XXIII

The Lister Hill National Center for Biomedical Communications

Research and Development in the Library

FROM the time of Director Cummings' early days in the Library he was captivated by the idea of converting the institution from a traditional medical library into an active information center. He felt that rapid communication involving radio, television, telephone systems, computers, and other devices was the way of the future in libraries, that research ought to be carried out to test new networks for communicating biomedical information and to evaluate information retrieval techniques, graphic storage and retrieval, computer software for information retrieval, and other devices and systems. He was given an opportunity to express his views in 1965 when Surgeon General Luther Terry, concerned about the role of communications among the many new health programs, asked the Board of Regents for a statement of the Library's policy. The policy, drafted by members of the staff and the Board, stated that the Library should, among other things "support experimental programs, both intramural and extramural, to test multiple approaches to meeting the needs for biomedical information . . be a national resource for information systems research and development relevant to human health . . . serve as a clearinghouse and coordinating agency for information systems R and D within the Public Health Service."[1]

While the policy was being drafted, the Department of Health, Education, and Welfare asked all of its agencies to draw up their plans for the next 5 years, fiscal years 1966 through 1970. In its forecast the Library outlined the task it hoped to accomplish through the establishment of a Center for Biomedical Communications, housed in a new building, staffed by scientists carrying out research and development in information systems, and developing and demonstrating methods for the continuing education of workers in the health professions.

In the meantime Cummings talked to Representative John Fogarty and Senator Lister Hill, whom he knew, about the possibility of obtaining authority and facilities to carry out research. They encouraged him to seek permission

from Congress, and Fogarty promised to support a bill to appropriate funds if authority were obtained. At Fogarty's suggestion Cummings conferred with Representative Paul Rogers about the need for research, and also met with members of the pertinent subcommittee staff.

As a result of these discussions the House Subcommittee on Reorganization issued in 1966 a report recommending that the Library establish a research center in biomedical communications, coordinate all health communication activities in the Public Health Service, establish a national biomedical information clearinghouse and referral service, and have transferred to it the Medical Audiovisual Branch, at that time a part of the PHS's Communicable Disease Center in Atlanta, Georgia. And most importantly the House and Senate Subcommittees on Appropriations recommended that NLM receive $118,000 and four new positions to begin R&D.

With the funds Cummings engaged Ruth Davis of the Department of Defense as the Library's associate director for research and development. She arrived on April 24, 1967, and for a while worked alone, laying the foundation for the program. During the second half of 1967 she recruited several engineers and scientists to serve as the nucleus of the R&D staff. She and her associates began to draft plans for a biomedical communications network, to be developed over the following 5 years.

The Lister Hill National Center for Biomedical Communications

Parallel with Cummings efforts to gain authority and funds for a R&D program was his attempt to obtain a building to house a research staff, facilities, and employees hired within recent years. In the interval since the Library building had been occupied in 1962, NLM had expanded its activities. It had acquired the computer-based MEDLARS system, a grants program, a drug literature program, and a toxicology information program. Three hundred and forty employees were squeezed into space designed for 250 Areas in the stacks intended to house books had been converted into offices. Space for the Extramural Program staff had been rented in a structure in Bethesda. The R&D employees that Cummings hoped to hire would have overflowed from the Library building.

In early 1967, after Congress had indicated that it would appropriate funds for research, Cummings engaged the firm of O'Connor and Kilham, designers of the Library building, to draw up a preliminary plan for an annex to house the Library's recent activities. And since the Library's interior had been modified from the original design by the installation of computers and other equipment, the firm was also asked to plan a renovation of the existing structure, when and if an annex were built.

The architects presented three possibilities, an annex the height of the Library building, one with a tower 15 stories high, and one with a tower of medium height. The annex would be close to but not against the south side of

the Library, be connected at the underground levels, and have underground parking. Following the transfer of the National Medical Audiovisual Center to NLM on July 1, 1967, Cummings asked O'Connor and Kilham to prepare another feasibility study that would explore the alternatives of providing space for the center in the annex, or expanding the center's facility in Atlanta, Georgia.

The following year Senator Lister Hill closed his long career in public life. After coming from Alabama to Washington as a Representative in 1923, he had served in the House until 1938 and then in the Senate. He had sponsored more influential health laws than any legislator in this century, including the Hospital and Health Center Construction Act, the Comprehensive Health Planning and Public Health Services Act, the National Library of Medicine Act, the Medical Library Assistance Act, the Regional Medical Programs Act, and the Hill-Harris Act of 1963.[2]

Learning of Senator Hill's decision to retire, Cummings suggested that he be remembered for his role in improving health care by having the annex named in his honor. Through Joseph F. Volker, a friend and a constituent of Hill, his suggestion was relayed to Senator John Sparkman, Hill's colleague, and to Alabama Representatives. They were enthusiastic about the idea.

A short time later on June 20, 1968, the NLM staff, Board of Regents, Secretary Wilbur Cohen, Senators, Representatives, and friends held a reception for Senator Hill in the Library. Senator Sparkman, the main speaker, emphasized the fitness of naming the annex the Lister Hill National Center for Biomedical Communications, "to perpetuate the name of the man who has done so much for the health of the nation, who has exhibited an abiding concern for . . . libraries in general and the National Library of Medicine in particular." Upon Senator Sparkman's suggestion Cummings and Scott Adams drafted a resolution embodying the sentiments expressed at the reception, and Senator Sparkman introduced this into Congress as a joint resolution on July 19. It was passed unanimously by the Senate, passed unanimously by the House on July 24, and signed by President Johnson on August 3.[3]

Cummings redesignated the Library's R&D program as the Lister Hill National Center for Biomedical Communications. Secretary Cohen of HEW assigned to the center its functions, the most important of which were: to design, develop, construct, and manage a biomedical communications network; to apply advanced technology to improve biomedical aspects of biomedical communications, information systems and networks; and to represent DHEW in biomedical communication activities.[4]

Planning the Biomedical Communications Network

In drafting the development plan the R&D group obtained advice from medical societies, professional associations, the Library's Board of Regents, and consultants to determine the needs of the medical community and establish priorities. It tried to envision the ways in which television, satellites, films,

computers, lasers, and other devices could be applied to medical communications. It supplemented its own thinking with surveys made under contract by research institutes and university groups.

When completed in June 1968 the plan outlined the logical, orderly production of a biomedical communication network during the next 5 years. It envisioned a national network composed of Library, Specialized Information Service, Specialized Education Service, Audio and Audio-Visual Service, and Data Processing and Transmission components. The network was to be managed by a staff of 64 persons with a budget of $16 million by fiscal year 1974. But Congress never appropriated funds for such a network; by 1974 the staff comprised 20 persons and the budget $2,931,000, and by 1976, 24 persons and $1,475,000.[5] Under the circumstances the only policy the Library could follow, dictated by relatively low funds, was to have the Lister Hill Center manage the research and development of parts of the network, with much of the work being done by contractors, and, after the systems had been demonstrated and evaluated, turn them over to others for operation.

During its formative years the center staff engaged in a variety of tasks. They compiled an inventory of all the projects sponsored by DHEW involving the use of communication and information science technology. They set up a DHEW Scientific and Technical Information Publication Data System. They compiled a data bank, the medical resources file, containing all manner of statistics of use to Federal agencies, the biomedical community, and for use in planning the biomedical communications network. They were given the responsibility of evaluating the decentralization of the MEDLARS system. They monitored the Library's contract with the Interuniversity Communications Council, the purpose of which was to determine how biomedical information might best be distributed over a network to physicians, hospitals, and schools. They helped evaluate the proposals for development of MEDLARS II. They pioneered in the development of individualized biomedical communication modules, containing a projector-viewer and tape recorder, for use in the education of students and the continuing education of physicians. But during the first decade their major activities became the development of a time-shared, on-line retrieval system for searching data bases of citations to medical literature; the illustrative application of biomedical communications to education through the development of an interactive television network and a computer-assisted instructional network; and the demonstration of the usefulness of satellite communication in medical education and treatment.

AIM-TWX

The technology that permitted persons at a distance from a computer to communicate directly with the computer had been worked out only a few years before the Library began research in biomedical communications. As Davis and her associates drew up the Lister Hill Center's technical development plan,

they included in it an on-line bibliographic retrieval system that would make the MEDLARS data file available to physicians nationally through the use of remote terminals. To work on this system Davis brought from the Defense Intelligence Agency Ralph Simmons, who had been in charge of the development of an on-line system for the Air Force. Simmons assisted with Lister Hill Center's development plan, but his main task was setting up a Remote Information Systems Center, a room containing terminals connected to data bases on computers in other locations. In the center MEDLARS operators familiarized themselves with the equipment and techniques for querying other data bases. Simmons and those associated with him used the terminals to learn about various data banks, models, programs, and programming languages of possible use to NLM. Using the computer of one contractor, System Development Corporation, located in Santa Monica, California, and the firm's on-line, time-shared retrieval system named ORBIT, the staff experimented with a small data base of citations to neurology articles and books.[6]

Simmons was certain that a system could be developed that would permit researchers, educators, librarians, and practicing physicians to communicate with MEDLARS. But the questions were, could it be done with the relatively small amount of money that was available, and would the benefits be worth the cost and time. The staff estimated the potential benefits by an analysis of the use of other systems, particularly the system opened by the State University of New York at Syracuse, SUNY in December 1968 using a MEDLARS data base. These estimates convinced them that MEDLARS would be searched by many more users if an on-line system were available. But as valuable as a system might be for NLM patrons, it had to be developed at a low cost or not at all.

A relatively cheap communication link between the computer and terminal had to be found. Existing remote access systems communicated with their computers through special terminal equipment connected to leased telephone lines or teletypes and telephone lines. These communication methods were too expensive for NLM. The staff decided that the Teletypewriter Exchange System, TWX, could be utilized in place of telephone lines. TWX terminals had been installed in more than 500 libraries for transmission of interlibrary requests, and these could also be used for retrieval without purchasing additional terminal equipment.[7] Other remote access systems had tried the TWX network as a communications link, but in such a way that users had to lease new equipment or special devices to place on their teletypewriters.

The MEDLARS data base contained more than 1 million citations, too many at that time for use in an available remote access system. An analysis of the *Abridged Index Medicus* base, containing approximately 100,000 citations from the most widely used journals in clinical medicine, indicated that it would be manageable and useful, particularly if supplemented by citations from additional journals. The *AIM* base was chosen for the proposed on-line system.

The *AIM* data base and the TWX network provided two components of an

experimental system. The third component, the computer, was chosen after consideration of three alternatives. One alternative was a contract with SUNY to provide access to its computer system through the TWX network. NLM discarded this idea because it felt that the system could not be used over the entire nation unless it were improved substantially. Another alternative was to move the ORBIT or SUNY system to the Library and use the Library's computer. But transfers of the system would have been expensive, and operation within the Library would have interfered with the operation of MEDLARS. The third alternative was to provide service through System Development Corporation in Santa Monica, using the corporation's time-sharing computer, the TWX communication system, and the *AIM* data base. A contract with SDC would also give NLM a head start, for the corporation had already accumulated considerable experience with remote access systems while developing one for the Air Force.

In the autumn of 1969 the Library engaged SDC to provide an experimental on-line retrieval system called AIM-TMX that would enable NLM to test the feasibility, use, and acceptance of such bibliographic service. The bibliographical information published during the preceeding 5 years in over 100 journals of clinical medicine was stored in SDC's computer in California. The retrieval program was named ELHILL, for Lister Hill. NLM selected a group of hosptials, medical libraries, MEDLARS search centers, NIH institutes, and other users willing to cooperate in the experiment. The Library inaugurated the service in June 1970. Users could call the computer each day between 11:30 a.m. and 3:30 p.m. Eastern time from TMX terminals or from computer terminals connected to telephone lines. As many as 18 searchers could use the system simultaneously. The users paid the cost of calling the computer, NLM paid other costs. The Library kept the AIM-TWX data base available for users until Nov. 22, 1972 and then replaced it by a much larger data base, MEDLINE.

The Experimental Computer-Assisted Instructional Network

The success of the AIM-TWX network, which linked institutions all over the country to the Library's computer through economical communication lines, suggested to the LH staff that the same kind of network could be used for other purposes. One of these was a network of educational institutions joined through telephone lines and Tymshare to a computer in which instructional programs would be stored.[8]

A few institutions had already written programs for their students. Massachusetts General Hospital employed its computer to teach students by simulating disease syndromes, biomedical models, and clinical encounters. The Ohio State College of Medicine computer courses assisted first- and second-year medical students, nurses, nursing students, optometry students, graduate students, and physicians in community hospitals. The University of Illinois Medical Center's computer programs offered simulated clinical encounters which

allowed free vocabulary entry and an interactive file of multiple choice questions.

In 1972 Harold Wooster, the LH project officer, contracted with these three institutions to permit other schools to connect with their computers and employ their courses. Arranging for the teaching computers and the communications network, Tymshare, was only half of Wooster's task. The other half was publicizing the experiment and finding institutions willing to try computer-assisted instruction, CAI. Lister Hill paid for the use of computer facilities, the users bore the cost of communication to the nearest Tymshare city and provided their own terminals.

Massachusetts General Hospital opened its computer to the network on 8 a.m., July 1, 1972. Ohio State connected its computer in September, and Illinois in January 1973. By February 1973 students in 45 institutions were learning various subjects with the help of computers. In May the Lister Hill Center held a meeting of users to evaluate the experiment and determine the direction it should take. Institutions were almost unanimous in their enthusiasm for the network. It was estimated that 70 percent of the audience were medical students, 5 percent were physicians, and the remainder were nurses, dental students, and other health workers.

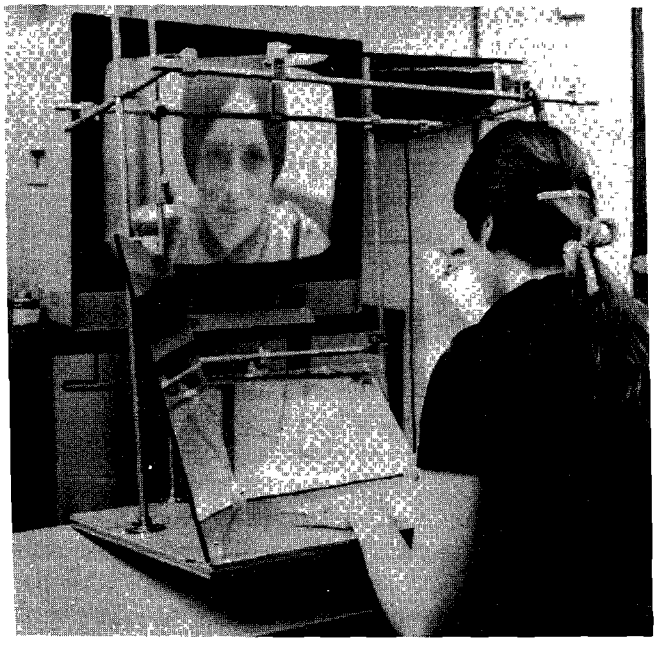
Through 1973 LH financed the cost of the computers and the Tymshare network. At its peak the network provided 3,000 connect hours a month to 100 users. Wooster calculated that the Library was paying $18.77 for each connect hour. The ever increasing cost became so great that the Library felt compelled to ask users to share the expense. Beginning in February 1974 institutions were charged $2.50 for each connect hour. In July the charge was increased to $5.

The intention of Lister Hill had been to start and test the utility of CAI, not to operate an instructional network indefinitely. The experiment completed, Lister Hill prepared to close the network on May 30, 1975. Users had found CAI so valuable that they begged Lister Hill to continue financing it, but the Library did not have the funds—it had already paid $677,494 to Massachusetts General, Ohio State, and Illinois. Fortunately on June 1 users were able, with further assistance from LH, to start managing and financing their own health education network.

The New Hampshire-Vermont Medical Interactive Television Network

By the time the Lister Hill Center came into existence, educational television, ETV, was well established. Approximately 120 stations were operating in the United States. The Lister Hill staff saw the potential usefulness of ETV in medicine, and it entered the field by contracting with Rand Corporation for a study of costs of ETV stations and the percentages of physicians within reach of those stations.

In the meantime an event took place that led LH to sponsor a large-scale



Speech therapy session on the New Hampshire Vermont Medical Interactive Television Network (Interact).

test of ETV in medicine. In 1968 NIH's National Institute of Mental Health financed a two-way closed circuit television hookup between Dartmouth Medical School and Mary Hitchcock Memorial Hospital, Hanover, New Hampshire, and Claremont General Hospital, 30 miles away, to see how effectively psychiatrists in a medical school could examine patients in a distant small community hospital. The system was interactive; that is, persons at both ends communicated with each other. The experiment worked so well that Dean Seibert, assistant dean of community affairs of Dartmouth, talked with Ruth Davis about the possibility of LH's financing a network to explore the uses and benefits of interactive television in the rural areas of New Hampshire and Vermont. Since this fitted into the center's plans, and the Board of Regents had requested that priority be given to the application of biomedical communications in education, Davis agreed and placed Harold Wooster in charge of the project.[9]

Lister Hill engaged a research firm to study the proposed network, eventually named Interact. After the firm reported that Interact was technically feasible, the LH staff had to decide what proportion of their relatively small funds they should allot to the project. This amount was not sufficient to finance the entire network, but it was enough to test a smaller system involving four

types of institutions: medical schools, hospitals, community colleges offering courses in health care, and prisons.

Construction of a four-station duplex network, with three mountain relay points, began in 1971. In the network were Dartmouth Medical School, University of Vermont Medical School, Claremont General Hospital, Central Vermont Hospital, Rockingham Memorial Hospital, Claremont Vocational Technical College, and Windsor State Prison. The stations began operating in 1972 and were augmented by other facilities in 1973. Practicing physicians used Interact to continue their medical education and to seek advice on diagnostic and patient care problems. Professors at the medical schools taught student nurses in the hospitals and students in health care courses at the Vocational Technical College. Physicians in community hospitals participated in surgical rounds and conferences at university hospitals. Participants benefited from a variety of programs presented over the network approximately 40 hours a week. Lister Hill provided funds until the concept had proved practical and then withdrew in 1975, leaving the operating network in other hands.

Medical Assistance and Education via Satellites

The responsibility of Lister Hill to improve biomedical communication by means of advanced technology was carried out, as funds permitted, mainly through the use of satellites. The National Aeronautics and Space Administration launched the first communication satellites in 1960. They were spheres 100 to 135 feet in diameter, circling the earth at altitudes of 600 to 6,700 miles, with reflective surfaces that bounced radio signals back to sending stations. These "passive" communication satellites were followed by craft that contained receiver and transmitters, powered by solar cells, that amplified and returned radio signals. In 1963 NASA sent aloft the first satellite to relay a live television program from Europe to America.

The round satellites were soon replaced by cylinders, orbiting at higher altitudes, remaining in a stable position by spinning. They relayed telephone, teletype, and television transmissions across the ocean. A further improvement was a spin-stabilized machine in an orbit approximately 22,000 miles high traveling at a velocity that kept it over a certain area of the Earth. Satellites at this altitude could see about one-third of the globe. In 1966 NASA sent into a 22,300 mile high orbit the first of the Application Technology Satellites, ATS-1. The ATS satellites were geostationary, hovering over a spot instead of an area, and their antennas maintained a fixed orientation toward the Earth, allowing radio beams to be directed with precision.

During the planning of the Library's research and development program the Lister Hill staff considered satellites to be one of the means by which medical information would be disseminated over a large geographical area. The staff visualized a satellite communications system that could be utilized for the education of medical students, the continuing education of physicians, and even the education of the public. This system would be composed of a national

The Native Health Clinic, Galena, Alaska ATS-1 antenna at left

network, regional networks, and interconnections between regional networks. The Library asked Comsat Corporation to estimate the cost of designing and developing the system. Comsat replied that it would cost about $6 million, not counting yearly operating expenses. Since the total Lister Hill budget at that time was only about one-sixth of this sum, the scale of the plans had to be reduced drastically

Lister Hill carried out its first experiment in satellite communication in April 1970 With the assistance of ATS-1, LH tested a four-way voice conference network joining the Library, University of Wisconsin, University of Alaska, and Stanford University. This satellite network was also used to demonstrate the transmission of electrocardiograms, the sending of photographs by means of a photo facsimile system, and the relay of questions to and answers from a computer.[10]

These tests prepared the way for the development of a communication network for supplying medical information to remote villages in Alaska. By means of the ATS-1 satellite, equivalent to a transmission tower 22,000 miles high, two-way conversations were made possible between a physician in the Indian Health Service hospital in Tanana and health aides in 26 remote villages. The aides, who had been trained to provide primary health care in their com-

munities, were supplied with VHF transmitters and receivers. With this equipment they were able to talk to the physician daily to report on or obtain advice about the treatment of sick villagers. In emergencies the aides used the system to call for a plane to carry patients to a hospital.

This satellite network was also shown to be useful for teaching medicine to students, nurses, and health aides in remote locations, as well as permitting physicians, separated by long distances, to consult with each other. Satellite communications were a major improvement over shortwave radio in arctic regions since radios were inoperable much of the time because of ionospheric disturbances.

In May 1974 NASA launched ATS-6, a much more complex, versatile and powerful satellite. The ATS-6 enabled two-way television communication to be carried on between the Tanana hospital and village aides. The aides were supplied with simple and relatively inexpensive ground terminals capable of receiving and sending video and audio signals. A physician at Tanana could now see patients through television, diagnose their illnesses, and give instructions to the attending health aides. In May 1975, with the Alaska health experiment proved to be practical and valuable, Lister Hill withdrew, and the state took over maintenance of the network.

Satellite ATS-6 was also utilized to set up a network for medical instruction in the states of Washington, Alaska, Montana, and Idaho. The area of these four states comprised 22 percent of the territory of the Nation but were populated by only about 6 million people. In 1971 the University of Washington Medical School had begun an experiment in decentralized medicine in this region. Named WAMI, from the initials of the states, the program had several objectives in health care and education, among them an increased opportunity for medical education without the construction of additional medical schools.

In 1973 the Lister Hill Center contracted with the University of Washington to explore the use of satellites in the WAMI program. Courses taught at University of Washington Medical Center in Seattle were beamed to the universities of Alaska, Montana, and Idaho for an audience of first-year students. Upon completion of the year the students enrolled at University of Washington for the remaining 3 years. Clinical instruction was transmitted from the medical center to third- and fourth-year students in clerkships at the Family Medicine Clinic in Omak, Washington. The WAMI project demonstrated the possibilities of sharing educational facilities within a large area. The two-way video, audio, and data communication network allowed instructors and students separated by long distances to participate in a coordinated medical education program.

In January 1976 NASA launched the Communications Technology Satellite, CTS, developed by Canada and the United States. At that time CTS was the world's most powerful and versatile communications satellite. In addition to industrial firms and universities, it was used by several agencies of the Public Health Service, including the Library, for medical education, dental education, teleconferences, training seminars, and health consultations. CTS permitted

expansion of the WAMI program, provided the Lister Hill staff with an engineering laboratory for experiments and demonstrations, and had other uses.

For the Library's CTS network the Lister Hill staff designed, developed, and installed six sophisticated Earth terminals at locations as far apart as Fairbanks, Alaska, and Bethesda, Maryland. This network operated for 818 days, logging 2,083 broadcast hours before making its final telecast on June 27, 1979. During the course of its operations more than 16,000 persons appeared before the cameras. The June telecast ended a decade of satellite experiments by the Lister Hill Center, demonstrating the wide range of health communications services that could be offered by this medium.

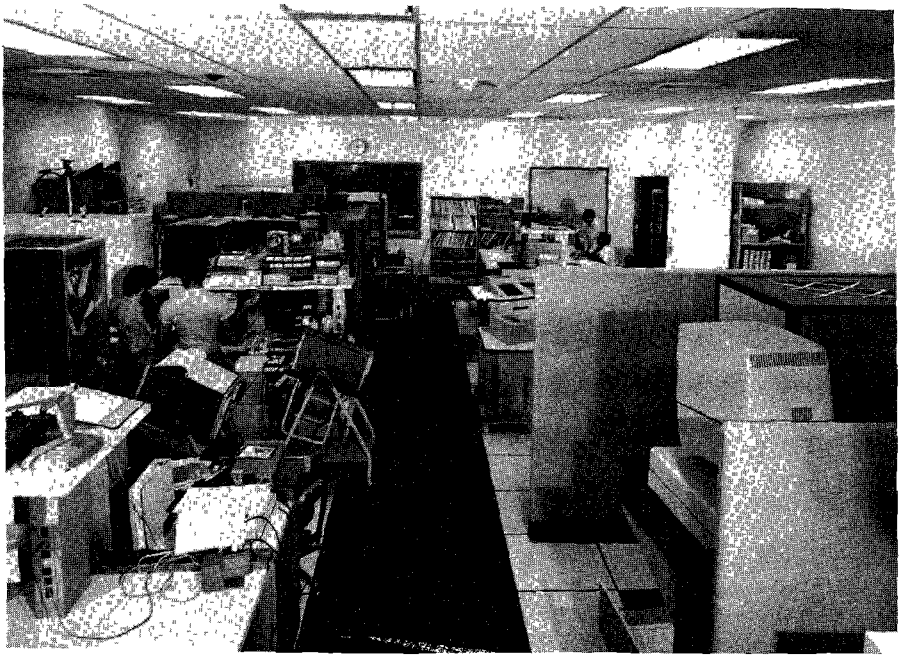
Construction of the Lister Hill National Center for Biomedical Communications

In the spring of 1970 Congress appropriated $900,000 for architectural and engineering designs of the Library's annex, the Lister Hill National Center for Biomedical Communications, but the Office of Management and Budget would not release the funds until 2 years later, January 1972. The General Services Administration negotiated a contract with the firm of Carroll, Grisdale and Van Alen which, over the next 2 years, produced plans for a 10-story annex with three underground levels containing approximately 200,000 gross square feet of space for 428 employees.[11]

Each year at budget time Cummings asked for money for construction, and each year he came away empty handed. Other buildings needed by NIH, PHS, and DHEW received priority. He became pessimistic about the Library's chances of ever receiving an appropriation. Slowly, however, he was gaining support. Members of the Board of Regents, very knowledgeable about Library affairs, lost patience with the pace of events and asked Congressmen from their states for help. Mrs. Frances Howard, sister of Senator Hubert Humphrey, who knew about the shortage of space from personal observation, introduced Cummings to several Congressmen to whom he explained the need for an annex. Representatives Paul Rogers, Robert Michel, and Daniel Flood; Senators Humphrey, Edward Kennedy, Warren Magnuson, and Norris Cotton, all influential in health legislation, were coming to the rescue of the Library.

Not knowing that funds were on the verge of being appropriated, Cummings became very discouraged. Feeling that he could not contribute further to the development of the institution he decided to retire from the Federal service. He notified the staff and his superiors of his intention of leaving and had tidied up his official business when he received word that Congress was going to appropriate funds. Pleasantly surprised, he cancelled his retirement party and looked forward to the construction, completion and occupancy of the Lister Hill building.

Congress appropriated $26 million in January 1976 for construction of the center and renovation of the Library building. During the spring and summer of 1976 the National Capital Planning Commission approved the architects'



The Communications Research and Development Facility of the Lister Hill National Center for Biomedical Communications.

plans, the Library met the requirements of the National Environmental Protection Act, and the General Services Administration awarded the contract to George Hyman Construction Company on a low bid of $13 million.

Excavation of the site and construction took place without unusual incidents or delays, and the building was ready for occupancy in May 1980. The staff of the extramural program moved from a rented office building in Bethesda, employees of the National Medical Audiovisual Center moved from their quarters in Atlanta, and the Lister Hill group, Toxicology Information Program, and other units shifted from the Library building. The Lister Hill National Center for Biomedical Communications was dedicated on May 22 with Senator Hill in attendance.

Notes

[1] Information on the LHNCBC may be found in publications by staff members, fact sheets, records of the Board of Regents, annual reports of the Library, and *NLM News*. Information was obtained from the above, and from Martin Cummings, Harold Wooster, and Harold Schoolman.

[2] Some account of Senator Hill's activities in sponsoring legislation on behalf of medicine may be found in *Congressional Record*, Oct. 8, 1968, pp. S12254–S12259; Oct. 9, S12325; Oct. 12, S12735–S12754; Nov. 1, E9565.

[3] *NLM News*, August 1968. Senate Joint Resolution 193. Public Law 90–456. Directors

of the center have been Ruth Davis, August 1968–November 1970, Davis McCarn (Acting Director) November 1970–May 1971, Albert Feiner, May 1971–September 1974, Robert Bird, September 1974–December 1976, Kenneth M Endicott (Acting Director) January 1977–June 1977, Lionel Bernstein (Acting Director) July 1977–July 1978, Director August 1978

[4] F R Doc 68–13778, Nov 14, 1968

[5]

Fiscal Year	1967	'68	'69	'70	'71	'72	'73	74	75	76
Obligations millions			0 828	0 911	1 366	1 883	1 949	2 931	2 234	1 475
Personnel, June 30	1	10	12	10	14	15	17	20	22	24

Source Annual reports of the Library

[6] Information on the development of AIM-TWX may be found in records of the Board of Regents, articles by members of the staff, Library network/MEDLARS technical bulletins, On-line services references manuals, and *NLM News* Information was also provided by Ralph Simmons

[7] NLM acquired TWX facilities in the spring of 1966 to cooperate with the Medical Interlibrary Communication Exchange System, MICES, in servicing interlibrary loan requests

[8] Information on the CAI network may be found in records of the Board of Regents, articles by members of the staff, annual reports of the Library, and H Wooster, "The LHNCBC Experimental CAI Network, 1971–1975 an Administrative History," in Edward C DeLand, ed , *Information Technology in Health Science Education*, 119–42, see also publications cited in this article Tape-recorded autobiography of Harold Wooster, Feb 23, 1979

[9] Data on the New Hampshire Vermont medical TV network may be found in records of the Board of Regents, *NLM News*, annual reports of the Library, articles by staff members, and Dean J Seibert, Interact—a Decade of Experience Using Two-way Closed Circuit Television for Medical Care and Education Contract no 2-LM-4-4704, April 1977

[10] For details of the satellite experiments see annual reports of the Library, records of the Board of Regents, articles by members of the staff, *NLM News*, contractor's reports, and Lister Hill Center reports George Thoma also provided information

[11] Information on the events leading up to the appropriation for the Lister Hill Building were obtained from Martin Cummings