

federal agencies urging them to use incentive prizes to spur innovation and solve tough problems. The administration wants prizes to be “among the standard tools in every agency’s toolbox,” says Sturm, but “in no way sees [them] as a substitute for funding fundamental research.”

In September the White House launched <http://challenge.gov> as a clearinghouse for such government-sponsored prizes. Among the challenges already listed are the L-Prize, the Department of Energy’s competition to stimulate the development of high-quality, high-efficiency solid-state lighting products. NASA has put out a dozen challenges, including one to build an aircraft that uses less than one gallon of gas per occupant, and another to develop methods for doing laundry in space. The America COMPETES

Reauthorization Act pending in the Senate includes a provision to further empower public-sector use of prizes to spur innovation.

Among the advantages of using prizes and challenges is that the sponsor pays only for success. The money spent on research spurred by challenges—from the Diadem to the Ansari X Prize—far exceeds the prize purses. Solvers, as they are often called, have to find other sources of funding to participate.

Prizes also “allow the government to articulate a bold goal without having to select a team or an approach,” says Sturm. Grant decisions typically favor “applications that promise incremental steps over those with potential to give rise to disruptive innovation,” she says. Prizes also increase the number and diversity of people who tackle problems.

Besides the advantages of stretching money and pulling in talent, technology is driving the comeback in incentive prizes. Growth in nanotechnology, biotechnology, robotics, and other “key technologies” is, Diamandis says, “effectively enabling small groups of people to do what only large corporations could do before.” And, he adds, “You don’t see Boeing or Northrop Grumman participating in the challenges, but you do see them come in afterwards and buy scale composites” for possible incorporation of challenge-generated ideas into their products.

For the right set of problems, prizes are incredibly powerful, says Diamandis. “I fundamentally believe that every challenge we face as a species can be overcome by the committed and passionate human mind.”

Toni Feder

NIH is first to sponsor research on a ‘national laboratory’ in space

Three biomedical research projects are selected to fly on the International Space Station, but NASA can’t say when.

For most people of a certain age, NASA’s Apollo program likely conjures memories of lunar landings and a courageous survival story. But some scientists, including former astronaut Millie Hughes-Fulford, see in Apollo an intriguing biomedical question: What caused more than half of the program’s 29 astronauts to develop infections while aboard the spacecraft or within a week of their return to Earth? Why, in particular, was *Apollo 13* astronaut Fred Haise sickened by a strain of *pseudomonas* bacteria that infects only individuals whose immune systems are depressed?

Hughes-Fulford, a professor of biophysics and biochemistry at the University of California (UC), San Francisco, is getting an opportunity to further investigate the link between weightlessness and immunosuppression, thanks to a collaboration between NASA and the National Institutes of Health. She is the principal investigator for one of three research projects that were competitively selected by NIH in September to have their biomedical experiments flown aboard the International Space Station. The grants are small—totaling \$1.3 million—but the real payoff is having NASA pick up the tab for having the scientific payloads delivered to the ISS, having the ISS crew tend to them, and having them transported back to Earth.

There is just one catch—NASA officials can’t tell the awardees when their

experiments will fly. Once the space shuttles are retired—probably in mid-2011—NASA plans to pay the Russian Federal Space Agency for crew and payload transport to and from the ISS. For the next two years, though, the chosen investigators will be busy preparing their experiments for flight.

Five years in the making

NIH’s BioMed-ISS program is the fruit of 2005 legislation that designated the ISS a national laboratory and thus offered federal agencies, universities, and the private sector access to the station’s experimental facilities. In 2007 Elias Zerhouni, NIH director at the time, and former NASA administrator Michael Griffin signed a memorandum of understanding in which NIH pledged to consider funding proposals for research on the ISS. Since then, with urging from Stephen Katz, the director of the National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), nine of NIH’s more than two dozen institutes and centers have agreed to participate.

Although NASA has memoranda of understanding with other federal R&D agencies, including the Departments of Energy (DOE), Agriculture, and Defense, NIH is the first to have solicited, peer reviewed, and awarded grants, says Mark Uhran, assistant associate administrator for the ISS. Additionally,

NIH has committed to holding solicitations next year and in 2012. NASA itself has a standing solicitation for ISS research concepts from private firms and nonprofit institutions. If an industry-proposed experiment is accepted, NASA can offer essentially the same terms—the company pays the entire cost of the experimental apparatus, with NASA providing the transportation and “on-orbit accommodations,” Uhran says.

The deal may sound too good to be true, and it may be for a limited time only. Uhran says the White House recently ordered NASA to establish an external organization to help determine how to allocate the ISS’s limited experimental resources, should that become an issue. Uhran, for one, thinks it will. “We are going to need a management mechanism that does this portfolio management for us.”

Experimental space inside the ISS is measured in “racks,” each about the size of a refrigerator-freezer. NASA has dibs on 23 racks—13 in the US lab module and 5 in each of the European and Japanese modules—and will require roughly half of that space for its own research program. The racks are tailored for different sets of experimental conditions. Eight of the NASA racks are general-purpose, three are configured for experiments at temperatures of -80°C , and two are tailored for human-related research.

A different sort of user facility

Investigators back on Earth will be able to communicate directly with the ISS crew if observations or changes in the experimental parameters are needed, Uhlan says. "We do encourage all of our experimenters to design their experiments in such a way that they can minimize the need for on-orbit crew."

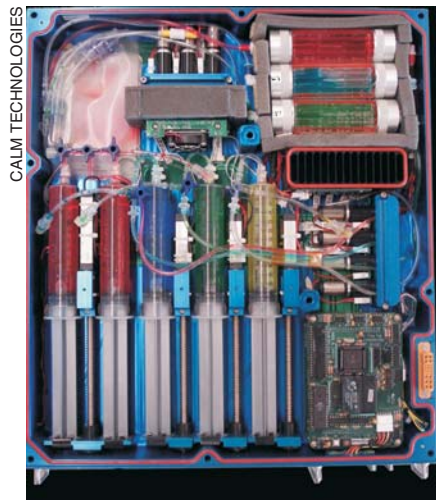
Joan McGowan, director of the musculoskeletal diseases division at NIAMS, says that NIH's ISS research agenda parallels but differs from NASA's narrower interest in the human health impacts of spaceflight. "We're interested in understanding bone, muscle, intestinal absorption, immunology, and microbiology," McGowan says. Just as some NIH-sponsored researchers use a synchrotron or other specialized instrumentation at the DOE national laboratories, she notes, the ISS "is allowing researchers who are interested in fundamental biological phenomena that have importance for life on Earth to experiment in a unique environment."

Paola Divieti Pajevic, an NIH awardee who is an assistant professor of medicine at Harvard Medical School and Massachusetts General Hospital, plans to put the microgravity environment of the ISS to work in her search for the molecular mechanisms through which osteocytes, a type of bone cell, can sense and respond to mechanical forces such as gravity by increasing or decreasing bone mass. Astronauts on long visits to space lose bone mass, as do bedridden and paralyzed individuals. Discerning the molecular pathway of that process could lead to treatments to prevent such loss, she explains.

To simulate microgravity in the lab, Divieti Pajevic has used a rotating bioreactor containing osteocytes. Some of those experiments have shown elevated levels of certain biomarkers or genes in the cells, potential targets for interventions. "The ISS will be like our proof of principle of the model we have developed in the lab," she says.

No maintenance required

The third NIH grantee, UC San Diego scientist Declan McCole, will try to grow a culture of human epithelial cells that line the intestines. "Under conditions of microgravity, we can create a more accurate three-dimensional model of how these cells will behave inside the body, versus the conventional two-dimensional model used in laboratories," McCole explains. His project will also explore whether the effects of alcohol, which is known to damage epithelial cells' ability to block bacteria



An experimental payload similar to the one that will carry bone-cell cultures on the International Space Station.

and other toxins from entering the bloodstream and which may cause conditions such as alcoholic liver disease, will differ in a weightless environment. "The benefit of using alcohol in our

studies is twofold," he says, "in that it has relevance to human health on Earth, but it also makes a very useful agent that we can use to injure the barrier and see if greater injury occurs under conditions without gravity."

McCole's experiment is designed to be self-contained and will require no tending while aboard. What's more, he says, "fail-safe measures" will be taken to guarantee that some experimental data will be collected even if the cells can't be retrieved intact from space. Specifically, the electrical resistance of the cells, an indicator of both their barrier properties and viability, will be measured and downloaded from the ISS in real time. At a set point during flight, fluorescent molecules will be robotically released on one side of the cells. The quantity of those molecules showing up on the other side will measure the cells' permeability.

McCole says he enjoys seeing how his colleagues at UCSD's medical school react when he tells them about his ISS project. "Once you mention space, their eyes light up; it still has that effect."

David Kramer

DOE helps small energy-technology firms through the 'valley of death'

Earlier this fall, the Department of Energy (DOE) announced its award of grants totaling \$57 million to help 33 small companies scale up manufacturing capabilities for their proven clean-energy technologies. The news might have passed unnoticed amid the steady stream of funding announcements that have flowed out of DOE as a result of last year's American Recovery and Reinvestment Act (ARRA), but for the description of the funding source. The Small Business phase-three Xlerator grants that were unveiled on 15 September are the first instances of a new source of early stage federal financing intended to bring small businesses' innovative energy technologies to the marketplace.

Whereas the long-standing Small Business Innovation Research (SBIR) program leaves off at successful demonstration of the technology, the phase-three Xlerator grants are meant to help businesses take their product down the path toward commercialization. What's more, the grants—up to \$3 million—are far bigger than other SBIR technology development grants that have been parceled out by DOE in amounts rarely exceeding \$1 million since the advent of the program in 1982.

"What this [phase three] focuses on

is giving companies staying power to get across the so-called valley of death"—the point where many technology startups fail for lack of capital—says Kristina Johnson, the DOE undersecretary who championed the new funding mechanism. The concept, she says, stemmed from her own experience starting up a 3D movie technology company during the 1990s. The business, which was later bought by RealD, won a grant from NIST's Advanced Technology Program. With that support, her startup was able to gear up manufacturing of its product, 3D glasses that are now used in movie theaters.

New mechanism is needed

Despite having had to operate since 2008 under a series of temporary extensions by Congress, the SBIR program is healthy and continues to grow in tandem with the inexorably rising R&D budgets of the largest federal research-sponsoring agencies. All 11 SBIR agencies, which include DOE, the Department of Defense (DOD), the National Institutes of Health (NIH), NASA, and NSF, are required to set aside 2.5% of their extra-agency R&D budgets to pay for competitively obtained awards to businesses with 500 or fewer employees