are low enough and people should not worry so much." He also took part in the soil contamination study organized by Tanihata. Those activities, Tamura says, "have nothing to do with our research. We are just waiting for our beam time."

Nuclear-power future?

Power restrictions have been in place since the nuclear accident. Nagamiya says that ongoing restrictions on electricity use are his "biggest headache." J-PARC and other power-consuming experiments will have a rough time if electricity restrictions continue. At the University of Tokyo, says Aihara, "we cut consumption by 30%" over the summer. That meant darker hallways, less air conditioning, not using elevators, and doing high-use activities at off-peak hours. "It took a couple of months to get used to it," he says.

Not surprisingly, public opinion in Japan has turned against nuclear power. The island nation gets about 30% of its electricity from nuclear reactors; oil provides 25%; natural gas 25%; and the rest is hydroelectric plus a small amount from renewable energy sources.

Over the past months, all of the country's nuclear power plants have been turned off for safety checks. A debate is raging over whether to phase out nuclear power; in the wake of the accident in Japan, Thailand froze its plans to build its own nuclear power plants, and Germany and Switzerland announced they would phase out nuclear power over the next decade or so. The Science Council of Japan recently presented the government with six different scenarios, from continuing to generate nuclear power to abandoning it altogether. The council analyzed the costs and benefits of each scenario. "Very active discussions are in progress," says Nagamiya, a member of the council, "but no consensus has yet been reached."

Unlike his predecessor, Japan's new prime minister, Yoshihiko Noda, who took office on 2 September, has come out in support of nuclear power for the future. "Nobody knows yet what will happen. It's a political decision," says Aihara. "But if the government does not allow reactors to come back, the overall power shortages will affect research."

Toni Feder

Universities seek culture change for improved STEM teaching

The Association of American Universities is pushing to institute new methodologies, but success will require big changes by academic departments.

Much has been said and written over recent decades about urgently needed improvements in the teaching of science, technology, engineering, and mathematics (STEM) at all levels of the US educational system. All manner of indicators of US students' pitiful performance in STEM relative to other nations have been aired. What's been lacking is a systematic adoption of new teaching methodologies that are proven to increase learning of STEM. But now an association of the nation's top research universities has decided the time has come to adopt better STEM teaching throughout their institutions.

In September the Association of American Universities, a group of 59 US and 2 Canadian public and private research universities, announced a five-year plan to propagate successful new STEM teaching modes. "AAU is not conducting another study or research project on STEM education," said association president Hunter Rawlings III, former president of Cornell University. "We are moving to implement the results of the latest research into science and math pedagogy." While specific methodologies vary, in general, more effective STEM teaching requires the active participation of students in the classroom.

A three-phase program

The initiative aims to improve the retention of students majoring in STEM fields and to raise the level of science literacy in other students. In its draft white paper on the five-year initiative, the AAU cited research showing that of the 25% of entering college freshmen who plan to major in STEM fields, more than 40% switch to non-STEM majors by graduation. The dropout rate is 50% for the physical sciences and 60% for mathematics, the white paper said, compared with 30% for the humanities and social sciences.

The AAU, whose members awarded more than half of the nation's doctorates in 2008, including 61% of those in the physical sciences and mathematics, describes itself as being "in a position to help convene and focus the attention of campus administrators, as well as to facilitate conversations among administrators, policymakers, and funders." The association is developing an analytical framework for measuring improvements in the quality of undergraduate STEM teaching and learning. That phase is expected to last two years and will be followed by a two-year demonstration at an undetermined number of member universities, says Tobin Smith, an AAU vice president. In the final year, the practices from the demonstration phase will be more broadly disseminated.

The AAU leadership hopes that the federal government will do its part to encourage the new practices. For example, NSF might count the adoption of improved pedagogy toward the "broader impacts" criterion that the agency includes in its evaluation of all investigator-initiated grant applications. The government might also create endowed chairs for STEM professors who want to improve undergraduate science education. Although the federal government doesn't endow academic chairs, Smith notes, other governments do, including Canada's.

Most faculty members believe themselves to be effective teachers, but they value academic research far more highly than teaching, according to the AAU white paper (http://www.aau.edu/policy/article.aspx?id=12588). The white paper cites a survey by *Nature* last year in which responding faculty members said they would favor a star researcher with no teaching experience (48%) over a superb teacher with no significant research projects (16%) or a decent teacher having legitimate but nonsignificant research (36%) in tenure considerations.

"We believe that teaching of undergraduates is the area where we can have the greatest impact," Rawlings said. The AAU's program will complement efforts by other groups, such as the Association of Public and Land-grant Universities, for improving STEM education at the K–12 level.

Administration approval

The White House Office of Science and Technology Policy applauded the AAU's move. Carl Wieman, OSTP associate director for science, says the "specific and substantial changes" called for are "really quite unprecedented for a university organization" and are "long overdue."

But Wieman, the AAU, and other proponents of better undergraduate STEM teaching agree that wide-scale adoption of new methodologies hinges on buy-in by academic departments, which they say currently put little value on quality of teaching in decisions about hiring, tenure, and promotion. "The challenge is to persuade faculty members, who want to be good teachers, to implement these practices in their own classes," the AAU white paper declares. "This . . . will require cultural change at universities." The AAU said its initiative will include exploring methods by which faculty and departments can be rewarded for improving teaching.

Individual efforts

Wieman says that physics has led innovation in STEM teaching. "All the other disciplines look to physics and are building on what physics has done in discipline-based education research, and also in improved techniques [of instruction]," he says. Wieman formerly was on the physics faculty at the University of British Columbia and the University of Colorado; at both institutions he directed efforts to upgrade STEM teaching (see the article by him and Katherine Perkins in Physics Today, November 2005, page 36). Although notable efforts have taken place at the University of Maryland, Harvard University, Colorado, the Ohio State University, and Arizona State University, in all cases individuals rather than the institutions have been responsible for the use of new methods, he says. Maryland physics professor S. James Gates Jr says Arizona State's unconventional structure, consisting of "units that are not quite departments," may be a factor in its readiness for innovation.

Wieman notes that no one deliberately strives to weed out STEM students, but he says there are some "peculiar incentives" for departments to discourage students early on from pursuing their studies. Departmental budgets are determined mainly by the number of faculty, he says, which can only change slowly. "If you have a department that starts teaching better, they start attracting more students, and those students are staying for a second and third year. Suddenly there are a lot more demands on the department; the classes get bigger, you've got labs that you can't fit the students in. There are real costs associated with that, and that does put in a real disincentive to be

An observatory that comes home every morning

The Stratospheric Observatory for Infrared Astronomy (SOFIA), the world's largest mobile observatory, made a rare stop on the US East Coast in September. This photo, taken at Joint Base Andrews in Maryland, shows the outside of the German-made 2.5-meter telescope, which is housed in a Boeing 747 flown by NASA. The telescope is equipped with an IR spectrometer known as the German Receiver for Astronomy at Terahertz (GREAT), built by a research collaboration that included the University of Cologne and the Max Planck Institute for Radio Astronomy.

Cruising at an altitude of 40 000 feet (12 200 meters), SOFIA flies above 99% of atmospheric water vapor, which gives it access to IR wavelengths that are blocked from ground-based IR telescopes, says Paul Hertz, chief scientist at NASA's science directorate. Based at NASA's Dryden Flight Research Center in California, SOFIA typically flies for 10 hours, including the two hours required for the optics to cool to ambient temperature. Because it returns home each day, SOFIA can easily be maintained and upgraded. Indeed, by the end of this year, it will be refitted with a precooling system, vibration dampers, and improved navigation and data systems, Hertz says. Four instruments are awaiting their turn on the observatory, and NASA is currently soliciting proposals for more.

Teachers can apply to accompany scientists aboard SOFIA flights. Mary Blessing, a high school teacher in Herndon, Virginia, calls her flight "the highlight of my career." She says she was particularly impressed by the number of people involved in building and operating a large scientific instrument.

The mobility of SOFIA allows it to record celestial events not otherwise visible. In June, it flew out over the Pacific Ocean to observe Pluto passing in front of a star. The shadow that Pluto cast on Earth was only 65 miles across and moved at more than 60 000 miles per hour. With the help of some ground-based astronomers, SOFIA's pilots were able to position it to sample the moving shadow and obtain data on the composition of Pluto's atmosphere.

David Kramer

effective," Wieman says. "It's clearly something that needs to be fixed if we want to improve education."

Active engagement is key

Gates began adopting new methods of connecting with students more than a decade ago. A member of the President's Council of Advisors on Science and Technology, Gates cochairs a subcommittee currently drafting a report and recommendations on the federal role in improving postsecondary STEM teaching. He also cochaired a 2010 PCAST report on K–12 education (see PHYSICS TODAY, January 2011, page 26). "A very substantial research literature" he says, shows that "active engagement" of students is the formula for effective teaching. There are numerous ways of engaging, but "one thing it doesn't mean is the traditional lecture, where someone simply stands up and lectures at students."

Peter Bruns, when he was vice president for grants and special programs at the Howard Hughes Medical Institute (HHMI), started up a grants program providing $1 million over four years for biomedical researchers to "go out and do neat things in undergraduate education," he says. There are now 40 such "HHMI professors," among them Yale University biochemist Scott Strobel. His course includes a trip to the Ecuadorian rainforest, where students have discovered multiple new species of endophytes—fungi growing within plant tissues—and have developed their own assays and experiments to characterize them. Some of the newly discovered fungi produce multiple hydrocarbons that are found in gasoline or diesel fuel. Another was discovered to be capable of decomposing polyurethane. Yale molecular biologist Jo Handelsman, another HHMI awardee, started a summer institute for STEM faculty members at research universities who want to improve their undergraduate teaching skills. About 40 participants from 20 research universities attend the week-long program each year.

Gates is one of nine members on a technical advisory panel formed by the AAU to guide its initiative. Each member is considered an expert on undergraduate STEM teaching, the association said in a news release. Other physicists on the panel include Noah Finkelstein, associate professor at Colorado, and Cornell professor Peter LePage.

YouTube and whiz-bang

Gates says he prepares lectures in presentation software, but then often turns to the blackboard if a set of equations in his presentation elicits questions. He's found "amazing resources at YouTube"; repurposing videos he finds there, he creates "a little snippet of something that you can insert into a QuickTime movie, for incorporating in the lecture. There's a whole new way of teaching that many of us are starting to embrace, not just because of the call for increased efficacy of our teaching but also because of the evolution of information technology."

Gates credits fellow Maryland professor Edward (Joe) Reddish, a pioneer of physics education research, with introducing him to novel pedagogies more than a decade ago. He says he agreed to try out courses that Reddish had developed on what set apart students who learned physics well from those who didn't.

Bassam Shakhashiri, a University of Wisconsin chemistry professor, is known for his efforts at popularizing science; one such effort includes the annual whiz-bang public show "Once upon a Christmas cheery, in the lab of Shakhashiri." When teaching, he asks his students to submit a weekly one-page paper reflecting on what they learned during the previous week. When his initial appeal brought responses from just 1 in 10 students, he began offering them a small reward, amounting to 1% of their grade, if they complied. Participation shot up to 80%. "That's engagement," he says.

In Wieman's view, the common denominator to the new pedagogy is "getting students to practice thinking like experts in the subject." He says, "Rather than the student just sitting there passively listening, you are giving them a task, a question, things to solve, that really force them to think." Instead of memorizing long lists, students should be thinking about whether certain effective concepts can be applied to solve a particular problem.

The OSTP is now completing an inventory, ordered by Congress last year, of federal STEM education programs. Preliminary results have identified 252 STEM programs at 13 federal agencies, with combined spending of \$3.5 billion annually. About \$2.5 billion of that is devoted to STEM education generally, and the remaining funds go to train individuals for agency-specific missions, such as National Institutes of Health programs for new biomedical researchers. The complete results and analysis of the inventory are to be released later this fall and should help shape a strategic STEM education plan that OSTP is scheduled to deliver to Congress in January.

David Kramer

Taking the pulse of magnet labs

As fields get stronger and electronics improve, demand for pulsed magnets is growing; the newest lab is in China.

Two magnet labs achieved new highs in pulsed-field strengths this past summer. In June the Dresden High Magnetic Field Laboratory (HLD) in Germany created a 91.4-tesla field. That was topped in August by the Los Alamos branch of the National High Magnetic Field Laboratory (NHMFL), with 97.4 T; in the coming months Los Alamos National Laboratory expects to boost the highest field it offers users from 85 T to 92 T.

"The first 100-T projects were advertised 20 years ago," says Oliver Portugall, technical director of the National Pulsed Magnetic Field Laboratory in Toulouse, France. "But somehow nobody was capable of getting much beyond 70 T or 80 T until recently. A 5-T increase is quite significant. Higher fields open new horizons for fundamental research."

At the Toulouse lab, the maximum field is 70 T, but "we are currently upgrading our installation in order to keep up with Dresden and Los Alamos," says Portugall. His lab, he adds, "has the unique possibility to combine high magnetic fields with advanced photon and neutron sources."