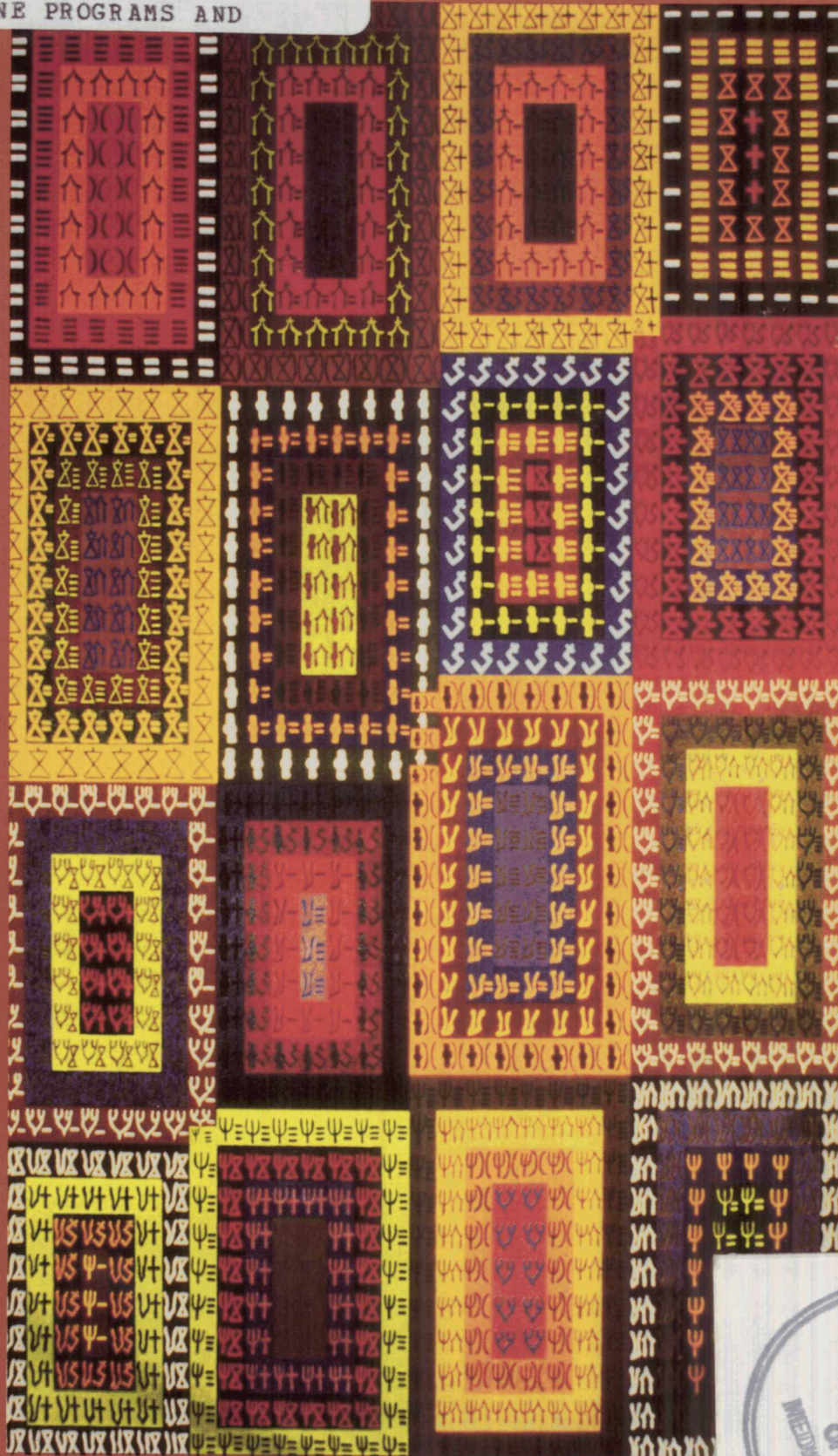


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National  
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Medicine

Programs  
and  
Services

Fiscal Year 1987



*Further information about the programs described in this  
administrative report is available from*

*Office of Inquiries and Publications Management  
National Library of Medicine  
8600 Rockville Pike  
Bethesda MD 20894  
(301) 496 6308*

*Cover This huge mural oil painting, 25 feet high by 15 feet wide, is in the lobby of the Lister Hill Center. It was painted in 1979-1980 by Alfred Julio Jensen. Although it gives the impression of one solid canvas, it is actually 16 panels of Belgium linen bolted together. The title is 'Art and Science'.*

**National  
Library of  
Medicine**

**Programs  
and  
Services**

**Fiscal  
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**U.S. DEPARTMENT OF HEALTH  
AND HUMAN SERVICES**

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## Preface

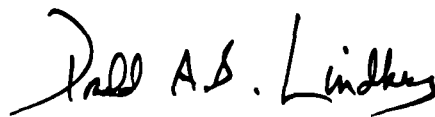
This year we were set on a path to the future mapped out by the Long Range Plan. The Plan was received from the printer in January and widely distributed to the health science and health information communities. We are grateful for the help of some 130 experts from around the country who invested substantial amounts of time in preparing the Plan. Now it is our responsibility to make it a living document, adapting it as circumstances change and opportunities arise.

I especially draw the reader's attention to the chapter titled "1987 Special Initiatives." In it may be found brief descriptions of three high-priority areas—the Unified Medical Language System, biotechnology, and the effort to encourage the use of permanent paper in biomedical publishing.

All of us in the medical library world were saddened by the death, on July 27, of Frank Bradway Rogers. Dr. Rogers, a physician who also had a

degree in library science, was the director of the National Library of Medicine from 1949 to 1963. He was responsible for the planning and early developmental work that went into MEDLARS; the worldwide acclaim that MEDLARS has since received is proof that he planned well.

The continued success of our programs is dependent on the quality of the staff who do the work and on the quality of the advice we receive from our consultants. I would like to express my deepest appreciation and admiration to all our employees, and to the members of the Library's various advisory bodies.

A handwritten signature in black ink that reads "Donald A. B. Lindberg". The signature is written in a cursive, flowing style.

Donald A. B. Lindberg, M.D.  
Director

Last year's report described three "special initiatives" Planning, the Unified Medical Language System, and Biotechnology This section updates the Library's activities in Biotechnology and the Unified Medical Language System, and adds a section on Permanent Paper

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### Unified Medical Language System

Today's health care professionals and researchers need to obtain and integrate information from a variety of information sources in order to make intelligent patient care decisions and to build on the results of previous research The principal barrier to effective integrated access to the wide range of biomedical information in machine-readable form is the tremendous array of classification and representation schemes used in the available information sources and the dissimilarity between all of these terminologies and the users' own vocabulary

The purpose of the Unified Medical Language System (UMLS) is to (1) compensate for the disparity between the users' language and the vocabularies used to organize machine-readable information and (2) overcome the lack of precise links among related biomedical information in different automated systems The goal is *not* to impose a single medical vocabulary on all users and systems, but to make the myriad of classifications of medical knowledge invisible to the user while providing a single logical path to a broad range of biomedical information sources

Figure 1 represents the principal elements of the UMLS as currently envisioned There will be two categories of components knowledge sources and functional features Direct users of computer applications will be able to select individual components or combinations of components to interpret questions, identify appropriate information sources, translate queries into a variety of different target vocabularies, and retrieve, evaluate, and organize information relevant to a particular query

The UMLS will contain at least two new knowledge sources a Metathesaurus and an Information Sources Map Encompassing or complementing the current Medical Subject Headings or MeSH® file, the Metathesaurus will store medical concepts and terms in a canonical form to which multiple existing vocabularies and classifications will be mapped The Metathesaurus will include concept definitions and will represent a variety of relationships among terms

The Information Sources Map, or Directory, will include information about the scope, location, vocabulary, syntax rules, and access conditions of medically relevant databases of all kinds The map will be used by both UMLS components and other applications systems to determine the most appropriate information sources for a particular query

A variety of UMLS features will interact both with the UMLS knowledge sources and with the broad array of machine-readable files of medically relevant bibliographic and factual information The Query Interpreter will interact with the user to verify that the user's real intent has been understood The Graphical Displayer will allow the user to see and traverse the relationships among terms and concepts in the Metathesaurus

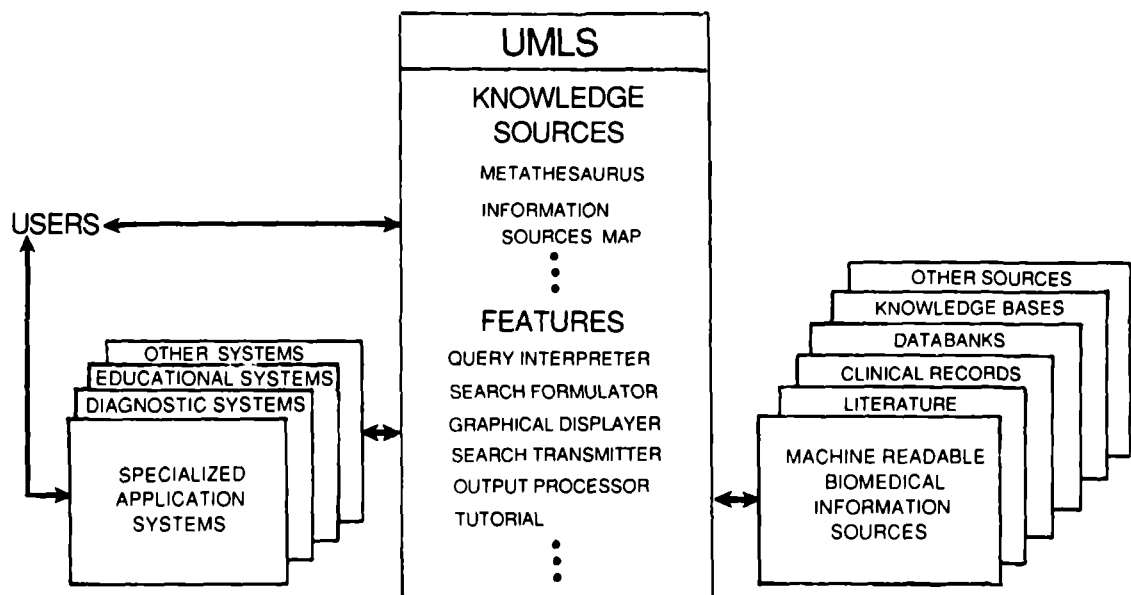
An interactive search formulator, which may also make use of the Graphical Displayer, will help users refine their queries, will consult the Information Sources Map to identify appropriate targets for the queries, and will use the Metathesaurus to translate the question into the vocabulary understood by appropriate information sources A search transmitter will transmit the formatted search statements to relevant computer systems and receive the output from these systems An output processor will merge, organize, evaluate, and rank the information retrieved according to its relevance to the user's query

The development of the UMLS is a major, long term project which must necessarily draw on a broad range of expertise, including contracts with

external research groups and consultation with professional societies, coordinated by the American Medical Association. In 1986, the Library embarked on several inhouse projects related to the UMLS and awarded four 2-year UMLS support contracts.

During the current two-year phase of the UMLS project, the contractors and NLM staff are collaborating to: (1) develop tools that will assist the long-term research effort; (2) define more precisely the features a functioning UMLS should contain; (3) perform background research to obtain key information needed in the design of a functioning UMLS; and (4) as a by-product of these activities, create interim products that will have an immediate beneficial effect on the ability of health professionals and researchers to retrieve relevant information.

Several research groups are addressing two critical issues related to the design of the Metathesaurus: (1) what kinds of information about medical terms and concepts should be represented in the UMLS and (2) what structure should be used to store the information needed. Yale University School of Medicine is attempting to identify those semantic features and relationships which are particularly useful in refining bibliographic retrieval and therefore should be represented in the Metathesaurus. Brigham and Women's Hospital is heading a joint project involving several research groups to define a possible semantic network structure for the Metathesaurus. The University of California, San Francisco is creating a structured file of disease descriptions, using where possible standard terminology from MeSH.



UNIFIED MEDICAL LANGUAGE SYSTEM (UMLS)

Figure 1



The University of Pittsburgh, the University of Utah, and Carnegie-Mellon University are experimenting with a frame-based representation structure to map the terminology for signs and symptoms of cardiopulmonary diseases in the INTERNIST-1 knowledge base and the HELP hospital information system. NLM is also working on the problem of mapping and merging vocabularies. Specific projects include mapping the thesaurus used in the National Cancer Institute's PDQ® (Physician's Data Query) system to MeSH. PDQ provides access to information about types of cancer, cancer treatment protocols, and individuals involved in related clinical research or practice.

NLM has also mapped the most heavily used terminology in GenBank, the National Institutes of Health's gene sequence databank, to the MeSH vocabulary. The GenBank mapping has been incorporated in the 1988 version of MeSH. Not all the mappings between MeSH and other vocabularies can be stored in the MeSH file, as presently constituted, however. As an interim solution to this problem, NLM is creating the MeSHLINK file, in which the unit record is based on the external vocabulary term and the MeSH equivalent is stored as a boolean expression or mainheading/subheading combination if necessary. Initial entries in MeSHLINK will include mappings from PDQ to MeSH and from Library of Congress Subject Headings to MeSH.

Projects related to UMLS features include the development and ongoing enhancement of GRATEFUL MED®, NLM's microcomputer software package which serves as a user friendly front-end to the MEDLARS bibliographic retrieval system. GRATEFUL MED already includes, at least at a preliminary level, query interpretation, search formulation, search transmission, and output processing features. These will be gradually enhanced as new versions of GRATEFUL MED are developed. For example, the next version of the program will include a Search engine feature which will make it

easier for other systems developers to integrate access to MEDLARS into their applications programs.

Both Massachusetts General Hospital and Brigham and Women's Hospital are exploring ways to search, traverse, and display graphically complex relationships among terms and concepts. Massachusetts General Hospital has developed MicroMeSH, a microcomputer-based graphical tool centered around the hierarchical MeSH vocabulary. Brigham and Women's Hospital is using the KEE (Knowledge Engineering Environment) expert systems shell as the basis for graphical representation and browsing of relationships in a semantic network. This research will feed into the development of the Graphical Displayer feature of the UMLS.

Some UMLS projects involve prototyping several components of the UMLS to produce a functional test. Yale is developing a limited test system which will allow users of a database of clinical case summaries to retrieve related MEDLINE® citations. This prototype will include a canonical form of the important concepts in a restricted medical domain to which both relevant MeSH terms and SNOMED codes will be mapped.

In the area of general tools for the research effort, NLM itself is developing a test collection of medical search questions and citations to the literature judged relevant or irrelevant to each question. This test collection will be used to determine whether proposed UMLS attributes actually do improve retrieval of health related information from the published literature. NLM has also established a special single year subset of MEDLINE for use in the research effort.

As the research needed for the development of a fully functioning UMLS continues, NLM will identify and make available interim products that can provide immediate improvements in information services. The approach will be to create successive approximations of the various features in the UMLS.

and make them available for use by both direct users and in computer applications. Gradual expansion and transformation of the current MeSH file and the new MeSHLINK file will be one vehicle for moving toward the planned capabilities of the Metathesaurus. Enhancement of NLM's microcomputer-based search interface, GRATEFUL MED, will be the mechanism for development of preliminary versions of other UMLS features. Specific interim links will be established between MEDLARS and other systems, such as PDQ, AI/RHEUM, and GenBank, to permit users of those systems to identify relevant literature more quickly and easily.

*B. Humphreys*

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#### Permanent Paper

A fundamental responsibility of the National Library of Medicine is to preserve permanently the content of books, periodicals, and other library materials pertinent to the biomedical sciences. A senior NLM Preservation Planning Team surveyed the physical state of the holdings and in 1985 developed a preservation plan. Significant resources have been provided by the U. S. Congress to launch an extensive effort to preserve the national treasure that is the Library's collection. Funds have been appropriated for microfilming of deteriorating documents, conservation of rare and valuable items, and for research into electronic storage of images.

A major threat to the survival of printed matter published since the mid-nineteenth century is the deterioration of paper caused by residual acids introduced into it by paper making processes adopted at that time. The NLM is committed to prevent that threat in the future by taking steps now.

Acid attacks and weakens the molecular links of cellulose, the main component of all paper, causing paper to deteriorate from within. The majority of literature in existence today is printed on paper that is destined to become brittle and to crumble over

the period of a lifetime without selective and expensive efforts at preservation. Technology which made it possible to meet the rapidly expanding demand for paper following the Industrial Revolution inadvertently contributed to the preservation problems of today. A hundred years later, paper making processes that use alkaline-based chemistry to produce paper which is acid-free have begun to come into use. Acid-free paper will last for centuries rather than decades in ordinary library use.

It is not responsible to publish important material on acidic paper when we know its fate. It is inefficient and illogical to continue to apply costly, labor-intensive remedial measures to volumes of perishable paper when the problem can be prevented. The preservation policy the Library's Board of Regents adopted in February 1986 notes that much of the preservation problem can be stopped at its source by publishing on permanent, archival media that are not predisposed to rapid deterioration, such as acid-free paper. It also states that in order to lessen the need for preservation treatment of new publications, the NLM shall actively encourage the publishing industry to use more permanent materials in the production of biomedical literature.

To that end, the Board of Regents sponsored a hearing at the Library in January 1987 on the use of permanent paper for biomedical literature. Nearly 100 publishers, editors, paper manufacturers and distributors, printers, librarians, and health professionals joined in a forum to share experiences with the use of acid-free paper, to increase the awareness of the need to publish on such paper, and to discuss means for assuring its broader use.

As a result of the hearing, a task force of concerned parties has been established to develop a plan to encourage the use of permanent, acid-free paper and to work actively with medical and scientific publishers for its implementation. Necessary strategies will include identifying principles to guide permanent paper use and integration into

production by biomedical publications, educating publishers about the problem of acid paper, increasing awareness among paper manufacturers about publishers' needs and requirements for acid-free paper, and encouraging the development and application of standards in the making and use of permanent paper

The driving forces are present for the gradual expansion of the alkaline process in fine paper manufacture, even though the paper making industry is slow to change. The industry is production-oriented, employs an efficient but conservative technology, and has a high level of capital investment in the existing plant. For any paper maker, the advantages of the alkaline process are that it reduces water consumption, facilitates waste treatment and compliance with environmental controls, saves energy and materials costs, and is cleaner and less corrosive to machinery than acid-based manufacturing processes. The 10 to 15 percent of domestic fine paper now produced alkaline is more than enough to accommodate the potential scientific publication demand. That segment of the publishing industry represents only a small proportion of the fine paper market.

Using more acid-free paper in publications is the preventive medicine for reducing the problem of their deterioration.

*C Kalina*

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## Biotechnology

Understanding Nature's mute but elegant language of living cells is the quest of molecular biology. From an alphabet of only 4 letters, represented by the chemical subunits of DNA, emerges a syntax of life processes whose most complex expression is man. The unravelling of this "language" and using this language to form new "words and phrases" in the form of engineered genes and protein products, is the central focus of the field of biotechnology. In biotechnology, more than any other area of the life

sciences, the staggering volume of molecular data and its cryptic and subtle patterns have led to an absolute requirement for computerized databases and analysis tools. The rapid expansion of research data in the field has been accompanied by a proliferation of highly specialized databases, built independently from one another using dissimilar computer systems, incompatible searching methods, and few conceptual linkages between them. This electronic "Tower of Babel" currently frustrates even the most dedicated researchers, and is a growing impediment to the advancement of science.

Recognizing the importance of computerized information processing methods for the conduct of biomedical research, the National Library of Medicine has several ongoing projects to improve the content and useability of biotechnology factual databases. They include new ways to build and maintain databases for molecular biology, and new ways to retrieve information from those databases.

- Procedures have been initiated to apply special identifiers to new MEDLINE entries which contain molecular sequence data (both DNA and proteins). Monthly subset tapes containing this data have been offered to other NIH institutes which support biotechnology databases, to serve as a reference and/or "kernel" on which to build new records for those databases.
- NLM is "mapping" the keywords used in the GenBank nucleotide sequence database to relevant Medical Subject Headings (MeSH®), so that once a researcher has found a set of GenBank records of interest, relevant literature indexed by the same concepts may be easily and automatically retrieved. In addition, the MEDLINE database structure is being modified to insert "pointers" to GenBank and other factual databases, so that a user who retrieves literature will know if the data described in an article is also available from a computer database.
- The Online Reference Works research project of

the Lister Hill Center maintains an online, full text version of *Mendelian Inheritance in Man*, the premier medical textbook describing more than 4000 human genetic diseases. This is described more fully in the chapter on the Lister Hill Center.

- Many national and international databanks contain biotechnology information. A contract to build a "database of databases" of directory information for genetics and molecular biology information is being initiated by the NLM. This database will serve as a pointer to other databases, and may become part of the Library's DIRLINE® (DIRectory onLINE) file.

As the science of biotechnology grows, so will the Library's contributions to the informatics aspects of this research. The NLM plans to become a major national site for coordination and dissemination of biotechnology research information. There will be two complementary themes for NLM activities: the first will be information resource programs, serving as "library of record" for factual research data much the same way that the Library maintains the biomedical literature; the second will be a focus of support for scientific discovery, using information databanks as a substrate for experimentation.

Legislation has been introduced in Congress to create a National Biotechnology Information Center at the Library. If authorized and funded, this Center will undertake the following new initiatives:

- In the area of information resources, the Library will use contract and cooperative agreements to support key molecular biology databanks located around the country. The contents of these databanks will be available through the NLM via gateways (i.e., translators which allow different types of computers to speak a common digital language) and networks, and will also be available on various physical media to researchers and value-added resellers.

- The Center will develop standards for data interchange and computerized tools for distributed data entry and annotation by investigators.
- The Center will sponsor research in universities and industry to develop new methods of information representation and retrieval from factual databases of biological information. A parallel effort will be conducted in the intramural laboratories of the Lister Hill Center.
- The design of such databanks and their resulting utility will, of necessity, need to follow scientific trends in research. The stimulus to maintain state-of-the-art systems will come from an intramural and extramural program supporting scientific discovery. A core group of resident investigators and postgraduate fellows will develop new algorithms for analysis and hypothesis testing within the oceans of molecular data resident in the Center's databanks.
- Intramural research activities will be complemented by a visiting scientist program, and an active extramural grant program. Fertile areas for such research in the next decade will include molecular sequence-to-structure prediction and determination of biologic similarity by expert system techniques. In addition, the Center will sponsor informatics workshops and short courses, to instruct molecular biologists and medical researchers in the use of advanced computerized methods of data analysis.

In an era of spectacular advances in both biological science and computer science, the National Library of Medicine looks forward to serving as a national focal point where these two disciplines merge for the advancement of biomedical knowledge.

D. Masys

# Library Operations

Lois Ann Colaianni

Associate Director, Library Operations

The staff of the Library Operations Division

- Acquires and preserves the world's biomedical literature,
- Organizes the literature by cataloging and indexing,
- Disseminates indexing and cataloging data in publications, online files, and other machine readable forms,
- Lends or copies documents in the NLM collection as a backup to document delivery service by other U.S. biomedical libraries, and
- Provides reference and research assistance to health professionals

The more than 250 librarians, technical information specialists, subject matter experts, health sciences professionals, and administrative support personnel in Library Operations are organized in four main divisions: Bibliographic Services, Public Services, Technical Services, and History of Medicine, two special units—the Medical Subject Headings Section and the Regional Medical Library Program Office, and a small administrative group in the Office of the Associate Director

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## Planning and Management

Nearly half of the recommendations in NLM's Long Range Plan will require some level of action in Library Operations (LO). In FY 1987, LO staff developed preliminary operational plans for many of the recommendations and either continued or initiated work toward their implementation. Accomplishments related to the Long Range Plan are described throughout this chapter.

LO essentially completed the remaining 4 in a series of 7 management studies of LO functions. These studies were required under a government-wide productivity improvement program, which is governed by the Office of Management and Budget's A76 circular. During FY 1987, several recommendations from the FY 1986 studies of

document delivery, serials processing, and indexing were implemented. These included the establishment of a new unit to refer document requests NLM cannot fill, several improvements to NLM's automated serials system, and changing the schedule for pick-up and delivery of journals by contract indexers.

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## Collection Development

The collection development function includes maintaining literature selection policies, identifying and acquiring biomedical literature in all formats and languages, processing materials as they are received, and maintaining and preserving the collection. NLM's collection currently contains approximately 1,828,000 printed books, journal volumes, theses, and pamphlets and 1,950,000 other items, including audiovisuals, computer software, microforms, prints, photographs, and manuscripts.

*Selection*—Materials are selected for the NLM collection according to the guidelines published in the *Collection Development Manual of the National Library of Medicine* (1985). This year, NLM expanded and clarified its collection development policy for the field of biotechnology, bringing together in a single explicit statement information previously stated or implied in several different sections of the *Manual*.

The Library also refined its guidelines for acquisition of historical films and developed an initial policy for the acquisition of computer-based educational materials. As a first step toward establishing a new policy for NLM's own archives, the History of Medicine Division prepared a background report identifying major issues for consideration and funded a survey of NLM's post-1955 records to identify the volume and types of material which should be preserved.

Continuing the commitment to coordination of selection policies among the U.S. national libraries, NLM and the National Agricultural Library (NAL)

Library Operations

published a joint statement clarifying their respective responsibilities for acquisition of materials in the field of human nutrition.

**Acquisitions.** The size of the NLM collection increased by 36,970 volumes and 32,482 other items, such as audiovisuals, computer software, microforms, prints, photographs and manuscripts. About 148,600 modern books, individual serial issues, audiovisual programs, and computer software packages were received and processed by Library Operations staff.

Significant additions to the Library's historical collections included: Marcello Malpighi's *De pulmonibus observationes anatomicae* and *De pulmonibus epistola alteia* (Bologna, 1661), the first description of the capillary system; Bernard Peyrilhe's *Dissertatio academico de cancro* (Paris, 1774), which describes the first experimental study to determine the nature of cancer; a folio ledger of medical accounts of the noted Philadelphia physician, John Kearsley, from the period 1717-1735; an elephantine folio of Joseph Swan's *A demonstration of the nerves of the human body* (London, 1865) with 26 engraved plates; a collection of letters and publications of Fielding H. Garrison, received from his daughter, Mrs. Margaret Estey, which includes letters from leading figures in medicine and medical history, office correspondence from Garrison's tenure at the Welch Medical Library, and a previously unknown photograph of John Shaw Billings; an 1864 autograph letter from Florence Nightingale discussing nurse training programs and other matters; and Clara Barton's first publication on the Red Cross, *The Red Cross of the Geneva Convention: What It Is* (1878). The History of Medicine Division also initiated a program for systematic acquisition of public health posters from around the world.

**Collection Preservation and Maintenance.** In FY 1987, NLM continued to implement its comprehensive program for preserving the biomedical

literature. The major elements of the program are: the preservation of NLM's own collection; support for preservation of important biomedical literature not held by NLM; research on the use of new technologies for preserving library materials; and encouraging the use of more permanent materials in biomedical publications. This year the Preservation Section staff surveyed the collection and generally confirmed the low percentage of brittle paper (about 11.7 percent) found in the 1985 survey, but revealed that about 86 percent of NLM's book and journal collections are printed on acidic paper and thus in danger of deterioration. Consultants were employed to survey the NLM manuscripts collection and advise on its preservation.

In the first year of a 4-year contract for preservation microfilming of brittle materials, the contractors filmed 4,208 volumes. Another 346 rare books and manuscripts received special conservation and preservation treatment. Preservation copies were made of 376 historical films. NLM also took several steps to improve storage and use conditions for the collection. The humidification of the areas where prints and photographs are housed was improved; the project to insulate NLM's film vault was funded; and a special photocopier was obtained for copying fragile materials.

An LO working group prepared a draft National Preservation Plan for the Biomedical Literature to address the preservation of important biomedical literature not held by NLM. The plan, which was circulated for discussion in the Regional Medical Library Network, recommends a preliminary assessment of the preservation needs of other U. S. biomedical libraries and the identification of special collections of important materials not held by NLM. The New York Academy of Medicine will conduct this survey in FY 1988. Another important element of this plan calls for other medical libraries to lend to NLM serial issues missing from the NLM collection so that complete runs of serial titles can be filmed.

The Library's research activities related to preservation are described in the report of the Lister Hill Center. Progress in the campaign to encourage the use of permanent paper in the biomedical literature is described in the chapter, "1987 Special Initiatives."

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### Bibliographic Control

Bibliographic control includes the development of intellectual schemes for organizing the biomedical literature by subject; the cataloging of all types of library materials in the health sciences; and indexing journal articles on biomedical subjects. Providing intellectual access to the content of the world's biomedical literature is one of NLM's primary services.

*Thesaurus.* The hierarchical thesaurus used in NLM cataloging and indexing is *Medical Subject Headings* (MeSH). MeSH contains 14,893 subject headings; the Supplementing Chemical File contains 46,510 terms, most of which are chemical names. MeSH provides the foundation for the Library's efforts to create uniform subject access to the biomedical literature.

Each year MeSH is reviewed, updated, and modified as necessary to keep abreast of developments in biomedicine and changes in terminology. In FY 1987, 246 new MeSH headings and 1500 cross-references to existing MeSH headings were added to the MeSH file for use in calendar year 1988. The MeSH annotations for catalogers were also extensively revised for 1988. Of the new terms added, 31 headings and 210 cross references were the result of a special project to map heavily used terminology in GenBank, NIH's gene sequence databank, to MeSH. This mapping supports NLM's effort to improve access to biotechnology information, which is described in the chapter, "1987 Special Initiatives," and in the section on the Lister Hill Center. Several new headings were added to permit more precise

indexing of review articles. MeSH staff also completed a preliminary analysis of MeSH coverage of health technologies as a first step in a joint NLM/Institute of Medicine project to improve access to technology assessment information.

In FY 1987, a new MeSHLINK file was created to store the mappings between MeSH and other vocabularies which cannot be accommodated in the current MeSH file structure. For example, the current MeSH file cannot store a mapping from a single term in another vocabulary to a combination of multiple MeSH terms. The MeSHLINK file will be used initially to store mappings between the Library of Congress Subject Headings (LCSH) and MeSH and the National Cancer Institute's PDQ (Physician's Data Query) Thesaurus and MeSH. Work also began on a new automated system to create and maintain the MeSH vocabulary. Efforts to enhance the content and improve the maintenance of MeSH are directly related to the Unified Medical Language System project which is described in the chapter on 1987 Special Initiatives.

*Cataloging.* At NLM, the cataloging function includes: (1) the creation of a standard bibliographic description of each new work added to the NLM collection, containing author's name, title, publisher, date of publication, etc.; (2) the assignment of MeSH headings to describe its subject content; (3) the assignment of a classification code shelving number which identifies the item's principal subject; and (4) the maintenance of automated files of cataloging records and the authoritative forms of names used in those records.

In FY 1987, the Library cataloged 18,654 books, serials, audiovisual programs, and Cataloging in Publication (CIP) galley. NLM continues to obtain cataloging assistance from contractors and from the Library of Congress under an interagency agreement, although the amount of cataloging received from outside sources unfortunately declined in FY 1987.

In FY 1987, NLM created its first machine-readable cataloging records for prints and photographs on the Research Libraries Information Network (RLIN) system. The conversion will proceed over the next few years. RLIN was chosen because it supports the MARC visual images format which is not yet available in NLM's internal cataloging system. The records will eventually be loaded into the NLM system.

This year, NLM began to use descriptive cataloging records produced by the Library of Congress and the Government Printing Office when these are available for items acquired by NLM. NLM also revised the policy for providing separate "analytic" cataloging for individual issues of serials to reduce overlap between indexing and cataloging. Both of these actions reduce unnecessary duplicate work and allow staff to provide cataloging for more items for which bibliographic access is not already available.

Background work continued on the project to develop an expert cataloger system. An analysis of the time spent on various aspects of the cataloging process revealed that name authority work would benefit substantially from improved automated assistance. Hardware and software tools for an expert systems workstation have been procured. Additional progress awaits the recruitment of a person to begin actual development of a prototype system.

*Indexing.* At NLM, indexing is the creation of records that describe the contents of specific articles in the journals the Library has selected for indexing. An indexing record includes descriptive information (authors' names, article title, pagination, journal title, date, etc.) essentially as it appears in the journal, and a number of MeSH terms assigned to describe in detail the content of the article.

In FY 1987, the consultants who advised NLM on the selection of literature to be indexed in *Index Medicus* reviewed 230 candidate journals. Of these, 57 were accepted for inclusion. At the end of the

year 2,786 titles were being indexed for *Index Medicus*<sup>TM</sup> and a total 3,344 titles were represented in MEDLINE. As a result of a review of the policies related to selection of titles for MEDLINE, NLM has decided to modify the mechanism for obtaining outside advice on selection. The distinguished independent consultants which have served the Library well for the past 20 years will be replaced in FY 1988 by an official NIH advisory committee to be called the Literature Selection Technical Review Committee.

The new committee will have two responsibilities: to review newly published journals and advise on their suitability for *Index Medicus* and MEDLINE; and to review subject groupings of journals, including indexed and nonindexed titles, to determine the most important journals to be indexed in particular subject areas. NLM intends to work with professional and scientific societies to review journals in several subject areas each year and to recommend the most useful journals in their area of expertise for consideration by the Literature Selection Technical Review Committee.

A total of 317,531 indexed citations to articles were added to MEDLINE in FY 1987. Abstracts were entered for 186,572 or 57 percent of the citations added. Of the articles indexed for *Index Medicus*, 21.5 percent were indexed by NLM staff; the remainder were indexed directly by the international MEDLARS centers, through arrangements made by these centers with U.S. commercial firms, or by NLM contractors. Indexing throughput, or the elapsed time between receipt of journal issues at NLM and the completion of the indexing of those issues, continues to be very good.

FY 1987 was the first year in which the Library updated MEDLARS citations to include information about error notices published after the original articles were indexed by NLM. More than 1800 records in MEDLINE and the Health Planning and Administration file now contain the errata rubric.



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## Network Services

NLM's services to local and remote users include: (1) disseminating authoritative cataloging and indexing data in publications, machine-readable formats, and an online retrieval service; (2) providing reference assistance in response to in-person, telephone, and written requests; (3) providing documents or copies of documents to health professionals and researchers as a backup resource to other U.S. medical libraries; and (4) directing the Regional Medical Library Network, which links U.S. biomedical libraries in an effort to make quality information service readily available to all health professionals irrespective of their geographic locations.

*Publications.* Publications were the first means employed by the Library for distributing its cataloging and indexing data, and they remain an important vehicle for worldwide dissemination of this information. In FY 1987, NLM produced issues of some 30 recurring indexes and catalogs on paper or microfiche. NLM publications include *Index Medicus*, the *National Library of Medicine Current Catalog*, *Health Sciences Serials*, *Health Sciences Audiovisuals*, and the *NLM Catalog*, among many others.

In addition to its catalogs and indexes, NLM also publishes specialized bibliographies and literature searches on specific topics of current interest, such as sickle cell disease, localized prostate cancer, and health benefits of pets. The Library produces and distributes a quarterly literature search on acquired immunodeficiency syndrome (AIDS) and, in FY 1987, published a special *AIDS Bibliography 1986-1987* for distribution at the III International Conference on AIDS, held in Washington, D.C. Approximately 50,000 copies of various literature searches were distributed by NLM during FY 1987.

LO staff also contributed to the development of a variety of special publications describing NLM services, including a new MEDLARS brochure, a

GRATEFUL MED brochure, and a DOCLINE® pocket card.

*Machine Readable Databases.* In order to provide the broadest possible access to its authoritative data, NLM leases complete databases and subsets in machine-readable form. Organizations obtaining NLM data under license include commercial database vendors, international MEDLARS centers, academic health science centers, and a variety of commercial organizations. In FY 1987, NLM distributed 2,200 tapes of various databases. The Library also drafted a single new tape license agreement covering both full databases and subsets, which includes quality assurance provisions. The quality assurance program is an effort to ensure that licensees of NLM data provide their users with: (1) reasonably current and correct NLM data; (2) an accurate description of the type and amount of NLM data available on their systems; and (3) a clear and accurate explanation of their system's retrieval capabilities.

In addition to its regular license agreements, NLM now has 15 experimental agreements with commercial organizations for redistribution of MEDLINE on compact disk. In FY 1987, several MEDLINE CD-ROM products came to market as a result of this program. The Library has developed a pricing policy for licensees who intend to distribute MEDLINE on CD-ROM.

The Library continues to distribute its cataloging records in the MARC format. In FY 1987, RLIN became the latest subscriber to AVLINE records in MARC format. Specifications are now being developed for MARC conversion of the MeSH file and NLM cataloging records for computer software and archival films.

*Online Services.* NLM currently provides online access to 27 MEDLARS databases. The total annual usage of the MEDLARS system at NLM this year was 282,708 connect hours, an increase of 9.9 percent from FY 1986. This figure does not reflect use of

MEDLARS data on the computer systems of foreign and domestic licensees.

During FY 1987, the number of domestic and foreign codes authorized to use the MEDLARS system increased by over 50 percent to a total of 13,584. Most of the new code holders are individual health professionals and researchers. Many of these use GRATEFUL MED, an NLM micro-computer-based software package which assists users in searching MEDLINE and other MEDLARS databases. Some 6500 copies of GRATEFUL MED have been sold through the National Technical Information Service. A second version of the package, introduced in March 1987, contained several new features, including the ability to search for appropriate MeSH terms and automatically insert them in search queries.

To learn more about those who use MEDLARS directly, their level of satisfaction with the system, and their views on beneficial system improvements, NLM has distributed a survey to all individual code holders. The results of this study will be available in FY 1988. To facilitate use of the online system by students, NLM instituted a new educational code policy, which will cut the charge for student access in half. Individuals in a professional, graduate school, or residency program may apply for codes or institutions may obtain codes for students enrolled in their programs. Institutions may also request that a limit be placed on the usage of their student codes. The new policy goes into effect in FY 1988.

An analysis of NLM's costs to provide online access in FY 1986 has resulted in a modest increase in charges to be effective October 1, 1987. Online charges for use of the TOXNET® system have been adjusted down. In FY 1987, NLM and the National Technical Information Service, which collects the fees for NLM's online services, instituted interest charges for overdue online services bills.

New ELHILL® system features include: (1) the "Print Browse" capability, which permits users to print a single designated data element without

incurring the citation portion of the online charge; (2) the availability of records for computer software in the AVLINE® file; (3) the restructuring of the TOXLINE® file into royalty and nonroyalty segments; and (4) the ability for users to move from files on the TOXNET system to ELHILL files and back again. Additional information about TOXLINE and TOXNET changes appears in the Specialized Information Services report.

Although there is no longer a requirement for new MEDLARS users to receive online search training before obtaining an access code, many users still elect to attend NLM-sponsored training. In FY 1987, approximately 670 people attended classes taught by NLM and the 3 Regional Medical Libraries that also provide MEDLARS online training. NLM also conducted a satellite broadcast session on the use of GRATEFUL MED, which was attended by approximately 600 people at 22 sites. In FY 1987, the Library, in consultation with the Regional Medical Libraries, decided to discontinue the annual online update sessions and replace them with update information through the *NLM Technical Bulletin*.

*Reference Services.* NLM responded to 69,966 requests for reference assistance in FY 1987, 62 percent from onsite patrons and the remainder by telephone or correspondence. Requests come from researchers, practitioners, scholars, and librarians, as well as members of the general public. Many people who call or write to NLM are unaware of biomedical information resources available locally or of the various Federal information clearing-houses for health information for the lay public. In addition to providing some information to answer the requestor's immediate question, staff direct people to other agencies that can help. The reference staff also provides rapid responses to a variety of special information requests from members of Congress, the Supreme Court, the Office of the President, the Office of the Secretary of the Department of Health and Human Services, and other Federal agencies.

In FY 1987, the decision was made to use GRATEFUL MED as the online catalog interface for onsite users and to provide these users with online access to a special MEDLINE subset of citations to journals shelved in NLM Reading Room. These new services will be implemented in FY 1988.

**Document Delivery** NLM provides document delivery services—to remote requestors as a back-up to other libraries in the Regional Medical Library Network and for onsite patrons. In FY 1987, NLM received 192,559 interlibrary loan requests, 21 percent more than FY 1986. An additional 842 institutions began to use DOCLINE during the year, bringing the number of DOCLINE participants to 1,432. SERHOLD®, the NLM computerized serials holdings database used by DOCLINE to route serial requests automatically, now contains more than one million holdings statements for 2,300 libraries. A total of 788,105 document requests were transmitted via DOCLINE, 91 percent of which were filled. DOCLINE participants are now receiving regular statistical reports summarizing their borrowing and lending activity.

In July 1987, NLM began regular telefacsimile service for documents needed for patient care emergencies. NLM received 182 such requests during the first 3 months of the service and filled all of them within 2 hours. There is an additional \$3 charge for this service.

While the volume of interlibrary loan requests increased dramatically in FY 1987, NLM took steps to slow the tremendous growth of the last 5 years in onsite requests for documents. By ceasing to retrieve from the stacks additional copies of items shelved in the Reading Room and reducing the number of items any user may request per hour from 9 to 5, the Library kept the increase in onsite requests to 2 percent. The number of onsite requests received was still 287,108, however, and the combined volume of interlibrary loan and onsite requests was more than could be handled efficiently. As a result, throughput and fill rates for

both onsite and interlibrary loan requests suffered. In an effort to improve this situation, the Library is seeking a contract to reshelve requested materials and has allocated more staff to the document delivery operation. Other alternatives are being considered.

**Regional Medical Library Program** The purpose of the Regional Medical Library Network is to equalize access to medical information throughout the United States by linking health professionals and researchers to the resources needed irrespective of their geographic location. The network comprises health sciences libraries of all sizes in all parts of the country. In each of 7 multi-state regions, NLM has contracted with a distinguished medical library to coordinate a regional document delivery program, develop outreach services to health professionals in areas without adequate library services, promote resource sharing among health sciences libraries, encourage and support the use of online services within their regions, and foster the development of innovative services to health professionals. The 7 Regional Medical Libraries (RMLs) are supported by more than 120 large resource libraries, generally in medical schools, and many hospital and special libraries, individually and in effective consortia. NLM's Regional Medical Library Program Office provides national coordination for the network.

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#### Regional Medical Libraries

- 1 Greater Northeastern Regional Medical Library Program  
The New York Academy of Medicine  
2 East 103rd Street  
New York, New York 10029  
Phone: 212-876-8763  
States served: CT, DE, MA, ME, NH, NJ, NY, PA, RI, VT, and Puerto Rico,  
Online center for regions 1 and 2

2. Southeastern/Atlantic Regional Medical Library Services  
University of Maryland  
Health Sciences Library  
111 South Greene Street  
Baltimore, Maryland 21201  
Phone: 301-328-2855  
States served: AL, FL, GA, MD, MS, NC, SC, TN, VA, WV, the District of Columbia and the Virgin Islands
3. Greater Midwest Regional Medical Library Network  
University of Illinois at Chicago  
Library of the Health Sciences  
P.O. Box 7509  
Chicago, Illinois 60680  
Phone: 312-996-2464  
States served: IA, IL, IN, KY, MI, MN, ND, OH, SD, WI
4. Midcontinental Regional Medical Library Program  
University of Nebraska  
Medical Center Library  
42nd and Dewey Avenue  
Omaha, Nebraska 68105-1065  
Phone: 402-559-4326  
States served: CO, KS, MO, NE, UT, WY  
Online center for regions 3, 4, and 5
5. South Central Regional Medical Library Program  
The University of Texas  
Health Science Center at Dallas  
5323 Harry Hines Blvd.  
Dallas, Texas 75235-9049  
Phone: 214-688-2085  
States served: AR, LA, NM, OK, TX
6. Pacific Northwest Regional Health Sciences Library Service  
Health Sciences Library and Information Center  
University of Washington  
Seattle, Washington 98195  
Phone: 206-543-8262  
States served: AK, ID, MT, OR, WA
7. Pacific Southwest Regional Medical Library Service  
Louise Darling Biomedical Library  
University of California  
10833 Le Conte Avenue  
Los Angeles, California 90024-1798  
Phone: 213-825-1200  
States served: AZ, CA, HI, NV, and U.S. Territories in the Pacific Basin

An estimated 2 million requests for journal articles, books, and audiovisual programs are filled for health professionals each year by libraries in the Regional Medical Library Network. In FY 1987, the RMLs themselves filled 124,988 requests; NLM, as national backup, filled 135,883. As described previously, an increasing number of these requests are handled through DOCLINE, NLM's automated document request and routing system. By the spring of 1987, DOCLINE was available to libraries in all 7 regions.

The RML contracts allow for a series of enhancement projects to be awarded at intervals throughout the 5-year contracts. These projects include investigations of the information needs and information-seeking behavior of health professionals, pilot development of new information services, tests of new technologies or procedures to improve health information processing, and other similar activities. To date, 8 enhancement projects have been awarded. New projects funded in FY 1987 include: an assessment of the preservation needs of medical libraries by the New York Academy of Medicine; a study of the administrative aspects of health professional access to DOCLINE by the University of California, Los Angeles; the

development of a portable PC demonstration center by the University of Washington; and a biotechnology awareness study and a bibliometric study of molecular biology by the University of Maryland.

During FY 1987, NLM and the RML staffs made effective use of teleconferencing to discuss problems and issues facing the network. Among the topics addressed in this manner were changes in online training policies and procedures, the development of a formal membership system for the RML network, and modifications to the DOCLINE system to avoid repeated routing of requests for no-cost interlibrary loans to institutions which charge for this service. The last issue arose, was discussed, and solved in a two-week period, illustrating the potential of this kind of communication.

NLM's contract with the Medical Library Association to write a history of the RML program was completed in FY 1987. "The Nation's Health Information Network: History of the Regional Medical Library Program, 1965-1985" by Alison Bunting, Director of the Pacific Southwest Regional Medical Library, was published as a supplement to volume 75, number 3, July 1987 of the *Bulletin of the Medical Library Association*.

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### Special Onsite Programs

In addition to the reference and document delivery services provided to onsite patrons, NLM offers a variety of other services including guided tours and briefings about NLM and historical exhibits and symposia. The Library also has a Visiting Historical Scholar program and conducts a one-year onsite training program for library school graduates with potential for successful careers in health sciences information.

*Public Tours and Briefings.* Each year, the Library hosts many visitors from throughout the United States and the world. In FY 1987, LO staff

conducted 139 regular tours for a total of 503 visitors. More than 1400 people (125 groups) received special orientation programs and tours arranged by the Office of Inquiries and Publications Management (Office of the Director). An additional 200 people came to the Library during the Open House held as part of the celebration of the Centennial of the National Institutes of Health. NLM staff also arranged special briefings on library programs and services for many individual visitors.

*Historical Programs.* The FY 1987 Visiting Historical Scholar was Thomas Bonner, Ph.D., Distinguished Professor of History, Wayne State University. Each year under the Visiting Scholar Program, a recognized scholar is competitively selected to spend 6 to 12 months at NLM to engage in research that will use the Library's collections, to give one or more public presentations, to assess segments of NLM's historical collection, and to consult with staff in his or her areas of expertise. Dr. Bonner used NLM's collection in his comparative research on 19th and 20th century medical education in England, Germany, and the United States. He presented a public lecture on "Women, Medicine, and Foreign Study, 1860-1915" and prepared a selective bibliography on "Educating Physicians in the Nineteenth Century."

In FY 1987, the History of Medicine Division assisted in the preparation of several special exhibits, presentations, brochures, and other materials, many in conjunction with the NIH Centennial. Major lobby exhibits were mounted on American contributions to Physiology, in collaboration with the American Physiological Society, and the development of the great health laboratories, in observance of the centennials of NIH and the Pasteur Institute in Paris. Background work was done for two symposia to be held at the Library in early FY 1988 on the "Images of the Health Professions in the Popular Arts" and the History of Medical Informatics. This latter symposium will be sponsored by the Association for Computing Machinery.

*NLM Associate Program.* The NLM Associate Program is a one-year competitive program that provides 3 to 6 library school graduates an opportunity to learn about NLM's operations and those of other health sciences libraries, to use new information technologies, and to develop their skills by conducting special projects. Associates have an opportunity to visit the other national libraries and various types of health sciences libraries or information centers and to attend professional meetings. NLM offers an international traineeship for one

librarian from outside the United States to participate in the NLM Associate Program.

Three Associates completed the program in the summer of 1987; 4 new Associates began the program in September 1987. Selected NLM staff members also attend portions of the Associates' formal curriculum. In September 1987, faculty from 3 library schools were invited to attend the initial orientation for the new Associates so they could promote interest in the program and the Library could learn about the current composition of the student body and their job placement prospects.

**Table 1**  
**Growth of Collections**

<i>Collection</i>	<i>Previous Total (Sept. 1986)</i>	<i>FY 1987</i>	<i>New Total</i>
<i>Book Materials</i>			
<i>Monographs:</i>			
Before 1500 .....	568	0	568
1501-1600 .....	5,702	13	5,715
1601-1700 .....	9,990	23	10,013
1701-1800 .....	24,170	70	24,240
1801-1870 .....	39,738	26	39,764
Americana .....	2,332	5	2,337
1871-Present .....	480,462	13,119	493,581
Theses HMD .....	281,788	6	281,794
Pamphlets .....	172,021	0	172,021
Bound serial volumes .....	804,436	26,380	830,816
Volumes withdrawn .....	(30,078)	(2,672)	(32,750)
Total volumes .....	1,791,129	36,970	1,828,099
<i>Nonbook Materials</i>			
<i>Microforms:</i>			
Reels of microfilm .....	35,289	2,422	37,711
Number of microfiche .....	185,416	10,266	195,682
Total microforms .....	220,705	12,688	233,393
Audiovisuals .....	44,295	1,182	45,477
Computer Software .....	0	52	52
Pictures .....	75,612	230	75,842
Manuscripts .....	1,577,489	18,330	1,595,819

**Table 2**  
**Acquisition Statistics**

<i>Acquisitions</i>	<i>FY 1985</i>	<i>FY 1986</i>	<i>FY 1987</i>
Current serial titles received	22,087	22,621	22,293
Publications processed			
Serial pieces	125,243	125,584	124,898
Other	27,212	27,264	23,696
Total	152,455	152,848	148,594
Obligations for			
Publications	\$2,128,787	\$2,318,192	\$2,908,000
Included for Rare Books	(\$116,154)	(\$92,813*)	(\$115,455)

\*Adjusted figure

**Table 3**  
**Cataloging Statistics**

<i>Item</i>	<i>FY 1985</i>	<i>FY 1986</i>	<i>FY 1987</i>
Completed Cataloging			
Full	11,174	11,716	13,869
Limited	5,676	8,569	4,785
Total	16,850	20,285	18,654

**Table 4**  
**Bibliographic Services**

<i>Services</i>	<i>FY 1985</i>	<i>FY 1986</i>	<i>FY 1987</i>
Total citations published*	307,333	316,585	326,162
For <i>Index Medicus</i>	280,379	297,772	298,160
Recurring bibliographies	23	27	28
Journals indexed for <i>Index Medicus</i>	2,730	2,740	2,786
Abstracts entered	177,000	187,662	186,572

\*Includes special list articles audiotapes and Health Administration citations

**Table 5**  
**Online Searches**

Databases	FY 1985	FY 1986	FY 1987
AVLINE	11,155	13,277	11,357
BIOETHICS	5,392	5,997	7,410
CANCERLIT*	51,582	54,876	58,066
CANCERPROJ*	1,875	2,337	1,162
CATLINE*	138,818	135,546	145,525
CCRIS		14,582	2,608
CHEMLINE*	28,459	27,056	26,725
CLINPROT*	3,378	3,394	3,044
DIRECTORY	50		
DIRLINE	2,758	3,534	3,887
EXPRESS	1,173		
HEALTH	99,666	108,719	119,426
HISTLINE*	3,766	4,842	4,555
HSDB*	4,999	32,375	22,407
INFORM	117	176	184
INTROTOX	292	282	146
INTROMED*	4,906	10,087	5,825
MEDLINE	1,282,755	1,442,598	1,722,711
MED83		269,614	422,022
MED80	353,978	313,112	291,216
MED77	153,886	133,060	136,132
MED75	86,758	83,168	80,049
MED71	57,985	56,845	60,846
MED66	45,598	46,223	50,848
YEAR86			302
MESH VOCABULARY	10,083	13,186	15,693
NAME AUTHORITY	4,499	3,473	3,214
PDQRS	21,168	25,994	32,791
POPLINE	25,588	20,058	21,085
RTECS*	10,535	10,658	8,938
SDILINE*	28,856	33,010	37,241
SERLINE*	30,307	36,982	44,835
STORED SEARCH	88	95	95
TDB*ELHILL*	8,849		
TBD-TOXNET	372	5,325	
TOXLINE	71,959	68,869	73,630
TOXBACK76	20,216	18,681	13,228
TOXBACK65	14,158	13,395	9,388
TOXLIT			3,520
TOXLIT65			1,439
	2,586,024	3,011,426*	3,441,550

\*Adjusted figure

**Table 6**  
**Offline Searches**

Databases	FY 1985	FY 1986	FY 1987
AVLINE	278	194	178
BIOETHICS	19	30	27
CANCERLIT	5,989	5,676	5,272
CANCERPROJ	18	1	2
CATLINE	357	329	343
CHEMLINE	81	31	
CLINPROT	6		2
DIRLINE	3	1	1
EXPRESS	35		
HEALTH	11,664	12,765	11,596
HISTLINE	5	23	13
HSDB			
MEDLINE	19,949	14,098	10,871
MED83		17,380	18,376
MED80	26,653	21,739	16,582
MED77	21,080	14,073	10,730
MED75	16,379	11,137	7,606
MED71	10,309	6,650	4,979
MED66	7,631	4,481	3,227
MESH VOCABULARY	17	2	4
POPLINE	12,804	11,694	7,842
RTECS	248	37	11
SDILINE	228,039	244,165	238,172
SERLINE	2	1	1
TDB-ELHILL	243		
TOXLINE	17,230	17,189	14,060
TOXBACK76	1,370	1,418	561
TOXBACK65	1,164	1,280	516
TOXLIT			123
TOXLIT65			110
	381,573	384,394	351,205



**Table 7**  
**Circulation Statistics**

<i>Activity</i>	<i>FY 1985</i>	<i>FY 1986</i>	<i>FY 1987</i>
Requests Received	390,058	438,678	479,667
Interlibrary Loan	144,346	153,797	192,559
Readers	245,712	284,881	287,108
Requests Filled	327,125	364,661	381,994
Interlibrary Loan	110,849	119,591	135,883
Photocopy	102,698	110,379	124,821
Original	6,606	7,595	9,423
Audiovisual	1,545	1,617	1,639
Readers	216,276	245,070	246,111
Requests Unfilled	57,347	74,017	94,714
Interlibrary Loan	27,911	34,206	56,805
Referred	1,504	1,169	2,972
Returned	26,407	33,037	53,833
Reader Service			
Returned as unavailable	29,436	39,811	37,909

**Table 8**  
**Reference Services**

<i>Activity</i>	<i>FY 1985</i>	<i>FY 1986</i>	<i>FY 1987</i>
Reference Section			
Requests by telephone	24,218	25,744	25,883
Requests by mail	2,100	1,104	898
Readers assisted	42,561	44,444	43,185
Total	68,879	71,292	69,966

**Table 9**  
**History of Medicine Activities**

<i>Activity</i>	<i>FY 1985</i>	<i>FY 1986</i>	<i>FY 1987</i>
<b>Acquisitions:</b>			
Books .....	438	296	162
Modern Manuscripts .....	193,101	146,105	18,330
Prints and Photographs .....	298	190	230
<b>Processing:</b>			
Books cataloged .....	326	313	150
Modern manuscripts cataloged .....	91,304	62,650	18,782
Pictures cataloged .....	163	995	38
Citations indexed .....	4,954	5,880	5,390
Pages microfilmed .....	94,594	134,546	21,836
<b>Public Service:</b>			
Reference questions answered .....	3,093	4,560	5,512
ILL and pay orders filled .....	2,042	1,936	2,880
Reader requests filled .....	4,981	6,228	9,996
Pictures supplied .....	3,252	5,262	5,494

## Office of Computer and Communications Systems

John Anderson

Director, Information Systems

The Office of Computer and Communications Systems (OCCS) provides information processing capability to meet NLM needs and, in so doing, determines and meets the data processing and data communication requirements for: (1) disseminating biomedical information to thousands of institutional and individual health professionals around the nation and world; (2) operating the world's largest library in a single technical area—biomedicine; and (3) providing MIS (Management Information System) services to NLM, including Office Automation.

OCCS: (1) implements computer and communication systems using cutting-edge technology and state-of-the-art techniques; (2) analyzes, plans, and provides real-time, online, around-the-clock information services for increasingly sophisticated users; (3) schedules and controls maintenance and publication of dozens of databases, each measured in the billions of bytes (characters); (4) operates a modern computer center of fully redundant, fail-safe hardware and software; (5) conducts performance measurement and capacity planning for computer hardware, operating systems, database management systems, transaction processors, etc.; and (6) produces and distributes data and software for distribution to approximately two dozen International MEDLARS Centers.

The organization of OCCS is a direct reflection of these responsibilities. Computer and communication systems are:

- Developed and implemented by the Development Branch;
- Enhanced and maintained by the Application Services Branch;
- Executed on computers under operating system control by the Systems Support Branch; and
- Provided as an around-the-clock service by the Computer Services Branch.

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### Development Branch

The Development Branch is responsible for analyzing, designing, and implementing computer-based systems to support NLM's library processing requirements for new applications. The MEDLARS III effort is that type of application. The work of the MEDLARS III contractor, Logicon, Inc., ended in September 1986. The contractor provided a design, using the personal computer as a workstation, the Local Area Network (LAN) for communications, IBM's CICS as the teleprocessing monitor, and the Model 204 DBMS. The branch has reviewed the system design and proposed a procedure whereby the MEDLARS III design would be validated.

Since the initial implementation of the Asynchronous Data Service Network (ADSNET) on the LAN physical cable plant in August of 1984, 379 ADSNET user connections had been installed by the end of FY 1987. The IBM Personal Computer Network (PCNET), using the same physical cable plant, has grown to support 175 users since its implementation in October 1985. The two data services of the LAN are providing the major data communications, e.g., connections to the host for electronic mail, and record and file maintenance for all NLM program areas.

DOCLINE, the interlibrary loan software, has grown to support a request rate at the end of FY 1987 which is equivalent to more than one million requests per year for more than 1,400 active users. NLM has continued to enhance the interlibrary loan system by improving the response time, providing statistical reporting software, and developing a message capability through the DOCLINE system.

A number of milestones have been reached in support of GRATEFUL MED. Version 2.0 was developed and a new GRATEFUL MED User's Guide was completed. A gateway version of GRATEFUL MED was developed for American Medical Association (AMA) members on their

AMANET. The gateway provides access for AMA members through a GRATEFUL MED file server at NLM via SoftSearch's AMANET in Boulder, Colorado.

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### Applications Services Branch

The Applications Services Branch (ASB) is responsible for analysis, design, creation, maintenance, enhancement, and problem resolution for more than 2,000 application programs and data streams, and 149 databases. This is in direct support of the various diversified programs within the NLM.

These support services are provided utilizing sophisticated programming software such as: PL/I, ALC, RPG, INQUIRE, and Model 204, on state-of-art computer hardware and systems, with variable length records and interactive database/programming methodologies.

The ASB is organized into 13 functional support areas. Each functional support area has a team leader and from 1 to 3 team members. Furthermore, a team leader on one Project Team is often a team member on several other functional support teams: The teams are:

1. Information Support Services—a centralized point of contact for computer-related problems, managing changes, project analysis, monitoring, and reporting. The Section is developing OASIS (Online Automated Status Information System), a PC-based user interactive control and tracking system that will be supported through the LAN using PC-NET. OASIS will be completed in 1988.
2. MicroComputer Information Support Services—a centralized point for all matters regarding microcomputer and office automation at NLM (some 350 configurations).
3. Publications Support Services—produces more than 60 recurring bibliographic and other specialized publications through laser printer, photocomposition machines, and microfilm production.
4. MEDLARS II Information Retrieval System Databases and Subset Services—services 30 bibliographic databases containing hundreds of thousands of records; also supplies subset data to licensees throughout the world.
5. Database Management Systems and Documentation (INQUIRE)—services some 120 INQUIRE databases.
6. Year-End Processing Services—does class maintenance (adding, deleting and replacing terms and/or fields of data in 16 databases).
7. Phase-Out Systems Services—concerned with 6 Online Data Entry Systems that will be replaced by MEDLARS III software.
8. Machine Readable Catalog (MARC) Services—involves converting MEDLARS II to MARC format for data distribution.
9. NLM Billing System Services—operates a dynamic system that manipulates resource usage from 3 NLM information retrieval systems—ELHILL, TOXNET, and PDQRS—to produce the invoices sent to users.
10. Computer Output Microfiche (COM) Services—provides for microfiche output. The software includes INQUIRE, Information Retrieval System, Publication System, and specialized programs.
11. Maintenance to Online Systems (MOS) Services—supports online data entry and maintenance for indexing more than 25,000 articles per month and supports the interlibrary loan system that provides interactive processing of requests for library materials.
12. Medical Subject Headings (MeSH) Services—supports all aspects of the NLM controlled thesaurus for bibliographic data. MeSH files contain 60 fields of contextually related data.
13. Model 204 Support Services—provides information retrieval, report generation, file maintenance, and cross-referencing for user generated formats. M204 will replace many of the INQUIRE databases.

In the past year the Branch's Information Support Section (ISS) completed 105 of 137 change requests dealing with enhancements, modifications and new developments for the various NLM program areas. The remainder are in various stages of completion.

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### Systems Support Branch

During FY 1987 the Systems Support Branch supported all NLM mainframe operating systems and related software and data communications, and provided training and resolved user-reported problems and inquiries. Major efforts this year were to take advantage of the capacity of the IBM 3081 system and to provide the necessary support for the MEDLARS III interim systems.

Notable activities of the Systems Support Branch during FY 1987 include:

- Installation and maintenance of systems software packages - MVS/XA - the current version of the IBM operating system that provides support for the recently installed 3380-E disk storage units as well as increased system reliability and performance.
- Installation and support of more than 100 software products for programmers, users, systems support staff, and computer operations specialists.
- System support for Model 204 and INQUIRE Data Base Management Systems which are key to MEDLARS III interim systems and MEDLARS III development.
- Data communications support was provided for the conversion from UNINET to TELENET and phase out of conventional data lines within the NLM buildings.

The computer systems are IBM models 3081 and 3084 with the MVS/XA (Multiple Virtual System/Extended Architecture) operating system. Telecommunication software is both TCAM and VTAM (Telecommunication Access Method and Virtual

Telecommunication Access Method). Transaction processors are CICS and TSO (Customer Interface Communication System and Time Sharing Option).

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### Computer Services

The Computer Services Branch provides data processing services and support for users of the Library's large mainframe systems. Currently installed and operational are two IBM systems, one of them a 3081K with the performance characteristics of processing 13.5 million instructions per second, or MIPS. The second IBM system is a newly installed 3084Q with the performance characteristics of processing 24.4 MIPS. In addition, there are 2 Data General minicomputers, a DG350 and a DG230.

The peripheral equipment attached to the IBM mainframes consists of:

- 2.25 billion characters of data on 144 3380 disk drives, 8 3351 disk drives and 2 STC 4305 solid state disk drives;
- Data transfer via 6 3420 tape drives, 8 3480 tape drives, and 8 3480 tape cartridge drives; and
- An IBM 3800 laser printer and an IBM 3211 impact printer.

## Specialized Information Services

Henry Kissman, Ph.D.

Associate Director

Programs and  
Services, FY 1987

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### Background

In 1987, the Specialized Information Services's (SIS) Toxicology Information Program celebrated its twentieth anniversary. Born during a decade when the threat of environmental calamity first became appreciated by the public, SIS responded to the information challenge. Environmental issues, such as those documented in 1962 in Rachel Carson's *Silent Spring* and the question of drug safety, due in large part to the thalidomide disaster, had the public worried. It soon became obvious that there was a distinct lack of information on the effects of long-term, low-level exposure to the ubiquitous chemicals around us.

Citizen pleas for better controls over the use of chemicals were finally heeded in the 1970s by the creation of Federal agencies (such as the EPA) and laws (such as the Clean Air Act) to regulate uses of potentially hazardous chemicals. But by this time, toxicology had already established a reasonably firm footing as an interdisciplinary science. As early as 1966, the President's Science Advisory Committee grappled with the problems of handling toxicology information. This committee found an urgent need for a readily accessible computerized file of toxicological information, more comprehensive than any yet existing. The Toxicology Information Program founded the following year, is a direct outgrowth of this recommendation.

The Toxicology Information Program has set the pace in using the latest technology to impose a coherent structure on the growing and widely dispersed literature and activities of toxicology. The Program has initiated a number of "firsts" widely hailed by the toxicology community as being of critical importance in answering important research, clinical, and emergency needs. Indeed, as its twentieth anniversary approached, the Society of Toxicology issued a special commendation to the Program for two decades of sustained high quality services to toxicology. The Society cited the Program's "vital chemical and toxicological services,

used in the development of knowledge for the improvement of public health and safety and the protection of the environment." A similar honor was bestowed upon the Program by the American Academy of Clinical Toxicology for superior informational services in the area of clinical toxicology.

Among SIS's groundbreaking innovations was the creation of TOXLINE, in 1972. This was the first online retrieval service dedicated to the toxicology literature. CHEMLINE, a companion file, became the first online chemical dictionary to link nomenclature, structural information, and CAS Registry Numbers to the location of information in other files containing references and data. In 1978, the Toxicology Data Bank (TDB) became the first nonbibliographic online factual databank focusing upon the toxic and other attributes of potentially hazardous chemicals. The extensive peer review process developed for TDB was unique in the building of databanks. TDB was eventually subsumed by the larger and more comprehensive Hazardous Substances Data Bank (HSDB) in 1985 as part of the new TOXNET system.

TOXNET is novel by being a fully integrated system of toxicologically oriented files. While only the powerful search component of TOXNET is visible to online users, other modules are used by SIS to build, edit, and review records. HSDB has retained the peer review process through a newly established Scientific Review Panel. It has not taken long for HSDB to prove its worth as an invaluable information adjunct for emergency response personnel in the handling of chemical spills and other accidents.

Joining HSDB in the TOXNET system in 1986, was the Chemical Carcinogenesis Research Information System (CCRIS) of the National Cancer Institute. Additional files, such as the Registry of the Toxic Effects of Chemical Substances (RTECS) of the National Institute for Occupational Safety and Health (NIOSH) will become part of the TOXNET family in 1987. A major SIS activity was the creation, in 1983, of DIRLINE, one of the first online

interactive directory databases, listing biomedical, scientific, and other organizations organized to respond to public inquiries. It is likely that DIRLINE will serve as a model for other directory databases at NLM. SIS looks forward to its next twenty years and will continue to strive for innovative means to handle specialized information challenges.

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#### Databases under ELHILL

*CHEMLINE (Chemical Dictionary Online)* is an online chemical dictionary and directory file which allows users to verify chemical nomenclature and structure, and to formulate optimum search strategies for other NLM files. Each chemical record also has pointers to these other files which contain information about that chemical substance. CHEMLINE is built and maintained in collaboration with Chemical Abstracts Service (CAS). It is updated bimonthly and regenerated annually. Originally implemented in January 1974 as the TOXLINE Chemical Dictionary with slightly more than 59,000 records, the file now contains over 765,000 records of unique chemical substances.

During FY 1987, several changes were made to enhance CHEMLINE's content and increase its effectiveness in retrieving chemical identification information. Additional nomenclature from the agricultural and cosmetic chemistry areas was added to CHEMLINE from the *CTFA Cosmetic Ingredient Dictionary*, the Official ANSI Pesticide List, nomenclature data for chemicals used at the U.S. Department of Agriculture and from EPA's *Catalog of Pesticide Names and Their Synonyms*.

The CHEMLINE classification code (CC) field for over 48,000 records, was enriched with the addition of classification codes from the RTECS file. Together with the classification codes from the *USAN and the USP Dictionary of Drug Names*, these codes significantly improved the ability to locate general classes of chemicals in the CHEMLINE file. The addition of the Related Registry Number (RR) field to CHEMLINE now

allows users to see the Registry Numbers of the major salts and hydrates of the specific chemical for which information is being sought.

*TOXLINE (Toxicology Information Online)* is an online bibliographic retrieval service, produced by merging "toxicology" subsets from some thirteen secondary sources, including *Biological Abstracts*, *Chemical Abstracts*, *Government Reports Announcement and Index* (report literature), *International Pharmaceutical Abstracts* and MEDLINE. The newly reorganized TOXLINE and the two royalty-based files, TOXLIT and TOXLIT65 (see below) now contain some 2,300,000 records. This represents more than a ten-fold increase in the number of bibliographic records since the file was first made available by NLM in September 1972.

During FY 1987, TOXLINE was regenerated and restructured into a set of nonroyalty and royalty-based files. TOXLINE presently contains non-proprietary data from 12 sources and consists of 833,000 bibliographic records. The remainder of the previous TOXLINE citations (CAS, BIOSIS and IPA) is split between the TOXLIT and TOXLIT65 files which together contain 1.5 million citations. Three new subfiles were added to TOXLINE during FY 1987. These were the Epidemiology Information System from the Food and Drug Administration, a major portion of the NIOSHTIC file from the National Institute for Occupational Safety and Health, and a Poisonous Plants Bibliography, prepared specially for TOXLINE, which covers the toxic effects of poisonous plants reported in the literature prior to 1976.

The first evaluation of the scope and coverage of TOXLINE was conducted under contract using bibliometric analysis techniques. The results of this evaluation will be used to determine the areas of toxicology not adequately covered in TOXLINE and to identify sources of information that would address these areas.

*RTECS (Registry of Toxic Effects of Chemical Substances)*, another online data retrieval service, is based upon a NIOSH file by that name which NLM restructures for online searching. In 1987, the file was enriched by adding Chemical Abstracts Service (CAS) Registry Numbers to RTECS records lacking them. These identification numbers are crucial for unequivocal data retrieval and for matching RTECS records with those in other files. Some 17,000 records have been enhanced in this way. RTECS now contains more than 90,000 records. Work is underway to move this database from ELHILL to the TOXNET system during the fall of 1987.

*DIRLINE (Directory of Information Resources Online)*, is an online directory which assists MEDLARS users by providing an alternative resource for information needs not met by bibliographic or factual databases. DIRLINE, which has been available as one of NLM's online services since August 1984, uses data from (1) the Library of Congress' National Referral Center (NRC) database (14,406 multi-disciplinary records); (2) the Health Information Center database (1059 records on health-related organizations) of DHHS' Office of Disease Prevention and Health Promotion; (3) a poison control center list (PCC) compiled and maintained by the publication, *Emergency Medicine* and the American Association of Poison Control Centers (115 records indicating certified and/or state-designated centers); and (4) the DHHS Alcohol, Drug Abuse and Mental Health Administration's Drug Abuse Communications Network (DRACON) (49 records which link the user to over 10,000 local drug abuse and alcoholism information and assistance centers). Plans are under way to add new component subfiles to DIRLINE in scientifically and socially important areas of interest.

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#### Microcomputer-Based Products

During FY 1987, SIS produced two software packages associated with its chemical and

toxicological files for use on a personal computer. The first is a Demo Diskette that provides an overview of the CHEMLINE, TOXLINE, RTECS, CCRIS, and HSDB files, along with an interactive simulated search of each file. The second product is a PC-based training package, CHEMLEARN, that provides detailed instruction in the effective use of the CHEMLINE file. CHEMLEARN is the first in a series of PC-based, self-instructional tools for selected MEDLARS databases.

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#### TOXNET and Its FILES

With funding from the Superfund Amendments and Reauthorization Act (SARA) of 1986, the NLM has been supporting the Agency for Toxic Substances and Disease Registry (ATSDR) with relevant information activities, including file building and creating improved methods of access to information resources in the areas of hazardous wastes and emergency response. The predominant SIS activities supported by SARA involve the continued development of TOXNET, an integrated file building and online search system, and the enhancement of Hazardous Substances Data Bank (HSDB).

TOXNET became available to the NLM online user community on July 1, 1985, allowing online searching and retrieval from its two major data banks, the HSDB and the Chemical Carcinogenesis Research Information System (CCRIS). Soon to join these data banks are RTECS and the files of the Environmental Mutagen and Environmental Teratology Information Centers (EMIC/ETIC).

Major activities in 1987 involving the TOXNET system included: (1) implementation of a TOXNET-to-ELHILL gateway that allows users to access files on both the TOXNET and the ELHILL computers; (2) an Online User Survey to determine who searches the TOXNET databases and for what purposes; (3) installation of "Data Status Tags" to indicate the degree of review of data by the NLM's Scientific Review Panel; and (4) initiation of TOXNOTES to



carry news about books, meetings, conferences and other events of significance to toxicologists.

*HSDB (Hazardous Substances Data Bank)* is a direct outgrowth of the former TDB (Toxicology Data Bank), which became operational in 1978. HSDB, with its 4200 chemical records described in 150 data fields has completely subsumed the TDB file for the last 2 years. The scope of HSDB has been expanded to include more comprehensive information in the areas of environmental fate and exposure potential, standards and regulation, and safety and handling. Data are extracted from monographic sources, Government reports and the primary scientific literature. Data statements in HSDB are referenced and reviewed by a body of experts known as the Scientific Review Panel (SRP).

During 1987, over 400 HSDB records were enhanced by the various data extraction contractors. The SRP toxicology and environmental groups were able to peer review 256 and 211 of these records respectively. Another 347 HSDB records were enhanced by means of Express Update. The usage of HSDB averaged around 400 hours per month.

Also mounted on TOXNET is the *Chemical Carcinogenesis Research Information System (CCRIS)* of the National Cancer Institute (NCI), which became publicly available in February 1986. CCRIS is a scientifically evaluated and fully referenced data bank containing carcinogenicity, mutagenicity and tumor promotion test results. Data are derived from primary journals, current awareness sources, and a special core set of monographic sources, including a wide range of NCI reports. CCRIS, like the HSDB file, is organized by chemical substance; this facilitates cross-file searching and printing in TOXNET.

TOXLINE, RTECS, HSDB, CCRIS, and DIRLINE files were updated. As a result, updated fact sheets for these files and the TOXNET system were prepared. SIS continued to provide training for its online files both as a part of the MEDLARS Training Program and for other users at special training sessions and at professional meetings.

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### Microcomputer Workstation

A project was begun in 1984 to develop a microcomputer-based workstation to assist the information needs of ATSDR's emergency response personnel. Vital to this effort were scripts—or programmed searches used to run the workstation software—that allow users rapid access to a wide variety of data/information located in diverse public and private sector computer systems. During FY 1987, primary emphasis was given to the enhancement of the bibliographic script and to continued collaboration with the ATSDR in developing the workstation for field operations.

In the area of retrieval from bibliographic files, GRATEFUL MED functionalities (with full MeSH capabilities) have been added to the workstation software. This will allow workstation users accessing NLM through the bibliographic script to utilize the full power of GRATEFUL MED to search NLM's MEDLINE, CATLINE, and soon also the CHEMLINE, TOXLINE, and DIRLINE files.

Enhancements initiated during the period include: optimizing the toxicology/chemistry (TOXCHEM) script to search for multiple chemicals and Registry Numbers; investigation of CD-ROM and/or hard disk technology as local storage devices for databases, such as HSDB; and designing a new script, to be called the Substance Identification Script, which will query databases using terms based on chemical-physical characteristics or noticeable health effects caused by a chemical whose identity is not known.

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### User Support Services

User support for all online files is an ongoing SIS function. User Guides for the CHEMLINE,

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### Expert System

In FY 1987, SIS and the Lister Hill Center collaborated on developing an Expert System to assist responders to chemical emergencies in obtaining and using information. The project is considered part of the microcomputer workstation work.

An R&D contract with Rutgers University was used to develop a prototype of this Expert System. The Rutgers-developed system shell, EXPERT, with which NLM has had long experience through its work on AI/RHEUM, was selected for this project. Rutgers staff working with emergency response personnel at ATSDR, completed a multi-module prototype system that operates in conjunction with the workstation software to collect facts about the emergency from the responder, decide which databases to search for the required information, perform the searches, and bring the formatted results back to the responder. Testing of this prototype and further expansion into an operational system is planned for FY 1988.

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### Biotechnology

As part of NLM's overall effort in the field of biotechnology, SIS instituted a seminar series in order to provide to the NLM/NIH community an introduction to the basic biology and the information needs of this rapidly growing discipline. Talks were given by Drs. Arthur Nienhuis (NHLBI), Helen Donis-Keller (Collaborative Research), Temple Smith (Harvard), Fredric Richards (Yale), David Kingsbury (NSF), Daniel Masys (NLM), and Mark Pearson (DuPont). Attendance averaged about 80, and comments on the presentations were typically enthusiastic. Video tapes of these presentations are being used as learning tools at Stanford University. The success of this series has prompted plans for its continuation next year.

Also in the area of biotechnology, the American Type Culture Collection was awarded a contract to build *Directory of Biotechnology Information*

*Resources.* This Directory will constitute a much-needed "database of databases" in the field, providing guidance in identifying the myriad technical resources currently available. While identifying and characterizing publicly accessible factual sources, it will also list various repositories and collections of cellular and subcellular elements available for experimental use. Similarly, it will identify groups which are grappling with nomenclature issues in biotechnology. The Directory will be mounted online at NLM and will also be made available for distribution in hard copy and on disks. This initiative is a response to recommendations of the NLM-sponsored National Academy of Sciences Workshop on *Biotechnology Nomenclature and Information Organization*, held in May 1986.

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### Information Services to Other Agencies

As described above, SIS continues to work with the Agency for Toxic Substances and Disease Registry on various information resource building activities. The required resources are provided to SIS through the Superfund Amendments and Reauthorization Act of 1986.

SIS provides data and information concerning the effect of chemical substances on human health and the environment to users in other Federal and in state scientific, health, and regulatory agencies as well as to users in academe and industry. SIS also continues to chair the Subcommittee on Information Coordination of the DHHS Committee to Coordinate Environmental Health and Related Programs and represents NLM on several of its other Subcommittees.

SIS also continues to provide information support services to the Food and Drug Administration and the Department of the Army through the Toxicology Information Response Center at the Oak Ridge National Laboratory.

# Lister Hill National Center for Biomedical Communications

Daniel Masys, M.D.

Director

The Lister Hill National Center for Biomedical Communications (LHNCBC) was established in 1968 by a joint resolution of Congress. The Center serves as the intramural research and development arm of the National Library of Medicine. LHNCBC research programs explore the use of state-of-the-art computer and communications technologies to disseminate biomedical knowledge. This knowledge takes the form of electronic representations of text, images and sound, as well as the procedural knowledge encoded in rule-based expert systems. LHNCBC programs develop innovative methods for acquiring, storing, retrieving, analyzing, and presenting information to biomedical researchers and health care professionals.

During its first decade, the Center devised prototype systems for computer-assisted instructional networks, two-way audio and video communications via satellite, and system designs for online information retrieval which were later incorporated into the NLM's precedent-setting MEDLINE system. The Center has gradually turned to research projects with long-term potential for improving patterns of information processing, analysis and retrieval on a national scale. Document image processing, video-disc-based computer assisted instruction and simulation, artificial intelligence for medical decision assistance, and molecular biology information systems are among important areas currently under investigation by Lister Hill Center staff.

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## Organizational Structure

Leadership for the Lister Hill Center programs is provided by a Director and Deputy Director, overseeing the activities of five branches:

- Computer Science Branch
- Information Technology Branch
- Communications Engineering Branch
- Audiovisual Program Development Branch
- Educational Technology Branch

During 1987 Branch Chiefs were selected for the Computer Science Branch and the newly formed Educational Technology Branch giving the Center a full management staff. Dr. Lawrence Kingsland of the LHNCBC staff and project leader in Expert Systems was appointed Chief, Computer Science Branch. Dr. Michael Ackerman, Head of Biomedical Engineering, Naval Medical Research Institute was selected to head the Educational Technology Branch. This latter branch was formed in February 1987 by merging the Health Professions Applications Branch and the Training and Consultation Branch.

A Board of Scientific Counselors (BoSC) meets to review the quality and content of the intramural research programs within NLM, with particular attention directed to the Lister Hill Center. It is composed of scientific and technical experts (see Appendix 4 for a list of the members) who are prominent leaders in the fields of medicine, computer science, and health professions education. The BoSC meets twice yearly to review and make recommendations on the LHNCBC programs to the NLM Director and the Lister Hill Center Director.

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## Research Program Overview

The research and development programs of the LHNCBC fall into 3 categories:

1. Computer and information science as applied to the problems of the Library, of biomedical research, and health care delivery;
2. Biomedical image engineering, including image acquisition, processing, storage, retrieval, and communications; and
3. Use of computer and image technologies for health professions education.

Within each of these major program areas, there are a number of ongoing projects.

*Lister Hill Center*

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## Computer and Information Science

*Artificial Intelligence/Expert Systems Program.* A research program in artificial intelligence concentrating on expert systems was established at LHCBC in 1984. Expert systems are computer programs which combine knowledge of a particular subject area with inferencing mechanisms enabling them to use this knowledge in problem-solving situations. The Expert Systems Program explores research topics in artificial intelligence for the development of knowledge-based expert consultant systems in biomedicine and in information classification and retrieval. Of particular interest to the Expert Systems Program investigators are problems in knowledge representation and knowledge base structure, in human factors design for expert systems, in the uses of high-resolution graphics to illustrate system reasoning, in interactive videodisc capability to extend system utility and educational potential, in the linking of expert systems to visual databanks, in the linking of expert systems to large-scale mainframe databanks, and in high-performance microcomputers and workstations as delivery vehicles for these complex programs.

Expert systems can be categorized in two primary types: systems to assist experts in coping with conditions of information overload, and systems for the transfer of expertise. The latter systems can amplify the accessibility of specialist-level expertise by encapsulating portions of this expertise and making it available when the human specialists are not. Systems of both types are under active development at the Lister Hill Center. The efforts of the researchers are directed to extending both in-house capability and the extramural aspects of technology transfer, research community-building, and information dissemination appropriate to the Library's mission.

The in-house capability has been enhanced by the continuing development of an Artificial Intelligence Laboratory which provides hardware and software environments appropriate to this research

and to the demonstration of its results. A recent addition to the Artificial Intelligence Laboratory is the KEE (Knowledge Engineering Environment) software, an extremely flexible expert system shell for high-performance graphics workstations such as the Sun-3 systems which will become the focus of several research projects in FY 1988.

Expert Systems Program staff during FY 1987 addressed the technology transfer issue by adding further new functionality to the shell called EXPERT, a major expert systems software development tool. EXPERT, developed for mainframe computers by Rutgers University, was ported to the IBM PC AT microcomputer system by the NLM group in FY 1986. The capabilities added at NLM include a new user interface with a mouse pointing device, color and context-sensitive help frames; a videodisc interface and video image bank utilities; a direct link to GRATEFUL MED, NLM's PC-based front end for access to the MEDLARS mainframe databanks; and a criteria table translator front end. With its new functionality, the current NLM version of EXPERT offers an excellent test-bed for the development of expert systems in widely varied subject areas.

One focus of the Expert Systems Program is the continuing development and evaluation of the AI/RHEUM consultant system in rheumatology, one of the world's largest medical artificial intelligence systems. Since AI/RHEUM runs under EXPERT, it takes full advantage of the NLM-developed user interface and the new functional capabilities. The Lister Hill Center has with recent AI/RHEUM development been at the forefront of an encouraging national trend away from expert systems in isolation and toward systems having explicit linkages to useful information in other forms wherever it may reside. AI/RHEUM is unusual among expert systems in offering the user direct access to information from four knowledge sources: text definitions; videodisc images; the disease criteria tables which are the foundation of its medical knowledge base; and GRATEFUL MED for

automated dial-out, logon, searching and downloading from NLM's MEDLARS family of databases without leaving the running rheumatology consultant program.

In its current state, the AI/RHEUM diagnostic system contains in its knowledge base information on 32 rheumatologic diseases. It reasons from 913 patient findings (basic information such as signs, symptoms, laboratory tests and radiographic observations) through 726 intermediate hypotheses to these 32 disease conclusions. It has nearly 200 text definitions available in a fraction of a second to explain those patient findings which might not be familiar to its intended users. In addition, the system offers direct access to an "image bank" of 1,900 videodisc images illustrating specific rheumatologic findings.

AI/RHEUM has been tested with more than 500 clinical cases. Its overall level of agreement with the consensus diagnosis of Board-certified rheumatologist clinicians is above 90%. Further validation of the knowledge base with five hundred additional test cases from widely separated clinical settings is nearly complete.

The evaluation of medical expert systems such as AI/RHEUM is a difficult problem for which no generally accepted paradigm has yet been developed. Members of the Expert Systems Program have begun with other NLM staff and with nationally known evaluation specialists to develop a general methodology for the evaluation of medical expert systems. AI/RHEUM will be used as the specific vehicle for the testing of this methodology at multiple clinical sites in an NIH-funded evaluation program of several years' duration.

AI/RHEUM has both a diagnostic and a patient management component. The patient management program provides therapy recommendations for patients having rheumatoid arthritis, a rheumatologic disease chosen both for its complexity and its prevalence. On the basis of specific information it requests, the program assesses patient condition and makes treatment suggestions at

several levels, from basic measures through cytotoxic drug therapies. The system has "Tell Me More" information on line for users who wish detailed explanations of its recommendations.

The Expert Systems Program also works with knowledge-based consultant systems in other areas of medicine. An example is AI/COAG, which like AI/RHEUM was developed at Missouri and brought to NLM in 1984 by Dr. Lindberg and Dr. Kingsland. AI/COAG offers diagnostic assistance for problems in human hemostasis. This system also has a modular architecture. The first module performs a differential interpretation of 6 coagulation laboratory screening tests, and offers "Tell Me More" and "Tell Me Reference" information to support its conclusions. The second module acquires and stores a detailed hemostasis history. It prints a summary record for the user, then analyzes the history to determine whether the presence of a hemostatic defect makes a further workup desirable. A third AI/COAG module, developed with a hemostasis/ blood banking expert who spent a sabbatical period with the Expert Systems Program team, advises emergency room physicians on blood component replacement therapy for cases of major trauma.

Expert Systems Program staff are currently involved in a consultant role in the development of a prototype system to advise response teams in hazardous substances emergencies. They are involved in the startup phases of a "cataloger's assistant" system to assist in the NLM cataloging process for new acquisitions and of an "expert searcher" system to perform some of the functions of an expert medical reference librarian assisting a user in the formulation of queries for MEDLARS searches. In addition, staff members are actively involved in the artificial intelligence initiatives of NLM's Unified Medical Language System project.

The extramural aspects appropriate to artificial intelligence research at NLM have been addressed in several ways. The issues of technology transfer have been explored by focusing on methods of

delivering these large-scale artificial intelligence programs on powerful microcomputers more widely available than the mainframe systems on which many such programs have previously been developed. The porting of the development system called EXPERT to the IBM PC AT is an example of such an effort. Numerous presentations, seminars, panels and system demonstrations at national and international conferences testify to significant contribution to the research community beyond NLM.

The dissemination of information on artificial intelligence in medicine has been further addressed by a collaborative effort with LHCNBC's Audiovisual Program Development Branch in the production of a series of brief (10-15 minutes) videotape segments on medical expert systems. These taped video productions help to explain artificial intelligence research in presentations which include statements of purpose and function by the system developers themselves. When appropriate, they use electronic graphics to illustrate the reasoning process of the system being presented. The tapes are available through the Regional Medical Library loan process for audiovisual materials. The series will be expanded in FY 1988.

In FY 1987, LHCNBC staff produced a museum exhibit on "Artificial Intelligence in Medicine." It is a fully interactive videodisc system with: touch-screen control by the museum visitor, overlying videodisc sequences with computer-generated graphics frames, and synthetic voice response to user choices. This exhibit, one component of a larger exhibition called "The Age of Intelligent Machines" which opened at the Museum of Science in Boston in January of 1987, has been very well received and will appear in 8 museums of science nationwide over the next 3 years. The Boston Museum of Science estimates that three million visitors will have seen this exhibit by the end of 1989.

*Automated Classification and Retrieval Program (ACRP).* The objectives of this program are to

conduct basic and applied research leading to the development of automated systems for representing, identifying and retrieving relevant information from biomedical documents. Current work centers on developing an expert system to assist in the process of indexing the biomedical literature (MedIndEx), developing a natural language understanding system, and exploring issues in the mapping and merging of thesauri.

*MedIndEx Project.* The objective of the MedIndEx Project is to develop and test interactive knowledge-based systems for computer-assisted indexing of the medical literature currently indexed in the MEDLINE database using terms from the Medical Subject Headings (MeSH) thesaurus. By encoding the indexing scheme in a knowledge base and using it to assist indexers, the system is expected to promote "expert indexing"—indexing consistent with the published indexing tools upon which human indexers currently depend. The published indexing tools of course provide no interactive assistance.

Frames, a well known data structure in the field of artificial intelligence, are used for encoding the knowledge base and the indexing output. Both indexing rules and medical facts needed for indexing are encoded in knowledge base frames. The indexer, with the help of the system, creates for each document indexed a set of indexing frames patterned after the knowledge base frames. The system prompts the indexer to consider indexable aspects of a document; processes the indexer's input (the terms the indexer adds to slots of indexing frames); and provides guidance, validation and suggestions during the indexing session. It can provide hierarchical displays of terms in the knowledge base in general or of permissible terms for the current slot, in response to user-initiated requests. The knowledge base applies rules not only for producing indexing frames, but also for generating conventional MeSH indexing terms at the level of expert indexing. These indexing terms will be used in

evaluating the system when the knowledge base has been sufficiently developed and a new user interface has been built.

Research on the MedIndEx System prototype has proceeded in two areas: the functionality of the user (Indexer) interface, and development of the knowledge base frames and the rules for generating the MeSH indexing terms.

Accomplishments in the first area include: an algorithm which uses the knowledge base hierarchy to enforce the use of a more specific frame when one is available for the current concept; suggestions of alternative terms for a concept when the indexer enters a term; hierarchical displays of terms; and interactive modification of stored frames.

Selected accomplishments in the second area include the creation of new high-level frames in the medical domain; the expansion of the relations in the frames; the collapsing of some relations (which function as user prompts) to simplify data entry; the refinement of the hierarchy; the insertion of additional rules for system generation of MeSH indexing terms; and the development of software for generating frames automatically from the MeSH tree structures.

*Natural Language Systems Project.* The Natural Language Systems research group addresses fundamental issues in language analysis with the long-term goal of designing intelligent systems for improved access to biomedical information. This research lies at the intersection of the fields of linguistics, computer science, and information science. The work is based on the assumption that systems combining domain knowledge with sophisticated linguistic analysis will lead to improved representation and retrieval of biomedical information. Such systems will need heuristics to improve their ability to handle incomplete or conflicting information.

A significant portion of this research in FY 1987 has been devoted to the development of a natural language parser for the biomedical domain. The

project team has designed and implemented a prototype parsing system in PROLOG on the VAX-11/780 super minicomputer. In addition, the team has designed and implemented a set of software tools which speed the task of developing lexical and syntactic components for the system. These include a lexicon building tool, a set of text processing programs, and programs which identify Medical Subject Headings (MeSH) in free text. The group has begun to develop tools for extracting necessary information from the machine readable version of *Dorland's Illustrated Medical Dictionary*. These tools will also be used to extract information from the machine-readable version of the recently acquired *Oxford Advanced Learner's Dictionary*.

In addition to work in developing the parser itself, the Natural Language Systems group is carrying out a large-scale analysis of the language of actual user queries submitted to the MEDLINE system. The results of this work will have direct implications for the natural-language processing system and for the Unified Medical Language System. The group has also been involved in developing a test collection of queries and corresponding citations from MEDLINE for use in evaluating UMLS project results.

*Thesaurus Research Project.* This project investigates issues in the mapping, merging and display of thesauri. It seeks to emphasize the principles by which similarities among knowledge bases can be detected, differences exploited, and quantitative comparisons of value made. One focus of work in FY 1986 involved investigating the effect of synonym augmentation upon MeSH indexing of medical journal articles. Continuing with this research and using automated indexing software developed previously, the group concluded that contrary to expectations, the inclusion of synonyms in the indexing process had no significant effect upon the process.

Additional work by Dr. Roy Rada and the thesaurus research group resulted in the publication of manuscripts on patterns in the MeSH vocabulary, a medical informatics thesaurus, a method of building medical knowledge bases, knowledge-sparse and knowledge-rich learning for information retrieval systems, and the role of identity and part-whole in relating two knowledge bases.

During FY 1987, the group developed a prototype of a PC AT-based MeSH workstation for thesaurus maintenance. The project group also continued its research into the merging of multiple thesauri, for which current efforts involve the use of the Lister Hill Center's Britton Lee relational database machine to store and manipulate information from the MeSH and SNOMED thesauri.

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#### Computer and Information Science

*Online Reference Works.* The Online Reference Works (ORW) program addresses the issues of how to use most effectively the extensive published body of medical reference works in an online, interactive manner and how to aid in the scholarly process of text creation and maintenance. An objective of the program has been to define and prototype a "scholar's workstation" that can serve as an integrated information resource for both the creation and the retrieval of reference works.

The platform for research in this program has been an experimental text retrieval system known as IRX (Information Retrieval Experiment). Experimental work during the past 2 years has tested the limits of statistically based retrieval techniques and has provided guidelines for implementing end user systems. Studies have been done on document ranking algorithms and the use of automatic suffixing of user queries. The most recent study, "A Failure Analysis of the Limitations of Suffixing in an Online Environment," was presented at the international meetings of the ACM Special Interest Group on Information Retrieval in June 1987.

IRX has also served as an end-user, interactive retrieval system for access to a human genetics database at Johns Hopkins and for searching molecular biology databases as part of the LHC biotechnology information program. The ORW program has a collaborative project with the Welch Library at Johns Hopkins in which research concepts can be tested and evaluated in the operational environment of the Johns Hopkins medical school and the Welch Medical Library. Collaborative activities over the past year have involved conducting a study of the information needs of JHU faculty and house staff and creating a test collection of queries and relevance judgments for the *Mendelian Inheritance in Man* (MIM) database. A primary part of the collaboration has been the LHC development of an integrated text creation, revision, and retrieval system for the MIM database, which is considered to be the authoritative catalog of human genetic diseases. In August 1987, the Howard Hughes Medical Foundation began supporting national online access to MIM and other genetics information using the IRX software. A standalone version of IRX has also been used during the past year in support of meetings of the Human Gene Mapping Committee in Florida and in Paris.

Current research in augmenting IRX and access to the genetics database includes the addition of photographs, drawings and radiographs to the database. Approximately 10,000 visuals (primarily of skeletal dysplasias) have been cataloged and are now being transferred to an edit videodisc. PC-based software has been developed which allows graphics overlays and editing of the images prior to creation of the final videodisc. The completed system will allow a user to enter a natural language query ("What syndromes cause ear deformities") and retrieve a text description of the syndromes as well as a set of related photographs and x rays.

Dr. Steven Pollitt, from Huddersfield Polytechnic in Great Britain, joined the ORW project as a special expert for the past year. Dr. Pollitt had previously developed a front-end for searching



cancer therapy information in the MEDLINE database. While at LHC, Dr. Pollitt designed and implemented a menu-based, concept-driven approach for searching MEDLINE by selecting combinations of terms from panels of Mesh terms. Implementations have been demonstrated for a molecular biology subset of MEDLINE on both the Sun workstation and the PC.

*Biotechnology Information Program.* The Biotechnology Information Program was initiated in the summer of 1986 in response to a report from the NLM Long-Range Planning Panel which recognized the importance of computer and information science in the management and analysis of molecular biology data. With advances in DNA sequencing technology and with serious consideration being given to large-scale sequencing projects, such as the human genome project, there will be a growing need to structure, search, and analyze the rapidly growing volume of data. During the past year NLM staff have begun several short- and long-range projects which have been aimed at improving the content and usability of factual databases.

The role of NLM in biotechnology information has been recognized nationally as well as internationally through invitations to discuss and to participate in the planning of the databases of the future. During the past year, members of LHCNBC have given invited papers at a workshop on future databases for molecular biology held at the European Molecular Biology Laboratory in Heidelberg and at a meeting on nucleic acid and protein sequencing data sponsored by CODATA, the international standards organization. LHCNBC was also the organizer of a workshop to develop specifications for a "Biotechnology Environmental Release Database."

One of the key databases in molecular biology is NIH's GenBank, a DNA sequence database for which NLM is a cosponsor. During the past year Lister Hill has investigated how MEDLINE as a comprehensive source of biological information

can contribute to data generation for GenBank. A procedure has been established for creating monthly subsets of MEDLINE which contain citations with base sequence information from journals that are not regularly scanned by the GenBank data extractors. An SDILINE search is run at NLM and the results are sent over the ARPANET to the GenBank staff at Los Alamos. Beginning with the 1988 version of MeSH, the searches will become more precise since indexers will apply a new MeSH heading (Molecular Sequence Data) to citations which contain actual listings of amino acid or DNA sequences. MeSH has also been augmented through the mapping of several hundred keywords from GenBank records to corresponding MeSH entries so that once a searcher has identified a relevant set of GenBank records, the keywords can be used as search terms for a MEDLINE search to retrieve the current, related literature. As a result of analyzing the correspondence between GenBank literature citations and their occurrence in MEDLINE, a modification is being planned that will insert a "link" in MEDLINE citations to indicate whether a particular citation has sequence data that can be found in another database such as GenBank. Similar vocabulary mapping and database cross-linking activities are also being considered for the Protein Identification Resource (PIR), the amino acid sequence database.

In order to help users locate sources of biotechnology information, the Specialized Information Services division of NLM, with assistance from LHCNBC, is building a directory of information resources that will be available online. Organized in a similar fashion to DIRLINE (Directory Online) file, it will serve as a pointer to databanks, organizations, and reference monographs in the biotechnology area, particularly in the molecular biology and genetics domain.

With the rapid growth in the sequence databases, a key issue is how to store, access, and manipulate the data. LHCNBC is focusing its immediate software efforts on the development of an integrated

databank retrieval and analysis system that will be prototyped and made available for evaluation by the NIH community of molecular biologists. The search engine for database retrieval is based upon the IRX software which was developed at LHCBC for generalized text searching (see previous section in this chapter). IRX provides an easy to use, uniform interface for the sequence databanks (GenBank, PIR, EMBL) as well as other factual and bibliographic databases. Work is underway to integrate sequence analysis tools and to provide a customized front end for dial-up access by PCs. Working relationships have been formed with several groups both inside and outside NIH in order to coordinate software development efforts and facilitate the participation of NIH laboratories.

A 56-kilobit communications link has been installed between LHCBC and the National Cancer Institute's Advanced Computer Research Facility in Frederick that will link Ethernets at both sites and provide joint access to such computer resources as a Cray X-MP, Sun database server, ARPANET, and NSFNET. Another 56-kilobit link has been installed between LHCBC and the NIH Division of Computer Research and Technology (DCRT). Since the Advanced Laboratory Workstation project at DCRT represents a future operational environment for the LHCBC prototype software, efforts are being made to adopt a standardized software development environment. During the past year a network of 5 Sun workstations and 1 Sun file server has been integrated into the LHCBC computer resource and is being used to develop software and as a target system for the next generation of laboratory workstations. As part of the biotechnology program, NLM has established a seminar series in which distinguished research scientists are invited to present seminars on the basic as well as applied aspects of molecular biology. Workshops for NIH staff on the use of sequence analysis software have been presented by Dr. David Lipman of NIH, the developer of one of the most widely used sequence searching algorithms.

*Biomedical Image Engineering.* The focus of this research area is electronic imaging technology in the capture, storage, processing, online retrieval, transmission and display of biomedical documents and medical imagery. Research areas include image compression, image enhancement, image understanding, pseudo-grayscale rendition, image transmission and networks, omnifont text recognition, and man-machine interface design. Experiments are under way to investigate the applicability of advanced imaging techniques to the problem of preserving the NLM's biomedical collection. Research into imaging techniques that support medical educational packages employing digitized radiographic, dermatological, and other imagery is also being pursued.

*Electronic Document Storage and Retrieval Program.* Preserving the biomedical collection from continual deterioration is a mandated responsibility of the NLM. In large part this deterioration is embrittlement caused by the conventional use of acid-containing paper as a print medium, which poses the risk of spontaneous destruction of printed works in as little as thirty years. The standard means for archiving such endangered materials is photographic. LHCBC is investigating advanced electronic technologies as an alternative means of preservation which promises improved access and communications as well as image enhancement possibilities. Additionally, the principles governing the acquisition, storage, and retrieval of document page images are potentially applicable to a wide range of biomedical images as well.

The LHCBC has developed a laboratory facility to investigate the role of electronic document storage and retrieval in library information processing activities. The facility is implemented as an integrated prototype system that includes document capture devices for both loose-leaf pages as well as bound volumes, magnetic buffer storage, digital optical disk drives, high resolution softcopy displays rendering a legible bit-mapped image of a

full page of a book or journal, modules for dynamic thresholding and pseudo-half-toning, high speed digital image transmission subsystems, and modules for image enhancement and manipulation. A system controller, based on a minicomputer, has been designed and implemented to control the basic functions of capturing the document images, transferring them to magnetic and optical disk storage, retrieving them in conjunction with bibliographic databases such as MEDLINE and CATLINE, and displaying them at remote workstations.

In the process of implementing archival storage capability in the prototype system by means of digital optical disk technology, research was conducted on hardware and software interface design techniques, image data transfer error performance, design factors limiting transfer rate, image compression, and modification of optical disk drives to interchangeably handle optical media having different characteristics. These studies have been reported in the technical journal literature.

While traditional preservation activities do not emphasize access, it is recognized that access and retrieval are significant characteristics of electronic imaging. To implement access to and retrieval of document images at a remote workstation, research was conducted in image transmission techniques. Three high-speed (10 Mbps) digital transmission interfaces have been developed using various signal modulation techniques, design factors affecting speed and reliability were identified, application protocols and software modules to support high speed image transmission were developed, and remote distance transmission was demonstrated.

Document capture by means of the book scanner (for bound volumes and brittle material that would be damaged by rapid transport through the loose leaf scanner) results in page images that have borders and that are off-center. Software and hardware interfaces, including a mouse-controlled cursor-based system, were developed to remove the borders electronically and to center the images. Apart from the aesthetic value of this processing,

studies showed that it substantially improved image compression performance. Custom interface hardware was also developed to allow pseudo-gray (half-tone) rendition of multiple gray level imagery.

It is desirable to maximize the number of documents on each disk by employing image compression techniques. The storage density is directly related to the compressibility of the digitized image or, equivalently, the ability of the selected compression technique to remove the redundancy in the image as completely as possible. The considerations in the implementation of image compression upon document capture are: selection of a technique that is likely to be commercially available; large number of stations; selection of a technique that yields respectable compression ratios for the documents actually in the collection of interest, rather than the "test" documents typical of, say, an office environment; implementation of appropriate image enhancement techniques during the capture stage to maximize the effectiveness of the compression algorithms. As a result of these considerations, three different hardware implementations were used in a comparative study of performance. While all three boards were based on a recently developed VLSI chip implementing CCITT run length coding algorithms, there were differences in architecture. Performance data, mainly compression ratio and time to compress and expand, pointed to one optimum implementation.

In March 1986 an Experiment Plan for investigating document preservation by electronic imaging was presented for review by the NLM Board of Scientific Counselors. The Plan identified several preservation objectives and the corresponding research questions. It also described experiments designed to address these questions by using the laboratory prototype system as a testbed. The issues of interest included throughput and conversion costs, document classification strategies, errors encountered in the conversion process, quality control strategies, and image enhancement techniques, among others.

Using a statistically representative sample of the Library's collection and the prototype system as a testbed, data was collected and analyzed. Conversion rates were measured and event analyses showed limitations in the system that led to the relatively low throughput. A major outcome of this work was the realization that a system comprising intelligent standalone workstations for the critical functions of document capture, quality control, and archiving (image transfer from magnetic disk buffer to optical disk) would better serve the process of accomplishing document preservation via electronic imaging.

The first workstation, for citation search via GRATEFUL MED and the retrieval and display of document images, has been completed. The hardware includes an IBM AT-class microcomputer serving as the system controller, an optical disk drive serving as a store for document images, a high-resolution 2200 line bitmapped softcopy display device and a printer/plotter for hardcopy. The control software allows a user to search the Library's citation database, display the citations, and automatically have the document images displayed. While this workstation is intelligent in the sense that no external computer is required for its local operation, it is not strictly speaking "standalone" since for a brief moment its GRATEFUL MED software makes contact with remotely located databases to search for citations. Once the citations arrive at the workstation, however, its subsequent operations are indeed completely local and hence could properly be termed standalone. The other workstations to serve the functions of document capture, quality control and archiving are being designed.

Since throughput is a significant factor in any operational system that is required to convert large quantities of documents, the document capture station is being redesigned to allow higher throughput. From the analysis of the data to date, it is clear that conversion could be speeded by a) replacing the current 2048-element CCD array

with a recently available 4096-element array to allow the simultaneous capture of two adjacent pages of an open volume; b) incorporating the mouse-driven image segmentation feature for rapid bordering; c) incorporating thresholding and pseudohalftone circuitry; d) possibly including an automatic image segmentation algorithm as an aid to the operator to permit automatic bordering at least for the majority if not all of the pages; e) implementing voice response for alerting the operator to perform the required sequence of tasks; f) replacing the 1-D CCD array with a 2-D array to allow an electronic "snapshot" of the page to be taken; g) considering an alternative approach to compression: on the fly as data streams in from the CCD; and i) increasing the field of view to eliminate excessive book handling and rescans. As part of the continuing experiment, a cost model was developed on the basis of certain assumptions, most prominently, on the two most time-consuming stages, document scanning and quality check.

For document classification, over a dozen optical and mechanical characteristics of the approximately 400 volumes were recorded. Cluster analysis succeeded in creating 6 document classes and a formula that allows a document picked arbitrarily from the NLM collection to be placed in one of them. The identification of these classes is a basis for estimating improvements in throughput and cost over the baseline system and procedures by batching document by class.

In the experiment investigating error performance and a quality control strategy, the baseline procedure developed for quality control involved a quick check of the image after initial scan, a check of the quality and retrievability of the image on magnetic disk followed by a rescanning if necessary, and a final check of the image on optical disk. The contribution of quality control to throughput was determined. The types and frequency of errors were also determined. As a result of error rate tests it was found that the magnetic

disk to optical disk transfer was error-free. Consequently the quality control procedure was modified to eliminate the final check on the optical disk.

Research into the applicability of electronic imaging to the problem of preserving the biomedical literature is continuing. An interim report on this work was presented to the Board of Scientific Counselors in November 1986.

*Digital Biomedical Image Processing* This R&D area involves developing and evaluating improved techniques to capture, store and display medical images for computer-based educational systems. Biomedical images of interest include both multiple gray level images (e.g., radiographs) and color (e.g., dermatologic slides). Techniques presently being implemented and evaluated include digital capture and encoding of radiographs to improve the signal-to-noise ratio, and windowing techniques to provide high resolution images in video format on standard television video (also called NTSC) systems. Compared to analog systems, these techniques provide improved image quality on low cost personal computer workstations.

Image processing techniques are also being explored to isolate and display localized regions of interest on digitized radiographic images. As part of this research, a prototype x-ray imaging system (XRIS) has been developed using an IBM AT controlling a "frame grabber" subsystem and a CD-ROM storage unit capable of online access to half a gigabyte of image data and displaying a 512x512 pixel image.

The Center for Devices and Radiological Health supported the project with images from its library of digital x-ray images. Fifty-eight cases, a total of 121 images, were selected from the library for the XRIS visual database. Cases selected included examples of different body areas, with images for both male and female, and patient case impressions for different age groups.

Each image in the database is provided with a patient history text file and two bit map files, one

consisting of a low resolution image and the other of a high resolution image. The low resolution image files are structured as 8-bit binary files with a spatial resolution of 512 x 512 pixels with 256 gray levels. High resolution files use the same data structure and contain 2048 x 2048 pixels of spatial resolution. A menu driven user interface to a relational database was developed to retrieve and display image files. The database is structured using a record management system allowing relational access to the files by case number, medical impression, and body area. This retrieval schema was developed to support the prototype system, any future retrieval system will be integrated into the host computer-based educational system it supports.

Because the bandwidth and spatial resolution of NTSC (TV-like video) systems limit the display capability of the monitor to the size of low resolution images, a windowing technique is used to display segments of the high resolution image. Each low resolution image contains one-sixteenth the area of a high resolution image, this is equivalent to an image one-fourth the height and width of the full high resolution image. A movable fixed size window is superimposed onto the low resolution image which correlates to a mapped segment of the high resolution image file. By locating this window over a selected area using a "mouse" pointing device, the system can effectively increase the resolution of that area by a factor of sixteen, that is, equivalent to the resolution yielded by a 2048 x 2048 pixel display.

In addition to the XRIS prototype a laboratory system involving a high resolution (2048 x 2048 pixel, 8 bit/pixel) gray scale and color image capture system, and a Gould IP8500 Image Processing System hosted by a DEC PDP 11/44 has been developed for the capture and processing of high resolution digitized biomedical imagery. Software developed inhouse allows zoom, scroll and roam through a 2048 x 2048 pixel bit image both gray scale and color with a 1024 x 1024 pixel display.

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### Audiovisual Program Support

The Audiovisual Program Development Branch (APDB) applies current and emerging video communications technologies and audiovisual techniques to Lister Hill Center research, development, and demonstration projects and to the information needs of the health sciences community.

The APDB maintains a videodisc premastering facility. A sophisticated electronic videographics system, activated in 1986, and the installation of improved one-inch videotape recording equipment have allowed the facility to produce state-of-the-art visual materials. A flexible, computer-controlled still video transfer system (the "RIG"), installed early in FY 1987, enables the Branch to integrate slides, transparencies and hard-copy visuals—either static or in motion—into videotaped project materials with higher quality and greater effectiveness than was possible before its introduction.

Working closely with Project Leader Dr. Lawrence Kingsland, APDB used both traditional and emerging technologies in the production of a Level III (computer-controlled) videodisc on "Artificial Intelligence in Medicine" (see earlier section on Artificial Intelligence/ Expert Systems Program).

The Branch continues to provide premastering expertise in the recording, creating and editing of visual materials and narration audio to the pathology (videomicroscopy) interactive videodisc series. Work was completed on Dr. James Byers' "Circulatory Disturbances: Thrombi, Emboli, and Infarctions" and Dr. Robin Jones' "Necrosis" units. In addition to the use of videomicroscopes and the new video still image transfer system, this series has benefitted from the creative use of the BOSCH electronic videographics system. Other units still in various stages of production include Dr. Lawrence Wheeler's "Cellular Accumulation," Dr. Louis Johnson's "Chronic Inflammation," and "Neoplasia, Parts I and II," by Dr. Robert Shikes and Dr. Gary Miller, respectively.

Another project completed during FY 1987 is the Dr. Frank Allan "Human Light Microscopic Anatomy" interactive videodisc. All premastering work was done by the branch and a Level III, 8-inch videodisc was mastered containing some 3,000 separate microscopic images, individually identified, plus blue frames (to provide neutral visual material during pauses in the use of clinical visuals for instruction) and a variety of test and reference frames to allow playback monitors to be properly aligned. The computer programming permits natural language queries to all recorded materials.

APDB continued working with the TIME project during FY 1987 (described in the following Educational Technology section of this chapter). Faculty training sessions at NLM were videotaped and teacher/student interactions in Cincinnati, Albany and at Georgetown University Medical School were location videotaped to show how "The Case of Frank Hall" and "The Case of Patricia Fletcher" are being used in medical school curricular settings. Early in FY 1988, a final composite videotape will be edited to document the TIME Evaluation Project.

The Branch remained active in developing, recording, editing and premastering NLM education program materials. Among them:

- Videotape and still photographic coverage of highlights in last year's Sesquicentennial celebration were edited into a "Sesquicentennial Overview" videotape which was placed in the NLM distribution system.
- Seven Auditorium presentations in a "Biotechnology Seminar Series," originally videotaped for internal information purposes, only, were later edited and turned over to NLM for distribution.
- Two colloquia, "Space Medicine" and a "Medicine and the Arts," were edited and made available to the health sciences community. Previously taped programs on "MEDLARS/an

Overview," "MEDLARS/Indexing," "MEDLARS/DOCLINE," and the "Toxicology Information Program" were updated, re-edited and pre-mastered for a Level II videodisc which was delivered to the Library for use in the Visitor's Center.

- Consultation, advice and production work was provided to a "GRATEFUL MED Teleconference" broadcast on January 22 (in the midst of a raging snowstorm) from the studio facilities of the U.S. Chamber of Commerce. Previously videotaped training materials and live interactive presentations by NLM employees were received by 22 Veterans Administration sites in the western United States. An "aircheck" videotape of the entire teleconference was later edited and entered into NLM distribution.
- As a test of the technique, "open caption" and "closed caption" versions of "Communicating for Health" were produced to permit viewing by the hearing impaired.
- During FY 1987, site surveys of all Regional Medical Libraries were conducted, a script was developed, and location videotaping was begun for a special videotape explaining, and illustrating, the many aspects and activities of the RML network system.

APDB's Graphics and Still Photography Labs continue to provide visual information materials to Lister Hill Center research and demonstration projects and to other elements of the Library. The Graphics Lab contributes to the upgrading of the Branch's premastering facility and to the more efficient and effective generation of personally designed slides and other graphics materials through the creative use of electronic videographics, microcomputer and the exploitation of microcomputer graphics programs. The Still Photo Lab made similar contributions by providing video camera operation and creating the still video transfer system installed in FY 1987. The Branch also provides projection, audio recording and other

audiovisual support to meetings scheduled in the Lister Hill Center Auditorium and the NLM Board of Regents Room.

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### Educational Technology

*Computer-based Curriculum Delivery Systems (CCDS)*. The Computer-based Curriculum Delivery Systems Program continued to expand its collaborations with health professions schools in the U.S. and abroad. At the end of the year, there were 60 schools in the field-testing network, including 5 in Canada, 1 in the Philippines, and 1 in Austria. Individual schools continued to add hardware for additional student learning stations so that there are now over 100 student stations associated with the program. Field-testing of the Teenage Suicide program began with 26 schools. The suicide program was used by the American Medical Association National Conference on Impaired Health Professionals and by the George Washington University for a continuing education course on suicide. The program also received a Certificate of Merit Award at the annual Nebraska Videodisc Symposium.

The Orthopaedic Surgery programs were again presented at the 1987 annual meeting of the American Academy of Orthopaedic Surgery and were used for the first time in a regular continuing education course. The Academy has decided to make both programs a regular feature of the annual meeting as a part of the Individual Orthopaedic Instruction program.

Production was initiated on the remaining modules for the Basic Medical Pathology Project and sufficient progress achieved to insure that the project will be completed during the first quarter of FY 1988. The Radiology Project was enhanced by adding the capability to display digital images with a microcomputer and by recruiting of a senior radiologist as a Guest Worker at the Lister Hill Center.

The entire CCDS program was described by Dr. James Woods at 3 invited presentations in

Europe a special meeting of the Norwegian Medical Society in Oslo, an international symposium at the University of Leiden, and the First European Conference on Visual Documentation in Medicine (DocuMed87) in Amsterdam

*The Time Project* The focus of the Lister Hill Center's TIME Project (Technological Innovations in Medical Education) has been to address the perceived need by many medical educators for more patient-centered teaching during the early phases of medical student training. The project has created the "interactive case study," a voice-activated, videodisc patient simulation model to provide a patient context for faculty teaching in the medical school classroom.

In the spring of 1986 the prototype for the TIME model, *The Case of Frank Hall*, was successfully field tested in the classroom at Georgetown University Medical School with second-year students. Based on this preliminary evaluation, the TIME Project was awarded NIH set-aside funds to conduct an expanded, more rigorous evaluation of the interactive case study model in FY 1987.

The evaluation plan included field testing the model at selected medical schools, videotaping the faculty's classroom presentations, and data gathering through a variety of evaluation instruments. The intent was to gather data on the learning effectiveness of the material in both large and small groups, the usefulness of the method by faculty trained to present the material, and the level of acceptance of the approach by students and faculty. The University of Cincinnati Medical School, Albany Medical College and Georgetown University Medical School were chosen as the field test sites and 2 faculty from each school were selected and trained to present the case study material to second-year students in the introduction to clinical medicine curriculum.

For the purpose of the field test a second TIME case study, *The Case of Patricia Fletcher*, was completed. The case concerns a college professor with

chronic morbid obesity and some serious personal problems. It consists of over 300 video scenes depicting the medical, social and psychological problems of obesity and offers 3 contemporary therapeutic alternatives for patient management, including an eating disorders clinic, gastric bubble and gastroplasty.

In the spring of 1987 the 6 faculty members made 12 90-minute presentations of *The Case of Frank Hall* and *The Case of Patricia Fletcher* to approximately 400 students in both large (80-120 students) and small (10-15 students) group settings at the 3 test sites. Analysis of the findings shows significant learning gain by students, highly effective performances by faculty and high levels of acceptance of the model by both. There is also a clear indication that the model offers an effective means of changing students' attitudes, clarifying their values and revising patient stereotypes. The evaluation will continue in 1987-88 with a focus on expanded use of the materials in second-year medical school classrooms and more rigorous measurement of the model's ability to influence students' attitudes and values concerning patients and health related issues.

*Dermatology* The Dermatology project is exploring the technical requirements for building a library of electronic images of skin lesions. Project efforts have primarily been concentrated on technical developments to improve image quality. As yet, no commercially available technology for capturing and displaying color video images has matched the decision error rate achieved with color photographic transparencies. Experiments in color digital and analog recording at several levels of spatial resolution for both image capture and image display are in progress to determine the minimal information content necessary for accurate dermatologic decision-making.

*Library Growth* The Library Growth Project completed and published *Research Library Trends*,



*1951-1980 and Beyond* and forwarded copies to the National Technical Information Service for distribution. This 181-page report is based on annual statistics that span the years 1951 through 1985 and represent 58 "first tier" American research universities. A central finding is that the decade of the seventies was a unique and difficult period, one in which several well-established growth trends faltered or stalled. Nevertheless, between 1970 and 1980, a time of reported "austerity," library spending doubled and collections grew at annual rates of about 3.5 to 4.5%. Also, across the entire period from 1951 through 1985, the average collection grew by a factor of 3.56 (and in many instances, collections had more than quadrupled), annual acquisitions by a factor of 2.70, and spending by a factor of 22.6 (i.e., a dollar expended in 1985 corresponded to 4.4 cents in 1951). During the same period, library staffs tripled in size, but the vast majority of this increase occurred during the 1951-1970 period, before the onset of the "difficult seventies."

*The Learning Center For Interactive Technology.* The Learning Center for Interactive Technology (TLC) opened in March 1985 as a central location where various computer-video information and educational technologies are demonstrated, reviewed and evaluated. In FY 1987 TLC activities were expanded to include a personal computer training facility for NLM staff. The TLC Training Facility offers a variety of courses in microcomputer operating systems, word processing, database management, and other specific applications. A major renovation of the TLC was undertaken and completed to accommodate personal computer training activities and to provide space for the future expansion of demonstration and review activities. A permanent display area of backlighted transparencies and other mounted and free standing materials was created in the hallway leading to the TLC facility. Innovative, thematic exhibits relating to educational and information technology and to

the TLC are periodically developed and revised for display.

The TLC Training Facility became operational in March 1987. Twenty-five classes totaling 505 course units were taught to NLM staff members during its first 6 months of operation. In addition, 15 special demonstration sessions were held in the TLC Training Facility. The Learning Center staff provided 147 demonstrations and "hands on" experiences for 341 health professionals from the United States and foreign countries. Demonstrations available in the TLC represent examples of education and information technologies developed by staff of the LHCNBC, by individuals at other institutions, and by private companies.

Demonstrations are currently grouped in the following categories:

- Health Science Education and Information Networks;
- Stand-alone microcomputer courseware;
- Interactive videodiscs;
- Knowledge-based Information Systems; and
- CD-ROM Technologies (to be added during FY 1988).

## Extramural Grants and Contracts

Arthur J Broering

Acting Associate Director, Extramural Programs

*Programs and  
Services FY 1987*

**T**he National Library of Medicine's Extramural Programs provide a variety of assistance opportunities through grants and contracts to the health science community. This support, authorized by the Medical Library Assistance Act of 1965 and extensions, and by Section 301 of the Public Health Service Act as amended, has assisted authors and scholars, researchers and academicians, librarians, media and communication experts, computer and cognitive scientists, and information network designers and managers in improving the organization of health knowledge.

Supported projects range from research on fundamental questions about information in medical decision making, to the planning and operation of large-scale institution-wide integrated information networks, to historical writings on significant health topics, to the development of basic information access services at local and smaller health facilities. Regional Medical Library contracts, as authorized by the Medical Library Assistance Act, are described in the section on Library Operations.

A Long-Range Plan for the NLM was published during this fiscal year following more than a year's efforts by numerous experts and advisors. The Plan provides guides for future grant activities as well as the gauge by which progress will be measured. Accordingly, this annual report of grant activities and future such reports will include summary comments regarding contributions and accomplishments related to long-range objectives.

For the Extramural Programs, high priority areas for immediate attention and accelerated actions in FY 1987 were in the general areas of research career stimulation in medical informatics, introduction of an important NLM initiative in the computer and information science aspects of molecular biology data management, and, in the area of IAIMS (Integrated Academic Information Management Systems), continued efforts to promulgate the principles and potentials of this relatively new concept as well as to facilitate the final award (implementation) phase at IAIMS model institutions.

Specifically, medical informatics research career development efforts were considerably enhanced in FY 1987 by designated funds that provided for a doubling in the number of trainees in NLM's institutional training grant programs. Increased programming efforts, as well as improvements in the NIH new investigator award mechanism, resulted in heightened interest in this post-training, career support. The new FIRST (First Independent Research Support and Transition) award will assist in ensuring a continuum from trainee, to new investigator, to seasoned researcher in medical informatics and will expedite the recommendations in the long-range plan concerning the expansion of career development opportunities.

Another critical area is that related to the management of molecular biology data. Congressional Bills introduced in 1987 to establish a National Center for Biotechnology Information as a component of NLM, carry with them the anticipation of an extramural grant assistance initiative in research related to biotechnology information. Consequently, in FY 1987, NLM's grant assistance role was announced through the widely circularized NIH Guide for Grants and Contracts. Similar announcement of NLM's interest in this area were also made to the Assembly of Training Program Directors at their June 1987 meeting at NLM. Fiscal Year 1988 should see the first NLM grant awards in this area.

Regarding IAIMS, the proceedings of the second annual IAIMS symposium were distributed and planning began for a third symposium in FY 1988. The more advanced IAIMS institutions are progressing rapidly toward the final implementation phase (scheduled to begin in the first quarter of FY 1989) aided by third party participation in the IAIMS efforts. Steps have also been taken to remove some of the barriers (e.g., limitations on grant amounts) which would otherwise inhibit IAIMS progress.

Extramural Program expenditures for FY 1987 totalled \$14,284,000 for 97 new and continuing awards. Descriptions of the grant programs, including examples of funded projects, are contained in the following sections.

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### Training and Career Development

The National Library of Medicine continues its support of research training in the field of medical informatics. It is clear that this discipline goes beyond the use of the computer as a computational tool and extends into the process of knowledge representation, storage, retrieval, and manipulation largely to support inferential reasoning and to rationalize decision making in the health sciences. There remains a need for qualified, talented investigators, well equipped to address fundamental issues in the use of computers and automated information systems in health care, health professions education, and biomedical research. The investigators will contribute to the growth of science by their studies of knowledge management and by advancing the frontiers of the computer sciences for organizing, retrieving, and utilizing health knowledge. It is also intended to foster medical informatics as a growing discipline with an appropriate place in academic medicine. It is expected that the trainees will become able, cross-disciplinary translators, taking the computer sciences to all of medicine.

In fiscal year 1987, NLM received an additional \$1 million for the purpose of fostering this training endeavor. It was decided that the training program would be expanded to include doctoral candidates as well as postdoctoral research training and that the grant competition would permit existing grantees to extend and expand their FY 1984 awards as well as encourage new institutions to apply as training sites. Applications were received from 20 institutions in response to the published invitation. Grants were made to 8 institutions for a total outlay in excess of \$2 million and a doubling in the number of trainees, from 29 to 58. The institutions receiving grants are Stanford University; University of California, San Francisco; Washington University, St. Louis; University of Minnesota; University of Pittsburgh; Yale University; Harvard University; and the New England Medical Center.

The National Library of Medicine also offers research career grant programs in the fields of medical informatics and in health information science designed for individuals who have completed postdoctoral training and are now pursuing an independent research track. The First Independent Research Support and Transition (FIRST) award provides 5 years of support and a maximum total direct cost of \$300,000. Of 13 applications received in FY 1987, 4 were funded. To be eligible for this award the principal investigator must be a beginning investigator who is not in training status and who has not been designated previously as principal investigator on any peer-reviewed project supported by the PHS.

A supplementary career supporting mechanism is the Research Career Development Award (RCDA). These awards are given to institutions on behalf of candidates with promising research potential. The grants provide 5 years of salary support so that the individual can develop and advance as an independent investigator. The award is intended to make a significant difference to the individual's career growth. Research resources and support are not provided as a part of this award but must be available for use of the awardee. Although no new RCDA awards were made in FY 1987, support was provided to 6 individuals for continuation of support initiated in previous years. Five of these continuation awards are in the medical informatics area.

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### Research Grants

The Library continued to support innovative research into two specific areas: medical informatics, and health-library information science. Medical informatics, a relatively new interdisciplinary field, combines the medical sciences with information and computer sciences, computational linguistics, decision analysis, and related disciplines in addressing health knowledge issues.

Health-library information science represents a more traditional discipline dealing with issues of medical literature and bibliography

NLM supports investigations which are of a basic or fundamental character, and also work representing more applied studies, so long as the project design is scientifically rigorous and the results can be anticipated to make a contribution to the field. In medical informatics, NLM continued its support of 20 investigators who were initially funded in earlier years and also issued 7 new awards

The new work includes an investigation of computer graphic aids, or icons, in systems for medical models at the University of California, San Francisco. At the Georgia Institute of Technology, a major study was initiated for a knowledge-based system for cardiac image interpretation. At Carnegie-Mellon University, a computerized consultant system based on artificial intelligence methodologies will be designed to optimize the utilization of nuclear magnetic resonance imaging

Although NLM's medical informatics activity is quite small, its freedom from the constraint of categorical disease applications allows investigators in biomedicine and the computer sciences to consider complex problems of knowledge representation and retrieval. In this small but growing field, NLM's grant-supported investigators have achieved significant recognition. Edward Shortliffe, M.D., Ph.D., whose work on therapy planning strategies for consultation by computer will receive initial field testing this year, was elected to the Institute of Medicine. Jack Smith, M.D., Ph.D., received an annual award from the American Association for Medical Systems and Informatics for a young investigator's research accomplishments in medical knowledge systems

Health-Library Information Science was a somewhat more active area this year than last. Three investigators received support for work initiated earlier, while 5 entirely new projects were funded. For example, at the University of Michigan, Professor Miranda Pao is investigating two separate

information retrieval techniques with a view toward synthesizing them for a more effective bibliographic system. At the University of Missouri-Columbia, Professor Mary Ellen Sievert has undertaken a comparative study of index terms and their relationships to the full texts of medical documents. At West Virginia University, Professor Marie Abate is studying the utility of computer systems for organizing and retrieving drug information

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### Resource Grants

The Medical Library Resource Grant Program is designed to develop resources and services for the nation's health sciences libraries. Support ranges from assisting libraries to begin services to funding computerization projects for established health sciences libraries. Because Resource Grants are intended to provide "start-up" funds, the grant recipients contribute matching funds to assure continuation. There are two types of Resource Grant: the Improvement Grant and the Project Grant

The Medical Library Resource Improvement Grant is intended to develop basic collections for libraries in community health-related institutions. It is available to single institutions as well as consortia of multi-type institutions. In FY 1987, Improvement Grants were awarded to 6 hospitals and to 3 previously funded consortia in order to add new members

The Medical Library Resource Project Grant is available to established health sciences libraries and is designed to make existing information resources and services available to the ultimate users in a more effective, expeditious, and economical way. In FY 1987, 3 Medical Library Resource Project Grants were awarded, all for the installation of computerized library information systems. The University of New Mexico Medical Center Library's Library Information System will be linked to the library of a local hospital as a test site for eventual expansion into a statewide network. One unique feature of this system is the mounting of a database

of the publications and research projects of the medical center's faculty. The other 2 grants are to the Albany (NY) Medical College and to the Texas Tech University Health Sciences Center.

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### IAIMS Program

Integrated Academic Information Management Systems (IAIMS) are institution-wide computer networks that link and relate library systems with individual and institutional databases and information files, within and external to the institution, for patient care, research, education, and administration. Grants are awarded to assist medical centers and health science institutions in planning and development projects that will lead to the implementation of IAIMS. The overall goal is to create organizational mechanisms within health institutions to manage more effectively the knowledge of medicine, and to provide for a system of comprehensive information access.

Utilizing the Resource Project Grant mechanism, NLM provides support for: 1) institution-wide IAIMS planning and policy analysis; 2) model development and testing of some segment or cross-section of the IAIMS plan; and 3) implementation of detailed, tested plans for a full-scale IAIMS.

Some of the functions undertaken during planning include the preparation of a 10-year strategic plan for the institution, development of an institution information policy, assessing the technological capabilities of the institution, and defining the information management needs and requirements. From these activities an IAIMS plan is created which serves as the guide for the second phase of activity, model development.

In Phase II, IAIMS concepts are tested on a small scale in research, education, and/or patient-care areas. Those health science institutions which have completed an IAIMS plan and can demonstrate examples of successful modeling of critical elements of their plan may request NLM assistance to proceed with full-scale IAIMS implementation. These

various phases of IAIMS activity are considered sequential, and successful completion of each phase is required before applying for subsequent support.

During FY 1987, 11 IAIMS planning and model development projects were active, including those funded in previous years. IAIMS Phase I Planning was underway or nearing completion at the American College of Obstetricians and Gynecologists, Baylor College of Medicine, Harvard University, Johns Hopkins University, and Rhode Island Hospital. IAIMS Phase II Model Development and Testing began or was underway at Columbia University, Duke University, the University of Cincinnati, the University of Maryland, and the University of Utah.

Duke University is the newest member of the select group receiving NLM support for information management large-scale systems. Duke is the first in the IAIMS Program to receive Phase II support without having first received an NLM grant for IAIMS Phase I planning. In its application, Duke presented a well-documented IAIMS plan based on a successful 20-year history of commitment to the better management of information utilizing computer technology. This impressive effort, largely supported by institutional resources, more than satisfied all program requirements for IAIMS planning, according to the grant reviewers. Also during FY 1987, another institution began Phase II Development, the University of Cincinnati. Cincinnati began planning in 1984 with support from NLM, and successfully completed the process by creating an IAIMS Plan for the institution and establishing an IAIMS management group in the university.

The IAIMS concept and how it is being developed at selected sites continues to receive widespread interest. Reports from IAIMS grantees are in demand and, as described in last year's annual report, a symposium about the support of health sciences education and IAIMS was very well attended. Proceedings for the symposium were published, and more than 1,000 copies have been distributed.

**Table 10**  
**Extramural Grant and Contract Program**  
(Dollars in Thousands)

Category	FY 1985		FY 1986		FY 1987	
	Number	Amount (\$)	Number	Amount (\$)	Number	Amount (\$)
Research .....	39	\$ 5,431	37	\$5,609	40	\$6,391
Resource Projects .....	25	2,507	19	2,604	15	2,758
Resource Improvement ...	17	528	15	190	10	195
Training .....	5	1,091	5	1,095	8	2,147
Regional Med. Libraries ...	7	2,054	7	2,325	7	2,318
Publications .....	15	403	17	426	17	475
(IAIMS Projects)* .....	(11)	(1,717)	(9)	(2,205)	(9)	(2,549)
(Med. Info. Research) .	(31)	(4,489)	(28)	(4,029)	(28)	(4,256)
<b>Total .....</b>	<b>108</b>	<b>\$12,014</b>	<b>100</b>	<b>\$12,249</b>	<b>97</b>	<b>\$14,284</b>

\*Includes both IAIMS Resource & Research Projects

### Publication Grants

The Publication Grant Program, a domestic program authorized under the Medical Library Assistance Act, provides selective, short-term support for a variety of not-for-profit biomedical publications, expediting access and availability of health information for U.S. practitioners, research scientists, planners and educators. The companion Special Foreign Currency Program, described in the chapter on International Programs, is authorized under Public Law 480 and is also administered by the International Programs Branch of NLM's Extramural Programs Division.

Projects prepared and/or published under the Publication Grant Program include critical reviews and monographs in health fields; publications on biomedical communications and in library and information sciences; secondary literature tools (such as annotated bibliographies, atlases and catalogs); temporary support for periodical publications;

studies in the history of medicine; translations of current foreign biomedical monographs; and proceedings of symposia related to U.S. health needs.

During FY 1987, NLM awarded 16 Publication Grants, totaling \$434,047. Of these, 8 were new awards, including one for the preparation of a book-length manuscript on the evolution of social policies for managing adolescent fertility. The average amount of a Publication Grant in FY 1987—approximately \$27,000 including both direct and indirect costs—reflects the continuing emphasis in this program upon high quality, low cost, projects that are scheduled for early publication.

Among the studies published in FY 1987 which the Publication Grant Program funded was a monograph on *Sympathy and Science: Women Physicians in American Medicine*, by Regina M. Morantz-Sanchez (New York: Oxford University Press, 1985). The book explores the contributions of the early women pioneers in medical education

and the professional handicaps under which medicine was practiced in the mid-20th century. Another significant volume published this year is the first of several catalogs listing cloned DNA segments from *Drosophila*: "The Molecular Genome of *Drosophila Melanogaster*," by J. Merriam, S. Smalley, A. Merriam and B. Dawson (*Drosophila Information Service*, No. 63, 1986). This catalog will make it possible for a scientist interested in a particular chromosome site or gene to see if it has already been cloned by another worker.

Also completed this year with grant support was

a book, *Pandemic Influenza, 1700-1900: A Study in Historical Epidemiology*, by K. David Patterson (Totowa, New Jersey: Roman and Littlefield, 1986). Dr. Patterson's study is the first modern, in depth investigation of influenza epidemics in the 200 years prior to the 1918 epidemic, identifying and describing the great pandemic waves of the 18th and 19th centuries and addressing the question of their seasonality, geographical origins and spread patterns, age-specific morbidity and mortality patterns. The book is intended as a valuable historical resource for specialists in epidemiology. A complete list of supported publications is in Appendix 2.

*Extramural Programs*

The international programs of the National Library of Medicine (NLM) are integral to NLM's responsibilities in biomedical information. On the one hand, the U.S. health community benefits from the international character of both the NLM collection and the information retrieval services based on it. On the other hand, the world health community shares the benefits of NLM's advanced information systems.

During the past year NLM has continued its bilateral cooperative MEDLARS agreements with individual countries; its cooperation with international governmental organizations such as the World Health Organization (WHO) and the Pan American Health Organization (PAHO); and international nongovernmental organizations such as the International Council of Scientific and Technical Information (ICSTI). The Special Foreign Currency Program was active in the production of critical reviews and history of medicine projects. Other NLM international activities have included specialized training for colleagues from abroad, the NLM publications exchange program, as well as numerous professional visitors from abroad.

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#### International MEDLARS Agreements

The National Library of Medicine has MEDLARS agreements with partners in 15 foreign countries and with the Pan American Health Organization (Table 11).

India has shown an interest in sharing advances in science and technology with NLM. There were discussions with a science and technology delegation from India and with the Minister of Health about setting up a MEDLARS center in New Delhi. The Indian Government has since decided to nominate the National Informatics Center as the organizational entity to serve as a MEDLARS center.

**Table 11**  
Non-U.S. MEDLARS Centers

<i>Tapes</i>	<i>Tapes/Software</i>	<i>Online NLM</i>
France	Australia*	BIREME (PAHO)*
Germany	China	Canada
Japan	Sweden	Colombia
BIREME (PAHO)		Egypt
		France*
		Italy
		Kuwait
		Mexico
		South Africa
		United Kingdom

\*Combined online/tapes

In early 1987, two members of the staff and the Director of the National Informatics Center visited NLM for additional technical and economic information. It is anticipated that limited online access will begin at this center in New Delhi, followed by a national network of MEDLARS service centers.

The National Library of Medicine has enjoyed 20 years of collaborative activities with the Pan American Health Organization. The PAHO Regional Medical Library (BIREME) in Sao Paulo, Brazil is a tape center that serves users in Latin American and the Caribbean countries with a subset of MEDLINE. Since international communications have become more accessible and less expensive to users in this region, PAHO has instituted online access for major medical schools in Chile, Jamaica, and Costa Rica.

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#### Collaboration with the World Health Organization

The National Library of Medicine continues to cooperate with the World Health Organization (WHO) to produce the *Quarterly Bibliography of Acute Diarrhoeal Diseases*. NLM searches the literature, classifies the articles retrieved, and prepares camera-ready copy; WHO prints and



distributes the bibliography to thousands of institutions in developing countries. The Library also supports the *Quarterly Bibliography of Major Tropical Diseases*, printed in India and distributed internationally by WHO. NLM provides MEDLINE bibliographies in camera-ready form to PAHO, and PAHO prints and distributes these in the *Bibliography of Respiratory Infections in Children*.

NLM and WHO also continue a collaborative arrangement to provide photocopies of journal articles for the use of health professionals in developing countries in Africa, the Eastern Mediterranean and South East Asia. Library resources in developing countries are usually insufficient and the need for biomedical and health information can be met only by drawing on the collections of the developed world. Even though NLM provides approximately 3,000 photocopies a year to developing countries, this number can only partially meet their demand. Unless other resources in developed countries can be found, the need for interlibrary loans to developing countries will continue to grow.

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#### Special Foreign Currency Program

The Library's Special Foreign Currency Program, which is authorized under Public Law 480, employs U.S.-owned, local foreign currencies to support biomedical scientific publications useful to U.S. health professionals. The oldest of the National Library of Medicine's extramural support activities, the Public Law 480 Program is administered in the International Programs Branch of the Extramural Programs Division.

During FY 1987 53 projects totaling \$887,101 (equivalent in foreign currencies) were active in the Library's Public Law 480 Program. Sixty-eight percent of the projects were in India, 23 percent in Poland, and the remaining projects were active in Egypt and Israel.

Slightly more than half of the Public Law 480 projects active in FY 1987 were research

monographs and translations of classics in the history of medicine. Thirty percent of the projects were state-of-the-art critical reviews and monographs which analyze research and practice in biomedicine. Fourteen percent were translations into English and printing of foreign medical studies: Five percent of the awards funded secondary literature tools (bibliographies, biomedical guides, etc.).

Among the new studies in NLM's Resources in Medical History Series to be published in India in FY 1987 was an English translation, edited by Dr. George Mora, of Vincenzo Chiarugi's major work, *On Insanity and Its Classification*, originally published in Italian in 1793-1794 in three volumes. A second translated study, funded in part through the Publication Grant Program, was also printed in India in 1987 with Public Law 480 funds, i.e. L.J. Rather, et al., *Johannes Muller and the Nineteenth Century Origins of Tumor Cell Theory*. The Amerind Publishing Company in New Delhi also published for NLM a translation in the history of physiology prepared in Egypt with P.L. 480 funding: R. Magnus, *Body Posture*, edited and with a preface by the late Dr. A. Van Harreveld.

Two reprints of notable historical studies in English were also published through the Indian program in FY 1987: Walter B. Cannon, *The Mechanical Factors of Digestion*, with a new introduction by Dr. Horace Davenport, and Charles White's *A Treatise on the Management of Pregnant and Lying-In-Women* with a new introduction by Professor Lawrence D. Longo, M.D.

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#### International Conferences, Seminars, and Meetings

The National Library of Medicine is a member of the International Council for Scientific and Technical Information (ICSTI). This organization serves as a meeting ground for information and abstracting agencies, commercial and governmental, in a number of countries around the world. Common interests include economics of primary

and secondary publications, transborder flow of information, electronic publication, standardization, and the information needs of developing countries. At the 1987 general meeting of ICSTI held in New York City, NLM was represented by the Assistant Director for International Programs.

Many official delegations came to scrutinize the Library's operations and to discuss technical issues with NLM staff, usually with a view to identifying applications that might prove useful. In addition to foreign visitors, NLM received many trainees, students, and professionals in observer roles for short periods.

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### **International Visitors**

The Library continues to attract hundreds of foreign visitors each year, including doctors, medical librarians, public health specialists, and government officials. Many of these visitors have responsibilities for medical, scientific or technical information in their own countries. Their interest in NLM is more than cursory, and they are officially received and briefed on relevant aspects of NLM operations and research. In 1987, visitors came from the following countries:

Australia, Belgium, Bulgaria, Chile, China (PRC), Congo, Costa Rica, Czechoslovakia, Denmark, France, Germany (FRG), Honduras, Hong Kong, Hungary, India, Iraq, Ireland, Italy, Ivory Coast, Jamaica, Japan, Korea, Kuwait, Malawi, New Guinea, New Zealand, Pakistan, Peru, Portugal, Singapore, South Africa, Sweden, Taiwan, Trinidad, Upper Volta, United Kingdom, U.S.S.R., Venezuela, Yugoslavia, Zaire, and the West Indies.

## Administration

Kenneth G Carney  
Executive Officer

Administration

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### Financial Resources

In FY 1987, the National Library of Medicine had a total appropriation of \$61,838,000. Table 12 displays the FY 1987 budget authority plus reimbursements from other agencies, and the allocation of these resources by program activity.

**Table 12**  
**Financial Resources and Allocations FY 1987**  
(in thousands of dollars)

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Budget authority	
Appropriation, NLM	\$61,838
Plus Reimbursements	4,287
Total	<hr/> \$66,125
Budget allocation	
Extramural Programs	\$14,282
Intramural Programs and Services	45,994
Library Operations	(29,632)
Lister Hill National Center for	
Biomedical Communications	(10,386)
Toxicology Information	(5,976)
Research Management and Support	5,849
Total	<hr/> \$66,125

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### Personnel

Henry Riecken, Ph D, former Associate Director for Planning and Evaluation, retired in February after concluding 21 years of government service.

Michael Ackerman, Ph D, was appointed Chief of the Educational Technology Branch, LHCNBC, in March 1987. Dr. Ackerman previously served as Branch head, Biomedical Engineering Branch, Naval Medical Research Institute, where he was responsible for directing research on man/machine interface and the use of computers in diving operations.

Lawrence C. Kingsland, III, Ph D, was appointed Chief of the Computer Science Branch, LHCNBC, in April 1987. Dr. Kingsland had been with the NLM as a Senior Electronics Engineer since 1984, designing and developing software for research into artificial intelligence systems.

Mr. William Hagerty was appointed Chief of the Computer Services Branch, OCCS, in April 1987. Mr. Hagerty, previously Branch Chief, Financial Management Services, Computer Services Division, U.S. Department of the Treasury, comes to NLM with extensive experience in directing and coordinating production support and computer operations services.

Dorothy Hanks retired from her position as Librarian, History of Medicine Division, Library Operations, May 1987. Ms. Hanks devoted almost 24 of her 30 years of Federal service in HMD.

Richard Hsieh, Dr. P.H., was appointed Director for International Programs in June 1987. Dr. Hsieh had been serving as Acting Associate Director for International Programs. Dr. Hsieh previously served in the extramural program of the National Cancer Institute.

Elliot Siegel, Ph D, was appointed Assistant Director for Planning and Evaluation in August 1987. Dr. Siegel had served as Acting Assistant Director since February 1987. Susan Buyer-Slater has been appointed as Deputy Assistant Director for Planning and Evaluation.

Pamela A. Meredith was appointed Head, Reference Section, Public Services Division, Library Operations, in August 1987. Ms. Meredith has been with NLM as a systems librarian since May 1985. Prior to that, she worked for the Himmelfarb Health Sciences Library of the George Washington University Medical Center.

Gerald L. Geison, Ph D, was appointed as a Special Expert in the History of Medicine Division. Dr. Geison will be on a leave of absence from Princeton University to participate in HMD's Historical Scholar Program. Dr. Geison is Associate Professor at Princeton University.

**Awards**

NIH Merit Awards were presented to

Martha B Leroy, Office of the Director, "for extraordinary professional secretarial skills and dedication to the advancement of the mission of the National Library of Medicine "

James S Main, Jr , Division of Lister Hill National Center for Biomedical Communications, "for development and management of an intramural research resource in biomedical videodisc technologies "

Sarah J Singer, Division of Library Operations, "for exceptional productivity and competence as an indexer and reviser "

Patricia D Williams, Division of Specialized Information Services, "for outstanding contributions to administrative management and automation for the support of improved and expanded NLM Specialized Information Services "

The NIH Director's Award was presented to Lois Ann Colaianni, Associate Director, Division of Library Operations, "for foresight, leadership, and management skill in improving the effectiveness, efficiency, and accessibility of biomedical information service in the United States "

The Commissioned Officers Commendation Medal was presented to Dr Daniel Masys, Director, Lister Hill National Center for Biomedical Communications, "for his outstanding foresight, leadership, and management skill in directing research-oriented projects in order to improve biomedical information processing, analysis, and retrieval "

The NLM Director's Award was presented to Dorothy T Hanks, Librarian, History of Medicine Division, Division of Library Operations, "for outstanding contribution to the advancement of the Library's mission "

**Table 13**  
Staff, FY 1987 Full-Time Equivalents (FTEs)

<i>Program</i>	<i>Full-Time Permanent</i>	<i>Other</i>
Office of the Director	18	2
Office of Inquiries and Publications Management	5	2
Office of Administration	44	2
Office of Computer and Communications Systems	59	3
Extramural Programs	18	2
Lister Hill National Center for Biomedical Communications	67	8
Specialized Information Services	28	4
Library Operations	217	31
<b>Total</b>	<b>456</b>	<b>54</b>
<b>Total FTE Usage</b>	<b>510</b>	

**Equal Employment Opportunity**

In March 1987, the NLM EEO Committee published a newly revised edition of NLM's Affirmative Action Plan. The new plan includes monitoring mechanisms for the action items and criteria for measuring their accomplishment. The EEO Committee designed these features to provide more accountability in the affirmative action program.

During the year, EEO Committee members sponsored several open meetings for employees. These included a Women's Program with emphasis on safety in the workplace, a Handicapped Employee meeting for supervisors, handicapped employees, and friends, and an operating Division Open Forum that provided opportunity to informally address

EEO issues in the workplace Also in 1987, the Committee sponsored a program on drug abuse and its impact on "You, Your Family, and Your Job " The featured speakers were Jim Vance, WRC TV news anchorman, and Dr Michael Sitar, psychologist and drug counselor

To keep employees informed in EEO matters, the Committee continues to publish the EEO UPDATE The UPDATE contains items of interest from the EEO community, including employee contributed articles, and statistical summaries of minority employment The EEO Officer also provides quarterly statistics which chart NLM employment progress

## Appendix 1: Staff Bibliography

*Programs and  
Services, FY 1987*

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## Appendix 3: Board of Regents

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**T**he NLM Board of Regents meets three times a year to consider Library issues and policies and make recommendations to the Secretary of Health and Human Services on matters affecting the Library.

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### Appointed Members:

Edward N. Brandt, Jr., M.D., Ph.D.  
Chancellor  
University of Maryland, Baltimore  
(Chairman)

H. Robert Cathcart  
President  
Pennsylvania Hospital

Don E. Detmer, M.D.  
Vice President for Health Sciences  
University of Utah

Edward A. Feigenbaum, Ph.D.  
Professor of Computer Science  
Stanford University

Russell L. Fenwick  
Senior Vice President (retired)  
Bank of America

Nina W. Matheson  
Director, Welch Medical Library  
The Johns Hopkins University

Ann K. Randall, D.L.S.  
Chief Librarian  
City College of CUNY

Grant V. Rodkey, M.D.  
Associate Clinical Professor of Surgery  
Harvard University

Eugene A. Stead, M.D.  
Professor Emeritus of Medicine  
Duke University

### Ex Officio Members:

Librarian of Congress

Surgeon General  
Public Health Service

Surgeon General  
Department of the Air Force

Surgeon General  
Department of the Army

Surgeon General  
Department of the Navy

Chief Medical Director  
Veterans Administration

Assistant Director for Biological, Behavioral, and  
Social Sciences  
National Science Foundation

Director  
National Agricultural Library

Dean  
Uniformed Services University of the Health  
Sciences

## Appendix 4: Board of Scientific Counselors

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**T**he Board of Scientific Counselors meets periodically to review and make recommendations on the Library's intramural research and development programs.

*Members:*

Gwilym S. Lodwick, M.D.  
Department of Radiology  
Massachusetts General Hospital  
(Chairman)

Arthur S. Elstein, Ph.D.  
Professor of Health Professions Education  
University of Illinois at Chicago

Susan J. Grobe, Ph.D.  
Associate Professor of Nursing  
University of Texas at Austin

Gregory H. Hamm  
Director, Molecular Biology Computing Laboratory  
Rutgers University

Jerome P. Kassirer, M.D.  
Associate Chairman, Department of Medicine  
Tufts University School of Medicine

M. Lucius Walker, Jr., Ph.D.  
Dean, School of Engineering  
Howard University

Bonnie L. Webber, Ph.D.  
Associate Professor of Computer and Information  
Science  
University of Pennsylvania

Victor Lin-Kai Yu, M.D.  
Associate Professor of Medicine  
University of Pittsburgh School of Medicine

## Appendix 5: Biomedical Library Review Committee

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**T**he Biomedical Library Review Committee meets three times a year to review applications for grants under the Medical Library Assistance Act.

*Members:*

Rachel K. Anderson (Chair)  
Health Sciences Librarian  
Columbia University

Anthony R. Aguirre  
Director of Library  
Philadelphia College of Physicians

Marsden S. Blois, Jr., M.D., Ph.D.  
Professor and Chairman  
Section on Medical Info. Science  
University of California  
San Francisco, California

Virginia M. Bowden  
Director, Briscoe Library  
The University of Texas  
Health Science Center at Dallas

Charles P. Friedman, Ph.D.  
Director, Laboratory for Computing  
School of Medicine  
University of North Carolina

Reed M. Gardner, Ph.D.  
Professor of Medical Informatics  
University of Utah

G. Anthony Gorry, Ph.D.  
Vice President for Information Tech.  
Baylor College of Medicine

Donna P. Johnson  
Director, Resource Center  
Abbott Northwestern Hospital  
Minneapolis, Minnesota

Randolph A. Miller, M.D.  
Associate Professor of Medicine  
University of Pittsburgh

Joyce A. Mitchell, Ph.D.  
Director, Info. Science Group  
University of Missouri  
Columbia, Missouri

Ramesh S. Patil, Ph.D.  
Asst. Professor, Computer Science  
Mass. Institute of Technology

Thomas E. Piemme, M.D.  
Asst. Dean for Continuing Educ.  
School of Medicine  
George Washington University

Linda C. Smith, Ph.D.  
Associate Professor  
Graduate School of Library Science  
University of Illinois

William W. Stead, M.D.  
Director, Medical Center Information Systems  
Duke University

D. Dax Taylor, M.D.  
Medical Laboratory Director, MetPath  
Wood Dale, Illinois

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# Organization Chart National Library of Medicine

