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Incentive prizes reinvented to solve problems

The public and private sectors are recognizing that in casting a wide net and paying only for success, incentive prizes have the potential to spur breakthroughs.

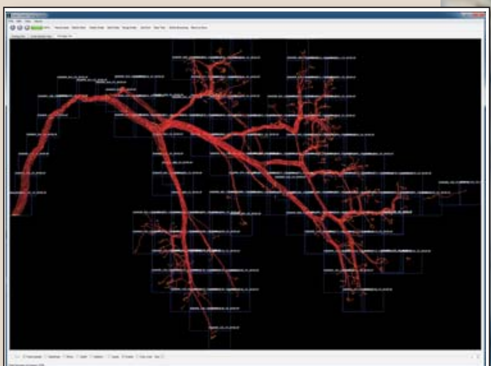
Every keystroke counted during the face-off of the Digital Reconstruction of Axonal and Dendritic Morphology (Diadem) Challenge. In late summer, five teams of finalists gathered for three days at the Howard Hughes Medical Institute's (HHMI's) Janelia Farm Research Campus in Virginia to pit their algorithms against each other. "They had us in a glass-enclosed room. They timed us with stopwatches," says the University of Houston's Badri Roysam, who develops computer vision systems for biology. Roysam led one of the four teams that split the $75 000 purse that HHMI, the Allen Institute for Brain Science, and the Krasnow Institute for Advanced Study at George Mason University (GMU) offered for automated tracing of single neurons.

Until now, neuronal morphology has been mapped mostly by hand. Tracing a single neuron involves analyzing hundreds of stacks of microscopy images—with each stack being a series of two-dimensional images that form a 3D reconstruction at a particular spot. The process takes days or even weeks of a graduate student's time. One of the data sets in the final round of the Diadem Challenge consisted of 14 000 images. The commercial software products available so far haven't proved satisfactory. The Diadem Challenge grew out of a discussion during which experimentalists dreamed of creating a cellular map of the brain, says GMU's Giorgio Ascoli, who proposed and was an organizer of the competition. "All the computer people said, we can do this already. And all the neuroscientists said, no, you can't."

The challenge attracted more than 100 teams of computer scientists, engineers, and physicists. None of the finalists met the stated goal of a 20-fold speed-up in tracing for three out of five data sets, but a 10-fold increase was achieved in some cases. The difficulties lay largely in the variety of methods used to collect data, including different labeling techniques and different forms of microscopy.

Still, everyone involved agrees the challenge was a success. One goal was to bring data producers and programmers together "to initiate a feedback loop," says Karel Svoboda, a Janelia Farm scientist and co-organizer of the Diadem Challenge. "The algorithm producers will tell experimentalists that there are features [in the data] that are damaging to the algorithms, and some may be easy to fix. This is a first step." The challenge, he adds, "has a catalyst function. It gets the competitive juices flowing and produces focused work."

Prizes that, like the Diadem Challenge, aim to motivate people to solve a specific problem are on the rise. According to a 2009 report by the consulting firm McKinsey and Co, the total number of prizes offered is going up and the number of incentive prizes—as opposed to Nobel and other retrospective prizes, which recognize past work—is growing fast. Before 1991, 97% of the total value of big-prize purses in the McKinsey analysis was dedicated to recognizing prior achievement. By 2009, 78% of such prize money was for incentive, or inducement-style, prizes. Moreover, prizes focused on climate, the environment, science and engineering, and aviation and space increased sevenfold in the past decade, and most of the money goes to those who solve predefined problems.



A typical scene at the Digital Reconstruction of Axonal and Dendritic Morphology Challenge face-off. Armen Stepanyants (standing, arms folded), a biophysicist from Northeastern University, led one of the winning teams. Data provider German Barrionuevo (touching screen) of the University of Pittsburgh's Center for Neuroscience served as a judge, and timekeepers (the two other seated men) kept track of all human intervention while the algorithms were at work. A reconstruction of mouse neuromuscular axonal fibers created during the competition by the team of Badri Roysam is shown in the inset.

JAMES KEGLEY

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Longitude, canning, comets

Historically, incentive prizes were popular. Among the most well known are the longitude prize launched in 1714 by the British government and a series of prizes offered during the French Revolution for food-related advances that led to large-scale processing of beet sugar, a canning method that is still in use today, and other inventions. "There was beet sugar before, but a big prize from the emperor [Napoleon] focuses the mind, and people found a way to make it commercial," says Deborah Warner, a curator of the history of science at the Smithsonian Institution's National Museum of American History. Often, she notes, such prizes bring more glory to the prize-givers than to the inventors or discoverers who win them.

In 1847 Maria Mitchell of Nantucket, Massachusetts, discovered a comet and duly collected a gold medal on offer from King Frederick VI of Denmark. An amateur astronomer, she would have been looking at the skies in any case, says Warner. But the prize did boost her academic career: Some years later, she was the first faculty member appointed by Vassar College. And Charles Lindbergh's 1927 pioneering flight across the Atlantic was motivated by the $25 000 offered by New York hotel owner Raymond Orteig.

In Europe in the 18th and 19th centuries, scientific societies regularly offered prizes for solving theoretical and applied problems of the day; mathematician and physicist Leonhard Euler, for example, won a dozen such prizes. But incentive prizes largely died off after the French Revolution, once science moved from learned societies to universities and royal and aristocratic patronage waned. Jeremy Gray, a historian of mathematics at the UK's Open University, says that in trawling through the literature "you see prizes extended and ultimately awarded for something else. It looks like the prizes didn't have enough cachet" to focus people's research.

Peter Diamandis, founder and CEO of the nonprofit X Prize Foundation, which creates, manages, and finds sponsors for prizes with the aim of bringing about radical breakthroughs for the benefit of humanity, says many prizes were offered in the US in the early decades of the 20th century. "When you put up a prize, there is fixed money and objective, and you leave time as a variable. Then World War II came along, and the Defense Department needed innovation on a schedule. Money didn't matter." Large corporations "became enamored" of the influx of money for research, he adds, and incentive prizes for innovations faded. Today's grants system, and the likes of the MacArthur Fellows Program "genius awards," hearken back to medals that were given in 18th-century Europe to support scientists with proven track records.

DAVID FREERS

Three winners were announced on 16 September in the $10 million Progressive Insurance Automotive X Prize competition to develop a safe, fuel-efficient car.

Crazy ideas

In recent years, though, incentive prizes have come back with a bang, inspired at least in part by the Ansari X Prize, the X Prize Foundation's inaugural prize, which in 1996 promised $10 million to the first private team to send a spacecraft with three people aboard to an altitude of 100 km twice in a two-week period; the prize was awarded in 2004. Meanwhile, in 2000 the Clay Mathematics Institute in Cambridge, Massachusetts, launched its $1 million prizes for solutions to seven "millennium" problems.

Incentive prizes are effective for certain types of problems, says Diamandis, whose foundation this summer awarded the $10 million Progressive Insurance Automotive X Prize for safe cars that get the equivalent of 100 miles to the gallon or better, and—in the wake of the BP drilling-platform explosion in the Gulf of Mexico last spring—launched a $1.4 million challenge to develop speedier methods of cleaning the sea surface after oil spills. Suitable problems, he says, have a clear metric to meet or exceed. And in areas "where things are stuck, prizes are a no-lose option." He points to the US Department of Defense's Defense Advanced Research Projects Agency (DARPA) Grand Challenge for autonomous vehicles. From 1980 to 2000, the DOD spent well over $200 million trying to create autonomous vehicles, says Diamandis. "They had very little success. After 9/11 it got urgent, and they launched the prize." In the second year, a group of Stanford University graduate students created a robotic car that was "leaps and bounds beyond what DOD had previously done. And they did it [spending only] $500 000."

Now, he notes, DOD is using elements of the Stanford robotic car, and Volkswagen, a backer of the project, has implemented technologies from the winning car to assist steering, braking, and parking.

Besides tackling societal problems and achieving seemingly impossible feats, says Diamandis, "sometimes incentive prizes are useful in areas where there is a stigma. For example, it might be interesting to look at zero-point energy, cold fusion. We [at the X Prize Foundation] have talked about whether there is something [worth pursuing] on the fringe side of science. But it would require a benefactor who was interested." The foundation, he says, "is constantly looking at what is radical and far enough out that we would accelerate the future or change behavior with a prize." Diamandis likes to say that "the day before something is a breakthrough, it's a crazy idea."

Effective and high-impact

The US government is keen to be in on the action. Robynn Sturm at the White House Office of Science and Technology Policy co-leads a group that aims to make it easier for funding agencies to offer prizes. "We are helping to break down legal and administrative barriers and to build expertise about what sort of problems to use prizes for, and how to design prizes to be effective and high-impact," she says.

This past March the Office of Management and Budget sent a memo to all 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.