life sciences panel, says, "Many of the visions coming out of the panel's consultations could have come from more conventional brainstorming sessions, but the key element was the surprising consensus on priorities between the academics and industrialists."

Some sector panels emphasized the importance of issues traditionally considered peripheral to the realm of science and the links between different fields. The health and life sciences panel, for example, considered research on people's assessment of risk as a key adjunct to technical developments in genetics to understand how information can be applied to preventing and treating common multifactorial diseases. "It is important to consider these questions," says Ferguson.

On the whole, scientists have supported the exercise, but some have raised concerns about how the results will be used. "What really matters is how this is taken forward," says Oxford University physicist John Mulvey, who heads the lobby group Save British Science. "The danger is it will be used as a prescription for what research councils should fund. The potential problem with emphasizing wealth creation is that less and less money may be available for free-ranging and exploratory research across all fields," he says.

That task of carrying the exercise forward is now in the hands of the OST. As the OST only controls the government's expenditure on science and technology through the research councils, other government departments must consider the results of the exercise when defining their research priorities if it is to have any real impact on public-sector science. However, although a small sum has been earmarked in this year's budget for foresight-inspired programs, Stewart is opposed to fencing off a large fixed proportion of the budget of the research councils specifically for foresight projects. "I don't think it is sensible. ... It depends on what the quality of the proposals are, what comes up, what competition there is. My own view is that it is up to us to suggest broad mechanisms, and that is one of the things that will come out of the technology foresight program."

"No other country has carried out foresight in the breadth of the U.K."
—David Hunt

Crucial to foresight's success is the response of the private sector, which is notoriously difficult to monitor. Many of the larger companies that took part in the exercise have been enthusiastic and carry out their own foresight exercises. But a key need is to involve small and medium-sized enterprises, argues Stewart. Academic scientists too are keen to push this point, as it could lead to more R&D spending by the private sector. "Unless industry puts in the investment as a result of this exercise, we won't achieve anything in the long term," says Mulvey.

Such an intensive and large-scale exercise has heightened expectations, so the OST will have to move fast on implementation to prevent the momentum already generated from fizzling out. "It would be nice if a few things were started now, but it may take up to 5 years for the full effects of the exercise to be noted," says Ferguson. But Stewart, who retires next month, believes the exercise will have a substantial impact. "My own view is that this technology foresight program will be as influential in shaping U.K. science and technology as was the 1993 white paper. It will be shaped ... with an appreciation that the world is changing and that we'd better be part of that changing world." The first indication of how the program will shape science policy here will come later this month, when Stewart's steering committee releases its overview of priorities needed to sustain the momentum of the foresight exercise.

–Nigel Williams

OIL SPILL

Russian Arctic Battles Pipeline Leak

The spring thaw is usually a welcome event to inhabitants of northern Russia's Komi Republic, 1000 miles northeast of Moscow. It's a time for commercial fishing and driving reindeer herds to summer feeding grounds. This spring, however, brings a major worry—a potentially disastrous run-off from the largest oil accident ever on Arctic soil. Beginning last August, an estimated 100,000 barrels of oil have leaked from a corroded pipeline in nine spills covering 70 hectares of peat bog. The oil threatens salmon fisheries and marshlands used for grazing cattle and reindeer. "There's an enormous potential for environmental disaster," says Jonathan Brown, chief of the infrastructure, energy, and environment division of the World Bank.


AP/WIDE WORLD PHOTOS

Slick work. Crews race the spring thaw to clean up the Arctic's largest oil spill on land.

The Komi spill, which involves three times the amount of oil released in Alaska's *Exxon Valdez* catastrophe in 1989, threatens a fragile ecosystem of bogs and braided rivers. Experts say the ecosystem cannot be completely cleaned and will take years to recover. "The moss will absorb a huge volume of oil, just like a sponge," says Michael Miller, a University of Cincinnati limnologist who has conducted research on the effects of oil spills in northern Alaska.

Last month the World Bank agreed to provide $99 million in loans to Komineft, a Russian firm that produces the oil and maintains the deteriorating Kharyaga-Usinsk pipeline, to help mitigate the damage. Cleanup efforts began in early March but were hampered by a thaw that started several weeks earlier than normal and by delays in shoring up makeshift earthen dikes keeping much of the oil from draining into the nearby Kolva River. "Up until the end of April, none of the cleanup work was done well," says Vladimir Zamoisky, a biologist with the Socio-Ecological Union, a nongovernmental organization based in Moscow that has monitored the activity on behalf of the Russian National Security Council's interagency commission on ecological security.

The World Bank money will help to strengthen the dikes, suck up some of the pooled oil, and repair the pipeline, sections of which are more than 20 years old and are weakened by the salt water that flows along with the oil. It will also fund studies of various cleanup techniques, including burning the oil and spraying oil-degrading bacteria, as well as environmental monitoring in the region. Komineft has hired two foreign companies to oversee the project, and a 300-person base camp in Usinsk operates "24 hours a day, essentially in a race against time, to stabilize the containment structures," says Douglas McKay, a World Bank project manager. There is little debate about what needs to be done. "It's eminently sensible given the money made available," says Paul Horsman, a marine biologist with Greenpeace who visited Komi last week, about the World Bank's plan.

The two largest spills, which occurred last

August and September, spewed oil along stretches of shore along the Kolva River near Kolva village, damaging grazing areas for cattle and reindeer. A team of scientists from the Institute of Biology in the Komi Scientific Center in Syktyvkar reported last November that the bottom of the Kolva River was denuded of life. A "complete absence of benthos from bottom sediments," the researchers stated, suggests the ecological condition of the waterways in Usinsk is "critical." Any additional pollution from further run-off "should be expected to disrupt the food web at every level," says stream ecologist Anne Hershey of the University of Minnesota, Duluth.

The spill is the latest insult to an ecosystem already weakened by previous oil spills, and observers fear the Komi's inhabitants may lose a valuable resource—commercial fishing for salmon, whitefish, flounder, and perch—if the health of the watershed is further degraded. According to the World Bank, the fish catch in the Usinsk region had declined from 68 tons in 1976 to 8.4 tons in 1994. In a recent study, Komineft concluded that recent spills have decreased the fish populations in several Usinsk streams by 70% to 75%, a level that begins to threaten even subsistence fishermen. If the dikes break, oil swept into the Kolva River could contaminate the much larger Pechora River, "threatening salmon and important fishery spawning grounds," concludes a World Bank report.

Even if the oil is cleaned up, however, the taiga marshes are likely to remain damaged. "One of the absolute hallmark rules is that if you spill oil in a marsh, you'll do more damage getting the oil out than the oil does itself," says Jerry Galt, an oceanographer with the National Oceanic and Atmospheric Administration's hazardous materials response division in Seattle. "Some of the marshes will be destroyed for a very long time," he says. That will pose the greatest problem for reindeer herders, who will be forced to drive their herds along a different route between summer and winter grazing areas.

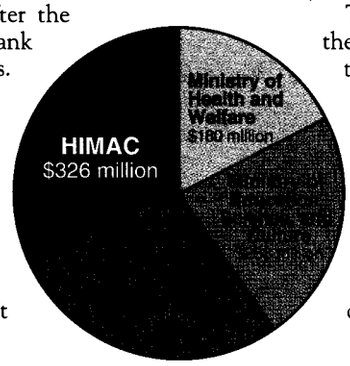
Russian authorities at first were reluctant to come to grips with the spill, and Komineft's official estimate of its extent—14,000 tons—is seven times smaller than independent estimates. But the World Bank's McKay says he has seen a change in attitude in recent months. Russian officials "are much more willing and open now," he says. That new attitude is essential, McKay says, for Russian scientists to gain access to the threatened regions to monitor water quality and the spread of oil into cattle and reindeer grazing areas. Armed with that information, experts may be able to predict whether next spring will signal a time of renewal or resignation for the residents of Komi.

–Richard Stone

JAPAN

Chiba's Heavy-Ion Accelerator Battles Cancer and Critics

CHIBA, JAPAN—The world's only heavy-ion accelerator dedicated to cancer therapy has performed well in its clinical debut, say researchers at Japan's National Institute of Radiological Sciences (NIRS): In late March the institute reported that the first three patients to undergo treatment were able to return to work after the therapy significantly shrank their primary head tumors. Although these preliminary results are far from conclusive, they are welcome news to the Japanese government, which put up $326 million to build the facility and is spending $45 million a year to operate it. But they won't damp down a controversy about the wisdom of putting so much money into an unproven therapy. Nor do they erase concerns about the way clinical trials, involving thousands of patients over the next several years, will be evaluated.



Hefty slice. The program that funded HIMAC is part of a $2.4 billion anti-cancer effort in the past decade.

The project was recognized as a costly scientific gamble ever since the government, in the early 1980s, decided to build an accelerator-based cancer therapy center as part of a national 10-year plan to combat cancer. Completed last year, the Heavy-Ion Medical Accelerator in Chiba (HIMAC), outside Tokyo, is designed to tackle hard-to-treat cancers of the head and neck, brain, and lungs (*Science*, 3 September 1993, p. 1270). Previous experiments with particle beams, including tests conducted in the United States, indicated that the technology shows promise in treating such cancers. But some Japanese cancer researchers have questioned whether this promise is sufficient to justify the huge investment in HIMAC—a third of the 10-year plan and 13% of all cancer-related research spending in Japan over the past 10 years (see pie chart).

Cancer researchers elsewhere will be watching the clinical trials closely. Already, provincial officials in Hyogo prefecture, west of Osaka, are planning to build a facility similar to HIMAC as part of a multibillion-dollar science park, and researchers in Germany will soon start treating a handful of patients on an experimental basis. And although there are at present no plans to fund trials in the United States, Joseph Castro, professor of radiation oncology at the University of California, San Francisco, says he is hopeful of restarting the work if HIMAC and the European programs yield promising results. Castro led a 15-year series of tests using an accelerator at Lawrence Berkeley National Laboratory that was shut down in 1993.

This international interest in the therapy rests on the theory that particle beams should be more effective than x-rays and gamma radiation in attacking some types of tumors. That's because the charged particles generated by two synchrotrons can be focused more precisely than other forms of radiation. In addition, the mass and charge of heavy ions allow them to pack more of a wallop to the cancerous tissue. Last month's results at HIMAC involved three patients irradiated with two streams of carbon-12 ions—one vertical and one horizontal—that converged on their tumors for 90 seconds, three times a week for 6 weeks. In all three cases, according to NIRS scientists, the tumors shrank significantly with minimal side effects.

These are the first of what is expected to be a stream of results from HIMAC. NIRS is building a $129 million, 100-bed hospital on an adjacent site to accommodate up to a thousand patients a year for full-scale clinical trials. And researchers hope to move beyond head tumors as they get more experience with the machine. "The range of applications will expand as experience with the technique is gained," says Kozo Morita, director of charged-particle therapy at NIRS, noting plans to extend trials to uterine, liver, and prostate cancers.

Working the system. Japan is leading the way in part because of its approach to funding science, in particular its affinity for large projects. Decision-making in Japan is widely perceived by outsiders as a painstaking process of consensus-forming, but as the history of HIMAC shows, funding agencies often operate more like individual fiefdoms, making little effort to integrate their plans with other agencies. "Each ministry is practically an independent nation," says Takashi Sugimura, president emeritus of the National Cancer Center in Tokyo.