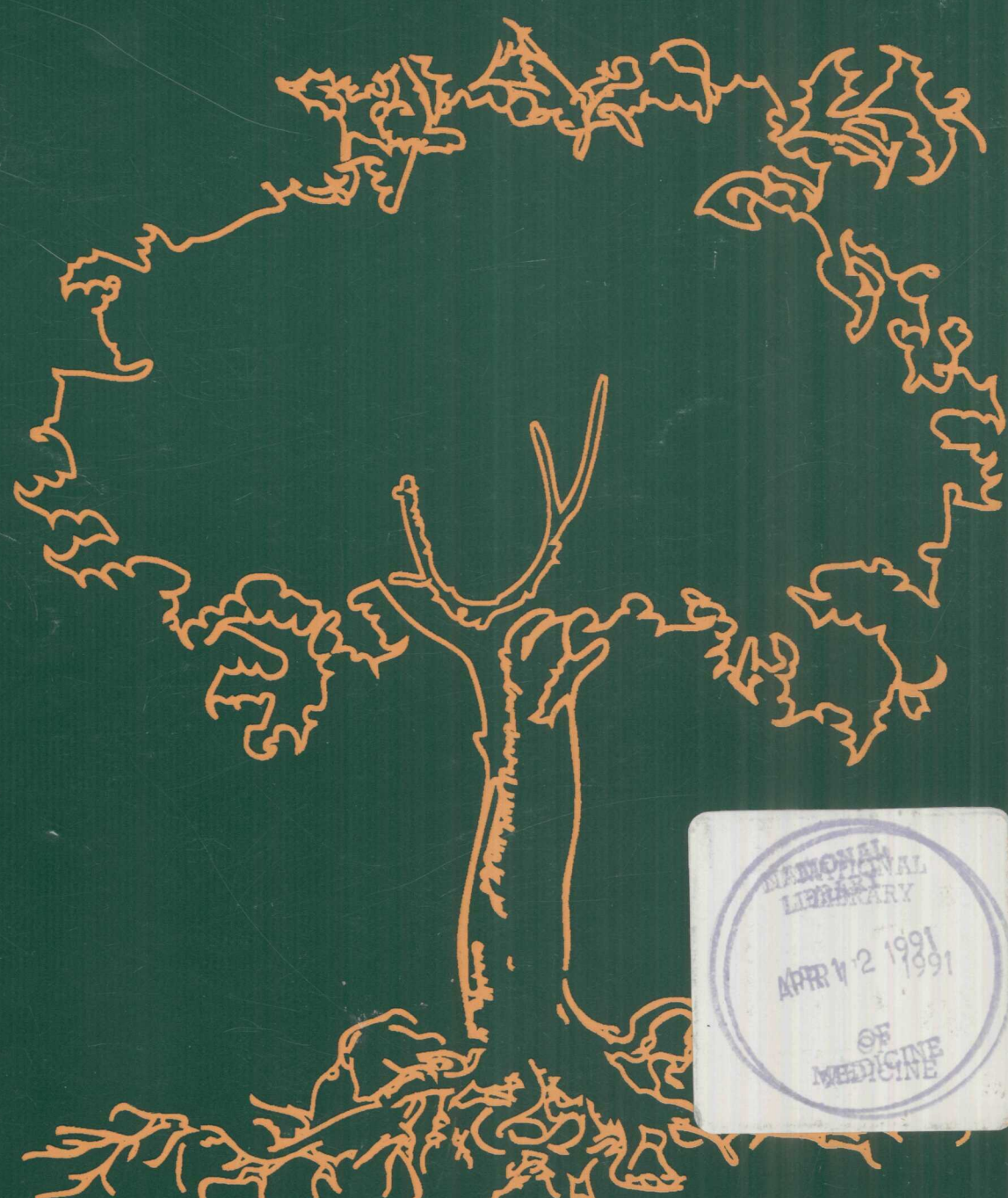


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Programs and Services

Fiscal Year 1990



Unified Medical Language System

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES •
Public Health Service • National Institutes of Health

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: The Unified Medical Language System "tree of knowledge": was designed by Becky Cagle of NLM's Lister Hill Center. Tree structures have been employed to elucidate relationships among medical concepts at least since Francesco Torti published "Fever Tree" in 1712. Trees are also a cardinal feature of NLM's Medical Subject Headings.

NATIONAL LIBRARY OF MEDICINE

**Program
and
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PREFACE

This annual report, covering the activities of the National Library of Medicine during the first year of a new decade, reveals the maturing of a number of programs begun in earlier years. To mention just three examples: Grateful Med® and its effect on usage patterns of the Library's online databases, the first publicly available products of the Unified Medical Language System, and the implementation at several major universities of Integrated Academic Information Management Systems.

The 1986 Long Range Plan continues to be the lodestar guiding the Library. In 1989, the broad plan was updated in the area of "outreach," a concept that was introduced as the result of the ad hoc planning panel headed by Dr. Michael DeBakey. This year another planning panel recommended that the Library undertake a "Visible Human" project. Both of these additions to the Long Range Plan, enthusiastically endorsed by the NLM Board of Regents, are described in the section on Special Initiatives.

I would like to express the thanks of all of us at the National Library of Medicine to our partners throughout the Nation and around the world. Our collaboration means that never before have so many health professionals—in research, education, and healthcare delivery—had such widespread access to the biomedical literature. We look forward to continuing and expanding our mutual undertaking.



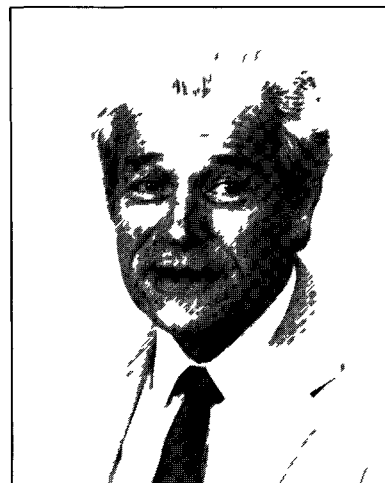
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Donald A. B. Lindberg, M.D.
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Kent A. Smith
Deputy Director



Harold M. Schoolman, M.D.
Deputy Dir. for Research
and Education

CALENDAR OF EVENTS—FISCAL YEAR 1990

1989

Oct-Dec: "Medicine and the Naturalist Tradition" (exhibit)
Oct 24-26: Toxicology Information Program Committee
Oct 26-27: Board of Scientific Counselors (LHC)
Nov 2-3: Biomedical Library Review Committee
Dec 5: General NLM toll-free number instituted
Dec 11-12: Toxicology Information Program Committee

1990

Jan 18-19: Board of Regents
Jan: "Electronic Imaging" planning panel report published
Feb-Mar: History of cataract surgery exhibit
Feb-Mar: "To Your Health: An Exhibition of Posters"
Feb 1-2: Literature Selection Technical Review Committee
Feb 6: Visit by Education Secretary Lauro F. Cavazos
Feb 7: Toxicology Information Program Committee
Feb 8-12: Visit of Delegation from USSR's Soyuzmedinform
Mar 7-8: Biomedical Library Review Committee
Mar 19: Teratology Information Users Group
Mar 23: Demonstration of TRI database to Congressional staff
Apr-May: "The Surgeon at Work"—exhibit of paintings by Dr. Joseph Wilder
Apr 3: Visit of Polish Vice Minister of Health and delegation
Apr 20: Leiter Lecture: "Evolution of a Premier Information Center," Dr. Michael DeBakey
Apr 23-24: "The Medicinal Muses" (symposium)
May 3-4: Board of Scientific Counselors (LHC)
May 12: NLM Director receives honorary degree from University of Missouri-Columbia
Jun-Aug: History of Experimental Embryology (exhibit)
Jun 1: NLM-Agency for Health Care Policy and Research agreement in force
Jun 2: MEDLINE® updating becomes weekly
Jun 7-8: Board of Regents
Jun 8: Lectures on the history of embryology
Jun 14-15 Literature Selection Technical Review Committee
Jun 18: Memorandum on medical information exchange signed by Soyuzmedinform (USSR) and NLM
Jun 18-19: Toxicology Information Program Committee
Jun 27-28: Biomedical Library Review Committee
Jul 16: GenInfo™ Backbone Database announced at NCBI meeting of software developers
Aug 3: Board of Scientific Counselors (NCBI)
Aug 9: Lecture by Dr. David Satcher, Meharry Medical College President
Sep 13: CENDI Technical Forum on High Performance Computing/Networking
Sep 14: NCBI lecture series in Computational Molecular Biology
Sep 19: Taiwan becomes an International MEDLARS Center
Sep 25: Outreach presentation to NLM staff
Sep 27-28: Board of Regents

1990 SPECIAL INITIATIVES

NLM Outreach Activities

In response to the recommendations contained in last year's DeBakey planning panel report (*Improving Health Professionals' Access to Information*) NLM has begun a wide variety of outreach activities. This has been aided with funding of \$3.8 million appropriated by the Congress in FY 1990.

The focus of these activities has been on improving access by individual health professionals to NLM's information products and services, especially by persons presently unaffiliated with an institution or who are located in rural or other medically under-served settings. Many of the latter locations are comprised of predominantly minority populations.

A series of presentations on outreach was made to the NLM staff on September 25, 1990, in the Lister Hill Center Auditorium. Two days later, several of these presentations were made to the Board of Regents.

The RML Network. Through special enhancements to the existing RML contracts, NLM has funded demonstration projects in 12 states to test varying means of increasing awareness of and access to NLM's information products and services by health professionals located in underserved areas. Some of the projects are being carried out directly by the RML; others involve the RML subcontracting with another network library. Work began in eight of these states as a direct result of new outreach funding; a project was already under way in five states in the Pacific Northwest, but this project was expanded as a result of the new funds.

Another program, which was developed entirely with new outreach funds, provides for small competitive contracts awarded directly by NLM to network libraries for the purpose of introducing online searching via Grateful Med to health professionals in rural and inner city areas. Thirty such contracts will be awarded by the end of September, 1990, to network libraries from Hawaii to Maine. NLM will be assisting these libraries in a variety of ways during the projects, including providing non-billed demonstration codes, application packets and blocks of online codes, and tracking system usage as part of the evaluation phase of each project.

Improving hospital access to national information sources.

The new Information Access and Information Systems Grants foster access to information resources and services utilizing today's computer and communications technologies. For example, among some recently awarded Information Access Grants aimed at small- and medium-size hospitals are those to two groups of health-related libraries in Eastern Kentucky to introduce Grateful Med and provide the concomitant end-user training. An Information Systems Grant, which is directed towards larger hospitals and medical centers, was awarded to the University of Miami's medical center library to assist in developing an AIDS information service for health professionals in Southeast Florida. Both types of grants have significant outreach potential.

The IAIMS (Integrated Academic Information Management Systems) Program assists health institutions to plan and develop computer and communication networks that link and relate library systems with individual and institutional databases and information files—inside and outside the organization—for applications in patient care, research, education, and administration. (For more on this subject, see the IAIMS section in the Extramural Programs.)

Undergraduate Research Study Program. NLM has developed an intramural Undergraduate Research Study Program to provide two-year scholarships and research assignments in medical informatics for sophomore students majoring in electrical engineering, computer science, computer engineering, or physics at participating historically black colleges and universities (HCBUs). The program, scheduled to begin in late 1990, will select several schools (from nine HCBUs with engineering departments) to collaborate with NLM for a five-year period. Participating students will complete two summer internships at the Lister Hill Center and two academic year assignments under the guidance of their preceptors.

New information products and services. NLM has increased its efforts to obtain feedback from users and non-users concerning the adequacy of its products and services. Extensive studies are being undertaken in South Texas (in collaboration with the Health Sciences Library at the University of Texas, San Antonio), and rural

Tennessee (in collaboration with Meharry Medical College) to identify impediments to use and strategies for improving access among health professionals in geographically isolated areas. The results of these studies will provide important insights for the design of new products and services as called for in the Outreach Report.

Enhancements to existing products and services are also proceeding. "Loansome Doc," a link between the Grateful Med user and a network library, is being tested in four western states. Using Loansome Doc, the health professional will be able to electronically order documents identified in an online search from a designated DOCLINE® library. The system should be especially helpful to health professionals who do not currently have access to a medical library.

Publicity. Publicity activities are targeted both to health professionals and to general audiences. Among those for health professionals are the preparation of a kit for "training Grateful Med trainers," including a planning guide, suggested curriculum, pamphlets, slides and overheads, and a videotape, to be used by medical librarians and others to train health professionals in the use of Grateful Med; and a campaign to inform dental professionals about the benefits of Grateful Med/MEDLINE searching in their professional work. Other activities that target health professionals: a series of five Public Service Announcements being developed for professional journals; press releases on specialized subjects such as that announcing the new ChemID™ database; working with the American Library Association on a videotape for updating librarians about the NLM's services; the institution of a toll-free number professionals may use to call the NLM; and a continued high level of exhibiting at professional meetings.



Elliot R. Siegel, Ph.D., Ass't. Dir. for Planning and Evaluation; Susan Buyer Slater, Deputy Ass't. Dir.

Among outreach activities intended for general audiences: the widespread advertisement of the 54-page pamphlet, "Health Hotlines," available free from the NLM; support for a PBS series being produced by WNET (New York) on the future of medicine, a nationally distributed television news release on the Toxic Chemical Release Inventory; general press releases on lectures and exhibits; and the production of a new film, "Pathways," and its translation into four foreign languages for use with visiting groups.

E. R. Siegel

Unified Medical Language System

The UMLS project was initiated in 1986 as a long-term NLM research and development effort designed to facilitate the retrieval and integration of information from multiple machine-readable biomedical information sources. The sources of interest include: descriptions of the biomedical literature, clinical records, databanks, knowledge-based systems, and directories of people and organizations.

The variety of vocabularies and classifications used in these different sources is a significant barrier to the use of machine-readable information by health professionals and biomedical researchers and to the development of effective search interfaces to assist these users. The UMLS approach assumes continued diversity in the terminology employed in different systems and by users themselves. The goal of the project is to develop products that can facilitate the establishment of a conceptual link between the user's question and relevant information in machine-readable form.

Participants in the UMLS project include an internal NLM research and development team, several contractors, and advice and input from professional societies.

Knowledge Sources. In FY 1990, NLM released the initial versions of the Metathesaurus™ and the Semantic Network, two machine-readable "Knowledge Sources" developed as part of the UMLS. The Knowledge Sources are designed primarily for use by system developers. They are meant to be consulted and used by search interface programs to interpret and refine user queries and to map the user's terms to appropriate controlled vocabularies and classification schemes. The Knowledge Sources are also useful as reference tools for medical librarians, database builders, and other information professionals.

Meta-1™, the first version of the Metathesaurus, is a database of information about biomedical terms that appear in several different controlled vocabularies and

classifications. It contains all terms from the 1990 MeSH® (NLM's Medical Subject Headings), and DSM-III-R, the American Psychiatric Association's Diagnostic and Statistical Manual of Mental Disorders, third edition, revised. It contains selected terms from several other sources, including the International Classification of Diseases (9th edition, Clinical Modification) and the Library of Congress Subject Headings. Meta-1 preserves the meanings, hierarchical contexts, and relationships among terms present in its source vocabularies, while adding certain basic information about each term and establishing new relationships between terms from different source vocabularies.

All concepts in Meta-1 have been assigned to one or more of 131 basic semantic types or categories, e.g., "Disease or Syndrome," "Virus," "Medical Device," "Hazardous Substance." The Semantic Network defines these basic types or categories and represents a variety of useful potential relationships among them, e.g., "Virus" causes "Disease or Syndrome."

The strategy for the development of UMLS components is to build successive approximations of the capabilities ultimately desired. Accordingly, Meta-1 and the Semantic Network provide relatively modest, although potentially powerful, enhancements to existing machine-readable biomedical vocabularies and classifications. Additions in scope and complexity will be based on feedback received from those who attempt to apply these first versions to a variety of information problems. While it will probably always be necessary for system developers to add some information of local importance to these sources, the goal is centrally maintained knowledge sources that can reduce the cost and complexity of developing medical information systems in various contexts.

Availability. To encourage the broadest possible experimentation, NLM is providing copies of Meta-1 and the Semantic Network under the terms of an experimental agreement. Those who elect to receive the UMLS Knowledge Sources must provide feedback to NLM on how the products are being used and on the ways in which they could be improved. Users of Meta-1 and the first version of the Semantic Network should be aware that there may be substantial changes in the content or format of subsequent editions.

The UMLS Knowledge Sources are available in several file formats contained on two CD-ROMs; sample sets are available on diskettes. In FY 1990, the Library distributed copies of the sample records, documentation, and experimental agreement to more than 100 institutions and individuals.

Fact Sheets on the Unified Medical Language System and the two initial Knowledge Sources are available from NLM's Office of Public Information.

B. L. Humphreys

Health Services Research

In December 1989 Congress created a new agency within the Public Health Service: The Agency for Health Care Policy and Research (AHCPR). This new agency is the focal point in the Federal Government for health services research and the development of clinical practice guidelines, expanding on the work of its predecessor, the National Center for Health Services Research and Health Care Technology Assessment.

The law that created AHCPR (P.L. 101-239) calls for the new agency and NLM to work together to develop and enhance information services in the field of health services research, encompassing health technology assessment and the development of practice guidelines. As a result, the NLM and the AHCPR entered into an interagency agreement in FY 1990. With funds transferred from AHCPR, the Library has created a new Office of Health Services Research Information in the Public Services Division and is working to develop and enhance its services in this important field.

A study recently begun by the Institute of Medicine, also funded by the AHCPR, will provide NLM with a clearer picture of the information needs of the users of technology assessment and related health services research studies, and of the new and enhanced services that will be required to meet these needs.

The Library currently provides substantial, although partial, coverage of health services research in its Medical Subject Headings (MeSH) vocabulary, its collections of literature, and its indexing and cataloging of databases. Access to the health services research information and literature now available at the Library is provided via NLM's online and information services, publications, reference services, and document delivery services.

In response to the legislation that created the AHCPR, over the next few years NLM will review and enhance as necessary these products and services. In this connection, current activities include: review and revision of MeSH terminology by a panel of subject experts selected by NLM and AHCPR, expansion of the UMLS Metathesaurus in the field of health services research, re-examination of NLM's policies for acquisition and bibliographic control of technical report literature, enhancement of DIRLINE's® coverage of organizations involved in health services research and the development of practice guidelines, indexing of additional technology assessment literature, research and development on online access to the full-text of AHCPR-approved practice guidelines, and the provision of special literature searches and document delivery assistance to the AHCPR panels charged with developing practice guidelines.

B. L. Humphreys

Electronic Imaging

Much of what is known about biological form and function is best communicated by pictures. This was true in the time of Vesalius' carefully penned renderings of human anatomy, and it now has added dimensions provided by modern technologies that produce remarkably detailed patient-specific medical images. The NLM has long been the world leader in managing and providing access to the knowledge of medicine and biology, and in its printed document collections as well as in its historical prints and photos and film collections there are uncounted millions of images. For as long as medical libraries have existed, they have been repositories of pictures as well as words.

The perennial importance of pictures to biomedicine finds new modes of expression in the era of digital electronics: specialized large-memory graphics computers that can quickly compute and display the millions of points of light that comprise complicated images; high-resolution color video displays; optical disc and other storage media capable of storing billions of bits; and high-speed computer networks capable of moving electronic image representations over long distances quickly. The rapid development of these enabling technologies led the NLM's Long Range Planning panels in 1985-86 to recommend that the NLM "investigate the feasibility of creating digital image libraries" for purposes of medical education.

In June 1988 the Library brought together representatives from academic medical centers where three-dimensional computer reconstruction of anatomic images was under development. When these pioneers of a new technology considered what the NLM might do in this field, they immediately and unanimously conceived a project to build a digital image library that none of them had the resources to individually create: a complete set of x-y-z numerical coordinates representing the internal and external structure of an entire human being at millimeter-level resolution. This "Visible Human" project would yield a computer data set of unprecedented detail and form the basis for a virtually unlimited number of image renderings of the human body. For, given the numerical coordinates of body structure, computer algorithms can be used to reconstruct an image from any perspective, thus creating "living" images that can be rotated, viewed, and dissected like the physical objects they represent.

To develop in greater detail an overall role and strategy for the NLM in images, a planning panel was convened in 1989. This group of researchers, clinicians, and medical educators was charged with answering important questions related to digital imaging and the NLM. Is the time right to begin actually building and distributing

image collections in electronic format? Would such image collections, if available today or in the near future, be used sufficiently to justify the expense involved in their creation and maintenance? Would a Visible Human project be a good start? If so, how should it be pursued? Were there other equally or more meritorious imaging projects that the NLM might undertake?

The panel findings, as summarized in a report released in 1990, highlight a number of conclusions. The first is that NLM should be involved in the creation, management, and distribution of digital image collections as a natural component of the Library's mission to organize and make available the scientific knowledge of medicine and biology. As a group, the panelists believed that the relevant computer technologies are now, or will be in a very few years, sufficiently powerful and economical to store, render, and display digital images of real value in clinical, research, and educational applications.

They noted that the needs of each of these communities differ. Teaching collections focus on the best and most representative examples of normal and abnormal biological structure. Researchers need tools and standards by which they can manipulate, analyze, and share imaging data with one another. Clinical practice makes limited use of normal images for comparison purposes, focusing primarily on the acquisition and management of patient-specific images. All agreed that fundamental research problems need to be addressed, such as the development of methods to identify and define biologically important objects within images, and the formats and standards for optimal rendering, exchange, comparison, and editing of biomedical images. And all concurred that a future era in which NLM is positioned as a national resource for digital images will depend upon high-bandwidth computer networks capable of transmission speeds thousands of times faster than the current commercially available networks that provide access to MEDLINE.

On the basis of these findings, the planning panel recommended that the NLM should proceed with the Visible Human as a first project in digital image libraries. This would involve creating a digitized representation of a human male and female, derived from carefully selected cadavers, including the image coordinates that correspond to computed tomography, magnetic resonance imaging (MRI), and digitization of photographic sections—thin slices of the frozen cadavers.

Though the Visible Human would be of greatest use as an archetypal normal for computer-assisted medical education applications, it would also serve as the centerpiece for the development of technical standards for data representation, communication, and image rendering. In addition, it would provide a substrate for research in the

fledgling field of "structural informatics," which seeks to organize and relate the image-based knowledge of biomedicine to conceptual, language-based understanding of biological form and function.

The findings of the Planning Panel on Electronic Imaging were reviewed and enthusiastically approved by the Board of Regents in the spring of 1990, and the panel recommendations made a formal part of the NLM Long Range Plan. The closing months of FY 1990 saw the publication of a Request for Proposals to begin the first phase of building the Visible Human database; award of a research contract to undertake this first important step for the Library of the future is planned for next year.

D. R. Masys

National Center for Biotechnology Information

The National Center for Biotechnology Information (NCBI) was established by Public Law 100-607 in November 1988 as a division of the National Library of Medicine. The establishment of the NCBI reflects the importance of developing new information technologies to aid in the understanding of the molecular processes that control health and disease.

Basic Research. NCBI has had great success recruiting American and foreign scientists of international standing to work at NLM within the NIH Intramural Program. There are presently 25 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.

In the last year, NCBI scientists have developed new mathematical methods for assessing the statistical significance of molecular sequence features and have incorporated these into a new fast algorithm for sequence similarity searches of protein and nucleic acid databases. The speed of these methods is crucial for strategies of

database exploration and for the discovery of new structural similarities and functional associations of biological macromolecules.

Recently, the identification of the gene product of the newly discovered neurofibromatosis-1 gene as a GTPase activating protein was made at the NCBI through the use of these methods. These advanced analytical methods are being applied by NCBI scientists in their own research as well as in collaboration with laboratories in the U.S. and Europe.

Database Building and Enhancement. NCBI, in collaboration with Library Operations, is creating a new biosequence database, the GenInfo Backbone. The GenInfo Backbone includes MEDLINE records that contain the sequence data, integrates DNA and amino acid sequence information, and maximizes the use of standard nomenclature and gene names from official sources. It is the first major database to be made available in ASN.1 (Abstract Syntax Notation), an International Standards Organization data description language. These design features increase the power of the analyses molecular biologists perform on sequence databases, and improve the usefulness of GenInfo as a foundation to which the rapidly increasing number of specialized biology databases can be linked.

In a parallel effort, NCBI has created explicit definitions for biosequence objects using ASN.1. ASN.1 will be used to provide a hardware- and software-independent version of the information contained in the GenInfo Backbone's relational database. NCBI has also built tools for producing ASN.1 versions of the GenBank DNA sequence database and the PIR amino acid sequence database. Other database producers are beginning to provide ASN.1 versions of their databases. NCBI plans to distribute ASN.1 versions of GenInfo, as well as other sequence databases, on CD-ROMs along with information retrieval and sequence searching tools for PC's and Macintosh computers.

D. J. Lipman

LIBRARY OPERATIONS

Lois Ann Colaianni
Associate Director

NLM's Library Operations (LO) Division acquires and preserves the world's biomedical literature; organizes this literature through indexing and cataloging; disseminates NLM's authoritative bibliographic records in publications, online files, and machine-readable formats; lends or copies documents in the NLM collection as a backup to the document delivery service provided by other U.S. biomedical libraries; provides reference and research assistance to health professionals; and coordinates the Regional Medical Library Network, a nationwide network of more than 3,000 U.S. health sciences libraries. LO also conducts research and evaluation related to its basic responsibilities and maintains an active research program in the history of medicine.

More than 250 librarians, technical information specialists, library technicians, subject matter experts, health professionals, and administrative support personnel carry out LO's programs and services. The LO staff is organized in four main divisions: Bibliographic Services, Public Services, Technical Services, and History of Medicine; two smaller units: the Medical Subject Headings Section and the Regional Medical Library Program office; and a small administrative group in the Office of the Associate Director.

Planning and Management

LO develops its strategic and operational plans within the framework of NLM's Long Range Plan, as augmented by the reports of the special Panels convened to expand and enhance particular segments of the basic NLM plan. Activities related to the NLM Long Range Plan, its supplementary Outreach Plan, and LO's operational plan are described throughout this chapter.

In the FY 1990, LO staff members directed an NLM-wide effort to identify and implement a more cost-effective electronic mail and file transfer system for use within the Library. Other administrative improvements included the installation of additional PC-networking capabilities for sharing administrative and production data within the Division.

Collection Development

Collection development includes: establishing and revising literature selection policy, identifying and acquiring biomedical literature in all formats and



Right, Lois Ann Colaianni, Associate Dir. for Library Operations; Left, Betsy L. Humphreys, Deputy Asso. Dir.

languages, processing materials as they are received, assessing the effectiveness of the selection and acquisition process, and maintaining and preserving the collection. The NLM collection now contains 1,957,389 printed books, journal volumes, theses, and pamphlets and 2,728,388 nonprint items, including audiovisuals, software, microforms, prints, photographs, and manuscripts (table 1).

During FY 1990, LO completed an item by item inventory of the prints and photographs collection and eliminated many duplicate, poor-quality images from the collection. As a result, NLM's picture collection is now known to contain 56,600 images, rather than the 77,993 reported at the close of FY 1989.

Selection and collection assessment. NLM staff members select materials for the NLM collection according to the guidelines in the Collection Development Manual of the National Library of Medicine. The last general revision of the Manual was completed in 1985. In keeping with NLM's policy of conducting a general review and revision of the Manual every 5 to 8 years, a plan has been prepared for the next wholly new edition to be completed in 1992. FY 1990 work on collection development policy included revised guidelines for animal welfare literature, a draft policy statement on collection of electronic formats, and a joint NLM/Library of Congress statement on collecting the AIDS literature.

The Library has a continuing program to assess its success in implementing collection development policies and to examine how these policies serve the needs of health professionals and researchers. In FY 1990, LO completed a comprehensive evaluation of NLM's dermatology collection and began a similar evaluation of neurology. The results of the dermatology project indicated that NLM's collection is appropriately strong in all time periods. Some work is needed to ensure consistent acquisition of materials issued by noncommercial publishers. A review of general physics journals in NLM's collection led to the cancellation of about \$20,000 in subscriptions to titles that currently have little or no biomedical content. NLM's collection of medical statistics was also reviewed. In FY 1990, NLM participated in the National Shelflist count, the American Library Association's periodic effort to provide comparative measurements of major U.S. research library collections.

Acquisitions. NLM added 40,637 volumes and 159,744 other items (e.g., audiovisuals, microforms, software, pictures, manuscripts) to its collection in FY 1990 (table 2). The Library staff processed 165,424 modern books, serial issues, audiovisuals, and software packages. NLM's historical collection was enhanced by the acquisition of *Lektsii o Rabote Glavnykh Pishchevaritelnykh Zhelez* (St. Petersburg, 1897) Ivan Pavlov's classic book on the physiology of digestion. Other important additions to the rare book collection included: Robert Thomas, *Medical Advice to the Inhabitants of Warm Climates* (Bahamas, 1794), thought to be the only book printed in the Bahamas in the eighteenth century; *Der Vrouwen Natuere Ende Complexie* (Antwerp, ca. 1520-1530), an extremely rare and early illustrated book on midwifery; *Le Grand Herbarier* (Paris, ca. 1535), an herbal illustrated with over 300 woodcuts; and a collection of 17th-19th century broadsides and pamphlets on medicine in Mexico.

Significant items acquired for the manuscript, picture, and historical audiovisual collections include: two Civil War manuscripts, a medical journal for the U.S. brig *Bohio* and a prescription book for a regiment of New Hampshire volunteers; the papers of Dr. Marsden Scott Blois, a pioneer in the field of medical informatics; 220 photographs of NIH activities donated by former NIH Director Dr. Donald Fredrickson; a film on transfusion featuring Dr. Michael DeBakey; and five early German radiological films.

In FY 1990, NLM negotiated lower service charges for serials subscriptions to realize a savings of about \$40,000. A new online data entry system for creating monograph and audiovisual acquisitions records was implemented.

Collection preservation and maintenance. The Library's preservation program includes: preserving and maintaining NLM's own collection, supporting the preserva-

tion of important biomedical literature not held by NLM, promoting the use of more permanent materials in new biomedical publications, and investigating new technologies for preservation of library materials. FY 1990 preservation activities affecting the NLM collection included:

- Microfilming 6.1 million pages of brittle books and serial volumes. To allow the contractor to film complete runs of serials, the Library borrowed 443 volumes missing from its own collection from 37 different U.S. and foreign libraries.
- Storing microfilm masters in an underground offsite facility to provide additional security in the event of a disaster affecting the Library building.
- Establishing policies, procedures, and a new contract for producing service copy microforms needed to fill interlibrary loan and purchase requests.
- Giving special conservation or preservation treatment to 268 rare books, manuscripts, and historical films in NLM's collection.
- Purchasing new exhibit cases to provide a benign and secure display environment for items from the special collections.
- Awarding a new bindery preparation contract and completing work on an improved automated support system for binding and recording issues missing from the NLM collection.
- Reviewing and revising the 20-year plan for shelving the NLM collection; NLM must acquire additional compact shelving to accommodate the projected growth in the size of the collection.

As part of NLM's National Preservation Plan, contracts for preserving important items not held by NLM were awarded to: the Houston Academy of Medicine - Texas Medical Center Library for conservation and preservation of some of the papers of Dr. Philip S. Hench (1896-1965), a recipient of the Nobel Prize for research on the effects of corticosteroids on rheumatic diseases; the Library of Kirksville College of Osteopathic Medicine for conserving selected papers of Dr. Andrew Taylor Still, founder of the College; and Tufts University Health Sciences Library for microfilming four dentistry serials for which NLM has very incomplete or no holdings. NLM funds 50 percent of the cost of the projects; the institutions receiving the contracts fund the balance of the cost.

The Library continues its campaign to promote the use of acid-free paper in new publications as a means to reduce the growth of the preservation problem facing health sciences libraries. In FY 1990, NLM began flagging in *List of Journals Indexed in Index Medicus* and the *List of Serials Indexed for Online Users* those titles that are printed on acid-free paper and that also include a notice to that effect. A total of 506 (17 percent) of *Index Medicus* titles

will have this flag in 1991. NLM staff members also directed the effort to revise the current American National Standard for Permanence of Paper (Z39.48-1984) to include coated as well as uncoated papers. A revision incorporating the results of a discussion draft will be voted on by the National Information Standards Organization in FY 1991.



Peri L. Schuyler, Head, Medical Subject Headings Section

Bibliographic Control

NLM provides effective bibliographic control of 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; cataloging biomedical publications in all formats; and indexing articles from selected biomedical journals.

Thesaurus. MeSH, the hierarchical thesaurus used in cataloging, indexing, and searching NLM's online databases, currently includes 16,131 subject headings. MeSH's supplementary chemical file contains about 57,400 additional terms, most of which are names of chemicals. NLM staff members review, update, and modify the terminology annually to ensure that MeSH keeps pace with developments in biomedicine and changes in the usage of biomedical terms. In FY 1990, 308 new MeSH main headings, 3 new subheadings, and 1,239 new cross-references to existing terms were added. The vocabulary was expanded in several subject areas including AIDS, molecular biology, lymphomas, and retroviridae.

Other enhancements to MeSH included the elimination of the distinction between major and minor headings in the vocabulary, the development of general "consider also" references (e.g., HEART consider also terms beginning with CARDIAC), and the creation of a

new publication type element to allow clearer distinctions between what an article is and what it is about. New "pre-explosions" were created to allow combined searching of all "adult" (i.e., adult, middle-aged, aged) and "child" (i.e., infant; infant, newborn; child; child, pre-school; adolescent) descriptors in MeSH. Pre-explosions were also created to allow combined searching of subheadings in certain categories, e.g., all the subheadings for therapies.

During FY 1990, MeSH staff members were also heavily involved in creating and reviewing key segments of the content of the first versions of the Metathesaurus and Semantic Network. A description of the UMLS project appears in the Special Initiatives section of this report.

Cataloging. At NLM, the cataloging function includes: cataloging new works added to the Library's collection; updating NLM's automated files of cataloging and name authority records; contributing NLM's cataloging data to the national bibliographic apparatus; and maintaining the NLM classification (used by health sciences libraries world-wide to assign shelving locations to cataloged items based on their subject content). In FY 1990, NLM cataloged a total of 19,369 modern books, serials, nonprint items, and Cataloging-in-Publication galleys, using a combination of in-house staff, contractors, and an interagency agreement with the Library of Congress (table 3). The inventory of uncataloged books was reduced by 565 to a total of 7,303 items, most in languages other than English.

Work continued on improving the bibliographic control and access to NLM's retrospective holdings. Emilie Savage-Smith, Ph.D., a distinguished scholar in the history of Arabic medicine, began a detailed review of NLM's Arabic manuscript holdings preparatory to the Library's creating machine-readable bibliographic and name authority records for these items. Dr. Savage-Smith's review has revealed that the previous project to list these items overlooked some of the manuscripts that were bound together and misidentified others. NLM's collection of Arabic manuscripts is therefore larger and more significant than previously thought. Staff upgraded 12,000 abbreviated records for items in NLM's picture collection to a fuller format in conjunction with the joint Lister Hill Center/LO project to develop an integrated automated catalog and videodisc for the Library's historical pictures.

NLM intends to dispose of its name-title catalog cards and most of its shelf-list cards in early FY 1991. The cards have been stored in the Library's basement since 1985 when they were removed from public service. In preparation for the disposal of the card catalog, cards were retrieved for approximately 30,000 theses and for books bound with other books that had not been converted to machine-readable form because they were not

in the shelf-list. Both categories of records will be converted to machine-readable form at a future date.

Substantial progress was made in implementing a new automated system for cataloging that distributes data creation and validation tasks between PC workstations and the mainframe computer. The data creation portion of the system was implemented for all in-house catalogers in FY 1990. It includes the ability to download name authority and bibliographic records from the Library of Congress's online files for use as the basis of NLM's cataloging and name authority records. In a related development, a prototype of segments of the name authority portion of an expert cataloger system is under development. The tape of the machine-readable version of the current NLM classification was mounted online for staff use to support the continuing effort to revise the classification. Procedures were drawn up for the revision of the classification.



Left, Duane W. Arenales, Chief, Technical Services Division; Right, Sally Sinn, Deputy Chief

Indexing. NLM's basic indexing operation involves selecting the journals to be indexed, keyboarding descriptive information and abstracts from the articles to be indexed, indexing the content of the articles, reviewing the accuracy of the keyboarding and indexing, and maintaining the citation databases to correct indexing errors and to annotate citations to articles that have been retracted, corrected, or called into question by commentaries. Following a successful pilot test, NLM's indexing activities have been expanded significantly to include description of the characteristics of gene sequences published in journals indexed by the Library. These special indexing data are incorporated into the products and services of NLM's National Center for Biotechnology Information.

The Literature Section Technical Review Committee (LSTRC) (Appendix 7) advises NLM on the selection of journals to be indexed in MEDLINE and *Index Medicus*. In FY 1990, the LSTRC reviewed 306 journals and gave 71 of them a sufficiently high priority to warrant their

immediate addition to MEDLINE and *Index Medicus*. After reviewing reports prepared by professional associations in the fields of dermatology, oncology, and epidemiology, the Committee recommended the selection of 14 titles in these fields and the deselection of 19 others. A LSTRC subcommittee completed written guidelines on the selection of titles to be indexed. A new module of the Library's Master Serials System was implemented to support the journal selection and review process. Staff also compared a sample of LSTRC evaluations of journals with citation impact factors for the same journals.

About 391,000 indexed citations were added to MEDLINE during the year (table 4). NLM entered the authors' abstracts into the database for the 70 percent of the articles that included them. MEDLARS indexing is done by a combination of NLM staff, international MEDLARS centers, cooperating agencies such as the American Dental Association, the American Journal of Nursing, and the American Hospital Association, and commercial contractors. The NLM staff is responsible for quality review of all indexing.

In its continuing effort to alert users to data in biomedical journals that have been identified as fraudulent, erroneous, or potentially flawed, NLM added information to MEDLARS databases about 14 retractions, 2,906 published error notices, and 8,189 substantive commentaries on previously indexed articles. The Library has also developed a procedure for announcing retracted monographs or parts of monographs in CATLINE®.

Enhancements to automated support for indexing included the replacement of the terminals used by NLM's indexing contractors with more modern and reliable hardware, the conversion of the last of the contractor indexers to the online system, the acquisition of the first of the new PC workstations to be used by NLM indexers, and the beginning of an effort to modify the indexing system to accommodate the nonjournal citations included in such files as BIOETHICSLINE® and HISTLINE®. In FY 1990 the Library contracted for two research projects related to indexing:

- William Hersh, M.D., will evaluate the relative retrieval performance of AIDS meeting abstracts indexed by: 1) text words only, (2) text words in combination with MeSH headings assigned by a program that makes use of information in the UMLS Metathesaurus, and (3) textwords in combination with MeSH headings assigned by human indexers.
- Herner & Company will analyze data about how well NLM's indexing covers the significant points in biotechnology articles as identified by researchers in the field. If the results of this study suggest that the methodology used in this analysis can be adapted to other subjects, several clinical subjects will be examined in a similar fashion.

Network Services

NLM's direct services to local and remote users include: disseminating authoritative bibliographic data in publications, machine-readable formats, and an online retrieval service; providing reference assistance in response to visitor, telephone, and written requests; providing documents from the NLM collection to onsite users and to remote health professionals and researchers as a back-up to other U.S. libraries; and directing the Regional Medical Library Network, which attempts to equalize access to information for all U.S. health professionals regardless of their geographic location or institutional affiliation. The expansion and enhancement of these traditional outreach activities are a critical part of the major outreach initiative recommended in the Board of Regent's Outreach Panel's report and mandated and funded by Congress (see Special Initiatives Section).

Publications. Despite the wide availability of its data in machine-readable databases and online services, NLM's publications continue to be an important vehicle for worldwide distribution of the Library's authoritative indexing and cataloging data and of information needed by users of NLM's online services. In FY 1990, NLM produced more than 100 individual issues of some 27 recurring indexes and catalogs, ranging from comprehensive publications such as *Index Medicus*[®] and the *National Library of Medicine Current Catalog* to more specialized tools such as the *AIDS Bibliography*.

Publications introduced or substantially revised in FY 1990 included: *Gratefully Yours*, a newsletter aimed at individual users who search NLM's databases online; the 1984-1989 cumulation of the *Bibliography of the History of Medicine*; a reprint of the current edition of the *National Library of Medicine Classification*; the *1990 Medical Subject Headings Tree Structures* to which special "tree annotations" were added; and the *AIDS Bibliography*, which was expanded to include citations from CATLINE[®] and AVLINE[®].

A preliminary report of the results of the U.S. library survey portion of the study of the current use of *Index Medicus* and *Abridged Index Medicus* was prepared by the Region 4 RML Office. Samples of *Index Medicus* subscribers in other countries are also being surveyed. The purpose of the study is to determine how these products are used, when and why they are consulted in preference to some machine-readable form of MEDLINE, and how they and NLM's electronic products can be enhanced to serve users better. The results will be published in FY 1991.

Machine-readable databases. To facilitate access to its authoritative data, NLM leases complete databases and subsets of selected databases in machine-readable form. The licensees include commercial database vendors, other segments of the information industry, international



Sheldon Kotzin, Chief, Bibliographic Services Division;
Lou Knecht, Deputy Chief

MEDLARS centers, and academic health science centers. These organizations then make NLM data available online or in CD-ROM products.

In FY 1990, the Library distributed more than 4,500 tapes of various databases to domestic and international licensees. MEDLINE data are now available to licensees on a weekly schedule. License agreements were established with 14 new organizations, bringing the total number of agreements up to 87. At the end of the year there were 12 commercially available CD-ROM products containing MEDLARS data. Specific actions in FY 1990 included:

- Upgrading of AVLINE MARC tapes to conform to the current version of the MARC format and to allow distribution of MARC records for computer software.
- Revising the charges for MEDLARS data to be incorporated on CD-ROMs to differentiate between single and multiple use products and to ensure similar charges for similar use of MEDLARS data whether on tape or CD-ROM.
- Distributing a quality assurance "self-test" including sample searches to licensees of full databases. This is part of NLM's effort to ensure the currency and accuracy of the MEDLARS data provided through other organizations and the effectiveness of their retrieval programs.
- Improving the efficiency of the tape distribution process by contracting out the distribution of some databases.
- Developing a prototype expert system to assist with pricing MEDLARS data.

Online services. NLM provides online access to 43 databases, including the MEDLINE and TOXLINE[®] backfiles. In FY 1990, online users were connected to

NLM's system for a total of 333,685 hours and conducted 4.8 million searches (tables 6 and 7). These figures do not reflect use of MEDLARS data on the computer systems of other organizations that lease NLM files.

As a result of outreach efforts by NLM and the RML Network libraries, the number of codes for use of NLM's online system continues its 5-year pattern of extremely rapid growth. At the end of FY 1990, there were 39,758 assigned codes, an increase of 28 percent from the end of the previous year. The special student code program continues to be popular and has been extended to Canada and, through Great Britain, to the Republic of Ireland. There are now 7,068 institutional and individual student codes. Individual users of NLM's online services now outnumber institutional users and represent 52 percent of all domestic code holders.

Eighty-four percent of the individuals who received new codes in FY 1990 indicated an intention to use the Grateful Med microcomputer front-end package to access NLM's databases. Version 5.0 of Grateful Med for the PC and Version 1 of Grateful Med for the Apple Macintosh microcomputer were issued in FY 1990. A total of 28,128 copies of Grateful Med (25,041 IBM PC versions; 3,087 Macintosh) have been sold by the National Technical Information Service since the package was introduced in March 1986. Purchasers receive new versions at no additional cost as they become available.

In FY 1990, NLM produced demonstration disks for both versions of Grateful Med. The disks simulate simple searches and have order forms and code application forms that can be printed out, completed, and returned to NLM. Improvements incorporated in Version 5.0 of the PC Grateful Med included: additional MeSH information; an expanded citation review capability, allowing both forward and backward browsing; easy incorporation of MeSH terms suggested by the program into follow-up searches; and improved "set-up" features to simplify telecommunications and trouble-shooting.

In addition to enhancing Grateful Med, NLM made improvements to MEDLARS databases, to the capabilities of ELHILL (the retrieval software used on NLM's mainframe computer system), and to the support mechanisms for NLM's online users. To make current information available more rapidly, the Library increased the frequency of MEDLINE updates from biweekly to weekly. AIDSLINE®, a database of citations to the literature about acquired immunodeficiency syndrome, was further expanded to include abstracts from international AIDS conferences. The Author's Address is now retained in new citations added to MEDLINE. The ELHILL retrieval system was enhanced to permit online sorting of citations, automatic "EXPLODE" of all tree numbers to which a MeSH term is assigned, and an increase in the maximum size of an index to a MEDLARS database.

The Library continued its efforts to streamline procedures for assigning online codes and is preparing to obtain contract assistance for keying data for new online codes and address changes. The test of flat-rate per-code online pricing was expanded to a total of five institutions.

The tremendous growth in the number of individual online users has increased the number and altered the character of calls received at NLM's online service desk. The Library now receives an average of more than 200 service desk calls per day. Many additional requests for information or assistance are received via the Grateful Med Bulletin Board. As in past years, NLM analyzed service desk calls in general, and Grateful Med-related calls in particular, to identify major user problems and concerns.

As part of its increased emphasis on outreach, the Library staff exhibited NLM's products and services and presented short courses on searching via Grateful Med at a number of meetings of associations of health professionals. Expanding on a program begun in FY 1989, NLM trained selected FASEB Summer Research Conference attendees to demonstrate Grateful Med to their colleagues at all such summer conferences held in 1990. A total of 915 librarians and other search intermediaries received basic or follow-up training in online searching from staff at NLM or one of the three Regional Medical Libraries that provide such training under contract to the library.



Left, Eve-Marie Lacroix, Chief, Public Services Division; Right, Martha Fishel, Deputy Chief

Reference services. NLM provides reference and research assistance to onsite users and to remote users as a back-up to the services of other U.S. health sciences libraries. In FY 1990, the Library received 60,630 requests for reference assistance, 67 percent from onsite users, 31.7 percent in telephone calls, and 1.3 percent in letters (table 8). A new telephone answering system implemented in FY 1990 has reduced considerably the number of calls referred to reference staff by allowing callers to select recorded answers to frequently asked questions.

Service to onsite users and NLM staff was improved substantially through the implementation of a CD-ROM network that provides access from the same workstation to a variety of CD-ROM reference tools and to MEDSTATS, an expert system designed to help users and staff locate the sources of answers to specific statistical questions. Work was completed on the content of an automated guide to the use of NLM's onsite services. The guide will be installed and evaluated in FY 1991.

NLM's reference staff provide special literature search service in support of the NIH Consensus Development Conferences. The searches prepared as background for conference attendees are also published as part of NLM's Current Bibliographies in Medicine. Among the topics covered in FY 1990 were: treatment of early-stage breast cancer; sleep disorders of older people; and cocaine, pregnancy and the newborn.

This year NLM began to provide extensive literature search service to panels convened by the new Agency for Health Care Policy and Research to develop clinical practice guidelines. (See Special Initiatives Section). Segments of these literature searches will also be published in the Current Bibliographies in Medicine series.

Document delivery. NLM provides document delivery service to remote requesters as a back-up to the service provided by other libraries in the Regional Medical Library Network and also to onsite users who need items from NLM's closed stacks (table 5). In FY 1990, the Library received 258,421 interlibrary loan requests, 13 percent more than in FY 1989. Seventy-one percent of the requests were filled; if requests for which the requestor was unwilling to pay NLM's charge are removed from the calculation, 78 percent were filled. NLM received 81 percent of its interlibrary loan requests via DOCLINE, NLM's automated document request and routing system. A total of 4,088 requests were received via telefacsimile transfer; 2,619 of these were for materials needed for clinical emergencies and were processed within two hours.

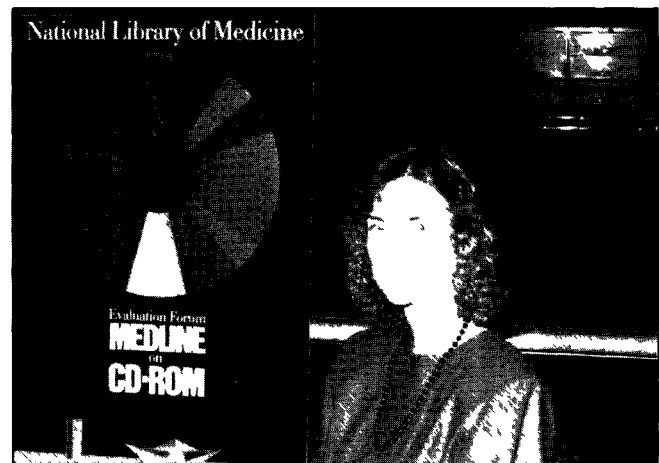
In FY 1990, NLM issued a contract for assistance in retrieving items requested under interlibrary loan. A backlog of requests for items from the historical collections which had to be microfilmed before the requests were filled was eliminated. LO, the Lister Hill Center,

and the Office of Computer and Communications Systems are collaborating to test the combined use of stored images of selected journal articles, DOCLINE, and telefacsimile technology to allow NLM to fill some of its interlibrary loan requests without retrieving the physical items from its stacks. This project, known as the System for Automated Interlibrary Loan (SAIL), is also described in the Lister Hill Center Chapter.

A total of 1,977 libraries are current DOCLINE users. In FY 1990, these libraries entered 1,877,754 requests into the system; 93 percent were filled. DOCLINE now routes serial requests based on more than 1,200,000 SERHOLD® records, representing the serial holdings of more than 2,900 institutions. During the year DOCLINE was enhanced to allow cancellation of requests, to increase the number of simultaneous users accommodated, and to include a fax-only routing option.

Loansome Doc, a system that allows health professionals to use Grateful Med to request copies of documents from a specific library in the RML network, is currently undergoing testing in Region 7. Using the Loansome Doc software, Grateful Med creates a document request and uploads it to DOCLINE for transmission to the library that has agreed to serve the user. If this library cannot provide the requested item, the request is routed through DOCLINE to a library that can fill it. If the results of the Region 7 test are positive, Loansome Doc will become available to Grateful Med users throughout the country in FY 1991.

Onsite users made 198,483 requests for documents from the NLM stacks in FY 1990, 8 percent more than in the previous year. Eighty-four percent of the requests were filled, 82 percent within 30 minutes of receipt. Since the implementation of NLM's online patron registration and request logging system in February 1988, 24,320 people have registered to request documents onsite at the Library.



Becky Lyon-Hartmann, RML Program Coordinator

Regional Medical Library Program. The purpose of the Regional Medical Library Network is to improve and equalize access to biomedical information in the United States by linking health professionals and researchers to the information resources they need, regardless of their geographic location. There are 3,373 network members including health sciences libraries of every size and type in all parts of the country. NLM's Regional Medical Library Program Office provides national coordination of the network. The RML Program is a cornerstone of NLM's outreach program and its services are being revised and enhanced as part of NLM's expanded outreach initiative (see also Special Initiatives Section).

In each multistate region of the Network, NLM contracts with a distinguished medical library to coordinate network members within the Region to provide document delivery, encourage resource sharing, support use of online services, and develop innovative outreach services to health professionals. The Regional Medical Libraries are supported by more than 130 large Resource Libraries, generally in medical schools, and many hospital and special libraries, individually and in consortia.

FY 1990 was the last full year of the current 5-year RML contracts and recompetition of new contracts is under way. Under the new contracts, the RML Network will be reconfigured from 7 to 8 regions, with the New England states designated as the eighth region. The new contracts, to be awarded in 1991, increase the role of the RMLs in outreach to individual health professionals, calling on them to serve as a "field force" for NLM and its products and services.

The role of the RMLs in outreach has expanded through several outreach enhancement projects. In addition to established outreach projects being conducted through the RMLs in West Virginia and the Pacific Northwest, six new outreach enhancement projects were funded this year. Some are being carried out directly by RML staff while others involve the RML working through network libraries in the targeted areas. The six new projects are in Massachusetts, New York, Western Maryland, Southern Iowa, Oklahoma, and North and South Dakota.

NLM has also increased its support of outreach efforts to specific network libraries by awarding 30 competitive contracts aimed at introducing Grateful Med to health professionals who are not currently affiliated with a medical library, and providing them with a link to information services from a health sciences library. Proposals were solicited from members of the RML Network in March 1990. The contracts, which range up to \$25,000, were awarded to 17 hospitals and 13 academic institutions and associations. Overall management of this outreach effort will be handled by staff in NLM's RML Office.

The projects will target a wide range of health professionals in both rural and urban underserved areas and will be based in 22 states and the District of Columbia. Training packets were sent by NLM to all recipients as well as to the Regional Medical Libraries. The contracts, all of which have an evaluation component, will cover an 18-month period ending in March 1992.



Right, Robert Mehnert, Chief, Office of Public Information (Office of the Director); Left, Roger Gilkeson, Deputy Chief

Special Onsite Programs.

In addition to the reference and document delivery services provided to onsite patrons, NLM offers a variety of special programs and services to people who come to the Library in Bethesda, including guided tours, briefings on NLM's services and operations, and historical exhibits and symposia. NLM also sponsors a Visiting Historical Scholar Program and conducts a one-year training program for library school graduates with potential for leadership roles in health sciences information.

Public tours and briefings. Each year NLM entertains many visitors from throughout the United States and around the world. In FY 1990, LO staff members conducted 147 regular daily tours for a total of 413 visitors. The Office of Public Information (Office of the Director) arranged special tours and orientation programs for 127 groups (1,354 visitors). NLM staff members also arranged special briefings on library programs and services for many individual visitors.

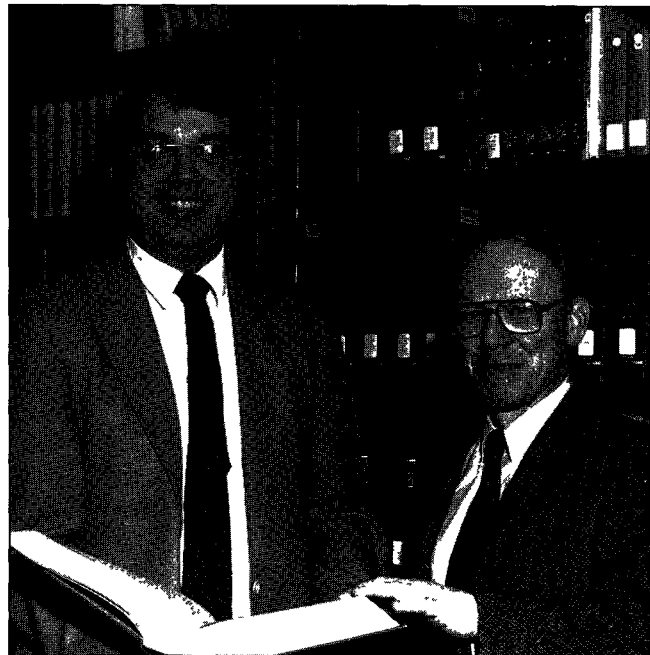
Historical Programs. The FY 1990 Visiting Historical Scholar was Diana Long, Ph.D. Each year a recognized historical scholar is selected competitively to spend 6 to 12 months at NLM to engage in research that will use the Library's collections, to give one or more public presentations, to assess segments of NLM's historical collection and to consult with staff. Dr. Long used NLM's

collection to carry out research on the history of the Index-Catalogues and early indexing policies at NLM. She presented a lecture on "The Index-Catalogues of the Surgeon-General's Library, 1880-1961: Indexers, Vocabularies, and Values."

In FY 1990, the History of Medicine Division prepared several special exhibits, presentations, brochures, and other materials. With the aid of consultant William Helfand and the NIH Medical Arts and Photography Branch, NLM prepared a traveling exhibit of public health posters from its collection. After an initial showing at NLM, the exhibit will appear at 10 museums and medical libraries over the next 2 years. Also, major lobby exhibits were prepared on natural history and its relationship to medicine, experimental embryology, and public health in nineteenth century New York City.

The Library co-sponsored with the University of Maryland a third medicine and the arts symposium entitled "The Medicinal Muses: The Therapeutic Value of the Arts." Individual staff members continued their research using NLM's historical collections. Staff research was published in several publications and presented at invited lectures throughout the year.

NLM Associate Program. The NLM Associate Program is a one-year competitive program that provides library school graduates an opportunity to learn about NLM's operations, to gain a better understanding of the key issues facing all health sciences libraries, to use new information technologies, and to develop their skills by conducting special projects. Projects undertaken by Associates in FY 1990 included a study of the feasibility of using search statements devised for accessing MEDLARS databases as a basis for searching non-NLM databases, an analysis of the subsequent publication in journals of work presented at AIDS-related meetings, and testing of optical scanners for use in converting



Left, John L. Parascandola, Ph.D., Chief, History of Medicine Division; Right, Philip Teigen, Ph.D., Deputy Chief

manuscript finding guides to machine-readable form. Associates also have an opportunity to visit the other national libraries and various types of health sciences libraries or information centers and to attend professional meetings. NLM staff members continue to attend portions of the Associates' formal curriculum.

Four Associates completed the 1990/90 program. Three have made career plans: One accepted a position at NLM; one joined an academic medical library; and one joined a private information company. Four new Associates began the program in September 1990.

Table 1
Growth of Collections

<i>Collection</i>	<i>Previous Total (9/30/89)</i>	<i>FY 1990</i>	<i>New Total</i>
<i>Book Materials</i>			
<i>Monographs:</i>			
Before 1500	571	0	571
1501-1600	5,735	13	5,748
1601-1700	10,044	13	10,057
1701-1800	24,320	42	24,362
1801-1870	39,843	78	39,921
Americana	2,340	1	2,341
1870-Present	523,302	14,665	537,967
Theses (historical)	281,794	0	281,794
Pamphlets	172,021	0	172,021
Bound serial volumes	891,724	25,917	917,641
Volumes withdrawn	(34,942)	(92)	(35,034)
Total volumes	1,916,752	40,637	1,957,389
<i>Nonbook Materials</i>			
<i>Microforms:</i>			
Reels of microfilm	48,269	5,846	54,115
Number of microfiche	223,871	14,885	238,756
Total microforms	272,140	20,731	292,871
Audiovisuals	48,598	1,578	50,176
Computer software	244	268	512
Pictures'	55,958	642	56,600
Manuscripts	2,191,704	136,525	2,328,229

*1989 total adjusted based on retrospective conversion of prints and photographs collection

Table 2
Acquisition Statistics

<i>Acquisitions</i>	<i>FY 1988</i>	<i>FY 1989</i>	<i>FY 1990</i>
Serial titles received	20,726	21,781	21,557
Publications processed:			
Serial pieces	133,226	137,849	144,356
Other	20,101	18,382	21,068
Total	153,327	156,231	165,424
Obligations for:			
Publications	\$3,495,123	\$3,526,901	\$3,632,746
Included for rare books	(\$156,446)	(\$182,584)	(\$203,559)

Table 3
Cataloging Statistics

<i>Item</i>	<i>FY 1988</i>	<i>FY 1989</i>	<i>FY 1990</i>
Completed Cataloging			
Full	14,567	11,985	12,060
Limited	5,721	6,748	7,309
Total	20,288	18,733	19,369

Table 4
Bibliographic Services

<i>Services</i>	<i>FY 1988</i>	<i>FY 1989</i>	<i>FY 1990</i>
Citations published in MEDLINE	329,019	372,806	391,172
For <i>Index Medicus</i>	313,963	352,206	363,890
Recurring bibliographies	28	26	28
Journals indexed for <i>Index Medicus</i>	2,855	2,888	2,973
Abstracts entered	197,674	233,707	275,000

Table 5
Circulation Statistics

<i>Activity</i>	<i>FY 1988</i>	<i>FY 1989</i>	<i>FY 1990</i>
Requests Received:	415,137	414,354	456,904
Interlibrary Loan	204,484	227,841	258,421
Readers	210,653	186,513	198,483
Requests Filled:	316,508	310,363	349,999
Interlibrary Loan	143,151	158,840	183,950
Photocopy	131,870	146,679	170,605
Original	9,810	10,753	12,054
Audiovisual	1,471	1,408	1,291
Readers	173,357	151,523	166,049
Requests Unfilled:	96,283	101,009	106,905
Interlibrary Loan	61,333	69,001	74,471
Referred	2,125	2,850	3,431
Returned	59,208	66,151	71,040
Reader Service			
Returned as unavailable	34,950	32,008	32,434

Table 6
Online Searches

DATABASES	FY 1988	FY 1989	FY 1990
AIDSDRUGS	—	48	247
AIDSLINE	2,977	18,940	24,525
AIDSTRIALS	—	95	768
AVLINE	11,937	11,989	12,879
BIOETHICS	7,888	8,196	8,505
CANCERLIT*	54,759	61,070	63,898
CATLINE	160,129	157,783	158,293
CCRIS	2,894	3,060	2,983
CHEMID	—	—	3,497
CHEMLINE ^N	24,907	24,674	22,683
CLINPROT*	2,956	2,763	2,432
DART TM	—	—	1,244
DBIR TM	—	657	1,942
DENTALPROJ	—	121	262
DIRLINE	6,107	7,271	7,120
DOCUSER*	973	2,646	3,309
EMICBACK	—	331	1,517
ETICBACK	—	1,316	1,627
HEALTH	121,589	128,658	136,616
HISTLINE	4,131	4,341	4,643
HSDB*	31,976	32,641	34,939
INFORM	146	115	127
INTROMED*	4,955	692	—
INTROTOX	43	—	—
IRIS	—	—	4,959
LOAN STATUS	—	—	211
MEDLINE	1,895,591	1,782,750	2,058,301
MED86	—	567,991	602,394
MED83	526,338	492,092	402,341
MED80	276,753	254,539	225,340
MED77	140,990	144,562	132,976
MED75	16,018	—	—
MED72	75,518	99,358	91,601
MED71	15,731	—	—
MED66	64,423	70,202	68,373
MESH VOCABULARY*	20,158	20,542	20,448
NAME AUTHORITY*	3,120	3,580	3,179
PDQ	44,822	69,158	69,684
POPLINE*	20,849	22,534	19,140
REFLINE	31,967	38,799	41,902
RTECS*-ELHILL	2,703	—	—
RTECS-TOXNET	13,693	17,346	16,303
SDILINE*	38,956	39,812	41,185
SERLINE*	49,137	53,532	55,038
STORED SEARCH	83	130	107
TOXLINE*	68,398	71,101	68,911
TOXLINE65	—	5,202	9,962
TOXLIT	24,171	20,877	15,516
TOXLIT65	8,742	7,087	5,116
TRI	—	12,158	30,625
YEAR86	201	2	655
Total	3,776,729	4,260,761	4,478,323

Table 7
Offline Searches

DATABASES	FY 1988	FY 1989	FY 1990
AIDSLINE	5	191	1,294
AVLINE	208	126	103
BIOETHICS	34	38	25
CANCERLIT	3,726	3,842	3,654
CATLINE	517	558	536
CHEMLINE	4	—	1
CLINPROT	3	2	0
DIRLINE	2	—	4
DOCUSER	—	1	0
HEALTH	11,173	11,516	10,983
HISTLINE	8	6	9
MEDLINE	8,960	6,115	4,630
MED86	—	7,380	5,993
MED83	13,862	8,823	5,211
MED80	11,014	5,971	3,557
MED77	7,332	3,830	2,073
MED75	1,320	—	—
MED72	3,141	2,440	1,452
MED71	871	—	—
MED66	2,757	1,510	838
MESH VOCABULARY	7	1	1
POPLINE	5,337	5,378	5,107
RTECS-TOXNET	3	—	—
SDILINE	231,269	247,812	229,625
SERLINE	3	6	10
TOXLINE	15,474	12,731	6,608
TOXLINE65	—	35	76
TOXLIT	366	145	5,497
TOXLIT65	312	119	103
Total	317,708	318,576	287,390

Table 8
Reference Services

<i>Activity</i>	<i>FY 1988</i>	<i>FY 1989</i>	<i>FY 1990</i>
Reference Section:			
Requests by telephone	26,429	21,481	19,222
Requests by mail	743	985	585
In-person requests	48,935	39,374	40,823
Total	76,107	61,840	60,630

Table 9
History of Medicine Activities

<i>Activity</i>	<i>FY 1988</i>	<i>FY 1989</i>	<i>FY 1990</i>
Acquisitions:			
Books	125	127	360
Modern manuscripts	166,429	946,750	128,088
Prints and photographs	214	3,420	642
Processing:			
Books cataloged	442	346	232
Modern manuscripts processed*	**	48,001	112,541
Pictures cataloged	138	0	0
Citations indexed	5,645	5,479	5,136
Pages microfilmed	48,774	27,140	66,581
Public Services:			
Reference questions answered	10,077	10,244	13,982
ILL and pay orders filled	3,607	2,406	3,506
Reader requests filled	10,416	8,309	9,358
Pictures supplied	6,642	6,045	5,872

* Revised category.

** Figure not available

SPECIALIZED INFORMATION SERVICES

Henry Kissman, Ph.D.
Associate Director

Concern about the environment and the effects of environmental pollutants on human health reached new heights in 1990. The twentieth anniversary of Earth Day was celebrated in April with extensive fanfare worldwide. According to a recent Gallup Poll, a large majority of Americans think that action is necessary in order to avoid major environmental disruptions. The need for information about the consequences for man and the environment of pollution by hazardous chemicals is great. NLM's Specialized Information Services Division (SIS), through its Toxicology Information Program, continues to respond to that need with a variety of information services.

The NLM online files for which SIS has responsibility are made available to the public through two computer systems—NLM's mainframe system, ELHILL, and TOXNET, a system specially built for the toxicology databases. In FY 1990, SIS made major changes to its files in both of these environments.

On the ELHILL side, SIS introduced a new, royalty-free, online chemical dictionary and directory file, called ChemID (Chemical Identification File). ChemID helps users identify chemical substances and formulate strategies to search other MEDLARS files. ChemID also contains a set of unique capabilities, collectively known as SUPERLIST, which provide the names and the source of chemicals found on one or more of 16 Federal and State government lists having major regulatory or biomedical importance.

Health Hotlines, a publication derived from DIRLINE (Directory of Information Resources Online), was updated. This publication contains descriptions of organizations with toll-free telephone numbers that provide health-related information and other services to the public. *Health Hotlines* is a very popular item; over 60,000 copies have now been distributed.

In the TOXNET (Toxicology Data Network) system, the number of online databases was expanded to 10. The 1988 reporting year data for the Toxic Chemical Release Inventory (TRI88) file has joined the 1987 data (TRI87) as the first two in a series of annual files operated by NLM for the Environmental Protection Agency (EPA). These data collections were required by the Emergency Planning and Community Right-to-Know Act of 1986. They provide the public with information about the release of EPA-specified hazardous chemicals to the air, water,



Right, Henry M. Kissman, Ph.D., Associate Director for Specialized Information Services; Left, George J. Cosmides, Ph.D., Dep. Asso. Dir.

or land. The data are collected on an annual basis by the EPA from certain industrial facilities throughout the country.

DART (Developmental And Reproductive Toxicology) was made available to the public, as a new TOXNET bibliographic file. During the first year of operation, about 3,600 records are being added to cover the literature published since 1989.

A joint two-year effort involving SIS and NLM's National Center for Biotechnology Information is now under way for a total redesign of the TOXNET system in a Relational Database Management System (RDBMS) structure that can be operated within the Library.

Thus, through its computerized services, SIS strives to provide information that will be used by professionals and the public-at-large in making informed decisions on how to protect the environment and preserve the public health.

SIS Databases under ELHILL

ChemID (Chemical Identification File) is a new online chemical dictionary that covers primarily chemicals of biomedical and regulatory importance. Available at normal MEDLARS rates without the royalty charges required by CHEMLINE, ChemID allows users to search by a variety of chemical and biological identifiers; to for-

ulate strategies for searching other MEDLARS files; and to locate other files on the ELHILL and TOXNET systems, or external sources, which contain more information about the chemical in question. The first version of ChemID, containing 180,000 records, was made available on the ELHILL system in February 1990.

In July 1990, a new set of data, collectively known as SUPERLIST, was added to the file. Over 5,600 records were augmented with the name and an indication of source for chemicals mentioned in one or more of 16 lists of regulatory or biomedical importance. Coverage included such lists as the Department of Transportation Hazardous Materials List, the Hazardous Substances Reportable Quantities (RQ) List, and the Massachusetts Substance List. These new 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. Another nine lists are being processed into this file. SUPERLIST begins an important new link to the variety of information sources which are of importance in creating a Federal and State regulatory picture of a chemical.

CHEMLINE (Chemical Dictionary Online) 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); users must pay CAS royalty fees to use CHEMLINE. Originally made available in January 1974 with about 59,000 records, the file now contains over 975,000 records of chemical substances.

During FY 1990 the scope of coverage of the CHEMLINE file continued to increase. CHEMLINE now covers substances in the AIDS DRUGS file on ELHILL, as well as the TRI, IRIS, DART, and EMICBACK files on TOXNET. For seekers of regulatory information, the data from the U.S. Environmental Protection Agency's Toxic Substances Control Act (TSCA) Inventory was updated, and new pointers were added for EINECS, the European Inventory of Commercial Chemical Substances. Data from all sources contributing to CHEMLINE were updated and enhanced during the file regeneration of 1990. This included a major improvement in the indexing of the molecular formula field, which makes comprehensive searching with these data easier and somewhat less expensive.

TOXLINE (Toxicology Information Online) is an online bibliographic retrieval service produced by merging "toxicology" subsets from some 17 secondary sources, including Biological Abstracts, Government Reports Announcement and Index (report literature),

International Pharmaceutical Abstracts, and MEDLINE. TOXLINE and its backfile, TOXLINE65, contain data from sources which 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 approximately 3 million records, more than a ten-fold increase in the number of records since TOXLINE was first made available in September 1972.

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.

During FY 1990 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. One new subfile was added to TOXLINE, and another is under development and is expected to be added in early 1991. The new FEDRIP subfile expands the coverage of research reports in toxicology by obtaining information from Federal Research-In-Progress (FEDRIP), an NTIS resource covering mostly Federally supported research projects. This new subfile allows TOXLINE to carry more than the Public Health Service-supported research projects in toxicology that have already been covered by the CRISP subfile. Under development is the DART subfile, derived from a new database on Developmental and Reproductive Toxicology, available on NLM's TOXNET system.

DIRLINE (Directory of Information Resources Online) is an online directory of organizations with information resources and subject expertise, that 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.

DIRLINE is made up of 11 subfiles from such sources as the National Referral Center database from the Library of Congress; the DHHS Office of Disease Prevention and Health Promotion's National Health Information Center database; the National Center for Education in Maternal and Child Health; the National Institutes of Health directory of research resources; a subset of the National AIDS Information Clearinghouse database of national AIDS-related organizations; and the Self-Help Clearinghouses, organizations collaborating with the Surgeon General's Initiative in Self-Help and Public Health. The newest subfile, Health Care Technology Assessment (HCTA), was added in 1990. Most of the

organizations in this subfile conduct such assessments and produce reports of the results.

A contract to provide MeSH indexing for all the records in DIRLINE was completed in 1990. The availability of MeSH terms will facilitate online retrieval from DIRLINE. Grateful Med 5.0 was programmed to include the ability to use MeSH in order to search DIRLINE.

Health Hotlines, a booklet listing organizations in DIRLINE with toll-free telephone numbers, was updated and redistributed in February 1990. This has been a very popular and sought-after publication; over 60,000 copies have been distributed to all sectors of the public, including libraries, health departments, newspapers, magazines, and private citizens.



Melvin L. Spann, Ph.D., Chief, Biomedical Information Services Branch

AIDS

The Health Omnibus Programs Extension Act of 1988 mandated the development of several AIDS-related information services, including a data bank on clinical trials and treatments. In response to that mandate, SIS and OCCS have built two new MEDLARS databases, AIDSTRIALS and AIDS DRUGS. These databases, which became publicly available at the end of last year, were enhanced and improved during FY 1990.

AIDSTRIALS contains descriptions of experimental clinical trials of agents being tested for effectiveness against AIDS, HIV infection and AIDS-related opportunistic infections. This database was enhanced through the addition of indexing using Medical Subject Headings (MeSH). Trial categories were defined and added to the database to improve retrieval. The format of the trial location information was improved to permit better selection of trial sites.

AIDS DRUGS contains information about the agents being tested in clinical trials; it was enhanced with the addition of bibliographic references to allow users to find additional relevant information about these experimental agents. The AIDS component in DIRLINE was expanded from approximately 350 records to over 1,100 by the addition of Federal and international organizations.

SIS staff participated in the Sixth International Conference on AIDS in San Francisco. A poster session was presented highlighting the importance of information in the fight against this epidemic. An exhibit displayed all of NLM's AIDS-related activities and gave visitors an opportunity to search the online databases. Staff also participated in the Conference's Media Center to provide access to NLM's databases for representatives of the press.

TOXNET and Its FILES

With funding authorized under the Superfund Amendments and Reauthorization Act of 1986, SIS has worked for several years on information activities for the Agency for Toxic Substances and Disease Registry (ATSDR). These activities include file building and the creation of improved methods of access to information resources for hazardous chemicals and emergency response. The continued development of the TOXNET system, the enhancement of the Hazardous Substances Data Bank (HSDB), and the development of a microcomputer workstation for chemical emergency response (see below) have been the predominant SIS activities under this collaboration.

During FY 1990, three new files were added to the TOXNET system, bringing the total to ten. They were: TRI88 (the Toxic Chemical Release Inventory's 1988 reporting year data), IRIS (Integrated Risk Information System), and DART (Developmental and Reproductive Toxicology). TOXNET's online usage increased substantially throughout the year. Usage of the TOXNET-to-ELHILL gateway, a transparent switching mechanism whereby users can gain access to all other NLM files, has also set new usage records in 1990.

One of the major system-wide enhancements to TOXNET was the implementation of CROSSFILE searching and printing among certain chemically linked files, such as HSDB, RTECS, CCRIS, and IRIS, as well as the TRI files (TRI87, TRI88). CROSSFILE permits users to search for and/or display data from multiple files simultaneously; it can greatly improve search efficiency.

As TOXNET grows in size and usage, NLM is considering some fundamental changes in the basic design of the system. A 1989 evaluation study recommended that the system be rewritten from MIIS, its current computer language, to the MUMPS language. MUMPS is

available to operate on many hardware platforms including—potentially—the NLM mainframe computer. As a result of this recommendation, a MIIS-to-MUMPS conversion of the total TOXNET system is now under way. When this is completed, the system will continue to be operated for the next two years by a contractor.

In parallel with this contractor-based effort, the use of Relational Database Management System (RDBMS) technology is being explored for the cluster of files now on TOXNET. This in-house effort was initiated because of expertise in RDBMS technology now available in NLM's National Center for Biotechnology Information. An RDBMS-based system could be operated in-house on NLM equipment. The new system is expected to be available in about two years.

The Hazardous Substances Data Bank (HSDB), an important NLM file on the TOXNET system, experienced a substantial increase in usage in 1990. This file is co-supported, as a Superfund activity, by ATSDR. Enhancements this year included the addition of emergency medical treatment data supplied by MICROMEDEX, Inc. During this period, 325 chemical records were peer-reviewed by the Scientific Review Panel (SRP), and over 560 records went through Public System Updates. Hazard summaries are now being prepared, by in-house staff, for each peer-reviewed record; while environmental summaries are being prepared by a contractor. Staff-prepared toxicity summaries for peer-reviewed record will be added during the next year.

A special HSDB two-day planning retreat was held in May 1990 to examine various alternatives for increased efficiency in building and reviewing this data bank. Members of the SRP participated in this activity.

The Toxic Chemical Release Inventory (TRI) files (TRI87 and TRI88) quickly established themselves as important information resources. TRI is 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, with the names and addresses of the industrial facilities reporting for the years 1987 and 1988. Public interest and online usage of these files have been high.

The TRI files incorporate several new TOXNET features designed specifically for them. The "novice" menus, allowing inexperienced users easy access, are being enhanced to permit greater search flexibility. A SORT feature now permits data to be arranged numerically or alphabetically by virtually any TRI data element.

The Chemical Carcinogenesis Research Information System (CCRIS) is maintained on TOXNET by the National Cancer Institute. This data bank contains test results from carcinogenicity, mutagenicity, and tumor promotion studies. Tumor inhibition studies and addi-

tional negative mutagenicity studies were added in FY 1990. CCRIS now contains more than 2,000 records.

During FY 1990, the Developmental And Reproductive Toxicology (DART) database was made available on the TOXNET system. DART contains about 3,600 citations from 1989 and later to publications on agents that 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 for all chemicals mentioned in the publications. Over half of the records are derived from MEDLINE and supplemented with additional chemical index terms. Additional records that are not found in MEDLINE, such as meeting abstracts, articles from journals not indexed for MEDLINE, books, and technical reports, make up the remainder. Plans are under way also to add the records in DART to TOXLINE.

DART is a continuation of the Environmental Teratology Information Center Backfile (ETICBACK) database on TOXNET that was produced by the Department of Energy's Oak Ridge National Laboratory (ORNL). ETICBACK contains over 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. A backfile for EMIC (EMICBACK) has been publicly available through NLM's TOXNET system since June 1989. EMICBACK contains over 70,000 citations to literature, published since 1950, on agents that have been tested for genotoxic activity.

Records in EMICBACK contains bibliographic citations, EMIC special keywords, and the names and CAS Registry Numbers for all chemicals tested. Beginning in FY 1991, the EMIC database for literature since 1990 will be built and maintained on the TOXNET system.

These four bibliographic databases on TOXNET are funded by the Agency for Toxic Substances and Disease Registry (ATSDR), the Environmental Protection Agency (EPA), and the National Institute of Environmental Health Sciences (NIEHS), and are operated by NLM.

IRIS (Integrated Risk Information System) is another new file which had its debut on TOXNET in 1990. IRIS is generated by the EPA and contains health risk and EPA regulatory information on over 400 chemicals. Health risk assessment data is provided for both carcinogenic and non-carcinogenic effects by oral and inhalation routes of exposure. IRIS data, when combined with information related to chemical exposure assessment, can help State and local regulatory agencies manage chemical risks to the public.

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 of 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. This year, references to the National Occupational Exposure Survey and the National Occupational Hazard Survey, conducted by NIOSH, were added. In addition, SIS continues to enrich RTECS records that lack CAS Registry Numbers with these important identifiers. So far about 30,000 records have been so enhanced. RTECS now contains over 100,000 records.



Bruno M. Vasta, Chief, Biomedical Files Implementation Branch

Microcomputer Workstation

SIS, in conjunction 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 operational 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 emergency 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 (Micro-CSIN)[®] 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 files.

The Workstation has been made available for testing to 13 sites, including selected State health departments and several poison control centers.

User Support Services

User support for all 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 NLM manual are provided directly to system users on request or in training classes. In addition, a special reference manual and other training materials were prepared for SIS by the Oak Ridge Associated Universities (ORAU). 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 was provided in conjunction with the Agency for Toxic Substances and Disease Registry to environmental health specialists from ATSDR and selected State agencies. This program is conducted under SIS direction by ORAU in Oak Ridge, Tennessee. In FY 1990, the project was expanded, with a 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. Individuals from eleven occupational health clinics and the seven organizational members of the American Minority Professional Health Schools have also taken this training.

During FY 1990 SIS developed ELHILL LEARN, a microcomputer-based tutorial for the ELHILL search and retrieval software that supports the majority of the MEDLARS databases. It is intended as a precursor to the CHEMLEARN[®], TOXLEARN[™], and MEDTUTOR[™] microcomputer-based tutorials. While this tutorial is designed primarily for new ELHILL users, it can be used as a quick reference tool to reinforce or recall previously learned search procedures.

The MEDTUTOR and TOXLEARN tutorials were updated to reflect 1990 MeSH and other changes to the MEDLINE and TOXLINE databases. CHEMLEARN is being updated to include the new ChemID file and to reflect any changes to the CHEMLINE file. These programs provide an alternative or augmentation to formal classroom training.

Additionally, the TIP Files Demo Disk was updated to include all the files supported by the Toxicology Information Program. A new feature was added to allow the Demo Disk to run automatically without user-interaction. This should prove useful at exhibits and in reading rooms and libraries.

Other Programs

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

Biotechnology. The Directory of Biotechnology Information Resources (DBIR) was first offered in January 1989 as an online file on TOXNET. It lists various resources available for use by the biotechnology and molecular biology communities. DBIR is now offered to the public as a separate file on TOXNET and as a subset of DIRLINE on the ELHILL system. The resources described include relevant databases and other electronic information services, organizations, collections and repositories, publications, and sanctioned nomenclature committees. During 1990, DBIR has grown to over 1,500 records.

The Seminar Series in Biotechnology has been continued, with these informative talks being videotaped and distributed to NLM's Regional Medical Libraries and to NLM-sponsored medical informatics training programs.

Information services to other agencies. As described, SIS provided support to ATSDR by building, maintaining, and deploying computer-based information resources supportive of ATSDR's legislative mandates. These data and information resources have proven to be of utility to those who are concerned with the effects of chemical, biological, and physical agents on human health and the environment.

SIS provided leadership for the Subcommittee on Information Coordination (SIC) of the HHS Committee

to Coordinate Environmental Health and Related Programs (CCEHRP). Among the activities of this Subcommittee are the development of a DHHS Directory of Risk Assessment Projects, and an attempt to identify the information needs in environmental health epidemiology. SIS also represents NLM on CCEHRP's Subcommittees on Environmental Health Risk Assessment; Hazardous Waste Information Evaluation; Testing and Test Method Validation; and Research Needs.

SIS staff continued to represent the Library on the Congressionally mandated Interagency Task Force on Environmental Cancer and Heart and Lung Diseases and on the National Institute of Environmental Health Sciences' (NIEHS) Annual Review of Carcinogens (ARC) Working Group, which completed deliberations on the structure and content of ARC 6 and 7. The Library also continued to be involved with development of the National Toxicology Program (NTP) Annual Plan and Review of Current DHHS, Department of Energy, and EPA Research Related to Toxicology.



Sidney Siegel, Ph.D., Chief, Office of Hazardous Substances Information

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 National Library of Medicine. 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 signals, images, and sound. 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 4 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 3 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.

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 automated indexing for informa-



Left, Daniel R. Masys, M.D., Director, Lister Hill Center; Right, B. Earl Henderson, Deputy Director

tion classification and retrieval. Issues in knowledge representation, knowledge base structure, knowledge acquisition, the validation of automated consultant systems, the human-machine interface, the use of high-resolution graphics, interactive videodisc capability, and the linking of knowledge-based systems to large-scale mainframe databanks are important components of this research.

Branch staff members are involved in individual and team research projects in various aspects of NLM projects such as the Unified Medical Language System initiative and in the medical informatics and information science research communities. Recognizing the importance of addressing the future of medical informatics by helping to train new researchers, Branch Chief Lawrence Kingsland directs the 8-week annual NIH-sponsored "Medical Informatics" elective for third-year and fourth-year medical students.

Expert systems. Expert systems are computer programs that combine knowledge of a particular subject area with inferencing mechanisms enabling them to use this knowledge in problem-solving situations. An artificial intelligence research program concentrating in expert systems was established at LHNCBC in 1984. The objective of the Expert Systems 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.

During FY 1990, the primary research projects of the Expert Systems Program included the AI/RHEUM consultant system in rheumatology, the rheumatology videodisc image library, the CTX "criteria engine" shell and its family of Clipper-based tools, the medical expert systems evaluation project, the AI/COAG hemostasis consultant system, and the COACH™ expert searcher system.

The flagship project of the Expert Systems Program is the continuing development and evaluation of the AI/RHEUM expert consultant system. The AI/RHEUM knowledge base has been updated, extended, and linked to the new rheumatology image library. Useful critique by advisory groups has resulted in improving the system's data entry process in preparation for testing in clinical settings in Utah and Missouri in FY 1991.

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. The power, simplicity, and flexibility of this representation are augmented by a new expert system shell written at NLM for the development of criteria-based reasoning systems. The shell, called "CTX" for its use in criteria table expert systems, will reach beta-test phase in early FY 1991. CTX was deliberately designed to write dBASE III- and Clipper-compatible case data files. It is extensible and maintainable, and potentially a very 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. In the context of AI/RHEUM, the user has immediate access to more than 6,300 still images and 15 minutes of brief motion sequences on a videodisc created to help users make accurate observations. Voice-over narration for the video motion sequences will be the final stage in the production of NLM's rheumatology image library. Several software tools written as adjuncts to the CTX shell provide utilities assisting the developer in handling multi-thousand-frame image banks and in automating the performance evaluation of CTX-based consultant systems against benchmark sets of test cases.

The shell, with its explicit multimedia links to knowledge sources in different forms 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, became in FY 1990 the basis for a collaboration between LHNCBC's Expert Systems

Program and the Medical Informatics Program, and the Department of Laboratory Medicine at Yale University. Building on the AI/COAG knowledge base, the Yale groups have produced a hemostasis advising system for in-house testing and potential distribution.

The COACH expert searcher system, the most recent of the Expert Systems Program projects, is now a running prototype. It works with NLM's Grateful Med program to help improve retrieval from MEDLINE for users who have gotten too little, too much, or poorly focused search results. COACH will use the inference engine from CTX for reasoning in which it emulates some of the actions of an expert human searcher diagnosing and responding to retrieval problems.

The interactive videodisc exhibit on "Artificial Intelligence in Medicine" completed a 3-year national tour in early FY 1990 after being seen by nearly 3 million visitors. This exhibit, one component of a larger exhibition called "The Age of Intelligent Machines," opened at the Museum of Science in Boston in January 1987. It has spent 3-month periods there and at such other institutions as the Franklin Institute in Philadelphia, the Fort Worth Museum of Science and Industry in Texas, the California Museum of Science and Industry in Los Angeles, and the Museum of Science and Industry in Chicago.

Dr. Kingsland of the Expert Systems Program served again in FY 1990 as coordinator for an 8-week NIH "Medical Informatics" elective for third-year and fourth-year medical students. Thirteen students from medical schools across the U.S. completed the elective. The course included a seminar series of 37 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 made important contributions to Expert Systems Program projects.



Lawrence C. Kingsland III, Ph.D., Chief, Computer Science Branch

Natural Language Systems. The Natural Language Systems (NLS) research program was established at LHNBCB in 1986. NLS research questions lie at the intersection of the fields of computer science, information science, and linguistics. The research involves methods and approaches used in all these fields, with the goal of developing natural language processing systems that improve access to biomedical information in computerized databases.

The primary focus of the NLS program continues to be the development of SPECIALIST, an experimental system for parsing, analyzing, and accessing biomedical text. The system is implemented in Quintus Prolog with some supporting programs in C. It runs on Sun workstations.

The parsing system, based on principles of linguistic analysis, includes a lexicon together with rules of morphology, syntax, and semantics. The system is designed to capture the regularities of general English as well as the specialized nature of biomedical text. The lexicon, a central part of the system, incorporates general English lexical items as well as items specific to the domain of biomedicine. Each lexical entry encodes syntactic and semantic information. Syntactic information includes information about the syntactic category, or part of speech; inflectional variants; allowable complements; and allowable transformations. The semantic information includes information for logical interpretation.

The building of an adequate lexicon for a natural language processing system is one of the most time-consuming and labor intensive aspects of such a system. For that reason, a separate lexicon development project was initiated during FY 1990. This project involves the efforts of several highly qualified individuals who will use LEXTOOL, an interactive menu-based lexicon building tool, to add many thousands of entries to the SPECIALIST lexicon. Terminology from the UMLS Metathesaurus will also be added to the system. Both activities are expected to result in a significantly augmented lexicon by the end of the year.

The syntactic and semantic components of the SPECIALIST parser are based on the Definite Clause Grammar formalism. The grammar includes context-free phrase structure rules and context-sensitive restrictions that constrain the structures actually built. The parser currently gives a 2-level output as it analyzes sentences. The first level is a parse tree showing the detailed constituent structure of the sentence. The second level is a representation which more clearly shows its logical structure.

Knowledge of the relevant domain is a necessary component of a natural language processing system. This knowledge must be in such a form that a computerized system can interpret it and reason with it. Work carried out under the UMLS project has direct implications

for this aspect of the SPECIALIST system. Recent UMLS efforts have included enhancing the MeSH indexing vocabulary by making explicit the implicit relationships between the terms in the hierarchy; the development of a Metathesaurus of biomedical concepts; and the development of a semantic network for these concepts.

The labeling of relationships between "parent" and "child" terms in selected portions of the MeSH vocabulary was carried out by subject matter experts. The NLS group developed a menu-based tool called MESHLINK to facilitate this work. MESHLINK presents the expert user with a child and parent MeSH pair and prompts the user to choose from the available set of about 30 relationships. The tool steps the user through terms in a MeSH sub-tree, providing access both to the MeSH definition and to definitions in a medical dictionary.

The Metathesaurus is the central vocabulary tool of the UMLS. It contains information about specific biomedical concepts, including their representation and context(s) in a variety of controlled vocabularies. Meta-1, the first version of the Metathesaurus, incorporates all of the MeSH terminology and selected vocabulary from other sources. Each concept in Meta-1 is assigned to at least one of the semantic types available in the accompanying UMLS Semantic Network.

The purpose of the Semantic Network is to provide a consistent categorization of all concepts represented in the UMLS Metathesaurus and a set of useful relationships between these concepts. All information about specific concepts is found in the Metathesaurus. The network provides information about the set of basic semantic types, or categories, which may be assigned to these concepts. The first release of the Semantic Network includes 131 semantic types. Major groupings have been established for organisms, anatomical structures, biologic function, chemicals, events, physical objects, and concepts or ideas. In addition, a set of potentially useful non-hierarchical relationships between the types has been identified. These include relations such as "causes," "process of," "property of," "uses," and "treats."

A major NLS effort during FY 1991 will be the continued development of the Semantic Network. This will involve the testing and evaluation of the network itself as well as the development of application systems for linking this knowledge source to the information stored in Meta-1. Programs to facilitate intelligent traversal of the network will be designed and implemented. The network and the large number of concepts to which semantic types have been assigned will then be tested as a source of domain knowledge for the SPECIALIST system.

Machine Learning Project. A new research project began at LHNBCB in 1989 to investigate the subfield of artificial intelligence known as machine learning. The field encompasses a wide variety of mechanisms for creating

computer programs that improve their performance with use. The objective of this project is to develop and apply methods by which programs can automatically acquire knowledge and put it to work.

The underlying motivation for this work arises from the explosion of available biomedical information and the less well acknowledged explosion of the analytical tools and techniques applied to that information. NLM, having long recognized the need for automated assistance in gaining access to this valuable corpus of knowledge, has supplied the community with a wide variety of databases. However, dramatic improvements in automated knowledge manipulation, analysis, and inference will be necessary if we are to take full advantage both of the anticipated exponential growth of biomedical data and of the increasingly evident interrelationships among previously disparate information sources.

Programs like expert systems have already moved from the manipulation of information toward the manipulation of knowledge. The goal of the Machine Learning Project is to create computer programs that not only manipulate knowledge but also can acquire it themselves. Ideally, a researcher or clinician with a question should be able to have a machine learning program identify where to find relevant information, retrieve that information (possibly from multiple data sources), and analyze and assemble the information into a complete, accurate, and comprehensible response.

Machine learning research may also help transcend the traditional computer interaction of a user issuing commands and a program responding. In a world of rapidly advancing knowledge, programs will have to do more than retrieve information when asked; they will have to manage information retrieval and inference over time. Once a user has specified a question of interest, a machine learning program should be able to continuously and intelligently track evolving knowledge sources for potentially relevant information. It should then automatically assemble and analyze that information and present it to the questioner. These visions are the driving force behind the LHCBC Machine Learning Project.

Currently, machine learning technologies focus primarily on inducing concept definitions from externally specified datasets. The project endeavors to advance significantly the state of the art in machine learning, pursuing the vision by creating a computationally tractable theory of how to use diverse sources of knowledge and to deploy diverse (and complex) analytical tools in pursuit of explicitly stated goals. This approach, called knowledge acquisition planning, is in an early stage of development. Although achieving the vision described above is clearly a long-term goal that will require fundamental advances in basic computer science, the process of developing the theory and implementing prototypes has already produced some useful results.

The primary testbed for research in knowledge acquisition planning at LHCBC is a program that selects and manages the use of computerized analytical tools and database searchers to achieve specific goals. This experimental program, INVESTIGATOR, operates by selecting other programs such as statistical analysis packages and database search engines, which can be applied to achieve its human-provided knowledge acquisition goals. Each program INVESTIGATOR deploys must have an internal representation describing the preconditions for its execution, the data formats it requires, its expected outputs, how long it takes to run, and so forth. From this information, INVESTIGATOR's planning mechanism can select the appropriate tools and databases to accomplish a variety of tasks.

INVESTIGATOR has been programmed to use several computerized analytical tools and to plan to acquire knowledge in several different domains. The analytical tools include inductive category formation, heuristic Bayesian classification, marker-passing intersection search, analysis of variance, random sampling, and back-propagation trained artificial neural networks. The databases INVESTIGATOR has accessed include MEDLINE, GenInfo, the Protein Information Resource, Brookhaven National Laboratory's Protein Databank of crystallographic structure information, and others. Results of INVESTIGATOR-managed knowledge acquisition plans have addressed questions in diverse domains including early Eukaryotic evolution, classification of the structural elements of proteins, and changes in protein conformation after point mutations.

Our research in knowledge acquisition planning has the potential for high payoff in improving the capabilities of machine learning systems in general. Current machine learning technology is fundamentally limited by the computational complexity of exploring the space of hypotheses compatible with a set of data. The knowledge acquisition planning approach provides important constraints on the space of hypotheses which must be searched, using the specific goals of the learning system to focus computation on the available methods and data most likely to lead to answers to its questions. This method of using the content of desired knowledge to constrain the search space may result in significant improvement in the performance of machine learning systems.

The general problem of selecting and coordinating diverse and complex sources of knowledge touches on many open questions in cognitive science. The only available models for designing systems that might accomplish these tasks are human beings. A significant component of the project's research, therefore, is the analysis of human subjects as they acquire knowledge. Machine learning project staff work with biomedical researchers to gather data on how people manage

knowledge acquisition tasks. Protocols of researchers using computer tools and devising retrieval and analysis strategies have been gathered and analyzed to provide insight into this complex cognitive process.

Results from these experiments have led to the identification of connections between attentional phenomena in cognitive and social psychology and computational complexity considerations in the design of machine learning systems. Potential implications of this research for the understanding of human cognitive phenomena are also being pursued. The machine learning research program places a strong emphasis on the use of cognitive models in the design of artificial intelligence systems.

Building artificial intelligence systems generally requires gathering extensive data about how people do the task to be mechanized. This information comes in the form of interviews, think-aloud protocols, interactive problem-solving sessions, and other verbal interactions. Traditionally, the information gathered is painstakingly transcribed and the transcripts are then analyzed by a knowledge engineer. To eliminate the transcription step, the staff of the Machine Learning Project designed the Audio Knowledge Acquisition Tool (AKAT) for digitally recording audio onto an optical disk and building an extensive set of indices into the information.

Points or passages of the audio can be marked and annotated, and the annotations can be grouped or organized into a hierarchy. The user can hear the original audio segment on speakers or headphones by simply pointing to an annotation with a mouse pointing device. This software tool both obviates the need for transcription and retains the original audio in easily accessible form, preserving potentially valuable nonverbal information such as pauses or "hmmm" sounds. A prototype of the AKAT tool running on Macintosh computers is in the alpha-testing stage, with versions in use at NLM and at external test sites.

MedIndEx Project. The objective of the MedIndEx Project is to develop and test interactive knowledge-based systems for computer-assisted MEDLINE indexing using MeSH. By encoding the indexing scheme in a knowledge base (KB) and using it to assist indexers, the system is designed to facilitate "expert indexing"—indexing consistent with published indexing tools upon which indexers currently depend. Published indexing tools are unable to provide this type of interactive assistance.

The MedIndEx (Medical Indexing Expert) System is written in a frame language, a type of object-oriented language where objects, known as frames, are used for representing concepts. In a frame, a concept (the frame name) is described as a list of pairs of slots and values. A slot is a relation; a value is another frame name that completes the relationship, for example "Heart LOCATION

Thorax." Frame descriptions contain both this detailed factual knowledge and procedural knowledge. Specifically, slots contain both values and executable procedures that enable the system to assist indexers interactively. Just as slots link frame concepts with values (other frame concepts), facets link slots with these procedures.

An important relation in the KB is known as "inherits-from," which links the entire KB into a single classification. Inheritance, whereby lower-level frames automatically assume descriptions of higher-level frames to which they are linked by this inherits-from relation, achieves a number of important KB functions. These include maintaining consistency of the KB, detecting redundancy in the KB, and simplifying algorithms for accessing frames based on these explicit hierarchical paths from higher-level frames to lower-level frames.

Human indexers, with system guidance and help from the KB, create for each document indexed a set of indexing frames patterned after KB frames. These indexing frames are descriptions of instances of KB frames. These instances correspond to objects, events, procedures, and other specific descriptions as discussed in documents being indexed. Each indexing frame is linked to its corresponding KB frame by the same inherits-from relation used for linking frames in the KB classification. Indexing frames inherit slots from these KB frames, and since KB frames include executable procedures (indexing rules), the indexing system can give help specific to the concept being indexed.

Indexing assistance includes offering slot names as prompts for indexers to consider indexable aspects of a document, validating indexers' input, prescribing or suggesting slot values based on KB rules, and showing hierarchical KB displays for browsing permissible values for the current slot. The KB contains rules both for creating and filling indexing frames and for generating in the background conventional MeSH indexing terms at the level of expert indexing. This output can be used to compare the system to conventional indexing, and would provide actual MEDLINE indexing for current retrieval systems.

Indexing frame output, which consists of a network of linked frames, would describe a document more precisely than conventional indexing. Project staff are therefore investigating frame databases for retrieval. The use of this knowledge-based system as a front-end for an intelligent searching assistant by guiding searchers in creating query frames, is also being explored.

Recent project developments have included the creation of a KB manager to assist knowledge engineers in ensuring a consistent, compact, and syntactically correct KB. This software uses the inheritance feature of frame languages and special scripts employing menu and cut and paste interfaces. Additional enhancements are the

graphical display of hierarchies and the creation of frames in batch mode. New developments in the indexer interface program include the detection of inconsistencies in previously stored indexing frames; system suggestion of specific terms; the retention of canceled frames for possible reuse; caching for quick access to large hierarchies; and regular-expression searching and other improvements in the browsing of hierarchical displays. A word-level aliasing technique has been developed to permit truncation of individual words in a term, which then would be recognized by the system as lead-in vocabulary for frame terms.

The KB has been significantly augmented with about 1000 new frames. Existing frames have been edited using the advanced features of the new KB manager. As an experiment, the Art and Architecture Thesaurus (AAT), received on diskette, was loaded into the MedIndEx System and a demonstration prototype developed for using this AAT KB in indexing a journal in this domain. A 250-page technical report on the MedIndEx System (NLM-LHC-90-03), titled "The MedIndEx System: Research on Interactive Knowledge-Based Indexing and Knowledge Management," by Susanne M. Humphrey, leader of the MedIndEx Project, and De-Chih Chien, was completed in July 1990 for distribution by NTIS (Publication No. PB90-234964/AS).



Charles M. Goldstein, Chief, Information Technology Branch

Information Technology Branch

The Information Technology Branch (ITB) pursues applied R&D in computer and information science with a current emphasis on full-text publication and retrieval. Areas of activity include development of generalized windowing interfaces across multiple platforms, object-oriented retrieval systems encompassing both text and graphic 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, multi-processing, client/server distributed processing models, and advanced memory management.

Online Reference Works. The Online Reference Works (ORW) seeks to enhance and improve 1) the extensive and valuable body of information to be found in published medical reference works, and 2) the scholarly process of text creation and maintenance by establishing complementary online versions of the published works. An ancillary objective of the program has been to create a prototype "scholar's workstation" that can serve as an integrated information resource for both the creation and the retrieval of online reference works. The platform for research in this program has been an experimental text retrieval system known as IRx™ (Information Retrieval Experiment). IRx supports Natural Language Query (NLQ) searching of full-text databases providing a ranked output of search results to the user. It also allows the explicit use of Boolean combinations of terms where required or preferred.

Mendelian Inheritance in Man (MIM) by Dr. Victor A. McKusick was the first online reference work implemented under IRx in collaboration with Dr. McKusick and the Welch Library, Johns Hopkins University (JHU). OMIM, the online version of MIM under IRx, is presently available from JHU via dial-up access and Telenet to an international community of biotechnology researchers. MIM, along with many other biotechnology databases, is also available under IRx to NIH researchers from the NLM's National Center for Biotechnology Information (NCBI). Terminal access to IRx is via standard terminals, IBM PC-compatible computers, and sophisticated Sun Workstations.

In 1989, a new collaborative effort with JHU was initiated to explore the requirements of a reference text of more generalized structure than MIM. This effort is being based on *Principals of Ambulatory Medicine (PAM)*, Drs. Barker, Burton, and Zieve, editors. The characteristics of PAM that recommend it as a research prototype include: multi-author (over 60), multi-editor (3), hierarchical text (105 chapters), tables, line-drawings, and images. In 1990, the three editors utilized specialized editing workstations to prepare for a third edition of PAM. The online, full-text retrieval of more generalized reference works such as PAM dictated the need for a complete redesign of IRx. This resulted in the design of an object-oriented version of IRx called IRx.2.

CD-ROM Program. NLM has a growing need to 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 MS-DOS, Macintosh, and Sun/Unix. CD-ROM represents a unique storage medium for the dissemination of such information. Its salient features include a nominal computer

storage of 600 Mbytes per side and a duplication cost of less than \$2 per disk in large quantities. The effective utilization of CD-ROM, however, is encumbered by an access time much slower than magnetic hard disks. This impacts the response to the user of search software accessing data on a CD-ROM and, hence, requires special consideration in design and implementation of such applications.

In 1990, ITB established a laboratory for CD-ROM development and began to establish technical expertise in CD-ROM design and pre-mastering. The primary laboratory tool is a CD-ROM Pre-mastering and Simulation Workstation that will allow the formatting of tapes for mastering and the simulation of CD-ROM applications even prior to mastering. Two UMLS CD-ROM disks were produced this year, one with a Macintosh HyperCard application and the other with a series of ASCII files relating to UMLS.

AHCPR Program. In the pursuance of its mission, the new Agency for Health Care Policy and Research (AHCPR) has a requirement for an online, full-text retrieval system. The NLM has a specific Congressional mandate to support AHCPR in the development of a state-of-the-art capability for online full-text retrieval. Based on previous full-text retrieval work (e.g., IRx), ITB has undertaken the task of developing and establishing an operational capability in support of the AHCPR requirements. Present plans call for the development of an online full-text system based on both natural language and Boolean search queries. The retrieval system shall initially reside on a computer located within the LHCNBC laboratories. Terminal access will be available via standard ASCII terminals, personal computers, and workstations supporting a number of standard Graphical User Interfaces. Communications access will be available via dial-up telephones and existing networks (Internet, Telenet, Tymnet).

The initial text chosen for the development of full text retrieval capabilities suitable for AHCPR requirements is Guide to Clinical Preventive Services, An Assessment of the Effectiveness of 169 Interventions. A copy of the photocomposition tapes of the text was obtained from the publishers, Williams & Wilkins. The text, which was parsed and entered into IRx for testing, will also be used to evaluate other full-text retrieval systems.

Communications Engineering Branch

The focus of this research area is the capture, storage, processing, online retrieval, transmission, and display of biomedical documents and medical imagery. Ongoing activities include image compression, image enhancement, image understanding, pseudo-grayscale rendition, image transmission and networks, omnifont text recogni-

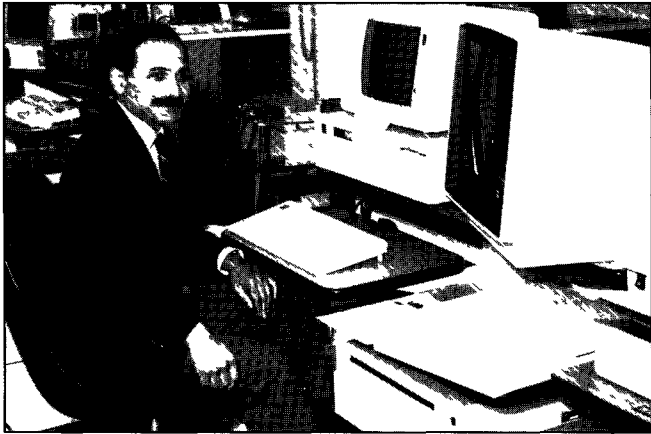
tion, and man-machine interface design. An example of current research is an investigation of advanced techniques in electronic imaging to address the problem of preserving and accessing the biomedical collection. In addition, research into imaging techniques that support medical educational packages employing digitized radiographic, dermatological, and other imagery is also being pursued.

Electronic Document Delivery System. Following the completion of a long-term program named Electronic Document Storage and Retrieval (EDSR), the Branch undertook to develop an electronic imaging system for document delivery. The motivation for the EDSR program was the preservation of the biomedical collection in electronic bitmapped form on optical disk media.

In summary, research in EDSR yielded several products: (a) a detailed hardware design on a system and a subsystem basis; (b) a complete software package in C and assembly languages to implement the three stages of document conversion, as well as rapid and random image retrieval from local and remote optical disks; (c) a cost analysis; and (d) a throughput performance analysis applicable to a scaled-up version of the prototype system. These findings were presented to the LHCNBC Board of Scientific Counselors in May 1989, accompanied by a three-volume final report entitled "Document Preservation by Electronic Imaging" (available through the National Technical Information Service). This research has resulted in over a dozen papers published in the electronic imaging literature.

Component technologies developed in the EDSR program allowed the development of the EDDS prototype. The objective of the EDDS program is to demonstrate 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, directly access an electronic store of document images, and receive the document images through fax, mail, or local pickup. The user's DRW consists of affordable, off-the-shelf components, such as an IBM-AT compatible microcomputer and a standard fax machine. It also requires special in-house-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 American Society for Information Science*.

System for Automated Interlibrary Loan (SAIL). In light of the successful outcome of the EDSR program for document preservation, and the potential for electronic document delivery demonstrated by the EDDS prototype, a new program was begun involving both electronic document preservation and delivery to support



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the NLM's interlibrary loan (ILL) service. 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 that are to be preserved. 2) The development and implementation of a Document Storage, Retrieval, and Transmission (DSRT) system that is linked to NLM's DOCLINE system used to request documents. 3) Employing this system to fill a portion of the ILL requests arriving at NLM. A number of engineering studies were done in support of SAIL development and the library's ILL activity. Among these are the following:

Interlibrary loans via facsimile. This study focused on the impact of introducing fax in NLM's ILL service to replace conventional mail as the method of document delivery. First, performance data was collected for both advanced fax machines and conventional machines, the former equipped with internal hard disks enabling store and forward capability. Then, mathematical models were developed to relate various decision measures such as the number of machines 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 (June 1990) is available through the National Technical Information Service.

Image archiving software: Engineering tradeoff study. The tradeoffs were evaluated between recently available commercial software and ARCHIV, the in-house-developed software for archiving and retrieving document image files to and from WORM media over a LAN. This effort is consistent with NLM's objective to incorporate into its systems commercial products that follow industry standards. The study focused on speed, storage overhead, compatibility issues, system flexibility, data security and software development issues. The study concluded that the in-house 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 commercial software is being integrated into current system development efforts and more complete tests of its performance are planned.

LAN-based document image server: Performance evaluation. Recognizing the general lack of quantitative performance information for systems combining WORM drives and LANs for image file distribution, a study was performed in which the laboratory's prototype system for document image distribution was used to simulate a system with several users. The objective of the study was to predict the performance of a practical multi-user system. A database of document images, whose compressed file size distribution 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 NLM-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 image server was found to perform in accordance with a standard and mathematically described model of queuing 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.

Machine-Readable Archives in Biomedicine (MRAB). This program exploits advanced technologies becoming available in modular form and builds on previous NLM work in electronic imaging. The goal is to build a prototype system for a machine-readable archive.

While the EDSR program addressed the problem of efficiently converting the paper documents to electronic bitmapped image form for purposes of permanent storage, the access to the stored material remains at the image level. Although this level of access is certainly faster

and more convenient than that available with paper and film archives, electronic imaging offers the potential for far greater access than merely to the image. It allows the creation of vast machine-readable text/image databases in very compact space (the equivalent of 350,000 to 400,000 document pages on a single disk, or about 50 million pages on a 128-disk jukebox), the capacity of rapidly and randomly navigating through this store, the ability to apply library processing (indexing and cataloging) to parts of the older literature, and the capability to access this store remotely.

In May 1989, the LHNBCB presented to the Board of Scientific Counselors the outline of a program to investigate the technologies involved in the creation of a machine-readable archive. There are several considerations supporting such a program, some of which are presented below:

- This program will demonstrate the potential for making the biomedical literature available in compact and accessible electronic form.
- It would support certain objectives of the national preservation effort in biomedicine spearheaded by the NLM. Medical libraries would not need to replace their brittle documents with thousands of reels of microfilm. Furthermore, their users would be better served by the access to both bibliographic pointers and content.
- It would enable far greater access to the older biomedical literature than available today.
- The availability of the older material in machine-readable form will allow it to be indexed and cataloged to levels that are more sophisticated and useful than at present.
- It would permit research into historic terms corresponding to modern medical vocabularies.

Making documents machine-readable, in principle, is a result of applying optical character recognition (OCR) technology, which in some form has been commercially available for several years. At the low end of the cost range, there are desktop OCR devices that adequately handle typewritten, uniformly spaced material such as office correspondence. At the high end, there are devices that do omnifont recognition for typeset, proportionately spaced material such as books and journals. However, none can adequately meet all of the following conditions: bound documents, fragile paper, material with poor print to paper contrast, and compound documents with intermixed text and graphics where it is required to save these different data types in a form suitable for display in the original format. For the material under consideration here, all of these factors hold.

The MRAB program intends to address the problem by: (a) developing a prototype system to demonstrate the feasibility of creating, maintaining, and accessing a machine-readable archive of documents, (b) using this

prototype as a testbed to answer questions concerning the process of creating this archive, (c) evaluating the role of such an archive at the NLM, and (d) defining the technical specifications for an operational system. Current activities in MRAB include evaluations of commercial OCR devices and investigation of artificial neural networks as tools for image segmentation.

OCR evaluation studies. Performance evaluations were conducted with an in-house system built around a Calera OCR engine as well as an off-site Kurzweil 5100 system. The material tested included the Index-Catalog and journals representative of those indexed for MEDLINE. The performance criteria included conversion error rate and conversion time. 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.

Imaging projects. Image Segmentation Using Artificial Neural Networks. A particular implementation of an artificial neural network (ANN) model, the back error propagation paradigm, was explored as a tool for automatic segmentation of document images. The paradigm is known for its ability to "learn" to classify data. Two approaches were tried, both using unprocessed document image data generated in the lab. In one approach, the image was divided into tiles. The network then determined if the image data within the tile was text or nontext. In the other approach, histograms of the total numbers of black bits in vertical columns across the page image and in horizontal rows down the page were generated. These histograms were presented to the network, which then determined the location of the edges of the text. Error rates for both approaches ranged from 5 to 25 percent, encouraging enough to pursue additional study. Future efforts will focus on methods to reprocess image data to extract features that are more representative of each image data class.

Biomedical Digital Image Processing (BDIP). This is a program to develop and evaluate improved techniques to capture, store, and display medical images for computer-based educational systems. Biomedical images of interest include both multiple gray-level images (e.g., radiographs) and high-resolution color (e.g., dermatologic slides). Other images of interest include monochrome and color material from NLM's historical collection. The results of research in this area are reported in the Proceedings of the Society of Photo-Optical Instrumentation Engineers and similar publications.

Digital Color Imaging for Dermatology. A study was undertaken to determine the level of image compression acceptable for images used to teach dermatology. Data for this study was taken at the 1989 convention of the American Academy of Dermatology. This forum afforded access to a large number of expert participants.

The results of the study are reported in the Proceedings of the SPIE, vol. 1232.

The research showed unequivocally that dermatologists can identify skin lesion morphology from images compressed to about 10:1 with a Hadamard transform-based algorithm as well as they can from the original 35mm slide. It also showed that, although compression ratios of about 20:1 and 30:1 did not degrade performance except in one case, subjective opinions indicate that these compression ratios result in images of slightly degraded quality. The images were digitized at 1000x1000 pixels over a 35mm slide with 5 bits for each of the red, green, and blue color components. Selection of the images was based on a previous study involving 91 second year medical students. This study indicated no statistically significant difference in morphology recognition performance between 35mm slides and uncompressed electronic versions.

Image Compression Techniques Evaluation. A study was undertaken to compare the performance of a Hadamard transform-based image compression algorithm with a discrete cosine transform-based algorithm. 35mm slides of four morphologic types of skin lesions were digitized at 1000x1000 pixels with 8 bits for each of the red, green, and blue color components. Using the discrete cosine transform (DCT) algorithm, the resulting image files were compressed at compression ratios of about 7:1, 28:1, and 70:1. The original scans and the decompressed files were written to a 35mm film recorder. Together with the original photo slides, the slides resulting from digital images were evaluated in a study of morphology recognition and image quality assessment. On the strength of the rating of image quality by 15 dermatologists, we conclude that the use of DCT-based compression yields acceptable performance for skin lesion images. Image quality evaluation does not correlate significantly with level of compression. The results of this study will be published in the Proceedings of the SPIE's Medical Imaging V Conference. Future work in the area of image compression will include the evaluation of a high-speed nondestructive algorithm applied to radiographs.

Image Classification via Artificial Neural Networks. To evaluate artificial neural net technology and its applicability to image classification problems, several experiments have been undertaken. In the first, an artificial neural network characterized as feed-forward, restricted coulomb energy, has been trained to classify feature vectors derived from fine needle aspirates taken from human breasts. Each vector consists of elements which represent cytology features such as size uniformity or shape uniformity. Using 369 vectors as a training set and 101 different vectors as a test set, the system accurately classifies each test case as either malignant or benign.

Performance of the system is compared with another algorithm that is based on a nonconvex piecewise linear model. The comparison shows that the neural net performs as well as the piecewise linear model while exhibiting features that have no reported counterpart in the piecewise linear model. These features include the ability to report uncertainty or indecision, to distinguish between more than two classes (up to 255) and to include other new or different information without extensive re-training. The details of this experiment are reported in *Analytical and Quantitative Cytology and Histology*, 2 July 1990.

The same artificial neural network has been trained to classify feature vectors derived from skin lesion images. Each vector consists of 18 elements which represent relative color characteristics. The digitized images are first segmented and then processed to obtain appropriate color metrics. A set of 217 vectors is partitioned into training and test sets from 90 percent training and 10 percent testing to 10 percent training and 90 percent testing. Performance of the net will be compared with the performance of an artificial intelligence (AI) expert system. The AI system has user defined if-then-else rules to categorize vectors while the neural model does not employ this mechanism. This experiment is still in progress.

Digital X-ray Prototype (DXP) Workstation. NLM is collaborating with the National Center for Health Statistics (NCHS) and the National Institute of Arthritis, Musculoskeletal and Skin Diseases (NIAMS), which have a program for the digitization of x-ray film to support the National Health and Nutrition Examination Surveys (NHANES). The existing collection consists of about 17,000 images; the image set currently being acquired will augment this collection by an additional 20,000 images.

The Communications Engineering Branch is participating in this program by integrating and testing a prototype low-cost workstation that provides access to this image collection. Initial design of the workstation, including test software, was done in the radiology department of UCLA's medical school. This organization also is under contract to NCHS to digitize the existing collection of 17,000 films. NLM involvement includes assembly and test of the hardware components and developing an extensive software system. The purpose of the software is to link the image collection with the NHANES data base and then build a user interface to form an effective research tool. Thus far, the hardware components have been integrated and tested. The first batch of digitized images will be compared with the original films by a radiologist.

Preliminary observations suggest that the test software supplied by UCLA may not be adequate for effective quality verification. This software crops,

subsamples, and quantifies images in order to fit them into the available display memory. Improvements to these programs have been suggested to UCLA and are also being studied here. A histogram analysis of a sample from the first batch of digitized images also suggests that the electronic system's full dynamic range is not being utilized. This assessment has been submitted to the digitizing laboratory at UCLA to determine whether improvements are feasible.

The software component of this project is both the most challenging and the most potentially useful. The key to success will be to identify and satisfy user needs. The software will make the image database accessible. It 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. If the NHANES database is not available online, then an alternative search mechanism will be devised based on a subset of the database.

The test phase of this project will be initiated by publishing the features of the facility and inviting researchers to make use of it. The user interface will include software that collects user evaluations. These evaluations will be used to design improvements in both hardware and software.



Michael J. Ackerman, Ph.D., Chief, Educational Technology Branch

Educational Technology Branch

Computer-based Curriculum Delivery Systems (CCDS). The goal of CCDS is to produce and test experimental health professions curricula that are delivered through the use of interactive technology.

The first CCDS prototype curriculum for Basic Medical Pathology was offered to U.S. medical schools in June 1983, when two programs on a two-sided videodisc were completed. Since that time the field-testing network has grown from 12 to 102 schools that have tested not only the pathology curriculum but also prototype curricula in mental health (Teenage Depression and Suicide Risk Assessment) and in orthopedics. In the beginning there were 12 student work stations. By the end of FY 1990 there were at least 400. There are now 82 health professions schools in the U.S., Canada, Europe, Southeast Asia, and Puerto Rico involved in the pathology project.

The Basic Medical Pathology is the largest and most extensive of the CCDS projects. In FY 1990 three new videodiscs were mastered ("Cellular Accumulations," "Cellular Alterations and Adaptations," and "Cell Injury and Cell Death"). The last two are new editions of the first two programs issued in 1983. The second edition brings these two programs up to standards used since 1985, e.g., single-frame slide banks in addition to the "mini-lectures," professional narration, and dBASE databases for each videodisc. These three programs complete the production phase of the project.

During FY 1990 CCDS also produced a new engine for the delivery of 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.

By the end of the year CCDS had furnished to the test sites over 900 videodiscs and diskettes containing revised code for the pathology delivery engine and associated files. The impact of the pathology project can, in part, be judged on the basis of the rapid adoption of its products and the following data:

- Over 4,000 student evaluations of the programs have been received. On a scale of 1 to 5, students rated the programs 4+ as a learning experience.
- Comparison of pre- and post-test scores of those students not passing the pre-test show that students master the material in about one-third the amount of time devoted to it by traditional curriculum delivery systems.
- 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.

CCDS staff, in collaboration with a guest investigator in the laboratory, completed two new orthopedic prototype programs for use at the 1990 annual meeting of the American Academy of Orthopaedic Surgeons (AAOS). The new programs were a "repurposing" of the 1984 Level I videodisc on anatomy of the knee. These new programs, and others to be developed in the same

series, are under consideration for use in a large orthopedic residency program. The new programs correlate magnetic resonance and anatomic images of normal and abnormal human knees. CCDS has again been asked to participate in the AAOS annual meeting.

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 U.S. Navy has decided to adapt the program to its CAMUS system. The program is now distributed by the National Audiovisual Center (NAC). The original pressing of the videodisc was sold out and NAC re-mastered the videodisc in 1989.

Dermatology visual database project. A research review by the LHNBC Board of Scientific Counselors (BOSC) recently noted four significant contributions of this project. First, it establishes technical requirements for an electronic imaging system necessary to display images of tissue at quality equivalent to that of photography. Second, it collects a large-scale image library valuable for medical education. Third, it represents a model collaboration within the Lister Hill Center and with academic investigators and users outside the government. Fourth, it develops a model for the continuing evaluation of educational technology.

In response to recommendations of the BOSC, investigations of image quality emphasized dynamic range requirements. Experimental design was expanded to assess aesthetic judgments of image quality as well as objective performance in morphology recognition. Findings to date suggest that film scan resolution of 2000 dpi vs 1000 dpi does not offer a substantial improvement in image quality measured by either objective performance or subjective assessment. The use of 24-bit vs. 15-bit color does enhance aesthetic judgments of image quality, although no difference in morphology recognition performance was noted. Images scanned in 24-bit color depth can be optimized to an 8-bit color palette with minimal aesthetic compromise and possibly minimal impact on objective performance. We have tested algorithms for file compression (Hadamard and discrete cosine transform) and found that files can be compressed to approximately 10:1 without any notable difference in either aesthetic rating or morphology recognition performance, and that the latter is not affected until file compression exceeds 30:1.

In collaboration with the Sulzberger Institute for Dermatologic Education, Dr. Robert Schosser, an academic dermatologist and biological photographer from the University of Arkansas, has provided a collection of photographic slides to test image transfer to both film (microform and internegative) and electronic (high definition analog and digital) archival media. The results of these studies in progress will be used to develop photographic standards for collection of a large-scale image

database with the support of the American Academy of Dermatology.

Collaboration with the Sulzberger Institute has also resulted in mutual efforts in evaluating educational technologies. Formative evaluation of the interactive video tutorial on melanoma at the Medical College of Virginia resulted in positive student response to the tutorial content and the interactive learning method, but revealed technical deficiencies in the IBM Infowindows hardware and software. The Sulzberger Institute is supporting revision of the tutorial to support online collection of student performance data. Several NLM staff members met with Sulzberger Institute subcommittees on electronic text and image archiving to provide requested technical consultation.

Library growth project. The Library Growth Project's major accomplishment of the year was the completion and publication of a sequel to the 1987 Research Library Trends . . . report. The new report, RLT-II, analyzes trends in 35 academic research libraries (seven Canadian and 28 U.S.), libraries that are generally smaller and "younger" than the 58 studied earlier. All are members of the Association of Research Libraries and their trends show two groups that behave similarly: the 35 libraries' expenditures have been increasing at an annual rate near eight percent; for both groups, the 1970's were a time of declining collection growth rates and few staff increases; both also experienced a brief period of recovery during the early 1980's; and both show that, over a long run, the average collection has managed to double in less than 20 years, in spite of repeated recent declines in growth rate.

The proportion of expenditures devoted to salaries and wages has also declined, although gradually, and it now approaches 50 percent, while the proportion devoted to materials acquisition (and binding) has increased from a customary level near 33 percent to a level that may soon exceed 40 percent, an increase that probably results from the libraries' efforts to counteract increasing materials prices and control the continuing decline of growth rates. However, in light of the fact that expenditure increases have regularly outpaced or at least matched increases in the Consumer Price Index (see below), that half of total expenditures is for salaries and wages, and that only about 1/5 of the total is for serials, it is very doubtful that serials price increases, "inflation," or "austerity" are sufficient to account for the slackening growth that libraries have experienced during most of the last 18 or 20 years.

Some estimates developed from results in both Trends studies are these: since 1951, collections have increased by a factor of 4.2, staff size by a factor of 3.1 or 3.2, entering professional salaries by a factor of 7.9, total expenditures by a factor of 32 (salary and wage expenditures by a factor of 30), and the Consumer Price Index by a factor of 5.0. Also, the 108 academic libraries that are

ARL's core membership represent current total expenditures of \$1.3 billion, of which about \$475 million is spent to acquire materials; this total will exceed \$2.6 billion before the year 2000; and the average entering professional salary in that year is likely to be \$36-38,000 (it is now \$22,000; in 1951 it was \$2790).

The Learning Center For Interactive Technology (TLC). The TLC is a "hands-on" laboratory for medical educators, researchers, and scientists. Visitors can explore the comparative applications and various uses of interactive educational technology in the health sciences.

The Learning Center consists of two components: 1) a central facility where various microcomputer and interactive video information and educational technologies are demonstrated, reviewed, and evaluated; and 2) a Training Facility with 6 microcomputer workstations for teaching about interactive technology.

A total of 72 interactive health science programs are displayed at 22 demonstration carrels. An additional 32 programs are obtainable on request. 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 data bases, and information retrieval.

In FY 1990 The Learning Center staff provided over 350 demonstrations and hands-on experience for 925 visitors. This brings the number of visitors to 3,463 since the TLC opened in March 1985. Center staff also conducted demonstrations and exhibits in conjunction with seven national association meetings. An additional four workshops and seminars were conducted at health professional institutions. The first in-house 3-day tutorial on Videodisc Repurposing was also held. TLC hosted three series of invitational seminars for nurses from several Federal health agencies. Two series were on interactive technologies, including hardware and software, for educational and performance assessment purposes. The third addressed technologies involved in authoring systems, expert systems and artificial intelligence, and emerging interactive technologies.

In FY 1990 the TLC Training Facility conducted 46 classes, providing training for 322 NLM staff. In addition, 13 software demonstrations were presented to 256 attendees.

The TLC Monograph series was expanded to four titles with the publication of *Computer-Based Education in Nursing* by Susan M. Sparks, Ph.D. and *Interactive Technology* by Eldon J. Ullmer, Ph.D. An innovative videotape "sampler" of available interactive technology was produced. It is soon to become available on videodisc.

In February 1989, E.T.Net (Educational Technology Network) came online through a local Bethesda telephone number and in May 1989 became available through Telenet. Access via the Internet is scheduled

for the fall of 1990. E.T.Net is an online computer conferencing system specially designed to facilitate online discussions. Its purpose is to link electronically developers and users of interactive technology in health care education. One of the problems facing health science educators is a lack of information on interactive courseware: What is available and where it can be obtained? Which of it is useful? What needs to be developed? E.T.Net is designed to alleviate this problem by enhancing communications among developers and users of health science interactive courseware. Users of E.T.Net are able to share: software, hardware, and videodisc reviews; information on courseware and videodiscs that are available, under development, or need to be developed; and new applications of interactive hardware to health science education.

E.T.Net is open to professionals engaged in either the development or use of interactive technology in health science education. E.T.Net is available at no cost, 24 hours a day, 7 days a week, 365 days a year. Since its debut in February 1989, 815 health professionals have registered as E.T.Net users, including colleagues in Canada, Europe, South Africa, and Australia. A pocket E.T.Net Quick Reference Guide may be requested from the Learning Center for Interactive Technology. E.T.Net has been demonstrated at several professional association meetings.



James S. Main, Chief, Audiovisual Program Development Branch

Audiovisual Program Development Branch (APDB)

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 APDB operates a videodisc premastering facility employing state-of-the-art video, graphics and audio systems to produce high

quality and creative materials for the LHCBC's research and demonstration projects and for the NLM's educational and information programs.

Technical issues such as image quality, resolution, color fidelity, image repeatability, generation loss, film to video transfer, transportability of images to different technology platforms, and image file management provide the framework against which new projects are accepted or initiated. For that reason, the premastering facilities must be upgraded continuously and new generation equipment integrated with proven systems.

As digital video continues to have impact on the generation, storage, and delivery of image materials, the premastering facility was upgraded with the addition of a D-2 format, composite digital recorder and a digital special effects system. These systems will allow a new level of quality in recording and playback of materials, and a more dynamic presentation of images for medical educational materials. Improved graphics generation and offline editing capability should provide more efficient and better quality productions for all of the Branch projects.

APDB completed the photography and the film-to-video transfer for the History of Medicine Prints and Photographs Collection videodisc project. During FY 1990, the entire collection of more than 55,000 images was transferred to the premaster videotape. Several DRAW (Direct Read After Write) videodiscs were then made and are being used to verify the accuracy of cataloging and the completeness of the image capture, before final laser videodiscs of the entire collection are mastered.

A D-2 (digital) edit master videotape of the Rheumatology Image Library visuals was created, and an optical videodisc was produced, as a comparative test of premastering methods using traditional analog versus digital recording technologies. The consensus of technical and content personnel provided additional evidence for the movement toward digital video techniques for improved image quality.

In collaboration with the University of Arkansas for Medical Sciences, several hundred dermatology slides, made under differing lighting conditions and using various film stocks, were transferred to a newly introduced 35mm color negative filmstock. These images were then transferred to video using transfer techniques developed in collaboration with private industry in a joint research project. This procedure was designed both to evaluate the technical aspects of image transfer and the human interface of medical experts with the transfer system, which will be used in various stages of videodisc premaster productions.

Late in the fiscal year, APDB began designing a collaborative project with the National Cancer Institute in which a large number of video, audio, text, and com-

puter graphic materials will be employed in the production of an interactive education program on Cervical Cancer Screening. The goal will be to create program materials that will be transportable to a wide variety of technology platforms and to analog and digital media, to address the educational needs of several health sciences professional audiences and the lay public.

APDB also continued to support the Library's Congressionally mandated outreach, educational, and information activities:

- Four additional presentations by biotechnology experts were videotaped, edited, and made available to the Library's distribution system in the Biotechnology Seminar Series. These included two presentations given at the national meeting of the American Medical Informatics Association.
- Three more interviews with scientists at NIH were videotaped and edited in conjunction with the Association of Neurological Surgeons.
- Two short versions of "Pathways...", a 17-minute program on the impact of NLM programs on the health of the public were produced. Russian, Japanese, Chinese, Spanish and open-captioned English versions of the 9-minute videotape were subsequently produced.
- In conjunction with the Center's Educational Technology Branch, APDB continued to produce and edit a series of short videotapes on the many interactive videodisc programs housed in The Learning Center. To be titled "Interactive Technology Sampler," these premaster videotapes will be used to create Level II and Level III optical videodiscs.
- The Branch was responsible for coordinating, producing, and editing the premaster videotape for "Computers in Medical Research," an Infowindows interactive videodisc program, as part of an NIH Clinical Center exhibit.
- In cooperation with Dr. Robert Hilfer of Temple University, a number of films and videotapes were edited and converted to videodisc format, for use in an NLM lobby exhibit, "The Emergence of Experimental Embryology in the United States."
- Six presentations for a "Medicinal Muses" Symposium, held in the Lister Hill Center Auditorium were videotaped, edited, and entered into the NLM distribution system.
- Five videotapes were edited, with titles and visual effects added, for NLM use in a national CODATA meeting.
- Several NLM program videotapes were edited for use by Library representatives at this year's national MLA meeting.

- The latest Joseph Leiter Lecture, given by Dr. Michael DeBakey in the Center's Auditorium, was videotaped, edited, and entered into the Library's distribution system.
- Two NLM-sponsored lectures on embryology, presented in conjunction with the earlier mentioned exhibit, were videotaped, edited, and entered into the Library's History of Medicine Division collection.
- Ten satellite teleconferences on a range of biomedical subjects were downlinked and fed to attendees in the LHC Auditorium or to other locations on the NIH campus as part of the Branch's teleconferencing consultation and coordination role.

APDB's Graphic and Still Photography Laboratories continue to provide presentation, publication, and exhibit materials for the Library. The graphic artists are efficiently generating presentation slides and publication materials through the creative use of computer workstations and graphics software. The Still Photography Laboratory has made comparable improvements in the use of film processors, lighting, and camera equipment. The Branch also provides total video, audio, and projection support for scientific and educational meetings in the Lister Hill Center Auditorium and the NLM Board of Regents Room.

NATIONAL CENTER FOR BIOTECHNOLOGY INFORMATION

David Lipman, M.D.
Director

The National Center for Biotechnology Information (NCBI) was established by Public Law 100-607 in November 1988 as a division of the National Library of Medicine. The establishment of the NCBI reflects the importance of developing new information technologies to aid 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 25 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.

The establishment of the NCBI serves to strengthen a number of ongoing NLM projects, and provides resources for new programs. Current NCBI projects are divided into three areas: (1) building new databases and enhancing existing ones which involve genomic information; this includes NLM-developed databases and extramural support for other research information resources; (2) improved information retrieval and analysis techniques for genomic databases; and (3) communication, which includes sponsorship of meetings, workshops, and tutorials on what might broadly be termed computational biology. Within each of these three program areas there are a number of ongoing projects.

Database Building and Enhancement

NCBI, in collaboration with Library Operations, is creating a new biosequence database, the GenInfo Backbone. The GenInfo Backbone includes the MEDLINE records that correspond to the sequence data extracted from the literature, integrates DNA and amino acid sequence information, and maximizes the use of standard



David J. Lipman, M.D., Director, National Center for Biotechnology Information

nomenclature and gene names from official sources. It is the first major database to be made available in ASN.1 (Abstract Syntax Notation), an International Standards Organization data description language. These design features increase the power of the analyses molecular biologists perform on sequence databases, and improve the usefulness of GenInfo as a foundation to which the rapidly increasing number of specialized biology databases can be linked.

NCBI has designed and implemented a relational database and 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 indexed literature. The work sequence:

- NLM indexers identify articles containing sequence data as part of normal MEDLINE processing;
- Corresponding MEDLINE records are loaded into NCBI's relational database;
- Journal issues are scanned by sequence indexers;
- Indexers select appropriate sequences for inclusion into database and add annotation into relational database;
- Copies of selected articles are sent out for contract key-boarding of sequence data;
- For sequences with complex sequence features, indexers add annotation in a second pass to the keyboarded sequence data.

In a parallel effort, NCBI has created explicit definitions for biosequence objects using ASN.1. ASN.1 will be used to provide a hardware- and software-independent version of the information contained in the GenInfo Backbone's relational database. NCBI has also built tools for producing ASN.1 versions of the GenBank DNA sequence database and the Protein Identification Resource (PIR) amino acid sequence database. Other database producers, such as Dr. Amos Bairoch, University of Geneva, the creator of the Swiss-Prot amino acid sequence database, are beginning to provide ASN.1 versions of their databases. NCBI will soon distribute ASN.1 versions of GenInfo, as well as other sequence databases, on CD-ROMs along with information retrieval and sequence searching tools for PC's and Macintosh computers.

The NLM, in conjunction with other NIH institutes and the National Science Foundation, also provides funding for databanks that are major resources for biological research, including GenBank, the PIR, 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.



James M. Ostell, Ph.D., Chief, Information Engineering Branch

Software toolkit. A major mandate of the NCBI is to develop new tools and systems for information retrieval and analysis. The mere accumulation of new data can be futile unless scientists are able to retrieve and analyze it using convenient and powerful software tools. NCBI software development efforts have been directed to developing computer programs that are modular, easily adaptable to other systems, useful in the near term on present machines but also flexible enough to accommodate future advances in software engineering and hardware design. The creation of a software environment that

divides large, complex systems into small independent pieces, which still act in concert, is at the cutting edge of software development. We are exchanging ideas and attempting to coordinate our efforts with other agencies and industry-sponsored groups such as Lawrence Berkeley Laboratories and the Object Management Group of the Open Systems Foundation, who are also addressing these issues in their areas.

The first tool to come out of this project is the Software Toolbox User Interface, which will allow scientists to implement quickly newly developed algorithms as user-friendly programs. The interface is graphical and high-level. For example, applications that require the user to pick from a set of choices can offer either a radio button group, menu choice set, or scrolling list box. The interface, which currently exists on the Macintosh, will be portable among the computers most often found in biological laboratories and computer science departments, allowing the same application program to run virtually unchanged on the Macintosh, IBM PC under Microsoft Windows, and Unix workstations under OSF/Motif. The object-oriented internal design of the interface allows any number of objects to be created at run-time, and the interface automatically positions these objects on the screen. Major changes to the user interface of an application during program development can thus be made quickly and easily.

NCBI is also using this highly modular approach in building the infrastructure for its online retrieval system. For sequence searching and comparison, a new, very rapid search tool named BLAST has been implemented as a network-based retrieval system. A number of research groups around the country have been provided with preliminary 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 service will not only provide sequence analysis but will be an important entry point for retrieval of related information for both the Sequence Backbone and MEDLINE databases

Basic Research

NCBI has a strong multidisciplinary group of in-house scientists carrying out research on fundamental biomedical problems at the molecular level using mathematical and computational methods, and the theory and technology of the methods themselves. These two strands are 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 have developed new mathematical methods for assessing the statistical significance of molecular sequence features (in collaboration with Stanford University) and have incorporated these into a new fast algorithm for sequence similarity searches of protein and nucleic acid databases (in collaboration with Pennsylvania State University and the University of Arizona). New methods for searching for 3-way alignments have been added. The speed of these methods is crucial for strategies of database exploration and for the discovery of new structural similarities and functional associations of biological macromolecules.

These discoveries, including the identification of the neurofibromatosis-1 gene product as a GTPase activating protein, are already being made frequently by NCBI scientists, in some cases in collaboration with scientists in other institutions. Rapid and sophisticated retrieval techniques for acquiring the information from the biomedical literature, using NLM and other databases, is also important for these discoveries.

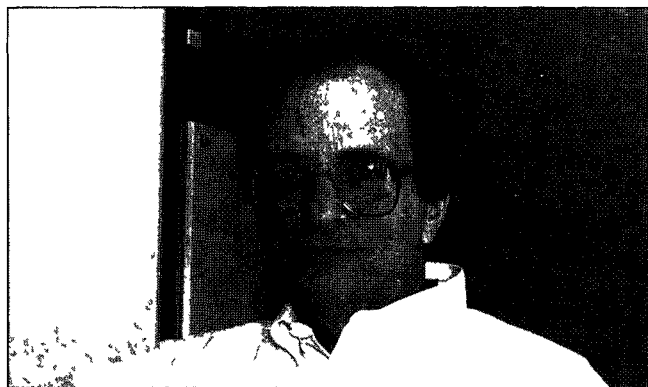
Other basic research carried out at NCBI in the last year includes a new statistical analysis of errors in DNA sequences, global analysis and characterization of the large set of proteins represented in sequence databases for features such as repeats, improvements to the vector method for text retrieval, and mathematical modeling of the binding of CD4 to the gp120 molecule of HIV.

Communication

As part of its mandate to support the development of new information technologies of relevance to biology and genetics, the NCBI has been a leader in sponsoring forums for the exchange of information among leading scientists from the fields of computer science and biology. The NCBI has sponsored the NLM Biotechnology Lecture Series, an international symposium and workshop "Macromolecules, Genes, and Computers," a series of workshops on databases for *E. coli* as a model organism, and a workshop on viral nomenclature. Under the auspices of the National Academy of Sciences, a Workshop on Computer Science in Molecular Biology Research was held in May to foster greater understanding and interest among computer scientists in the problems and opportunities in computational molecular biology. A meeting in July, focused on the design and implementation of the NCBI's GenInfo Sequence database for software developers, was attended by 120 representatives of government, commercial, and academic software groups. NCBI is organizing a course for NIH intramural scientists, to be offered in the fall of 1990, on the theory and practice of sequence analysis.

In addition to meetings, information dissemination is being provided by the GenInfo Data Repository, a network-based service for distributing software and data-

bases produced by the NCBI as well as by outside groups. 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. 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 that impact information exchange on a national level.



Dennis A. Benson, Ph.D., Chief, Information Resources Branch

Extramural Programs

The NLM's extramural division has a program of grants for computer analysis of molecular biology data. Its scope is 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. Research 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

- In the area of information resources, the NCBI will use contract and cooperative agreements to support key molecular biology databanks located around the country. The contents of these databanks will be available through the NLM via networks, and will also be available on various physical media to researchers and value-added resellers.

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

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, 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 accurately and usefully to health workers. This at a time 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.

Our 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 (initiated in 1989 and still in an early evolutionary phase).

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.)



Left, Milton Corn, M.D., Acting Associate Director for Extramural Programs; Right, Richard T. West, Chief, Office of Program Planning and Evaluation, EP

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 last year when the NLM adopted outreach as a major new initiative. As recommended last year 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. Resource information is summarized in the table.

Regional Medical Library support, 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 this document under International Programs.

Research Grants

NLM continued its programs of grant assistance for research on health knowledge issues. Enhancing knowledge utilization by exploiting computer and communication sciences raises numerous difficulties at the theoretical and practical level. To resolve these problems, NLM offers grant support in three separate but related areas. The first two, medical informatics and biotechnology information, are supported under the general NIH research authority, Public Law 301. Research in the health library information sciences is authorized by the Medical Library Assistance Act, as amended.

Medical informatics is an interdisciplinary field which combines medical specialty knowledge with the information and computer sciences, computational linguistics, and cognitive sciences, among others. For over 10 years, NLM has sponsored investigators who have published impressive contributions to a growing medical informatics literature. Partly in consequence, there is a growing appreciation for this field in academic medicine. Learning how to manage information is increasingly perceived as an essential skill for the health professional.

Among the new project grants awarded this year are two investigations that have to do with artificial intelligence in medicine methodology while addressing clinical information problems related to AIDS. At Stanford University, Dr. Mark Musen is developing computer software tools and techniques that will foster creation and dissemination of protocol guidelines in ways that can be easily incorporated into larger, computer-based protocol management systems. His work is one of several parallel medical computer science activities at Stanford. His goal is to develop methods for computer-aided design of new clinical protocols, so that investigators can better define the expected efficacy and toxicity of therapeutic agents for AIDS.

At the Robert Wood Johnson Medical School (University of Medicine and Dentistry of New Jersey), Dr. Frank Sonnenberg is designing a computer-based consultative assistance system for clinicians faced with complex choices among diagnostic and therapeutic options. A computer program, employing artificial intelligence techniques, will eventually automate the generation of decision models and analysis of these models to produce appropriate recommendations. The project focuses on evaluating pulmonary infiltrates in AIDS patients. This increasingly significant clinical problem involves high risks for individual patients and a bewildering array of options for clinicians, with many complex trade-offs.

It was also possible this year to renew support for fundamental work on artificial intelligence in medicine at the Massachusetts Institute of Technology. The investigator, Professor Peter Szolovits, and his colleagues have pioneered in work on basic knowledge representation problems. Together with collaborators such as Dr. Stephen Pauker at Tufts/New England Medical Center, they successfully join artificial intelligence methodologies with medical decision science.

Biotechnology information research is supported to investigate effective methodologies for organizing and analyzing data about molecular control of life processes. Relevant problems include design and management of large-scale databases, more powerful methods to retrieve information from multiple factual databases, and general pattern matching algorithms for biological sequences. Recognizing that major advances in molecular biology will depend in large part on successful resolution of knowledge and information issues, NLM published a formal request for applications and in 1989 set aside one million dollars for new starts in this vitally important informatics research area. NLM's special interest in this area continued in 1990.

In this area, there was some falling off this year in the number of applications received and, consequently, the number of highly ranked proposals was smaller still. This trend doubtless reflects the difficulty, at this comparatively early stage, of bringing together molecular biologists and computer scientists in projects of mutual interest.

The need for conveniently available information, however, continues in the molecular biology community. One response is in a recently funded project directed by Professor Ronny Woodruff of Bowling Green State University. He will develop computer-based methods for updating, printing, and mailing stock listings of *Drosophila* species and mutants to the research community. Professor Woodruff will bring a methodological exactitude to this project that will assure its credibility everywhere; his computer database has a potential for growing into a sophisticated and versatile knowledge resource.

Research in the health library and information sciences is authorized by the Medical Library Assistance Act. It is generally agreed that traditional information disciplines must continue to evolve; their services are essential to the health community. The bibliographic record remains not only the source for current medical knowledge, it constitutes the underlying archival structure of modern science. Continuing work on analysis of retrieval systems, following an intensive competitive review, is consistent with earlier project support on bibliographic retrieval.

In this area it was possible to award one project this year which continues the evaluation and comparison of

Grateful Med and other systems in providing drug information to community pharmacists and pharmacy students. A related aim is to investigate attitudes of users regarding computerized access, demands on users' time, and, in general, compatibility of computers, as presently developed, in the day-to-day collaboration of pharmacists and clinicians. The geographic area is rural West Virginia, so this project represents one of several efforts to determine the usefulness of Grateful Med as an outreach program to comparatively isolated communities. The investigator, Marie Abate, is an Associate Professor at the School of Pharmacy of West Virginia University.

During this year of varied research grant program activities, several challenging problem areas were identified. One is the difficulty of an effective joining of forces between graduate school and medical school. Establishing an intellectual alliance that can lead to a scientifically interesting proposal in a medical context is difficult at best; interdisciplinary collaboration makes heavy demands on investigators' time. Because most of the research proposals addressed to NLM involve eventual clinical application, questions of validation and evaluation are major review criteria, but applicants seldom satisfy evaluation concerns fully. NLM's reviewers will give attention to this issue in the coming year with a view to providing appropriate criteria and guidance.

For the young investigator, success with the grant review process is a major hurdle, even though the First Independent Research Support and Transition (FIRST) award is an assistance mechanism created just for this group. Through a variety of tutorial methods, NLM, and many of the senior investigators it supports, are attempting to help young scientists marshal evidence specifically and persuasively in grant applications. The problem is not one of language or "grantsmanship," but rather one of understanding the committee dynamic of peer review.

Gratifyingly, NLM was able to continue its support for many investigators initially funded in earlier years. The number of grant-related publications and presentations is encouraging. In a recent book, *Medical Informatics, Computer Applications in Health Care*, four NLM awardees bring together a large number of carefully written chapters on all aspects of computer applications in health care information management. For those who wonder what this field is about, this book provides an answer in exhaustive detail.

Training

The NLM continues its support of research training in the fields of medical informatics and biotechnology information. It is clear that these disciplines go beyond the use of the computer as a computational tool and extend into the process of knowledge representation, storage, retrieval, and manipulation to support inferen-



Roger Dahlen, Ph.D., Chief, Biomedical Information Support Branch

tial reasoning, and to rationalize decision making in the health sciences. There remains a need for qualified, talented investigators, well equipped to address fundamental issues in the use of computers and automated information systems in health care, health professions education, and biomedical research. These investigators will contribute to the growth of science by their studies of knowledge management and by advancing the frontiers of the computer sciences for organizing, retrieving, and utilizing health knowledge. NLM also intends to foster medical informatics and biotechnology information as growing disciplines with an appropriate place in academic medicine. It is expected that the trainees will become able, cross-disciplinary translators, taking the computer sciences to all of biomedicine.

Support is in the form of institutional training grants which supported 48 postdoctoral and 21 predoctoral trainees in 1990. The seven currently supported training sites are listed below. In addition to the institutional training grants, NLM supported 5 individual fellows. The current fellows are receiving their research training at the University of Utah, Columbia University-Presbyterian Hospital, University of Washington, Yale University, and Cold Spring Harbor Laboratories.

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 emphasis is 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 following: 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 to individuals with a career commitment to this field. The specialized curriculum focuses on the development of a new generation of researchers with a commitment to 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. Specific 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.

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.

During FY 1990, IAIMS Phase I planning projects were active at Dartmouth Medical School, Rhode Island Hospital, the University of Michigan, and the University of Pittsburgh. Additionally, new IAIMS planning grants were awarded to Tufts University School of Medicine and the University of Washington.

After planning, Phase II projects support testing IAIMS models on a small scale in research, education, and/or patient care areas. During FY 1990, Phase II grants were active at the universities of Cincinnati, Maryland, and Utah. A new Phase II project was begun with a grant to the American College of Obstetricians and Gynecologists.

Two new grant awards to assist in the full implementation of an institution-wide IAIMS (Phase III) were made to the Baylor College of Medicine and Duke University. These awardees joined Columbia University and Georgetown University who received continuation awards in FY 1990 for their second year of the five-year Phase III activity.

In an IAIMS-related activity, an NLM contract was in its second year at the Oregon Health Sciences University (OHSU) to implement a Biomedical Information Communications Center (BICC) to serve the University, the State, and the northwest region of the country. Primary activities over this five-year contract will include establishing a BICC organization and staff, developing campus telecommunications, appointing training faculty, implementing an automated library information

resources system, developing Infonet and a Regional Resources System and Network, creating a medical informatics curriculum for OHSU, and developing research programs in health informatics and in technology.

Resource Grants

FY 1990 witnessed the implementation of the revitalized Resource Grant Program with the award of 11 Information Access Grants and 3 Information Systems Grants. Information Access Grants, available to individual institutions as well as consortia of health-related institutions, assist in providing access to information resources and services utilizing computer and communications technologies. Information Systems Grants, which also utilize computer and communication technologies, are intended to encourage networking, connectivity, and integration directed towards developing an information infrastructure.

Four institutions receiving Information Access Grants to acquire CD-ROM capabilities are Central Maine Medical Center in Lewiston, Columbia Hospital in Milwaukee, Miami Children's Hospital in Florida, and Stamford Hospital in Connecticut. Odessa Memorial Hospital in Washington received an Information Access Grant to introduce Grateful Med to its staff. Three Information Access Grants were awarded to consortia of health-related institutions to offer access to Grateful Med: the North Idaho Health Information Network through the Kootenai Medical Center in Coeur D'Alene; the Eastern Kentucky Health Science Information Network based at Morehead State University; and the AHEC Mountain Information Access Cooperative headquartered in Hazard, Kentucky. The Northeastern Consortium for Health Information (Boston) received Information Access funds to compile a union list of monographs, and the University of North Dakota plans to use Information Access funds to expand the state online network to include the hospital/clinic library holdings. The University of Nebraska's medical center library received an Information Access Grant on behalf of health-related libraries in the Greater Omaha area to develop a plan for introducing end-user searching and delivering documents.

Information Systems Grants were awarded to: 1) Yale University to install a full-text database management system to integrate Current Contents, the preclinical curriculum syllabus, and a drug information database; 2) University of Miami to develop the Southeast Florida AIDS Information Network; and 3) Cleveland Medical Library Association for the Ohio Network of Medical History Collections to develop a system to catalog artifacts.

Four grants were awarded under the auspices of the former Medical Library Resource Grant Program.

A Medical Library Resource Project was awarded to the University of Texas Health Science Center at San Antonio on behalf of the 21 members of the Friends of (Georgetown University's) Library Information System to provide a model of system planning and development for automated library systems. Medical Library Resource Improvement Grants were awarded to: Valley Children's Hospital (Fresno, CA), Mercy Hospital (Janesville, WI), and the Laurel Highlands Health Sciences Library Consortium (Johnstown, PA).



Arthur Broering, Dep. Asso. Director for Extramural Programs; Jeanne L. Brand, Ph.D., Chief, International Programs Branch

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 annotated bibliographies, 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.

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 1990 NLM awarded 17 Publication Grants totaling \$390,377. Of these, 10 were new awards. This small grant program has a current 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 a comprehensive study of the history of public health services in the United States, John Duffy's *The Sanitarians* (Urbana, IL: University of Illinois Press, 1990). No similar modern volume on the history of public health is in existence and the work is expected to become a classic in the field.

Another notable work received in FY 1990 was the fourth and last installment of the current version of "The Genome of *Drosophila Melanogaster*" issued by the *Drosophila* Information Service of the University of California at San Diego. This project, which lists and describes all known genetic variations known in *Drosophila*, is an updated version of a fundamental reference work last published in 1968, *Genetic Variations of Drosophila Melanogaster*. The revision is an important tool for designing and interpreting genetic experiments with *Drosophila*. (A list of supported publications received in FY 1990 is in Appendix 2.)

National Reference Center for Bioethics

This year NLM renewed its support for a specialized center at Georgetown University. The National Reference Center for Bioethics has been supported by NLM by a variety of mechanisms for many years. The Center functions in association with a bibliographic database on the literature of bioethics, now funded by a contract with NLM. The Center collects, organizes, and disseminates a wide range of written materials in the broad field of bioethics. Over the years, the Center has drawn widespread praise for its high level of service and operation. The Center and its related bibliography, available electronically on NLM's BIOETHICSLINE, provide valuable information to the entire country at a time when ethical, moral, and legal issues concerning health care and biomedical research constantly increase. The Center is also a

major reference source for undergraduate colleges everywhere. The decision to renew support for the Center was based, in part, on an extremely favorable endorsement by a distinguished expert panel.

Highlights of Committee Activities

NLM's scientific merit peer review group—the Biomedical Library Review Committee (BLRC)—was expanded to 21 members in 1989 from its previous 15, adding experts in molecular biology information. During its regular three meetings in FY 1990, the BLRC reviewed 121 applications of which 95 were approved. 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. The subcommittees consider research applications in medical library projects, medical informatics, and biotechnology information respectively.

The final peer review of applications is performed by the Board of Regents, which meets three times a year approximately four months after the Biomedical Library Review Committee. One of the Board's subcommittees, the Extramural Programs Subcommittee, comes together the day before the full Board for the review of "special" grant applications. Examples of "specials" include applications for which the recommended amount of financial support is unusually large, when at least two members of the scientific merit review group dissented from the majority of either approval or disapproval, when a policy issue has been identified, and when an application is from a foreign institution. The Extramural Programs Subcommittee makes recommendations to the full Board.

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

Category	FY 1988		FY 1989		FY 1990	
	No.	\$	No.	\$	No.	\$
Research	40	\$5,857	45	\$7,666	47	\$11,343
Resource projects	15	3,474	14	3,487	15	4,492
Resource improvement	8	114	9	129	15	519
Training	8	2,619	7	2,537	7	2,886
Fellowships	0	0	3	99	5	189
Regional Medical Libraries	7	2,330	7	2,569	7	3,772
Publications*	12	330	13	346	16	390
(IAIMS projects*)	(9)	(2,822)	(9)	(2,962)	(8)	(3,821)
(Med. info. research)	(25)	(3,865)	(26)	(4,008)	(24)	(6,030)
(Biotech. research)	(7)	(1,000)	(14)	(2,747)	(17)	(4,179)
Totals:	90	\$14,724	98	\$16,833	112	\$23,591

*Includes one Special Scientific Project

**Includes both IAIMS resource and research projects

OFFICE OF COMPUTER AND COMMUNICATIONS SYSTEMS

John Anderson
Director, Information Systems

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

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

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

- developed and implemented by the Development Branch
- enhanced and maintained by the Application Services Branch
- executed on computers under operating system control by the Systems Support Branch
- 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 library processing requirements. Development activities during the past year include the implementation of a major subsystem of MEDLARS III, expansion of Grateful Med support, enhancements to



Right, John Anderson, Director, Information Systems; Left, Aaron Navarro, Ph.D. Dep. Dir. for Development; Center, Harry D. Bennett, Dep. Dir. for Operations

DOCLINE, development of Loansome Doc, and extensions to the local area network services.

The Technical Services System (TESS) is being developed to perform two functions for NLM's Technical Services Division: the Cataloging Front-End (CAFE) subsystem and the Selection and Acquisition (SAAS) Subsystem. TESS is a distributed processing system that integrates mainframe computer, personal computer (workstation), database, and local area network (LAN) technologies.

The CAFE subsystem was successfully implemented in September 1989. SAAS was developed using the CAFE software as a foundation and was implemented in the fall of 1990. The two subsystems will not only share the same architecture, but also much applications software. The basic approach is to develop a common set of system functions that drive the mainframe, database, LAN, and workstation, and then use them to construct the specific application functions.

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) have been released, and a Unix-based version is in the design stage. More than 2 million searches will be performed via Grateful Med this year by over 25,000 registered owners of the software.

Existing support contracts are expected to be renegotiated in the coming year.

The functionality and utilization of DOCLINE also continue to grow. Approximately 1.9 million interlibrary loan requests were processed by nearly 2000 libraries in FY 1990. The ability to CANCEL a request has been added, as that of handling FAX requests. System performance has been improved through a variety of hardware and software changes.

A major Development Branch effort has resulted in the pilot implementation of Loansome Doc, which provides an interface between Grateful Med and DOCLINE. This interface will enable the Grateful Med user to order journal articles electronically from a DOCLINE library during a Grateful Med session.

As the processing power at NLM staff and patron workstations continues to increase, greater requirements are placed on internal communications in terms of throughput and volumes of data traffic. NLM Local Area Networks (LANs) continue to be enhanced in order to keep pace with demands to share and transfer information among diverse systems. An extensive broadband cable system throughout NLM links workstations with servers and other processing resources using the Novell Netware operating system. Workstations can access internal hosts through gateways or direct links, and other LANs or wide area networks, such as the NLM Ethernet, are accessible by bridges or gateways. These communications facilities form an integrated network that supports office automation, electronic mail, distributed applications, and data processing activities.

Applications Services Branch

The Applications Services Branch (ASB) of OCCS supports the various NLM programs and serves as the nucleus of all automated programming support services. In FY 1990:

- A new database, ChemID, described in the Specialized Information Services chapter, became operational.
- Weekly updating of the MEDLINE database went into effect.
- New generations of software for some major Automated Indexing Management System (AIMS) subsystems became operational. The subsystems affected are INDEXING (the application of NLM controlled thesaurus keywords), LSTRC (Literature Selection Technical Review Committee), and BINDING (preparation of journals, etc. for binding).

- The NLM Machine Readable Catalog (MARC) software was updated to process CATLINE and AVLINE data according to the 1987 U.S. MARC (release 15) specifications.
- Many software enhancements were made to the Model 204 DBMS based MeSH system.
- A prototype Bioethics Citation Maintenance System was completed. This software is PC-based and will provide for individual citation maintenance. It is planned for production in FY 1991.
- Major enhancements were made to the Class Maintenance software for NLM bibliographic data. The new functions make it possible to change MeSH minor descriptors to major descriptors, to create subheading pre-explodes, to create MeSH heading fragments, and to create title fragments.

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), TCAM, and VTAM. An IBM 3081-K is used for system testing and development. A third system, an IBM 9370-60 with VM (virtual machine) is used for PROFS (the Professional Office System).

During FY 1990, storage capacity was expanded and the reliability of the IBM 3084 system was improved. Accomplishments for the year include:

- An increase in online storage capacity to 260 billion bytes.
- Expanded use of STC 4305 and Memorex 6890 solid state disks.
- Provision of systems software for the 3084, the IBM 3380-K disk storage and 3990 controller, the STC and Memorex solid-state disks, the Xerox and IBM printers, and the IBM 9370 PROFS system.
- Support of more than 100 software products used by programmers, users, and systems support staff.
- Operating systems support and communications connectivity for new terminals throughout the NLM.
- Development and distribution of procedures and status information for the mainframe system.
- Program changes to system software as required by ELHILL and other applications software development.



Left to Right: Melvin Beckelhimer, Chief, Systems Support Br.; William Hagarty, Chief, Computer Services Br.; Robert Kicklighter, Chief, Applications Services Br.; John Cox, Chief, Development Br.

Computer Services Branch

The Computer Services Branch (CSB) provides data processing services and support for subscribers and users of the Library through the use of the three mainframe computer systems described above.

Operational support is provided around the clock, seven days a week, 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 3084 mainframe consists of 220 direct access storage devices with a total online storage capacity of approximately 260 billion characters of data. In addition, there are 14 magnetic tape drives, 6 IBM 3420's, and 8 IBM 3480's, which are used in filling subscribers' requests for copies of the MEDLARS database files.

In FY 1990, the CSB created and mailed more than 5,200 magnetic tapes containing MEDLARS and TOXNET database files to domestic and foreign subscribers. Also installed are many telecommunications units to provide easy and quick access, worldwide, to the main MEDLARS database files.

Annual printed output exceeds 22 million pages or 989 million lines of local printing on the high-speed, fan-fold, 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 are printed through the use of remote printers.

INTERNATIONAL PROGRAMS

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

The National Library of Medicine plays an important role in making vital biomedical information available to health scientists and clinicians around the world.

During the past year NLM continued its bilateral cooperative MEDLARS agreements with individual countries, its cooperation with 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 173 institutions in 51 countries), as well as receiving numerous professional visitors from abroad.

International MEDLARS Agreements

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

The Indian National Informatics Center is continuing its efforts to set up a tape center in New Delhi to provide MEDLARS services to health professionals in India. NLM will soon conduct a test with NIC to determine whether the search software to be used by NIC can accurately retrieve citations from MEDLARS databases.

The Library, in collaboration with the American Institute in Taiwan and the Coordinating Council for North American Affairs, has reached an agreement for the Science and Technology Information Center (STIC) in Taipei to become a new International MEDLARS Center to provide MEDLARS service to health professionals in Taiwan. STIC has successfully demonstrated the use of Grateful Med (GM) for MEDLINE access and will soon be helping health personnel in the use of GM.

The other international organization with which NLM has a MEDLARS agreement is the Pan American 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, and soon access will be available to even more Latin American countries.



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

Another collaborative project with PAHO and the University of Chile is the development of a gateway system named BITNIS. This new system makes it possible for health professionals to conduct MEDLINE searches in Argentina, Chile, Mexico, and Venezuela. A MEDLINE search through BITNIS is initiated by using Grateful Med on a personal computer. The search commands created by Grateful Med 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's MEDLINE to health professionals in all Latin American countries where the high cost of international communication services inhibits normal access.

Collaboration with WHO

NLM and the World Health Organization (WHO) continue 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. Also, NLM provides MEDLINE bibliographies in camera-ready form to PAHO, and PAHO prints and distributes these in the *Bibliography of Respiratory Infections in Children*.

NLM and WHO also 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.

Table 11
International MEDLARS Centers

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

*Combined online/tapes

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 in local currency for the Library's program is presently available only in India.

During FY 1990, 26 projects totaling \$345,512 (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. Approximately 85 percent 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 funded studies received in FY 1990 was a translation from the German of Jacob Wolff's

The Science of Cancerous Disease from Earliest Times to the Present, with a new introduction by the eminent American medical historian, Dr. Saul Jarcho. No other English-language monograph in the history of the development of concepts of neoplasia in Western medicine has been available, and Wolff's work constitutes a unique reference source for investigators and medical historians in the search for understanding the etiology of cancer.

Also released in FY 1990 was an English translation of the *Developmental Genetics of Vertebrates* by B.V. Konyukhov, Institute of General Genetics, Academy of Sciences of the USSR (Springfield, VA: National Technical Information Service, 1990). Edited by Professor Bruce M. Carlson, M.D., Ph.D., of the University of Michigan Department of Anatomy, this monograph is a comprehensive study of the actions and interactions of genes during development. It covers a wide variety of human genetic defects, stressing the biological problems brought out by these conditions. (A list of supported publications received in FY 1990 is included in Appendix 2.)

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 1990 general meeting of ICSTI, held in Gatlinburg, Tennessee, NLM was represented by the NLM Deputy Director and the NLM Director for International Programs. Both hold office in ICSTI.

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, Australia, Bangladesh, Belgium, Brazil, Burundi, China (PRC), Colombia, Cyprus, Czechoslovakia, East Germany, Egypt, France, Granada, Great Britain, Haiti, Hungary, Iceland, India, Indonesia, Iraq, Japan, Korea, Malaysia, Mauritania, Morocco, The Netherlands, Norway, Pakistan, Papua-New Guinea, Peru, Poland, South Africa, Spain, Surinam, Syria, Taiwan, Thailand, Togo, the USSR, West Germany, Yemen, and Yugoslavia.

ADMINISTRATION

Kenneth G. Carney
Executive Officer

Financial Resources

In FY 1990, the Library had a total appropriation of \$81,861,000. Table 12 displays the FY 1990 budget authority plus reimbursements from other agencies, and the allocation of these resources by program activity.

Table 12
Financial Resources and Allocations FY 1990
(in thousands of dollars)

Budget authority:	
Appropriation, NLM	\$81,861
Plus: Reimbursements	16,432
Total	98,293
Budget allocation:	
Extramural Programs	23,618
Intramural Programs	67,806
Library Operations	(44,592)
Lister Hill National Center for Biomedical Communications	(11,199)
National Center for Biotechnology Information	(5,073)
Toxicology Information	(6,942)
Research Management and Support	6,869
Total	\$98,293

Personnel

As the National Center for Biotechnology Information continued its rapid growth, it became necessary to establish three branches within the Center:

- The Information Resources Branch, which supports intramural and extramural information resources to serve the molecular biology community;
- The Information Engineering Branch, which is concerned with the development of automated systems for data analysis and retrieval; and
- The Basic Research Branch, which conducts basic research in computational molecular biology.

There were significant NLM administrative staffing changes in 1990. These included the appointment of a new Deputy Executive Officer, Sally S. Burke; NLM Personnel Officer, Patricia Southcomb; NLM Budget



Kenneth G. Carney, Executive Officer; Sally Burke, Deputy Executive Officer

Officer, Susan Levine; and NLM EEO Officer, David Nash.

The effort to recruit and hire the most effective personnel to staff NLM programs continued to be a top priority in 1990. A development that should facilitate this effort was the delegation of authority by the Office of Personnel Management to the NLM to run the Librarian Register for all of NIH. This delegation will expedite hiring significantly.

Although a hiring freeze was imposed in late August by the Department of Health and Human Services on all agency components, the NLM closed the fiscal year at its full operating ceiling of 548 full-time equivalents (FTE's). The freeze was imposed pending resolution of a deficit-reduction program by Congress. Congressional action is required to avoid effects of the Gramm-Rudman-Hollings budget reduction law which would require major reductions in the FY 1991 budget beginning October 1, 1990.

Awards

NLM Director, Donald A.B. Lindberg, M.D was awarded an honorary doctor of laws degree from the University of Missouri-Columbia where he served on the faculty prior to accepting his current position at NLM. "Perhaps more than anyone else in the world, you have engineered the merger of the worlds of medicine and computers," said MU Chancellor Haskell Monroe, reading from the degree citation.

Rose Marie Woodsmall, Planning Office, and John Anderson, Director, OCCS were awarded the Frank Bradway Rogers Information Advancement Award. The award was given for their pioneering effort in the development of Grateful Med. The Rogers Award is sponsored by the Institute for Scientific Information and is given in recognition of an outstanding contribution in applied technology for the delivery of health sciences information.

NIH Merit Awards were presented in 1990 to:

William J. Hagerty, OCCS, "for superior performance in providing online availability of MEDLARS and other databases in NLM's computer facility."

Eve-Marie Lacroix, LO, "for exceptional leadership, foresight, and achievement in managing the programs and services of the Public Services Division."

Alice Ladson, LO, "for her exceptional contributions in maintaining effective service to patrons in the Reading Room throughout a period of change, and for sustained outstanding performance."

Carol Unger, LO, "for her exceptional contribution to developing and managing the Library's preservation microfilming program and for sustained outstanding performance."

Nancy Wright, LO, "for her excellent coordination of contract staffing needs under an extremely short deadline so as to implement the building of the GENINFO Backbone database."

The NLM Director's Awards for 1990 were presented to:

B. Earl Henderson, LHNCBC, "for your outstanding management of the scientific and engineering programs of the Lister Hill Center, and for planning and initiating an undergraduate research study program to support the professional engineering training of students from historically black institutions of higher learning as part of NLM's increased outreach to underserved communities."

Sheldon Kotzin, LO, "for your outstanding ability to manage the creation of the MEDLINE database and access to the MEDLARS system."

The Board of Regents Award was presented to David Kenton, Office of Information Systems, in recognition of over a decade of primary responsibility for NLM's biomedical information retrieval system, ELHILL.

The NIH Harvey Bullock Award was presented to Cynthia Gaines, SIS, to recognize her efforts in Equal Employment Opportunity (EEO). Ms. Gaines has made significant contributions in the past five years to the cause of EEO at NLM through service, communication, and coordination.

The Frank B. Rogers Award was established in 1989 to recognize an employee who has made a significant contribution to the Library's fundamental operational

programs and services. The first Rogers award was presented to Margaret Byrnes, LO for her outstanding leadership in the preservation of the biomedical literature.

Equal Employment Opportunity

"Get To Know EEO; It's For Everyone." This is the primary initiative being launched at the National Library of Medicine with the arrival of Mr. David Nash, NLM's new EEO officer. His extensive knowledge and insight into EEO derive from his previous experience at the Equal Employment Opportunity Commission and the Department of the Navy EEO office.

The EEO Officer has visited most NLM offices and has gotten to know many employees. He has spoken at various EEO-related meetings at the NLM and on the NIH campus. The Library's EEO program is addressing fundamental questions: What is EEO? How does it work? How will EEO be utilized at the Library?

Among the program's new goals and objectives: the Workforce 2000 challenge—how will the Library make best use of this diversified work force? Reinvigorating upward mobility for lower level employees—enhancing their skills so they can perform at their highest potential and advance in accordance with their abilities and the availability of opportunities. All these efforts will rely on career counseling and planning, training and education, job analysis, systematically identifying target jobs to meet staffing needs, and establishing ways to measure employee potential.

Working closely with the Library's EEO Advisory Committee, the new EEO Officer is emphasizing the systematic evaluation of EEO progress at NLM, identifying problem areas such as the need for more representation at NLM of Hispanic Americans, assessing the effectiveness of the overall EEO program, and reporting the results of the continuing evaluations.

To deal with the sensitive issue of discrimination complaints, the EEO Office is putting more effort into explaining to employees both the formal and informal complaints process. Guidance is being provided to managers and supervisors in how to avoid complaints by assuring that all employees are treated within the guidelines of the law. It is important to avoid even the appearance of unfair discrimination in working conditions, training opportunities, assignments, position descriptions, vacancy announcements, and the style and tone of oral and written communications. Managers and supervisors are being reminded that executive ability includes constant concern with staff development and fair treatment. In fact, the most crucial executive skill is to be able to motivate others.

In the areas of community outreach, the EEO Officer took part in the National Institutes of Health job fair and has attended workshops and conferences that addressed

concerns of minorities, women, and the disabled. Among the actions taken for specific minorities:

- The NLM EEO Office has been working closely with the National Association for Equal Opportunity in Higher Education and, related to this, with the NLM project with the Historically Black Colleges and Universities group.
- Also being targeted are groups such as the National Hispanic University, where NLM is attempting to get access to a large pool of qualified Hispanic American employee candidates.
- There are efforts to improve training and career opportunities for Native Americans and Alaskan Natives

- The NLM EEO Officer has been consulting NLM staff with disabilities about their special needs, with NLM management about the attitudinal and architectural barriers in employing people with disabilities, and with such organizations as the NIH committee on persons with disabilities and the Kaiser Foundation.

Late in FY 1990, at the NLM Annual EEO Open Meeting, David Satcher, MD, president of Meharry Medical College in Nashville, Tennessee (and president of the Association of Minority Health Professions schools), addressed the NLM staff on the history and current state of minority health science education in the U.S. At this meeting, also, the new EEO Officer presented his overall EEO plans for the Library.

Table 13
Staff, FY 1990 Full-Time Equivalent (FTEs)

<i>Program</i>	<i>Full-Time Permanent</i>	<i>Other</i>
Office of the Director	19	1
Office of Public Information	5	2
Office of Administration	44	4
Office of Computer and Communications Systems	62	3
Extramural Programs	16	2
Lister Hill Center	66	11
National Center for Biotechnology Information	11	11
Specialized Information Services	35	3
Library Operations	224	31
Total	482	68
Total FTE Usage	550	

APPENDIX 1: ACRONYMS, ABBREVIATIONS, AND INITIALISMS

- AAOS (American Academy of Orthopaedic Surgeons)
 AAT (Art and Architecture Thesaurus)
 AHCPR (Agency for Health Care Policy and Research)
 AI/COAG (Artificial intelligence hemostasis consultant system)
 AI/RHEUM (Artificial intelligence rheumatology consultant system)
 AIDS DRUGS (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)
- BDIP Program (Biomedical Digital Image Processing)
 BICC (Biomedical Information Communications Center)
 BIOETHICSLINE (BIOETHICS onLINE)
 BIREME (Biblioteca Regional de Medicina - NLM's MEDLARS Center in Brazil)
 BITNET (Because It's Time Network)
 BITNIS (BITNET NLM Intercommunication System)
 BLAST (Basic Local Alignment Search Tool)
 BOSCO (Board of Scientific Counselors)
 CAFE (Cataloging Front-End)
 CANCERLIT (CANCER LITerature)
 CAS (Chemical Abstracts Service)
 CATLINE (CATalog onLINE)
 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)
 CHEMID (Chemical Identification File)
 CHEMLEARN (Microcomputer-based training for CHEMLINE)
 CHEMLINE (CHEMical Dictionary OnLINE)
- CLINPROT (CLINical cancer PROTOcols)
 COACH (Expert searcher prototype system for Grateful Med users)
 CODATA (Committee on Data for Science and Technology)
 CRISP (Computer Retrieval of Information on Scientific Projects)
 CROSSFILE (Permits TOXNET users to search for data from multiple files simultaneously)
 CSB (Computer Science Branch)
 CTX (Criteria Table Expert Systems)
- DART (Developmental and Reproductive Toxicology)
 DBIR (Directory of Biotechnology Information Resources)
 DENTALPROJ (Dental Projects database)
 DHHS (Department of Health and Human Services)
 DIRLINE (Directory of Information Resources Online)
 DOCLINE (DOCuments onLINE)
 DOCUSER (DOCument delivery USER)
 DRAW (Direct Read After Write—Disc)
 DSM-IIIIR (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)
 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)
 ETICBACK (Environmental Teratology Information Center Backfile)
- FASEB (Federation of American Societies for Experimental Biology)
 FEDRIP (Federal Research-In-Progress)
 FIRST (First Independent Research Support and Transition)

- FTE (Full-time equivalents)
- GenBank (National, NIH-supported DNA sequence database)
- GenInfo (Databank of biological information about sequences, including the sequence itself, reflecting the journal literature)
- GM (Grateful Med)
- HBCU's (Historically Black Colleges and Universities)
- HCTA (Health Care Technology Assessment)
- HEALTH (HEALTH planning & administration)
- HISTLINE (HISTORY of medicine onLINE)
- HSDB (Hazardous Substances Data Bank)
- IAIMS (Integrated Academic Information Management System)
- ICSTI (International Council for Scientific and Technical Information)
- IEEE (Institute for Electrical and Electronics Engineers)
- ILAR (Institute of Laboratory Animal Research)
- ILL (Interlibrary Loan)
- INFORM (Used to obtain online NEWS and systems information)
- INTROMED (A training/practice database)
- INTROTOX (A practice subset of HSDB for TOXNET users)
- INVESTIGATOR (A research program for knowledge acquisition planning)
- 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)
- LEXTOOL (An interactive lexicon building tool for SPECIALIST)
- LHNCBC (Lister Hill National Center for Biomedical Communications)
- LO (Library Operations)
- LSTRC (Literature Selection Technical Review Committee)
- 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)
- Micro-CSIN (Chemical Substances Information Network)
- MIIS (Modified Interpretative Information System)
- MIM (Mendelian Inheritance in Man)
- MRAB (Machine-Readable Archives in Biomedicine)
- MRI (Magnetic resonance imaging)
- MUMPS (Massachusetts Utility Multi-Programming System)
- NAC (National Audiovisual Center)
- NCBI (National Center for Biotechnology Information)
- NCHS (National Center for Health Statistics)
- NHANES (National Health and Nutrition Examination Surveys)
- NIAMS (National Institute of Arthritis, Musculoskeletal and Skin Diseases)
- NIEHS (National Institute of Environmental Health Sciences)
- NIH (National Institutes of Health)
- NIOSH (National Institute for Occupational Safety and Health)
- NLQ (Natural Language Query)
- NLS (Natural Language Systems)
- NTIS (National Technical Information Service)
- 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)
- PAHO (Pan American Health Organization)
- PAM (Principals of Ambulatory Medicine)
- PDQ (Physician Data Query)
- PIR (Protein Identification Resource)
- POPLINE (POPulation information onLINE)
- RDBMS (Relational Database Management System)
- REFLINE (Subset of MEDLINE for NLM patrons)
- 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)
SIS (Specialized Information Services)
SPECIALIST (experimental system for parsing, analyzing, and accessing medical text)
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)

WHO (World Health Organization)
WORM (Write Once Read Many—Disc)

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APPENDIX 3: FY 1990 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:

DETMER, Don E., M.D. (Chairman)
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University of Virginia
Charlottesville, VA

ANDERSON, Rachael K.
Director, Health Sciences Library
Columbia University
New York, NY

BEERING, Steven C., M.D.
President, Purdue University
West Lafayette, IN

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

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

DeNARDIS, Lawrence J., Ph.D.
President, Connecticut Public Expenditure Council
Hartford, CT

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

SMITH, Alvy Ray, Ph.D.
Executive Vice President, Pixar
Richmond, CA

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

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

ERNST, Ruann F , Ph D
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Information Systems
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FOSTER, John, Ph D
Professor and Chair
Department of Electrical Engineering
North Carolina A & T State University
Greensboro, NC

FRISSE, Mark E , M D
Assistant Professor of Medicine
Washington University School of Medicine
St Louis, MO

FRYBACK, Dennis G , Ph D
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University of Wisconsin-Madison
Madison, WI

HAMM, Gregory H
Director, Molecular Biology Computing Laboratory
Waksman Institute
Rutgers University
Piscataway, NJ

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, Department of Chemistry
Rutgers University
Piscataway, NJ

CANTOR, Charles R., Ph.D.
Professor, Department of Molecular Biology
University of California
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:

- STEAD, William W., M.D. (Chairman)
Associate Professor of Medicine
Director, Medical Center Information Systems
Duke University Medical Center
Durham, NC
- ABARBANEL, R.M., M.D., Ph.D.
Manager, Engineering Computing and Analysis
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Clark-Atlanta University
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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:

GUNN, Albert E., M.D. (Chairman)
Associate Dean for Admissions
The University of Texas Medical School at Houston
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ANDERSON, Philip C., M.D.
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Department of Dermatology
University of Missouri School of Medicine
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BRACHMAN, Philip S., M.D.
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Emory University
Atlanta, GA

CASHEL, C. Michael, M.D., Ph.D.
Chief, Section on Molecular Regulations
National Institute of Child Health and Human
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DeBAKEY, Lois E., Ph.D.
Professor of Scientific Communication
Baylor College of Medicine
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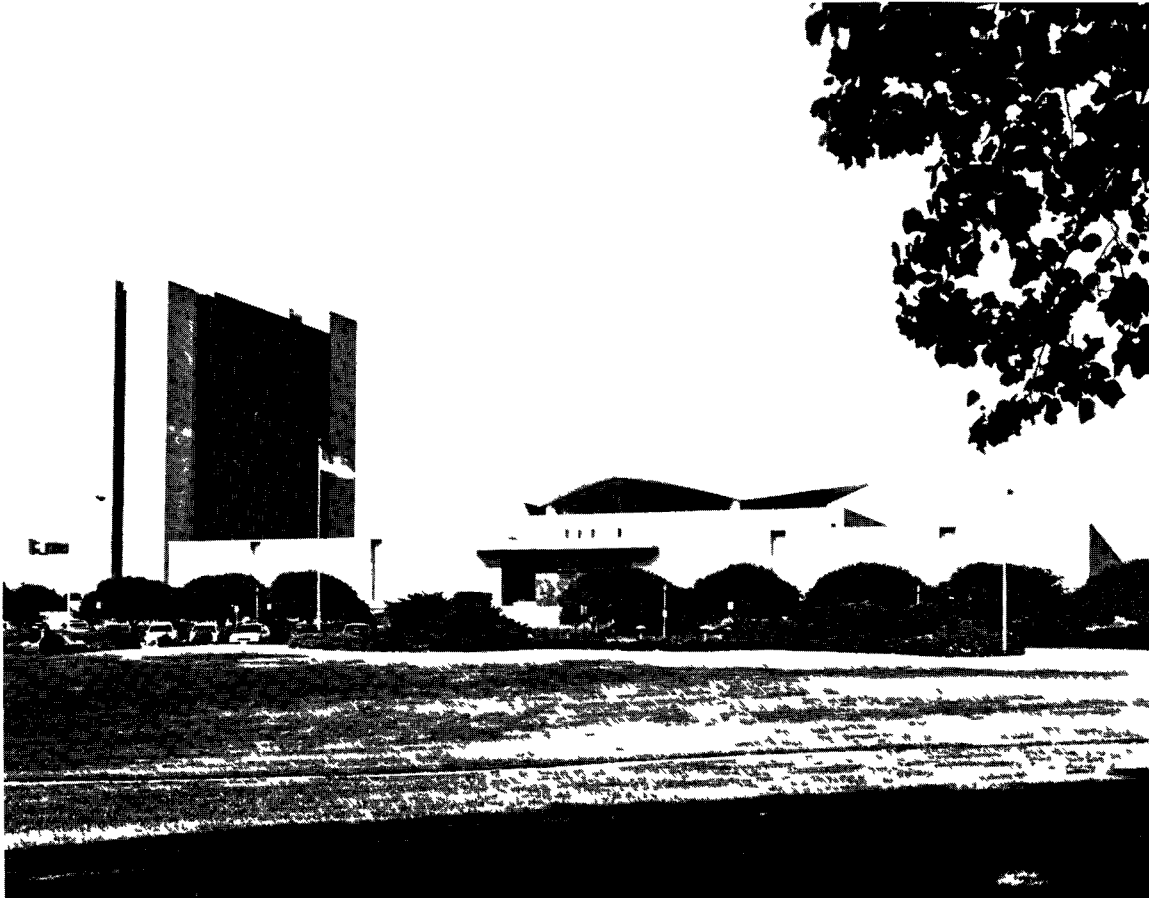
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PARKER, Curtis L., Ph.D.
Professor and Chairman of Anatomy
Morehouse School of Medicine
Atlanta, GA

RABSON, Alan S., M.D.,
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National Cancer Institute
Bethesda, MD

UTIGER, Robert D., M.D.
Deputy Editor
New England Journal of Medicine
Boston, MA

WEAVER, William Lynn, M.D., F.A.C.S.
Director of Surgery
Interfaith Medical Center
Brooklyn, NY



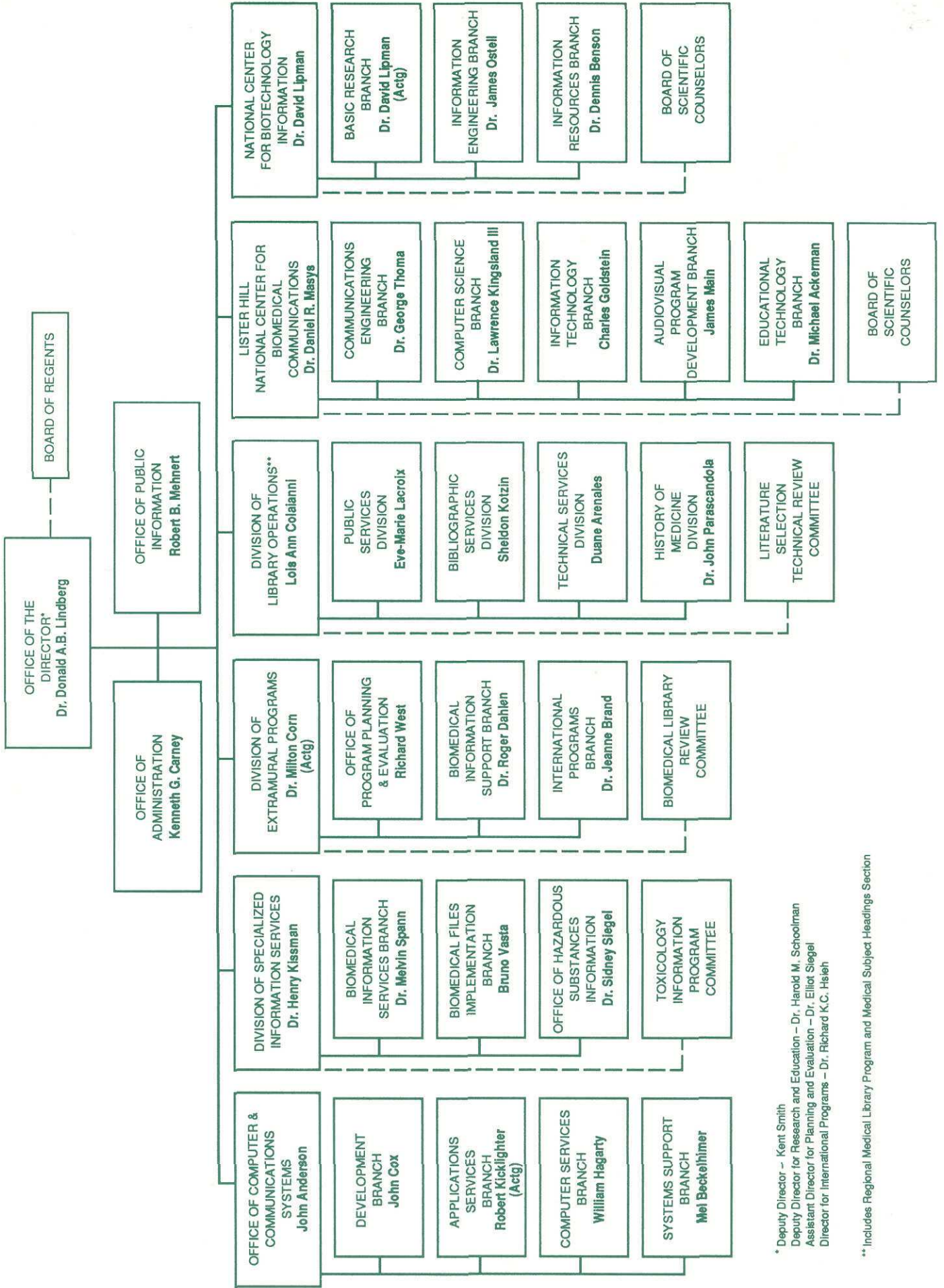
Board of Regents (June 1990): Second row, from the left: Dr. Donald A. B. Lindberg; Dr. Alvy Ray Smith; Dr. Lawrence H. Cohn; Col. Howard E. Fauver, Jr.; Col. Charles K. Maffet; Mr. Duane Staub. Front row, from the left: Dr. Jeanne Spurlock; Dr. Kathleen A. McCormick; Dr. Ronald E. Cape; Ms. Nina W. Matheson; Dr. Edward A. Feigenbaum; Dr. Steven C. Beering; Ms. Karen Renninger; Dr. Mary E. Clutter; Dr. Don E. Detmer (Chairman).



The National Library of Medicine (building on right) contains the collection, Reading Rooms, offices, and work areas associated with the collection. The 10-story Lister Hill Center (left) houses the Library's computer and audiovisual facilities, auditorium, cafeteria, offices, and communication laboratories.

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National Library of Medicine



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