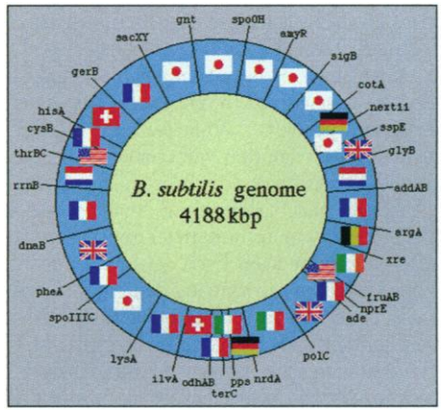
COMPUTER NETWORKS

Explosive Growth Helps Japan Take Its Place on Global Team

Floating in the waters of the equatorial western Pacific, an array of buoys collects and transmits data on the large-scale, long-term interactions between the ocean and the atmosphere that affect global climate. Next year, when Japan's new R.V. *Mirai*, the world's largest oceanographic research vessel, begins servicing them, the 70-buoy array will start sending out a second message: Japan has become a major contributor to an international effort to monitor the Earth.

A similar message, for geneticists, will be broadcast next month with the release of data from the new Kyoto Encyclopedia of Genes and Genomes. KEGG will allow researchers to analyze the functions of novel genes by looking at their molecular and genetic information pathways. The data from KEGG will complement the work of several groups outside Japan.

These two events would not have been possible 2 years ago, when Japan's computer networks were a jumble of disconnected and competing systems (*Science*, 18 November 1994, p. 1172). Rapid growth in network capacity has not only paved the way for such high-profile international ventures; it has also allowed an ever-rising number of scientists to engage in an unprecedented number of collaborations within Japan and around the world. This new capability has begun to open up the traditionally isolated culture of Japanese science, and is forcing researchers and agencies to think in new ways. "I think the Internet situation has put a lot of pressure on scientists to share data," says Minoru Kanehisa, a computational molecular biologist at Kyoto University.



JAPANESE HUMAN GENOME PROGRAM

Follow the flag. Scientists from 10 countries are helping to sequence the *Bacillus subtilis* genome. The database, maintained by the University of Tokyo, can be found at http://bacillus.genome.ad.jp:8008/

That is quite different from the situation a decade ago, says Kanehisa, who leads an informatics project in the Ministry of Education, Science, Sports, and Culture's Human Genome Program. A project to help sequence a portion of *Escherichia coli*, he recalls, foundered in part because scientists shared their data only "when they felt satisfied" to do so, not as soon as possible. Even now, says Kanehisa, "the funding system in Japan does not have rules to make data available immediately."

Anchoring the country's vastly improved science information infrastructure are two networks—the Interministry Network (IMnet), which was formed last year and which links 130 government research labs, and SINET, which has grown rapidly since its formation in 1992 and which now connects 250 local area networks at universities around the country. Data from the ocean monitoring project, for example, flow into IMnet as part of a showcase U.S.–Japanese program known as the Global Observation Information Network (GOIN) Project [http://www.goin.nasda.go.jp]. KEGG is accessible through Japan's GenomeNet, formed in 1991, which also connects to IMnet [http://www.tokyo-center.genome.ad.jp/kegg/kegg2.html].

Not surprisingly, Japan's burgeoning network is already overburdened, with the amount of information flowing through IMnet doubling every 6 months (see box). But help is on the way. Networking is expected to receive a healthy slice of the government's new 5-year plan to boost spending on basic research. In addition to expanding capacity and increasing speed, the plan also aims by the end of the decade to give all researchers access to computers with network connections, to provide all national R&D institutions with local area networks, and to build new databases on science and technology.

GOIN home. Japan's participation in the 3-year-old GOIN collaboration is a good example of how computer networking is raising Japan's standing in the international community and enriching the science on both sides of the Pacific Ocean. Deep-ocean images from the *Alvin* submersible vehicle at Woods Hole Oceanographic Institution (WHOI), for example, are swapped with those from the Japan Marine Science and Technology Center (JAMSTEC), whose *Shinkai* submersible

New Networks Aren't Good Enough

Japan has moved so rapidly in the past 2 years to link islands of information in university and government laboratories that its science networks are now choked with traffic. While plans are in place for upgrades in speed and capacity, it is not clear whether the money available will be enough to keep up with the explosive growth.

"We have made satisfactory progress, but we want to enhance this activity and speed up our communications links," says Hiroshi Inose, director-general of the National Center for Science Information Systems (NACSIS). The academic network it operates, SINET, is Japan's largest scientific network, and also provides a gateway to networks in the United States, Europe, and elsewhere.

NACSIS has requested an increase in its current $62 million budget to more than $80 million for the next 2 years, Inose says. That influx, he adds, would allow it to bump up SINET's speed from its present range of 2 to 16 megabits per second to 156 Mbps, followed by another jump, to 600 Mbps, within several years. By comparison, the very high-speed network that connects the U.S. National Science Foundation's supercomputer centers operates at 155 Mbps and is being upgraded to 622 Mbps, although the typical U.S. university is connected to the Internet at rates of either 1.5 or 45 Mbps.

SINET connects to the Science and Technology Agency's (STA's) new Interministry Network (IMnet), which has a 45-Mbps line between Tokyo and Tsukuba Science City and a 3-Mbps line between Tokyo and Osaka. IMnet also connects to other, smaller Japanese networks and to networks in the United States and Korea as the first step in developing full international links.

Although most IMnet links are already faster than SINET, the STA is not satisfied. "Present networks are not fast enough to transfer massive amounts of multimedia information and data in the form of three-dimensional live images. And researchers can't facilitate discussions through video conferences," says Nobuaki Teraoka, director of the research information network at STA. But he says financial constraints—IMnet's current annual budget is just over $8 million—prevent a more rapid conversion to high-speed lines. –L.V.

can go down 6500 meters, about 2000 meters deeper than *Alvin* goes. "The information helps to determine where we should dive," says Susumu Honjo, a WHOI geophysicist.

Bolstered by Japan's increased networking capabilities, *Mirai* has allowed JAMSTEC to become a full partner in the international Tropical Atmosphere Ocean buoy array. In addition to servicing the current array, maintained by the U.S. National Oceanic and Atmospheric Administration through its Pacific Marine Environmental Laboratory (PMEL) in Seattle, *Mirai* will set up 21 additional buoys to measure current along with ongoing readings of temperature, winds, and humidity. GOIN is also forcing Japan to modernize its data-handling systems. "GOIN is having a real impact on how Japanese research organizations handle their ocean data," says Nancy Soreide, PMEL's associate director for information management.

Shoichiro Nakamoto has seen that process at work. A former observational oceanographer at JAMSTEC, Nakamoto last spring moved to the Earth Science and Technology Organization, a new agency formed to help Japan's Science and Technology Agency participate in GOIN and other international programs. "It is not an easy task to unify the databases in Japan because there are many institutions involved in ocean sciences and observations," he says. But Japan's growing international connections, he adds, make that task imperative.

Tapping the KEGG. Japan's belated entry into the world of networking has also been a boon to geneticists. "The most useful information for us is electronic mail from collaborators," says Hidetoshi Inoko, a professor of molecular life sciences at Tokai University's School of Medicine in Isehara. "And the next is outcomes from analysis tools like GRAIL and BLAST/FAST," he adds, referring to tools for searching genetic databases for sequence homologies.

Inoko, who is exploring a 1-megabase region on chromosome 6 suspected to be involved in the immune response, leads one of four Japanese teams that last year received human genome sequencing grants (*Science*, 15 September 1995, p. 1504) from the government. The others focus on band 21.3 of chromosome 3, the Down syndrome region of chromosome 21, and the immunoglobulin-2 and cat's eye syndrome regions on chromosome 22. Data from the four projects will be posted on Japan's GenomeNet database, adding to the cDNA and *Bacillus subtilis* databases that are among the few unique genome databases in Japan.

U.S. scientists who rarely use Japan's GenomeNet now because they can find similar information at home expect the four sequencing projects to yield some unique databases, notably on chromosome 21. "Chromosome 21 is a very competitive area, and the cooperation of the international scientific community will be absolutely essential," says David Patterson, president of the Eleanor Roosevelt Institute in Denver, who is collaborating with Yoshiyuki Sakaki, a molecular biologist at the University of Tokyo's Human Genome Center. "The biggest problem we must confront is how to use the information [being collected]."

Inoko and others say that Japan can make a special contribution to science by helping to solve that problem. "What we need is bioinformatics software that will enable us to decipher the function of a novel gene," says Inoko.

KEGG, part of the second, 5-year phase of Japan's Genome Informatics Project, aims to take that great leap. Each gene will also be linked to entries in existing databases. "I will look at data in terms of binary relations—how this gene affects that gene or how this molecule affects that molecule, and synthesize how a network of interactive molecules will be formed," says Kyoto's Kanehisa. Kanehisa's group is also developing an integrated database retrieval system, called DBGET, to retrieve entries on 17 different GenomeNet databases by combining a database name and an entry name.

While most scientists expect the government's 5-year plan for science to benefit networking, some worry that officials will seek quick fixes rather than permanent improvements. "It may be spent like the money won in Las Vegas casinos and not generate a long-lasting infrastructure for networking and archiving," says physicist Tsuneyoshi Kamae of the University of Tokyo, who administered the TISN network for government labs that was folded into IMnet last spring. An important part of that infrastructure is the talent to run it, says Yusuke Nakamura, director of the Human Genome Center at the University of Tokyo's Institute of Medical Science. "Although computer science in the life sciences is getting more and more important," he says, "the number of Japanese scientists interested in [biological informatics] is very low." Raising those numbers is essential, he says, for Japan to take full advantage of the rest of the new world of science being delivered via electronic networks.

–Lori Valigra

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NATURAL HISTORY MUSEUMS

A Plea To Protect Threatened Collections

CAMBRIDGE, U.K.—As species after species slide into extinction around the globe, natural history museums, with their vast repositories of specimens, provide an increasingly important record of past biodiversity and a source of data for future studies. But the central message from the Second World Congress on the Preservation and Conservation of Natural History Collections, which convened here last month, is that the museums themselves are a threatened species. Many collections, particularly in developing countries, may even become extinct without a concerted effort to preserve them. "If nothing is done, there's a good chance of losing both in situ organisms and collections in the tropics," says Richard Leakey, the Kenyan paleontologist turned politician.

CHIP CLARK

Cuban connection. Smithsonian project aids Cuban marine collection.

The concern is not new. Four years ago, the first in this series of high-profile congresses, held in Madrid, Spain, drew attention to the problems, and delegates resolved to develop a number of initiatives. High on the list was the setting up of an international coordinating organization, says geologist Chris Collins of Cambridge University, who coordinated last month's meeting. But no effective organization has been established, and many researchers at the Cambridge meeting were disappointed at what had been achieved. "Some of the original drive appeared to have evaporated," says Steve Blackmore, head of the botany department at the Natural History Museum in London. Yet many felt that international coordination is needed now more than ever.

Take the situation in Kenya. With a rapidly rising population of 20 million, increasing infant mortality, and an ever-growing number of AIDS cases, there is little money for museums. "Is it possible to say that biodiversity is more important than medical treatment?" Leakey asked the conference. And even in industrialized countries, economic pressures are forcing museums to turn to private sources for funding. The Natural History Museum in London, which was wholly government funded 8 years ago, now finds one-third of its income elsewhere. "It is no longer sufficient for us simply to assert our importance;