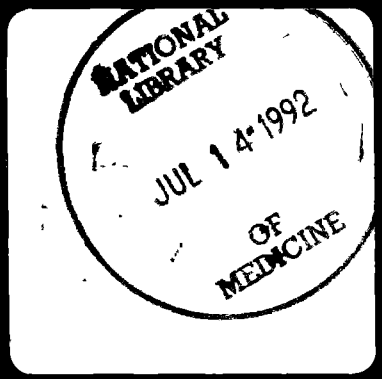
ITUTES OF HEALTH

NATIONAL LIBRARY OF MEDICINE

PROGRAMS & SERVICES FISCAL YEAR 1991



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

Office of Public Information
National Library of Medicine
8600 Rockville Pike
Bethesda, MD 20894
(301) 496-6308

Cover: In Fiscal Year 1991 the Regional Medical Library Network was expanded from seven to eight regions. It also underwent a name change and is now designated the National Network of Libraries of Medicine (abbreviated NN/LM). The network is described on page 10 of this report.

NATIONAL INSTITUTES OF HEALTH

NATIONAL LIBRARY OF MEDICINE

PROGRAMS & SERVICES FISCAL YEAR 1991

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PREFACE

The reader of this year's report will note a number of important events. New 5-year contracts were signed with the eight Regional Medical Libraries that, together with 130 Resource Libraries (primarily at medical schools) and 3600 Local Libraries (primarily at hospitals), make up the National Network of Libraries of Medicine. In addition to supporting the basic structure and programs of the National Network, the new contracts emphasize Grateful Med® and Loansome Doc training, demonstrations, exhibits, and other activities related to outreach.

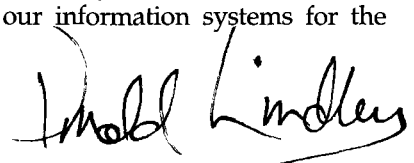
The online information retrieval network continues to grow, both in number of users and breadth of services. Statistics contained in the chapter on Library Operations reveal that the number of users and searches both hit an all-time high this year.

Two new network capabilities were introduced in 1991. In January, the Library introduced the "clinical alert" service (described in the "Special Initiatives" chapter) designed to accelerate the speed with which potentially life-saving medical information from the NIH is disseminated to the practicing community. Another enhancement to the network was the introduction of "Loansome Doc." Loansome Doc (see Library Operations chapter) allows the Grateful Med user to place an online order to a network library for a copy of any article referenced in MEDLINE®.

Among other notable events in 1991, all of which are described in this report:

- A Long Range Planning Panel on Toxicology and the Environment began its work to advise the NLM about its services in that area.
- The first year of operation of the new NLM Office of Health Services Research.
- The release of a second version of the UMLS Knowledge Sources, including a prototype of the Information Sources Map.
- The award of a first contract to create, in complete anatomical detail, three-dimensional representations of the male and female human body.
- The introduction of a new retrieval tool called Entrez, which searches nucleotide and protein sequence databases and MEDLINE citations in which the sequences were published.
- Progress in the Library's campaign to encourage medical publishers to issue their works on acid-free ("permanent") paper is described in the Special Initiatives chapter.

On behalf of the staff of the National Library of Medicine, I would like to thank our many partners throughout the nation and around the world for their help. The creation and dissemination of medical knowledge is a truly international undertaking; working together we continue to improve our information systems for the benefit of all.



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

CONTENTS

TABLES

CALENDAR OF EVENTS—FISCAL YEAR 1991

1990

Sept-Dec: "Public Health in New York City in the Late Nineteenth Century" (exhibit)
Oct 1: Network awards contracts to 30 "unaffiliated" health professionals
Oct: NCBI initiates Technical Reports Series
Oct: Friends publish NLM calendar
Oct 2: Lecture: DNA Regulatory Sequences & Local DNA Structure—D. Ghosh, R. Nussinov
Oct 3: Florence Mahoney Lecture by A. Sabin
Oct 12: President signs PL 101-423 establishing a national policy on permanent paper
Oct 31: IMPAG (International MEDLARS Policy Advisory Group) meets at NLM
Nov: NLM bookmark wins "Blue Pencil" Award
Nov 16: Conference on improving NLM's information services for hospitals
Nov 19: Secretary Sullivan names R. Anderson, L. DeNardis and R. Kahn to Board of Regents
Nov 20: NLM Honor Awards Ceremony
Dec 3: Lecture: "Molecular Scene Analysis,"—J. Glasgow and S. Fortier
Dec 5: Lecture: "Seeing Diseases: Visual Sources and the Meaning of History—S. Gilman

1991

Jan-Apr: "Dentistry in Paris, 1830-1860: Georges Fattet and His Contemporaries" (exhibit)
Jan 18: Transmission of first Clinical Alert over MEDLARS
Feb 14: Literature Selection Technical Review Committee Meeting
Feb 19: Lecture: African American Perception of the Constitution—Rep. Major Owens
Feb 28: Board of Regents
Mar 5: LHC seminar: Mass Storage Systems and Technology—Sanjay Ranade
Mar 6: Biomedical Library Review Committee Meeting
Mar 13: Lecture: Another Kind of Glory: Black Doctors in the Civil War—R. Davis
Mar 15: Lecture: Some Famous Persons with Visual Problems—F. Blodi
Mar 28: Lecture: Nurturing Tradition, Fostering Change—Rep. Constance A. Morella
Apr: Grateful Med Mac 1.5 version released
Apr 5: Board of Scientific Counselors Meeting, NCBI
Apr 25: Training Directors Meeting
May-Sept: "A Decade of Historical Acquisitions at the NLM, 1981-1990" (exhibit)
May: Phase I of Loansome Doc released
May 1: RML Network renamed National Network of Libraries of Medicine
May 1: Eighth region established for New England
May 2: Board of Scientific Counselors Meeting, LHC
May 6: Lecture: NIH: The Crucible Years (1930-1948)—D. Fredrickson
Jun 10: Lecture: High Performance Computing and Communications—A. Baratz
Jun 13: Literature Selection Technical Review Committee Meeting
Jun 20: New NIH director, Bernadine Healy, M.D., addresses NLM staff
Jun 20: Board meeting of Friends of the National Library of Medicine
Jun 20: Board of Regents Meeting
Jun 26: Biomedical Library Review Committee Meeting
Jul 3: Lecture: Biological Queries Using a Transcription Factors Database—D. Ghosh
Aug 7: LHC lecture: Fuzzy Logic—Lotfi Zadeh
Aug 15: First meeting of Toxicology Information Outreach Panel held at NLM

SPECIAL INITIATIVES

Unified Medical Language System

The goal of the Unified Medical Language System (UMLS®) project is to give practitioners and researchers easy access to machine-readable information from diverse sources, including the scientific literature, patient records, factual databanks, and knowledge-based experts systems. The barriers to integrated access to information in these sources include: the variety of ways the same concepts are expressed in the different machine-readable sources (and by users themselves) and the difficulty of identifying which of many existing databases have information relevant to particular questions.

The UMLS approach to overcoming these barriers is to develop "Knowledge Sources" that can be used by a wide variety of application programs. These programs can compensate for differences in the way concepts are expressed, identify the information sources most relevant to a user inquiry, and negotiate the telecommunications and search procedures necessary to retrieve information from these information sources.

The three UMLS Knowledge Sources are: a Metathesaurus® of concepts and terms from several biomedical vocabularies and classifications, a Semantic Network of the sensible relationships among the broad semantic types or categories to which all concepts in the Metathesaurus are assigned, and an Information Sources Map that describes the content and access conditions for the available biomedical databases in both human-readable and machine-readable form.

In the fall of 1990, NLM issued the first experimental edition of the UMLS Knowledge Sources which contained initial versions of the Metathesaurus and the Semantic Network. During FY 1991, NLM distributed 160 copies of this edition to medical libraries, university research groups, and commercial companies in the U.S. and abroad under the terms of an experimental agreement. The agreement requires the recipients to inform NLM about their use of the Knowledge Sources and to provide feedback on how they can be enhanced. Recipients are informed that future editions of the Knowledge Sources may differ substantially in content and format.

Information received to date indicates that the Knowledge Sources are being applied to a wide variety of projects including linking patient records to relevant MEDLINE citations, analysis of medical and dental school curricula, user query interpretation, and natural language processing. NLM itself has applied the UMLS components in the Coach expert search system and to research in natural language processing (see the Lister Hill Center chapter in this report).

In late FY 1991, NLM issued the second experimental edition of the UMLS Knowledge Sources containing the second versions of the Metathesaurus and Semantic Network and the first version of the Information Sources Map. This last includes descriptions of all of NLM's publicly available databases and a small number of databases produced by other sources. The second experimental edition of the Knowledge Sources was sent to all those who had received the first edition and is available to new requestors under the same agreement.

The UMLS project continues to involve an interdisciplinary team of NLM staff and a number of research and development contractors as well as a widening circle of experimental UMLS users. In July 1991, NLM issued a new set of competitively awarded UMLS research and development support contracts to Brigham and Women's Hospital, Columbia University, Massachusetts General Hospital, the University of Pittsburgh (with the University of Utah as subcontractor), and Yale School of Medicine. Lexical Technology, Inc. continues to be the principal contractor for development and maintenance of the Metathesaurus.

The key objectives for the next three years of the UMLS project are to develop and implement important applications that rely on the UMLS Knowledge Sources, to establish production systems for ongoing expansion and maintenance of the Knowledge Sources, and to expand the content of the Knowledge Sources to support the applications being developed.

B. Humphreys

Paper Preservation

A fundamental responsibility of the NLM is to preserve permanently the content of periodicals, books, and other library materials pertinent to the biomedical sciences. Significant resources have been provided by the Congress for preservation of the Library's collection by microfilming of deteriorating documents, conservation in the original form of those that are rare and valuable, and research in the electronic storage of images.

A major threat to the survival of books and journals published since the mid-nineteenth century is the deterioration of paper caused by residual acids it contains. Without expensive efforts at preservation, the majority of printed matter now on library shelves across the nation is destined to become brittle and to crumble over the period of a lifetime. NLM has not been immune to the problem. A Preservation Planning Team surveyed the physical state of the holdings in 1985 and identified some 158,000 volumes, over 12 percent of the collection, as having become so brittle that they would not be able to withstand one more library use, and estimated that another 5,000 volumes would be entering that endangered category annually.

More recently, papermaking processes that employ alkaline rather than acid-based chemistry have begun to come into use. Paper so produced is acid-free and available in commercial quantities and at competitive prices in most paper grades. Acid-free, permanent paper will last for centuries rather than decades in ordinary library use. 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 recommends that NLM encourage the publishing industry to use more permanent paper in the production of biomedical literature.

To that end, the Board sponsored a hearing at the Library in January 1987 on the use of permanent paper for biomedical literature. As a result of the hearing, an NLM Permanent Paper Task Force of academic, commercial, and professional society publishers, editors, authors, paper manufacturers and distributors, printers, librarians, preservationists, and concerned citizens was established. It was charged with exploring the problem of paper deterioration, the economics, esthetics, and the manufacturing technologies of acid-free paper, and fostering positive action in its use, particularly in journals, the most important repository of contemporary biomedical knowledge.

Initially, there were many stubborn myths for the 33-member Task Force to dispel and much skepticism to overcome that acid-free paper would ever amount to more than an archival curiosity. Task Force members joined NLM staff in communicating with publishers, urging them to use acid-free paper and to identify its use in their publications. They developed educational materials; wrote articles for professional and popular journals and provided information to the press and broadcast media in order to increase awareness about acid-free paper use; appeared on the public radio network; conducted and participated in seminars and panels, made individual presentations, and arranged displays at professional society meetings; served on standards development and public agency and industry advisory committees; organized and chaired a major paper industry symposium on paper permanence; testified at Congressional hearings; and worked at converting publications with which they may have been themselves involved to use acid-free paper.

The Library's campaign has made encouraging progress. In 1987, merely 4 percent of the 3,000 journals indexed by NLM were acknowledged by their publishers to be using acid-free paper. In 1991, one half are on permanent paper. Of the U.S. journals indexed, four fifths are now acid-free. Beginning in 1990, journals indexed in MEDLINE and *Index Medicus* that are printed on acid-free paper and that also carry a notice to that effect are marked as such in the *List of Journals Indexed in Index Medicus*, the *List of Serials Indexed for Online Users*, and in SERLINE®, the Library's online file of serials information.

The campaign to encourage domestic publishers in permanent paper use continues, with intensified efforts to bring the message of paper permanence to non-U.S. publications. Together with increasing expressed demand by users, the advantages of the economics and technology of alkaline papermaking are also becoming reflected in the paper market. The alkaline papermaking process reduces water consumption, facilitates waste treatment, saves energy and materials costs, and is cleaner and less corrosive to machinery than acid-based paper making.

The use of acid-free paper is the preventive medicine for reducing the problem of deterioration of publications and the threat of their being lost to the record of civilization forever.

C. Kalina

Outreach

The recent report of the NLM Board of Regents, *Improving Health Professionals' Access to Information*, published as an update to the NLM Long Range Plan, and based on the work of a distinguished panel chaired by Dr. Michael DeBakey, recommends: (1) major enhancements to NLM's national network as a way of improving

NLM's outreach to health professionals; (2) expansion of Resource Access Grants as well as access to national networks and the Integrated Academic Information Management Systems (IAIMS) program; (3) substantial increases in the number of Medical Informatics training centers, individual awards for research and career development and demonstration grants; and (4) research to ascertain the information requirements of U.S. health professionals, the suitability of current means for acquiring health-related information, and impediments to such acquisition, with an emphasis on the needs of minority health professionals and other underserved groups.

Outreach continues to be NLM's highest priority. NLM is investing its fiscal and intellectual resources not only in acquiring scientific information but in devising new and more efficient and effective methods for making it readily available to the health and scientific community. Large numbers of health professionals in our nation do not have easy access to biomedical information because of geographic isolation, nonaffiliation with a hospital or medical school library, or lack of information about available services. With the increased funding available for outreach, we have identified institutions and individuals to help us reach out to these underserved health professionals.

An important role in this effort is being played by the libraries in the National Network of Libraries of Medicine (NN/LM). The network was reconfigured in FY 1991, from seven regions to eight. The new 5-year contracts, signed with the Regional Medical Libraries this year, mandate important outreach responsibilities. The chapter on Library Operations has more information about the NN/LM.

Results of these network outreach initiatives include extensive efforts to train physicians and other health professionals in the use of Grateful Med in almost 50 communities. This is being accomplished through special projects at the Regional Medical Libraries, and awards to individual small-to-medium sized libraries in the network, with an emphasis on those in rural and inner city areas.

It is clear that within the population of health professionals in underserved areas, there is a subgroup of health professionals serving minority populations who have a special set of problems in accessing information. NLM has geared a variety of new outreach initiatives to these communities in the belief that direct access to NLM's databases—especially MEDLINE via Grateful Med—can help compensate for the absence of other health resources. More than 20 outreach projects have a minority focus. Major examples:

NLM is collaborating with Meharry Medical College (Nashville, TN) to develop and put in place an innovative outreach demonstration project for health care practitioners, including family practice residents and their preceptors, who are located in remote and professionally isolated settings. The plan focuses on identifying impediments to information access and incorporates a wide variety of technological and behavioral interventions geared to their removal.

In South Texas, the effectiveness of the circuit librarian concept as a means of improving information access among health professionals has been evaluated in a joint project with the University of Texas at San Antonio. Communities in this region are geographically remote, largely rural, with large Hispanic populations, and distant from the nearest health sciences library. The circuit librarian makes weekly visits to the nine participating hospitals in the region and performs MEDLINE searches for the staff. She also provides for the delivery of needed documents by return trip or FAX and trains health professionals to perform their own MEDLINE searches using Grateful Med.

Through the NN/LM, 45 purchase orders have been awarded to a number of Area Health Education Centers, academic health centers, academies, associations, and hospitals, to identify "unaffiliated" health professionals in underserved areas and to encourage them to gain access to information through electronic sources such as Grateful Med.

NLM has initiated an Undergraduate Research Study Program to stimulate undergraduate medical informatics research programs in Historically Black Colleges and Universities (HBCUs) for electrical engineering and computer science students. Four electrical engineering students from three institutions—Morgan State University, Southern University at Baton Rouge, and North Carolina A & T State University—make up the first class. These students will complete two school year R&D assignments and two summer internships at the Lister Hill Center.

A new initiative in NLM's Toxicology Information Program (TIP) is aimed at establishing a mechanism that would strengthen the capacity of historically black colleges and universities to train medical and other health professionals in the use of toxicological, environmental, and occupational information resources developed at NLM. This audience represents a group that would otherwise not get exposure to these valuable information sources and also is considered one of the high priority groups within NLM's outreach efforts.

The Library's outreach activities this year included two new MEDLARS® online network capabilities. First, in January, the Library introduced the "clinical alert" service. This was a move designed to accelerate the speed with which potentially life-saving medical information from NIH is disseminated to the practicing community. The need for such a service was repeatedly stressed at a January 15, 1991, meeting at the National Institutes of Health, at which prominent health communicators,

medical editors, and government medical research administrators met to discuss ways to improve the speed with which highlights of important clinical trial findings can be disseminated *before* publication in medical journals.

Three days later, on January 18, the NLM transmitted its first clinical alert over the online network. The alert, which remained on the network for 30 days, was a 74-line statement issued by the National Institute of Child Health and Human Development regarding the efficacy of a drug used to treat HIV-infected children. Before the fiscal year ended, six more clinical alerts had been put up.

The second major enhancement to the network in 1991 was the introduction, in May, of "Loansome Doc." Loansome Doc allows the individual user to place an online order for a copy of the full article for any reference retrieved from MEDLINE. This new service is described in the chapter on Library Operations.

E. R. Siegel

High Performance Computing and Communications

The President's Office of Science and Technology Policy has initiated a multiagency High Performance Computing and Communications (HPCC) Program to strengthen research and education nationwide. The HPCC program has four components: Advanced Computer hardware design, with a goal of a "teraops" (1 trillion operations per second) supercomputer by the end of the decade; Advanced Software Technology and Algorithms to run on such supercomputers; the National Research and Education Network, a billion bits-per-second computer network; and Basic Research and Human Resources, focusing on training in the design and use of high performance computing systems.

NLM is the lead medical organization in this program, along with several other NIH components. The enhanced NLM program includes intramural and extramural research and development in several areas: molecular biology computing, creation and transmission of electronic images, the linking of academic health centers via computer networks, the creation of "intelligent gateways" to retrieve information from multiple life sciences databases, and expanded training in biomedical computer science. The HPCC program as planned will support advanced technology aspects of the IAIMS program, the Visible Human digital image library project, biotechnology databases and research grants, and medical informatics training grants.

NLM's initiatives in high performance computing and networking go hand in hand with its outreach programs. High-speed computer networks will be the avenue of choice for the dissemination of much biomedical information in coming years. It is not enough to publicize NLM's products and services without assisting institutions in connecting to national information resources, nor is it enough to provide high-technology innovations without reaching out to ensure that everyone has access to the new technology. A number of steps are being undertaken to assure the participation of HBCUs and health professionals in under- and un-served areas. Through the HPCC initiative, funds will be available to academic health science libraries, and to smaller hospital libraries, to provide connections to the national high speed network. The purpose of these efforts is to facilitate access to and delivery of health sciences information via pathways employing the most up-to-date and effective computer and telecommunications technology available.

D. Masys

LIBRARY OPERATIONS

Lois Ann Colaianni
Associate Director

NLM's Library Operations Division (LO) is responsible for: acquiring and preserving the world's biomedical literature; organizing this literature through indexing and cataloging; disseminating NLM's authoritative bibliographic records in online files, machine-readable formats and publications; lending or copying documents in the NLM collection as a backup to the document delivery service provided by other U.S. health sciences libraries; providing reference and research assistance to health professionals; and coordinating the National Network of Libraries of Medicine (NN/LM) which includes more than 3,500 U.S. health sciences libraries. LO also conducts research and evaluation related to these basic responsibilities and maintains an active research program in the history of medicine.

A staff of more than 250 librarians, library technicians, technical information specialists, subject matter experts, health professionals, and administrative support personnel carry out LO's programs and services. LO has four main divisions: Bibliographic Services, Public Services, Technical Services, and History of Medicine; two smaller units: the Medical Subject Headings (MeSH®) Section and the National Network Office; and a small administrative staff in the Office of the Associate Director.

Planning and Management

LO carries out its strategic and operational planning within the framework of the NLM Long Range Plan, as extended by the reports of the special Panels convened by NLM's Board of Regents to examine particular facets of the Library's programs and services. In FY 1991, LO developed a strategic plan for FY 1992-FY 1996. The major objectives of the plan are: (1) to eliminate redundant data creation and maintenance and provide easy integrated access to acquisitions, bibliographic, preservation, circulation, and other inventory control data for monographs and serials in the NLM collection; (2) to develop and implement an integrated vocabulary control system for MeSH and the Unified Medical Language System (UMLS) Metathesaurus to ensure consistent description of and access to material in NLM databases; (3) to develop and implement a National Collection Plan for the Biomedical Literature which ensures the availability and preservation of published and unpublished literature that is not part of the NLM collection; (4) to develop mechanisms to ensure that health professionals have easy and rapid access to the text of published information held in the National Network of Libraries of Medicine (NN/LM); (5) to define the MEDLARS retrieval capabilities needed to provide more effective service to the rapidly growing population of NLM online users (this is a shorter term objective than the other five); and (6) to increase health professionals' knowledge and use of NLM products and services through development and implementation of an expanded LO component of NLM's outreach program. Activities related to the NLM Long Range, its supplementary Outreach Plan, and LO's Strategic Plan are described throughout this chapter.

Collection Development

Collection development activities include: establishing and revising literature selection policy, identifying and acquiring biomedical literature in all formats and languages, processing materials as they are received, assessing whether the selection and acquisition process is meeting the goals established by the selection policy; and maintaining and preserving the collection. NLM currently holds 2,000,511 printed books, journal volumes, theses, and pamphlets, and 2,820,295 non-print items, including audiovisuals, computer software, microforms, prints, photographs, and manuscripts (table 1).

Selection and collection assessment

The NLM staff selects items for the Library's collection in accordance with guidelines in the *Collection Development Manual of the National Library of Medicine.* NLM conducts a complete review and revision of its selection guidelines every 5 to 8 years and modifies specific sections of the *Manual* each year as developments in biomedicine or problems in applying the guidelines warrant. During FY 1991, substantial progress was made in preparing a major revision of the Manual to be completed in 1992.

As part of a continuing program to determine how successful NLM has been in implementing its collection development policy, the Library staff reviewed NLM's collection of recent dental monographs, AIDS-related materials, and publications issued by associations. A review of the general physics journals in NLM's collection led to the cancellation of a number of titles with minimal biomedical content. The Library also initiated a comprehensive assessment of its neurology collection.

Acquisitions

The Library acquired 43,105 volumes and 92,175 other items (e.g., audiovisuals, microforms, software, pictures, manuscripts) for its collection in FY 1991 (table 1). The NLM staff processed 182,283 modern books, serial issues, audiovisuals, and software packages (table 2). Two important gaps in NLM's historical collection were filled by the acquisition of Johannes Gerson's *De Pollutione Nocturna* (Cologne 1466), considered to be the first medically related book printed with moveable type, and Dr. William T. G. Morton's broadside, *To Surgeons and Physicians*, (Boston, 1846), thought to be the first printed document on anesthesia. The Library also acquired two large collections of Italian and German broadsides and pamphlets dealing with public health matters from 1611 to 1830. NLM's manuscript collections were enriched by a number of important documents related to the history of the National Institutes of Health (NIH) including a collection of materials concerning Dr. Joseph Kinyoun, the first director of the Hygienic Laboratory (forerunner of NIH), the personal files of the late Dr. DeWitt Stetten, Jr., former NIH Deputy Director for Science, and the chart prepared by NIH Nobel Laureate Dr. Marshall Nirenberg during his work on breaking the genetic code. Former NIH Director Dr. Donald Fredrickson donated to the library a 1968 film showing an NIH celebration in honor of Nirenberg's receipt of the Nobel Prize for Physiology and Medicine.

Responding to deficiencies identified in previous collection assessment studies, NLM implemented a more active acquisitions strategy for association publications and other biomedical literature not available through commercial sources. The staff continued its efforts to acquire issues missing from NLM's serials collection and began a more systematic program to fill lacunae in the book collection. Several key improvements were made to the automated systems that support serials processing and monograph acquisitions, including more efficient transfer of data between modules of the serials system and automatic generation of data elements previously entered manually.

Collection preservation and maintenance

NLM's preservation program includes: preservation and maintenance of the Library's collection; promotion of the use of acid-free paper in new biomedical publications; and exploration of new technologies for preservation of library materials. As funding permits, the Library also provides support for preservation of important biomedical literature not held by NLM.

In FY 1991, NLM microfilmed 2.08 million brittle pages and preserved 254 items from the special collections. New competitive contracts were awarded for microfilming and for preservation and conservation of artifactually valuable materials from NLM's historical collection. In FY 1991, NLM improved access to information about what it has microfilmed by updating CATLINE® to indicate which books have been preserved. Information about serials that NLM has microfilmed is already available in SERLINE. Microfilm service copies of items the Library has preserved can now be ordered from an NLM contractor.

NLM's campaign to increase the use of acid-free paper in new biomedical publications continues to have positive results (see "Paper Preservation" in Special Initiatives section). NLM staff continue to be heavily involved in the effort to revise the American National Standard for Permanence of Paper (Z39.48-1984) and to extend its coverage to coated paper.

Bibliographic Control

NLM fulfills its mission to organize the biomedical literature by maintaining and enhancing the Medical Subject Headings (MeSH) and the NLM classification scheme for the shelf arrangement of biomedical library materials; by cataloging biomedical publications in all languages and formats; and by indexing articles from selected biomedical journals.

Thesaurus

MeSH, the hierarchical thesaurus used to catalog, index, and search NLM's online databases, now has 16,681 subject headings. MeSH's supplementary chemical file contains about 62,000 additional names of substances. MeSH is updated annually to keep pace with developments in biomedicine and changes in the usage of biomedical terms. In FY 1991, 554 new main headings and 2,203 new entry terms were added to the vocabulary. A joint NLM/Agency for Health Care Policy and Research (AHCPR) Task Force is advising the Library on how to improve MeSH terminology in the field of health services research: the first phase of these improvements was completed in FY 1991. MeSH's bacteria terminology was revised and expanded to conform to the *Bergey's Manual of Systematic Bacteriology*. The Library also continued to update terminology related to AIDS and molecular biology. An expert consultant reviewed MeSH's chemical and drug classification and nomenclature and recommended a number of changes that will implemented over the next several years.

In FY 1991, the structure of the MeSH file was enhanced to accommodate 9 levels of hierarchy in place of the current 7 levels. This permits more accurate hierarchical organization of chemicals, neuroanatomy, and gene terminology. A number of other changes were made to the MeSH file to facilitate the integration of MeSH and the UMLS Metathesaurus. MeSH section staff members continued to be heavily involved in reviewing and editing the UMLS Knowledge Sources.

Cataloging

NLM's cataloging responsibilities include: cataloging new works added to the NLM collection, creating and maintaining the Library's automated files of cataloging and name authority records, contributing NLM's cataloging data to national cooperative bibliographic databases, and maintaining the NLM classification scheme, which is used by NLM and other health science libraries to assign shelving locations to materials based on their subject content.

In FY 1991, the Library cataloged 19,187 modern books, serials, nonprint items, and Cataloging-in-Publication galleys, using in-house staff, contractors, an interagency agreement with Library of Congress, and assistance from the MEDLARS Center in China. In the past year, NLM expanded the amount of serials cataloging received from outside sources. The year's cataloging production was roughly equal to last year's excellent performance, but because of a sharp increase in receipts of new titles the inventory of uncataloged modern works increased by 4,359. In FY 1991, some of NLM's contract catalogers began to use the new NLM online cataloging system from remote locations, and one of NLM's own catalogers began to work from home for part of the work week. NLM also continues to explore ways to simplify national cataloging practices. Library staff members participated in a national conference on approaches to simplifying subject cataloging and actively supported a review by the three U.S. national libraries of potential mechanisms for simplifying descriptive cataloging.

More than 14,000 abbreviated machine-readable records for items in NLM's picture collection were upgraded to fully cataloged status in FY 1991. An operational system for integrated retrieval of the catalog records and the videodisc images of the picture collection created under the direction of the Lister Hill Center is being developed; a prototype system is currently available in the History of Medicine Division.

Dr. Emilie Savage-Smith, an authority on the history of Arabic medicine, made substantial progress on the project to review NLM's Arabic manuscript collection and to provide the information necessary for NLM staff to prepare complete cataloging records for the collection. The History of Medicine Division completed the processing of several important manuscripts collections with the aid of volunteers and student interns. Detailed findings guides were prepared for the papers of John Adriani, a nationally known expert on anesthesiologist and drug evaluation, and Mike Gorman, a significant figure in American health policy in the twentieth century.

In early FY 1991, NLM disposed of its post-1800 card catalog (which had been removed from the public service area in late 1985). The massive catalog card cases were donated to the Library of Congress. The Louise Darling Biomedical Library at the University of California, Los Angeles kindly provided some smaller surplus card catalog cases to house the sections of the NLM serials shelf-list that are still needed by Library staff.

Indexing

NLM's indexing operation includes: selecting the journals to be indexed, keyboarding descriptive information and abstracts from the articles to be indexed, indexing the content of the articles, providing special indexing of the gene sequences that appear in indexed articles, reviewing the accuracy of the keyboarding and indexing, and maintaining the citation databases to correct any indexing errors and to annotate citations to articles that have been retracted, corrected, or challenged in subsequent commentaries.

The Literature Selection Technical Review Committee (LSTRC) (Appendix 8) provides advice to NLM on the journals that should be indexed for MEDLINE and *Index Medicus*®. In FY 1991, the LSTRC reviewed 370 journals and ranked 93 sufficiently high for NLM to begin indexing them. Professional societies in the field of ophthalmology and rheumatology prepared reports on journals in their specialties considered useful for practice, research and education to assist the LSTRC in its review of indexing coverage for these subject areas. Guidelines for selection of journals for indexing were approved and published in an NLM Fact Sheet.

MEDLARS indexing is done by NLM staff, commercial contractors, some international MEDLARS centers, and cooperating agencies such as the American Hospital Association, the American Journal of Nursing Co., and the American Dental Association. The NLM staff performs quality review of all indexing. In FY 1991 the Library added 363,344 citations to MEDLINE (table 4) and entered English-language abstracts for the 72 percent of the articles that included them. Previously indexed citations in MEDLARS databases were updated to reflect information about 16 retracted publications, 2,722 published error notices, and 18,885 substantive commentaries.

The Library continued the phased acquisition of new PC workstations for its indexers. The project to modify NLM's online indexing system to accommodate the nonjournal citations in BIOETHICSLINE® and other MEDLARS files was essentially completed; the new software will be implemented for BIOETHICSLINE in FY 1992. NLM also began to investigate optical scanning as an alternative to keyboarding citations and abstracts. To ensure rapid indexing of gene sequences for the National Center for Biotechnology Information's backbone database, Library Operations hired additional gene sequence indexers. In FY 1991, four NLM indexers began working from home several days a week.

Network Services

NLM's services to onsite and remote users include: distribution of authoritative bibliographic data in publications, machine-readable formats, and an online retrieval service; reference assistance provided in response to onsite, telephone, and written requests; delivery of documents from the NLM collection to onsite users and to remote requesters as needed to supplement the resources of other U.S. libraries; and overall direction of the National Network of Libraries of Medicine. These services provide the essential foundation for NLM's outreach initiatives.

Publications

NLM's publications continue to be "best-sellers" for the Government Printing Office and the National Technical Information Service despite the wide availability of NLM data in machine-readable formats and online services. In FY 1991, NLM produced more than 100 individual issues of some 23 recurring indexes and catalogs, including *Index Medicus*, the *National Library of Medicine Current Catalog*, and more specialized publications such as the *Bibliography of the History of Medicine*. In FY 1991, the Library issued a new publication, *NLM Recommended Formats for Bibliographic Citations*, prepared by Karen Patrias. The MeSH publications were enhanced in several ways, including the permutation of word roots (e.g., hepato-) in the *Permuted MeSH*.

Machine-readable databases

To promote access to its authoritative data, NLM leases complete databases and subsets of selected databases in machine-readable form. Commercial database vendors, other segments of the information industry, international MEDLARS centers, universities, and other organizations obtain machine-readable data from the Library and make them available online or in CD-ROM products.

In FY 1991, NLM distributed more than 6,000 tapes of various databases to licensees worldwide. The Library added MARC records for its computer software and historical film collections to the array of available NLM data. Nine new license agreements were established, bringing the number of licensees up to 100. At the end of the year, nine licensees were producing CD-ROM products containing data from six different MEDLARS databases. After considering comments and suggestions from many constituents, NLM proposed changes in revised charges for MEDLARS data in light of changes in CD-ROM and network technology and to facilitate NN/LM outreach efforts.

Online services

NLM makes 43 databases available online. In FY 1991, NLM's online users conducted 5.8 million searches and were connected to the NLM systems for a total of 324,000 hours (tables 6 and 7). These figures exclude online searching performed on the computer systems of organizations that lease data from NLM.

As a result of special outreach efforts by NLM and health sciences libraries throughout the NN/LM, the number of users of NLM's online system continues to increase rapidly. At the end of FY 1991, there were 48,772 active codes for use of NLM's online system, an increase of 23 percent from the previous year. Most of the new codes were assigned to individuals rather than to institutions. Individuals now represent 53 percent of all U.S. code holders. The growth in the number of individual users has led to increases in the number and complexity of the calls received at the MEDLARS Management Service Desk.

Ninety percent of the individuals who received codes in FY 1991 indicated an intention to use the Grateful Med microcomputing front-end package to search the NLM databases. A total of 37,899 copies of Grateful Med (32,586 IBM PC versions; 5,313 Macintosh) have been distributed by the National Technical Information Service since the package first appeared in 1986. Purchasers receive new versions at no additional cost. In FY 1991, NLM issued version 1.5 of the Macintosh Grateful Med.

In addition to the new "Clinical Alerts" service (see the Special Initiatives section of this report), the Library made a number of other enhancements to its online databases, retrieval capabilities, and user support mechanisms. AIDSLINE®, NLM's database of citations to literature about acquired immunodeficiency syndrome was expanded to include AIDS-related records from CATLINE and AVLINE®, NLM's databases of catalog records for print and nonprint materials respectively, and additional abstracts from AIDS-related meetings. The individual words in multiword MeSH terms are now searchable in many NLM databases, and text word searching can be restricted to words in titles. Subheading "pre-explosions" facilitate searching by logical groups of subheadings, e.g., all subheadings that deal with some aspect of therapy. The new MEDLINE "publication type" field allows users to restrict searches to specific types of articles, e.g., guidelines and clinical trials. The new "gene symbol" field contains the gene name abbreviation used by researchers. The special characters (e.g., Greek letters, superscripts) that appear in gene symbols are tagged according to the conventions of the Standard Generalized Mark-up Language. The MEDLINE address field is now searchable.

In FY 1991, NLM concluded flat-rate per code pricing experiments with several institutions and is now analyzing the data gathered. The charges for online searching on NLM's system were revised to ensure full recovery of access costs. NLM now uses contract assistance to key data for new online code holders.

Exhibiting Grateful Med and NLM's online services at professional meetings continues to be an important part of the Library's outreach initiative. In FY 1991, the Regional Medical Libraries became even more heavily involved in exhibiting NLM products and services throughout the country, as NLM staff concentrated on exhibits in the Washington D.C. area. With the award of new 5-year contracts, RMLs in Regions 1, 4, and 7 are also continuing to provide online training to librarians and information professionals. In FY 1991 a total of 1,079 librarians and other search intermediaries received online search training from NLM or RML staff. The search training courses were modified to include a 3-day "Fundamentals of MEDLARS Searching" and specialized training modules for various databases. The MEDTUTOR® computer-assisted instruction package for command language searching was modified and updated.

Reference Services

NLM provides reference service and research assistance to onsite users and to remote requestors as a back-up to the service available from U.S. health science libraries. In FY 1991, NLM's Reference Section received 66,516 requests for reference assistance, 69 percent from onsite requestors, 31 percent in telephone calls, and less than 1 percent in letters (table 8). In addition, a large number of routine requests for hours of service, directions to the Library, etc., are handled by an automatic telephone answering system. In FY 1991, NLM installed NIK (NLM Information Kiosk), an automated guide to NLM for onsite users. NIK, which is implemented in Supercard and installed on a Macintosh computer, provides information on NLM's programs and services and explains how to locate and obtain materials and reference assistance.

NLM continues to upgrade and expand its internal CD-ROM network that provides access to a variety of CD-ROM tools and to the MEDSTATS expert system for locating sources of answers to statistical questions. In FY 1991, the content of MEDSTATS was revised and expanded to include sections on health care staffing, health facilities and services, costs, and general and vital statistics.

The NLM Reference staff provides a special literature search service to other NIH components in support of the NIH Consensus Development Conference. The searches prepared for attendees are published as part of NLM's *Current Bibliographies in Medicine* series as are other bibliographies on topics of special current interest. Topics covered in the series in FY 1991 included: acoustic neuroma, therapy-related second cancers, nutrition and AIDS, medical waste disposal, dental restorative materials, and adverse effects of fluoxetine (prozac).

Document Delivery

NLM provides document delivery service to remote requesters as a back-up to other member libraries in the NN/LM and to onsite users who wish to consult items from NLM's closed stacks (table 5). The total number of document requests submitted to NLM was 494,515, an increase of 8 percent from FY 1990. NLM received 281,606 interlibrary loan requests and filled 74 percent of them, an improvement of 3 percentage points from FY 1990. If requests for which the requestor was unwilling to pay are excluded, NLM's fill rate was 81 percent. The speed with which requests are filled improved substantially; 54 percent of all filled requests were processed within a single day of receipt. NLM received 84 percent of its interlibrary loan request via DOCLINE, NLM's automated request and routing system. Three percent or 7,470 requests were received via telefacsimile transfer; of these 3,728 were needed for clinical emergencies and were processed within two hours.

During FY 1991, NLM began a pilot test of the System for Automated Interlibrary Loan (SAIL) which uses scanned bit-mapped page images of selected journal titles to which NLM subscribes to fill requests referred to NLM via DOCLINE. Requested articles are printed out for mailing or converted to faxable form and sent directly without human intervention. The pilot involves journals recently selected for MEDLINE for which NN/LM holdings data may not be available yet. Thus far, 2,593 requests have been referred to SAIL.

The number of libraries using DOCLINE increased to 2,195 in FY 1991. These libraries entered 2.1 million document requests and filled 86 percent of them. NLM filled another 8 percent for an overall fill rate of 94 percent. DOCLINE routes requests to appropriate libraries based or approximately 1.26 million SERHOLD records, which represent the holdings of more than 3,000 NN/LM member libraries. Recent DOCLINE enhancements include a fax-only delivery option and allowance for separate bill-to and ship-to addresses.

At the end of FY 1991, Loansome Doc, a new feature of Grateful Med that allows individual health professionals to submit automated document requests to a specific NN/LM library, was made available to Grateful Med users nationwide. Loansome Doc allows users to request the full text of articles identified in a Grateful Med/MEDLINE search. If a user's designated library cannot fill the request, the request can then be routed via DOCLINE. In FY 1991, Loansome Doc users requested 6,290 documents.

Onsite users requested 212,909 documents from NLM's closed stacks, an increase of 7 percent from FY 1990. Eighty-five percent of the requests were filled, and 96 percent of filled requests were delivered to users within 30 minutes. This represents a substantial improvement in service from last year. In FY 1991, NLM modified its onsite service policies to raise the daily limit on free stack requests from 10 to 12 and to impose an annual limit of 150 requests per individuals. The use patterns of 98 percent of onsite users fall within these limits. The remaining high-volume users were operating commercial document delivery services. High-volume requestors may use either NLM's regular fee-based overnight photocopy service or an experimental information vendor service that was established after the change in the onsite service policy. Exceptions to the limits are made for visiting scholars on a case-by-case basis. As expected and desired, the new policy shifted some of the onsite request traffic to the overnight photocopy service.

National Network Program

The goal of the NN/LM is to improve and equalize access to biomedical information by linking U.S. health professionals and researchers to the information resources they need, irrespective of geographic location. There are over 3,600 Network members including health sciences libraries of every size and type located in all parts of the country. NLM's Network Office oversees and coordinates activities throughout the Network. The NN/LM program is a critical component of NLM's outreach initiative. In FY 1991, the network was reconfigured from 7 to 8 regions and the responsibilities of the 8 Regional Medical Libraries were modified to support increased outreach to individual health professionals. Many individuals network members were awarded purchase orders for specific outreach projects. (See Special Initiatives Section). To assist the RML staffs in carrying out their expanded responsibilities for exhibits, training sessions, and development of specific outreach projects, the NLM Network Office developed training materials, special facts sheets, an exhibit management packet, and exhibit backdrops for use in all Regions, and conducted a special 2-day workshop for RML employees who will exhibit NLM's products and services.

The Network Office also tested the use of a software package that can map data by U.S. zip code as a means for representing baseline demographic, online user, and Network member data for outreach projects. In FY 1991, NLM began to update DOCUSER®, an online file of information on network libraries that are DOCLINE users directly from the PC-based NN/LM network membership files maintained in each Region. This procedure allows for efficient maintenance of such information as availability of telefacsimile service, FAX and telephone numbers, names of contact people, etc.

Special Onsite Programs

In addition to the reference and document delivery services provided to onsite users, NLM offers a variety of special programs and services to those who visit the Library in Bethesda, including guided tours, briefings on NLM's operations and services, and historical exhibits and symposia. NLM also has a visiting Historical Scholar Program and a one-year post-master's training program for librarians with potential for substantial contributions to health sciences information services.

Public tours and briefing

NLM continues to be a popular attraction for domestic and international visitors with an interest in any and all facets of biomedical communication, medical librarianship, and information technology. In FY 1991, LO staff members conducted 145 regular daily tours for a total of 425 visitors. The Office of Public Information (Office of the Director) arranged 138 special tours and orientation programs for groups (1,271 visitors). NLM staff members also arranged special briefings on library programs and services for many individual visitors.

Historical Programs

In FY 1991, NLM prepared several special historical exhibits, including: "Dentistry in Paris, 1830-1860: George Fattet and his Contemporaries," in collaboration with the National Institute of Dental Research, "A Decade of Historical Acquisitions at the National Library of Medicine," and "Midwife Means With Woman: An Historical Perspective" in cooperation with the American College of Nurse-Midwives.

The Library sponsored a lecture by Dr. Donald Fredrickson, former NIH Director, on "NIH: the Crucible Years, 1930-1948," co-sponsored the Annual Meeting of the American Ophthalmic History Society with the National Eye Institute, and co-sponsored an oral history conference on clinical research with the Acadia Institute. LO's History of Medicine Division and the NLM Equal Employment Opportunity Office presented a lecture by Professor Robert Davis entitled "Another Kind of Glory: Black Doctors in the Civil War." The FY 1991 Visiting Historical Scholar was Sander Gilman, Ph.D. Each year a recognized historical scholar is selected competitively 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 collections, and to consult with staff. Dr. Gilman carried out research for his projected work "Freud, Race, and Gender" and served as a consultant on NLM's prints and photographs collection. He presented a public lec-

ture on "Seeing Diseases: Visual Sources and the Meaning of History" and an HMD staff seminar on "Nineteenth Century Racial Biology and the Origins of Psychoanalysis." Members of NLM's History of Medicine Division also continued their research using NLM's collections. Staff research appeared in several publications and was presented at professional meetings and invited lectures throughout the year.

NLM Associate Program

The NLM Associate Program is a one-year competitive program that allows library school graduates to become familiar with NLM's operations, to gain an understanding of key issues facing health sciences libraries, to use new information technologies, and to develop their skills by conducting special projects. Projects carried out by Associates in FY 1991 included an assessment of NLM's collection of publications produced by professional associations, the development of an exhibit management manual, and work on developing the knowledge sources and algorithms to be used by the Coach expert search assistant program. Associates also have an opportunity to visit the other national libraries and various types of health sciences libraries and information centers and to attend professional meetings.

Four Associates completed the 1990/1991 program and moved on to jobs in academic health science centers, a university library, and a professional library association. Four new Associates began the program in September 1991.

Health Services Research

In 1989, NLM received a legislative mandate to work with the newly created Agency for Health Care Policy and Research (AHCPR) to improve information services in the field of health services research. With funds provided by AHCPR under an interagency agreement, the Library established an Office of Health Services Research Information (OHSRI) and initiated a number of activities to improve access to health services research information and to support the development of AHCPR-sponsored clinical practice guidelines.

In FY 1991, NLM reviewed and revised its selection policy for health services research literature in conjunction with the general effort to revise the *Collection Development Manual of the National Library of Medicine.* Expansion of the NLM collection of health services research materials is already under way. With the help of a joint NLM/AHCPR Task Force, the Library has begun to revise and expand MeSH terminology in the field of health services research. A substantial number of new concepts and cross-references were added to MeSH for 1992 as a result of this effort. A more specific publication type, "Practice Guideline," was created to allow more precise retrieval of these important documents. It will be applied retrospectively to selected guidelines that have already been indexed or cataloged by NLM as well as to newly received guidelines.

The NLM/AHCPR Task Force has identified the need for a major reorganization of the MeSH hierarchies related to health services research. This restructuring will appear in the 1993 *MeSH.* NLM recently awarded a contract to ECRI (formerly the Emergency Care Research Institute) to expand its database coverage of health services research information. ECRI will index additional health services research literature, with an emphasis on technology assessment, will update and add information to DIRLINE (Directory of Information Resources Online) about organizations involved in all facets of health services research, and will also help the Library to add concepts and terms from ECRI's Universal Medical Devices Nomenclature System to the UMLS Metathesaurus.

To date, the NLM staff has provided extensive literature search support and backup document delivery service for nine panels convened by AHCPR to develop clinical practice guidelines. Other Network libraries have provided primary document delivery service to some of the panels. NLM is establishing several mechanisms to facilitate access to AHCPR-sponsored guidelines once they are approved. Electronic copies of some versions of the guidelines will be available for automatic document delivery. The Lister Hill Center is also developing an online system that will provide access to the full-text of AHCPR approved clinical practice guidelines. (See Lister Hill Center Chapter.)

At the end of FY 1991, NLM received from the Institute of Medicine a report titled "Improving Information Services for Health Services Researchers: A Report to the National Library of Medicine." The report, the result of a year-long IOM study funded by AHCPR, recommends expanding NLM's existing services, developing new services (e.g., a database of available datasets that are useful in health services research), and training for medical librarians to assist them in responding to the complex information needs of producers and users of health services research. In the coming year, the Library will develop plans and resource estimates for carrying out recommended activities that are not already under way.

Table 1
Growth of Collections

Collection	*Previous Total (9/30/90)*	*FY 1991*	*New Total*
Book Materials			
Monographs:			
Before 1500	571	0	571
1501-1600	5,748	2	5,750
1601-1700	10,057	4	10,061
1701-1800	24,362	1	24,363
1801-1870	39,921	5	39,926
Americana	2,341	0	2,341
1870-Present	537,967	13,860	551,827
Theses (historical)	281,794	0	281,794
Pamphlets	172,021	0	172,021
Bound serial volumes	917,641	29,365	947,006
Volumes withdrawn*	(35,017)	(132)	(35,149)
Total volumes*	1,957,406	43,105	2,000,511
Nonbook Materials			
Microforms:			
Reels of microfilm	54,115	2,218	56,333
Number of microfiche	238,756	14,556	253,312
Total microforms	292,871	16,774	309,645
Audiovisuals	50,176	1,941	52,117
Computer software	244	72	316
Pictures*	56,600	0	56,600
Manuscripts	2,328,229	73,388	2,401,617

*Revised figure

Table 2
Acquisition Statistics

Acquisitions	*FY 1989*	*FY 1990*	*FY 1991*
Serial titles received	21,781	21,557	21,181
Publications processed:			
Serial pieces	137,849	144,356	158,939
Other	18,382	21,068	23,344
Total	156,231	165,424	182,283
Obligations for:			
Publications	$3,526,901	$3,632,746	$3,943,338
Included for rare books	($182,584)	($203,559)	($184,742)

Table 3
Cataloging Statistics

Item	*FY 1989*	*FY 1990*	*FY 1991*
Completed Cataloging			
Full	11,985	12,060	12,707
Limited	6,748	7,309	6,480
Total	18,733	19,369	19,187

Table 4
Bibliographic Services

Services	*FY 1989*	*FY 1990*	*FY 1991*
Citations published in MEDLINE	372,806	391,172	363,344
For *Index Medicus*	352,206	363,890	341,874
Recurring bibliographies	26	28	23
Journals indexed for *Index Medicus*	2,888	2,973	3,020
Abstracts entered	233,707	275,000	281,644

Table 5
Circulation Statistics

Activity	*FY 1989*	*FY 1990*	*FY 1991*
Requests Received:	414,354	456,904	494,515
Interlibrary Loan	227,841	258,421	281,606
Readers	186,513	198,483	212,909
Requests Filled:	310,363	349,999	385,405
Interlibrary Loan	158,840	183,950	207,670
Photocopy	146,679	170,605	193,855
Original	10,753	12,054	12,606
Audiovisual	1,408	1,291	1,209
Readers	151,523	166,049	177,735
Requests Unfilled:	101,009	106,905	109,090
Interlibrary Loan	69,001	74,471	73,936
Referred	2,850	3,431	2,050
Returned	66,151	71,040	71,886
Reader Service			
Returned as unavailable	32,008	32,434	35,154

Table 6
Online Searches

DATABASES	*FY 1989*	*FY 1990*	*FY 1991*
AIDSDRUGS	48	247	310
AIDSLINE	18,940	24,525	36,904
AIDSTRIALS	95	768	646
AVLINE	11,989	12,879	15,760
BIOETHICS	8,196	8,505	11,221
CANCERLIT®	61,070	63,898	79,511
CATLINE	157,783	158,293	213,376
CCRIS	3,060	2,983	4,862
CHEMID®	—	3,497	7,939
CHEMLINE®	24,674	22,683	26,878
CLINPROT®	2,763	2,432	1,117
DART	—	1,244	4,632
DBIR®	657	1,942	2,241
DENTALPROJ	121	262	279
DIRLINE®	7,271	7,120	9,482
DOCUSER	2,646	3,309	9,475
EMICBACK	331	1,517	2,107
ETICBACK	1,316	1,627	1,776
GENETOX	—	—	919
HEALTH	128,658	136,616	175,285
HISTLINE®	4,341	4,643	5,918
HSDB®	32,641	34,939	42,479
INFORM	115	127	306
INTROMED®	692	—	—
IRIS	—	4,959	12,133
LOAN STATUS	—	211	737
MEDLINE	1,782,750	2,058,301	2,731,557
MED86	567,991	602,394	700,010
MED83	492,092	402,341	402,914
MED80	254,539	225,340	247,919
MED77	144,562	132,976	151,620
MED72	99,358	91,601	106,882
MED66	70,202	68,373	84,586
MESH VOCABULARY	20,542	20,448	27,079
NAME AUTHORITY	3,580	3,179	3,507
PDQ®	69,158	69,684	44,194
POPLINE®	22,534	19,140	17,260
REFLINE	38,799	41,902	51,393
RTECS®	17,346	16,303	17,684
SDILINE®	39,812	41,185	55,077
SERLINE	53,532	55,038	75,309
STORED SEARCH	130	107	154
TOXLINE®	71,101	68,911	80,191
TOXLINE65	5,202	9,962	10,411
TOXLIT®	20,877	15,516	17,653
TOXLIT65	7,087	5,116	5,634
TRI	12,158	30,625	35,674
YEAR86	2	655	18
Total	4,260,761	4,478,323	5,533,019

Table 7
Offline Searches

DATABASES	*FY 1989*	*FY 1990*	*FY 1991*
AIDSLINE	191	1,294	1,807
AVLINE	126	103'	129
BIOETHICS	38	25	30
CANCERLIT	3,842	3,654	3,586
CATLINE	558	536	555
CHEMLINE	——	1	1
CLINPROT	2	0	0
DIRLINE	——	4	0
DOCUSER	1	0	0
HEALTH	11,516	10,983	10,654
HISTLINE	6	9	2
MEDLINE	6,115	4,630	5,364
MED86	7,380	5,993	4,751
MED83	8,823	5,211	3,415
MED80	5,971	3,557	2,513
MED77	3,830	2,073	1,401
MED72	2,440	1,452	993
MED66	1,510	838	610
MESH VOCABULARY	1	1	1
POPLINE	5,378	5,107	3,778
SDILINE	247,812	229,625	226,397
SERLINE	6	10	8
TOXLINE	12,731	6,608	5,421
TOXLINE65	35	76	24
TOXLIT	145	5,497	4,441
TOXLIT65	119	103	22
Total	318,576	287,390	275,903

Table 8
Reference Services

Activity	*FY 1989*	*FY 1990*	*FY 1991*
Reference Section:			
Requests by telephone	21,481	19,222	19,889
Requests by mail	985	585	487
In-person requests	39,374	40,823	46,140
Total	61,840	60,630	66,516

Table 9
History of Medicine Activities

Activity	*FY 1989*	*FY 1990*	*FY 1991*
Acquisitions:			
Books	127	360	66
Modern manuscripts	946,750	128,088	73,388
Prints and photographs	3,420	642	0
Processing:			
Books cataloged	346	232	330
Modern manuscripts processed*	48,001	112,541	129,000
Pictures cataloged	0	0	0
Citations indexed	5,479	5,136	5,888
Pages microfilmed	48,774	66,581	88,524
Public Services:			
Reference questions answered	10,244	13,982	12,184
ILL and pay orders filled	2,406	3,506	3,477
Reader requests filled	8,309	9,358	5,992
Pictures supplied	6,045	5,872	4,683

* Revised category.

SPECIALIZED INFORMATION SERVICES

Henry Kissman, Ph.D.
Associate Director

The widely quoted results of a recent Louis Harris poll in which respondents rated a clean environment more important than a satisfactory sex life, are clearly a stronger indicator of the urgency of environmental issues than they are of the demise of romance. Society is recognizing that its environmental future cannot be deferred. Chemicals must be used safely and wisely today, so that their benefits can be reaped without deleterious consequences tomorrow. NLM's Specialized Information Services Division (SIS), through its Toxicology Information Program and other activities, is making available information now, to meet current and long-term environmental and toxicological needs. The past year has witnessed several significant milestones within the Division.

The much-used TOXNET (Toxicology Data Network) system now encompasses 12 files. Most recently added were GENE-TOX, a scientifically reviewed Environmental Protection Agency (EPA) file of mutagenicity data, and the 1989 edition of the Toxic Chemical Release Inventory (TRI89). The TRI series of files responds to Federal right-to-know legislation and anticipates continuing demands by the public to be apprised of routine or accidental releases of toxic chemicals to the environment. The TRI series, along with HSDB (Hazardous Substances Data Bank), RTECS (Registry of Toxic Effects of Chemical Substances) and IRIS (Integrated Risk Information System) account for the bulk of the usage on TOXNET. These and TOXNET's other files give researchers, physicians, emergency responders, and citizens information on hazardous chemicals to help them manage existing needs and plan for future ones.

TOXNET has also undergone an internal evolution to a new software system. This has been accompanied by a hardware switch from minicomputers to a PC-based cluster consisting of ten 386 microprocessor machines. This new approach results in improved processing time, greater flexibility and the ability to respond quickly to future technological changes, by expanding the number of PCs or stepping up to 486 or even 586 machines as may be warranted. It also resulted in considerable savings. SIS has continued investigating the feasibility of redesigning TOXNET in a Relational Database Management System (RDBMS) environment as another means of facilitating file building and maintenance capabilities.

Another major SIS initiative has been the development of a Toxicology Information Outreach Program for Historically Black Colleges and Universities. This initiative will attempt to facilitate the training of students and health professionals in the use of environmental and toxicological information resources.

SIS's AIDSTRIALS and AIDSDRUGS continue to provide extensive up-to-date information on AIDS clinical trials and the agents tested in such trials. While the AIDS toll has not subsided, research goes on, and these files offer much needed data on treating patients.

A Long Range Planning Panel for Toxicology and the Environment has been formed. During the coming year, it will explore the deep waters of toxicological and environmental information and help NLM chart a course to navigate them for the remainder of this decade. Environmental issues are clearly "hot." Addressing these issues head-on is fashionable but also imperative if we are to survive and thrive on this planet. SIS has been at the forefront of making data publicly accessible since the 1960's, when society first became aware of how susceptible the environment was to widespread damage. SIS is looking ahead, further into the 1990's and beyond, and assessing new information approaches to help in keeping man and the environment safe and healthy.

Databases under ELHILL

ChemID (Chemical Identification File) is an online chemical dictionary and directory, which covers primarily chemicals of biomedical and regulatory importance. ChemID allows users to search by a variety of chemical and biological identifiers, and to locate other files on the ELHILL® and TOXNET systems, or external data, which contain more information about the chemical in question. In August 1991 ChemID contained over 183,000 records, and was expected to contain over 200,000 records by the end of the fiscal year.

ChemID includes an important set of regulatory and scientific data, collectively known as SUPERLIST. More than 6,000 records are augmented with the name and an indication of source for chemicals mentioned in one or more of 16 lists of regulatory or biomedical importance. These data allow users to determine if a certain chemical is mentioned on a given list and under what name; to search for chemical classes on these lists; and to show coverage overlap between lists. In 1991, an additional seven lists were prepared for inclusion in SUPERLIST.

These include the Priority Based Assessment of Food Additives (PAFA) list, and the Generally Recognized as Safe (GRAS) list, both from FDA, as well as the Hazardous Air Pollutants (HAP) list, established under the Clean Air Act. Thus, SUPERLIST establishes a means to link a wide array of information sources and helps establish an overview of Federal regulation of a chemical substance.

CHEMLINE (Chemical Dictionary Online) is an online chemical dictionary and directory file that allows users to identify chemical substances via nomenclature and other identifiers, and to formulate optimum search strategies for other NLM files. Each chemical record has pointers to other files on the ELHILL and TOXNET systems which contain information about that chemical substance. CHEMLINE is updated every two months and regenerated annually. Most of CHEMLINE's data are supplied by the Chemical Abstracts Service (CAS) from its Registry System; users must pay CAS royalty fees to use CHEMLINE. The file now contains more than 1,000,000 records of chemical substances.

During FY 1991, the scope of coverage of the CHEMLINE file continued to increase. CHEMLINE now covers substances in the TRI87 and TRI88 files on ELHILL, as well as both the EMICBACK, ETICBACK and GENETOX files on TOXNET. For seekers of regulatory information, the data from the EPA's Toxic Substances Control Act (TSCA) Inventory was updated, as well as that for EINECS, the European Inventory of Existing Commercial Chemical Substances. Data from all sources contributing to CHEMLINE were updated and enhanced during the file regeneration of 1991.

CHEMLINE was also changed in 1991 to take advantage of features pioneered the previous year in ChemID. A new Name of Substance (NM) field was added to separate the more useful and important chemical names such as United States Adopted Names (USAN) for printing, and then for selection as search terms in files such as TOXLINE. Also, a MeSH Heading (MH) field was added to point out pertinent indexing, and a Name of Mixture (MX) field was added to identify names of drug mixtures which contain the drug record retrieved by a user.

TOXLINE (Toxicology Information Online) is an online bibliographic retrieval service, produced by merging "toxicology" subsets from some seventeen secondary sources. TOXLINE and its backfile, TOXLINE65, contain data from sources that do not require royalty charges based on usage.

Information from Chemical Abstracts Service (CAS), which requires usage royalties, is used for two other online bibliographic files, TOXLIT and TOXLIT65. The four databases in the TOXLINE family of services now contain more than three million records.

The TOXLINE indexing vocabulary mapping project which resulted in the addition of MeSH vocabulary to Biological Abstracts records added to TOXLINE since August 1985, is continuing. SIS staff developed a program that maps Biological Abstracts' Concept Codes and Biosystematic Codes to the MeSH vocabulary, and are currently working on the mapping of indexing terms for other TOXLINE components to MeSH.

During FY 1991, the TOXLINE files were regenerated to add current MeSH indexing vocabulary to the portion derived from MEDLINE, and to update several other components as well. The new DART (Developmental and Reproductive Toxicology) subfile, available on NLM's TOXNET system, was developed and is expected to be added to TOXLINE shortly.

DIRLINE (Directory of Information Resources Online), is an online directory of organizations with information resources and subject expertise who are willing to provide information and assistance in response to inquiries. This database assists MEDLARS users by providing an alternative resource for information needs not met by the usual bibliographic or factual databases. Medical Subject Headings (MeSH) indexing for all the records in DIRLINE has been provided. Grateful Med 5.0 was programmed to include the ability to use MeSH in order to search DIRLINE.

Health Hotlines is a booklet listing organizations in DIRLINE with toll-free telephone numbers. This has been a very popular publication; over 90,000 copies have now been distributed to all sectors of the public, including libraries, health departments, newspapers, magazines, and private citizens.

AIDS

NLM has continued to develop AIDS information resources including those mandated by the Health Omnibus Programs Extension Act. NLM is one of four Public Health Service agencies cooperating in the AIDS Clinical Trials Information Service.

The AIDSTRIALS and AIDSDRUGS databases, both a part of this cooperative project, have continued to grow. AIDSTRIALS, which includes both trials actively adding new patients and those which have completed this accrual, is an effective mechanism for health professionals to identify suitable clinical trials and locations to which they may refer patients.

AIDSDRUGS contains information about the agents being tested in the clinical trials listed in AIDSTRIALS. The information, extracted from handbooks, compendia, databases, and trial protocols, includes pharmacology, interactions, adverse effects, and chemical/physical properties. Under NLM's guidance, the contractor has added bibliographic references for those who seek additional information about these agents.

The AIDS component of DIRLINE was expanded to include more than 1,800 organizations.

TOXNET and Its FILES

The TOXNET computer system continues to provide one of the most comprehensive sources of information on toxicology and hazardous substances. Over the past year, the TOXNET system has undergone a complete software conversion and an entirely new hardware implementation. Transparent to the user, a networked PC-based system in a client/server architecture was built, and after extensive testing, became publicly available on May 6. This new system architecture consists of a cluster of 386 microprocessors with over 15 gigabytes of online disk storage and 224 user ports on three terminal servers. TOXNET's new mirrored configuration results in a twelve-fold increase in processing power over the former system which operated on a pair of minicomputers. The new hardware platform offers flexibility and growth together with the ability to accommodate rapid changes in technology without requiring a complete system conversion.

During FY 1991 two new files were added to the TOXNET system, bringing the total to 12. They were: TRI89 (the Toxic Chemical Release Inventory's 1989 reporting year data) and GENE-TOX, a scientifically reviewed file of mutagenicity data prepared directly on TOXNET by the EPA. TOXNET's online usage continued to increase throughout the year despite the system conversion. Usage of the TOXNET-to-ELHILL gateway, a transparent switching mechanism providing user access to other NLM files, has maintained its high usage in 1991.

Some of the major system-wide enhancement to TOXNET include online and offline sorting features for all TOXNET databases, and advanced TRI search menus. The sorting capability, combined with numerical calculation commands in the TRI databases, provide users with very sophisticated and powerful data manipulation capabilities. The advanced TRI menus (see below) have been extremely well received, doubling usage over the last six months of the year.

The **Hazardous Substances Data Bank** (HSDB) continues to be the most highly used file on the TOXNET system, averaging 645 hours of online access each month. The file building activities for HSDB continue to be supported by the Agency for Toxic Substances and Disease Registry (ATSDR). During this period, 369 chemical records were peer reviewed by the Scientific Review Panel, and 514 records went through Public System Updates. Hazard summaries were prepared for 67 peer-reviewed records and 150 toxicity summaries were written by staff.

The **Toxic Chemical Release Inventory** (TRI) files, including TRI87, TRI88, and TRI89, remain as important information resources with continued high usage on TOXNET. Mandated by the Emergency Planning and Community Right-to-Know Act (Title III of the Superfund Amendments and Reauthorization Act of 1986), these EPA-sponsored databases contain environmental release data to air, water, and soil for 325 EPA-specified chemicals. During FY 1991, TRI advanced menus were introduced to permit searching against any or all of the TRI files.

The **Chemical Carcinogenesis Research Information System** (CCRIS) continues to be maintained on TOXNET by the National Cancer Institute. The data bank contains test results from carcinogenicity, mutagenicity, tumor promotion and tumor inhibition studies. CCRIS now contains more than 2,800 records.

The **Developmental and Reproductive Toxicology** (DART) database continues to be accessible through TOXNET. DART contains approximately 9,000 citations from literature published since 1989 on agents that may cause birth defects. Records in DART contain bibliographic citations, abstracts (when available), Medical Subject Headings (MeSH), and the names and Chemical Abstracts Services (CAS) Registry Numbers (RN) for all chemicals mentioned in the publications. Over half of the records are derived from MEDLINE and supplemented with additional chemical index terms. Records not found in MEDLINE, such as citations to meeting abstracts, articles from journals not indexed for MEDLINE, books, and technical reports, make up the remainder of the database.

DART is a continuation of the Environmental Teratology Information Center Backfile (ETICBACK) database on TOXNET. ETICBACK, produced by the Department of Energy's Oak Ridge National Laboratory (ORNL), contains approximately 50,000 citations to literature published from 1950-1989.

The **Environmental Mutagen Information Center** (EMIC) database is produced by ORNL and is managed by NLM. Plans are under way to create a new EMIC database, with citations to literature published since 1991, that will be built and maintained on the TOXNET system. ORNL will also locate and add citations to publications not found in MEDLINE.

A backfile for EMIC (EMICBACK) has been publicly available through NLM's TOXNET system since June 1989. EMICBACK contains 70,000 citations to literature published since 1950 on agents that have been tested for genotoxic activity. Records in EMICBACK contain bibliographic citations, EMIC special keywords, and the names and CAS Registry Numbers for all chemicals tested.

These four bibliographic databases on TOXNET are funded by the EPA and the National Institute of Environmental Health Sciences and are operated by NLM.

The **Integrated Risk Information System** (IRIS), EPA's health risk assessment file, has grown considerably in its first year on TOXNET. Nearly 200 records were added to the file to make a total approaching 600 chemicals. Meanwhile, hundreds of these chemicals were edited with new or revised information. Though relatively small and new, IRIS is now TOXNET's fourth most heavily used file.

The **Registry of Toxic Effects of Chemical Substances** (RTECS) is a data bank based upon a National Institute for Occupational Safety and Health (NIOSH) file by the same name which NLM has restructured and made available for online searching on TOXNET. SIS continues to add new data to this file as NIOSH makes them available. In addition, SIS continues to enrich RTECS records that lack CAS Registry Numbers with these important identifiers. So far about 35,000 records have been so enhanced. RTECS now contains approximately 110,000 records.

GENE-TOX, a new online data bank created by EPA, contains genetic toxicology (mutagenicity) data on 3,000 chemicals. GENE-TOX is a multiphase effort to peer review the existing scientific literature and assay systems available in the field of genetic toxicology.

Other Programs

Microcomputer Workstation for Chemical Emergency Response

SIS, with the ATSDR, has built a portable, microcomputer-based workstation that provides information assistance to emergency response teams working on accidents involving hazardous chemicals. The prototype, known as ANSWER (an acronym for ATSDR/NLM's Workstation for Emergency Response), consists of software modules designed to facilitate easy access to information useful to response teams during emergencies.

The core modules of the Workstation are: a CD/ROM-based database containing information on both hazard management and medical management; a specialized database containing information gleaned from previous chemical emergencies; a modified version of software that facilitates searching of diverse remote online databases; a fax capability to transmit information to and from an emergency site; access to weather information from the National Weather Service; and a word processing capability for editing, sorting, merging, and transforming retrieved data fields.

The Workstation was made available for beta testing at 13 sites, including selected state health departments and several poison control centers. The results of the test show that ANSWER is fully functional in a command center environment in both emergency and nonemergency situations. Further, the test shows that additional chemical databases on CD-ROM would be very helpful in the field.

Relational Toxicology (RelTox) Project

In RelTox, a new initiative, SIS is investigating the use of relational database management system (RDBMS) technology for building and operating its chemical and toxicology files. The first phase of the project was to develop a relational model of the data elements of the relevant files from TOXNET and ELHILL. SIS then convened a panel to review the resulting report. The panel recommended that SIS proceed with developing an RDBMS-based file-building module for HSDB and some of the files now being built on TOXNET.

Outreach

A new outreach project was initiated by NLM to strengthen the capacity of Historically Black Colleges and Universities to train medical and other health professionals in the use of NLM's toxicological, environmental, and occupational information resources. This audience represents a group that might otherwise not get exposure to these valuable information sources. Also, this group is considered one of the high priority populations for NLM's outreach efforts. Further, it is intended to tie this initiative to NLM's High Performance Computing and Communications Program to allow access to a variety of textual and image computer resources.

A Toxicology Information Outreach Panel was established and held its first meeting at the Library in August 1991. Representatives from each institution presented their preliminary plans for implementing a training model. PC-based workstations which include user-friendly access software (Grateful Med), microcomputer-based tutorials, and multimedia demonstrations are to be provided by NLM and will be installed at each university.

User Support Services

User support for its online files is an ongoing SIS function. User Guides for the CHEMLINE, TOXLINE, RTECS, HSDB, CCRIS, and DIRLINE files are made available as part of NLM's Online Services Reference Manual. Guides for newer SIS files that are not yet covered in the manual are provided directly to system users on request or in training classes. In addition, a special reference manual and other training materials are prepared in conjunction with the Oak Ridge Associated Universities. Updated fact sheets for all databases and other related activities are prepared routinely. SIS staff continued to provide training for the SIS online files both as a part of the MEDLARS training program and, for other users, at special training sessions and at professional meetings.

Special training in the use of the toxicology files also was provided in collaboration with the ATSDR to envi-

ronmental health specialists from that agency and from state agencies. This program is conducted under SIS direction by ORAU in Oak Ridge, Tennessee. In FY 1990, the project was expanded, with an additional program designed to "train trainers"—state health department representatives—who teach the use of the NLM toxicology files back in their home states. To date, representatives from health agencies in 40 states and two U.S. territories have been trained. Also, individuals from 11 occupational health clinics and the 7 organizational members of the American Minority Professional Health Schools have taken this training.

During FY 1991, SIS completed development of ELHILL LEARN, a microcomputer-based tutorial for the ELHILL search and retrieval software that supports the majority of the MEDLARS databases. It is intended to be used as a precursor to the CHEMLEARN®, TOXLEARN®, and MEDTUTOR® microcomputer-based tutorials. While it is designed primarily for new users unfamiliar with the ELHILL software, it can be used as a quick reference tool to reinforce or recall previously learned search procedures.

The MEDTUTOR and TOXLEARN tutorials were updated. Perhaps the most important design feature of these tutorials is their systematic practice and diagnostic feedback. These programs provide an alternative or augmentation to formal classroom training.

The Toxicology Information Program Files Demo Disk, originally written for use in a DOS environment, was made available for Windows. It takes full advantage of Windows' multimedia capability by incorporating color graphics, photography, animation, and audio.

Alternatives to Animal Testing

SIS staff has undertaken a number of projects related to the use of alternatives to using live vertebrates in biomedical research and testing. Quarterly annotated bibliographies were prepared by the Oak Ridge National Laboratory under the direction of SIS staff and are distributed to those requesting them. *ILAR NEWS*, a publication of the National Research Council, announces their availability. Under an agreement with NLM, ILAR (Institute of Laboratory Animal Research) also publishes annually concatenated versions of the NLM/ORNL quarterly bibliographies.

Directory of Biotechnology Information Resources

CDBIR has been available online since January 1989, both as a separate file in TOXNET, and as a subset of DIRLINE in ELHILL. It currently contains more than 1,700 records describing databases and other information services, organizations, collections and repositories, publications, and sanctioned nomenclature committees, all related to biotechnology and molecular biology.

Long Range Planning Panel on Toxicology and the Environment

The Division has been cooperating with the NLM Office of Planning and Evaluation in developing charges to the Panel and in proposing candidates. The Panel will first convene in late October 1991, with subsequent meetings scheduled for January and March 1992.

Information Services to Other Agencies

As described, SIS provided support for building, maintaining, and deploying computer-based information resources for ATSDR, NIOSH, NCI, EPA, and NIEHS. SIS also provided leadership for the Subcommittee on Information Coordination of the DHHS Committee to Coordinate Environmental Health and Related Programs. Activities of Subcommittee include developing a Directory of DHHS Risk Assessment Projects and determining the need for information resources to support epidemiology projects. SIS also represents the Library on the Committee's subcommittees on Environmental Health Risk Assessment, Testing and Test Method Validation and Research Needs.

SIS continued to represent NLM on the congressionally mandated Interagency Task Force on Environmental Cancer, Heart and Lung Diseases as well as on the working group established to develop a Directory of Exposure Data and Information Resources. Staff also participated in deliberations of the NIEHS Working Group responsible for the Annual Report on Carcinogens. The Library, through SIS, helps to develop the National Toxicology Program Annual Plan and its review of current DHHS, DOE, and EPA research relevant to toxicology.

LISTER HILL NATIONAL CENTER FOR BIOMEDICAL COMMUNICATIONS

Daniel R. Masys, M.D.
Director

The Lister Hill National Center for Biomedical Communications (LHNCBC) was established by a joint resolution of Congress in 1968. The Center serves as an intramural research and development division of the NLM. LHNCBC research programs apply state-of-the-art computer and communications technologies to the management of biomedical knowledge. Such knowledge can take the form of procedural rules found in expert systems, information in bibliographic and factual databases, as well as images, electronic signals, and sounds. LHNCBC programs create innovative methods for acquiring, storing, retrieving, analyzing, communicating, and presenting information to biomedical researchers and health care professionals.

A Board of Scientific Counselors meets to review the quality and contents of the intramural research programs within the Lister Hill Center. The Board is composed of scientific and technical experts (see Appendix 5 for a list of members) who are prominent leaders in the fields of medicine, computer science, engineering, and health professions education.

The Center is organized in five component branches:

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

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

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

In 1991 the LHNCBC successfully initiated an Undergraduate Research Study Program to provide two-year scholarships and research assignments in image processing and computer visualization as they pertain to medical informatics for sophomore students majoring in electrical engineering, computer science, computer engineering, or physics at participating historically black colleges and universities. The program selected three schools, Morgan State University (Maryland), Southern University (Louisiana), and North Carolina Central University to begin a 5-year collaboration. Participating students began the first of two summer internsips at the Lister Hill Center and have now begun the first of two academic year assignments under the guidance of their preceptors.

Computer Science Branch

Research projects of the Computer Science Branch (CSB) concentrate on the application of artificial intelligence techniques to problems in the representation, retrieval and manipulation of biomedical knowledge. CSB projects involve both basic and applied research in such areas as expert systems, natural language systems, machine learning, and machine-assisted indexing for information classification and retrieval. The research addresses issues in knowledge representation, knowledge base structure, knowledge acquisition, the validation of automated consultant systems, and the human-machine interface for complex systems. Important components of the research include multimedia knowledge-based systems with interactive video capability, and embedded intelligence systems which combine local reasoning with access to large-scale mainframe databanks.

Branch staff members participate in individual and team research projects within the branch, in various aspects of such projects as NLM's Unified Medical Language System initiative, and in the medical informatics and information science research communities. Current efforts of the Computer Science Branch include the Expert Systems Program, the Natural Language Systems Program, the MedIndEx Project, and the Machine Learning Project (described in the FY 1990 report).

Expert Systems Program

Expert systems are computer programs that combine knowledge of a particular subject with inferencing mechanisms enabling them to use this knowledge in problem-solving situations. An artificial intelligence research program concentrating in expert systems was es-

tablished at LHNCBC in 1984. The objective of the program is to facilitate computer-assisted access to knowledge. This knowledge may reside in different forms, in different places, on different media, with different structures and naming conventions.

The primary research projects of the Expert Systems Program in FY 1991 were the AI/RHEUM consultant system in rheumatology, the Rheumatology Image Library videodisc, the CTX "criteria engine" shell and its family of automated testing and validation tools, the medical expert systems evaluation project, the AI/COAG hemostasis consultant system, and the COACH expert searcher system.

The flagship project of the program is the AI/RHEUM expert consultant system in rheumatology. The AI/RHEUM knowledge base has been updated and nearly doubled in scope in FY 1991. The system now offers online access to 468 text definitions, to more than 6,800 still images and 23 minutes of brief motion sequences on the Rheumatology Image Library videodisc, to 136 automated MEDLINE searches using the Grateful Med Search Engine, and to the 44 disease criteria tables which are the heart of its knowledge base. The system's data entry process has been significantly streamlined and a new Case Data Editor module added to facilitate its use in clinical settings.

AI/RHEUM is the best known of a series of knowledge-based medical consultant systems using the criteria table form of knowledge representation pioneered by NLM researchers. An expert system shell, called "CTX" for its use in criteria table expert systems, is designed to be widely applicable and is now in beta-test phase in several subject domains. It has the potential to be a useful building block for integration into complex projects which need decision-support components. The new shell allows direct coupling of video image libraries to expert systems. Voice-over narration for the video motion sequences, a major expansion of the number of motion sequences, and nearly 500 new still frames were added to the Rheumatology Image Library videodisc in FY 1991.

Several software tools written as adjuncts to the CTX shell provide utilities assisting the developer in manipulating multi-thousand-frame videodisc image banks and in automating the performance evaluation of CTX-based consultant systems against benchmark sets of test cases. The shell, with its explicit and very unusual multimedia links to knowledge sources in different forms and in different places, even on different machines, is one focus of the overall Expert Systems Program goal of providing users with access to knowledge. Its unique combination of capabilities can help developers build consultant systems in any domain which lends itself to the criteria form of knowledge representation.

The AI/COAG hemostasis consultant system, reported in prior years, is the basis of a hemostasis advising system now in daily use on the Yale Laboratory Network. Expert Systems Program staff in FY 1991 explored the linking of the AI/COAG consultant system running on a Macintosh workstation to the hospital information system at the NIH Clinical Center. In another instance, demonstrating the utility of intelligent local systems which reach out to huge mainframe databanks, the system successfully downloaded, parsed and interpreted appropriate hematology laboratory results.

The most recent project is the Coach expert searcher system. Coach brings to bear the UMLS Metathesaurus and other knowledge sources to assist Grateful Med users seeking help in improving retrieval from ELHILL on NLM's mainframe. Initial work has concentrated on MEDLINE and its backfiles, and in particular on the problem of null retrieval. Coach offers true ELHILL multifile searches, ELHILL sorting of output citations before download, and considerable flexibility in the print format of downloaded results. It works interactively with the user, with Grateful Med, and with ELHILL.

Coach emulates a number of the actions of an expert human searcher in diagnosing user search problems and determining which of a series of functions to invoke for their solution. It has access to multiple knowledge sources built to help augment or replace the user's query terms or to map to new terms in accordance with the user-stated goal of getting more or getting better focused retrieval. Coach's primary knowledge source, the UMLS Metathesaurus, is an extremely rich source of potentially useful related terms, lexical variants, relationships, definitions, co-occurrences and other information. MeSH and special Coach knowledge sources allow mapping for occupational specialty headings; subheading synonyms, subheadings, and conceptual clusters of subheadings; explodes and pre-explodes; "consider also" terms; and "forward see related" cross reference terms.

Dr. Kingsland of the Expert Systems Program served again in FY 1991 as coordinator for the 8-week NIH "Medical Informatics" elective for third-year and fourth-year medical students. Nine students from medical schools across the U.S. completed the elective. The course included a seminar series of more than 45 90-minute lectures, independent research projects under the direction of NIH preceptors, and oral and written presentations of research results. Some of these extremely bright, highly motivated students have themselves made important contributions to Expert Systems Program projects.

Natural Language Systems Program

The Natural Language Systems Program carries out research in automated language understanding with the goal of providing health professionals with natural and flexible access to biomedical information stored in computerized form. NLM's long range report has noted that

a desirable goal for information systems would be to "...allow humans and computers to function in their preferred states and attempt to develop technology that will permit them to communicate with each other, translating between their respective representation systems." This program's objective is to develop and test methods for biomedical language processing that will result in more effective interaction between users and the computerized information sources they attempt to access.

Efforts have concentrated on the development of SPECIALIST, a prototype system for parsing and accessing biomedical text. The system includes both linguistic and biomedical knowledge. Linguistic knowledge involves rules and facts about the grammar of the language. Biomedical knowledge involves rules and facts about the domain of biomedicine. The UMLS Metathesaurus and Semantic Network, as well as the UMLS test collection, have recently contributed to the further development of the SPECIALIST system.

The linguistic knowledge used by the SPECIALIST parser includes lexical information and rules of morphology, syntax, and semantics. The lexicon, which forms a central part of the system, contains both general English lexical items and items specific to biomedicine. During FY 1991 the program concentrated on increasing the size and scope of the SPECIALIST lexicon. Five consultants were brought on for this work. The one-year lexicon development project has increased the lexicon's size from 5,000 entries to over 40,000. When expanded to the full set of inflectional variants, this is actually over 75,000 lexical forms. Each lexical entry encodes graphemic, morphologic, syntactic, and semantic information. This information is used by the grammar rules as they attempt to produce structured representations of phrases and sentences in biomedical texts. Each lexical record includes entries for one or more parts of speech, inflectional information, information on complementation, logical interpretation, potential for transformation, and other information relevant to a specific lexical item. Acronyms and abbreviations are cross-referenced to their full forms; nominalizations of verbs are cross-referenced to their verbs. The syntactic/semantic component of SPECIALIST is an extended Definite Clause Grammar. The grammar includes context-free BNF (phrase structure) rules together with context-sensitive restrictions which constrain the structures actually built.

The biomedical knowledge needed by SPECIALIST includes knowledge of the important concepts in the domain of biomedicine, the relations among these concepts, and rules to process these concepts and relations. The Metathesaurus and the Semantic Network provide the sort of biomedical knowledge SPECIALIST requires. The program's head, Dr. Alexa McCray, and other staff have been involved in the UMLS project since its inception. The SPECIALIST lexicon was augmented with a large number of items from Meta-1 during this past year and a menu-based browser for the Metathesaurus knowledge source was developed. This application allows users (or programs) to search for Metathesaurus terminology, reporting the term and its source vocabulary; its definition, lexical tags and variants; and its synonyms, semantic types, related terms, other associated terms, or contexts as specified by the user. The global search capability allows the user to find all concepts in the Metathesaurus with a particular characteristic; e.g., all concepts that have a particular semantic type, or all concepts that are labelled as acronyms. The browser is written in C and runs under Unix on Sun workstations.

The first version of the UMLS Semantic Network contains 131 semantic types and 35 links, or relationships, that hold between them. During FY 1991 program staff have carried out initial tests of the feasibility of using the UMLS semantic types for expressing selectional restrictions. Selectional restrictions establish what may sensibly co-occur with an item. For example, a verb such as "administer" takes an agent as a subject and may take a therapeutic substance as one object and a body region as a second object. The use of such selectional restrictions can both help reduce the number of spurious parses generated by a parser that has only grammatical information, and give an indication of the meaning of the major concepts in a sentence. The investigations have used two approaches. The first has involved an analysis of highly frequent verbs and their nominalizations as they occur in biomedical texts. Sentences containing these verbs have been analyzed and their complements studied to see if a match to an existing semantic type can be made. The second approach has involved identifying the semantic types of all the nouns that are in the current SPECIALIST lexicon and also in the Metathesaurus. At last count there were over 10,000 such terms.

An additional lookup step has been added to the parser, so that if a semantic type exists for any of the lexical items in the sentence, it is reported as part of the final parse. This means that the semantic types are seen in context as part of normal development on the parser. Staff is working on an application that will allow the parser to reason in a variety of ways with the knowledge encoded in the Metathesaurus and the Semantic Network.

In order to test the extent to which natural language processing techniques may improve access to information, staff have developed an experimental database module. The module processes files such as MEDLINE citation records, creates an index for the items in all relevant fields, and provides for Boolean retrieval of these items. One of the major sources of textual material for the system is the UMLS test collection of queries and citation records. The collection, which was developed for use as an evaluation tool in the UMLS project, includes more

than 150 queries and some 3,000 citation records, with relevancy judgments. The queries were selected primarily from search request forms submitted to the NIH and NLM libraries. This test collection provides a large yet finite set of biomedical texts for experimentation and evaluation.

MedIndEx Project

The MedIndEx Project develops and tests interactive knowledge-based systems for computer-assisted indexing of medical literature currently indexed in the MEDLINE database using terms from the Medical Subject Headings (MeSH) thesaurus. The main objective of MedIndEx is to facilitate expert indexing that goes into the MEDLINE product. Another focus of this research has been to develop intelligent retrieval systems utilizing the same representations and environment of the indexing system. Background information about how MedIndEx is being developed was included in the FY 1990 *NLM Programs and Services.*

The prototype MedIndEx is written in Sun Common Lisp 3.0 and runs on Sun SPARCstation workstations under the SunOS operating system. Domain-independent project software includes a Lisp-based experimental frame language. MedIndEx is designed to run similar indexing and knowledge base manager applications in other domains. As of late FY 1991, the knowledge base contained nearly 3500 frames (MeSH concepts).

In FY 1991, an X Window System interface using X11 Release 4 and other public-domain software (CLOS, CLX, CLUE) was developed and installed, replacing a hardware-dependent interface. Use of X Windows should provide much flexibility in choice of computers on which to install the system. The system can now be run in a client-server architecture with two ethernetted SPARCstations and can be accessed from a PC with X server software. The new interface permits enhanced hierarchical displays of the knowledge base. In addition, direct manipulation of code as objects, which is a special interface for the knowledge base manager, has been extended.

Adapting the indexing system for new uses such as retrieval would integrate different applications of the same knowledge base into a single system and may allow re-use of the same interface design. This has been demonstrated during FY 1991 by extending the MedIndEx prototype for use by searchers who would index their queries, producing a set of query frames. In one approach, the system generates conventional indexing terms from these query frames (in effect, indexing the query with MeSH terms, similar to what MedIndEx does now to index documents). In this search application, indexing terms would serve as suggested terms for searching MEDLINE.

In the other approach, as in the first, query frames would be generated from MedIndEx. Instead of the conventional MEDLINE database, the database used is the indexing frame database in a relational form. Since it corresponds to indexing frames, this database provides a more precise representation of documents than MEDLINE. In this approach, rather than using conventional indexing terms generated from query frames, the search interface decomposes query frames into individual relationships. The user (searcher) clicks on selections and on Boolean operators with a mouse pointing device, combining them into more complex search statements to achieve a final statement which represents the query. The system then translates this statement into SQL queries used for searching the relational database.

Work planned for FY 1992 includes designing an evaluation of the indexing system, extending the system to include a module for indexers to tag conventional indexing terms as central concepts, and further automating the knowledge base manager in representing contextual hierarchies (similar to MeSH trees).

Information Technology Branch

The Information Technology Branch pursues applied research and development in computer and information science with an emphasis on electronic information generation, storage, and retrieval. Areas of activity within the current programs include development of generalized windowing interfaces across multiple platforms, object-oriented retrieval systems encompassing fielded data, full text, and graphics objects, editing workstations for manuscript preparation, computer-based publication, and CD-ROM technology. Within these programs many areas of applied computer science must be addressed including portability, object-oriented programming, multiprocessing, client/server distributed processing models, and advanced memory management.

Current efforts of the Branch are the Online Reference Works project, including the work on the Online Mendelian Inheritance in Man (reported in FY 1990 *NLM Programs and Services*), a CD-ROM program, and full-text and information retrieval projects.

CD-ROM Program

NLM has a growing need to effectively disseminate large full-text databases and/or digitized images and/or digitized audio in a number of program areas and across multiple platforms such as MSDOS, Macintosh, and Sun/Unix. CD-ROM represents a unique storage medium for the dissemination of such information. In 1990, the Branch established a laboratory for CD-ROM devel-

opments and acquired technical expertise in CD-ROM design and pre-mastering. The primary laboratory tool is a CD-ROM Pre-mastering and Simulation Workstation which will allow the formatting of tapes for mastering and the simulation of CD-ROM applications even prior to mastering.

During FY 1991, CD-ROMs were mastered in the laboratory for the NCBI and the UMLS. Procurements were also initiated for the acquiring a CD-ROM write-once mastering unit and an upgraded pre-mastering workstation. The Branch has extended the original object-oriented systems design for IRx2 to include fielded as well as full text data (see Information Retrieval, below).

Full Text Program

As reported last year, the Agency for Health Care Policy and Research (AHCPR) has a requirement for an online, full-text retrieval system. Based on previous full-text retrieval developments (e.g., IRx), the Branch completed in 1991 a full-text information retrieval capability designed to support medical guidelines. This extended the capability developed for IRx1 by including consideration of the structure inherent in the planned AHCPR guidelines. In addition to the available AHCPR draft guidelines, two other related databases were obtained and implemented: the monographic report, "Guidelines for Preventive Medical Services," and a database of 83 NIH Consensus Development Conference Reports. All of these databases have been mounted on the Lister Hill Full Text Server and will be accessed over dial-up telephone lines.

Information Retrieval

During 1991, the Information Technology Branch made operational several retrieval systems, each of which is made up of a search engine and modules to support windowing interfaces across different user workstations (MS-DOS, Macintosh, Unix) and/or character-mode terminals. Major developments have proceeded in full-text retrieval (noted above) and fielded-data retrieval.

Many databases targeted for CD-ROM are of the fielded-data type rather than full-text. Examples of such databases being addressed by the Branch are the SERLINE database of journal titles, the NLM ChemID and TOXLINE databases, and the EPA Toxic Chemical Release Inventory (TRI) database. An object-oriented search engine capability has been developed in FY 1991 incorporating incremental searching of terms and user defined data types. The latter allow the database fields to be of arbitrary hierarchy or complexity. The incremental search capability enables the user to select long or compound terms with the entry of a small number of characters. The search engines for the fielded-data databases have been designed to run on local personal computers.

Communications Engineering Branch

The research and development activities in this program focus on the capture, storage, processing, online retrieval, transmission and display of biomedical documents and medical imagery. Areas of active investigation center on image compression, image enhancement, image understanding, pseudo-grayscale rendition, image transmission and networks, omnifont text recognition, and man-machine interface design. This applied R&D is directed toward NLM's mission-critical tasks such as document delivery and preservation. In addition, research into imaging techniques that support medical educational packages employing digitized radiographic, dermatological, and other imagery is also being pursued.

System for Automated Interlibrary Loan (SAIL)

Following the successful outcome of an earlier imaging program for document preservation, a new program was initiated primarily motivated by the need for automated document delivery to support the NLM's interlibrary loan (ILL) service. Preservation remains a secondary objective in the program. This multiphase effort involves: 1. The creation of an electronic document image store on WORM-type optical disks; the images are of selected journals in the NLM collection for which there is significant demand. 2. The development of an interconnected complex of workstations that store, retrieve, and transmit the documents. 3. The linkup of this workstation complex to NLM's DOCLINE system to retrieve ILL requests. 4. Employing this prototype system to fill a portion of the ILL requests arriving at NLM. 5. Evaluating the system to determine performance, cost, and how it meets ILL objectives.

Following a review of SAIL by the Board of Scientific Counselors, a subset of the collection was selected for scanning and storage on optical disk. Capture of these documents began by using a Document Capture Workstation (DCW-1) already developed. Meanwhile, a baseline SAIL system for image tagging, indexing, quality control, image retrieval and transmission was developed. In April 1991, the system was placed in operation. To date, the SAIL prototype has received over 2500 requests, and has handled over 75 percent of them.

Recognizing the delays posed by the slow capture, a fast scanner was developed and placed in operation in March 1991. This system, Document Capture Workstation-2 (DCW-2), has tripled the rate of document capture. A number of engineering studies were done in support of SAIL development and the library's ILL activity.

Simulation: Studies were begun to predict a migration path for a scaled-up SAIL system. A discrete event simulation language, GPSS/H, is being used to model the image retrieval subsystem. This model consists of varying numbers of fax servers, optical disk drives, magnetic disk drives, and jukeboxes. Independent variables are the rate of ILL requests, the fraction of requests that are for fax service, and the distribution of requests over the optical platter set. The model will enable the testing of strategies on how the articles should be distributed over magnetic and optical media; for example, older articles could be on optical disks and more recent ones on magnetic disks. The results of the simulation will establish theoretical bounds on the number of system components and the overall system architecture for different levels of service.

Document Identification Strategies: An individual article in a journal issue may be identified either by its MEDLINE Unique Identifier (UI) or by a combination of the issue identifier (a number called the MRI) and the starting page number of the article. Though the SAIL input system accommodates both types of data, studies are under way to determine the need to do both. The working hypothesis is that the MRI-starting page number combination is adequate to identify the requested article and that the MEDLINE UI is superfluous. Eliminating the entry of the latter would have significant advantages in reducing the operator labor and also in eliminating data-intensive index files.

Factors Affecting WORM File Server Performance: Commercial software was selected to support archiving and retrieving document image files to and from WORM media over a LAN. Research was conducted to evaluate the performance of this software and ARCHIV, the inhouse-developed software for archiving and retrieving document image files. The study focused on the effect of several factors, such as network interface hardware, LAN organization, CPU clock speeds, remaining optical disk capacity, and the use of RAM by the WORM server for maintaining index files and for caching image files on performance. Performance issues included speed, storage overhead, compatibility, system flexibility, data security, and system reliability. The study concluded that the inhouse ARCHIV software would store and retrieve files from WORM disks at a rate about twice as fast as the commercial software, and, because of the way it stores file access data, would store about 5 percent more image files. However, these advantages are offset by the greater level of compatibility, flexibility, data security and ease of use afforded by the commercial software. The study also showed that throughput would be improved mainly by WORM server CPU speed and the use of RAM for index files and caching, whereas LAN organization and network interface hardware would have little effect. We are integrating the commercial software into our current system development efforts and are performing more complete tests of its performance. A paper describing this effort appears in the proceedings of an IEEE Mass Storage Conference.

Document Image Server Study

As a contribution to the technical literature of systems combining WORM drives and LANs for image file distribution, the laboratory's prototype system for document image distribution was used to simulate a system with several users. The objectives of the study were to predict the performance of a practical multi-user system and to evaluate the performance of an inhouse developed image transmission protocol. A database of document images, whose file size is representative of a cross section of NLM documents, was stored on WORM platters at the Image Server Workstation (ISW). An Image Retrieval Workstation (IRW), capable of expanding and displaying document images, retrieved images from the server over an Ethernet LAN using an inhouse developed protocol. Retrieval times and reliability were measured at the IRW and at the ISW while auxiliary workstations simulated larger scale conditions by providing varying loads to the Ethernet and to the ISW.

The document image server was found to approximate patterns similar to a standard and mathematically described model in queueing theory. Thus, this model can be used to extrapolate from the measured data to other cases. Also, if components of the image retrieval system are modified to improve performance, two basic measurements will suffice to predict server performance under most conditions. The study concluded that the current system would be able to support from five to eight workstations simultaneously with acceptable response times. It also determined that an image retrieval application could share an Ethernet LAN with other applications with little impact on the performance of either. Finally, it concluded that the speed of file retrieval from optical disks is significantly improved when the subsystem interface includes a large data buffer. Papers describing this work appear in the proceedings of IEEE conferences.

Facsimile Machines for Interlibrary Loans

In FY 1990 we investigated the impact of introducing fax in the library's ILL service to replace conventional mail as the method of document delivery. In FY 1991 this study was followed up with the acquisition of two advanced fax machines to aid the ILL service. Performance data were collected in the lab for both advanced fax machines and conventional machines, the former equipped with internal hard disks enabling store and forward capability. Mathematical models were developed to relate various decision measures, such as the number of ma-

chines required and costs to the fraction of the ILL load to be served via fax. The models yielded families of curves that served as decision tools leading to the acquisition of specific machines and the operational strategy to be followed. The final report is available from the National Technical Information Service.

Electronic Document Delivery System Program

An approach to document delivery different from that in the SAIL Program was undertaken. The motivation for this approach is the hypothesis that there exists a class of users who need direct access to an electronic archive of document images rather than the indirect route employing the interlibrary loan system. Three generations of a prototype system were built and tested, each succeeding generation possessing greater functionality than the previous one.

The EDDS program demonstrated in prototype form a system for direct document access and delivery, i.e., a system that allows a remote user equipped with a Document Request Workstation (DRW) to perform a search of MEDLINE via Grateful Med, and then directly access an electronic store of document images and receive the document images through fax, mail, or local pickup. The remote user's DRW consists of affordable, off-the-shelf components such as an IBM-AT compatible clone and a standard fax machine. It also requires special inhouse-developed software. At present, we have demonstrated the third-generation EDDS system and will plan to use it as a testbed to evaluate the role of such a system for local area document delivery. The results of work in this area appear in the Proceedings of the 53rd Annual Meeting of the American Society for Information Science.

Machine-Readable Archives in Biomedicine

The long-term goal is to build a prototype system for a machine-readable archive. Current activities in MRAB include evaluations of commercial OCR devices and investigation of techniques for image enhancement and image segmentation.

Image Enhancement: Rendering grayscale imagery with high fidelity is an important goal of this research. The current inhouse image capture systems employ ordered dithering to render grayscale images in a one bit/pixel matrix taking as input thresholded one bit/pixel data from the scanning engine. To investigate other options leading to better image quality, a project was undertaken to employ 8 bits/pixel data in a technique, the Floyd-Steinberg filter, that falls within the class of error-diffusion dithering techniques. A software implementation of this technique has been completed and applied to grayscale images from an old atlas of microscopic photographs (K. Birnbaum, printed in 1886 in Stuttgart, Germany). Early results indicate this technique has promise and a scanning engine with the capability of 8 bits/pixel output will be used to continue this research.

OCR Evaluation: An investigation was conducted in employing OCR to eliminate the keyboarding activity currently done to enter fields such as author, article title and abstract, into NLM's indexing database. Software was written to convert bitmapped images from a desktop scanner to machine-coded form, and to allow an operator to select regions representing the desired fields and to convert them to dBase files. Current work is in developing a database structure to incorporate selected portions of the scanned material with minimal operator intervention, and a prototype database management system.

Image Segmentation: Image segmentation, or the decomposition of a bitmapped image into its constituent parts, is of importance in a variety of EI functions, image compression and border (page edge effects) removal among them. A project was initiated to develop software to automatically remove unwanted borders. The techniques employed include: first order statistics, second order statistics and image morphology. The first method calculates the black pixel statistics and attempts to differentiate different regions on this basis. The second method uses an autocorrelation computation to get a measure of the inter-pixel relationships within each row and column of the image. The third method uses the morphologic dilation operator to create "blobs" of different sizes and shapes and differentiates regions on this basis.

Digital Xray Prototype Network (DXPNET)

This is a collaborative program in which the Communications Engineering Branch on behalf of NLM serves as Technical Manager. The other participants are the National Center for Health Statistics (NCHS) and the National Institute of Arthritis, Musculoskeletal and Skin Diseases (NIAMS). The general goal of the program is to support the National Health and Nutrition Examination Surveys (NHANES) which periodically produce statistics on the health status of the U.S. population. One element of the collected data consists of radiographs, 17,000 from a survey already completed and an expected additional 10,000 from a current survey. The Branch is participating in this program by integrating and testing a prototype low cost workstation that enables technicians from NCHS to perform quality control on the images produced by scanning the xrays. Hardware components were integrated and a complete image retrieval and display software system was developed. The workstation is currently being used for quality checking the images.

The next steps are to develop an archive of the digitized xrays implemented via an optical disk jukebox to be located at NLM, to develop a pair of more advanced "radiologist" workstations that will allow NCHS radiologists to create standardized readings, to develop the ca-

pability of linking the workstations over Internet, and to deploy one of the two workstations at NCHS to allow image retrieval from the archive located at NLM.

The software component of this project is both the most challenging and the most potentially useful. The key to success will be identifying and satisfying user needs. The software will make the image database accessible and will allow the retrieval of classes of images based upon user-supplied search terms. The NHANES database contains all of the information on each participant; the x-ray images are just one element of a unit record. The ideal system will have the entire NHANES database searchable online so that all possible search criteria are available. Local retrieval of images and other health statistics could be achieved through remote searching of the database.

Educational Technology Branch

Computer-based Curriculum Delivery Systems (CCDS)

The goal of CCDS is to produce and test experimental technology-deliverable curricula for the health professions. The first CCDS prototype curriculum for basic medical pathology was offered to U.S. medical schools in June 1983. Since that time the field-testing network has grown from 12 to 102 schools that have tested a variety of prototype curricula in mental health (teenage depression and suicide risk assessment) and in orthopedics.

The number of student work stations has grown to at least 800 (an accurate count is difficult to obtain since stations are added almost daily). There are now 78 health professions schools in the U.S. (including Puerto Rico), 5 in Canada, 3 in Europe, and 1 in Southeast Asia involved in the pathology project.

The basic medical pathology is the largest and most extensive of the CCDS projects. By the end of FY 1991 CCDS had furnished to the test sites over 1100 videodiscs and diskettes containing revised code (Version 3.6) for the pathology engine and associated files. The impact of the pathology project can, in part, be judged on the basis not only of its rapid adoption of its but on its evalution. Over 5,600 student evaluations of the programs have been received. On a scale of 1 to 5, the students rated the programs 4+ as a learning experience. Comparison of pre- and post-test scores of students not passing (a 70 percent score) the pre-test show that students master the material in about one-third the time devoted to it by the traditional curriculum. At least three schools have canceled all lectures on topics covered by CCDS lessons and others have reduced lecture time and made the CCDS lessons a required part of the course. During FY 1991 CCDS started field testing a new engine for the pathology programs which is programmed in CLIPPER with data (content and student performance information) stored in relational database (dBASE) files. This new engine was made necessary by the size and increased complexity of the content and performance tracking routines.

CCDS staff, working with a guest investigator, completed two new orthopedic prototype programs for use at the 1990 annual meeting of the American Academy of Orthopaedic Surgeons and revised them for the 1991 annual meeting. The new programs represent a "repurposing" of the 1984 Level I videodisc on anatomy of the knee. The new programs correlate magnetic resonance and anatomic images of normal and abnormal human knees.

The adolescent depression and suicide risk assessment videodisc program continues to be used in several schools both as required curriculum and as an enrichment tool. The program is now distributed by a commercial vendor and also the National Audiovisual Center.

Dermatology Visual Database Project

The Dermatology Visual Database Project emphasizes the integration of electronic imaging into currently available educational technology while continuing pursuit of standards for "diagnostic quality" imaging.

NTSC videodisc recording was further explored using a standardized test set of photographic images provided by the Sulzberger Institute of Dermatologic Education. These slides were captured by commercially available techniques. All tapes were edited together in LHNCBC facilities and premastered to videodisc. Dermatologists of the Institute's subcommittee on image archiving and standards ranked the image quality fairly consistently across a variety of images.

Evaluation of diagnostic performance as well as morphology recognition was included in FY 1991 physician studies; dermatologists' performance was not significantly impaired using either silver halide prints or super-VGA computer graphics (640x480 pixel/best 256 colors), but even aerial image transferred slides in NTSC video still failed to provide reliable recognition of papules from pustules. Sony Corporation recorded some of the test slides on HDTV videodisc, but lack of portability of this technology has precluded extensive evaluation to date.

The melanoma interactive video tutorial has been reauthored in LS/1 to evaluate student performance. The tutorial was evaluated at the Medical College of Virginia using a new instrument which emphasized students perception of their own educational outcomes; second-year students graded the tutorial as well-organized, challenging, and useful in developing clinical problem-solving skills. Trials of the LS/1 version of the tutorial with individual performance data have begun at University of Arkansas and University of South Alabama in collaboration with dermatology and family medicine faculty at those institutions.

Library Growth Project

The principal accomplishments for the year are: 1) the completion of a 15-year trend study, 1975-1989, based on data from 67 ARL-associated medical school libraries; 2) the near-completion of a collaborative project with the Commission on Preservation and Access staff on expenditures for preserving access to vulnerable materials; and 3) major progress toward explaining the serious problems that research libraries have experienced during the years since 1971. In addition, the databases developed and analyzed in the 1987 *Research Library Trends...* report, in the 1990 sequel, and in the 1991 study of medical school libraries have been maintained in a near-current state as each new year's data have become available.

A medical library study showed these libraries to be in relatively good health, with funding increases that average 9 percent, recent staff increases of 30 percent, and relatively rapid collection growth. In comparison with ARL libraries studied earlier, the medical libraries are expensive, personnel-intensive institutions, although they also allocate funds to staff and acquisitions essentially as ARL libraries do, both now and in the earlier years. A peripheral finding is that the medical libraries seem to have experienced a lower level of recent per-volume price inflation than either of the two known groups of ARL libraries. This was unexpected because of medical libraries' greater dependence on serials and the purported rapid inflation of serials prices.

The Learning Center For Interactive Technology

The Learning Center for Interactive Technology (TLC) is a "hands on" laboratory for medical educators, researchers, and scientists. Visitors to the TLC can explore the applications and various uses of interactive educational technology in the health sciences. The Center consists of two components: 1) a central location where various microcomputer and interactive video information and educational technologies are demonstrated, reviewed, and evaluated; and 2) an interactive training facility used for health professional faculty development workshops and training for NLM staff.

A total of 34 interactive health science programs are displayed at 22 demonstration carrels. Large group demonstrations are presented from a carrel configured for video/data projection and are also conducted in the training facility. Programs include applications representing patient management problems, tutorials, evaluation, visual databases, expert systems, and information retrieval.

In FY 1991, TLC staff provided more than 330 demonstrations and "hands on" experiences for 1,316 visitors. This brings the total number of visitors to 4,779 since the Center opened in March 1985.

In FY 1991, 60 health professionals attended 5 faculty workshops on videodisc repurposing conducted in the training facility. In addition, there were 52 training sessions for NLM staff members.

Among the year's highlights were the publication of a monograph on Authoring Systems, creation of a database of authoring system software (AuthorBase), and completion of The Interactive Technology Sampler videodisc. The sampler provides brief overviews of 20 interactive programs and serves both as a general introduction to interactive technology and The Learning Center itself.

The E.T.Net (Educational Technology Network), an online computer conferencing system begun in February 1989, has been described in previous reports. E.T.Net is open to professionals engaged in either the development or use of interactive technology in health science education. It is available at no cost, 24 hours a day, 7 days a week, 365 days a year.

Access via the Internet began in November 1990. As of September 1991, there were 578 health professionals registered as active users. Because SprintNet and the Internet have international connections, E.T.Net registrants include colleagues in Canada, Europe, South Africa, and Australia. Help and a User's Guide are available online. A new user-friendly menu system was installed in October 1990. Use of E.T.Net was demonstrated at several professional association meetings. In April 1991, NUCARE (NUrsing CAre REsearch) was added as a conference carried on E.T.Net. In addition to NUCARE, E.T.Net carries AVLINE, CAI, hardware, shareware, digital imaging, hypermedia, and "general" as conferences.

Visible Human Project

Images are an important part of biomedical knowledge. Pictures facilitate the understanding of biological structure and function, and are an essential component of education, research, and health care delivery. New computer-based technologies are providing an unprecedented opportunity to supplement the traditional two dimensional images of medicine, such as pictures in textbooks and plain radiographs, with dynamic three dimensional images. These images can be viewed, rotated, and reversibly dissected in a manner analogous to the physical objects they represent, providing valuable instruction to the student, insight to the researcher, and critical treatment planning information to the practitioner.

The NLM has long been a leader in archiving and distributing the print-based images of biology and medicine. NLM has also been a pioneer in the use of computer systems to encode and distribute the textual knowledge of the life sciences. The NLM's Long Range Planning effort of 1985-86 foresaw a coming era where NLM's bibliographic and factual database services would be complemented by libraries of digital images, distributed

over high-speed computer networks and by high capacity physical media.

Early in 1989, under the direction of the Board of Regents, a Long Range Planning Panel on Electronic Imaging was convened to explore the role of the NLM in this rapidly changing field. The panel found that the technologies underlying computer-based representation and display of complex three-dimensional biological structure are sufficiently mature that the NLM can proceed with building prototype digital image libraries. However, there remain fundamental research problems in the domain of computerized representation of biomedical structural data, and its linkage to related text and numeric data. The Panel made the following recommendation as an initial step:

The NLM should undertake a first project, building a digital image library of volumetric data representing a complete normal adult human male and female. This "Visible Human Project" would include digitized photographic images from cryosectioning, digital images derived from computerized tomography, and digital magnetic resonance images of cadavers.

With the recommendations of the advisory panels in mind, a four-phase plan, "The Visible Human Project," was initiated. Phase 1, a development phase, entails acquiring enhanced computed tomography images, magnetic resonance images, and cryosection images of representative, carefully selected and prepared male and female cadavers, at an average of 1 millimeter intervals.

The pixel library thus constructed will be made available by the Library in an electronic format (such as CD-ROM discs) and the derived image library as a photographic image set. Phase 2, an applied research phase to be carried on in parallel with Phase 1, will be necessary to determine the electronic format.

Phase 3 will entail the development of contour maps by anatomy experts, to define organs, tissues, and other structural entities in the CT, MRI and cryosection images. These contours will then be coded into the pixel library.

During the last phase, Phase 4, a series of evaluation studies will determine the most effective applications for this resource from the wide range of educational, diagnostic, treatment planning, and commercial uses envisioned for this pixel library.

The recommendation of the NLM Planning Panel on Electronic Imaging to complete Phase 1 and 2 of the project was adopted by the Board of Regents. Phase 1 was divided into two parts: Phase 1A includes the acquisition of the digital CT and MRI data and the cryosectional photographic data. Phase 1B includes the digitization of the cryosectional photographs obtained during Phase 1A.

A Request for Proposals (RFP) covering Phase 1A was circulated throughout the medical community. A competitive contract was awarded to the University of Colorado at Denver with a completion date of August 15, 1993. An RFP covering Phase 1B will be circulated in the future.

Under Phase 2, preliminary meetings were held with representatives of the National Electrical Manufacturers Association to explore the possibility of this standards organization establishing the canonical form under which the pixel library will be made available by the Library in an electronic format.

Audiovisual Program Development Branch

The 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 Branch operates a videodisc premastering facility employing state-of-the-art video and audio systems to produce high quality and creative materials for the LHNCBC's research and demonstration projects, as well as the NLM's educational and informational programs.

With identified technical issues such as image quality, resolution, color fidelity, and transportability, the Branch continued to upgrade and improve its electronic and audiovisual systems and capabilities. As part of the Center's efforts to improve the quality of electronic medical images, the Branch purchased a High Definition TV (HDTV) system—a newly available laser disc player and a special HDTV monitor. These have been configured in a test facility with a standard laser videodisc player and a monitor and a 35mm slide projection system so that direct comparisons of the several modes can be made and the image preservation capabilities of various electronic capturing, transferring, and display techniques can be evaluated.

In collaboration with the University of Arkansas for Medical Sciences, specially selected and photographed slides were recorded in laser videodisc format, after going through a number of differing film and electronic image transfer systems. Results are being evaluated by subject matter (dermatology) experts, and further collaborative experiments in medical image transfer and quality retention techniques are planned.

In collaboration with health sciences experts at the Universities of Missouri and Arizona, approximately 7,000 rheumatology images, in 35mm slide format, and motion video physical examination sequences, accompanied by special narration, were edited onto premaster videotape and then transferred to laser discs. This project is known as "Rheumatology Image Library—Phase II".

APDB continues to provide consultation, and technical advice to the History of Medicine Prints and Photographs Collection Videodisc project. Most of the fiscal

year was spent in crosschecking DRAW disc images against HMD cataloging, re-photographing and transferring to videotape missing images (from among more than 55,000 total images), and transferring certain images within the premaster videotape so that items will appear in proper sequence and on the correct side of the final laser videodiscs.

Much time and effort was expended in FY 1991 on a biological visualization project, in which 3-dimensional computerized representations of the embryonic development of the human heart are being created. With the guidance of Dr. Carl Jaffe, who is spending his sabbatical year from Yale University in APDB, the Branch's graphics staff is transferring images from the Carnegie Embryology Collection, as computerized planar sections and assembling them in 3-dimensional wire frame forms on Macintosh computers. Techniques of solid rendering, transformation, animation, and levels of transparency of the developing organ are being constructed in a common file format for display on microcomputer and, as motion sequences, on laser videodisc. Johns Hopkins and Yale Universities, as well as other health sciences organizations, are providing subject matter, design, and artistic cooperation.

In collaboration with the National Cancer Institute and the American College of Obstetricians and Gynecologists, the Branch used a large number of audiovisual, electronic, and computer technologies to create an interactive laser disc program on Cervical Cancer Screening. Stressing the importance of following recommended guidelines in early cancer screening, laboratory work, reporting and follow-up, these program materials will be shown at a meeting of the Academy of Family Physicians.

APDB also continued to support the Library's educational and informational activities:

- More than 20 interviews were videotaped featuring health sciences practitioners, educators, and administrators who participated in the Regional Medical Programs initiative, 1966-1974. This previously poorly documented program was the subject of a day-long conference held in the Lister Hill Center Auditorium in December 1991. Presentations will make use of four documentary videotapes prepared by APDB.
- To illustrate the activities of several federal agencies in carrying out the White House High Performance Computing and Communications Program (HPCC), the Branch produced a 10-minute videotape program which featured selected examples of HPCC Case Studies.
- Samples of more than 20 NLM/LHC programs were edited on premaster videotape for the production of Level II interactive videodiscs, called "NLM Videodisc Sampler III." These have been mounted in information kiosks at the NIH and in the NLM Visitor's Center.
- A short videotape program was produced highlighting historical medical films acquired by the Library's History of Medicine Division during the 1980's. The resulting tape was converted to videodisc format for use with an HMD exhibit.
- APDB cooperated with a Library Associate Project by producing a 14-minute videotape to help NLM Reading Room patrons use Grateful Med in retrieving references from the in-house database, REFLINE.
- To assist the Library's National Center for Biotechnology Information (NCBI), the Branch produced a videotape program explaining three software packages being used by the NCBI: "Medline Browser," "Vibrant Portable Interface," and "Network Services." The tape is used to educate collaborating educational institutions on this important phase of genetic research.

The Branch continues to provide audiovisual support to meetings in the Lister Hill Center Auditorium and the NLM Board of Regents Room. A number of modifications were undertaken this year to improve the projection quality and the efficiency of operator interfaces in both locations. A number of lectures and presentations were videotaped (see "Calendar of Events").

APDB's Graphic and Still Photography Laboratories continue to provide visual information materials for the Library and to support the Lister Hill Center's audiovisual research and demonstration projects. A number of computer graphics hardware and software improvements were added to the Branch's capabilities during FY 1991, including those to permit the transfer of video images to Macintosh computer systems and Macintosh-generated graphics to video formats.

NATIONAL CENTER FOR BIOTECHNOLOGY INFORMATION

David Lipman, MD
Director

The National Center for Biotechnology Information (NCBI) was established by Public Law 100-607 in November 1988 as a division of the Library. The establishment of the NCBI reflects the importance of information science and computer technology in the understanding of the molecular processes that control health and disease. The Center has been given the responsibility to:

- Create automated systems for storing and analyzing knowledge about molecular biology, biochemistry, and genetics;
- Perform research into advanced methods of computer-based information processing for analyzing the structure and function of biologically important molecules and compounds;
- Facilitate the use of databases and software by biotechnology researchers and medical care personnel; and
- Coordinate efforts to gather biotechnology information worldwide.

There are presently 34 senior scientists, postdoctoral fellows, and support staff working at the NCBI. These scientists have backgrounds in medicine, molecular biology, biochemistry, genetics, biophysics, structural biology, computer science, and mathematics.

NCBI programs are divided into three areas: (1) building of new databases and enhancing existing ones which involve genomic information; this includes NLM-developed databases and extramural support for other research information resources; (2) basic research in computational molecular biology; and (3) dissemination and support of molecular biology databases and services. Within each of these areas, NCBI closely coordinates its activities with other NLM divisions and integrates information from key NLM databases such as MEDLINE into specialized data resources.

Database Building and Enhancement

Beginning in September 1992, the NCBI will assume the responsibility of GenBank, the NIH DNA sequence database, and will be providing users with not only DNA sequence information but protein sequences and journal abstracts as well. NCBI, working with Library Operations, is now building the literature component of the database. These records will be supplemented with author-supplied direct sequence submissions which are processed and reviewed by Los Alamos National Laboratory, and the complete set of records will be distributed as the GenBank Sequence database in September 1992.

Comprehensive coverage of all sequence data, protein as well as DNA, will be provided along with the corresponding MEDLINE bibliographic information, including abstracts. At the NLM, more than 3200 journals are scanned for sequence data and the NLM has expanded its journal coverage to include all journals which regularly contain sequence data even if they are in nonmedical domains, e.g., plant science. An integral component of the database is the inclusion of abstracts and indexing terms from the MEDLINE records of sequence-containing articles. The concept of an "index" sequence has been introduced to capture sequences or portions of sequences that do not qualify for full database records (e.g., probes, consensus or previously published sequences) but which would be useful as "indexes" back to the journal articles in which they appeared.

NCBI is using a relational database system for developing a sophisticated data entry system for building the database from the scientific literature. Specialized sequence indexers, members of the Library Operations staff with advanced training in biological disciplines, are responsible for identifying and annotating sequence data from the MEDLINE literature. The work flow involves:

- Indexers identify articles containing sequence data as part of normal MEDLINE processing;
- Corresponding MEDLINE records are loaded into NCBI's relational database;
- Journal issues with sequences are scanned by sequence indexers and selected sequences are entered into database with the addition of biological annotation; keyboarding of sequences is performed by contractor;
- Accuracy of biological information is reviewed by NCBI biologists.

The GenBank data will be a key component in an integrated sequence database system known as GenInfo which will be a comprehensive source of DNA and protein sequence information. By using a well-defined data structure, the ASN.1 syntax described below, specialized

databases such as databases of sequence alignments or of specific organisms can readily be linked together in the GenInfo system to provide users with seamless searching across a wide range of molecular data.

Cooperative arrangements are being used to augment the in-house data capture operation. An interagency agreement with the National Agricultural Library as part of the Plant Genome Project will furnish coverage of the plant sequence literature. Similarly, an agreement with the U.S. Patent and Trademark Office has been established to capture sequence information from issued patents.

NCBI staff also are active in creating small-scale, special-purpose databases. These databases have included metabolic pathways, transcription factors, and integration of E. coli genetic map and sequence data. Collaborative work with the Drosophila research community has resulted in a prototype database that will be developed and maintained by an international consortium of laboratories. The NLM, in conjunction with other NIH institutes and NSF, also provides funding for databanks that are major resources for biological research, including GenBank, the Protein Identification Resource, and the Protein DataBank at Brookhaven National Laboratory. The NLM, through an interagency agreement, is working with NSF on a database initiative to help support the design and the development of biological databases and to foster interdisciplinary projects in biology and computer science.

Software Toolkit

Equally important as capturing molecular sequence data is the ability to access and retrieve the information using automated systems. The software toolkit concept addresses this need by focusing on the creation of software modules that will provide a set of high-level functions to assist developers in building application software. Among these tools are a Portable Core Library of functions in the C language that facilitates writing software for different hardware platforms and operating systems, an AsnTool Utility, and an ASN.1 function library. The ASN.1 (Abstract Syntax Notation) tools use an International Standards Organization data description language that provides a mechanism for defining and structuring data as well as a set of program definitions that can interact with databases structured in ASN.1.

NCBI's adoption of ASN.1 for database output has several advantages for users as well as developers. The data definitions in ASN.1 for biological objects enable the representation and structuring of complex biological data in data files without the need for a specific database management system. Manipulation of the complex objects is performed through the ASN.1 software tools which are being freely distributed to the biology community. Thus, complex analysis programs can be readily constructed from existing sets of modular tools, saving considerable time and effort for developing new, portable applications.

A major reason for adopting a standardized representation is to facilitate the exchange of data; currently ASN.1 versions have been developed for the major sequence databases (GenBank, PIR, and Swiss-Prot), the protein structure database at Brookhaven, the Protein Data Bank, and the OMIM database of Dr. Victor McKusick. ASN.1 is being used as a distribution format for the GenInfo databases to provide a hardware- and software-independent version of the data in the relational database.

User Retrieval Tools

A major application based upon the toolkit approach is a retrieval tool called *Entrez* which searches nucleotide and protein sequence databases and MEDLINE citations in which the sequences were published. With *Entrez* and a database on a CD-ROM or a local network, a user can rapidly search several hundred megabytes of sequence and literature data using techniques that are fast and intuitive. A key feature of the system is the concept of "neighboring" which permits a user to locate related references or sequences by asking for all papers or sequences that resemble a given paper or sequence. Neighbors are precomputed using statistical algorithms developed at the NCBI. The ability to traverse the literature and molecular sequences via neighbors and links provides a very powerful yet intuitive way of accessing the data. Moreover, the underlying software lends itself to a server-client model, whereby the user interface portion of the application can be on a local machine which then uses a network connection to query a retrieval engine.

NCBI is also using this highly modular approach in building systems for online retrieval. The BLAST sequence searching server has been implemented as a network-based retrieval system. Over 20 genome research groups around the country have been provided with versions of this software which enables them to transmit a query sequence from their local computer over the Internet network to a BLAST server running on a computer at the NCBI. In a few seconds, the BLAST server executes the user's query and returns the results to the client program for viewing by the user. The BLAST network server has been recognized by the research groups as an essential laboratory tool not only to analyze data but to aid in setting directions for wet bench research.

Basic Research

Basic research lies at the core of NCBI's mission. Its group of multidisciplinary scientists work on fundamental biomedical problems at the molecular level using

mathematical and computational methods. The basic research and database/software development have been found to be mutually reinforcing: the drive to make and substantiate new discoveries in biomedical science gives a rich stimulus, urgency, and direction to the development of new methods.

In the last year, NCBI scientists Mark Boguski, Stephen Altschul and Jean-Michel Claverie have collaborated on sequence analysis with major laboratories investigating disease genes. Boguski's work last year in the computer identification of the neurofibromatosis-1 (NF1) gene as a homolog of a yeast gene and implications for human tumor formation was followed up by experimental work at Cold Spring Harbor Laboratory which correlated the NF1 locus to mammalian GTPase activating proteins. Boguski and Altschul also participated in the analysis of the newly discovered genes for familial colon cancer. Structural analogies to proteins with coiled-coil regions give evidence of how the gene products could interact with other proteins. Claverie performed work on the analysis of a gene implicated in Kallmann syndrome, a genetic disease mapped to the X chromosome and characterized by anosmia, hypogonadism, and absence of puberty. The gene appears to be involved in regulating early neural development. NCBI databases and software tools played key roles in the discovery and analysis process.

Other basic research carried out at NCBI includes the development of models for molecular evolution, Bayesian classification of protein structure, detection of low entropy regions of protein sequences, methods for assessing the statistical significance of molecular sequence features, and enhanced methods for vector-based text retrieval. Continuing research on the BLAST similarity search algorithms has been incorporated into a suite of rapid sequence query programs for comparing new nucleotide or protein sequences against databases. The speed of the algorithm and implementation have been crucial to their success as a tool for database exploration and for discovery of new functional associations among genes.

Communication

As part of its mandate to support the development of new information technologies of relevance to biology and genetics, the NCBI has exercised a leadership role in sponsoring forums for the exchange of information among leading scientists from the fields the computer science and biology. NCBI has also extended its outreach to the library science community by invited presentations and workshops on biotechnology information topics. Staff from NCBI presented a series of 15 lectures on the theory and practice of sequence analysis for NIH intramural scientists in the fall. Over 350 NIH scientists are also supported through online access to 20 databases under the IRX system.

Workshops are being organized for software developers to have an opportunity to work with the NCBI software tools and the ASN.1 specifications for database objects. The first of the workshops will be held in the fall of 1991 and will facilitate the creation of software by academic and commercial groups which can directly make use of NCBI databases distributed on CD-ROMs. An interagency agreement has been set up with the National Technical Information Service to produce and distribute the CD-ROM versions of NCBI databases. Several hundred evaluation copies of CD-ROMs have been released that include the Entrez retrieval software and sequence databases; full-scale distribution will begin in the spring on a bimonthly basis.

The Visitors Program was established this year and has been successful in bringing members of the scientific community to the NCBI to engage in collaborative research in the bioinformatics area as well as joint activities in database design and implementation. Selection of candidates is coordinated through the NLM's Extramural Program and involves a peer review of candidates' experience and proposed program.

In addition to meetings, information dissemination is being provided by the GenInfo Data Repository, a network-based service for distributing software and databases produced by the NCBI as well as by outside groups. NCBI coordinated the production of the fifth edition of a classic compendium of immunological sequences edited by Dr. Elvin Kabat, *Sequences of Proteins of Immunological Interest*, and is continuing to work with Dr. Kabat in collecting the primary sequence data from NCBI and NLM databases. The NCBI also participates in an advisory role with other government agencies such as the Patent and Trademark Office and the Department of Agriculture on programs involving biotechnology information. Special workshops on sequence analysis have been organized for the patent examiners at the U.S. Patent and Trademark Office who evaluate sequence data. Within the NIH, the NCBI coordinates with the National Institute for General Medical Sciences and the National Center for Human Genome Research on databases and informatics programs which impact information exchange on a national level.

Extramural Programs

NLM's extramural division has a program of grants for computer analysis of molecular biology data. Its scope is quite broad and includes research into methods and algorithms for improving the efficiency of information retrieval and improving the efficiency of analytical operations which are computationally intensive. Re-

search applications to develop expert systems for annotating and linking databases are encouraged, as are proposals for work on algorithms for structure and function prediction. Software development for newer machine architectures is within the scope of the program as well, including molecular analysis by neural net techniques, and multiprocessor programming. Postdoctoral training in the cross-disciplinary areas of biology, medicine, and computer science is also supported through the NLM's informatics fellowship program.

Biotechnology Information in the Future

The design of molecular biology 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.

The NCBI will continue to develop software tools to facilitate gaining access to the growing volume of sequence and gene data and will encourage the widespread distribution of software and databases as essential components in the research process.

In the area of information resources, the NCBI will use contract and cooperative agreements to support molecular biology data banks located around the country and to encourage the development of specialized databases.

With the rapid advances of molecular biology research, NCBI will be engaged in developing and employing new methods for disseminating this new knowledge to the biomedical community.

EXTRAMURAL PROGRAMS

Milton Corn, M.D.
Acting Associate Director

The Extramural Programs Division provides support to the health science community in the biomedical areas for which the National Library of Medicine takes particular responsibility. NLM support for extramural programs stems from two sources: from the Medical Library Assistance Act of 1965 and its extensions, and from Section 301 of the Public Health Service Act as amended.

The dual basis of the funding sources as well as the historic mission of the Library explain the eclectic variety of the funded projects for which the Division takes responsibility, and for which an overview may be helpful in explaining Division activities.

The Research Grants Section of this report summarizes some recent activities in the area of basic and applied information science. The application of computers to biomedical information storage and retrieval has revolutionized the operations of biomedical libraries and has engendered the useful term, medical informatics, to describe the theory and practice of providing information and decision support accurately and usefully to health workers. Such research is vital now when the volume of biomedical information is growing at a rate that threatens our ability to keep track of what we know, and to use what we do know most efficiently.

Training efforts also merit specific description. Training of competent professionals in medical informatics must remain an important goal of the Division. This new field needs scientists who can exploit the enormous potential for improvement in health delivery which medical informatics is capable of providing. Merging information science with the peculiar complexities of modern health care and research poses complex problems whose solution will depend on well-trained specialists. NLM supports both institutional training programs and a fellowship program.

The NLM's Integrated Academic Information Management Systems (IAIMS) program addresses the insufficiently appreciated but vital issue of integrating usefully the myriad information systems which have sprung up at most of our medical centers. These systems are useful, to be sure, but all too often are unrelated, isolated, and very far from taking advantage of the synergism that can be realized by linking the various academic information systems present in our health centers, including the library, research material, academic administration information, medical education, and hospital information systems (particularly patient records.)

Medical Library Resource Grants have been an essential element of the Division's activities for years. It is clearly an NLM mission to make biomedical information easily available to health professionals. This emphasis was heightened when the NLM adopted outreach as a major new initiative. As recommended by the Board of Regents' Outreach Planning Panel, the outreach program involves a number of extramural responsibilities, including professional training, IAIMS, and improving access to national biomedical information by hospital libraries and physicians.

Improvement of access by physicians to medical information was specifically addressed by an amendment of the Resource Grant Program designed to expand the ability of hospital libraries, particularly in rural or underserved areas, to establish facile contact with the national biomedical library system.

Grants in support of publications have little to do with medical informatics but are a time-honored, important commitment by the Division to the scholarly activities which lie at the heart of libraries everywhere.

The support provided for the bioethics center is self-explanatory, as is the section on the Division's committee activities.

Support for the National Network of Libraries of Medicine, as authorized by the Medical Library Assistance Act, is described in the chapter on Library Operations. The Special Foreign Currency Program, administered by the Extramural Programs' International Programs Branch, is described elsewhere in the annual report under International Programs.

Budget information is summarized in table 10.

Research Grants

The Library continues to support innovative research in library information sciences, medical informatics, and biotechnology informatics. Library science represents the more traditional discipline dealing with issues of medical literature and bibliography. Medical informatics, an interdisciplinary field combines the medical sciences with information and computer sciences, computational linguistics, decision analysis, and related disciplines in addressing health knowledge issues. Biotechnology information deals with the vast amounts of data which are accumulating about the molecular control of life processes, and with techniques to be utilized in analyzing and comparing such data.

Librarianship and Information Science

In this program area, NLM supports a variety of activities and projects that have to do with the organization and utilization of the literature, i.e., medical bibliography. Projects of interest range from analyses of formalized retrieval mechanisms, through innovative arrangements of medical subject matter (so long as there is some analogy or compatibility with published work), to studies of medical information in its social context.

At Massachusetts General Hospital, a project is under way to develop and evaluate hypertext-based decision-support systems for pulmonary catheter management, skin breakdown, and ventilator management. The evaluation of the resulting systems will try to learn whether, or in what ways the health care team has benefited from computerized decision-support.

At Harvard University School of Public Health, a small grant assists development of a monograph on meta-analysis with supplemental computer software. Meta-analysis is a statistical methodology dealing with collection and analysis of data from independent but related studies. It is useful for the planning and analysis of clinical trials. The project goal is to help clinicians who lack advanced statistical skills understand and use this methodology. The accompanying computer disk will supplement the text with interactive problems, examples, and guides.

An ongoing project at the University of West Virginia is exploring the potential role of community and hospital pharmacists as information providers for drug therapy. A number of pharmacists are provided with desktop computer facilities for accessing bibliographic databases. How and in what ways their new capabilities are drawn upon by the professional community is being assessed. It is hoped that this form of information support will be especially helpful in isolated rural communities.

Medical Informatics

Although much of the informatics research NLM supports is basic, there are some opportunities for scientifically rigorous studies in applied informatics. NLM's medical informatics activity is quite small and free from the constraint of categorical disease applications. This allows investigators to consider complex problems of knowledge representation and retrieval. In this small but growing field, NLM's grant-supported investigators have achieved significant recognition. Twenty-eight medical informatics awards were made in FY 1991. Nineteen of these were to continue the support of projects begun in earlier years. In addition, nine new or competing awards were made, following the usual selective peer group review.

An example of research in this area is an award to the University of Washington, Seattle, on behalf of Dr. Cornelius Rosse, Professor and Chairman, Department of Biological Structure. This project concerns research issues in representing spatial and symbolic knowledge of human anatomy in advanced computer systems. The research is relevant to teaching, research, and clinical practice. Knowledge representation, graphic images as knowledge bases, and computer applications for medical education are the main areas of interest.

Another example, also from the University of Washington, involves Dr. Ira Kalet, Assistant Professor, Department of Radiation Oncology, as Principal Investigator. This project continues work on an artificial intelligence-based expert system for planning the radiation therapy of head and neck tumors. The goal is to produce a more effective program for interactive treatment modeling and to contribute to the general field of expert systems by developing a generic theory for design.

A final example is a FIRST (First Independent Research Support and Transition) Award to Georgia Institute of Technology and Dr. Norberto Ezquerra, Associate Professor, College of Computing. Dr. Ezquerra plans to develop a clinically useful, computer-based methodology to assist in decision-making tasks in cardiac imaging.

Biotechnology Informatics

The appearance of new experimental methods in the past several years has greatly increased the rate at which data are accumulating about the molecular control of life processes. Restriction enzymes, synthetic molecular probes, efficient microchemical methods for DNA and protein sequence determination, and recombinant DNA technology have developed to the point that it is now feasible to consider large-scale projects, such as the systematic analysis of entire eukaryote genomes. Because of their size and complexity, the data that are generated by such undertakings must be analyzed and compared using computerized techniques for storage, searching, and analysis. The computer databases that hold this information, currently numbered in millions of nucleotide base pairs and thousands of amino acids, are expected to grow by three orders of magnitude to encompass sequences totaling billions of nucleotides. Current methods for structuring, searching, and analyzing such databases need to be enhanced correspondingly.

An example of NLM support for this area is a research project from the University of Pittsburgh and Dr. Bruce Buchanan, Professor of Computer Science, Philosophy, and Medicine. He and his colleagues are providing other investigators with a program that provides a uniform retrieval interface to multiple databases scattered throughout the world. The program user need not remember where the database resides or its unique pro-

tocols. The Pittsburgh groups are also developing communications software to assist in the database utilization problem.

Another example of biotechnology informatics comes from Pennsylvania State University and Dr. Webb Miller, Professor of Computer Science. His project has produced 12 published papers in the past year concerned with such topics as searching and analyzing restriction maps, space efficient methods for comparison of two long sequences, and graphical user interfaces for utilizing sequence comparison algorithms.

Yet another example of a biotechnology informatics research project comes from the Cold Spring Harbor Laboratory and Dr. Richard Roberts, who is developing a database of protein sequence motifs which are predictive of protein function. The short motifs of interest represent the basic building blocks from which proteins have evolved.

Training

The NLM supports predoctoral and postdoctoral research training in medical informatics. Such training will help meet a growing need for qualified, talented investigators, well prepared to address information problems in health care, health professions education, and biomedical research. These investigators will contribute to the growth of information science by their studies of knowledge management, and by advancing the frontiers of the computer sciences for acquiring, organizing, retrieving, and utilizing health knowledge. The expectation is that trainees will become able, multidisciplinary informatics specialists.

Medical informatics goes beyond the use of the computer as a computational tool and extends into the process of knowledge representation, acquisition, storage, retrieval, and manipulation largely to support reasoning and decision-making.

To prepare trainees for research careers in a demanding research environment, the sponsorship of a research-oriented academic health sciences institution is critical. The core of training emphasizes the synthesis, organization, retrieval, and effective management of knowledge. The curricula are interdisciplinary, involving medicine and the biological sciences, the cognitive sciences, information science, and computer science. The training sites offer an excellent setting for instruction, and opportunities for meaningful trainee involvement in health-related computer science research.

In addition to its general goal of assisting in the education of persons who can take academic positions to conduct research and teach medical informatics, NLM also envisions several more specialized enhancements to the training programs, including such areas as high performance computing and communication, biotechnology, cancer, and information systems. Dental informatics is another area for which additional training slots may become available in the future.

Seven institutional training grants supported 51 postdoctoral and 21 predoctoral trainees in 1991. In addition to the institutional training grants, NLM supported 7 individual fellows. The current fellows are receiving their research training at the University of Utah, Columbia University-Presbyterian Hospital, University of Washington, Yale University, Cold Spring Harbor Laboratories, University of Pittsburgh, and Ohio State University.

Institutional training grantees:

1. Harvard Medical School
   Brigham and Women's Hospital
   Massachusetts General Hospital
   Robert A. Greenes, M.D., Ph.D., Director

Major research emphases are computer-based decision support systems, modeling of physician decision making, representation and structure of medical knowledge, application of information technology to medical education, database and data analysis systems, computer graphics, and the development and evaluation of digital imaging systems.

2. University of Minnesota
   Lael Gatewood, Ph.D., Director

The focus of this interdisciplinary program is to provide training in cognitive, information, and computer sciences. Current research includes physician decision making, diagnostic classification, nurse decision making, electronic communications for health professionals, physician training, and health information systems.

3. New England Medical Center
   Dartmouth College of Medicine
   Stephen G. Pauker, M.D., Director

This research training program emphasizes clinical decision making, artificial intelligence approaches to the structure and use of medical knowledge, and clinical cognition. The program focuses on research experience rather than on preparing for an additional graduate degree, although that option is available.

4. University of Pittsburgh
   Randolph A. Miller, M.D., Director

Operating under the Intelligent Systems Program at the University of Pittsburgh, this program uses the faculty and services of the School of Medicine, the Graduate School of Business, the Department of Computer Science, and the Interdisciplinary Department of Information Science.

5. Stanford University
   Edward H. Shortliffe, M.D., Ph.D., Director

This formal program in medical informatics offers Masters and Ph.D. degrees. The specialized curriculum focuses on developing a new generation of researchers interested in developing practical, computer-based solutions to problems in the optimal management of biomedical knowledge.

6. Washington University (St. Louis)
   Charles E. Molnar, Sc.D., Director

The development of skills in basic techniques of informatics, and experience in applying these techniques in a biomedical setting are inseparable goals of this program. Research opportunities for trainees are available from a wide range of options represented by the research of the core faculty and of a much larger group of participating faculty.

7. Yale University
   Perry L. Miller, M.D., Ph.D., Director

This training program will prepare individuals for careers in medical informatics research. The program will include both postdoctoral and predoctoral training. In addition to multidisciplinary research opportunities, the program will also offer didactic experiences.

Resource Grants

FY 1991 continued the implementation of the Resource Grant Program (as redefined in 1989) with the award of 14 Information Access Grants and 2 Information Systems Grants—all designed to improve access to information resources utilizing computer and communications technologies.

For example, an Information Systems Grant to the Alaska Health Sciences Library will assist in establishing a statewide computer network linking the outlying hospitals to the state's largest medical library in Anchorage. Similarly, the Information Systems Grant to the University of New Mexico Medical Center Library is helping to form the foundation of a statewide electronic network accessible to all health professionals engaged in research, education, and patient care.

The Information Access Grants encompass four types of project: 1) Grateful Med, 2) automated technical services, 3) document delivery, and 4) specialized automated reference services. Grateful Med grants were awarded to the Fayetteville, North Carolina, Area Health Education Center, the University of Nevada for a statewide network, Kootenai Medical Center for two additional members of the North Idaho Health Information Network which had received an NLM Information Access Grant in FY 1990, DuBois Regional Medical Center (DuBois, Pa.), J.C. Blair Memorial Hospital (Huntington, Pa.), and Navapache Hospital (Show Low, Arizona). Information Access Grants to automate library technical service functions were awarded to the Massachusetts Eye and Ear Infirmary in Boston, the Sacred Heart Hospital in Norristown, Pa., Richmond Memorial Hospital (Virginia), Mercer University (Macon, Georgia) for the Georgia Information Network, and Suburban Hospital (Bethesda, Md.). Access Grants to enhance document delivery and establish communications links were given to the Northeast Indiana Health Sciences Libraries Consortium in Fort Wayne, and to Marquette General Hospital (Marquette, Michigan). An Access Grant was awarded to Clara Maass Medical Center (Belleville, NJ) to establish a business information center for the 50-member administrative staff of this 475-bed hospital.

In FY 1991, NLM, for the first time, gave resource grantees an opportunity to apply for supplemental funding to provide minority undergraduate and graduate students a practical experience in health sciences librarianship to encourage them to pursue this profession. Two Information Access Grantees received such administrative minority supplements: Columbia Hospital Medical Library in Milwaukee and Kootenai Medical Center in Coeur d'Alene, Idaho.

IAIMS

Integrated Academic Information Management Systems (IAIMS) are institution-wide computer networks that link and relate library systems with a variety of individual and institutional databases and information files for patient care, research, education, and administration. Resource grants have been made to assist medical centers and health science institutions in planning and development projects that will lead to the implementation of IAIMS. The 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.

NLM has provided grant support for (1) institution-wide IAIMS planning and policy analysis, (2) model development and testing, and (3) implementation of full-scale IAIMS projects.

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

Publication Grants

The Publication Grant Program provides selective short-term financial support for not-for-profit, biomedical scientific publications. Studies prepared and/or published under this NLM program include critical reviews or monographs on special areas of medical research and practice; secondary literature tools (such as atlases and catalogs); research monographs in the history of medicine; publications on medical informatics, health information science and biotechnology; pilot or temporary support for secondary periodicals; and the proceedings of scientifically significant symposia related to U.S. health needs. Because funds for publication support have dwindled, available resources in recent years have been used principally for history of medicine projects.

The Publication Grant Program is supplemented by NLM's Special Foreign Currency Program, authorized under Public Law 480. (The Special Foreign Currency Program is described in the chapter on International Programs.) Both publication support programs aid in the dissemination of biomedical information important to an understanding of progress in medicine and the health sciences.

During FY 1991 NLM awarded 13 Publication Grants totaling $365,000. Of these, 7 were new awards. This small grant program has a current self-imposed annual ceiling on direct costs per grant of $25,000. The average grant awarded in FY 1990, including both direct and indirect costs, was under $23,000.

Among the books published in FY 1990 funded through the Publication Grant Program was Dr. Kenneth Zysk's *Asceticism and Healing in Ancient India; Medicine in the Buddhist Monastery* (New York, Oxford University Press, 1991). This book was one result of the grant-supported task of translating from the Sanskrit and preparing a critical edition of Vagbhara the Elder's *Astanga Samgraha*, "The Summary of the Octopartite (Science)." This medical history has not been available in a Western language, and it represents the earliest compilation of ancient Indian medical and surgical knowledge. This work led Dr. Zysk back to earlier contributions to medicine by ascetic Buddhists which resulted in the published monograph.

Another notable work published in FY 1991 with support from NLM was *Dangerous Passage: The Social Control of Sexuality in Women's Adolescence* by Dr. Constance Nathanson (Philadelphia, Temple University Press, 1991). Professor Nathanson's book examines the normative, structural, and political context in which pregnancy-related services for adolescents were developed, implemented, and put to use. The volume analyzes the social history of policy decisions toward adolescent childbearing, utilizing both historical and contemporary data. It provides an important contribution to the study of adolescent pregnancy and to the understanding of public health policy development. (A list of supported publications received in FY 1991 is in Appendix 3.)

Bioethics

With a specialized center grant, NLM continued its support for a National Reference Center for Bioethics at Georgetown University. The Center, which has been supported by NLM for many years, has grown as a major resource for bioethics information of every kind. Its collection, while selective, is also comprehensive in its range, because bioethical issues are frequently addressed in literatures other than medical ones. This collection is indexed, in part by a separate contract, and is made available to the world through BIOETHICSLINE®, one of NLM's online databases.

The Reference Center is available to visitors in a restored part of the original late nineteenth century University library. A toll-free telephone line offers distant inquirers convenient access; article photocopies are mailed for a small fee. Bibliographic overviews on ethical topics of broad concern, called Scope Notes, appear in pamphlet form as well as in a scholarly journal. Other Center activities include a clearinghouse for bioethics course syllabi and an archive for major unpublished documents. This resource and the related contract for the BIOETHICSLINE indexing constitute the major Federally supported activities that directly assist the national biomedical community in addressing the often thorny questions of ethics, law, and morality posed by current health care modalities.

Highlights of Committee Activities

NLM's scientific merit grant peer review group—the Biomedical Library Review Committee (BLRC)—met three times in FY 1991 and reviewed 130 applications, approving 97. The Committee operates as a "flexible" review group; i.e., it is composed of three standing subcommittees, consisting of seven members each: Medical Library Resource Subcommittee, Medical Informatics Subcommittee, and Biotechnology Information Subcommittee.

A final peer review of applications is performed by the Board of Regents, which meets three times a year. One of the Board's subcommittees, the Extramural Programs Subcommittee, meets the day before the full Board meeting for the review of "special" grant applications. Examples of "specials" include applications for which the recommended amount of financial support is

larger than some predetermined amount, when at least two members of the scientific merit review group dissented from the majority, when a policy issue is identified, and when an application is from a foreign institution. The Extramural Programs Subcommittee makes recommendations to the full board which votes on the applications.

Plans for FY 1992

Detailed grant-funding plans depend on the actual amounts made available by Congress. In general, all of the existing grant programs will be continued although some possible modifications are under discussion:

High Performance Computing and Communication (HPCC) funds, if allocated to EP, will be distributed among research, training, and IAIMS programs to help develop the various elements needed for useful application of HPCC to biomedical needs.

The very popular IAIMS program, now 10 years old, is being reevaluated, and may be modified so as to provide additional guidelines for the applicants, and to reduce the total duration and amount of support.

The current institutional informatics training grants expire in June 1992. The peer review system will be used to identify 6-10 universities to which new 5-year training grants will be awarded.

An NLM fellowship in applied informatics to complement the research training fellowship is under consideration as a means of training physicians, nurses, librarians, and others to use the new technology in biomedical organizations, research, and patient care.

The library resource awards may be redefined to reflect more faithfully the NLM long-range plan directive that emphasis should be given to facilitating access by health libraries to national databases.

The library information science awards program may be expanded to include research in questions about information-seeking behavior, a poorly understood field of enormous importance to informatics and to the NLM.

Table 10
Extramural Grant and Contract Program
(dollars in thousands)

Category	*FY 1989*		*FY 1990*		*FY 1991*	
	No.	*$*	*No.*	*$*	*No.*	*$*
Research	45	$7,666	47	$11,343	49	$11,231
Resource projects	14	3,487	15	4,492	17	4,721
Resource access/improvement	9	129	15	519	17	684
Training	7	2,537	7	2,886	7	2,714
Fellowships	3	99	5	189	9	306
Regional Medical Libraries	7	2,569	7	3,772	8	5,500
Publications*	13	346	17	390	13	365
(IAIMS projects**)	(9)	(2,962)	(8)	(3,821)	(9)	(3,693)
(Med. info. research)	(26)	(4,008)	(24)	(6,030)	(26)	(6,066)
(Biotech. research)	(14)	(2,747)	(17)	(4,179)	(16)	(4,192)
Totals:	98	$16,833	113	$23,591	120	$25,521

* Includes one Special Scientific Project
**Includes both IAIMS resource and research projects

OFFICE OF COMPUTER AND COMMUNICATIONS SYSTEMS

Aaron B. Navarro, Ph.D.
Acting Director

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

OCCS: (1) implements computer and communications systems using state-of-the-art technology and 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 billions of bytes (characters); (4) operates a modern computer center; (5) conducts performance measurement and capacity planning for computer hardware, operating systems, database management systems, transaction processors; and (6) produces and distributes data and software products to thousands of institutions and health professionals.

The organization of OCCS is a direct reflection of these responsibilities. Computer and communications 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
- provided as an around-the-clock service by the Computer Services Branch

Development Branch

The Development Branch is responsible for analyzing, designing, and implementing computer-based systems to support NLM's requirements. Development activities during the past year included the implementation of an additional subsystem capability for the Technical Services System (TESS), expansion of Grateful Med support, enhancements to DOCLINE, implementation of Loansome Doc, extensions to the local area network services, and the establishment of the Information Systems Laboratory (ISL).

The Technical Services System (TESS) is being developed to perform functions for the Technical Services Division. TESS is a distributed processing system that integrates mainframe computer, personal computer (workstation), database, and local area network (LAN) technologies. The basic approach has been to develop a common set of system functions that drive the mainframe, database, LAN, and workstation, and then to use them to construct the specific application functions. The Cataloging Front-End (CAFE) subsystem is one such set of application functions that has been successfully implemented.

During 1991 the principal effort on TESS has been directed toward the integration of authority control into the cataloging function. When this effort is completed in October 1991, all creation and maintenance of the Name Authority File will be performed within the TESS system, and authority control of name and subject fields of the cataloging record will be tightly integrated with the current cataloging creation and maintenance activities.

The scope and coverage of Grateful Med continue to grow. New versions for both the PC (version 5.0) and the Apple Macintosh (version 1.5) were released in 1991. PC version 6.0 reached the beta test stage in 1991, and a Unix-based version was initiated. More than 2 million searches were performed via Grateful Med this year by over 35,000 registered owners of the software.

The functionality and utilization of DOCLINE also continue to grow. Approximately 2.1 million interlibrary loan requests were processed by nearly 2,200 libraries in FY 1991. DOCLINE volume hit a new daily record on October 26, 1990, when 11,224 interlibrary loan requests were entered. In March 1991, the average number of interlibrary loan requests entered and processed via DOCLINE was more than 9,600 per day. This was the highest sustained volume since system inception.

DOCLINE enhancements include support for foreign libraries, expansion of message capability, improved performance, and increased capacity. The System for Automated Interlibrary Loan (SAIL), a pilot project

linking DOCLINE with the Lister Hill Center's electronic document delivery system, was implemented and is being evaluated.

Loansome Doc provided an interface between Grateful Med and DOCLINE, enabling the user to order journal articles electronically from a DOCLINE library during a Grateful Med session. Loansome Doc was distributed to more than 10,500 users during FY 1991. The initial reports have been very positive from participating DOCLINE libraries and from health professionals who have ordered documents using Loansome Doc.

NLM Local Area Networks (LANs) continue to be enhanced in order to keep pace with demands to share and transfer information among diverse systems. As the processing power of NLM staff and patron workstations continues to increase, greater requirements are placed on internal communications in terms of throughput and volume of data traffic. Currently a broadband cable system is used throughout NLM for both video applications and data communication links between workstations, servers and other processing resources, using the Novell Netware operating system. Workstations can access internal hosts through gateways or direct links. These communications facilities form a network that supports office automation, electronic mail, distributed applications, and data processing activities. Plans are being developed to replace the digital communications portions of the broadband system with Ethernet-based systems, which will ultimately include higher speed networking.

The Information Systems Laboratory (ISL) was established in 1991. It will be the focal point for defining and evaluating future OCCS computer systems concepts and operational enhancements. Thus, it will help support an orderly evolution of NLM capabilities and services, as well as allow OCCS to take advantage of advances in state-of-the-art technologies.

Applications Services Branch

The Applications Services Branch (ASB) supports the various NLM programs and serves as the nucleus of all automated programming support services. There were a number of advances in in FY 1991.

New generations of software for subsystems of the Automated Indexing Management System (AIMS) became operational. AIMS is an IBM mainframe computer application that runs under the Customer Information Control System (CICS). It provides access to the Inquire Database Management System (DBMS) for storage/retrieval of new records or old records to be maintained. The data entered, verified and validated is NLM bibliographic data that becomes part of the MEDLARS databases and associated publications. Subsystems affected were: (1) journal control; (2) indexing; (3) check-in; (4) bibliographic processing; (5) binding; and (6) gapping.

Many software enhancements were made to the Model 204 DBMS-based MeSH system. This system provides for data entry/verification and validation of the NLM controlled thesaurus, MeSH. Data are extracted daily from the Model 204 MeSH database and updated to the MEDLARS information retrieval MeSH database. These controlled thesaurus data are used to formulate searches of the MEDLARS online databases.

The Bioethic Citation Maintenance System (BCMS) became operational. This system is PC-based and provides for individual citation maintenance and new record creation of bioethics-related data.

More than 10 percent of over 7 million records of the NLM bibliographic data are class maintained each year. Class maintenance is the adding of new terms, deleting old terms, and replacing terms with preferred ones in the MEDLARS database records. Moreover, new data fields are introduced to the records as required. Major software enhancements to support the class maintenance effort included:

- Creation of "Publication Type" data
- Mapping of MeSH to chemical names
- Identification of inconsistent data between MeSH Chemical records and data carried in the MEDLINE family of files

A new database, USERS, became operational. USERS was developed to facilitate the Medlars Service Desk. USERS is used internally and eliminates the necessity to access two different systems while callers are waiting for information.

There are currently more than 52,000 users of NLM online services. Over 500 new codes are assigned each month. Computer software was developed to assign the new codes and passwords.

The In Process (INPROC) data entry/verification and validation system was implemented. This system is an IBM mainframe CICS-based application which utilizes the Inquire DBMS. It provides for creation and maintenance of records that identify monographs.

Systems Support Branch

The Systems Support Branch is responsible for hardware analysis, system software, and data communications. The current NLM production configuration is an IBM 3084-Q with MVS/XA (multiple virtual systems/extended architecture) and VTAM. An IBM 3081-K is used for system testing and development. A third system, IBM 9370 with VM (virtual machine) is used for PROFS (Professional Office System).

During FY 1991, online access was expanded and improved. Higher speed lines were installed, additional

online access capability was installed, and Internet connectivity was enabled. In addition, all online access was placed under control of VTAM (Virtual Telecommunication Access Method) and the use of TCAM (Telecommunication Access Method) was discontinued.

The IBM 3084-Q and 3081-K systems will be replaced during the winter of 1991/1992 with an IBM 3090-300J system, obtained from NIH in August 1991. Acquisition of this new system will: (a) permit NLM to upgrade its 3084 system to a system capable of effectively using new technology; (b) provide a base system for further MEDLARS development; (c) permit parallel testing and development of the NLM applications with the current production system; and (d) permit continued installation of new and/or enhanced capabilities well into the mid-1990s:

Accomplishments for the year include:

- Installation of two IBM 3725 communications controllers for increased capacity and speed.
- Installation of three Packet Assembler Disassemblers (PADS) for ASCII connectivity to VTAM.
- Installation of IBM 3172 interconnect controller for Internet connectivity to NLM applications.
- Increased line speeds of 56KBS for Telenet and 19.2KBS for Tymnet.
- Upgrade of 300/1200 to 1200/2400 for local direct dial users.
- Implementation of RACF (Resource Access Control Facility) to improve security for TSO users.
- Support of more than 100 software products used by programmers, users and System Support staff.
- Operating systems support and communications connectivity for new terminals and workstations throughout the NLM.
- Development and distributions of procedures and status information for the mainframe systems.
- Program changes to system software as required by ELHILL and other applications software development.
- Office automation support for personal computers and PROFS.
- Acquisition of an IBM 3090-300J.

Computer Services Branch

The Computer Services Branch provides data processing services and support for subscribers and users of the MEDLARS, DOCLINE, and other databases through the use of two mainframe computer systems installed at the NLM.

These systems are an IBM 3084Q with performance characteristics of 24.4 million instructions per second (MIPS) and an IBM 3081K with performance of characteristics of 13.5 MIPS. In addition, the Branch maintains the IBM 9370 in support of the Library's PROFS calendaring and messaging system. Operational support is provided on a 24-hour day, 7-day a week basis with computer operator coverage for all weekends and governmental holidays, as most subscribers, both domestic and foreign, continue to use the online system.

The peripheral equipment attached to the IBM 3084Q mainframe consists of 220 direct access storage devices (DASD) with a total online storage capacity of approximately 260 billion bytes. In addition, subscriber support of requested database files is performed through the use of 14 magnetic tape and cartridge drives. Also installed are many telecommunication units to provide easy and quick access into the main MEDLARS and DOCLINE databases for world-wide use.

During the past fiscal year, the Computer Services Branch created and mailed over 5,500 magnetic tapes of MEDLARS and TOXNET database information and files to both domestic and foreign subscribers.

Annual printed output exceeded 22 million pages or 989 million lines of local printing on the high-speed, fanfold and cut-sheet laser printers and high-speed impact printers attached to the IBM 3084 mainframe system. Another 550,000 pages or 38 million lines were printed through the use of remote printers.

INTERNATIONAL PROGRAMS

Richard K. C. Hsieh, Dr. P.H.
Director, International Programs

During the past year, NLM continued its international cooperation with individual countries, international government organizations such as the World Health Organization (WHO) and the Pan American Health Organization (PAHO), and international nongovernmental organizations such as the International Council for Scientific and Technical Information (ICSTI). The Special Foreign Currency Program was active in the support of critical reviews and history of medicine projects. Other NLM international activities included training for colleagues from abroad, the NLM publication exchange program (with 169 institutions in 51 countries, including the U.S.), as well as receiving numerous professional visitors from abroad.

Collaboration with Individual Countries

A collaborative project was discussed with the Academy of Scientific Research and Technology, Egypt, to initiate planning for a National Library of Medicine in Egypt. Egypt has an established International MEDLARS Center, but the library would be an important step toward improved health information services in the country. This project will improve the collections in three major health libraries.

International MEDLARS Agreements

NLM has MEDLARS agreements with partners in 15 foreign countries and with two international organizations (Table 11).

The National Informatics Center (NIC) in New Delhi, India, has begun to provide online search services, in addition to setting up a tape leasing center, for providing MEDLARS services to health professionals in India. NLM will conduct a test with NIC to determine whether the search software to be used by NIC can accurately retrieve citations from MEDLARS databases with search results in agreement with those of the NLM.

The National Science and Technology Information Center (STIC) in Taipei, Taiwan, is the newest International MEDLARS Center to provide MEDLARS services. STIC has successfully demonstrated the use of Grateful Med for access from Taipei. Australia, China, the U.K. and Sweden have also begun to distribute Grateful Med to their MEDLINE users.

NLM has a MEDLARS agreement with the Pan American Health Organization (PAHO), an intergovernmental health organization. In 1989, PAHO amended its leasing agreement with NLM to provide online access to MEDLARS databases from Argentina, Chile, Jamaica, and Costa Rica. In 1990, NLM continued a collaborative project with PAHO and the University of Chile to improve a gateway system named BITNIS. This new system demonstrated the capability for health professionals to conduct MEDLINE searches from Argentina, Chile, Costa Rica, Mexico, and Venezuela. A Beta test was conducted from February to August 1991 by several participating institutions in these countries. To use BITNIS, a MEDLINE search is initiated using Grateful Med; the search commands are transmitted to NLM through the BITNET network. The search results obtained from the NLM computer are transmitted back to the originator through BITNET; and Grateful Med is used again to edit and present search results. The objective of the BITNIS project is to provide NLM MEDLINE to health professionals in all Latin American countries where the high cost of international communication services now inhibits access.

Unfortunately, since August 2, 1990, NLM has been unable to make contact with the Kuwait International MEDLARS Center, but the Center is expected to become active in the very near future.

Table 11
International MEDLARS Centers

Tapes	*Tapes/Software*	*Online NLM*
France	Australia*	PAHO*
Germany	China	Canada
Japan	Sweden	Egypt
PAHO (BIREME)*		France*
Switzerland*		India (Provisional)
		Italy
		Kuwait
		Mexico
		South Africa
		Switzerland*
		Taiwan
		United Kingdom

*Combined online/tapes

Collaboration with the World Health Organization

NLM and the World Health Organization continued to cooperate in the publication of the *Quarterly Bibliography of Major Tropical Diseases* and the *Bibliography of Acute Diarrhoeal Diseases*. NLM prepares camera-ready copy from the MEDLINE system, and WHO prints and distributes these to thousands of institutions in the developing countries.

NLM and WHO also continued a collaborative interlibrary loan arrangement in which photocopies of journal articles are provided to WHO-referred requestors at a reduced rate. 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 and WHO continue to provide some photocopies of journal articles to developing countries, this arrangement can only partially meet the demand. Unless other resources in developed countries can be found, the need for interlibrary loans to developing countries will continue to grow.

Special Foreign Currency Program

Authorized under Public Law 83-480, as amended, the Library's Special Foreign Currency Program utilizes U.S.-owned local foreign currencies to prepare and publish biomedical scientific publications for the health-science community. This program, active since 1962, is the oldest of NLM's extramural support activities. Although over the years NLM has sponsored collaborative PL-480 projects in seven countries, support is presently available only in India.

During FY 1991, 20 projects totaling $345,500 (equivalent in foreign currency) were active in India. About 15 percent supported the translation and publication of biomedical monographs and bibliographies by noted foreign scientists. The remainder funded the translation and publication of major historical monographs. These classics in the history of medicine are selected in collaboration with the American Association for the History of Medicine.

Among the publications received in FY 1991 was a translation from the German of a classic text in the history of psychiatry: Emil Kraepelin's *Psychiatry, A Textbook for Students and Physicians*, in two volumes. Edited and with a new introduction by Jacques Quen, M.D., this translation of Kraepelin's is based on the sixth (1889) edition, which was the first to contain and compare his conceptions of dementia praecox and manic-depressive psychosis. Kraepelin successfully used the late 19th century model of scientific study and classification in developing a comprehensive nosologic system incorporating the etiology, course, prognosis and outcome in the clinical definition of disease entities. The translation will be of broad interest to psychiatrists, psychologists, medical historians and all those with an interest in understanding clinical psychiatry.

Also published in FY 1991 was an English translation of the research reports of L.V. Krushinsky (1911-1984) on reasoning capability and other complicated forms of behavior in animals in the natural habitat. Edited by Edith Tobach and Inge Poletaeva, the monograph is entitled, *Experimental Studies of Elementary Reasoning: Evolutionary, Physiological and Genetic Aspects of Behavior*, and records 50 years' experience with long-term research in the USSR on brain activity and behavior. This work is of interest to U.S. scientists studying the physiological and genetic aspects of animal behavior. (A list of supported publications received in FY 1991 is in Appendix 3.)

International Meetings and Visitors

The Library 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, from a number of countries. 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 1991 general meeting of ICSTI held in Orleans, France, NLM was represented by the Deputy Director and the Assistant Director for Planning and Evaluation.

The Library continues to attract many foreign visitors each year, including medical librarians, health professionals, and government officials. Many of these visitors have responsibility 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 1990 visitors came from the following countries:

Argentina, Bangladesh, Brazil, Burma, Chile, China, Colombia, Cyprus, Czechoslovakia, Ecuador, Egypt, England, Finland, France, Germany, Guyana, Hungary, Iceland, India, Italy, Ivory Coast, Jamaica, Japan, Latvia, Malaysia, Mauritania, Mexico, Mongolia, New Zealand, Nicaragua, Nigeria, Pakistan, Poland, Romania, Saudi Arabia, South Africa, Spain, Swaziland, Taiwan, Thailand, Tunisia, Turkey, USSR, Venezuela, Yemen, and Yugoslavia.

ADMINISTRATION

Kenneth G. Carney
Executive Officer

Financial Resources

In FY 1991, the Library had a total appropriation of $91,408,000. Table 12 displays the FY 1991 budget authority plus reimbursements from other agencies, and the allocation of these resources by program activity.

Table 12
Financial Resources and Allocations, FY 1991
(In Thousands of Dollars)

Budget Authority:	
Appropriation, NLM	$91,408
Plus: Reimbursements	13,638
Total	105,046
Budget Allocation:	
Extramural Programs	25,491
Intramural Programs	72,111
Library Operations	(47,208)
Lister Hill National Center for Biomedical Communications	(11,851)
National Center for Biotechnology Information	(6,130)
Toxicology Information	(6,922)
Research Management and Support	7,444
Total	$105,046

Personnel

The Library's efforts to recruit and retain the most effective personnel were productive in 1991. The NLM expects to close the fiscal year with 587 full time equivalents (FTEs), a significant increase over the 550 FTEs originally allocated.

Three senior positions in the Office of Computer and Communications Systems (OCCS) were filled during 1991. Aaron Navarro, Ph.D., was selected as Deputy Director for Development. Dr. Navarro also served as Acting Director, OCCS, replacing Mr. John Anderson who left the NLM to accept a position as Vice President, BIOSIS. Prior to his position at the Library, Dr. Navarro was a Senior Systems Scientist with the Mitre Corporation. Robert Kicklighter was selected as the Chief of the Applications Services Branch, and George Buckland, Ph.D., was selected as the Chief of the Development Branch.

Three special expert appointments were made at NLM during 1991. Mr. Victor Cid was appointed to serve as Project Leader within OCCS for the implementation and rehosting/migration of the Unix version of the BITNET-NLM Intercommunciation System gateway and its conversion to INTERNET; Ms. Marjorie Cahn was appointed to spearhead the establishment of the Office of Health Services Research Information in the Public Services Division, Library Operations; and Charles Walker, Ph.D., was appointed to the newly established Office of Health Information Programs Development, Office of the Director, NLM. Dr. Walker will assist the NLM in coordinating and evaluating new program opportunities in support of NLM's outreach activities.

To ensure NLM's continuing competitive stance in recruitment, the Director approved the concept of Alternative Work Schedules (AWS) for NLM employees. The AWS provides employees with a great deal of flexibility in determining work schedules, including compressed work weeks, flexitime, and the use of credit hours. Various components of the NLM are now implementing some form of AWS in their organizations.

Awards

NLM Director, Donald A.B. Lindberg, M.D. was the recipient of the highest award that can be bestowed on NIH managers by the President: the Meritorious Presidential Rank Award. Dr. Lindberg was cited for "instituting at the National Library of Medicine sophisticated and successful information programs and services responsive to the needs of the Nation's health professionals in dealing with biotechnology, AIDS, and other contemporary issues in medicine."

Charles Goldstein, Information Technology Branch, Lister Hill National Center for Biomedical Communications, received the Medical Library Association's Frank B. Rogers Information Advancement Award. Mr. Goldstein received the award in recognition of his pioneering effort on the Online Mendelian Inheritance in Man project.

In 1991, the NLM Director's Award was presented to two employees of Library Operations: Peri L. Schuyler, in recognition of outstanding work to increase the utility of NLM's Medical Subject Headings, and to support the development of the Unified Medical Language Systems; and Nelson C. Johnson, in rec-

ognition of his exceptional skill in supervising the interlibrary loan service at the NLM.

Two other NLM employees received the NIH Director's Award in 1991: Sheldon Kotzin, Library Operations, for outstanding contributions to the rapid and effective dissemination of the results of biomedical research; and Dr. Jeanne L. Brand, Extramural Programs, for outstanding leadership in promoting scholarship in the history of medicine through the grant programs of the NLM.

The Public Health Service's Commissioned Corps' Outstanding Service Award was presented to David J. Lipman, M.D., National Center for Biotechnology Information (NCBI), for creative leadership as NCBI Director and for establishing the organization as a national focal point in the field of biomolecular computing.

The NLM's Frank B. Rogers Award recognizes an employee who has made a significant contribution to the Library's fundamental operational programs and services. In 1991, Carolyn Tilley, Library Operations, received the award in recognition of her work to improve NLM's MEDLARS products and services, and for her efforts to extend their availability to librarians and health professionals throughout the Nation.

* * * * *

Table 13
Staff, FY 1991 Full-Time Equivalents

Program	*Full-Time Permanent*	*Other*
Office of the Director	19	1
Office of Public Information	5	2
Office of Administration	45	4
Office of Computer and Communications Systems	61	3
Extramural Programs	14	3
Lister Hill National Center for Biomedical Communications	66	11
National Center for Biotechnology Information	10	12
Specialized Information Services	35	4
Library Operations	224	31
Total	479	71
Total FTEs	550	

Equal Employment Opportunity

The most difficult resource to manage is "people." By the year 2000 it is projected that minorities and women will constitute the majority of the workforce. Does NLM have the vision to prepare for the future by developing the strategies needed to manage a culturally diverse workforce? Will NLM take the necessary actions to create an environment that fully taps the potential of all individuals?

There will be great benefits if NLM successfully manages its diverse workforce. Empowered people will accomplish the Library's objectives in a harmonious, nonadversarial environment. NLM managers will hire, train, and promote individuals exclusively because of their qualifications, skills, and abilities. There will be less confrontation over affirmative action and fewer time-consuming, costly discrimination complaints.

NLM's EEO Office has brought attention to the Library's diverse workforce through a series of special emphasis programs that have increased our awareness of the contributions that minorities and women have made to society. Among the programs in FY 1991:

In observance of Martin Luther King's Birthday, NLM presented a photo exhibit on Dr. King's quest for equality in America. The exhibit was borrowed from the Schomburg Center for Research in Black Culture. Mr. Arthur A. Schomburg was a foremost curator of African American culture. The exhibit also included materials in celebration of African American History Month. That part of the exhibit was entitled "Blacks and the United States Constitution." The Honorable Major Owens, U.S. House of Representatives, was the keynote speaker at a special NLM observance of African American History

Month. The EEO Officer extended an invitation to all public schools with the greater Washington, D.C. area to view the Schomburg exhibit.

In observance of Women's History Month (March 1991), the EEO Officer extended an invitation to the Honorable Connie Morella (Republican representative from Maryland in the U.S. House of Representatives) to be a guest speaker. Congresswomen Morella's remarks were on the theme, "Nurturing Tradition, Fostering Change."

Another event focusing on cultural diversity, sponsored by the History of Medicine Division, was a lecture by Robert C. Davis, Ph.D, Professor of Sociology at Case Western Reserve University in Cleveland. His lecture was titled "Another Kind of Glory: Black Doctors in the Civil War."

There have been a number of significant EEO-related actions in FY 1991: (1) the Library's Equal Employment Opportunity Advisory Committee distributed a pamphlet explaining its functions; (2) basic EEO training is being planned for supervisors to insure that NLM is in compliance with the latest EEO laws; (3) the EEO Officer has taken the first steps for NLM to participate in NIH's adopt-a-school program; (4) a series of talks by the NLM EEO Officer have been delivered at public schools regarding career planning ("The year 2000, Will You be Ready?"); (5) as part of the adopt-a-school program NLM is advising the D.C. public schools that are being converted into health academies about computerized access to health information; and (6) the NLM EEO Office has exhibited at the National Association for Equal Opportunity in Higher Education and the Congressional Black Caucus Foundation's 21st Annual Legislative Weekend.

NLM is also reaching out to the Hispanic and Native American communities in an effort to inform them of employment opportunities at NLM. Organizations such as the National Congress of American Indians are critical in the Library's efforts to expand training and career opportunities. In addition, the NLM EEO Office has addressed the concerns of NLM staff members with disabilities.

Over the last several decades, the Library has made progress in its commitment to Equal Employment Opportunity. This momentum must not be lost as we move toward Workforce 2000. The Library must adapt to the changing composition of the workforce to ensure that hiring, advancement, and training opportunities are afforded equitably to all.

David Nash
EEO Officer

APPENDIX 1: ACRONYMS, ABBREVIATIONS, AND INITIALISMS

AAOS	American Academy of Orthopaedic Surgeons
AAT	Art and Architecture Thesaurus
ADA	Americans with Disabilities Act
AHA	American Hospital Association
AHCPR	Agency for Health Care Policy and Research
AI/COAG	Artificial intelligence hemostasis consultant system
AI/RHEUM	Artificial intelligence rheumatology consultant system
AIDSDRUGS	AIDS drugs
AIDSLINE	AIDS information onLINE
AIDSTRIALS	AIDS Clinical TRIALS
AKAT	Audio Knowledge Acquisition Tool
ANN	Artificial neural network
ANSWER	ATSDR/NLM's Workstation for Emergency Response
APDB	Audiovisual Program Development Branch
ARC	Annual Review of Carcinogens
ARL	Association of Research Libraries
ASB	Applications Services Branch
ASN	Abstract Syntax Notation
ATSDR	Agency for Toxic Substances and Disease Registry
AVLINE	AudioVisuals onLINE
BCMS	Bioethic Citation Maintenance System
BDIPProgram	Biomedical Digital Image Processing
BI	Biotechnology Informatics
BICC	Biomedical Information Communications Center
BIOETHICSLINE	BIOETHICS onLINE
BIREME	Biblioteca Regional de Medicina NLM's International MEDLARS Center in Brazil
BITNET	Because It's Time Network
BITNIS	BITNET NLM Intercommunication System
BLAST	Basic Local Alignment Search Tool
BOSC	Board of Scientific Counselors
CAFE	Cataloging Front-End
CANCERLIT	CANCER LITerature
CAS	Chemical Abstracts Service
CASE	Computer Assisted Software Engineering
CATLINE	CATalog onLINE
CBM	Current Bibliographies in Medicine
CC	Chemline's Classification Code
CCDS	Computer-based Curriculum Delivery Systems
CCEHRP	Committee to Coordinate Environmental Health and Related Programs
CCRIS	Chemical Carcinogenesis Research Information System
CD-ROM	Compact Disk-Read Only Memory
CENDI	Commerce, Energy, NASA, NLM and Defense Information
CHEMID	Chemical Identification File
CHEMLEARN	Microcomputer-based training for CHEMLINE
CHEMLINE	CHEMical Dictionary OnLINE
CLINPROT	CLINical cancer PROTocols
COACH	Expert searcher system prototype. To help improve retrieval from MEDLINE with Grateful Med
CODATA	Committee on Data for Science and Technology
CPT	The AMA's Current Procedural Terminology
CRISP	Computer Retrieval of Information on Scientific Projects
CROSSFILE	Permits users of TOXNET to search for and/or display) data from multiple files simultaneously CSB (Computer Science Branch)
CTX	Criteria Table Expert Systems
DART	Developmental and Reproductive Toxicology
DASD	Direct access storage devices
DBIR	Directory of Biotechnology Information Resources
DBMS	Database Management System
DENTALPROJ	Dental Projects database
DHHS	Department of Health and Human Services
DIRLINE	Directory of Information Resources Online
DOCLINE	DOCuments onLINE
DOCUSER	DOCument delivery USER
DOE	Department of Energy
DRAW	Direct Read After Write

DRW	Document Request Workstation
DSM-IIIR	American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders
DSRT	Document Storage, Retrieval, and Transmission
DXP	Digital X-ray Prototype
E.T. Net	Educational Technology Network
ECRI	Emergency Care Research Institute
EDDS	Electronic Document Delivery System
EDSR	Electronic Document Storage and Retrieval
EEO	Equal Employment Opportunity
EINECS	European Inventory of Commercial Chemical Substances
ELHILL	MEDLARS software named after Senator Lister Hill
EMICBACK	Environmental Mutagen Information Center Backfile
EPA	Environmental Protection Agency
ER	Entity Relationship
ETICBACK	Environmental Teratology Information Center Backfile
FASEB	Federation of American Socities for Experimental Biology
FCCSET	Federal Coordinating Committee for Science, Engineering and Technology
FEDRIP	Federal Research-In-Progress
FIRST	First Independent Research Support and Transition
FLICC	Federal Library and Information Center Committee
FTE	Full-time equivalents
GenBank	National, NIH-supported DNA sequence database
GenInfo	Databank providing a core of biological information about sequences, including the sequence itself, that accurately reflects the journal literature
GM	Grateful Med
GRAS list	Generally Recognized as Safe List
HAP	Hazardous Air Pollutants List
HBCU's	Historically Black Colleges and Universities
HCTA	Health Care Technology Assessment
HEALTH	HEALTH planning & administration database
HISTLINE	HISTory of medicine onLINE
HOPE	Health Omnibus Programs Extension Act
HPCC	High Performance Computing and Communications
HSDB	Hazardous Substances Data Bank
IAIMS	Integrated Academic Information Management System
IARC list	International Agency for Research on Cancer List
ICD-9-CM	International Classification of Diseases, 9th Edition, Clinical Modification
ICSTI	International Council for Scientific and Technical Information
IEEE	Institute for Electrical and Electronics Engineers
ILAR	Institute of Laboratory Animal Research
ILL	Interlibrary Loan
IMPAG	International MEDLARS Policy Advisory Group
INFORM	Used to obtain online NEWS and systems information
INTELSAT	International Telecommunications Satellite Organization
INTROMED	A training/practice database
INTROTOX	A practice subset of HSDB for users to become accustomed to TOXNET searching
INVESTIGATOR	A research program for knowledge acquisition planning
IOM	Institute of Medicine
IRIS	Integrated Risk Information System
IRW	Image Retrieval Workstation
IRx	Information Retrieval Experiment
ISW	Image Server Workstation
ITB	Information Technology Branch
JHU	Johns Hopkins University
KB	Knowledge Base
LAN	Local Area Network
LC	Library of Congress
LCSH	Library of Congress Subject Headings
LEXTOOL	An interactive lexicon building tool for adding entries to the SPECIALIST lexicon)
LHNCBC	Lister Hill National Center for Biomedical Communications
LIS	Library Information Sciences
LO	Library Operations
LSTRC	Literature Selection Technical Review Committee

MACAW	Multiple Alignment Construction and Analysis Workbench
MARC	Machine-Readable Catalog
MedIndEx	Medical Indexing Expert
MEDLARS	MEDical Literature Analysis and Retrieval System
MEDLINE	MEDlars onLINE
MEDSTATS	Medical Statistics Expert System
MEDTUTOR	Microcomputer-based tutorial for MEDLINE
MeSH	Medical Subject Headings
MH	MeSH Heading
MI	Medical Informatics
Micro-CSIN	Chemical Substances Information Network
MIIS	Modified Interpretative Information System
MIM	Mendelian Inheritance in Man
MisHIN	Mississippi Health Sciences Information Network
MRAB	Machine-Readable Archives in Biomedicine
MRI	Magnetic resonance imaging
MUMPS	Massachusetts Utility Multi-Programming System
MX	CHEMLINE's Name of Mixture field
NAC	National Audiovisual Center
NARIC	National Rehabilitation Information Center
NCBI	National Center for Biotechnology Information
NCHS	National Center for Health Statistics
NEMA	National Electrical Manufacturers Association
NHANES	National Health and Nutrition Examination Surveys
NIAMS	National Institute of Arthritis, Musculoskeletal and Skin Diseases
NIC	National Informatics Center
NICHD	National Institute of Child Health and Human Development
NIEHS	National Institute of Environmental Health Sciences
NIH	National Institutes of Health
NIK	NLM Information Kiosk
NIOSH	National Institute for Occupational Safety and Health
NISO	National Information Standards Organization
NLQ	Natural Language Query
NLS	Natural Language Systems
NM	CHEMLINE's Name of Substance field
NN/LM	National Network of Libraries of Medicine
NTIS	National Technical Information Service
NUCARE	NUrsing CAre REsearch
OCCS	Office of Computer and Communications Systems
OCR	Optical character recognition
OHSU	Oregon Health Sciences University
OMIM	Online version, Mendelian Inheritance in Man
ORAU	Oak Ridge Associated Universities
ORNL	Oak Ridge National Laboratory
ORW	Online Reference Works
PA	CHEMLINE's MeSH Pharmacological Action Field
PADS	Packet Assembler-Disassemblers
PAFA list	Priority Based Assessment of Food Additives List
PAHO	Pan American Health Organization
PAM	Principals of Ambulatory Medicine
PDQ	Physician Data Query
PIR	Protein Identification Resource
POPLINE	POPulation information onLINE
RACF	Resource Access Control Facility
RDBMS	Relational Database Management System
REFLINE	Subset of MEDLINE for NLM patrons
RelTox	Relational Toxicology Project
RML	Regional Medical Library
RQ List	Hazardous Substances Reportable Quantities List
RTECS	Registry of Toxic Effects of Chemical Substances
SAAS	Selection and Acquisition Subsystem
SAIL	System for Automated Interlibrary Loan
SDILINE	Selective Dissemination of Information onLINE
SERHOLD	Serial Holdings
SIC	Subcommittee on Information Coordination
SIDE	Sulzberger Institute of Dermatologic Education
SIS	Specialized Information Services
SNOMED	The College of American Pathologists' Systematized Nomenclature of Medicine
SPECIALIST	Experimental system for parsing, analyzing, and accessing biomedicaltext
SPIE	Society of Photo-optical Instrumentation Engineers
STIC	Science and Technology Information Center
SUPERLIST	Chemicals having regulatory or health

	importance found on one or more of 16 Federal and State government lists
TESS	Technical Services System
TIP	Toxicology Information Program
TLC	The Learning Center for Interactive Technology
TOXLEARN	Microcomputer-based training for TOXLINE
TOXLINE	TOXicology Information OnLINE
TOXLIT	TOXicology LITerature from special sources
TRI	Toxic Chemical Release Inventory
TSCA	Toxic Substances Control Act
UMLS	Unified Medical Language System
URSP	Undergraduate Research Study Program
USAN	United States Adopted Names
WHO	World Health Organization
WORM	Write Once Read Many—Disc

APPENDIX 2: STAFF BIBLIOGRAPHY

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APPENDIX 3: FY 1991 EXTRAMURAL PROGRAMS-SUPPORTED PUBLICATIONS

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APPENDIX 4: BOARD OF REGENTS

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

Appointed Members:

DAVIS, Ruth M., Ph.D. (Chair)
President, The Pymatuning Group, Inc.
Arlington, VA

ALLEN, Beverly E.
Director, Multi-Media Center
Morehouse School of Medicine
Atlanta, GA

ANDERSON, Rachael K.
Director, Health Sciences Center Library
University of Arizona
Tucson, AZ

CAPE, Ronald E., Ph.D.
Chairman, Cetus Corporation
Emeryville, CA

COHN, Lawrence H., M.D.
Chief of Cardiac Surgery
Brigham and Women's Hospital
Boston, MA

DeNARDIS, Lawrence J., Ph.D.
President, University of New Haven
West Haven, CT

KAHN, Robert E., Ph.D.
President, Corporation for National Research Initiatives
Reston, VA

SMITH, Alvy Ray, Ph.D.
President, Altamira Software Co.
Mill Valley, CA

SPURLOCK, Jeanne, M.D.
Deputy Medical Director, and
Director, Department of Minority National Affairs
American Psychiatric Association
Washington, DC

WALKER, H. Kenneth, M.D.
Professor of Medicine
Emory University School of Medicine
Atlanta, GA

Ex Officio Members:

Librarian of Congress

Surgeon General
Public Health Service

Surgeon General
Department of the Air Force

Surgeon General
Department of the Navy

Surgeon General
Department of the Army

Chief Medical Director
Department of Veterans Affairs

Assistant Director for Biological Sciences
National Science Foundation

Director
National Agricultural Library

Dean
Uniformed Services University of the Health Sciences

APPENDIX 5: BOARD OF SCIENTIFIC COUNSELORS/ LISTER HILL CENTER

The Board of Scientific Counselors meets periodically to review and make recommendations on the Library's intramural research and development programs.

Members:

YU, Victor L., M.D. (Chairman)
Professor of Medicine
University of Pittsburgh
Pittsburgh, PA

BRUTLAG, Douglas L., Ph.D.
Associate Professor of Biochemistry
Stanford University School of Medicine
Stanford, CA

CIMINO, James J., MD
Assistant Professor of Medicine
College of Physicians and Surgeons
Columbia University
New York, NY

ERNST, Ruann F., Ph.D.
Director of Marketing
Information Systems
Hewlett-Packard Company
Cupertino, CA

FOSTER, John, Ph.D.
Dean, College of Engineering and Architecture
Prairie View A & M University
Prairie View, TX

FRISSE, Mark E., M.D.
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St. Louis, MO

FRYBACK, Dennis G., Ph.D.
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Madison, WI

LEHNERT, Wendy G., Ph.D.
Professor of Computer and Information Science
Department of Computer and Information Science
University of Massachusetts
Amherst, MA

APPENDIX 6. BOARD OF SCIENTIFIC COUNSELORS/ NATIONAL CENTER FOR BIOTECHNOLOGY INFORMATION

The National Center for Biotechnology Information Board of Scientific Counselors meets periodically to review and make recommendations on the Library's biotechnology-related programs.

Members:

SAUER, Robert T., Ph.D. (Chairman)
Professor, Department of Biology
Massachusetts Institute of Technology
Cambridge, MA

ALONSO, Rafael, Ph.D.
Assistant Professor
Department of Computer Science
Princeton University
Princeton, NJ

BERMAN, Helen M., Ph.D.
Professor of Chemistry
Department of Chemistry
Rutgers University
Piscataway, NJ

CANTOR, Charles R., Ph.D.
Principal Scientist of the Department of Energy
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Lawrence Berkeley Laboratory
Berkeley, CA

DEVEREUX, John R., Ph.D.
President, Genetics Computer Group, Inc.
Madison, WI

KELLY, Thomas J., M.D., Ph.D.
Professor and Director
Department of Molecular Biology and Genetics
The Johns Hopkins University School of Medicine
Baltimore, MD

APPENDIX 7. BIOMEDICAL LIBRARY REVIEW COMMITTEE

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

Members:

BUCHANAN, Bruce G., Ph.D. (Chairman)
Professor of Computer Science, Philosophy and Medicine
University of Pittsburgh
Pittsburgh, PA

ABARBANEL, R.M., M.D., Ph.D.
Manager, Engineering Computing and Analysis
Boeing Computer Services
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ABOLA, Enrique E., Ph.D.
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BECK, J. Robert, M.D.
Director, Biomedical Information Communication Center
The Oregon Health Sciences University
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Professor, Department of Computer and Information Science
Ohio State University
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STORMO, Gary D., Ph.D.
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VANNIER, Michael W., M.D.
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WILLIAMS, Arthur L., Ph.D.
Professor, Department of Botany and Microbiology
Howard University
Washington, D.C.

WRIGHT, Barbara A.
Director, Library and Information Services
Fayetteville Area Health Education Center
Fayetteville, NC

APPENDIX 8. LITERATURE SELECTION TECHNICAL REVIEW COMMITTEE

The Literature Selection Technical Review Committee meets three times a year to select journals for indexing in *Index Medicus* and MEDLINE.

Members:

ANDERSON, Philip C., M.D. (Chairman)
Professor and Chairman
Department of Dermatology
University of Missouri School of Medicine
Columbia, MO

BERG, Alfred O., M.D., M.P.H.
Associate Professor/Director of Research
Department of Family Medicine
University of Washington
Seattle, WA

BLODI, Frederick C., M.D.
Professor Emeritus
Department of Ophthalmology
The University of Iowa Hospital
Iowa City, IA

BONAPARTE, Beverly H., Ph.D.
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University of Medicine and Dentistry of New Jersey
Newark, NJ

CASHEL, C. Michael, M.D., Ph.D.
Chief, Section on Molecular Regulations
National Institute of Child Health and Human Development
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Professor of Scientific Communication
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GOLDBERG, Herbert S., Ph.D.
Associate Dean for Research and Academic Affairs
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UTIGER, Robert D., M.D.
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WALTER, Pat L.
Acting Biomedical Librarian
Louise Darling Biomedical Library, UCLA
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WEAVER, William Lynn, M.D., F.A.C.S.
Nashville, TN

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