Chapter 1
Summary

The United States must make better use of its scientific and technical information (STI) resources, if it wishes to be competitive in world markets and maintain its leadership. STI is an essential ingredient of the innovation process—from education and research to product development and manufacturing. It is a major product of the $65 billion per year the U.S. Government spends on research and development (R&D); researchers need ready access to STI if they are to stay at the cutting edge.[1] Many issues of our time—health, energy, transportation, and climate change—require STI to understand the nature and complexities of the problem and to identify and assess possible solutions. STI is important not only to scientists and engineers but to political, business, and other leaders who must make decisions related to science and technology, and to the citizens who must live with the consequences of these decisions.

The electronic collection, storage, and dissemination of STI is a vision of the future that is rapidly becoming reality. Electronic STI offers the prospect of fast, efficient, and inexpensive access to databases and documents. Scientists now use online computer networks to transmit STI around the nation and throughout the world. Others are experimenting with compact optical disks that can store a quarter million pages of text on one disk.[2]

The Federal Government has a golden opportunity to help the United States sustain a competitive position in scientific and technical information. The United States has, at the moment, the necessary information and technology base on which to build a strong national effort. Congress intended that the President's Office of Science and Technology Policy (OSTP), established in 1976,[3] provide executive branch leadership on STI; OSTP has thus far failed in this mission.[4]

During the 1980s, STI was subsumed in the larger debates over national information policy and science and technology policy. The Office of Management and Budget (OMB) dominated executive branch information policymaking and showed little interest in STI. OSTP failed to recognize STI as an integral part of overall S&T policy, and did not assert itself in many of the policy issues that affected STI. Federal STI programs suffered as a result.

Executive branch leadership is imperative because STI is generated by many Federal R&D agencies that must be coordinated if the government's STI efforts are to be successful. Agencies have set up a variety of ad hoc coordinating mechanisms for specific aspects of STI; but an overall, integrated approach is lacking. One of these existing committees could be expanded and chartered to serve a broader purpose. Alternatively, a new high-level interagency committee on STI could be established, with representatives from the R&D programs that generate STI, the agency data centers and technical document distribution offices, and governmentwide dissemination agencies such as the Government Printing Office (GPO) and National Technical Information Service (NTIS).

Whether through an interagency committee, OSTP and OMB guidance, or other means, the

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1 See, for example, U.S. Congress, House, Committee on Science and Technology, The Impact *of Information Technology on Science*, Science Policy Study, Background Paper No. 5 prepared by the Congressional Research Service, 99th Cong., 2nd sess. (Washington DC: U.S. Government Printing Office, September 1986); and National Academy of Sciences, Committee on Science, Engineering, and Public Policy, Information Technology and the Conduct of Research (Washington DC: National Academy Press, 1989).

2 See the appendix for a discussion of technological opportunities.

3 Public Law 94-282, the "National Science and Technology Policy, Organization, and Priorities Act of 1976," May 11, 1976.

4 OSTP is in the process of deciding how to address STI issues in the Bush Administration; see remarks of OSTP Director, D. Allan Bromley, before a March 21, 1990, forum of the Federal Library and Information Center Committee, Washington, DC.

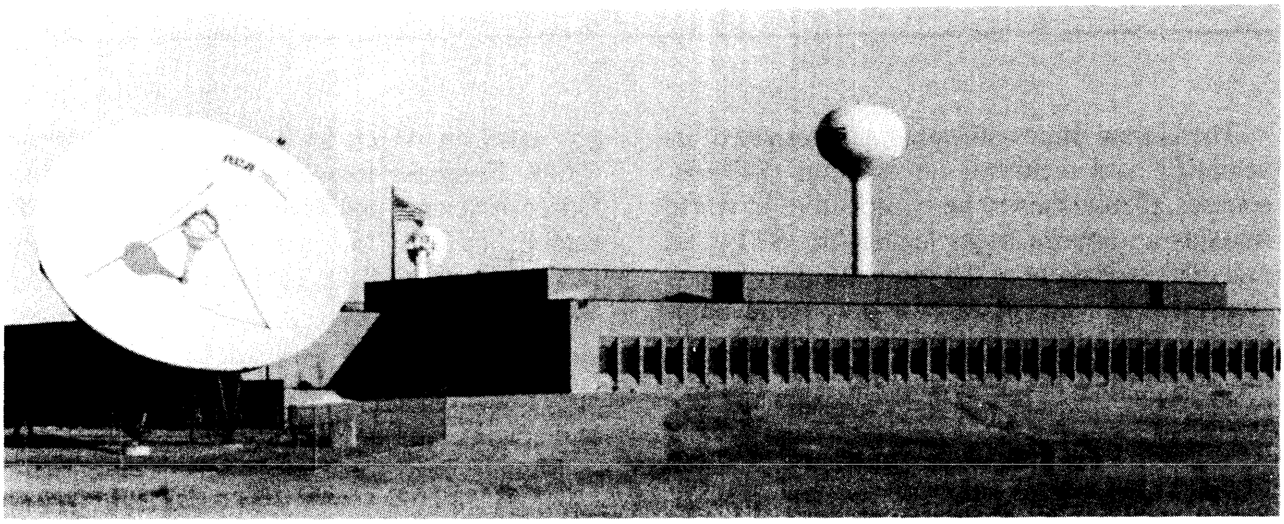

Photo credit: EROS Data Canter, USGS

The Earth Resources Observation Systems (EROS) Data Center in Sioux Falls, SD, receives and stores data from Landsat and other Earth-observing satellites. The total earth sciences data volume managed by Federal agencies (primarily NASA, USGS, and NOAA) is projected to increase over two orders of magnitude by the year 2000 to about 10,000 terabytes. NASA's Earth Observing System alone will generate an additional terabyte of data every day; this is equivalent to 10,000 Washington, DC telephone books (white pages) or 520,000 text books (at 200 pages each) per day.

success of the Federal STI program will depend on progress in four key areas:

1. technical standards for databases and documents (graphics as well as text), so that STI can be electronically moved among agencies and users with ease and efficiency;[5]
2. indexing of databases and documents, so that STI users in and out of the government know what and where STI exists;[6]
3. funding for basic STI activities in agency R&D budgets, to ensure the quality of STI, its proper storage, and dissemination to users;[7]
4. end-user involvement in all agency STI programs, so that Federal STI is disseminated in user-friendly formats that meet user needs and are compatible with the equipment and technical capabilities of the users.

Electronic media offer the only way to manage the massive volume and complexity of Federal STI; yet Federal agencies must avoid "technophoria," i.e., unrealistically optimistic expectations of the technology.[8] The transition to electronic formats, while inevitable, will be difficult for many users.[9]

[5]The standards-setting effort would heavily involve the National Institute of Standards and Technology, the designated lead standards agency for the Federal Government, and rely to the maximum extent possible on standards developed by private sector and international standards-setting organizations.

[6]Indexing would be coordinated with related activities by the National Technical Information Service and Government Printing Office; however, preparation of keywords and abstracts could, in any event, be the responsibility of the R&D agencies and their contractors and grantees.

[7]For a discussion of the severe problems that result from underfunding of agency STI activities, see U.S. General Accounting Office, *Space Operations: NASA Is Not Properly Safeguarding Valuable Data From Past Missions,* Report to the Chairman, Committee on Science, Space, and Technology, U.S. House of Representatives, GAO-C-90-1, March 1990. GAO is conducting similar audits of NOAA and USGS data archives.

[8]Term coined by C.R. McClure of Syracuse University in testimony before an Oct. 12, 1989, hearing of the House Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology.

[9]While OTA projects a dominant role for electronic formats, paper (and to a lesser extent microfiche) formats will be heavily used for the foreseeable future. But most paper documents will be produced by electronic printing from computerized databases; the same electronic database can be used to disseminate STI online over networks, on magnetic tape or diskette, or on compact optical disk, as well as on paper or microfiche. In this way, it will be possible to accommodate both high-tech and low-tech needs of STI users.

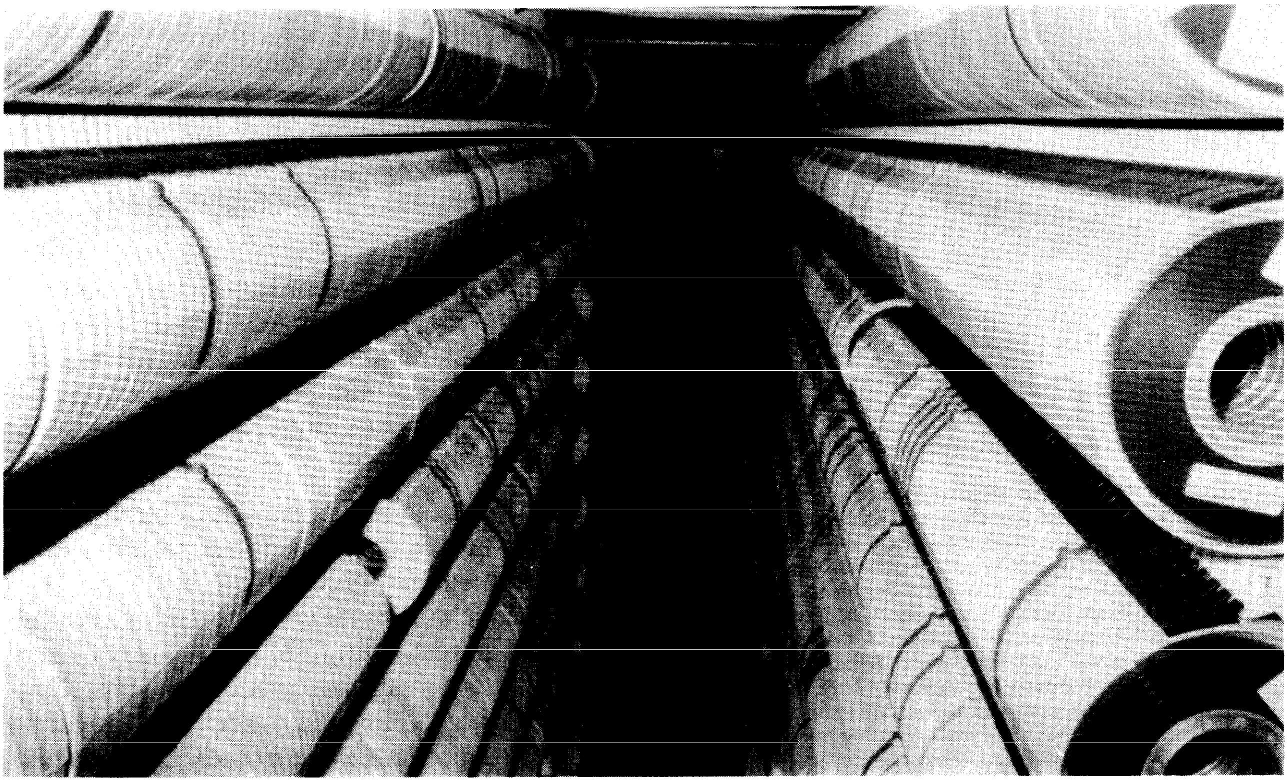

Photo credit: National Space Science Data Center, NASA

The National Space Science Data Center in Greenbelt, MD, is the largest space data-archive in the world, with about 120,000 magnetic computer tapes of digital data currently on file. The computer tape is still the dominant medium for storing space data, but the tapes are difficult and expensive for many researchers to use. New technologies make it possible to carry out a gradual transition from magnetic tapes to higher density storage media such as optical disks or tapes and digital tape cartridges.

Progress on STI also depends on resolving governmentwide information dissemination policy issues. During the 1980s, OMB used its authority under the Paperwork Reduction Act to favor private-sector responsibility for Federal information dissemination. The OMB view was controversial and sent mixed signals to the Federal R&D agencies about whether electronic STI should be aggressively pursued. Legislation pending before Congress would rebalance government policy to emphasize that Federal agencies (including the R&D agencies) have the primary responsibility for dissemination of information generated for agency missions, with an important supplementary or complementary—rather than preemptive—role for the private sector.[10] This legislation also addresses information management, pricing, public access, due process, and other policy matters that would directly affect STI.[11]

The U.S. scientific and technical enterprise depends on the open exchange of STI. Until the 1980s, the premise of openness was generally violated only in narrowly defined areas of

[10] See S. 1742, the "Federal Information Resources Management Act of 1989,' 101st Cong., 1st sess., Oct. 6, 1989; and H.R. 3695, the "Paperwork Reduction and Federal Information Resources Management Act of 1989," 101st Cong., 1st sess., Nov. 17, 1989, ordered to be reported by the House Committee on Government Operations, Mar. 13, 1990. Also see Office of Management and Budget, "Second Advance Notice of Further Policy Development on Dissemination of Information" *Federal Register*, vol. 54, No. 114, June 15, 1989, pp. 25554-25559; U.S. Congress, House, Committee on Government Operations, Subcommittee on Government Information Justice, and Agriculture, Federal Information *Dissemination* Policies and Practices, Hearings, 101st Cong., 1st sess., Apr. 18, May 28, and July 11, 1989 (Washington, DC: U.S. Government Printing Office, 1989); and U.S. Congress, Senate, Committee on Governmental Affairs, Subcommittee on Government Information and Regulation, Reauthorization of *the* Paperwork Reduction Act, Hearings, 101st Cong., 1st sess., June 12 and 16, 1989 (Washington DC: U.S. Government Printing Office, 1989).

[11] See OTA comments on S. 1742, prepared for a Feb. 21-22, 1990, hearing of the Senate Committee on Governmental Affairs.

Photo credit: National Space Science Data Center, NASA

NASA and other Federal science agencies are currently experimenting with optical disks-primarily the 12-inch WORM (Write Once-Read Manytimes) and 4.75-inch CD-ROM (Compact Disk-Read Only Memory). A typical CD-ROM can store up to about 600 megabytes. This is equivalent to roughly 300,000 text pages (at 250 words per page), 1,650 floppy diskettes, 30 of the 20-megabyte hard disks, or 15 of the 1,600 bits-per-inch 9-track magnetic computer tapes. For many applications, CD-ROM is much less expensive than computer tapes, and requires only a microcomputer and CD-ROM reader rather than a more expensive mini- or main-frame computer needed for tapes.

national security. In recent years, the bases for restrictions on open dissemination of information have been extended to: a) so-called "unclassified but sensitive" STI that might compromise national security; b) the transfer of control over federally funded technical data and technology from the government to the private sector to promote commercialization; and c) limitations on access by foreign governments and companies to Federal STI to maintain the economic competitiveness of the United States.

Globalization of the economy means that a growing fraction of U.S. domestic R&D companies operate under foreign ownership or with foreign partners, just as many U.S. corporations have their own foreign subsidiaries or partners. Similar trends are evident in the commercial information sector, to the point where one cannot assume that a U.S. information vendor operates under domestic rather than foreign ownership, and vice versa. Under these conditions, the old approaches to controlling the flow of STI do not work and need to be revisited. Many of them may not be needed at all.

Another vexing issue is the role of the governmentwide dissemination and archival agencies in the decentralized, increasingly electronic environment of Federal STI. The creation, storage, and dissemination of electronic STI is decentralized within the R&D agencies for several reasons:

- The volume of STI is vast. Centralizing all STI in one databank is not technically or administratively feasible.
- The technical systems for creating, storing, and disseminating STI are typically closely tied to agency automation systems. Centralizing STI could foreclose innovation and opportunities for improving productivity in the agencies.
- The diversity of STI uses spans a number of disciplines and research areas. Centralizing STI would complicate communications between the STI process and the users.

A key challenge is how to preserve and strengthen the indexing, archiving, and distribution roles of the: 1) GPO;[12] 2) Depository Library Program (DLP); 3) NTIS; and 4) National Archives and Records Administration (NARA). These agencies realize the need for change, but have thus far failed to develop workable strategies for electronic STI. If they are to flourish in the unfolding electronic environment, GPO, DLP, NTIS, and NARA must become innovative, flexible, and competitive in anticipating and meeting electronic information needs.[13]

[12] Including the Superintendent of Documents (SupDoes), who administers cataloging, sales, international exchange, and depository library programs, among others.

[13] For background discussion, see U.S. Congress, Office of Technology Assessment, *Informing the Nation: Federal Information* Dissemination in an Electronic Age, OTA-CIT-396 (Washington, DC: U.S. Government Printing Office, October 1988). For pending legislation see H.R. 3849, the "Government Printing Office Improvement Act of 1990,' 101st Cong., 2d. sess., Jan. 23, 1990, which centrally addresses GPO and DLP; S. 1742, op. cit., footnote 10, and H.R. 3695, op. cit., footnote 10, which touch on GPO, DLP, and NARA; H.R. 4329, the "American Technology Preeminence Act,"

A Presidential STI initiative could focus attention on these important issues. The list of designated presidential science and technology priorities, such as science education,[14] technology transfer,[15] high. performance computing and networking,[16] international competitiveness,[17] and global change,[18] justifies additional emphasis on STI. STI is crucial to the success of each of these initiatives, starting with the role of STI in science education.

Low-cost, user-friendly electronic STI could stimulate computer-based science, mathematics, and engineering education. Pilot projects here and abroad indicate that junior and senior high school students (and even some in the elementary grades) can handle electronic databases as part of the science curriculum. Computer-based STI can help capture the interest, imagination, and enthusiasm of students through "hands-on" science that could improve the quality of science education.

Improving the ''information literacy' of scientists and engineers must go hand-in-hand with upgrading STI; otherwise, the best STI systems will fall short. By integrating STI access, retrieval, and use into science education at all levels, the research skills and productivity of U.S. scientists and engineers could be strengthened in the long-term.

footnote 13 continued
101st Cong., 2d. sess., introduced and ordered to be reported by the House Committee on Science, Space, and Technology, Mar. 21, 1990, which addresses NTIS modernization, indexing, and electronic dissemination; statements of Fred B. Wood, OTA, and other witnesses before a Mar. 7-8, 1990, hearing on H.R. 3849 by the House Committee on Administration Subcommittee on Procurement and Printing; statements of Fred B. Wood, OTA, and other witnesses before a Mar. 8, 1990, hearing on NTIS modernization by the House Committee on Science, Space, and Technology, Subcommittee on Science, Research, and Technology; OTA and other comments provided on S. 1742 in connection with a Feb. 21-22, 1990, hearing of the Senate Committee on Governmental Affairs; statements of Joseph E. Jenifer, Acting Public Printer, and other witnesses before a Feb. 7, 1989, hearing of the House Committee on Appropriations, Subcommittee on the legislative Branch, a May 23, 1989, hearing of the Committee on House Administration, Subcommittee on Procurement and Printing, and a July 11, 1989, hearing of the House Committee on Government Operations, Subcommittee on Government Information Justice, and Agriculture; and the statement of Robert Houk, Public Printer, before an Apr. 6, 1990, hearing of the Senate Committee on Appropriations, Subcommittee on the Legislative Branch. Also see U.S. Congress, House, Committee on House Administration Subcommittee on Procurement and Printing, *Title* 44 U.S. C.-Review, Hearings, 101st Cong., 1st sess., May 23 and 24, and June 28 and 29, 1989 (Washington, DC: U.S. Government Printing Office, 1989), and U.S. Congress, House, Committee on Science, Space, and Technology, American Technology Preeminence Act, Report 101-481, Part 1, to accompany H.R. 4329, 101st Cong., 2d sess. (Washington DC: U.S. Government Printing office, 1990).

[14] For background discussion, see American Association for the Advancement of Science, *Science for All Americans: Project 2061 Report* on Literacy Goals in Science, *Mathematics,* and Technology (Washington DC: 1989); U.S. National Research Council, Everybody Counts: A Report to the Nation on the Future of *Mathematics* Education (Washington, DC: National Academy Press, 1989); and U.S. Congress, Office of Technology Assessment Educating Scientists and Engineers: Grade *School* to Grad *School*, OTA-SET-377 (Washington, DC: U.S. Government Printing Office, June 1988), and Power *On!* New *Tools for* Teaching *and Learning*, OTA-SET-379 (Washington, DC: U.S. Government Printing Office, September 1988).

[15] For related discussion, see U.S. Congress, Office of Technology Assessment, Technology and the *American Economic* Transition: *Choices for the* Future, OTA-TET-283 (Washington, DC: U.S. Government Printing Office, May 1989), Holding the Edge: Maintaining *the Defense* Technology Base, OTA-ISC-420 (Washington, DC: U.S. Government Printing Office, April 1989), and Arming Our Allies: Cooperation and Competition in *Defense* Technology, OTA-ISC-449 (Washington DC: U.S. Government Printing Office, May 1990). Also see H.R. 4653, the "Export Facilitation Act of 1990," 101st Cong., 2d sess., Apr. 26, 1990, ordered to be reported by the House Committee on Foreign Affairs, May 10, 1990.

[16] For discussion see S. 1067, the "High-Performance Computing Act of 1990," 101st Cong., 1st sess., May 18, 1989, ordered to be reported by the Senate Committee on Commerce, Science, and Transportation Apr. 3, 1990; H.R. 3131, the "National High-Performance Computer Technology Act of 1989," 101st Cong., 1st sess., Aug. 3, 1989; H.R. 4329, Title VII, the "National High-Performance Computer Technology Program Act of 1990," 101st Cong., 2d sess., introduced and ordered to be reported by the House Committee on Science, Space, and Technology, Mar. 21, 1990; U.S. Congress, Office of Technology Assessment, High *Performance* Computing & Networking for Science, OTA-BP-CIT-59 (Washington, DC: U.S. Government Printing Office, September 1989); and Executive Office of the President, Office of Science and Technology Policy, The Federal High *Performance* Computing Program, Sept. 8, 1989.

[17] For related discussion, see U.S. Congress, Office of Technology Assessment, Making Things Better: Competing in *Manufacturing*, OTA-ITE-443 (Washington, DC: U.S. Government Printing Office, February 1990) and Critical Connections: Communication for the Future, OTA-CIT-407 (Washington, DC: U.S. Government Printing Office, January 1990).

[18] See, for example, the discussion of global change data management needs in U.S. Federal Coordinating Council for Science, Engineering, and Technology, Committee on Earth Sciences, Our Changing Planet: The *FY* 1990 Global Change Research Plan (Washington DC: Office of Science and Technology Policy, July 1989), pp. 91-99; and U.S. National Aeronautics and Space Administration Earth Systems Science Committee, Earth Systems Science.' A Closer View (Washington, DC: NASA, January 1988).

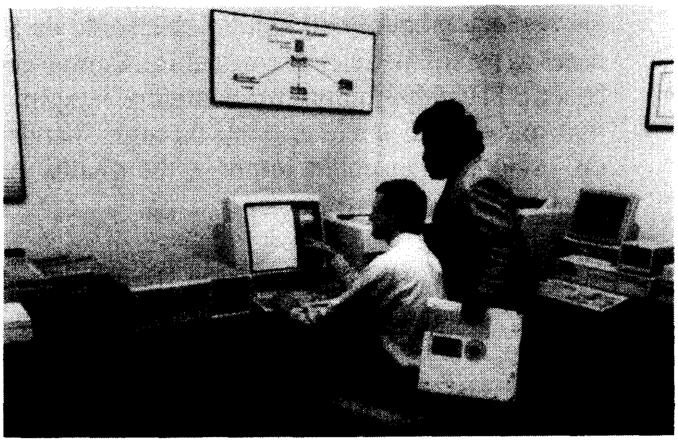

Photo credit: Office of Scientific and Technical Information, DOE

The Department of Energy's Office of Scientific and Technical Information is implementing information systems that use magnetic, optical, and online electronic technologies. DOE alone generates about 30,000 technical documents and articles per year; the governmentwide volume is about 200,000 items annually. New technologies are essential to cope with the burgeoning scientific and technical literature; for example, one double-sided 12-inch WORM can store about 1.2 million text pages or 6,000 technical documents (at 200 pages each).

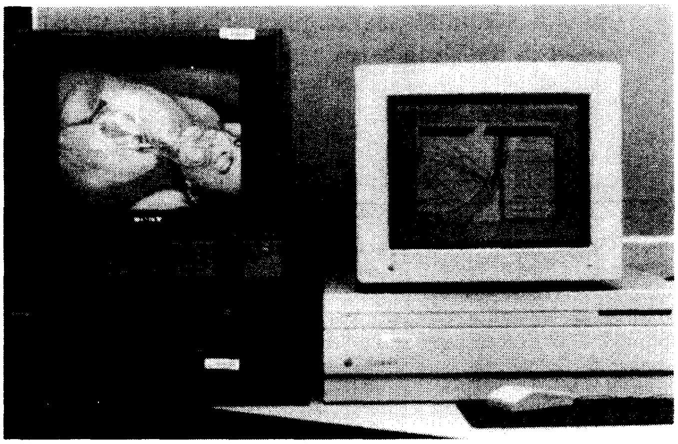

Photo credit: National Library of Medicine

This "Electronic Cardiology Textbook" represents the state-of-the-art in the use of electronic imaging to communicate scientific and technical information. The "textbook" stores images and sounds of the human heart on an optical disk; the user turns the pages electronically with a mouse and microcomputer.

Photo credit: Government Printing Office

Online information networks serve several important needs of the scientific and technical community. GPO uses an online system, shown here, to receive documents from remote locations; users simply "dial-up" the GPO system and transmit their material to GPO for processing. Online networks are used by several Federal science agencies to transmit documents, data, and messages; search bibliographic databases; transfer large streams of data; and remotely access large-scale high-performance computers.