The promise of democratic rule in Yugoslavia has rekindled scientists' hopes that their careers will eventually get back on track and that scientific cooperation between the former Yugoslav republics can be reestablished

Help Needed to Rebuild Science in Yugoslavia

BELGRADE—A sprawling nuclear lab on the Danube 15 kilometers downstream from this emotionally spent capital offers a window on this beleaguered nation's scientific past—and on the hopes of Serbian scientists that they may now have a future.

During the Cold War years, the Vinča Institute of Nuclear Sciences was a bastion of top-notch research, and as Yugoslavia warmed to the West in the late 1970s, foreign physicists beat a path to its door. Funding declined during the 1990s, but even as it was drawing worldwide condemnation for its role in the war in neighboring Bosnia-Herzegovina, the Serbian government in September 1992 broke ground on a state-of-the-art cyclotron facility at Vinča for everything from probing atomic structure to treating cancer patients.

By 1998, the government had cobbled together enough funding to allow three key components—a machine that churns out hydrogen ions, another for heavier elements, and a channel for blitzing targets for materials science experiments—to come on line. "It's the best ion source [of its class] operating in the world today," beams Dejan Trbojevic, a former Vinča physicist now at Brookhaven National Laboratory in Upton, New York. All that remained unfinished was work worth about $5 million on the centerpiece, the VINCY Cyclotron, and two more experimental channels. The entire TESLA Scientific Center, named after Yugoslavia's homegrown star from a century ago, electrical engineering wizard Nikola Tesla, was nearly complete. But suddenly it came to a screeching halt. In 1998, Serbia's newly appointed science minister, Branislav Ivković, without explanation pulled the plug on TESLA's financing—a move that Vinča scientists, who draw salaries of about $50 per month from the institute's tiny budget, were powerless to offset. United Nations and European Union sanctions, in place since 1992, ruled out a Western bailout. Hopes for the facility almost sputtered out.

Earlier this month, those hopes were suddenly rekindled when the European Union lifted sanctions against Yugoslavia on 9 October just hours after Vojislav Kostunica was sworn in as the new president of Yugoslavia. Free at last to cut deals with Western benefactors, Vinča has begun talks with organizations in Germany and elsewhere in Europe. "We now have real hopes of finishing TESLA," says Marina Sokcic-Kostic, a former Vinča physicist who works at the Forschungszentrum in Karlsruhe, Germany. She was in Belgrade for a conference during the demonstrations earlier this month that culminated in the ouster of former President Slobodan Milosevic. "It was a fantastic feeling, a feeling that you belonged to history," she says.

Sokcic-Kostic is not the only scientist basking in the glow of Yugoslavia's new day. The promise of a democratic nation has emboldened scientists across Serbia and its partner state, Montenegro, to start laying plans with colleagues around the world to resuscitate dormant collaborations or begin new ones. They have a lot of catching up to do. The Yugoslavian scientific community has withered in the past decade, crippled by a massive brain drain and starved for resources. The losses have been so great that the comeback of Yugoslavian science depends largely on how much assistance Western countries and expatriate scientists provide. "The real question may be not what the people in Yugoslavia are ready to do to improve this situation, but what the rest of the world is ready to do," says Boris Ivancevic, a specialist on fungi at the Natural History Museum in Belgrade.

Indeed, the daunting tasks ahead have begun to sober up scientists intoxicated by newfound political freedom. But in forging a new path, they may find lessons in countries that separated from Yugoslavia in 1991. Croatia and Slovenia are nurturing potentially vibrant—though underfunded—research establishments in their young nations, whereas Bosnia-Herzegovina has been slow in rebuilding its scientific community 5 years after the end of a devastating civil war (see p. 692).

"It must be remembered that science has always been an important part of Serbia's history," says Mark Edmond Clark, a fellow at the Council on Foreign Relations in New York City. "Things can only get better from here on out." Adds Martin Prochnik, who until 1995 ran the U.S. State Department's Office of Science and Technology Cooperation, "The end of the Milosevic regime will mean the end of the isolation from the world scientific community."

The dark years

Many scientists here yearn for the pre-Milosevic era, a feeling they call "Yugonostalgia." During the 35 years that Marshal Tito (born Josip Broz) ruled the country, Yugoslav scientists enjoyed a big advantage over their counterparts in other Eastern European countries. Although funding was modest during the Tito era, by maintaining a delicate diplomatic balance—not getting too

MAP: A. STONEBRAKER

Serbian University Law Causes Turmoil

BELGRADE—Whether the University of Belgrade was ruined or saved in May 1998 depends on one's political views. That was when the regime of Slobodan Milosevic pushed through the Serb parliament the University Act, a law that gave the minister of higher education the right to appoint deans at Serbian universities. The act "put Serbia's universities under political control," says Boris Ivancevic, a specialist on fungi at the Natural History Museum in Belgrade. "The chief criterion was loyalty to the regime."

The law also mandated that all professors, who are appointed by the deans, sign contracts. "It abolishes all autonomy of teaching," says University of Belgrade archaeologist Staša Babić. "There are some really fine scholars who signed" for fear of getting sacked and thus making their families suffer, she says. Babić decided to take a chance and refused to sign: "I only have a dog. We'll survive." She kept her job.

Milan Kurepa of the University of Belgrade physics department said in an interview in August that 58 electrical engineering professors—about a third of the faculty—were either expelled or forced into premature retirement. (Kurepa died last week after a prolonged illness.) Two years ago, Kurepa banded together with a handful of other scientists "to fight against the machinery." They formed the Association of Yugoslav Scientists and Professors and brought attention to their plight in the opposition press. Out of 4200 or so professors at the University of Belgrade, 300 belong to the association. One-sixth of those who joined the association lost their jobs, Kurepa claimed. Many of their replacements were not qualified, he said. "People have to know the university's completely ruined," Kurepa says.

Serbian science minister Branislav Ivković, who is expected to lose his post with the change in government, disputes this characterization. Appointments are "decided by all the staff of the faculty," he says. (The act stipulates only that deans may consult teaching staff.) "Simply said, the university structure is now quite similar to [that of] a state university in the U.S." Ivković argues that "the message of the law is that politics is banned at the universities": It purged professors who were using their positions and computers—state property—"against the country and against the president."

Gazo Knezevic, a member of the cabinet of president Vojislav Kostunica, says that the new government will revoke the act. "We expect that the universities in Serbia will transform and modernize," says Srbijanka Turajlić, an electrical engineer who now chairs the Alternative Academic Educational Network, a shadow university in an office building in downtown Belgrade supported by international philanthropies. The change in government has already brought changes at the University of Belgrade: Rector Jagos Puric handed his resignation to the Serbian government on 16 October, and Ivancevic says as many as 23 of 30 deans at the university have so far resigned. But, says Turajlić, full recovery "will take time." **–R.S.**

With reporting by Gillian Sandford in Belgrade.

Political act. Many faculty members were fired at the University of Belgrade.

chummy with either superpower—Tito afforded Yugoslav scientists the opportunity to work in the United States and Western Europe. "Science was a window to the world, and we had excellent connections abroad," says Croatian biophysicist Greta Pifat-Mrzljak of the Ruđer Bošković Institute in Zagreb, Croatia.

For most scientific disciplines, says Ivancevic, the decade following Tito's death in 1980 until Yugoslavia broke apart in the early 1990s was the most prosperous period for Yugoslav science. The country as a whole even presented a united front to the world. "There was rather astonishing internal Yugoslav cooperation in working with U.S. scientists, even among ethnic and national groups who ended up killing each other shortly after the war began," says Prochnik.

Now, Serbian scientists find it painful to compare their situation with that before the breakup of Yugoslavia. "It's difficult to convey the deepness of the tragedy," said physicist Milan Kurepa of the University of Belgrade in an interview in August. (Kurepa, a veteran fighter for the freedom of the university, died last week after a long illness.) After sanctions were imposed, inflation spiraled out of control. "The living standard was reduced to mere survival," says Ivancevic. "The common people suffered because of the sanctions, while Milosevic prospered." Due to widespread impoverishment and inflation, research support plummeted. In 1990, assistant professors at the University of Belgrade could expect to receive a salary of $500 to $600 per month. Now, they receive about $35.

Today, "there is no money even for postage stamps," says Ivancevic. This year through mid-September, his museum has received 2 million dinars (about $33,000) from the government, nearly 75% of which has gone to salaries—after taxes, about $40 a month for a curator. Consuming the remainder are routine expenses such as heating and electricity bills. Museum researchers must find nongovernmental support for any research projects, collection trips, or costs of attending conferences abroad. A decade ago, the Institute of Physics in Belgrade subscribed to 132 journals; today, seven or eight. "I haven't seen a new textbook from the West for 4 or 5 years," said Kurepa. "In science, that makes us illiterate. We have no idea what physicists outside Yugoslavia are doing."

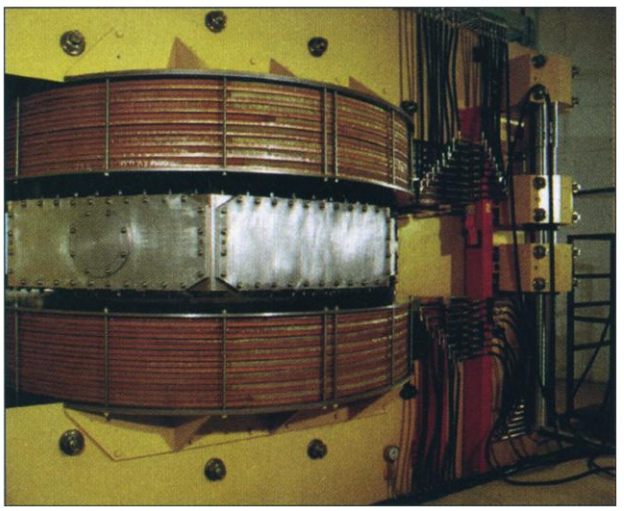
The poor conditions have driven several hundred thousand Serbs with university degrees abroad over the past 10 years. "Many have started successful careers in the West, where conditions for scientific work will be

CREDITS: (TOP TO BOTTOM) ALAN CHIN; BORIS IVANCEVIC

End of an era. Demonstrations help enforce election results that ended Milosevic regime.

incomparably better than anything even new, democratic Yugoslavia can hope to offer for a long time," says Ivancevic. "My generation is really all over the world," says Sokcic-Kostic. She has a son in 10th grade in Germany and would only return to Yugoslavia after he graduates. Indeed, added Kurepa, "the scientific community in Belgrade has almost ceased to exist."

Ivković, who as *Science* went to press was expected to lose his post as Serbia's science minister, disputes those claims. "Despite the sanctions, we have managed to maintain a thriving scientific community," he said in an interview in August, pointing out that the number of Serbian scientists actually rose from 15,100 in 1990 to 15,910 in 1999, as researchers who emigrated were readily replaced. Ivković also pointed out that Serbia currently has a few dozen joint projects with Russia and China, two countries that didn't agree to U.N. sanctions.



Physics centerpiece. Cyclotron at the TESLA Scientific Center near Belgrade may finally be completed with international help.

Scientists say, however, that the sanctions had long-term effects. Coming back from trips abroad, says electrical engineer Srbijanca Turajlić, "I smuggled vacuum tubes and other spare parts in my suitcases." Sanctions hit hard even on a personal level. Kurepa, who did his Ph.D. in nuclear physics at the University of Liverpool in the early 1960s before returning to Belgrade, maintained contacts and friendships over the years—until after the sanctions, when he said his British colleagues suddenly fell silent. "They didn't even ask, 'Milan, do you need a pencil?' " The sanctions, Turajlić says, "were one of the biggest mistakes the West made. We were not able to *live* under sanctions, let alone do research."

The NATO bombing campaign in spring 1999 dealt a further blow, bringing research to a virtual standstill for months. "Is it possible to think seriously about science when one sees tens or hundreds of people injured daily?" asks one Belgrade scientist. Rumors even spread that Vinča was on the NATO target list.

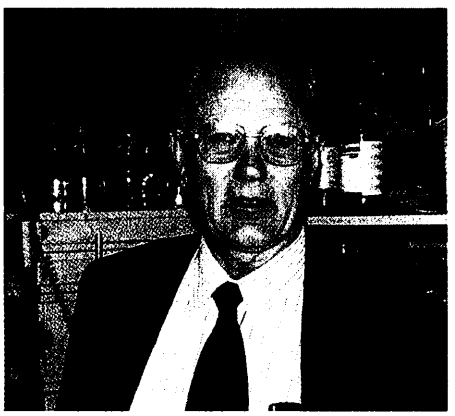
Repairing the damage

Undoing a decade's worth of damage may take years and require grooming a new generation of scientists to take the place of colleagues who went abroad—and probably

Science Survives in Breakaway States

LJUBLJANA AND ZAGREB—As Serb scientists start rebuilding a research system devastated by wars and international ostracism (see main text), they might draw some lessons—and hopes—from colleagues in the nations that won their independence from Yugoslavia during the past decade.

Slovenia, a country the size of New Jersey with 2 million people, has emerged from the chaos of the Yugoslav breakup with the biggest head start in science. One reason is that it escaped unscathed from its 1-week war of independence in 1991. But Slovenia has also tried hard to keep talented young scientists at home, and Slovenian researchers were able to join the European Union's (E.U.'s) flagship research program last year. "Because of our determination to join the E.U. and to focus our priorities on European programs and initiatives, science in Slovenia has improved at a faster rate than in other nations of the former Yugoslavia," contends plant biologist Lojze Marinček, Slovenia's science minister. In the initial rounds of the E.U.'s Fifth Framework Programme, the ministry says, researchers in Slovenia landed a role in 46 projects, about half as many as did scientists in Poland—a country with a population nearly 20 times as large.



Good start. But biochemist Vito Turk says more resources are needed to maintain momentum in Slovenian science.

But Slovenian scientists, although proud of the quality of their research, are worried, because government science spending has eroded over the past few years, forcing institutes to channel a higher proportion of their budgets into salary payments. This month, Slovenia's Association of Research Institutes even resorted to newspaper ads to call attention to their plight. Vito Turk, a biochemist who heads Slovenia's biggest research center, the Jožef Stefan Institute, says, "Farsighted initiatives in the past helped Slovenia preserve the quality of its science. But we won't be able to keep up this momentum without more resources for research."

Slovenia has slowed down the brain drain with a fellowship program called "2000 Young Researchers," but leading scientists fear that if government and industry don't focus more on R&D, many young researchers will grow pessimistic about their prospects for productive careers in Slovenia. "Without the Young Researchers program, we would have been devastated," says physicist Robert Blinc. "But what do we do with all these talented young researchers?"

Shaky start

Like Slovenia, Croatia also has a proud scientific tradition and has for centuries felt closer to its Alpine and Adriatic neighbors than to the Balkan nations to the east. But Croatia paid a much higher price than Slovenia paid for its freedom: a bloody war for independence that took nearly 4 years to settle. Serb rockets killed students and hit university buildings in downtown Zagreb in 1995 and nearly destroyed the university in Osijek, recalls Branko Jeren, rector of the University of Zagreb. The war, and Croatia's involvement in the related Bosnian conflict, sapped the country's economic vitality. And Western European governments barred Croatia from E.U. research programs because of a virulent strain of nationalism nurtured by former President Franjo Tudjman's regime, which ended after Tudjman's death late last year.

With the rise of a more democratic government in Croatia this spring, the nation's scientists are once again eligible to apply with partners for E.U. research programs. And, even though research spend-

CREDITS: (TOP TO BOTTOM) ALAN CHIN; R. KOENIG

aren't coming back. "You can definitely forget about the wave of scientists returning to their homeland," predicts Arseni Markoff, a molecular biologist at the University of Münster in Germany, who sees parallels between the nearly bloodless transition to democracy in Serbia and what happened in Bulgaria, his native land, 10 years ago. Serbian scientists agree. "We do not expect the return of a significant number of scientists to our country," says Ivancevic. "But we expect that they will continue to help us by sending us information and establishing contacts."

Inflation factor. Banknotes (featuring Nikola Tesla) tell the story of rampant inflation, which has crippled the Yugoslav economy.

Cultural changes are necessary too. "In an increasingly impoverished country, money-making, whichever way possible, has become the only goal," says Ivancevic. "I fear that it will take a long time for this attitude to change." Indeed, predicts Gligor Tashkovich, executive vice president of AMBO LLC's Trans-Balkan Oil Pipeline project, which will be the largest private infrastructure project in the region when construction starts in 2003, "as the economy gets restructured, scientists will be disproportionately squeezed out of jobs. Things will get worse for scientists before they get better, and the only ameliorating condition will be if [the U.S. National Science Foundation] and its counterparts across Europe take a leadership role at this early stage."

Like the rest of the Yugoslavian scientific community, Vinča and its 400-strong researchers are undertaking the seemingly paradoxical endeavors of rebuilding old ties and burying the past. It's hoping to start afresh with erstwhile collaborators like Oak Ridge National Laboratory in Tennessee and CERN, the European particle physics laboratory in Geneva, which helped set up TESLA's advisory committee before severing ties with Vinča after sanctions were imposed. Renewed cooperation "might attract some of our scientists who have left the country," says Nebojsa Neskovic, Vinča's associate director for science. Once the cyclotron is finished—Neskovic estimates that the center can be up and running within 30 months after construction resumes—the first project will hook up the hydrogen ion source to produce a beam of 30–million electron volt protons for use in manufacturing radioisotopes and for radiation research. So far, 15 institutes in eight countries, from Italy to Macedonia, have become members of the center.

The future is less certain for the resumption of close scientific ties between the nations of former Yugoslavia. "If democratization in Yugoslavia results in real—not

ing has been low for years, science minister Hrvoje Kraljević told *Science* that the new government "is committed to increasing support for research." He is trying to convince Parliament to set aside for R&D a small percentage of the income from the state lottery and from privatization of state-owned companies. That income, he says, could go to setting up something that Croatia doesn't have at the moment: a competitive granting agency. The government now spends only 0.4% of its gross domestic product on science, and "almost nothing comes from the private sector now," says Kraljević.

Although researchers at Croatia's institutes and universities are hurting because of the budget crunch, many are optimistic that—with more government support and eligibility for E.U. research programs—they will be able to improve the quality of science. "Croatian scientists have had to cope with aging buildings, old equipment, and a lack of innovative technology," says Krešimir Pavelić, who directs the Ruđer Bošković Institute's molecular medicine division. "But there is great potential here because of the young talent." Pavelić has tapped that potential by aggressively expanding his research division in recent years, and he has even attracted some scientists from abroad.

Nikola Zovko, a physicist who directs the Bošković Institute—Croatia's largest—also sees great potential for growth in Croatian science, but he says scientists have to find more international sources of funding. One possibility is to cash in on one of Croatia's assets: its natural beauty, a long Adriatic coast dotted by historic cities such as Dubrovnik and Split. Croatia now holds about 20 international scientific conferences a year. Such events, says Zovko, "show that good science is taking place in Croatia."

There are concerns, however, about whether Croatia can hold onto another of its national assets: its youth. At a recent biophysics summer school sponsored by the Bošković Institute, many Croatian undergrads told *Science* that they hoped to go westward for graduate study. "You want to get your Ph.D. where there is high-quality science," says Anita Krisko, a University of Zagreb undergrad. And, with the scarcity of jobs, it is tough to lure well-trained young students back to Croatia. "About half of the young scientists in my college class left Croatia, and I would say only about 10% have returned," says Nenad Ban, who graduated from the University of Zagreb in 1990. He later did a postdoc at Yale and recently landed a post at Switzerland's prestigious ETH Polytechnic. "The problem is that a scientist has to have something to return to."

Meager budgets. But Science minister Hrvoje Kraljević says Croatian government is committed to increasing research funds.

The problems of Croatian researchers pale in comparison to those in neighboring Bosnia-Herzegovina, governed by a fragile coalition of Muslim, Croat, and Serb ethnic groups. Top scientists fled Bosnia during the war, and few have returned. Some left because of bloodshed, others because their workplaces were destroyed. Energoinvest, once the former Yugoslavia's largest exporter, in its heyday had 11 R&D centers throughout the country. Ten were mostly obliterated during the war, driving three-quarters of the company's Ph.D. researchers abroad, says Bozidar Matic, president of the Bosnia-Herzegovina Academy of Sciences, which itself is estranged from a separatist Bosnian Serb academy. The astronomy observatory outside Sarajevo was also damaged beyond repair by the constant shelling of the war years, and other institutes—such as the Center for Balkan Research, a Sarajevo-based archaeological institute—are wasting away. The center wasn't bombed during the war. Rather, its best scientists simply died or left. Says Matic: "There was a process of 'negative selection' in science: The best researchers left."

—ROBERT KOENIG

CREDIT: R. KOENIG

cosmetic—changes of its former structures and goals, we expect the links with the scientific community of Serbia and Montenegro to be more intensive than they were before 1990," says Croatia's deputy science minister, Davor Butkovic. Georgi Efremov, president of the Macedonian Academy of Sciences, notes that although there is a "paper contract" for scientific collaboration between his academy and the Serbian Academy of Arts and Sciences, there are currently no research projects or exchange of people or lecturers. But, he says, "with democracy in Serbia, collaboration will be reestablished—this is the general feeling for scientists in Macedonia, and I'm sure for Serbian scientists as well." Croatian biomedical researcher Krešimir Pavelić, of the Ruđer Bošković Institute, thinks that scientists "should be the ones who take the first step towards the normalization of relations between Croatia and Yugoslavia."

There are promising signs that the next generation is ready to mend fences. Marko Popovic, a biology undergraduate at the University of Belgrade, was surprised at how warmly he was received when he attended a 2-week biophysics summer school in Rovinj, Croatia, last month. "When I arrived in Zagreb, I was scared, because a Serb tends to get defensive there," says Popovic. "But once you start discussing science, political problems go away." At least that's the hope for scientists trying to rebuild their war-torn countries. **–RICHARD STONE**

With reporting by Robert Koenig in Croatia and Slovenia and Gillian Sandford in Belgrade.

ENDOCRINE DISRUPTERS

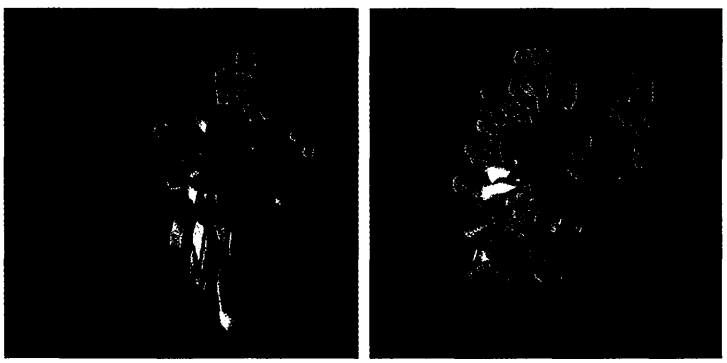
Panel Cautiously Confirms Low-Dose Effects

Expert panel says estrogenic chemicals can cause biological effects at levels below those normally found safe, but the implications for human health are unclear

Of all the evidence suggesting that hormone-like chemicals in the environment might be bending the gender of wildlife and people, a lab study 3 years ago sparked the greatest alarm. It suggested that minuscule amounts of a chemical that everyone is exposed to—in baby bottles and Tupperware, for example—could alter the reproductive organs of a developing mouse. Virtually no one had reported effects from so-called endocrine disrupters at such low levels before. The results suggested that the Environmental Protection Agency's (EPA's) plans to begin screening chemicals for estrogenic activity might have to be revised to detect effects at lower levels. The agency's conundrum only deepened when other labs—funded mainly by industry—couldn't replicate the findings.

Faced with the dueling studies and aware of other new research that might resolve the question, EPA enlisted the help of an expert panel.* Earlier this month it met to conduct an extensive review of the data. Chaired by toxicologist George Lucier, who recently retired from the National Institute of Environmental Health Sciences (NIEHS), the 36-member panel concluded that doses of some endocrine disrupters far below those normally found to be safe can indeed cause biological effects in lab animals—a finding that runs counter to the conventional wisdom in toxicology. Panel members cautioned, however, that scientists still don't know what relevance the subtle developmental changes observed in animals might have for human health.

The work that triggered this inquiry was conducted by reproductive biologist Fred vom Saal's group at the University of Missouri, Columbia. Published in 1997, the team's two studies found that at levels below the normal testing threshold, the potent chemical diethylstilbestrol (DES) had peculiar effects on the male offspring of pregnant mice. At some very low doses, it enlarged a fetal mouse's prostate, but levels above this had the opposite effect. If low doses of other chemicals produced effects with this same humped curve, then tests conducted at higher doses might be missing biological effects, vom Saal suggested. But it was the second study that proved most explosive: It found that the plastics ingredient bisphenol A enlarged the prostate in mouse fetuses at the extremely low levels—parts per billion—to which people are typically exposed.



Controversial result. Minuscule amounts of the common chemical bisphenol A fed to pregnant mice reportedly enlarged the prostate *(right)* in male fetuses.

CREDIT: B. TIMMS/UNIV. OF SOUTH DAKOTA AND F. VOM SAAL/UNIV. OF MISSOURI

Alarmed about what the results might mean for the multibillion-dollar plastics industry, companies launched a wave of new research on bisphenol A. But attempts by John Ashby at the Zeneca Central Toxicology Laboratory in Cheshire, United Kingdom, among others, to replicate vom Saal's study with the same mouse strain, CF1, failed to find any bisphenol A or DES effects.

The task of sorting out these data fell to the expert panel, formed by NIEHS's National Toxicology Program at EPA's request. Its examination went "far, far beyond the usual peer review," notes Lucier. Authors of 38 studies submitted their raw data, including unpublished results, to the panel, which also heard presentations from key scientists.

The bisphenol A studies proved to be the biggest puzzle. The negative data included two major new studies by Japanese and industry-supported U.S. groups that found no effects of bisphenol A on developing rats or their offspring. But curiously, when the panel picked apart the protocols and data, a summary statement says it found that both vom Saal's studies and the negative ones were "credible and sound."

The discrepancies may be attributable to lab animals' exquisite sensitivity to estrogenic chemicals. As scientists noted, many factors—such as whether animals are fed or injected with chemicals, as well as their diet—can influence hormone levels. Another issue, reported in *Science* last year (20 August 1999, pp. 1190 and 1259), is that rodent strains can vary dramatically in their response to estrogenic compounds. Some scientists speculate that Ashby's CF1 mice might be genetically less sensitive to estrogens than the vom Saal mouse colony, which was maintained as an inbred group for many years.

Not all panelists were satisfied that the discrepancies have been explained, however. Vom Saal's results have "not been reproducibly established," insists biochemist George Stancel of the University of Texas, Houston, Health Sciences Center. Although a

* Endocrine Disruptors Low Dose Peer Review, Research Triangle Park, North Carolina, 10–12 October.