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Current Comments

Has Scientific Communication Changed in 300 Years?

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In a recent editorial I discussed the future of scientific publication.[1] I mentioned Joshua Lederberg's EUGRAM—the process of sending messages and "publishing" papers via computer terminals.[2] While Lederberg's preview of the future may cause some readers "future shock," I wondered how much different publication will be in 2001 than it was 300 years ago.

Although the technology of producing copies of scientific communications has changed somewhat, it is the *scale* that has undergone the most dramatic changes. Copyists were available in 17th-century Europe to help you produce a dozen copies of a short paper. After all, that's about the number of readers most papers find anyhow. But just imagine what the copying process would have been like had 17th-century scientists been producing 1,000,000 papers per year. Undoubtedly the automatic ink "copier" would have been invented even earlier.

Since scientific journals and journal articles are so widespread as a means of scientific communication today, we tend to take them for granted. But like so many other things we take for granted, journals had to be "invented." In fact, until the 17th century the idea of the scientific journal had not yet been imagined. And this was about 250 years after the invention of printing.

Although scientific study itself has a long history, until the last few centuries the body of scientific information was so small that there was no need for a formal medium of communication. The ancient Greeks did considerable scientific work, and many other cultures, such as the Chinese and Indian, developed bodies of scientific thought in ancient times. Modern science is largely descended from the Greeks who, until the time of Aristotle, relied mostly on oral methods of handing down their knowledge. After the Greeks, the number of scholars pursuing scientific studies and the amount of scientific literature grew so large that a new form of scientific communication became a necessity. The oral method was certainly inadequate to the task of international scientific communication.

Two major means of communication developed—the private letter, and, following Gutenberg's invention of the printing press in the 15th century, books. Both forms have flourished well into the 20th century. Scientists still write hundreds of letters and other forms of unofficial communications to one another. The photocopying machine makes it even easier. I estimate that in the past 25 years I may have written or signed 100,000 letters of one kind or another. At least a small percentage were "scientific." And the production of books is still substantial. Hence the need for an *Index to Book Reviews in the Sciences*™.[3] But it is the journal article which has become the predominant form of scientific communication today.

The most used of the two types of 17th-century communication was the erudite letter. My old friend David A. Kronick, director of the library at the University of Texas Health Science Center (San Antonio), explained this recently in the new edition of his book, *A History of Scientific and Technical Periodicals*: "The erudite letter was used as a form of exchange for ideas and news of the learned world as well as a form of primary 'publication'. Leibniz, for example, wrote a complete treatise on philosophy in one series of letters...."[4] (p. 56)

Since 17th-century scientists generally worked alone, their letters usually described their own experiments and ideas. A letter was a convenient form and length to report the results of a single experiment. Normally, a letter was written to one particular scientist or, perhaps, copied by hand and sent to three or four people at the same time.[5] The recipient might show the letter to some other friends, but the number of people who actually saw a letter was never large. In addition, the recipients rarely criticized or debated the contents. As a result, unfounded theories frequently survived without challenge.[6]

Although rather less-used, books were a more public medium. A scientist who chose to publish his findings in books, however, had to wait until enough material had accumulated to warrant publication. As a result, books often reported a lifetime of work on a subject and contained so many ideas that they were difficult for other scientists to evaluate.[6] Like the research spread through letters, many unfounded ideas in books went unchallenged.

As a matter of fact there is considerable evidence that the same is true even today. The number of errors in textbooks is legion and some journals even have (or had) a policy against publishing exposures of such errors.[7] Providing access to "corrections" of such errors was one of the original motivations for the *Science Citation Index®*.

As the body of scientific knowledge grew during the 17th century, the tradition of manuscript copying broke down. At the same time, with the introduction of a new science philosophy and new science tools (such as the telescope and microscope), scientists developed an interest in working together.[8] Therefore, they began "to turn to associative gatherings at stated intervals as ways of fostering research and/or communicating...results to one another and the world at large."[9] The modern journal was a direct result of this development.

The associations, later to become societies, offered the scientist a way to legitimize findings and to communicate those findings to other scientists. In a recent article, Kronick pointed out that "one of the ways in which scientists tried to achieve the objectives of verification and consensus was by working together in groups on the same project...or by bearing witness to others' work by reviewing it in societies organized for that purpose."[10] The societies "provided the structure of authority which transformed the mere printing of a scientific work into its publication."[11]

Many societies were formed in Europe during the 17th century. One of the first, begun in Rome, was the Accademia dei Lincei (Academy of Lynxes).[12] The group published proceedings, *Gesta Lynceorum*, which have been identified by at least one historian as the earliest recorded scientific publication by a society,[13] (p. 75) although that fact is debated by other, more contemporary analysts.[4] Unfortunately, there are no details available about the frequency or format of this publication.

A second Italian society, the Accademia del Cimento, flourished in

Florence from 1657 to 1667. The member scientists conducted experiments together and, in 1667, published their results in a book called the *Saggi di Naturali Experienzo Fatte nell'Accademia del Cimento*.[13] The book, which gave the history of all the experiments undertaken by the academy, was translated from the original Italian into French, English, and Latin, and was widely used by other scientists. It is considered the "first important record of the work of a scientific society."[4]

Although the publications from these two societies were by no means journals, they were certainly quite similar. The first bona fide journals, the *Journal des Sçavans* and *The Philosophical Transactions*, appeared in 1665. Despite the fact that the *Journal* anticipated the *Transactions* by three months, most scholars agree that both journals had been planned in advance and this was mostly a matter of chance.[8] Both journals were independent ventures,[14] although they were closely associated with scientific societies. The *Journal* depended on the news and experiments of the members of the French Académie des Sciences of Paris, while the *Transactions* reported on the Royal Society of London.

Denis de Sallo, a counselor of the French Court of Parliament, liked to collect and organize information so that it was easily accessible when needed. He wanted to have a correspondence throughout Europe on events of state and matters of science. Toward this end he started the *Journal*.

The *Journal* was a compilation of "weekly" matters of general interest to the members of the Academy. Bernard Houghton, senior lecturer in information science at the Liverpool Polytechnic, department of library and information studies, says, "The avowed purpose of the journal was 'to catalogue and give useful information on books published in Europe and to summarize their works, to make known experiments in physics, chemistry and anatomy that may serve to explain natural phenomena, to describe useful or curious inventions or machines and to record meteorological data, to cite the principal decisions of civil and religious courts and censures of universities, to transmit to readers all current events worthy of the curiosity of men.' "[5] The *Journal* was a significant step for science as it opened the reports of scientific experiments to public scrutiny. For the first time, scientific work was available to a large number of scholars. (Unfortunately, notes Derek de Solla Price, most readers were Academy members.[8]) It is significant that there is no real modern international counterpart to the *Journal*. There has been a great deal of discussion about the need for a daily newspaper of science. Over ten years ago I made a proposal to the National Science Foundation about such a venture. So did others. I am still investigating the feasibility of a newspaper.[15]

Houghton says the *Journal* was so popular and controversial that it "attracted the attention of the government and it was for a little while suppressed for printing material which offended the crown."[5] In fact, its royal printing privilege was revoked and de Sallo was removed as editor. Under the editorship of other members of the Academy, however, the license was reissued and "publication with varying frequencies continued under the original title until 1816 when it became the *Journal des Savants*, still a leading periodical, but now of a literary nature."[5] The proceedings of today's French Academy of Science are published in the weekly journal *Comptes Rendus*.

Much of the content of the *Journal* was not scientific. Nevertheless, it did contain a number of reports of the

Academy's activities and some reports of original research. For example, in 1667, the *Journal* included a detailed account of Perrault's dissections, and in 1669 described the various machines examined by the Academy, a function mandated by the state. The *Journal* also included discussions on the question of blood transfusion. Christiaan Huygens, founder of the wave theory of light, wrote scholarly letters to the *Journal*. Books were reviewed or, at least, summarized in it. Some of the articles the *Journal* published came from outside France. For example, the Italian lens maker, Divini, contributed an article on his specialty for the 1665-66 volume.[13]

Like the *Journal*, the *Transactions* was initially the work of one man, Henry Oldenburg. Oldenburg was secretary of the Royal Society of London, which was formally recognized in 1662. As in other societies, its members performed experiments and discussed the results among themselves. But the members soon realized that a larger audience for their work would be beneficial. Explains Houghton, they recognized "the need for a truly scientific journal which would, unlike the *Journal des Sçavans*, exclude legal and theological questions but which would be used to record experiments conducted by members of the Royal Society and to publish selections from their correspondence with their counterparts in Europe."[5] Since Oldenburg kept up a voluminous correspondence with scientists abroad,[16] (v. 2, p. xix) he was the logical choice for editor of the *Transactions*. The first issue of this journal was published in March, 1665.[5]

The Royal Society charged Oldenburg with the official responsibility of putting out the journal, but refused until 1753 to designate the publication as an official periodical of the Society. Nevertheless, the *Transactions* contained materials "found" by Oldenburg and "first reviewed by some members" of the Royal Society before publication.[10]

The *Transactions* included more scientific articles than did the *Journal*. It was printed the first Monday of each month, and, except for a "period of dormancy between 1676 and 1683,"[5] it has had an unbroken history. The first issue contained 16 pages, which consisted of a dedication to the Society, nine articles, a selective listing of current philosophical books, and extracts from Oldenburg's foreign correspondence.[5] Articles in this and subsequent issues covered a wide range of subjects. Summaries of works from other publications were quite common, as were articles on scientific instruments. In addition, the *Transactions* soon "constituted an international battle ground of scientific opinions" as scientists used the *Transactions* as a forum for airing their different views.[13]

Science, Technology and Society in 17th-Century England, by Robert K. Merton (first published in 1938), gives an overview of the 17th-century *Transactions*. The book contains quantitative context analyses of the approximately 2,000 articles published in the *Transactions* between 1665 and 1702.[17]

Although the *Journal* and the *Transactions* are the best known predecessors of the scientific communications system we now know, they were not the only journals published in the 17th century. Following their lead, many journals soon appeared in Europe. Many merely imitated the earliest publications; some even borrowed the material printed in other journals, reprinting it exactly. Others summarized the findings presented in the major journals. Houghton points out, "Few of the early scientific journals contained only papers communicating the results of original experiments. Many of them were of the digest type of publication

which claimed 'read us and it is not necessary to read the others because we give you the best.' "[5] (They sound surprisingly like modern abstracting publications.) Nevertheless, there were, in addition to the *Journal* and *Transactions,* some other responsible journals. One such journal, *Miscellanea Curiosa sive Ephemeridum Medico Physicorum Germanorum,* was published in Germany under the auspices of the Collegium Naturae Curiosorum from 1670 to 1705. The Collegium, an association of physicians, was the oldest society in Germany, dating from 1652. Its main function was publication, and it encouraged contributions from all over Europe. *Miscellanea* dealt mainly with medical matters, but also included articles on botany, mineralogy, and zoology.[5]

Saul Jarcho, in his 1971 Morris Fishbein Lecture before the Chicago Society for the History of Medicine, analyzed the first volume of *Miscellanea,* which contained 160 articles: "The text proper consists of a brief communication—which usually ranged from a few lines to a few pages—followed by an editorial comment.... Usually the comment is an extensive review of the relevant literature.... Approximately two thirds of the essays deal with clinical medicine, therapeutics, and pathology, and six deal with some aspect of anatomy, microscopy, and experimental medicine. The remaining 45 papers concern botany, zoology, chemistry and mineralogy...." The articles were not necessarily long, and Jarcho reports that one piece ran only nine lines. He also notes that 14 of the articles were written by the editor, Dr. Philippus Jacobus Sachsius à Loewenheim.[18]

In 1682, another more general journal appeared in Germany—*Acta Eruditorum,* which was published monthly at Leipzig. Supported by the Duke of Saxony, the journal was published by Otto Mencke, "professor of morals and practical philosophy,"[13] in conjunction with the Collegium Gellianum, or Leipsicum, a learned body. Written in Latin, it covered both the sciences and what we today call the social sciences. It was primarily a book reviewing medium, but it served a very important purpose. The journal summarized the work of German scholars, bringing them to the attention of the outside world, while at the same time providing German readers with synopses of work done outside Germany.[13]

Anyone who wanted to publish in a scientific journal 300 years ago had a much easier time than scientists do today. Scientific papers did not follow a particular format or style, and results could be reported with little information to back them up. Says Houghton: "A feature of almost all of the early scientific journals was their lack of critical comment."[5]

More important, however, was the fact that editors were literally desperate for manuscripts (I could name a number of modern journals that have the same problem). "Though the journal was invented because of a growing deluge of printed matter, the early journals, paradoxically, suffered from a dearth of copy. Contributors not being plentiful, editors frequently were obliged to print inferior articles, their own or contributed. Copy which did come in had frequently to be eliminated out of deference to the censor."[19] As a result, any material written by a scientist expressly for publication in a journal was welcomed by the editor.

As today, editors had the prerogative to choose or reject a work, or to ask for revisions. But, because of the shortage of manuscripts, for the most part "editors were forced to adapt themselves to what they could get."[19]

Sociologists Harriet Zuckerman and Robert K. Merton explain that editors

did not receive many original submissions because at first scientists feared the new form of publication. Public disclosure of a scientist's discoveries meant that his work became public property, and authors were afraid that their work would be plagiarized.[11]

In England, authors' fears were assuaged after the Royal Society began to record in their official records the date on which communications were first received. This promoted "open disclosure in exchange for institutionally guaranteed honorific property rights to the knowledge given to others."[11] Scientists also began to recognize that the journals offered quick publication and therefore quick establishment of the ownership of new ideas.

The subject content of many of the early journals was often, by modern standards, quite unscientific. Authors and editors seem to have had a fascination with freaks of nature, and their level of credulity appears to have been high. As a result, much of what was published in the early journals seems outlandish today. One early article in *Miscellanea* "tells of a woman who vomited toads," and another "describes an equally unusual woman who vomited kittens." In the same journal, the editor's note after an article on pseudocyesis (false pregnancy) "tells of women who gave birth to frogs, mice, snakes, crabs, birds, toads, and little fishes."[18]

Journal editors and society members soon realized that by letting such stories go uncriticized, they were tacitly endorsing them. The Royal Society, even though it disavowed formal connection with the *Transactions*, soon developed a refereeing system. Explain Zuckerman and Merton, "The constituted representatives of the Royal Society, looking to its reputation, were in their turn motivated to institute and maintain arrangements for adequately assessing communications, before having them recorded in the *Transactions*. They repeatedly expressed an awareness that to retain the confidence of scientists they must arrange for the critical sifting of materials which in effect carry the *imprimatur* of the Society."[11]

The Society also began to distinguish in print between evaluated and unevaluated work. Pieces that had not been reviewed by the Society often carried this notation: "Sit penes authorem fides (let the author take responsibility for it): we only set it down, as it was related to us, without putting any weight upon it."[11]

Other journals found other ways to affirm the accuracy of the articles they published. For example, by 1702, the *Journal des Sçavans* was edited by state-pensioned specialists, and it is thought that the previous editor had "editorial colleagues during his tenure of the editorship...."[19] The next editor, the Abbé Bignon, developed a board of editors, who were assigned to particular departments of learning. The staff held weekly meetings which "provided an opportunity for criticism and revision of copy before going to press."[19]

These early attempts at journal publication, editing, and refereeing eventually evolved into the system of scientific communication we know today. By the end of the 17th century, the process was well under way. Houghton points out that by 1700, "about thirty scientific and medical journals had been published," and the number expanded "rapidly throughout the following century." By the middle of the 18th century the "journal had become the accepted medium of scientific communication... and its functions were becoming clearly identifiable."[5] In the 18th century the specialized journal became common,

and the research paper, with its characteristic system of citation, took shape in the 19th century.[20]

Now, in the 20th century, we look forward to applying electronic technology to scientific communication.[2] Certainly the editors and scientists who started this whole process more than 300 years ago would be astounded at the scope of the worldwide scientific endeavor. But I doubt that they would have any difficulty recognizing the basically similar characteristics of the system they started. In a future essay I would like to explore the limitations of science 300 years ago due to the oral tradition inherited from early Greek times.

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REFERENCES

1. **Garfield E.** Alternative forms of scientific publishing: keeping up with the evolving system of scientific communication. *Current Contents* (36):5-9, 3 September 1979.
2. **Lederberg J.** Digital communications and the conduct of science: the new literacy. *Proc. IEEE* 66:1314-9, 1978.
3. **Garfield E.** Introducing *Index to Book Reviews in the Sciences*. *Current Contents* (39):5-9, 24 September 1979.
4. **Kronick D A.** *A history of scientific and technical periodicals*. Metuchen, NJ: Scarecrow, 1976. 336 p.
5. **Houghton B.** *Scientific periodicals: their historical development, characteristics and control*. Hamden, CT: Linnet Books, 1975. 130 p.
6. **Porter J R.** The scientific journal—300th anniversary. *Bacteriol. Rev.* 28:211-30, 1964.
7. **Garfield E.** Deliberate omission of explicit citations of textbook errors is irresponsible science communication. *Current Contents* (35):5-6, 1 September 1971.*
8. **Price D J D.** Telephone communication. 28 January 1980.
9. **Garrison F H.** The medical and scientific periodicals of the 17th and 18th centuries. *Bull. Inst. Hist. Med.* 2:285-343, 1934.
10. **Kronick D A.** Authorship and authority in the scientific periodicals of the seventeenth and eighteenth centuries. *Libr. Quart.* 48:255-75, 1978.
11. **Zuckerman H & Merton R K.** Patterns of evaluation in science: institutionalisation, structure and functions of the referee system. *Minerva* 9:66-100, 1971.
12. **Drake S.** The Accademia dei Lincei. *Science* 151:1194-200, 1966.
13. **Ornstein M.** *The role of scientific societies in the seventeenth century*. New York: Arno Press, (1913), 1975. 308 p.
14. **Robertson S.** Cost equation adds up to changes in production methods and format. (Part of a series on scholarly journals.) *The Times Higher Education Supplement* (London) 14 December 1979, p. 10.
15. **Garfield E.** Ever think of *Current Contents* as a newspaper? *Current Contents* (40): 5-6, 6 October 1975.*
16. **Hall A R & Hall M B, eds.** *The correspondence of Henry Oldenburg*. Madison, WI: University of Wisconsin Press, 1966. 9 v.
17. **Merton R K.** *Science, technology and society in 17th-century England*. Atlantic Highlands, NJ: Humanities Press, 1978. 643 p.
18. **Jarcho S.** Seventeenth-century medical journalism, as exemplified by the *Ephemerides Naturae Curiosorum*. *J. Amer. Med. Ass.* 220:64-8, 1972.
19. **Barnes S B.** The editing of early learned journals. *Osiris* 1:155-72, 1936.
20. **Price D J D.** Communication in science: the ends—philosophy and forecast. (DeReuck A & Knight J, eds.) *Ciba foundation symposium on communication in science*. Boston: Little, Brown, 1967. p. 199-209.

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