wegian consortium. Also, the United States already operates two other small ionospheric heaters, at the Arecibo Observatory in Puerto Rico and at HIPAS, operated by the University of California, Los Angeles, 325 kilometers down the road from HAARP in Chena Hot Springs, Alaska. The HAARP facility, with three times the power of current facilities and a vastly more flexible radio beam, will be the world's largest ionospheric heater.

Still, it will not be nearly powerful enough to change Earth's climate, say scientists. "They are talking science fiction," says Syun-Ichi Akasofu, who heads the University of Alaska's Geophysical Institute in Fairbanks, the lead institution in a university consortium that made recommendations to the military about how HAARP could be used for basic research. HAARP won't be doing anything to the ionosphere that doesn't happen naturally as a result of solar radiation, says Akasofu. Indeed, the beam's effect on the ionosphere is minuscule compared to normal day-night variations. "To do what [the critics] are talking about, we would have to flatten the entire state of Alaska and put up millions of antennas, and even then, I am not sure it would work."

Weather is generated, not in the ionosphere, but in the dense atmosphere close to Earth, points out University of Tulsa provost and plasma physicist Lewis Duncan, former chair of the U.S. Ionospheric Steering Committee. Because HAARP's radio beam only excites and heats ionized particles, it will slip right through the lower atmosphere, which is composed primarily of neutral gases. "If climate modifications were even conceivable using this technology, you can bet there would be a lot more funding available for it," he jokes.

Critics also charge that the HAARP project is suspect because—having been funded directly by Congress—it has never undergone a formal, scientific review process. Mitch Rose, Stevens's chief of staff, counters that the critics shouldn't look a gift horse in the mouth. "Let's face it, the DOD has a good budget, and they have the resources to support this type of program. ... We are hoping that HAARP will be a harbinger for a different Silicon Valley for Alaska."

Whatever economic benefits HAARP bestows, they won't be felt for a few more years: While Congress has budgeted $15 million in the FY '97 budget for HAARP, Heckscher says that all the legislative hearings, requests for information, and piles of letters have slowed the project down. Still, the University of Alaska's Kan hopes the controversy will prove to be a boon for physics: "I see this as a tremendous opportunity to educate the public about physics and auroral studies."

–Lisa Busch

Lisa Busch is a science writer in Sitka, Alaska.

AAAS MEETING

Scientists Convene in Seattle To Discuss Science and Policy

SEATTLE—At the Annual Meeting and Science Innovation Exposition of the American Association for the Advancement of Science (which publishes *Science*), researchers, educators, and policy-makers shared their research results, and debated new developments in science policy and education. The conference ran from 13 to 18 February. Here are two reports from early sessions; more coverage will be published in next week's issue.

R&D Confronts Political, Fiscal Problems

To U.S. scientists, the $75.5 billion R&D budget released earlier this month by the Clinton Administration may seem like a blueprint for tough times ahead, with its projections of cuts in purchasing power over the next 4 years (*Science*, 14 February, p. 916). But to many top science policy-makers from around the world, who made up a panel on the opening day of the AAAS meeting, it must have seemed like an impossible dream.

Officials from both rich and poor countries spoke of inadequate budgets and a growing gap between the scientific resources and priorities of the industrialized countries and those of the developing world. "You scientists ... are part of a privileged world elite," said Peruvian R&D analyst Francisco Sagasti of researchers in the First World. He and other members of the AAAS panel urged R&D managers in developed countries to help heal the rifts between rich and poor nations by channeling resources into research in agriculture, telecommunications, and health.

In Russia, said Boris Saltykov, a former Russian science and technology minister who now runs a Moscow-based organization working to strengthen ties between Russian scientists and their counterparts in other nations, the challenge is simply to survive. Saltykov reported that R&D spending in Russia dropped by 70% over 5 years. Scientific employment in the former Soviet Union fell from a peak of 3,200,000 scientists and support personnel in the late 1980s to about 1,334,000 in 1995. Accompanying that decline were a host of reforms, many pushed by Saltykov, to unshackle science from the former Soviet Union's crippling bureaucracy. But the state research institutes created to protect Russian expertise in a host of scientific fields are now "inoperative" because only 60% of the money allocated by the Duma, or parliament, has been disbursed in 1996. One bright spot is increasing collaboration with Western researchers. "We are rapidly advancing toward ultimate integration into the world scientific community," he says.

For China, the challenge is to provide resources for a population expected to top 1.6 billion by the middle of the next century. That means focusing on agricultural research, says Zhou Guangzhao, who heads the China Association for Science and Technology. China needs to increase grain production by 50% by engineering new, pest- and drought-resistant strains of rice and wheat, among other endeavors. Zhou says that his country also must develop new energy-conservation technologies, and devise and build a massive transportation infrastructure that will be able to move millions with ease. "Achieving sustainability is a top priority," he says.

Latin America, meanwhile, is still trying to recover from the 1980s, a tumultuous decade in which R&D institutions were hard-hit by political and economic upheaval. "We really lost ground and have not been able to catch up," says Sagasti. He notes that in the late 1960s, Peru and South Korea both spent about the same amount—approximately $100 million—on R&D. Nearly 30 years later, Peru continues to spend at roughly the same level, while in South Korea, industry and government now spend $9.6 billion annually on R&D. Sagasti contends that Third World nations "cannot hold [on] to the illusion" that they will ever be able to spend and consume at First World levels, and, like Zhou, he calls for scientists to focus their efforts on devising and enhancing technologies that will allow people in all countries to live more sustainably.

Science managers from developed countries tend to be the most upbeat about the likelihood that science and technology will be able to knit together a fractured world. Jack Gibbons, U.S. President Bill Clinton's science adviser, cites CERN in Geneva as an example of a successful international endeavor that augurs stronger cooperation in the future in a variety of fields. He pointed to a proposal in the 1998 budget request for a U.S. plan to combat emerging infectious diseases as an example of research that will benefit people worldwide.

But U.K. science adviser Robert May of-

fered a word of caution: Increasing economic competition, he said, may pose challenges to international scientific collaboration. He argues that Britain must strengthen its ability to convert research into applications that can fuel the economy. Although Britain accounts for about 7% of all academic citations, it holds only 3% of the world's patents, he says. Japan, by contrast, has only 4% of citations but about 14% of all patents.

–Andrew Lawler

Scientists Describe Deep-Sea Rebirth

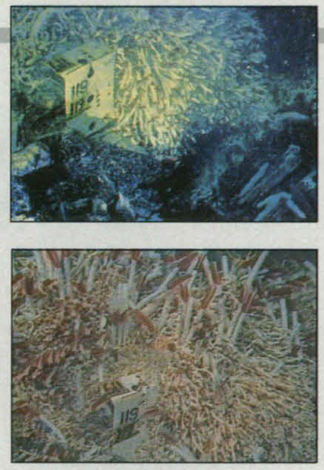
It has been 20 years since scientists discovered the strange communities of giant tubeworms, thick bacterial mats, crabs, and other species that flourish at the edges of boiling-hot deep-sea vents. Yet, these exotic communities continue to generate questions—how do organisms cope with such harsh living conditions, deriving energy not from photosynthesis but from hydrogen sulfide, and how do life-forms find and colonize these widely scattered vents? At the Seattle meeting, marine ecologist Richard Lutz of Rutgers University in New Brunswick, New Jersey, described the latest in a remarkable series of observations that are providing valuable clues to one of these puzzles: how a new vent is populated. The study, which recorded how a vent community that had been wiped out by an undersea lava flow rebounded over the course of 5 years, also may set the stage for experiments to help answer some of the other puzzles.

Lutz and his colleagues chanced upon the rare opportunity to witness this rebirth in April 1991 while surveying the East Pacific Rise—a submarine ridge where two tectonic plates pull apart—about 500 miles southwest of Acapulco. They discovered the devastated vents from the deep-diving submersible *Alvin*, at a depth of about 2500 meters. Fresh ash and lava were everywhere; the rocks were littered with dead tubeworms. They filmed the site, and a few months later, to help them relocate the vents on subsequent visits, laid down a trail of markers along the ridge crest.

Over the next 4 years, the researchers returned seven times. The changes were "absolutely spectacular," reports Lutz. Where at first, the only life was clouds of bacteria gushing out of fresh fissures, just 11 months later, the vents teemed with small tubeworms, crabs, fish, and other species. One year after that, giant tubeworms dominated the rocks, and Lutz's group reported that, at nearly 1 meter per year, the creatures are the fastest growing of known marine invertebrates. The team also chronicled what happens at those vents where, as Lutz puts it, "the hot water is turned off." When temperature and hydrogen sulfide levels fall, the tubeworms die, says Lutz. But even these failing vents sustain some life, including crabs and jellyfishlike siphonophores.

The researchers also made a startling geological discovery. Over just a few months, they observed metal-rich sulfide deposits created by the vents grow into towering chimneys, one over 10 meters tall. Lutz says geologists had once thought such formations rose up over thousands of years.

At the meeting, Lutz focused on new, unpublished findings from the last 2 years of the study. During that time, the overall number of colonizing species jumped from 12 to 29. Among the new arrivals were mussels and groves of small worms called serpulids. Lutz and his colleagues also have observed unusually dense clouds of amphipods, tiny crustaceans related to sand fleas. One surprise is that giant, footlong clams, which are common at east Pacific vents, haven't yet taken up residence. "We assumed these were a major, early colonizer, and even dated some vents based on that assumption," says Lutz.



On the rebound. Giant tubeworms recolonizing a vent.

Lutz's group plans to spend 3 more years studying the site. The real value of the research, Lutz says, is as a baseline for future ecology experiments. One possible study might investigate how excluding a predator species affects the community. The 1.4-kilometer-long ridge section would be ideal for such experiments because it contains 17 separate but similar vents that could be manipulated individually.

By helping "to figure out how a system that we never even knew existed works," those studies may complement other goals of vent research, such as finding out whether life began in a submarine volcano, says Phil Taylor of the U.S. National Science Foundation, which supports Lutz's work. Oceanographer John Delaney of the University of Washington, Seattle, who co-organized the session, adds that vent ecosystems may also yield clues as to how life could arise on other planets.

–Jocelyn Kaiser

HEALTH RESEARCH

U.S., Russia to Study Radiation Effects

One of the hottest of Earth's radioactive hot spots is a Russian town east of the Urals known formerly by its Soviet label, Chelyabinsk-65. It is the site of a once-secret nuclear production facility called Mayak. During the late 1940s and early 1950s, when Mayak was running flat-out, safety was not a big concern. Workers were contaminated with huge amounts of plutonium, and the factory itself leaked cesium and strontium into the environment. The nearby Techa River carried so much waste, according to one U.S. scientist, that "you could get a lethal dose" of radiation by standing on its banks long enough. (The radiation level was 5 rems per hour; 500 rems is considered lethal.) Tens of thousands of people—including local villagers who ate fish from the river and families of Mayak workers living in a town now called Ozyorsk—were exposed to dangerous levels of radiation and are prone to above-average cancer risks today.

For decades, Russian researchers have been collecting medical records on this evolving tragedy (*Science*, 24 February 1995, p. 1084). And for the past 2 years, they have been joined by U.S. researchers, who worked with the Russians to examine the feasibility of conducting a major research effort to probe the health effects of long-term exposure to radiation. On 11 February, officials from the two countries met at the National Academy of Sciences in Washington, D.C., to announce that they have concluded that the available records would support such an effort, and that they were signing a memorandum to launch half a dozen new, in-depth studies. But there's a catch: Both partners are short of cash.

Tara O'Toole, the Department of Energy's (DOE's) assistant secretary for environment, safety, and health, says DOE will provide analytical expertise and some funding for the project, which is to be run by the U.S.–Russian Joint Coordinating Committee on Radiation Effects Research. DOE is kicking in about $1 million this year out of a total U.S. contribution of $2 million. But because DOE's budget is tight, it may have trouble increasing its support in 1998. O'Toole says, however, that DOE's goal is to invest $20 million over the next 5 years. DOE is also hoping to get help from other agencies, including the Environmental Protection Agency, the Nuclear Regulatory Commission, the Defense Department, and NASA. The agreement was endorsed for the Russians by Sergei Khetagurov, vice minister of the disaster response agency. Russia will contribute raw data, facilities, analytical staff, and experienced clinicians—but not much money.

O'Toole and Khetagurov agreed that their scientific teams will carry out a long-