) services have existed for some time and should be improved. The concept of a review-writing center¹⁶ in conjunction with an information center with remote bibliographic access and reference services would be another step in strengthening the weak link noted earlier, and thereby the scholarship aspect of quality three, and thereby communication, quality four.

ADVANTAGES AND WEAKNESSES OF JOURNALS

This brings us to another natural place for pausing and taking stock. We have shown that the journal is a complex and large social institution, integrated into the very fabric of the larger social institutions called science and society. Like any such phenomenon, the journal possesses a momentum of its own, which, like Newton's "quality of motion," is proportional to the product of its sheer mass and how fast (in this case, how long) it has been going. We have shown that the institution contributes a number of definite values:

1. It affords priority and recognition to authors, without which their ability to perform as scientists would be weakened.
2. It supplies a means of controlling the quality of what enters the public domain as scientific information, without which we would be flooded by trash.
3. It affords a public archive of scientific information which is open for rebuttal, perusal, and the general forming of a consensus on the part of knowledgeable experts as to what the state of human knowledge is.
4. It is still the best way of transmitting scientific information to the readers.

We have noted that the institution has several weak links. The most important of these are:

1. The journal is a slow and inefficient means of transmitting information, even though it is the best we have. Its very slowness jeopardizes not only its capacity to transmit, but its capacity to properly reward its authors, as well.
2. The institution, in itself, does not seem to be able to motivate a sufficient number of authors to engage in the creative scholarship needed to actively distill the great mass of information down to more manageable packages for transmission and for comprehension.

We have also noted that of the several new ideas which have been presented to improve the information transfer quality, many would do more harm than good, in that they would destroy other journal values in order to improve dissemination speed. Because of the intrinsic momentum of the journal as an institution, it would probably "keep on rolling along," but it would serve us more poorly. The one short-term proposal which seems to have the most merit is selective dissemination of information according to group profiles, where the journal would still be distributed to libraries for archival and reference purposes, but individuals would receive separates according to their group interest. It should be noted before we

leave this subject that such an SDI system, even if made practical, would improve the efficiency of transmission, but not necessarily its speed. Most of the time delay in journals is caused by deficient technology, both in the production of journals and in the management of its own information by editors and publishers. Most designers of information systems are well aware of this aspect and are proceeding to build into their designs the requisite technological details for rectifying this situation. In the short run, it is much more likely that these "nuts and bolts" details will have a much greater effect on the transmission problem than any of the other ideas proposed.

JOURNAL OF THE FUTURE

I promised, earlier, to discuss the central depository idea in more positive terms. I will do this with reference to the blue-sky future, a time when everyone has an interactive terminal built into his desk, a terminal with which he can not only query the public file as if it were the public library (which it well may be), but also a terminal which is the key to his private mail box, with all the assurances of the first-class mail. Given the state of affairs when such a network is operative, we may imagine a system as depicted in Figure 2. We distinguish six types of users of the system—this clearly can be the case in which a single individual plays all six roles in the course of his professional activities. First, we have the user as author, transmitting his manuscript to the mail box of an appropriate editor, and also, if he wishes, to private mail boxes of any other correspondents. The user as editor, after consulting his private file of authors, referees, etc., transmits the manuscript with appropriate questions to the mail box of a referee. After an adequate interchange amongst these three, the editor has the authority to transmit the accepted manuscript to the public file; he is the gatekeeper. Of course, if it is rejected, the author has the same option which he now has—find a more sympathetic editor. Once in the public file, it is available to the user as analyzer (the information service) to put it into the appropriate SDI channels. The manuscript information is also available to the user as

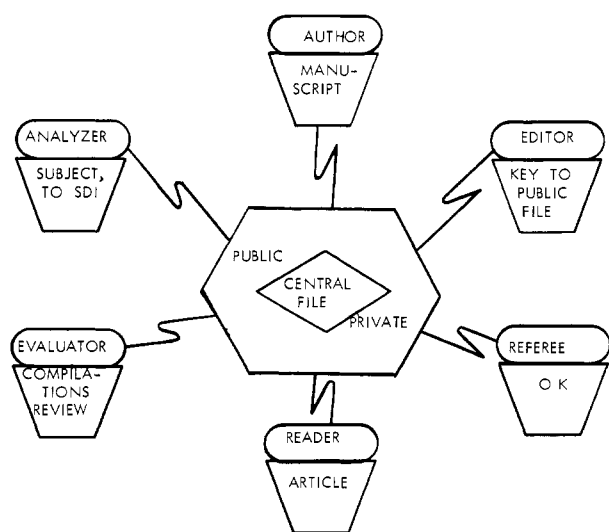


Figure 2. The on-line university

evaluator, through his SDI service to his mailbox or through direct browsing, for distillation into a compilation or review, at which point he becomes a user as author. It is also available to the user as reader, again through SDI or through browsing.

The system has all the requisites needed to preserve and improve the values we have noted. Its drawbacks are, of course technology (the access must be really universal) and tradition (esthetics). The visible evidence of one's progeny is not there. This does not mean that the copy which any user sees, either on his scope, or as printed matter, won't be typographically excellent—it will, but it won't be there to cover your walls and heft in your hand and lovingly finger. All that can be said to this is that when the technology is ready, perhaps we will be also.

CONCLUSION

My caveat today is toward careless planning of our institutions—something which we have had much reminding of in recent years. To summarize the point at issue, consider Figure 3, a semi-logarithmic plot of the way things change—the rate (in arbitrarily chosen units of per centum) in which technology has accelerated, as opposed to the more constant rate-of-change of social institutions. The actual points or curves are merely schematic. What the points refer to is the inverse time lag between the idea of a major invention and its implementation—the one at bottom is photography and the one at top, the transistor. The important thing is that sometime in the not-too-distant past, the curves crossed. Before that time one can speak, as the old saw had it, of "necessity being the mother of invention;" since then, however, it is technology which drives society. And because, by and

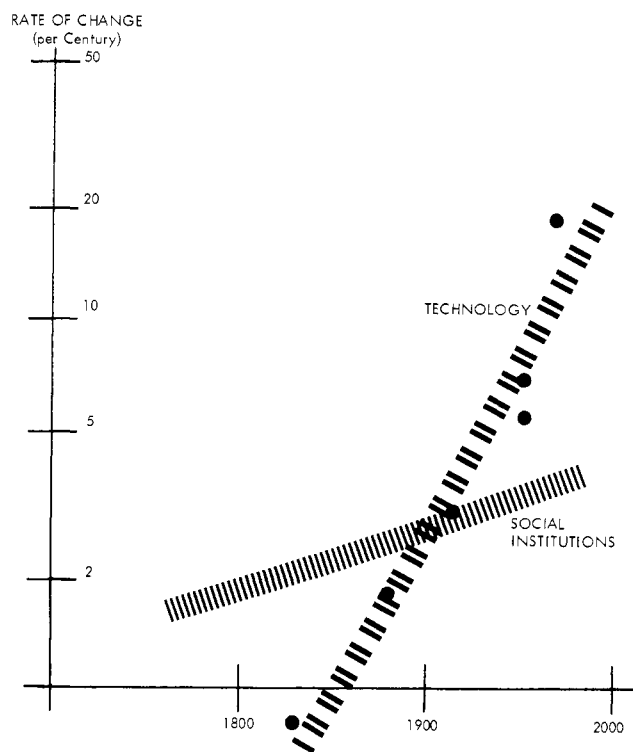


Figure 3. Technological vs. social change

large, the institutions have not kept up with the technology, we have undesirable (unplanned) "fall-out" from the technology. The name which we have given to this fall-out is pollution and the problem of how to fight pollution is one of the most serious which we face. Now the explosion of information, as indicated by the rapid growth of primary journals, is an off-shoot of the technological explosion. The development of information systems is, in this analogy, the development of social institutions to cope with this technological problem. If we allow these institutions to be "driven" by technology in their form of development, rather than plan them in a broader social context, we will increase rather than decrease pollution. In this case, we will degrade the quality of our scientific environment and damage science itself.

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New Developments in Primary Journal Publication*

JOSEPH H. KUNEY

American Chemical Society Publications, 1155 Sixteenth
Street, N. W., Washington, D.C. 20036

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The form and function of the journal as a medium of communication between scientists, that is, one scientist talking to another, have not changed greatly these past 300 years. But during that time, the journal has evolved into a highly effective medium for meeting the scientists' needs for publication, distribution, storage, and retrieval of scientific information. Kessler describes the journal as "the most successful and ubiquitous carrier of scientific information in the entire history of science." And the scientific paper, he adds, "is such a marvelous and accom-

modating invention that we seem to take it for granted and forget that it has form and structure that fit its function."¹

The notion seems to be growing that the journal is approaching obsolescence as a medium for the publication and distribution of scientific information. In his recent ACS Presidential Address, Dr. Cairns used the term, "unintentional obsolescence,"² to describe not only the fate of journals, but the shortcomings of our present information system in general. The report of the National Academy of Sciences Committee on Scientific and Technical Information³ concludes that the primary journal faces trouble because of delays in publication, impact of less

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