Dissemination of Medical Information: Organizational and Technological Issues in Health Sciences Libraries

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ABSTRACT

THIS ARTICLE DESCRIBES five programs that have been particularly significant to the evolution of biomedical communications over the last twenty years: the National Network of Libraries of Medicine (NNLM), Integrated Academic Information Management Systems (IAIMS), National Research and Education Network (NREN), Unified Medical Language System (UMLS), and the electronic journal. In addition to the changes that these programs have already brought about, each will continue to have major implications for health sciences librarianship.

INTRODUCTION

From a patient's bedside, a physician calls up the patient's chart, orders tests, consults a clinical data system, and examines relevant professional literature. Back at the office, the same physician consults with colleagues from the same institution and around the world with equal ease, sharing pertinent records and images, and consulting with the literature as needed. Carrying out research is facilitated by easy access to patient data, research calculations and findings, and the descriptions of earlier research results. To keep up to date, the physician reviews a personal database tailored to his or her interests that contains such things as notices of grants, new research findings, new reviews of clinical and research issues, and news of the institution. As large or small information needs arise, these too are met by the

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physician's information system with its access to a wide variety of clinical, research, administrative, and general information.

Views of extensive and readily available information sources and services have been with us for decades, going back to Vannevar Bush's 1945 vision of Memex—the library in a desk (Nyce & Kahn, 1991). The scenario of the physician adds detail to the picture, incorporating examples of the types of information sources needed and the ways in which they might be used. Over the years, these scenarios of "information when and where it is needed" have been used to stimulate thinking about steps toward the development of such a vision. Also to be considered, and the central focus of this article, is the role of the library in achieving such a vision.

In the previous *Library Trends* issue on health sciences libraries, Louise Darling (1974) wrote of the changes in information delivery in health science libraries through the 1960s and early 1970s. She concluded that developments in those years pointed health science libraries toward "one still distant goal" (p. 57), that of the library as "communications center working actively with informational materials of all kinds, close at hand or distant, for health professions users in the community as well as in the institution" (p. 58). In 1993, the goal remains the same, and health sciences librarians can report that significant progress has been made toward that goal. At the same time, there have also been major changes in the activities that libraries perform in support of biomedical communication.

Progress has been made in extending the range of materials that librarians handle, in improving the delivery of information and materials, and in reaching out to users in and beyond the local institution. Organizational and technological changes have been key to many of these improvements. Many new technologies are available, and libraries continue to be early adopters of the new technologies, applying them in innovative ways for the improvement of services. At the same time, librarians have built on and increased collaborative efforts, using this form of organization to create linkages with other libraries and with other information providers both internally and externally.

This article describes five programs that have been particularly significant to the evolution of biomedical communications over the last twenty years: the National Network of Libraries of Medicine (NNLM), Integrated Advanced Information Management Systems (IAIMS), the National Research and Education Network (NREN), the Unified Medical Language System (UMLS), and the electronic journal. In addition to the changes that these programs have already brought about, each will continue to have major implications for health sciences librarianship.

A Model of Biomedical Communication

Orr et al. (1964) have described the biomedical information complex as a system, in the same sense that a living organism is a system. Both have evolved in response to needs, and both are self organizing and were not intentionally designed. Society has institutionalized communication patterns for knowledge transfer, such as professional meetings and their recorded proceedings and the publication and distribution of papers. Each of these communication methods became institutionalized when there was a significantly large group to require a common service.

The system that has evolved is a complex one, including many functional activities that are essential to communication. There are also several groups of players in the system, each participating in the overall dissemination of information but acting with individual goals and constraints (King et al., 1981).

As shown in Figure 1, the biomedical communication system begins and ends with the research generation function. The form of the model, a spiral, suggests the continuous and regenerative nature of the communication process. As a result of research, manuscripts are composed—i.e., written, edited, and reviewed, and then recorded. These two functions are currently carried out by authors and publishers.

Reproduction and distribution are traditionally the role of the publisher, but authors and libraries can also play an important role. Once ready for use, materials are sometimes distributed directly but more often are acquired and stored for later use. Individuals, libraries, and other information centers perform this function.

Libraries and abstracting and indexing services carry out the organization and control function, describing materials so that they can be identified and located by the user. The descriptive or bibliographic material, too, must be distributed for use, generally by libraries or database vendors. The physical access function includes direct distribution between authors or publishers and users as well as indirect distribution through the libraries and information centers where they are stored. The final function in the spiral, assimilation, represents the user's activity of reading and understanding the information transmitted in the material.

While some of the functions may sometimes be combined into a single activity, each is required in the overall system of biomedical communication. The functions and the players are important to keep in mind as we consider recent developments affecting the communication system.

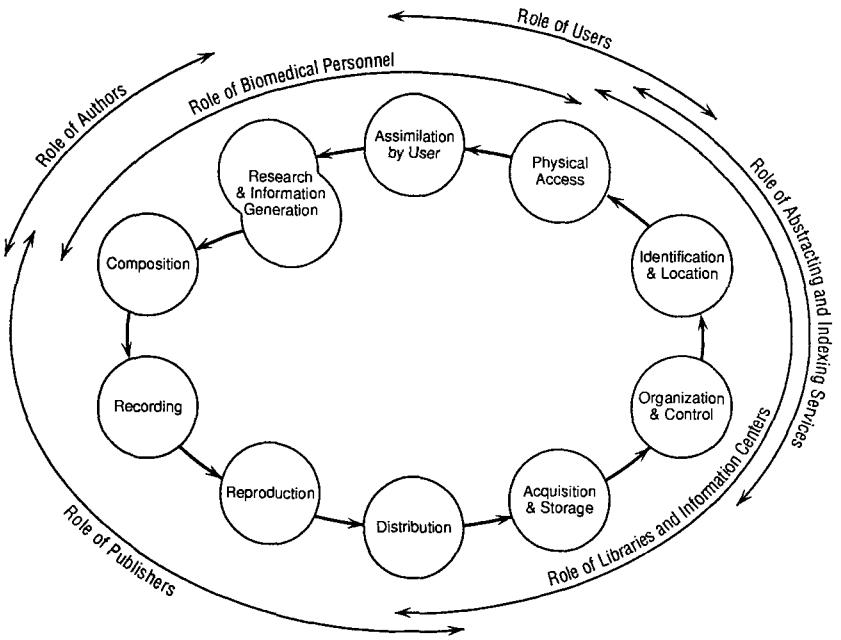

Figure 1. The biomedical communication system. (Source: Roderer, N. K. (1979). *United States expenditures for biomedical communications.* For the National Library of Medicine. Rockville, MD: King Research, Inc., p. 3. Derived from King, D. W.; McDonald, D. D.; & Roderer, N. K. (1981). *Scientific journals in the United States.* Stroudsburg, PA: Hutchinson Ross Publishing Co.

National Network of Libraries of Medicine

For more than twenty-five years, the National Library of Medicine (NLM) has been providing special support for the dissemination of medical information across the United States through its Regional Medical Library Program (RMLP), now known as the NNLM. The Medical Library Assistance Act (MLAA) of 1965 (Public Law 89-291) authorized NLM to provide grant funding for the development of a national system of regional medical libraries, and, since that time, the act and associated funding have been extended several times (Bunting, 1987).

"The goal of the NNLM is to improve and equalize access to biomedical information by linking U.S. health professionals and researchers to the information resources they need, irrespective of geographic location" (National Institutes of Health, 1992, p. 10). As of fiscal year 1991, the network included more than 3,600 members, including health science libraries of every size and type located in

all parts of the country. NLM's Network Office oversees and coordinates activities throughout the network.

The basic structure of the NNLM is hierarchical, consisting of activity at the local, regional,and national levels. Health professionals and researchers get materials through their (usually) local NNLM member library. Materials not available locally are provided within one of eight regions, and the NLM provides backup document delivery services at the national level. Activities are coordinated nationally, but the major focus of the NNLM is on the eight Regional Medical Libraries (RMLs) which receive contract funding to plan and coordinate network activities within specified geographic regions. With this arrangement, the RMLs can tailor their services to regional circumstances while taking advantage of NLM support.

The NNLM provides a variety of programs and services, most of which contribute, directly or indirectly, to the health professional's access to biomedical literature. Chief among these programs and services is interlibrary loan (ILL). In the years just prior to the passage of the MLAA, NLM processed a significant number of interlibrary loan requests for the nation's libraries. With the NNLM program, materials are borrowed first from resource libraries or other member libraries within the region. The number of documents delivered by the NNLM network has grown significantly over the years. The number of documents delivered by the NLM, the RMLs, and the resource libraries went from less than 200,000 in 1969 to more than 1.1 million in 1984 (Bunting, 1987), and recent figures for the total network, which show a volume of over 2 million loans suggest a continued increase.

To assist in the identification of libraries holding a particular journal title, the NNLM has supported a number of union list efforts, concentrating primarily on the submission of serials holding data from as many network libraries as possible to SERHOLD (SERials HOLDings, formerly known as the National Biomedical Serials Holding Database). SERHOLD data are available online and can be manipulated to produce regional union lists in various formats.

Significant increases in interlibrary loan traffic came about with the implementation of the DOCLINE request management system in the mid-1980s. DOCLINE allows a borrowing library request to be automatically routed to a library which, based on SERHOLD, holds the title.

Within some regions, cooperative acquisition programs have been developed to address the issue of the availability of appropriate resources within the region. In the Greater Northwest, for example, interlibrary loan requests were used to identify subject area and serial title gaps, and resource libraries were funded to purchase these needed

materials. The same region has also developed a serials acquisition and retention program called Regional Coordination of Biomedical Information Resources (RECBIR), through which larger libraries in the region have agreed to maintain subscriptions to specified journals.

The last twenty years have seen significant increases in the use of online searching as a way of identifying journal articles of interest. The National Library of Medicine was among the first providers of an online database—MEDLINE—and today provides more than forty databases. Over the years, the RMLs have had a significant level of involvement in the training of searchers, librarians, and, more recently, individual health professionals.

NLM's mid-1980s long-range planning activities included a panel on locating and gaining access to medical and scientific literature (National Library of Medicine, 1986). The Outreach Planning Panel, convened in 1988, extended this work, looking specifically at improving access to health information for the individual health professional (National Library of Medicine, 1989). Among the recommendations of the panel were the use of the RMLs "as a 'field force' for NLM products and services, providing information and services to health professionals directly and through network libraries, and providing feedback from health professionals to NLM" (p. 6) and the acceleration of "intramural R&D on products and services that are optimally responsive to the information needs of health professionals" (p. 8). Since that time, NLM has improved its GRATEFUL MED software, used primarily by individual health professionals to search MEDLINE, and added to it LOANSOME DOC, a feature that allows the individual health professional to submit automated document requests to a specific NNLM library. In 1991, the responsibilities of the RMLs were modified to support increased outreach to individuals through exhibits, training sessions, and the development of specific outreach projects.

The NNLM has had a significant effect on all its member libraries and on the individual health professionals that they serve. Database searching has been fostered and millions of journal articles have been delivered. With the NNLM, health sciences libraries have an organization that supports cooperation and collaboration both within the NNLM regions and nationally.

Integrated Advanced Information Management Systems (IAIMS)

The IAIMS program of the National Library of Medicine has as its overall goal the creation of mechanisms for effective management of, and access to, medical information within the individual academic

medical center (Goldstein, 1983; Broering, 1986; Lunin & Ball, 1988; Lorenzi, 1992).

The concept of integrated academic information management was originally described in a 1982 study report developed by the Association of American Medical Colleges (AAMC) and sponsored by the National Library of Medicine (Matheson & Cooper, 1982). The study united NLM's questions about how to meet the information needs of health professionals with the emerging reality of the potential benefits of computer and communications technologies and with the value of strategic planning for the better management of health science centers. The report recommended that libraries should lead in supporting the development of prototype information network systems; of programs that encourage the rapid integration of information technologies into health professions, education, and practice; and of programs that attract and retain people in medical information and knowledge base development in academic centers.

In response to AAMC's recommendations, NLM requested proposals to begin IAIMS planning, and four institutions received contracts in the fall of 1983. In 1984, an IAIMS grant program was announced as a part of NLM's extramural programs activity. Grants provided assistance for three sequential phases of: (1) institution-wide IAIMS planning (two years), (2) IAIMS model development and testing (three years), and (3) full-scale implementation of IAIMS projects (five years). In 1992, the IAIMS program was revised to include only two phases: (1) planning (one to two years) and (2) operational (five years) (Lindberg et al., 1992).

Through the end of 1991, forty institutions had made seventy applications for funding of one phase or another of IAIMS activity. From among these, thirty-one awards were made to seventeen institutions and organizations. Currently, five institutions are engaged in funded full-scale implementation activities: Columbia University, Georgetown University, Baylor College of Medicine, Duke University, and the Oregon Health Sciences University. Seven other institutions are in the planning or model development stage: the American College of Obstetricians and Gynecologists, University of Pittsburgh, Yale University, University of Michigan, Tufts University, University of Washington, and Vanderbilt University.

Even more importantly, the concepts of IAIMS have spread beyond the funded institutions. According to Lindberg, West, and Corn (1992): "It appears that the majority of health science centers are beginning to examine the role of information in their institutions, and many are investing resources in systems development and networking. The term *IAIMS* is becoming a generic acronym for the carefully planned information system" (p. 244).

While IAIMS was created in response to the needs of the academic medical center and remains primarily an activity of those organizations, it may also have relevance to others. A hospital, the Rhode Island Medical Center, received funding for IAIMS planning, and the American College of Obstetricians and Gynecologists is currently in the model development stage. These projects suggest a wider applicability of the IAIMS concept, and, in 1992, the National Library of Medicine changed the name of the IAIMS program to Integrated Advanced Information Management Systems.

The original IAIMS concept placed the library at the center of the program, coordinating and encouraging developments among all units involved in the management and distribution of medical center information. While this has been the case in some institutions, in other institutions, other departments—such as academic computing, clinical computing, or medical informatics—have taken the leadership role. Access to reference material and other information traditionally associated with libraries, however, is a constant feature of all programs.

Each IAIMS is different, although there appears to be a trend toward convergence of objectives and types of solutions as the program matures. Having said that, a description of one of the oldest and most comprehensive IAIMS can nonetheless elucidate the concept.

The Columbia-Presbyterian Medical Center, which includes the Columbia University Health Sciences division and the Presbyterian Medical Center, was one of the initial Phase I IAIMS sites in 1983 and received funding for Phase II in 1986 and Phase III in 1988 (Roderer & Clayton, 1992). Presbyterian Hospital's need to find a better solution to meeting clinical information needs was a major factor in the initial decision to seek IAIMS funding, and clinical systems-related activities have remained a key element of the program. The principal investigator of the IAIMS project, beginning with Phase III, holds the titles of Director of Clinical Information Services for the Hospital and Professor of Medical Informatics and Director of the Center for Medical Information Services for the University, thus representing both clinical systems and medical informatics units. The director of the Health Sciences Library at Columbia was instrumental in deciding to seek IAIMS funding and has played a major role in all three phases.

The goal of Columbia's IAIMS is expressed as "one-stop information shopping" (Roderer & Clayton, 1992, p. 253), that is, access from a single workstation to clinical, research, and library resources; university and hospital administrative systems; and utility functions such as word processing and electronic mail. An extensive network and a variety of host computers/servers provide access to

Clinical results reporting

laboratory
pathology
operative reports
obstetrics
admit-discharge history cardiology
head and neck
GI endoscopy
clinical profile (physician data entry and review)
radiology
discharge summary
neurophysiology
labor and delivery
demographic profile

Clinical decision making

surgery scheduling
medical records DRG coding
medical records
chart tracking/chart deficiencies

Scholarly information systems

Galen MEDLINE
Columbia Textbook of Medicine
Columbia Library Information Online
Concise Electronic Encyclopedia
anatomy textbook
Physician's Desk Reference
NIH Clinical Trial Alerts

Other

mail
phone directory
word processing/spreadsheets
grants and contracts newsletter
hospital and university administrative systems
laboratory-supported research initiatives

Figure 2. IAIMS resources and applications at Columbia-Presbyterian Medical Center. (Source: Roderer, N. K. & Clayton, P. D. (1992). IAIMS at Columbia-Presbyterian Medical Center: Accomplishments and challenges. *Bulletin of the Medical Library Association, 80*(3), 256.)

a growing number of databases and applications; Figure 2 shows the available items as of January 1992. At that time there were more than 2,700 active users of the system, making more than 7,000 data inquiries on an average workday. Also on an average workday, there were about 160 logons to MEDLINE, the most frequently used of the scholarly information sources available.

The IAIMS experience of other sites as well as Columbia supports the hypothesis that IAIMS programs can improve information

delivery to the health professional. These early experiences suggest that health professionals will make more extensive use of information when it is readily available from a convenient workstation, and that there is value in the ease with which multiple resources can be consulted. IAIMS brings together the many organizational units involved in information, allowing them to work together in providing coordinated access to their multiple resources.

The role of the library is somewhat different in each of the IAIMS programs, but most include major library contributions (Lorenzi, 1992). As noted earlier, the library at Columbia has been playing a significant partnership role in the IAIMS program there. At Georgetown, the other site nearing completion of its Phase III funding, the director of the library serves as principal investigator for the grant, and initial services were concentrated in the areas of library and other educational support materials, later adding clinical sources. At the University of Washington, a site now in the Phase I planning stage, the director of the library is also the principal investigator and initial projects are broadly addressed to meet needs in the areas of bibliographic retrieval, curriculum support, clinical systems, and campus-wide information systems. At Yale, a site now in Phase II, the library plays a significant partnership role, working closely with the Center for Medical Informatics in a project involving the provision of library information, curriculum support, and clinical information.

National Research and Education Network

Key to the rapid and widespread dissemination of biomedical information is effective communication and delivery channels. We are rapidly moving from a scientific and technical information system in which publication time is measured in months and years to one in which new information is available in hours or days, and from a system where access to materials is measured in days and weeks to one of almost instantaneous access. These changes will not be possible without the widely available communications infrastructure anticipated by the NREN (Lynch & Preston, 1990; Parkhurst, 1990).

Communication among computers was first demonstrated in the 1940s, and, by the 1960s, there was widespread access to remote computers and databases via telephone lines. In the medical world, this capability led to the development of MEDLINE, allowing libraries with terminals and modems to access that large bibliographic database. The 1970s and 1980s were the time for new levels of networking development with the proliferation of local- and wide-area computer networks (LANs and WANs), with LANs linking computers within a limited geographical area via a common

communication medium such as coaxial cable, fiber optics, or a radio channel, and WANs connecting machines (or more commonly entire local-area networks) through telecommunication links such as common carrier facilities, microwave, or satellite links and switches.

A major networking activity in the 1970s was ARPANET, developed by the Advanced Research Projects Agency (ARPA) of the Department of Defense. Here the concept of the Internet, a loose collection of multiple wide-area networks connecting myriad institutional LANs, was developed and institutionalized. By the late 1980s, the National Science Foundation put into place a new national wide-area network called NSFNET, which took the place of ARPANET as a critical part of the Internet backbone and signaled a role for the Internet as supporting the research and educational community. By 1990, the Internet included hundreds of institutional or corporate local-area networks, a series of NSF regional networks, the NSF backbone as the primary transcontinental traffic path, and a range of agency-specific or experimental networks. It provided connectivity among perhaps half a million computers and over 1 million people, most of them within the research and higher education community.

The concept of national networking continued to expand, first with the introduction of a series of legislative proposals for the NREN, and, more recently, with the High Performance Computing and Communications (HPCC) Program. NREN is envisioned as a high-capacity national research and education network combined with an information infrastructure of databases, services, and knowledge banks. HPCC is a multi-agency program initiated by the President's Office of Science and Technology to strengthen research and education nationwide. One of HPCC's four components is NREN; the others are advanced computer hardware design, advanced software technology, and basic research and human resources, which focuses on training in the design and use of high performance computing systems. HPCC was authorized in late 1991 under Public Law 102-194, which mandates the creation of NREN as an experimental test bed for high speed computer networking by 1996.

To coordinate these efforts, the National Coordination Office for High Performance Computing was established in summer 1992 and National Library of Medicine Director Donald Lindberg was named director. This appointment intensifies the role of the National Library of Medicine, already heavily involved in the HPCC program.

Other libraries and librarians are also heavily involved in NREN planning. In 1990, EDUCOM (a consortium of colleges and universities combining the technology of computers with higher learning), CAUSE (an association for the management of information

technology in higher education), and the Association of Research Libraries (ARL) announced the formation of a joint coalition to promote and address issues related to the availability and role of information resources on the NREN, and this group provides a good forum for collaborative efforts to define the NREN and to address related issues. Librarians can, and should, participate in addressing such NREN-related issues as intellectual property rights, standards, licensing and service arrangements, charging algorithms and cost recovery fees, economic models, and the identification of information resources for the network (Peters, 1992).

Unified Medical Language System (UMLS)

Articles, or other information of interest, can be identified in many ways—from the health professional's prior knowledge of an item in his or her files, from a reference by a colleague or other article, by browsing through potentially relevant materials, or by using an index. Indexes were developed when the volume of the journal literature reached the point that a more sophisticated scheme of organizing the literature was required (Price, 1961). A second significant development in the area of tools for finding journal articles came as the paper indexes were computerized. While early online databases were essentially replications of the printed indexes, today's bibliographic databases allow increasingly extensive searching to be done much more quickly, and the online databases are used much more frequently than were the print indexes.

The effectiveness of online searching depends heavily on the search techniques used, with probably the most important element being the vocabulary used for describing and searching for articles. The National Library of Medicine is the author of a very sophisticated controlled vocabulary, Medical Subject Headings (MeSH), but there are also many other controlled vocabularies related to biomedical topics, each designed with particular subject areas and purposes in mind. Thus the same concept can be addressed in a variety of ways in different machine-readable databases (as well as by different individuals), and the health professional seeking information in those databases must approach each with the appropriate vocabulary terms. A second barrier to effective use of online databases is the difficulty of addressing which of many databases have information relevant to particular questions; with more and more databases readily available, this is increasingly a problem.

In 1986, the National Library of Medicine began a long-term project to address these issues. The goal of the UMLS effort is to give practitioners and researchers easy access to machine-readable information from diverse sources—which include scientific literature,

patient records, factual databanks, and knowledge-based expert systems—by building an intelligent automated system that "understands" the meaning of biomedical terms and their relationships (National Library of Medicine, 1991, 1992).

UMLS is an ongoing project of the NLM that includes participation from an internal NLM research and development team and several contractors, currently Lexical Technology, Inc.; Massachusetts General Hospital; Brigham and Women's Hospital; the University of Pittsburgh and its subcontractor the University of Utah; Yale School of Medicine; and Columbia University.

Three knowledge sources make up the UMLS:

1. a *Metathesaurus* containing information about biomedical concepts and their representation in different vocabularies and thesauri;
2. a *Semantic Network* containing information about the types or categories (e.g., physiologic function, body system, health care activity) of terms in the Metathesaurus and the sensible or permissible relationships among these types (e.g., injury or poisoning disrupts physiologic function);
3. an *Information Sources Map* or directory containing information about the scope, location, vocabulary, and access conditions and protocols of biomedical databases.

The strategy for development of the UMLS is to build successive approximations of the capabilities ultimately desired. The knowledge sources have thus been issued in several experimental editions to date, and experimentation on a wide variety of information problems is encouraged. The first experimental edition of the UMLS Knowledge Sources was issued in 1990, containing initial versions of the Metathesaurus and the Semantic Network. During fiscal year 1991, NLM distributed 160 copies of this edition to medical libraries, university research groups, and commercial companies in the United States for their review and use.

To date, a wide variety of projects have used the knowledge sources for such activities as linking patient records to relevant MEDLINE citations, analysis of medical and dental school curricula, user query interpretation, and natural language processing. NLM itself has applied the UMLS components in its COACH expert system and to research in natural language processing.

In late fiscal year 1991, the second experimental edition of the Knowledge Sources, containing the first version of the Information Sources Map plus second versions of the Metathesaurus and Semantic Network, was sent again to interested organizations. Ongoing efforts of NLM and its UMLS contractors are directed at expanding the

content of the knowledge sources, establishing production systems for ongoing expansion and maintenance of the knowledge sources, and developing and implementing applications that rely on these knowledge sources.

Many of the groups working with the experimental editions of the Knowledge Sources are libraries, including the University of Maryland, which has an NLM grant to develop a Metathesaurus browser. Library experimentation is especially appropriate since libraries and their users will be among the major beneficiaries of operational Knowledge Sources and applications based on them. In a future scenario of the user's effort to identify a source of interest, for example, that user (or a computer system acting on his or her behalf) might consult the Information Sources Map to identify and connect to relevant resources and then consult the Metathesaurus and Semantic Network to develop queries in the vocabularies of those resources. This process, of course, closely parallels traditional library activities, and librarians have a role to play both in the development and testing of the UMLS.

The Electronic Journal

A large set of organizational and technological issues cluster around the electronic journal. This last of the program areas described as having a significant impact on medical libraries over the last twenty years is not, like the first four, a government-sponsored effort but is rather a collection of initiatives by different groups seeking to take advantage of technology to improve the reporting and distribution of research results and other information.

Journals have existed for over three centuries, and a complex system of support has evolved. As noted earlier, this system involves a number of players—publishers, abstracting and indexing services, database vendors, and libraries and other information centers as well as the users themselves.

As the number of users and articles has grown substantially, the system has been strained, and identifying and accessing relevant materials in a timely fashion has become increasingly challenging. An early response to the demand for a range of articles was interlibrary loan, which has been formalized and extended through new organizations and technologies. Medical libraries led the way here, and the existence of the NNLM and of DOCLINE have played a significant role in improving interlibrary loan within the biomedical community. In recent years, delivery of both requests and the actual articles has been speeded up by the use of facsimile machines, and projects such as the Research Libraries Group's ARIEL, which provides computer-to-computer transmission of scanned articles, offer

even greater potential for quick transmission of high-quality copies (Research Libraries Group, 1991).

Another development involves the use of computer technology to make an initial distribution of journal articles in electronic form, providing the advantages of reduced storage space and ease of duplication. One such system, highly relevant to the health sciences, is ADONIS.

ADONIS is the result of efforts by a consortium of publishers, and is a system that provides a large number of journal articles in electronic format, currently CD-ROM. A CD-ROM is distributed each week, and the system also includes software for searching the CD-ROM and the ability to print articles, with graphics, as they appear in the original print journal. Costs for a library subscribing to ADONIS include a subscription fee plus copying fees.

These developments are all concerned with the delivery of the traditional published-on-paper journal article. Other developments move toward elimination of the paper copy and, in at least some cases, use of the capabilities offered by computers to make changes in the form of the publication.

A few journals are published exclusively in electronic form. In the biomedical arena, *The Online Journal of Current Clinical Trials,* a project of the American Association for the Advancement of Science and OCLC, provides online access to reports of new clinical trials as soon as they are published. Abstracts of all sources cited as references are readily available, and corrections, retractions, and letters to the editor are connected to the original reports.

Another journal of note published only in electronic form is *The Public-Access Computer Systems Review,* developed by the University of Houston Libraries (Bailey, 1991). *The Review* grew out of PACS-L, a computer conference set up to allow librarians to discuss issues related to computer systems. It was established, in part, to help librarians explore the many issues associated with electronic publications. These issues, ranging from the practical considerations of how to identify, control, and provide access to the new journals to more complex issues of intellectual property rights and economics, will require both extensive discussion and experimentation before it becomes clear how the electronic journal will best fit into the array of library services.

Going yet another step beyond the totally electronic journal, there has long been discussion of an electronic alternative to journal publication, in which articles would be maintained in, and distributed from, a central electronic store. This concept was explored extensively as long ago as the late 1970s, as the federal government sought to consider what might be the long-term effects of the then-emerging

technologies (Ackoff, 1976; King & Roderer, 1978). More recently, Rogers and Hurt (1989), writing on "How Scholarly Communication Should Work in the 21st Century"; envisioned a "Scholarly Communication System," an electronic network on which scholars in all disciplines could publish their articles and read those of others. As a scholar completed an article, he or she would submit it to the system. After a period of being available for comments, the article would be reviewed by peers and categorized, as a "Logical extension of research in a field," "Restatement or interpretation of existing research," or "No scholarly contribution" (p. A56). Management groups would supervise each content area, specifying and arranging the review process. Authors would receive royalties, and these and the other costs of the system would come from membership fees and usage charges.

Such a system would radically change articles as we know them—the articles would no longer be packaged together into regularly distributed issues and volumes nor as a particular journal title. Additional features could be available—provision for notes and comments on articles, citation tracking, usage logs, searching of the full text of articles, and links among related articles.

Schatz (1991) extends the concept of a research reporting system even further, building on the capabilities of computer networking to describe a community systems project that collects "all" the knowledge of a scientific community—articles, data files, images, bibliographic citations, bulletin board messages, and others—into a digital library and developing the system's technology to transparently manipulate the library over nationwide networks. The community system that he envisions would encode all of this knowledge into an information space, with the goal of supporting retrieval and annotation of formal and informal data and information for any individual with a personal computer and network access.

Librarians are heavily involved in developing and testing these new forms of journals and must continue to be involved if their users are to be well served. The library provides an important test bed through which users can be reached, and the librarian's perspective on the overall journal communication system will help to ensure that the evolving journal forms bring continuing improvements.

Conclusion

The last twenty years have seen extensive changes in biomedical communications, and librarians have been active players in incorporating new developments into their organizations. Health sciences librarians have extended the range of materials handled,

particularly through the IAIMS emphasis on integration of information sources and with the emergence of new forms of journals. We have improved the delivery of information and materials through the interlibrary loan and search training activities of the NNLM and through the information workstation concept of IAIMS, and delivery is beginning to be affected by the search assistance developed under the UMLS program and by the rapid communications capabilities of the Internet and the NREN. NLM's emphasis on outreach has focused attention on the provision of library services to users beyond the local institution. Significant technological and organizational changes have come with all these new developments and will no doubt continue.

With the many changes in health sciences libraries over the last twenty years has come a significant level of speculation and concern about the future of the library and of the librarian. It is certainly true that many of the specific activities carried out by librarians have changed, and it seems inevitable that there will be more changes to come. At the same time, the mission so aptly described by Louise Darling (1974)—that of communications center working actively with information materials of all kinds, close at hand or distant, for health professional users in the community as well as in the institution—still remains critical and continues to challenge us.

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