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Nancy Fjällbrant
Chalmers University of Technology Library

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SCHOLARLY COMMUNICATION -

HISTORICAL DEVELOPMENT AND NEW POSSIBILITIES

Nancy Fjällbrant
Chalmers University of Technology,
Gothenburg, Sweden

Today we are at the threshold of the greatest change in scholarly communication and knowledge transfer that the world has ever seen (even including Gutenberg and the printing press). Developments in computer technology - cheaper processors and memory devices - provide the means for the production and storage of ideas, thoughts, research and experiments in digital form. When this is combined with the possibility for rapid global transfer by means of high capacity networks we can begin to envision a virtual global *knowledge society*. It is, therefore, appropriate to examine the phenomenon of *scholarly communication* in order to see which factors will promote change and the forces that will be in opposition to this. This 1997 IATUL Conference in Trondheim with its theme of ***Scholarly Communication in Focus*** will allow us to study the trends in electronic publishing and how this will affect the users of this literature and the libraries which manage information resources.

1. Introduction

This paper will provide an historical description of the development of the *scholarly journal article* which, in many disciplines such as science, technology and medicine, is the primary accepted means of formal communication - comparable to the automobile and the bicycle as a means for private transport. Will this change and how quickly?

I propose to examine the development and future of the scholarly *journal article* in accordance with the *Social Construction of Technology (SCOT)* technique as developed by Bijker and Pinch **1**,**2**,**3** The SCOT technique is based on the assumption that, for a given situation, a number of artefacts arise. After a time one or more of these artefacts prove to be the "most suitable" for the given purpose and "closure" occurs. The first stage involves flexibility of design with many possibilities. Through a process of selection involving different groups and factors, one solution crystallises out as best, and comes to dominate that particular situation. The SCOT method has, for example, been applied to the bicycle (Bijker & Pinch, 1987) and to the automobile, and to refrigeration and brewing by research workers at the Department of Humanteknologi at Gothenburg University. **4**,**5**,**6** I suggest that the SCOT technique is also applicable in scientific communication where many methods have been used for formal communication, yet one artefact - the *scholarly journal article* - came to dominate the scene. How did this *closure and stabilisation* come about? What are the possibilities for *reopening* the structure in the light of recent technological changes?

The paper will begin with a brief account of scholarly communication. The origin of the scientific journal article will then be discussed, and the various groups involved in the printed journal articles will be described, as well as problems associated with the use of the paper medium. This will be followed by a new scenario for electronic publication via the networks. Finally the possibilities for opening the "closure" of the scientific journal article will be outlined and forces acting for and against this will be discussed.

2. Scholarly communication

Scholarly activity - research - creates a need to spread and share information about the results, methods, new processes and products. The findings are shared and evaluated by colleagues and students. There is a need for both *informal* and *formal communication,* both locally and on a world wide scale. As has been pointed out by Kauffer and Carley (1993) there are a number of important aspects in academic writing: **7**

- ownership of an idea
- societal recognition for the author
- claiming priority for a discovery
- establishing an accredited (sometimes professional) community of authors and readers

Authors are concerned with the "reach" and diffusion of their ideas and findings. Their success and/or influence depends on the extent of the spread and recognition of their texts. This can, at least in part, be monitored by citation indexing, where the pattern of referral to references can be followed. The appropriate tool for the scientific field is the *Science Citation Index*. By this means it can be seen that a few authors are referred to with disproportionate frequency, thereby exerting great influence, whereas the majority of scientific authors are cited less than 50 times in a lifetime. **8**

Scientists communicate both informally and formally. Traditionally the main forms for *informal communication* in science, technology, medicine etc. have been through verbal communication channels - personal contacts with colleagues and teachers in the laboratories or whilst attending lectures, seminars and conferences. Established research workers gradually built up *"the invisible college"* an informal communication network **9**,**10**,**11** The advantage of this form is that the verbal channels were rapid and effective for conveying information and that they are easy and pleasant to use. New research workers, however, lacked to a large extent, this informal network. Today informal communication takes place to a great extent by use of the electronic invisible colleges, based on the use of e-mail, electronic conferences and discussion groups.

Scholarly communication normally leads to some form of *formal publication* (making public) results, findings, observations, and views arising from the researcher's work.

Traditionally these have taken some form of printed material. The advantages of these formal printed channels are that:

1. information can be spread to a widely scattered group of readers;
2. detailed information, such as descriptions of methods, tables, diagrams, results etc can easily be given;
3. printed documents contain information which can be critically examined and verified;
4. the documents can easily be referred to as and when required;
5. published documents provide a means for establishing "priority" of academic work, and thereby contribute to establishing academic merit for the author(s).

The structure of the published literature gradually came to be extremely well-organised. A model for a scientific communication system was described by Garvey and Griffith, 1972 [12]and Garvey, 1979. [13] This model was later found to be applicable in both the physical and social sciences. Literature was divided into *primary publications* and *secondary publications.* Academic libraries have had the role of collecting and preserving material that can be used by both research workers and students, thus giving scholars access to past work (or a portion of it). The journal article and the conference paper have been regarded as the most important types of primary documents for the spread of scientific and medical information.

3. The origins of the scientific journal article

The scientific journal in its earliest form came into being in the seventeenth century - a period of great activity in many areas including science. In the mid- seventeenth century there was a move to provide a co-operative forum for scientists and those interested in scientific work. This period saw the foundation of the learned societies such as the *Royal Society* (founded in London in 1660 and chartered in 1662) [14] and the *Académie des Sciences* founded in Paris in 1666. These learned societies represented a move towards a co-operative organisation for scientists, irrespective of political views or professional association. Many learned societies were established throughout Europe, for example a short-lived society was founded in Dublin in 1683, the *St. Petersburg Academy of Science* was founded in 1725 and the *Royal Swedish Academy of Science* in 1739 (on the insistence of Linnaeus), [15] and the Royal Society of Edinburgh in 1783. [16]

The first scientific journal - the *Journal des Sçavans* - was published in Paris on Monday, January 5th, 1665. This was a private venture of the editor Denis de Sallo. The journal contained "details of experiments in physics and chemistry, discoveries in arts and in science, such as machines and the useful and curious inventions afforded by mathematics, astronomical and anatomical observations, legal and ecclesiastical judgements from all countries, as well as details of new books and obituaries." [17] The journal was originally published on a weekly basis in order to supply readers with fresh and interesting news. The journal had a somewhat chequered career, being suppressed in March 1665. Publication was, however, resumed from January 1666, and a series of one hundred and eleven volumes was published between 1665 and 1792, when the journal was suppressed during the French revolution. It was continued as the *Journal des Savants,* Paris 1797. This journal was of considerable importance in that it provided a model and stimulus for other journals. It was translated as *Journal des Sçavans* , hoc est ephemerides eruditorium by Johan Friedrich Nietsche in Liepzig 1667-1671, and a counterfeit edition was produced in Amsterdam from 1665 to 1792. **18**

One of the aims of the Royal Society, London was to report on scientific work. Members of the Society had seen and discussed a copy of the *Journal des Sçavans*. They decided that a similar, but more philosophical, type of serial publication was needed to publish in particular accounts and experiments presented at meetings of the Society. The first volume of the journal *Philosophical Transactions of the Royal Society*, London, was published on March 6th, 1665. The editor was Henry Oldenburg, one of the two Secretaries of the Society. He was personally responsible for financing the publication. This was the first serial publication of a learned society. It was a medium for publication of new observations and original experiments in science, mostly carried out by the Fellows of the Society. This was a monthly publication of scientific material, together with book reviews and with space for discussions between people holding differing scientific opinions. The *Philosophical Transactions of the Royal Society*, provided a model for subsequent publications of scientific academies throughout Europe. It was translated into French - *Transactions philosophique de la Societé royale de Londres - from 1731 to 1744.* The *Histoire de l' Académie royale des sciences,* Paris (1666-1699) is one example of a publication modelled on the *Philosophical Transactions.*

The journals of the learned societies contained not only original scientific material - papers read at the meetings of the society - but also reviews of scientific work in specific subject areas. In addition, there were reprints of material published elsewhere, and in particular translations. Scientists frequently published their work in more than one journal. The learned societies were concerned with spread and diffusion of scientific knowledge. Indeed at the *Royal Swedish Academy of Science* J.J. Berzelius published *Årsberättelser om framsteg i fysik och kemi.*(Annual reviews of progress in physics and chemistry) from 1822-1850, and these research reviews were translated into both German and French. **19**

In parallel with the publications of the learned societies, scientific journals were published by private "commercial" groups. Thus the *Giornale de' Letterati* which was modelled on *Journal des Sçavans* , was published in Rome from 1668 to 1681. In contrast the *Acta Erutditorum* first published in Leipzig in 1682, editor Otto Mencke, followed the pattern of the *Philosophical Transactions of the Royal Society*. The *Acta Eruditorum* contained many papers by Leibnitz on his work on the calculus. There was a slow growth in the publication of scientific journals in the eighteenth century with some five new titles published between 1700 and 1750, followed by a more rapid growth in the second half of the century, with some seventy new titles including such well known titles as *Annales de Chimie (et de Physique)*, 1790; *Annalen der Physik*, 1799. The oldest Swedish technical journal is *Daedalus Hyperboreus* by Swedenborg, 17161718. The journal *Jernkontorets annaler* was first published in 1817 and *Tidskrift för teknologie och tillämpad naturlära* was published in Gothenburg 18591866. **20**,**21**,**22**

The scientific journal and the journal of the learned societies, did not, however exist in isolation. Other forms for scientific printed communication - were the **letter**, or personal communication, the **scientific book** and the **newspaper**. In addition there was the scientific cipher or **anagram** system.

In the early seventeenth century scientists established priority of discovery by means of an anagram. A sentence announcing a discovery was encrypted into an anagram, which was then deposited with an official witness. The scientist could then continue his work at leisure. If any competitor publicly claimed the same discovery, the original scientist could then refer to his witness to unscramble the anagram, and in this way establish his priority! Meadows (1974) gives the anagram that Galileo wrote to Kepler in 1610:

> *smaismrmilmepoetalevmibunenugttaviras*

Kepler was unable to solve the anagram and Galileo later told him that it stood for *altissimum planetam tergeminum observari (I have observed the uppermost planet triple).* This referred to the rings of Saturn which Galilei had observed for the first time. By this means he was able to gain time to check his observations before making a public official announcement. **23**

Communication of observations and new experiments was often made in the form of personal letters between scientists. This was a method used for transferring news about research carried out by both individuals and groups to other individuals and groups. These were often sent to a person who acted as a "gatekeeper" or a mailbox for transmitting news to other people. One of the most famous correspondents was Samuel Hartlib, born 1600 in Prussia. He emigrated to England and corresponded indefatigably with the European scientific and literary figures of that day, for example Boyle, Comenius (Komensky´), Cromwell, Descartes, Milton, Pascal. and Wren. He collected the papers of other savants and supplied information on demand. A considerable part of Hartlib's extensive correspondence is preserved in the archives of the Main Library of the University of Sheffield, U.K. Topics covered range from military science to astrology, from silkworm-rearing to Pascal´s computer. Much material is about bee-keeping, particularly important as a source of honey for sweetening and preserving. Indeed there is a drawing of a bee-hive designed by Sir Christopher Wren that bears remarkable resemblance to the dome of St Paul´s Cathedral! In 1987, a project was started - the Hartlib Papers Project - funded by the British Library and the Leverhulme Trust, to transcribe and make available the contents of this archive, providing access to the original manuscripts and drawings and to edited and transcribed texts. These will be made available both online and on optical discs. **24** Another well-known gatekeeper was Henry Oldenburg (see above). As Secretary of the Royal Society, he was required to read aloud at meetings of the Society, any letters dealing with scientific topic that he had received. He, in turn, informed his correspondents about new scientific developments in England and the activities at the Royal Society. Examples of these letters can be found in Thomas Birch's History of the Royal Society of London. **14**

> "*During the recess of the society Mr. OLDENBURG kept up his correspondences with several of the learned men abroad, and particularly*

HEVELIUS; the letters which passed between them being extent in the Letter-Book."

"Mr.OLDENBURG read an extract of Monsr. AUZOUT's letter to him from Paris, Decemb. 28.1666. N.S. mentioning a new method esteemed by him better than any hitherto practised, of taking the diameters of the planets to seconds, and of knowing the parallax of the moon by means of her diameter."

"Mr.OLDENBURG produced a letter to himself from Signor MANFREDO SEPTALIO. a curious gentleman at Milan, dated there Aug, 1667, N.S., containing some communications about cockle-shells digged out of a hill in Italy, and about quicksilver found at the root of the plant Doronicum."

"Mr.OLDENBURG produced a paper in Latin by Don ANTONIO AVAREZ DA CUNHA, dated Lisbon, 11 Feb, 1668, N.S...."

"Mr.OLDENBURG read a Latin letter written to him from Venice by Signor FRANCESCO TRAVAGINO dated May 1, 1668, N.S. giving an account of his progress in his new system of experimental philosophy"

"Mr.OLDENBURG remarked that he had several other letter and papers sent him since the last meeting of the society, from Seville. Milan, Paris, Bristol and Yeovil, all relating to philosophical matters;"

"Mr.OLDENBURG read a letter written to him from the Bermudas, dated July 16, 1668, by Mr. RICHARD STAFFORD, sheriff of that island, containing divers particulars relating to tides, whales, sperma ceti, poison-wood, extraordinary webs of spiders, some rare vegetables and the longevity of the inhabitants: which letter was ordered to be entered in the Letter.-Book."

"Mr.OLDENBURG communicated a letter to him from Mr. COLEPRESSE dated at Leyden Nov.20, 1668, accompanied by some facticitious opal , made by rule at Delft...."

"Mr.OLDENBURG produced likewise a letter dated at Seville, August 28, 1668, and some papers of observations made in Mexico, sent to him by Mr. RICHARD KEMP from Seville."

"Mr.OLDENBURG then communicated likewise a letter written to him in High- Dutch, January 30 1669, by a Colonel at Hamburg, named BERTRAND DE LA COSTE, pretending to have found out, after twenty three years search, an engine, called by him Machina Archimedis, able to move any weight whatsoever, which he was willing to show the society..."

As can be seen there was certainly an international information network in the seventeenth century.

The **scientific book** was an established form of communication in science (as well as in other subject areas) prior to the seventeenth century. The Royal Society, and other learned societies, printed books as well as journals. One of the most notable books published by the Royal Society was *Philosphiae naturae principia mathematica Autore Is..Newton. Imprimatur S, Pepys. Reg.Soc. Praeses. Julii5, 1686, 4to Londini 1687.* The publication of a book was, however, a slow and expensive process. The market for scientific books was not large, so a publisher would have to take a considerable financial risk. A book was often the medium to report the work of a lifetime.

The **newspaper** as a means of reporting recent and timely events appeared in the seventeenth century**.** The oldest recorded "modern" newspapers are *Avisa* and *Relation oder Zeitung* which were published weekly in Braunschweig and Strassburg from the year 1609. By 1630 there were some thirty German language newspapers. Newspapers were soon published in other European cities: Amsterdam 1619, London 1621, and Paris 1631 - *Gazette de France.* In Sweden an official news-sheet was published during the 1630s - the forerunner of the *Post- och Inrikes Tidning* published in 1645. The early newspapers aimed to provide news - information - with a minimum of editorial revision. The first newspapers were published weekly, but in 1760 the first daily newspaper was published in Leipzig. By this time roads had improved considerably and postal services were beginning to be reliable.

Seventeenth century Europe saw a large rise in population and this may have been a contributory factor in that the demand for information increased. The science journal and the newspaper thus emerged at about the same time. The newspapers often contained information about agriculture and husbandry. Meadows (1974) mentions that another source of news of a semi-scientific nature was the **popular almanacs** and **calendars** of that period. **23**

4. Closure of an artefact

In the seventeenth century there were a number of alternatives used by scientists for the publication of their work: the scientific anagram, the letter or personal communication, the scientific book, the learned society journal, the commercial periodical, the newspaper (see Fig.1). In addition scientific communication took place by means of verbal communication between scientific practitioners as for example at the Meetings of the new learned societies. Why did the journal paper become the accepted and preferred mode for scientific communication?

In order to understand the choice and final closure with respect to one artefact - the scientific article - we must look at the various sociocultural groups concerned in the diffusion of scientific and technical information. and examine the needs and problems of these various groups and the interactions between them. The dominance of one artefact, from a group of artefacts filling a similar function, is established through the process of selection, based on the needs of the various groups of people interested in, and concerned with, the use of the given artefacts. In many cases, as in scientific communication, there are many groups with an interest in an artefact. The needs of the various groups differ. Closure is likely to occur when a number of these needs can be solved by one and the same artefact or when the needs of a powerful social group are met.

Fig.1. Print media used for scientific communication in the seventeenth century

5. Groups concerned scientific communication

Many different groups were concerned with the spread of information in science and engineering:

- The scientists who wished to publish their work - the **authors - primary producers**
- The scientists who wished to read their work - the **readers**
- Students - **readers**
- The interested amateurs - the general public - **readers**
- The publishers - such as the Learned Societies and (increasingly) commercial publishers - **secondary producers**
- Libraries - which collected books and journals - acting as **facilitators of reading**
- Booksellers - who sold copies of books and journals - **facilitators of reading**
- Legal organisations concerned with settling claims ranging from priority of discovery and authorship of documents - **consumers**
- Industrial organisations - which could make use of the products of the scientific research - **consumers**
- Academic institutions - required a means of evaluating and selecting staff - **consumers** and **facilitators of production**
- Religious organisations - This group exerted influence on the practice and development of science during the seventeenth and eighteenth centuries.

Figure 2 shows the interactions between these various groups.

6. The needs of the various groups concerned with scientific communication

What were the needs of the **producers** of scientific "news." ? The **author** had a number of needs - first that of establishing *ownership* of a theory or experimental observation or result. This was closely connected to the need to *establish priority* and obtain recognition from scientific peers. This could be linked to the possibility of *obtaining sponsorship or funding* for carrying out further scientific work or of obtaining a secure post. It must, however, be remembered that many of the early scientists were in possession of private incomes. An equally important need was the desire to *spread scientific knowledge* to colleagues, a process which usually gives a feeling of *personal satisfaction.* In some disciplines an item may have *commercial exploitation* possibilities. One of the problems experienced by many scientists, even in the seventeenth century, was the *time delay* in the publication process.

Fig. 2. The relationships between groups concerned with scientific and technological communication

Scientists also functioned as **receivers** and wanted to get new information *as soon as possible.* This was important from the point of view of their own research and for teaching others. Another problem was that of *access* to the scientific information. In this context *cost* and *availability* are prime factors. One problem was that of language - if the information was written in Latin, this would only be available to those readers with a classical education. If each country used its own native language, this, in turn, led to limiting the readership. These factors also applied to other receiver groups such as the **general public.** There was, however, a difference between these two groups, in that an important factor for a scientific reader was that of *quality control.* - an early criterion for good scientific work was that of reproducibility.

What about the needs of the **publishers - secondary producers**? Both the learned society journals and the early "commercial" journals were interested in quality control of the material to be published and a vehicle for dissemination that attracted material of high quality. In addition they required a cheap means of printing if they were to achieve a large distribution of their journals. One very important factor in the growth of scientific journals (and other printed publications) was the development of much faster, and therefore cheaper, printing methods. The patent for a steam-driven hand press was taken out in 1790 and in 1810 Konig received a patent for the first implementation of a steam-driven hand press. In 1814 the introduction of the cylinder steam press with self inking rollers increased printing speed from 300 copies per day up to 1,100 per hour (McGarry, 1981). **25** The ease with which texts could now be produced was one of the greatest intellectual stimulants of the "industrial revolution." This development ranks in importance with that of Gutenberg's moveable type in the fifteenth century.

The **learned societies** provided a structure of authority for the publication of material that had been reviewed. The *Philosophical Transactions* of the Royal Society was produced by Henry Oldenburg (Secretary of the RS). In this connection Oldenburg, together with other members of the Society who were interested in publication virtually defined the role of the editor of the *Transactions.* The council of the Royal Society was involved in the running of the journal which amongst other things included the necessity of acquiring material of good scientific quality. This was at first a problem. It is worth noting in this context that initially the Royal Society was composed largely of non-scientists. The main difficulty in acquiring material seems to have been that of safeguarding intellectual property. Scientists still maintained an attitude of extreme secrecy and resorted to personal correspondence with a few chosen friends. The attitudes of scholars in the early print communities have been described by Eisenstein (1979). **26**

The new printing technology made fairly rapid communication possible, yet before this took place, there had to be some mechanism for guaranteeing the ownership of discoveries. The Royal Society played an important role in that it recorded the date on which communications were received. Oldenburg wrote to Robert Boyle as follows:

> "*The Society alwayes intended, and, I think, hath practised hitherto, what you recommend concerning ye registring of ye time, when any Observation or Expt is first mentioned."*

Somewhat later he wrote to Boyle again:

> *"...yet all Ingenious men will be thereby incouraged to impart their knowledge and discoveryes, as farre as they may, not doubtong of ye Observance of ye Ols Law of Suum ciique tribuere"* **27**

Boyle was afraid of "philosophical robbery" and Zuckerman and Merton, in 1971, describe how Oldenburg arranged for the quick publication of a batch of Boyle's papers. **28** In addition the Society provided a permanent record in their archives, a fact appreciated by Robert Boyle in his correspondence with Oldenburg. The Royal Society and the other learned societies had the power and the authority required to change the behaviour of scientists from secrecy to open publication. Scientists wished to have their work evaluated and validated. The Royal Society, though being made up of a majority of non-scientists, yet included the vast majority of English scientists, as well as some from abroad. This allowed judgements to have an authoritative stamp. Here we see the origins of the *review or refereeing of scientific work by peers.*

The need for establishing quality and priority was of great importance. In this connection the referee system in scientific journals plays an important role. The referee system is based on the judgement of academic peers - editors and referees - to assess the suitability of manuscripts for publication. These journal article referees usually express their views confidentially (in contrast to book reviewers). The referee system has origins going back to the seventeenth century, but as pointed out by Zuckerman and Merton, it did not "appear all at once as an integral part of the social institution of science. It evolved in response to the concrete problems encountered in working toward the developing goals of scientific enquiry and as a by-product of the emerging social organisation of scientists."

The method adopted for peer review had the additional advantage, from the publishers point of view, of being inexpensive. It is a measure of the effectiveness of this system that it still exists today in a largely unchanged form among the "prestige" journals in science and technology. The development of the peer review system has played a large part in establishing the scientific and/or professional article as the main vehicle for publishing scientific work. It has been of great importance for the closure mechanism.

Another aspect of importance was the relationship between the **legal authorities** such as the courts and the publishing industry and authors. During the sixteenth century, publishing in England had been the monopoly of a cartel - the Congers. This group possessed the right of granting publishing licences and this could be withheld from a freelance publisher. They insisted on fixed *copyright* fees and insisted on their right of perpetual copyright. Prior to 1709 an author had no copyright to his own work. In 1694 the Licensing Act lapsed and as a result there was a chaotic situation until a court ruling in 1709 - the Statute of Anne - which reduced copyright to 21 years. The court ruled that only the author could claim permanent copyright (the term "author" could however be used interchangeably with anyone who held a legal title). Authors were required of publishers to surrender their right to perpetual copyright in exchange for being published! This was later changed in a famous case - Donaldson v. Beckett (1774), which was instrumental in changing the perception of copyright to an author's property rather than that of the publisher. In this way a scientific author had some legal guarantee of intellectual ownership for his published material. The scientific journal in the seventeenth century was simply used as a method for improving communication between the research workers of that time. However the 1709 copyright act changed the concept of the journal article. This became a means to register "ownership" of a given theory, method or process. The journal article became a means of registering ownership and establishing scientific priority.

The issue of *quality control* was also of great importance to **academic institutions** and later to sponsors and the modern patrons of research - the funding organisations.

7. How did the various early artefacts meet these needs?

If we examine the various print media available n the seventeenth century, we can see that the *anagram* and the *deposited scientific account* were both aimed at establishing priority at the expense of diffusion of knowledge. The scientific *anagram* had obvious disadvantages and many anagrams were (purposefully?) very vague. Should priority be given to an idea or to the work which proved a given point? The anagram system did not provide the means for the dissemination of information and for scientific communication.

Personal correspondence continued between scientific practitioners. Leibnitz considered the possibility of establishing a network of correspondents towards the end of the seventeenth century, when he was trying to establish the Berlin Academy. Personal correspondence was used as a form of early communication - perhaps asking people to repeat and verify experiments. It could not, however, easily be used to establish priority or for widespread diffusion. The term letters has been preserved in some present day journals aimed at rapid publication, for example *Electronics Letters.*

The *scientific book* which was costly to produce and distribute, was also a very slow means of publication. It served, therefore, the role of diffusion but was unsuitable for establishing priority. Important research continued to be written up in the form of a scientific monograph, throughout the eighteenth century, but this tailed off toward the middle of the nineteenth century particularly in the physical sciences. The relationship between the book and the journal article for publishing primary findings was, however, not clearly limited. Bazerman (1988) examined the first hundred pages of the *Dictionary of Scientific Biography* and found a number of examples from the eighteenth century with mixed publication artefacts: Michael Adanson (naturalist), André Ampère and Franz Aepinus (mathematician-physicists) and Franz Karl Archard (chemist). In the biological sciences monographs were still used, one well known example being Charles Darwin's *The origin of the species,* which was published in 1859. Even in the twentieth century there are cases of primary information being presented in book form, for example the work of the radio physicist **29** Edward Appleton and the astronomer Robert Aitken. The price of the book also meant that it could only be bought by a limited number of research workers. The spread of knowledge was therefore facilitated by the **libraries** which enabled a greater number of readers to share the same published information. It can be noted that some early learned societies such as the Royal Society and the Académie Royale des Sciences published monographs as well as journals.

The *scientific journal,* in which a number of relatively short articles, not necessarily on the same subject, could be collected together, allowed for more rapid publication than the book. In addition, the journals that were published by the various **learned societies** carried a "hallmark of quality" in that they published experiments carried out at Meetings in front of Members of the Society. They provided a forum for discussion and authentication. The original commercial scientific periodical the *Journal des Sçavans* was aimed at "interested amateurs" with a weekly publication to meet the wish for up-to-date news and a slight publication. Subsequent commercial periodicals such as the *Acta Erutditorum,* however, tended to follow the pattern of the learned society journals. Thus the periodical published by both the learned societies and the commercial publishers came to solve many of the problems of the scientific authors: diffusion of knowledge, some form of quality control, and fairly rapid publication (as compared with the book).

The *learned society journal* was usually published in the national language of the country of the society. Latin was, however, acceptable for communications from countries such as Sweden or Denmark, with native languages that were not widely known. This had the advantage that people who did not have a classical education could understand most of the published information from their own country. There was that disadvantage, however, of many people not understanding the scientific information available from other countries. This was a particularly difficult problem for scientists working in a country with a little known language. Meadows gives the example of a seminal contribution to the new science of spectroscopy, in the mid-nineteenth century, that was almost entirely ignored because it was published in Swedish.**23** The journals produced by the academies were intended to be a record of the activities and interests of the societies. They often contained reviews and translations, as well as providing a forum for debate. One problem with these journals was the increasing time delay between actually presenting a paper and getting it published.

The commercially produced scientific *journals* as mentioned above began to increase in number towards the end of the seventeenth century. There was a clear dominance of German language publications during this period. These "free-standing" scientific journals were designed to fill some of the needs of scientific authors. For example the important journal *Observations et mémoires sur la physique, sur l'histoire naturelle et sur les arts et métiers* edited by the Jean Baptiste François Rozier and published in Paris 1773 was designed to include articles in the language of the author and to be published monthly and include more recent material than the journals of the learned societies. (The journal of 1773 is a continuation of a previous journal published in 1771) **18** In the information to the reader in the Preface of Vol.1, 1773 some of the reasons for the necessity of a new type of journal were given. **30**

> *"Cettes motifs ont fait desirer qu'un Ouvrage périodique, d'un débit sûr & animé, annonçât les découvertes que se font chaques jour dans les différentes parties des Sciences, soit par des Notices abrégées, soit par des Mémoires très-étendus, qui continssent le développement de toutes les preuves de ces découvertes, en traçant même la marche de l'esprit inventeur. On a pensé que ce moyen, le plus prompt pour la publication des découvertes nouvelles, accéléreroit également le progrès des Sciences, qui ne sont autre chose que la somme de ces découvertes."*

The new journal contained not only observations relating to physics, but also news from other scientific disciplines, as well as articles outlining the historical development of science.

The first truly subject specialised scientific journal - *Chemisches Journal für die Freunde der Naturlehre, Arzneygelahrheit, Haushaltungskunst und Manufakturen* - was produced and edited by Lorenz Florenz Friedrich von Crell from 1778 to 1781 (6 volumes), followed by *Neuesten Entdeckungen in der Chemie* (1781-86). Von Crell edited a number of chemical journals during the last quarter of the eighteenth century. These include *Chemisches Arkiv* (1783), *Neues Chemisches Arkiv* (1784-1791) and the*Chemische Annalen für die Freunde der Naturlehre, Arzneygelahrheit, Haushaltungskunst und Manufakturen* - (1784-1804).

During the last quarter of the eighteenth century twenty-five new journals were published. Of these thirteen were in German, five in English and three in French. These included the *Annales de Chimie, ou Recuil de mémoires concernant la chimie et les arts qui en dependant* published in Paris 1789-1815 and the *Philosophical Magazine, comprehending the various branches of science,* published in London, by Taylor and Francis, (1798-1813) and continued as the *London and Edinburgh Philosophical magazine and journal of science.* The relatively rapid rise in published scientific journals showed that these filled a need for publication and diffusion of scientific discoveries. The start of subject specialised journals indicates a growing volume of information within certain subjects and an attempt to meet the needs of the scientific reader for *easy access* to what was perceived as *relevant i*nformation.

The improved roads and postal services provided a means for relatively quick distribution of journals to a number of subscribers, at least within one country. Print media aimed at the general reader - the *calendar or almanack* and the *newspapers* - provided a fairly rapid form for publication and distribution, but was non-selective, so that a reader would have to go through a lot of material in order to find a very small item of scientific interest.

The interests of most of the sociocultural groups concerned with scientific publication appear to have been fairly well met by the journal article and this consensus led to the recognition and adoption of the scientific or professional article journal and/or conference paper as the most important vehicle for scientific dissemination in the majority of scientific and technical disciplines.

8. Will the closure persist?

The printed scientific and/or professional article has dominated the diffusion of scientific and technological information for some two hundred years. We may, however, be on the threshold of an "opening" mechanism. This is in part due to the problems with the traditional printed journal article, and in part to changes in technology which would enable an extremely rapid transfer of information.

9. Problems with the printed journal article

There are a number of disadvantages or problems with this traditional printed journal article. First of all current formal pattern of *printed* communication is relatively **slow.** If the research is such that a patent can be applied for, this will be the first form of printed communication. At about the same time some form of internal report and/or seminar paper may be published. This may be followed, after an interval of a few months, by a conference paper and/or an external report, possibly to a funding organisation. During this time the manuscript for a journal article is being prepared, checked and revised. This manuscript is sent off to the journal editor about four to six months after the completion of the research. Sometimes an article is accepted directly, but in the case of the refereed journal, it is passed on to one or more referees. These may suggest revision and alteration. The average time between the completion of a research project and a published journal article is often as long as eighteen months. It should be noted that there are some journals which specialise in more rapid publication - examples are *Electronics Letters, and Physical Review Letters.*

The traditional publishing process is **expensive** which means that few scientific and technological practitioners can afford to buy more than a limited number of journals. In this context **libraries** have played an important role in disseminating information by making periodicals available to many users. Increasing costs for serials, coupled with relative decreases in library acquisition budgets have led, however, to a shift in emphasis from collection building in anticipation of possible needs (JUST IN CASE) to information access on demand (JUST IN TIME) delivery. so that local immediate **access** is not always available. Indeed academics have begun to protest that they do the work, and provide the texts for journals that their institutions no longer have the money to buy. A few major libraries such as the British Library Document Supply Centre and Technische Informationsbibliothek, act as major suppliers. If a journal article has to be obtained from abroad, there is an access **time delay** due to time taken for delivery. Another problem for libraries is that the journals take up a lot of **storage** space.

In addition there are a number of problems associated with the **refereeing process** and the establishment of scientific priority: One undoubted effect of the refereeing process is the time delay in publication. **31** This situation is rather similar to that which we saw in the case of the learned society journals in the late seventeenth and early eighteenth centuries. Another disadvantages that has been pointed out is that the refereeing system tends to favour articles submitted from prestigious institutions (corporate sources). **32** Even more important, it has been suggested that the refereeing system tends to suppress new ideas **28,32,33** The question is sometimes asked "Is the refereeing system really impartial?" One of the problems is that there is so much at stake - as the validation provided by the scientific article is used for obtaining patronage or funding, the extremely competitive nature of modern research has created a situation when the referees may be, if knowledgeable about a given topic, active competitors for grants. The temptation to delay or downgrade information from a parallel research team is obvious.

10. An alternative scenario - electronic publishing

Traditional publication costs have risen sharply within the last ten years, whereas computing and communication costs have fallen. The vast majority of research workers produce material for publication with the help of word-processors. The text (and in some cases the graphics) is available in digital form. There are a number of alternatives for electronic publication. These have been examined by Schauder (1993) in some detail. **34** They include publishing on some form of transportable memory such as an optical disk, for example CD-ROM or CD-I, or making full-text, (with or without graphics and pictures) available online via communication networks. Fig. 3. outlines an alternative electronic publishing scenario.

Scholars now have access to global networks from their workstations and personal computers. These networks are increasing in speed and capacity. We have moved from the kilobit networks to megabit networks and are now approaching the era of the Gigabit (or "Quite a BIT") networks. How can the networks help the research worker? Can they provide a medium for alternative publication?

11. The development of network publishing

The research networks offer a possibility for the electronic publishing of information. This might in time revolutionise the procedures of scholarly communication, but at the present we are far from the "paperless society" envisaged by Lancaster 1977. **35** Early work on electronic publishing began in the 1970s with, for example the studies performed on behalf of the National Science Foundation by King and his associates. **36,37.** These studies examined the roles of the various actors: authors,

Fig.3. An alternative scenario - electronic publishing

publishers, librarians and readers with respect to journal publishing and the possibility of an electronic alternative. King concluded in 1980 that the main barrier to electronic publishing was the lack of incentive for participants to change their behaviour. An early European initiative was the BLEND (Birmingham and Loughborough Electronic Network Development Project) supported by the British Library Research and Development Department from 1980 to 1984. The aims of BLEND were:

> "*to explore and evaluate various forms of user communication through an ' electronic journal' and information network and to assess the cost, efficiency and objective impact of such a system" **38***

BLEND was followed by a second BLR&D project on electronic publishing - Project Quartet, which covered not only electronic publishing, but also e-mail, computer conferencing, online databases and automated document delivery services.(Tuck et al, 1990) **39** During Project Quartet a number of user studies were carried out. The results obtained showed that users were unwilling to change their styles of information handling or that "*inertia triumphed."*

In parallel with these surveys and research projects, a number of "academic" publishers began to offer selections of established journals in a full-text form, by means of the online database hosts such as BRS, DIALOG, SDC and STN. In 1983, the American Chemical Society offered full-text versions of eighteen primary journals through the BRS online system.(Garson & Howard, 1984). **40** The advantage to the user was speed of access. Similarly Elsevier offered a number of biomedical journals via the BRS system from 1983 onwards. The American Chemical Society developed a regular commercial parallel publishing system for both ACS journals and some chemical journals from other publishers by means of the *ACS Chemical Journals Online* service Martinsen, Love & Garson, 1989). **41** This form of parallel printing offers an interesting option of article access on demand - *Just in Time* - rather than the traditional option of - *Just in Case* - by means of either personal or library subscriptions.

The Internet offers an obvious potential for electronic publishing and distribution of scientific and technical information. There have been a number of trials of scientific journals in electronic form. Examples are the Elsevier TULIP and Nuclear Physics Preprints projects. **42** In April 1993 preprints of articles accepted for Nuclear Physics A and B, were made immediately available to subscribers over the Internet. **43** These articles were released prior to publication, thereby saving some 5 months. Other projects include Red Sage. **44** and the trial by the Institute of Physics within the field of materials science. These, and other tests, have lead to the development of commercially available electronic journals available by subscription

Within certain fields such as high energy physics and astronomy, there are already well-developed pre-print services which are available through the Internet. The following areas are particularly well-covered: high energy physics, superconductors and astrophysics. Communication in high energy physics or particle physics is characterised by the use of electronic preprints and e-print electronic archives (Ginsparg, 1994. & Hurd, 1996). **45**,**46** Similarly in astronomy, astrophysics and space physics, data is collected and tabulated and may be accessed by institutions or individuals. A guide to sources - Astronomy Web Resources (ASTROWEB) provides addresses for links to: guides and directories, catalogues and online databases, object oriented resources, telescope and observatory archives and home pages, software archives, preprints, newsletters and journals, library and information resources. The URL is:

http://ecf.hq.eso.org/astroweb/yp_astro_resources_new.html (Crawford,1996 & Taubes, 1996). **47**,**48** Another area in which electronic communication plays an important role is in biomedical field. One example is the Human Genome Project - the mapping and sequencing of the human genome with both bibliographic databases such as AGRICOLA; BIOSIS; VAS Online and MEDLINE and databases containing nucleic acid sequencing infomation: GenBank, European Molecular Biology Laboratory, DNA Data Bank of Japan, GSDB, the National Centre for Genome Research, Los Alamos Nantional Laboratory. Producers from all four databases co-operate in an effort to make available all known DNA and RNA sequences from any organism. (Bishop, 1994, & Weller, 1996) **49**,**50**

Will these areas show the way into a new model for electronic scientific communication? Will this be an electronic version of the Garvey/Griffith model, or will there be a radical change where journals no longer exist as such and peer-reviews are a thing of the past?

12. Groups associated with electronic publishing

The groups concerned with the electronic publishing of the scholarly journal article are:

- **Research workers in science, technology and medicine -** these act as both producers (**authors**) and consumers (**readers)**
- **Academic teachers**
- **Students**
- **General public -** interested amateurs
- **Journal Publishers** (These are of two main kinds: *the learned and professional societies,* such as the Institute of Electrical and Electronic Engineers (IEEE) and the American Chemical Society (ACS), and the *commercial publishers* such as Elzevier and Springer Verlag)
- **Computer and communication specialists**
- **Vendors - Subscription Agents** - for example Swets & Zeitlinger and Blackwells who handle the sales and distribution of the journals and periodicals
- **Booksellers**
- **Librarians** - university and research libraries buy a large number of the published journals
- **Academic Institutions** for the evaluation of research and the selection of staff
- **Funding organisations -** the modern "patrons" of research and development
- **Industrial organisations** - who make use of the products of research in science and technology
- **Legal organisations** concerned with settling claims ranging from priority of discovery to authorship of documents
- **Religious organisations** - This group is today a factor in the ethical aspects of scientific work - as in the discussions on genetic bioengineering
- **Politicians -** This group is becoming very active in promoting the use of information technology as exemplified by the networks - the information super- highways

How are the needs of the various groups being met today? A particularly interesting study has recently been carried out, in the United Kingdom, by representatives of three of the groups - the Royal Society (learned society), the British Library and the Association of Learned and Professional Society Publishers (ALPSP). [51] This study was directed towards the use made of learned journals, books, conferences and workshops and informal communications between individuals and groups of researchers in the scientific, technical and biomedical fields. The traditional print media system described above is under considerable strain due to the continuing growth of published material. Academic libraries no longer have the economic means to buy as much material as previously. In addition the possibility of dissemination by electronic networks presents alternative possibilities. We have, therefore, a system in a state of flux - a situation which may provide the opportunity for an "opening" of a previously fixed artefact.

The needs of the producers of information - the authors - are of prime importance. We have seen that scientific/professional article met needs of establishing priority, giving societal recognition and so on in the eighteenth century. Today these needs are not fulfilled to the same extent. The long delays in publishing in print form threaten both the diffusion of information and the establishment societal recognition and, therefore, security of employment and obtaining research grants. The refereeing process is coming under question. One of the reasons for the delay in publishing is based on the fact that the group of scientific authors is increasing. Many more students, in more and more countries, are now actively engaged in research which is publishable. Not only that, the use of modern computer-based tools for measurement, calculation and for word-processing has speeded up the actual process of research. The individual scientist has, as a receiver, a need to obtain information rapidly and cheaply and this need is only partly satisfied by the current printing on paper medium. What emerged very clearly from the Royal Society report was that many users of the STM system were unaware of many of the new tools and methods for information retrieval. This lack of awareness had been described by Kathryn Wareham, Project Co-ordinator, Royal Society, in a discussion in April 1993 - Personal Communication). The Report made the recommendation (R 2.) that :

> *In view of the widespread ignorance of the availability of the new library research tools, **libraries in academic and research institutions** should routinely provide training for user and information providers in information access.*

An important limiting factor is that the costs of traditional publishing in print form continue to rise. [52] Neither the libraries nor individual users can afford to buy as many journals as previously.

Another study on University Libraries and Scholarly Communication, was that carried out under the auspices of the Mellon Foundation and published in 1992. Chapter 9 was devoted specifically to electronic publishing. [53]

13. Problems associated with electronic publishing

In spite of the examples given above, it can be seen that electronic publishing can hardly be said to have taken off in a big way, and the question is why not? There are a number of problems associated with electronic publishing:

- Standardisation
- User resistance to change - inertia
- Network access
- Copyright and establishing priority
- Risk for plagiarism

Standardisation of format is a key issue for electronic publication. Clifford Lynch suggests that there are three approaches:

1. to deal with the basic "Raw" text by tagging such as with SGML - Standard Generalised Markup Language, which can deal with content - chapters, parts,

etc, but requires extra handling for images, thereby producing compound documents.
2. use of a page markup language such as PostScript, which includes text plus typesetting directives and allows a user with appropriate hardware and software to reproduce the page as it appears in print.
3. Use of bit-mapped images to produce a picture of a page. 55

Do the authors of scholarly publications know how to deal with all this? Until there is cheap, reliable and generally available software for the academic community, I suspect that authors will not be prepared to put in the extra effort involved. Another question is that of "critical mass." Until there is an easy way of distributing the journal to the sector of the academic community that the author wishes to reach, then interest will not be high. The distribution of the journal should be reliable and the product should be presented in an attractive form in order to attract readers.

Another very important issue is that of potential adulteration of text, plagiarism etc. It is much easier to change an electronic networked text than a printed text or a text available in CD-ROM form. The copyright question is complex, as well as varying from country to country. In some cases the conversion of material to electronic form is not permitted and storage in electronic form is not allowed.

14. Will there be an "opening" - a change in the dissemination of scientific information?

Will the **research workers** move towards electronic publishing? Why does an author publish a scholarly communication? It is certainly not for the direct financial reward! Indeed a number of journals, such as the *Astrophysical Journal* and the *Astronomical Journal,* ask for payment per page for the publication of scientific results. The rewards are to be found in the pattern of academic recognition. Scholarly achievement is an important element in academic appointments. There is a well-known structure for the traditional form of publications of the journal article and the scholarly monograph. Dare the researcher chance recognition (or plagiarism) through the academic networks? The question of quality control in an unrefereed journal arises. Would publication in such a source carry merit? Can priority be guaranteed when the text can so easily be altered? These issues will have to be solved before we get a wide acceptance of electronic publishing from the research workers.

At this IATUL Conference we have representatives of scientists, publishers, subscription vendors and database suppliers, academic teachers, members of the general public as well as library managers library managers. I am looking forward to hearing the views of the various experts on the Future of Scholarly Communication and hoping for lively discussions between participants.

15. Links

Links to sources dealing with **Scholarly Communication:**

- **New Horizens in Scholarly Communication** published by the Librarians Association of the University of California
- **Scholarly Electronic Publishing Bibliography** published by Charles W. Bailey, Jr., University of Houston Libraries

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