Support from senior Louisville administrators—including Martin and graduate dean Ronald Atlas, a nationally known bioterrorism expert who helped shape the new law as president of the American Society for Microbiology—has helped the process go "pretty smoothly" on her campus, Watts says. Louisville biochemist Russell Prough says it took him "just a few minutes" to confirm that he didn't deal with any of the agents in his four-person lab. But some scientists chose to avoid greater paperwork by disposing of potentially problematic research materials. "They decided they didn't want to have to fill out the forms," she says.

Overall, Watts estimates that fewer than two dozen Louisville researchers currently work with the regulated agents. Still, the university might develop new policies and rules that govern their conduct in the lab and go beyond current federal rules. There is already talk of a policy that would require a witness to certify that a researcher has properly destroyed regulated materials, for instance. More thorough and frequent laboratory inventories could also become routine, and some labs might have to be remodeled to meet security requirements. "We're not done; this will be a moving target," Watts predicts.

Other universities report similar discussions. Although a half-dozen institutions contacted by *Science* say that the notification process is going relatively smoothly, others report some bumps in the road. At Stanford University in Palo Alto, California, for instance, biophysicist Steven Block thinks that ESH officials have gone way too far in asking researchers to inventory "any and all biological agents and biological toxins that are used or stored" on campus. The request exceeds legal requirements, doesn't inform researchers about potential legal ramifications, and is maddeningly vague, he complains. "Does this mean [I have to report] even house plants or home-brewed beer? How about grad students?" he asks, only partly in jest.

Lawrence Gibbs, Stanford's associate provost for ESH, says the inventory is a "prudent measure" to create a baseline for future biosafety planning. "We don't want to have to poll the faculty every 2 months because of inconsistencies," he explains. Other faculty members applaud his strategy. "The [broader] survey was absolutely the right thing to do," says John Boothroyd, chair of Stanford's microbiology department. "The fewer requests, the better."

Universities are also pondering how to collect and store the information securely. Some have established supposedly hacker-proof Web sites and e-mail accounts. But other schools, including Louisville, are insisting that researchers deliver their signed notification forms in person. "We are not allowing anything to go through mail or e-mail," notes ESH director Karen VanDusen of the University of Washington, Seattle.

Virtually every university official *Science* contacted also voiced concern about unrealistic deadlines. "It is putting the squeeze on everyone," says L. Todd Leasia, director of the office of research safety at Northwestern University in Evanston, Illinois. And Gibbs worries about the uncertainties over how to handle certain classes of agents such as genetically engineered proteins. "The CDC needs to clarify its guidelines," he says.

That's expected to happen in the next few months as government agencies issue policies on a variety of research-related security issues. In the meantime, Watts and her colleagues are preparing to ride out the continuing aftershocks from last year's attacks. "It's certainly given us a lot to think about and a lot to do," she says.

It's also changed the nature of her professional interactions. "I get invited to some pretty high-level meetings now," she says. "Health and safety issues have always been important to universities, but now they are really in the limelight."

**–DAVID MALAKOFF**

With reporting by Erica Goldman.

UNDERGRADUATE EDUCATION

# New Lure for Young Talent: Extreme Research

**Science funding agencies are letting students experience weightlessness in hopes of keeping them grounded in science**

**HOUSTON, TEXAS**—Eleven thousand meters over the Gulf of Mexico, Graylan Vincent and Karen Kennell are floating—or diving to Earth in a 3-kilometer free fall, depending on how you look at it. The University of Washington (UW), Seattle, undergraduates are inside a KC-135 microgravity research airplane, running a self-designed experiment in a lab that flies in a sinusoidal wave pattern to mimic the weightlessness of space. The plane belongs to NASA, which doles out a fraction of its flying time to undergraduates looking to experience science on the edge.

Trying to hold himself steady, Vincent, a senior in aeronautical engineering and geology, hits a button on a laptop that's wired to a motor-controlled milling machine inside a Plexiglas cage. A half-inch (1.27-centimeter) drill bit whirs to life and slices through a slab of aluminum. For a few seconds, thousands of silvery shards hover aloft. They move as if in slow motion until Vincent flips another switch that turns on a converted Toro leaf blower, which blows the flecks into a mesh screen and out of the way.

At 8000 meters, NASA pilot Stephanie Wells gently pulls back on the yoke. The

CREDIT: JSC/NASA

**On the fly.** UW undergraduates Graylan Vincent (left) and Karen Kennell (front right) spend 25 seconds in free fall while running an engineering experiment aboard NASA's "Vomit Comet."

lights dim, and Vincent and Kennell settle onto the floor of the white, padded interior of the Boeing 707. A couple of seconds later their bodies weigh twice normal as the plane pulls up to reverse its fall and climb to the top of its arc. A bell chimes softly, the lights come back on, and Vincent and Kennell get another chance to experience the sensation of weightlessness that only astronauts normally encounter. After a couple dozen of these parabolas, Vincent looks up with a big grin on his face. "This is awesome," he says, bobbing over his equipment. "I can't wait to be on the space station."

It's just the reaction NASA officials were hoping for. NASA, the U.S. National Science Foundation (NSF), and other science funding agencies are expanding adventurous undergraduate research opportunities in the United States and other countries in an effort to encourage students to choose careers in science and engineering. According to NSF's *Science and Engineering Indicators*, the number of U.S.-born students pursuing Ph.D.s in the natural sciences and engineering declined more than 20% in the 1990s, despite the nation's increasingly technology-based economy. Offering undergraduates an inside look at cutting-edge research has long been considered a promising way to stem that tide. And today, research experiences like this trip on the "Vomit Comet" are taking more and more students out of darkened basement labs and into extreme environments.

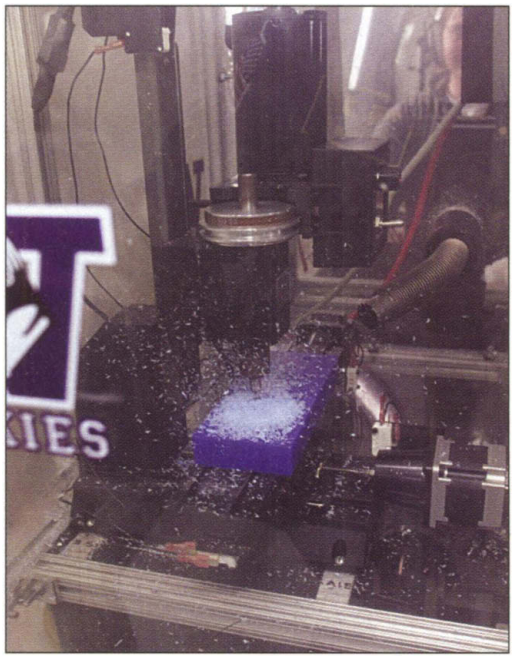
Astronomy students, for example, have an opportunity through NSF to pursue galactic questions at the Cerro Tololo Inter-American Observatory in La Serena, Chile. The agency also sends students aboard oceangoing research vessels and on projects everywhere from Iceland to the South Pole. The Department of Energy offers several research stints, including one at its magnetic fusion facility at Lawrence Livermore National Laboratory in California. And the European Space Agency gives undergraduates access to a weightlessness-research aircraft like NASA's.

According to Karolyn Eisenstein, who directs NSF's Research Experiences for Undergraduates program, there's more to these exotic research projects than adventure: "It's the opportunity to put students in the venue where the science is being done. That gives them an introduction to what the field is really like."

### Career boost

Do such programs work? It's hard to know for sure, says NSF's acting director of undergraduate research Norman Fortenberry, because so many factors influence career choices. Nevertheless, he says, many people are convinced that "these experiences elicit interest in science and technology and reinforce students' decisions to pursue careers in these fields."

Donn Sickorez, who heads NASA's student research program, doesn't track the career paths of student fliers. But he does know that none of the 1230 students who have gone through the program since its inception in 1995 has gone on to apply for astronaut training. That's not surprising, because the program is young and so are the alumni. Still, Sickorez says that he has anecdotal evidence that student fliers have stuck with careers in science. "That's our goal," he says.



**A cut above.** In a high-altitude test of drilling in zero gravity, flecks of blue wax hover around a robot-controlled milling machine until a blower whisks them away.

Joel Lohrmeyer, a member of the UW team who just completed his bachelor's degree, is convinced that his research adventure will lend cachet to his résumé: "It was great for me as someone who is going into the job market." He imagines someone noticing and saying, " 'Wow, he took the initiative to be involved in this competition and has experience with NASA.' " Lohrmeyer sees "a definite benefit."

### Not just a joy ride

Setting your heart on joining exotic research projects is problematic, though: They can be hard to come by. Vincent, Kennell, Lohrmeyer, and their fourth teammate, Holly Devlin, spent over a year preparing their experiment. They had to come up with an idea, submit a proposal, pass a competitive peer review at NASA, raise money, design the equipment, put it together, make sure it passed NASA's rigorous safety precautions, and, of course, collect data on the flight—all work for which they received no course credit. "I was determined to get on that aircraft," says Vincent, who first heard about the program in high school. His flight, he says, "was the culmination of 6 years of thinking about it, 2 years of planning, and 14 months of actually working on it. It has been a lot of work. But it was every bit as exciting as I had hoped."

The UW team's experiment, Lohrmeyer explains, was designed to test the feasibility of making precision machine parts in microgravity. A machine shop could come in handy aboard the international space station, where astronauts could use it to make replacement parts long before a spare could be sent from Earth. But weightlessness could raise havoc with the machining process. Whereas shards are pushed to the side of the cutting blade in a normal environment, in weightlessness they might float in the way, reducing performance. The UW team wanted to see if this happened aboard the KC-135. And although the cuts look fine, the UW team is now using a variety of precision metrology techniques to see whether there was any difference between those made at zero gravity (0*g*), 1*g*, and 2*g*.

Not all experiments aboard the KC-135 work out so well. Desiree D'Orazio, a mechanical engineering student at Rowan University in Glassboro, New Jersey, for example, was a member of a team whose experiment didn't go as planned. It was designed to determine whether weightlessness slows the diffusion of heat, a condition that could affect countless pieces of equipment in space. The apparatus consisted of a water-filled tank with a wire inside and a speaker nearby. When heated, the wire generates air bubbles on its surface, which were supposed to be dislodged by the speaker's sound waves. But during the students' flight an electrical connection to the speaker failed, limiting the amount of useful data they could collect. "It was somewhat disappointing," D'Orazio says. "But I learned that complex research experiments rarely work the first time."

All is not lost. D'Orazio says she and her team will likely propose a modified experiment in the fall. "I definitely want to try this experiment again next year," she says—not just for the data, but for another shot at being weightless. "It was better than anything I could have imagined." Vincent, too, says his team might consider submitting a revised proposal on its experiment. Then again, he says, he might look for another adventure altogether: "I might have to see if I can get on one of those oceanography research programs."

–ROBERT F. SERVICE

CREDIT: JSC/NASA