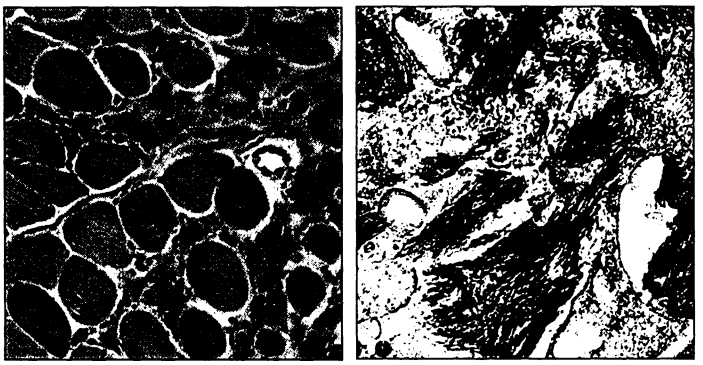


Telltale sign? A French study says aluminum-filled macrophage cells (blue, left, and close-up, right) could be linked to a rare muscle ailment.

might help settle the MMF debate by examining tissue samples taken from cadavers. Other high-priority projects, he says, may include setting guidelines for the amount of aluminum that should be allowed in injectable vaccines (the current standard applies to oral vaccines), collecting more data on how young children process aluminum, and examining whether changing the way some aluminum-adjuvated vaccines are injected might further reduce the risk of adverse reactions. Also possible are clinical studies to evaluate the differences between the three kinds of aluminum adjuvants and the role that adjuvants alone play in causing swelling and muscle pain.

Ironically, some of the new studies may get a boost from a controversy surrounding the U.S. military's anthrax vaccine, which includes aluminum. Last year, after some soldiers and pilots refused to take the vaccine as ordered by the Defense Department, Congress called for a large-scale clinical trial to answer safety questions. That trial, due to begin later this year, may now be designed to answer questions about aluminum adjuvants, too. Sparked by the French research, vaccine manufacturers are also jumping into the act. SmithKline Beecham researchers, for instance, are in the midst of large-scale animal studies of aluminum's biological impacts, as well as surveys designed to detect adverse reactions among patients.

Vaccine researchers hope the new data will help avoid what several call "Thimerosal II." Thimerosal, a mercury compound used to prevent vaccines from becoming contaminated by bacteria or fungi, is now scheduled for elimination from several common vaccines after federal officials and some public interest groups raised questions about its safety. During debate over the last few years, however, many vaccine researchers felt hamstrung by a lack of data on everything from mercury's interaction with other vaccine compounds to acceptable doses for infants. Indeed, when the aluminum issue arose, "I had a sense of déjà vu," says Alison Mawle, a researcher with the Centers for Disease Control and Prevention in Atlanta, Georgia. "There are huge gaps in what we know about the toxicity of aluminum."

For the moment, researchers and public health officials, including Gherardi, see no reason to remove aluminum from vaccines. But they may examine the feasibility of reducing the amount used in some vaccines—just in case. Scientists say that it's not clear, for instance, that the adjuvant is necessary to ensure the effectiveness of booster shots, which are administered after the immune system has already reacted to the initial dose. However, manufacturers say any effort to replace aluminum with another adjuvant would be costly and complicated. Regulatory and manufacturing requirements, for instance, would make it "a nightmare" to create different formulas for an initial vaccine and its booster, says Nathalie Garcon-Johnson of SmithKline Beecham Biologicals in Rixensart, Belgium.

Most researchers left the San Juan meeting feeling reassured about aluminum's safety. But some government officials remain worried that the subject could blow up into a legal and political battle. Web sites published by some anti-immunization groups, for instance, already finger aluminum as a cause for concern. In light of such sentiment, Caserta urged a panel drafting the workshop's summary statement on MMF to tread cautiously. "We have to be very careful with our ideas," he says. "The courts don't know how to deal with [uncertainty about] causality."

–DAVID MALAKOFF

EUROPEAN SCIENCE

A Blow to Austria's Scientific Revival

Since the Nazi occupation tore apart its scientific community, Austria has revived many fields. Now budget cuts threaten the momentum

VIENNA—Less than a century ago, this cultural bastion on the Danube was a vibrant scientific capital, nourishing great minds such as theoretical physicist Erwin Schrödinger and psychoanalyst Sigmund Freud. But a mass exodus in the late 1930s crippled Austria's intellectual dynamo, and the impoverishment deepened after much of the city was destroyed during World War II. Slowed by stingy postwar government support, the seeds of good science did not take root again until the late 1960s, giving rise to centers such as Vienna's Atom Institute and, later, Anton Zeilinger's quantum teleportation labs in Innsbruck and Vienna (see sidebar on p. 1327). And although Austria still lags many other European nations in broad science indicators, a government pledge last year to pour more money into research fueled hopes of a true scientific resurgence. "In the last few years, you got the feeling that science was improving rapidly here," says Helmut Ruis, who heads the University of Vienna's Institute of Biochemistry and Molecular Cell Biology. But Austria's budding scientific renaissance is suddenly in jeopardy.

Glorious past. Schrödinger was part of Austria's vibrant prewar scientific community.

Last week, the Austrian Parliament approved an austere science budget that slashes support for the Austrian Science Fund (FWF)—the country's basic research granting agency—by 26% and savages spending on laboratory upgrades by nearly two-thirds. "These budget cuts—coming at a time when Austrian science has been on the upswing—threaten to endanger basic research here," says solid state physicist Peter Skalicky, rector of the Technical University of Vienna. And the embattled Austrian government's recent contretemps with many of its European Union partners could doom a major project on the drawing board, the AUSTRON neutron

CREDITS: (TOP TO BOTTOM) R. K. GHERARDI; CORBIS/HULTON-DEUTSCH COLLECTION

From Wasteland to Biomedical Wonderland

VIENNA—When Max Birnstiel first set eyes on the decrepit site of his future institute in 1985, he was crestfallen. "It was nightmarish," he says: "An abandoned radio factory in the middle of an outmoded industrial district. I couldn't imagine turning it into a modern research campus." *He quit a top post in Zurich for this?* Fifteen years later, Birnstiel's "glass palace," the Institute of Molecular Pathology (IMP)—now surrounded by a vibrant complex of research establishments—has put Vienna on the biomedical research map.

IMP, now headed by Cambridge transplant Kim Nasmyth, exemplifies the promise of Austria's scientific rehabilitation. With groundbreaking work in such areas as chromatid separation in yeast and cell adhesion in cancer, IMP's 13 research groups—which boast 120 scientific staff members from 25 nations—have "made a great contribution to Austrian science," says Walter Schaffner, director of Zurich University's Institute for Molecular Biology.

IMP, bankrolled by German drugmaker Boehringer Ingelheim, also stands out as one of Austrian industry's few significant investments in basic research. Although Austria's public research spending per capita (0.65% in 1998) is only slightly less than average among European Union member states, private-sector contributions (0.83%) trail far behind those in other countries, including Germany (1.57%), France (1.37%), and the United Kingdom (1.22%).

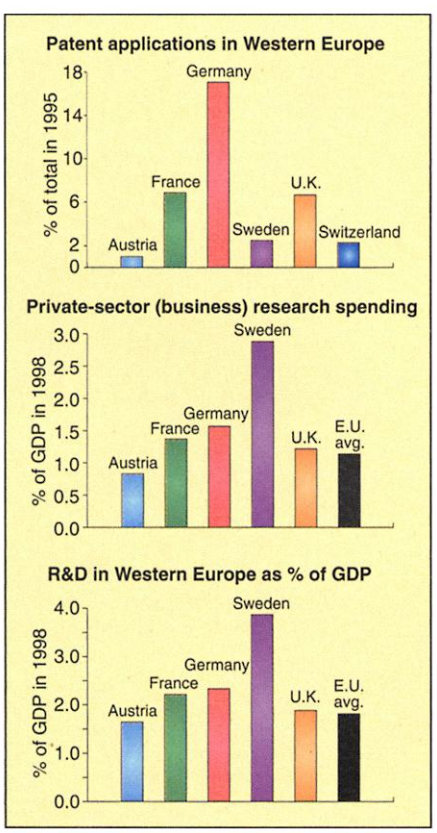
IMP's true impact reaches beyond its research domain, thanks to founding father Birnstiel's early demands that the Austrian and Viennese governments build a biomedical campus around the institute. Four years after IMP opened its doors in 1988, the University of Vienna moved five life science and medical research institutes into a new Biocenter building next door. Several biotech start-ups, including InterCell, which is developing synthetic vaccines, and VBC Genomics, which does custom sequencing, have also sprouted up. And last fall, the Austrian Academy of Sciences announced an unprecedented move to cast its lot with industry on a project; it will join forces with IMP and the city of Vienna to create a new Institute of Molecular and Cellular Bioinformatics. When it opens in 2 years, the institute is expected to employ about 80 scientists, whose main task will be to glean insights into human diseases from the draft of the human genome.

More expansion is in the works. Erwin Heberle-Bors of the University of Vienna's Genetics and Microbiology Institute says the university plans to open an Institute of Structural Molecular Biology this fall at a new Biocenter building. Although he's worried about the new government's budget cuts, Heberle-Bors thinks the research ministry will stick to its promise to expand the Biocenter. "They recognize that the Biocenter is a bright spot in Austria's research landscape," he says. **–R.K.**

source that physicists want to build this decade. Bemoans FWF head Arnold Schmidt: "We just can't afford to lose the research momentum of the last few years."

That momentum has taken a half-century to build since the dark years that began when Adolf Hitler annexed his native country in 1938. Many of Austria's top scientists fled: Freud went to London, Schrödinger to Ireland, Victor Hess, discoverer of cosmic rays, escaped to the United States, and molecular biologist Max Perutz ended up in Cambridge, where he won a Nobel Prize. Of those luminaries, only Schrödinger came home; he died a few years later. "That emigration was an incredible loss to Austrian science," says Zeilinger.

But decades of Austrian government neglect was also to blame for the slow pace of the rejuvenation, which didn't start in earnest until 1968, when the newborn FWF began training and funding a new generation of scientists. "When I was a Ph.D. student in the late 1970s, we had only two sets of Gilson pipettes for the whole department and two or three gel apparatuses that we had to build ourselves," says Renée Schroeder, a University of Vienna biochemist who worked as a postdoc in the United States, France, and Germany during the 1980s. After returning to Vienna in 1989, she says, she saw "a huge difference in the quality of science." Adds Zeilinger: "It's only in the last 10 years or so that physics here has begun to recover."



SOURCE: EUROPEAN COMMISSION, RESEARCH DIRECTORATE

Playing catch-up. Austria trails in major science indicators.

Not all problems have been overcome. Many scientists complain that the universities stifle creativity and that the Austrian Academy of Sciences is too timid in moving into new research areas. Moreover, says Erwin F. Wagner, senior scientist at the Institute of Molecular Pathology in Vienna, the turnover in midlevel research posts is too slow: "There just aren't enough positions for talented young scientists."

When Austria's coalition government came to power in February, many researchers thought the opprobrium resulting from the right-wing Freedom Party's membership in the center-right alliance posed the greatest threat to their work. Members of the European Union began freezing Austrian officials out of policy discussions, and Austrian researchers feared that colleagues in Europe and elsewhere might be forced to back out of collaborative projects. But it turned out that the real threat came from within.

European sanctions have had little impact on research, whereas the new Austrian government has so far reneged on its pledge to honor its predecessor's commitment to sharply increase research spending from the current 1.65% of gross domestic product to 2.5% over 5 years. "Our good intentions and commitments remain, but the money simply isn't there right now," explains Daniel Kapp, chief spokesperson for Education and Science Minister Elisabeth Gehrer. The minister defends the cuts, pointing out that the government has avoided decreasing university salaries or operating budgets, instead wielding the knife in discretionary accounts such as lab upgrades. Gehrer says she will try to pump up the research budget next year.

But Austrian labs may need upgrades sooner rather than later. According to Skalicky, Technical University's main competitors in German-speaking Europe—Zurich's ETH Polytechnic and Munich's Technical University—have budgets that are seven times the size of his. Now, he says,

Teleportation Guru Stakes Out New Ground

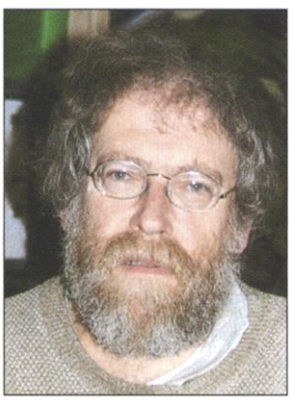
VIENNA—It's a long way from the University of Vienna's Experimental Physics Institute to the Hollywood studios that dreamed up *Star Trek*'s "Beam me up, Scottie" brand of teleportation. But behind this venerable institute's 19th century façade is a burnished-steel, laser-packed realm in which a form of teleportation has indeed become reality. Nobody here is planning to transport *Star Trek* red shirts onto hostile planets: Macroscopic teleportation remains firmly in the realm of science fiction. Rather, the teleporter of Vienna is Anton Zeilinger, a pioneer in exploiting the peculiarities of quantum mechanics—the best explanation physicists have for the weird actions of individual atoms—to teleport the quantum state of photons over short distances.

Zeilinger has earned an international reputation for devising experiments to test quantum theory. "He's one of the most original researchers in the foundations of quantum mechanics in the world today," says quantum physicist Seth Lloyd of the Massachusetts Institute of Technology (MIT). "His tenacity has been rewarded by great results." Before entering the teleportation rabbit hole, Zeilinger cut his teeth in the quantum world as a postdoc at the Technical University of Vienna, where he worked on neutron interferometers, then did a stint at MIT. He returned to Technical University in the 1980s, but it was not until he moved to the University of Innsbruck as a full professor that in the early 1990s he began devising experiments in quantum optics, a field in which researchers exploit the quantum nature of photons.

What helped guide him in this new direction, Zeilinger says, was a pioneering 1993 report in which IBM physicist Charles H. Bennett and his colleagues first proposed that "entanglement," a beloved concept of Austrian-born Erwin Schrödinger, could be exploited to teleport information. A pair of entangled particles—be they photons, ions, or atoms—always possess correlated quantum states: If one photon is horizontally polarized, for example, the other must be vertical. But according to quantum mechanics, the state of either particle is only revealed when it collapses—that is, when it is measured. So Bennett and his colleagues argued that if one photon collapses to a vertically polarized state when it is measured, its entangled partner will immediately "know" that it is horizontally polarized, no matter how far away it is. The "message" transmitted from one particle to the other must therefore travel faster than the speed of light—something that Albert Einstein once called "spooky action at a distance." The revolutionary concept that Bennett's group proposed was that "one can actually transfer a quantum state of a specific particle applying entanglement," Zeilinger says.

"When that paper came out, I thought the experiment to test it was completely impossible," Zeilinger recalls. But in his quest to extend entanglement to three photons, Zeilinger devised a series of elegant quantum optics experiments in which his group was able to produce and manipulate entanglement at will, laying the groundwork for the teleportation experiments. Finally, last February, Zeilinger and colleagues in Oxford and Munich reported that they had succeeded in observing three-photon entanglement. "The interesting feature here is that even the perfect correlations between the three photons are in striking conflict with any classical picture one could make," he says.

Although he remains fascinated with quantum optics, Zeilinger says he does not want to spend the rest of his career working on it. "Quantum optics is just a means for me to study the foundations of quantum mechanics," he says. "What really fascinates me is the possibility of bridging the gap to biological systems"—for example, by using the techniques of quantum optics to learn more about simple microscopic organisms such as viruses. "It's difficult to see how quantum physics could play an active role in biological systems," he says, "given the fact that a quantum state usually requires the system to be well isolated from the environment, and living systems usually die when you isolate them—they need breathing, they live at a finite temperature. Yet I am not convinced that living systems are just classical machines."



Quantum guru. Zeilinger has put Austrian physics on the map.

It was not an easy decision for Zeilinger to leave Innsbruck, in the heart of the Alps, for Vienna in 1999. Now it takes longer for him to get to the Tyrolean slopes for skiing, his passion along with jazz and classical music. He also collects antique maps, including a favorite one of central Europe around 1830 depicting only four nations, including the former Austrian empire. Zeilinger's colleagues point out that he's redrawing the map in his own field. "While Austria produced many world-class physicists over the last century or so, very few of them did their great research in Austria," says Austrian-born Kurt Gottfried, a professor emeritus at Cornell University and an expert on quantum physics. "But Zeilinger has a clear commitment to putting Austrian physics on the map. **–R.K.**

"we won't be able to replace badly need equipment like electron microscopes or infrared spectrometers."

In an open letter posted on its Web site last month, Austria's conference of rectors—the heads of the nation's universities—pleads with the new government to live up to its previous commitments and restore the science budget or, at least, commit to "a drastic increase" in university and research spending in 2001.

The FWF's budget hit has forced it to consider, for the first time, scrapping its fall grant competition. Hoping to avert this, Schmidt has appealed to the Transport and Innovation minister, Michael Schmid, whose ministry oversees FWF, to find more money for the research fund. Another potential savior is the Austrian National Bank, which each year contributes a portion of its currency exchange profits to academic R&D. It may up its contribution to the FWF this year.

One major project that could be in trouble is the AUSTRON pulse-spallation source, a $400 million facility for neutron scattering studies that backers hope to build in eastern Austria by 2007. Austria has offered to put up one-third of the construction funds if other European governments kick in the rest. But Skalicky says that commitments have fallen short so far, and AUSTRON "could only proceed if Austria is prepared to pay a larger share." The innovation ministry says it is working on a plan to save the project.

Some of Austria's research labs should be able to weather the storm. The cuts—slated to go into effect on 1 July—have not eroded the $42 million annual budget of Austria's Academy of Sciences, which operates 20 institutes. The academy's secretary-general, engineering professor Herbert Mang, told *Science* that the academy still plans to expand with new institutes and partnerships, including its share in the Institute of Molecular and Cellular Bioinformatics at Vienna's Biocenter (see sidebar on p. 1325).

Despite the setbacks, many scientists are optimistic that key research areas, such as Zeilinger's work on quantum teleportation, will continue to prosper. However, other seedlings that have taken root in Austria's once-blighted research landscape could be more vulnerable in a prolonged funding drought. Says Schmidt, "There is still tremendous potential for growth in Austrian science," but that growth needs nurturing.

–ROBERT KOENIG

CREDIT: R. KOENIG