cation of the long-range approach we've taken." The Loma Prieta earthquake broke the first 50 kilometers of fault, reaching a bit north of the point Lindh predicted, but the rupture was contained within the nearly uninhabited Santa Cruz Mountains.

Given this vindication, some seismologists are once again tackling a long-range forecast for the Peninsula segment, uncertainties or no. The USGS working group had estimated that the Peninsula segment had a 20% probability of generating a magnitude 7 shock during the next 30 years, compared with 30% for Loma Prieta. The earlier debate on Loma Prieta reveals how seismologists would like to revise this risk estimate for the upper Peninsula. Scholz sees the rupture of the first 50 kilometers of his 75-kilometer segment justifying his entire analysis. "I would upgrade the remaining 25 kilometers," says Scholz, to the next-to-highest probability category possible, something between 50% and 90% probability of failure during the next 30 years. More subjectively, "it's likely in the next 5 years," he says.

Thatcher doubts that. "I'd be surprised if it ruptured, but certainly we should keep an eye on it." Unlike Scholz, who relies on 1906 slippage as revealed in fault movement at the surface, Thatcher prefers surveys of crustal distortion, which reflect slippage deep within the fault. Thatcher's geodetically determined movement appears to be so large that the fault would not rupture again until the next great earthquake, perhaps a century or more from now.

Lindh, who has one good call to his credit, takes a middle ground. "We clearly got an increment of strain added [to the Peninsula segment] by this earthquake. We've got to worry about it. Whether we have to upgrade the probability, I don't know." However, he points out that if the actual distance traveled during the 1906 slip is much below Thatcher's estimate, and if the slip rate is at the high end of current estimates, "the arithmetic starts getting scary." Lindh sees a possibility that the segment that could fail is 50 to 70 kilometers long, not just Scholz's 25 kilometers, which would make for another magnitude 7 ripping right up to San Francisco.

Although this reading of seismic entrails leaves something to be desired, it is likely to provide the best forecast available for many years. And while the debate on the timing and location of the next big event will continue, the Loma Prieta tragedy has already strengthened one grim prediction on which geologists agree: The San Francisco Bay Area faces a new, increased likelihood of being hit by severe earthquakes.

■ RICHARD A. KERR

Japan Boosts Genome Research

After a lumbering start, the Japanese government is picking up the pace of its various genome initiatives. Several new programs have been launched in the past few months and another is slated to begin next year, reported Nobuyoshi Shimizu of Keio University School of Medicine at the recent Human Genome I meeting in San Diego.

But, while Japanese spending is up, it is still just a fraction of the $90 million the United States has committed to its genome projects at the National Institutes of Health and the Department of Energy for next year. Said Shimizu: "Our bureaucracy goes very slowly, no matter how hard you push."

Moreover, efforts remain fractured among several different agencies, which are all vying for a lead role. In fact, the interagency rivalries in Japan make the early turf battles between NIH and DOE here seem tame by comparison.

Human Genome Program. The core of Japan's efforts is the new Human Genome Program launched by the Ministry of Education, Science, and Culture about 2 months ago, said Shimizu, who is involved in the program. Directed by Kenichi Matsubara of Osaka University, it involves researchers at 30 different institutions. Although the budget, at $4.5 million for the first 2 years, is still small, Shimizu expects a tenfold hike in the next budget cycle.

As now envisioned, the program will focus on five areas. The first is human genome analysis, which includes genetic and physical mapping and chromosome analysis.

The second aim is to construct high-quality complementary DNA (cDNA) libraries for specific tissues, such as brain, liver, and heart—an ambitious goal that no other country has taken on, said Shimizu. A cDNA library is a collection of pieces of DNA that correspond to the expressed genes. A mere 5% of the human genome codes for proteins, but that 5%, obviously, is of prime interest both biologically and medically. A cDNA library will allow investigators to home in on these regions first.

Until now the problem has been that not all expressed genes show up in such libraries. Genes that are expressed at very low levels—that is, that make just one or a few copies of messenger RNA—are typically underrepresented. The Japanese program will focus on new methods to "amplify" these rare genes so that all the expressed genes are equally represented in the library.

The third area focuses on innovative DNA sequencing technologies—not improvements to the current generation of sequencing machines, said Shimizu, but entirely new approaches.

The fourth area includes both efforts to improve existing databases and to devise new software for genome analysis.

Finally, as in the United States, the Japanese program will focus on obtaining the maps and sequences of model organisms, such as nematode, *Drosophila*, or certain plant species. An ambitious project to se-

Congress Set to Pass R&D Budgets

Although Congress is still trying to decide how to bring the 1990 budget deficit down, the funding picture for the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) is becoming clearer. A House-Senate conference committee has finally agreed on appropriation levels for the agencies—2 weeks after the start of the new fiscal year.

NSF is slated to receive $2.07 billion, up from $1.9 billion in 1989. While overall agency funding increases 10%, NSF's research spending account rises just 7% to a total of $1.69 billion. As expected, science education received more than the $190 million requested by the Administration—$206.7 million. Another $153.6 million is appropriated for NSF's Antarctic research program.

NASA is to have its budget increased to $12.4 billion, a large boost from the $10.9 billion in 1989. Funding for the space station is $1.8 billion, which is $200 million less than NASA sought from Congress. The budget for construction and operation of the space shuttle orbiter is $3.4 billion, $425 million below NASA's request.

As *Science* went to press, the budget picture for NSF and NASA remained clouded by the possibility that the funding bill covering independent agencies and the Department of Housing and Urban Development (HUD) could be amended. A possible change in one HUD program could require an across-the-board reduction of 1% for all agencies covered in the giant appropriations bill. NSF, NASA, and other research agencies may face additional reductions when Congress decides how it wants to reduce the federal deficit.

■ M.C.

quence the entire *Escherichia coli* genome, led by Takashi Yura of Kyoto University, has been folded into this effort but retains independent support. A separate program, funded by the Ministry of Agriculture, is also under way to develop a physical map of the rice genome.

Riken. Japan's first venture into genome research began in 1981 when the Science and Technology Agency funded Akiyoshi Wada to develop automated sequencing technology at the Institute of Physical and Chemical Research, better known as Riken, in Tsukuba City. Now, reported Shimizu, Wada has left and that project has been transferred to the private sector.

Under the new project leader, Yoji Ikawa, the Riken Institute has two programs, with a yearly budget of about $1.5 million. One is a collaborative effort with Maynard Olson and his colleagues at Washington University in St. Louis to sequence a small yeast chromosome. The other is to develop a physical map and, eventually, to sequence human chromosome 21.

Yoken. Japan's equivalent to the NIH, Yoken, is negotiating with the Ministry of Health and Welfare for funds to seek out and then sequence the genes that cause human disease, with an eye toward diagnostic and therapeutic applications. The agency is angling for a budget of $2 million, and the program is expected to begin next year.

Genosphere Project. This year the Research and Development Corporation of Japan, a semigovernmental organization located in Tokyo, launched the Genosphere Project, with a budget of $14 million to $18 million for the first 5 years. The focus is on understanding chromosome function and structure, but the program has a hefty component of technology development as well. Researchers have already developed a laser beam microdissector for slicing chromosomes under a microscope, and they are working on new equipment that will enable them to observe chromosome movement during cell division.

Human Frontiers Science Program. While the genome project does not figure explicitly in the new Human Frontiers Science Program—Japan's international effort in basic research—funds are available for genome research, said Shimizu, "if researchers are smart." The Science and Technology Agency and the Ministry of International Trade and Industry, or MITI, have contributed about $24 million to Human Frontiers for 1990. Under the program, some 2 dozen grants will be awarded to international teams of scientists working in two broad areas: neuroscience and the molecular basis of biological functioning.

■ **Leslie Roberts**

Mud-Slinging Over Sewage Technology

Scientists in Boston and San Diego have recommended a money-saving technology for treating waste water, but EPA is opposed

MIT engineer Donald Harleman ought to be the most popular Bostonian since Carl Yastrzemski roamed Fenway Park. Though he has not proved a heavy hitter for the city as yet, he's suggested a way to clean up infamous Boston Harbor while saving local taxpayers $2.5 billion in sewer construction costs.

Sound too good to be true? That's the way the city's environmentalists and the Environmental Protection Agency (EPA) see it. They have rejected Harleman's contention that Boston, whose notoriously dirty harbor was made an issue in last year's presidential elections, should use an innovative—and, he contends, far cheaper—method to treat waste water. Harleman's persistence in pushing his proposal has rankled them so much that the current chief of the White House Council on Environmental Quality (CEQ), Michael Deland, when he was the EPA's regional director in Boston, wrote a letter to the president of MIT, complaining that Harleman was "fomenting public dissatisfaction" with federal plans to clean up Boston Harbor.

If Harleman is giving EPA headaches, it's not because he lacks credentials. He is the current chairman of one of EPA's own advisory committees—the one that evaluates federal researchers' modeling of the Chesapeake Bay—and he is also the former director of MIT's water resources and hydrodynamics laboratory and a member of the National Academy of Engineering.

Harleman is only one of several notable researchers who claim that there is a better way for some coastal cities to get rid of waste water. For example, several scientists at Scripps Oceanographic Institution, including former director Roger Revelle and chemist Edward Goldberg, recently became embroiled in San Diego politics when they voiced strong support for the very method Harleman has been touting back in Boston—advanced primary treatment with polymer technology.

But their battle is a different one from Harleman's. For one thing, their hometown sewage plant at Point Loma has been using an advanced primary system with polymers since 1985. To the Scripps scientists, it's a good method and the city should stick with it. But because San Diego is still out of compliance with federal water quality standards—its offshore waters have high coliform counts in a kelp bed—the city has been sued by the EPA to compel it to build a secondary system.

As Harleman has argued for Boston, Revelle, Goldberg, and several other Scripps scientists have argued in the San Diego case that the construction of a secondary treatment plant at Point Loma would be squandering a fortune. They have said that the proposed plant would cost $750 million to build but would do only a marginally better job than the current system. The Scripps scientists also contend that the EPA is mistaken in claiming that effluent from the advanced primary plant at Point Loma has harmed the marine environment.

EPA has fired back. It argues that Point Loma's effluent has changed the marine ecology near the outfall. Who's right? The city set up a task force to tell it whom to believe.

On 12 September, the verdict was announced and the scientists won the day—at least for the present. The task force recommended to the city council that the construction of a secondary treatment plant at Point Loma be delayed for 25 years and that the city instead spend funds on water reclamation.