CURRENT
NATIONAL SCIENCE FOUNDATION

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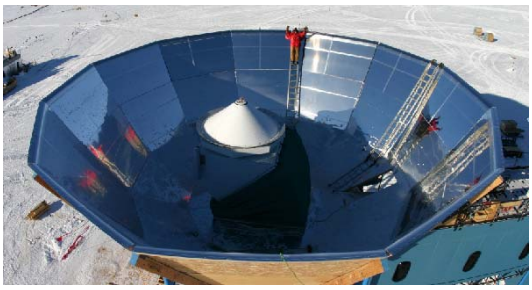
NSF AT WORK

What Is the Universe Made Of?

New experiments carried out at the South Pole confirm that the universe is made almost entirely of something we know next to nothing about. The results, obtained using a unique instrument located at the U. S. Antarctic Program's South Pole Station, confirm an earlier theoretical prediction that 95 percent of everything in existence is either dark matter or dark energy, whereas only 5 percent is ordinary matter. The instrument used to make these observations, the QUaD telescope, is managed by the National Science Foundation (NSF) through its Office of Polar Programs.



The QUaD Telescope, South Pole Station. Credit: Sarah Church

Little is known about dark matter and dark energy, but investigators have now been able to detect these indirectly through measurements of the universe's cosmic microwave background, or CMB, radiation. The faint CMB glow is all that remains of the universe at its earliest moments after the Big Bang. Dark matter interacts with regular matter through gravitational forces and, thus, affects the rate at which galaxies retreat from each other as the universe expands. This gravitational effect influences the CMB. The cold, dry conditions in Antarctica make it the ideal location for precise measurements of CMB radiation without interference from water vapor.

The new data confirm earlier calculations made with the standard cosmological model, also known as the Big Bang theory. Sarah Church, principle investigator of the QUaD telescope project and co-author of an article published in the November 1 issue of *The Astrophysical Journal* in which these new measurements were analyzed, says "It's extremely important for us to amass strong evidence using many different measurement techniques that this model is correct." Read more about the work here.

The Robot's The Thing in This Shakespearian Night

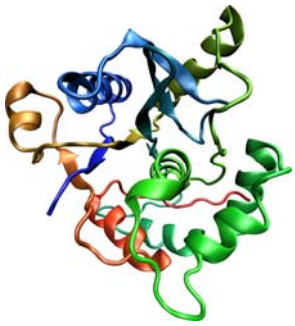
William Shakespeare. Credit: JupiterImages Corporation

Robin Murphy is a professor at Texas A&M whose NSF-funded research involves developing and deploying robots specially designed to assist rescue personnel in the event of a natural or man-made disaster. Recently, Murphy and her colleagues wanted to test how some flying robots used for military operations in Iraq interacted with people and how people reacted to them. The solution? The robots were cast alongside human actors in a production of Shakespeare's *A Midsummer Night's Dream,* where they played the role of flying fairies, swooping and swooning throughout the performance.

In addition to adding another layer of fantasy to the Bard's impish classic, the experience offered valuable insights for Murphy and her collaborators. They learned that actors and audience members alike assumed the robots were smarter and sturdier than they actually are, and that people felt little apprehension around the robots, even large ones. The team also learned that audience members would react and handle the robots based on how the actors treated them. These insights will be incorporated into future robot designs and will help shape how the robots' operators use the devices in the field. Read more about this project here.

Promising Protein Synthesis Technology

A new method for producing proteins has potential for commercial-scale health applications. The method, known as "cell-free protein synthesis," involves only those cellular components needed to manufacture specific proteins, rather than whole cells. This approach enables researchers to optimize and control the environment for producing properly folded proteins at improved yields, without worrying about cell viability.



A folded protein. Credit: Peter Virnau, MIT

The technology was discovered at Stanford University by James Swartz, professor of engineering, as part of a long-term program of NSF-funded basic research focused on the cell-free protein synthesis technique. Sutro Biopharma, Inc. (formerly Fundamental Applied Biology) has been developing the technology since 2004 through an exclusive license. The company holds eight U.S. patents and three elsewhere, and they have submitted 57 additional patent applications.

Through NSF Small Business Technology Transfer awards, Swartz and Sutro have collaborated to reduce production time and costs for the proprietary technique. In addition, Sutro has optimized the system such that it can be scaled up from microliter-sized containers to 100-liter production vessels, allowing for predictability from the research bench through production. One area of focus is manufacturing IGF-1 (insulin-like growth factor-1), which may have potential for diabetes treatment. The team has found high expression yields of antibody fragments and whole antibodies using the method and are now investigating the manufacture of protein-based vaccines.

Why Humans Smell Tasty to Mosquitoes

Walter Leal and Zain Syed at work in University of California-Davis Laboratory. Credit: Kathy Keatley Garvey

NSF-funded entomologist Walter Leal and postdoctoral researcher Zain Syed have determined the dominant chemical signal that attracts the *Culex* mosquito to its next meal. Because *Culex* mosquitoes are primarily responsible for transmitting West Nile virus from birds to humans, this work could have tremendous impact on public health and efforts to control the spread of the virus.

The chemical signal, a molecule called nonanal, is produced by both humans and birds and can be detected by the mosquitoes at incredibly low levels—allowing them to sniff out their next blood meal. The researchers screened a range of odorants produced by humans and birds and found that nonanal elicited a strong response in the mosquito's antennae, the organ it uses to "smell" its surroundings.

The investigators also discovered that baiting traps with nonanal and carbon dioxide (CO_2), a well-known mosquito attractant, increased the number of mosquitoes caught by 50 percent over CO_2 alone. This technique for baiting traps provides an important new method for monitoring mosquito populations. Leal and Syed previously made news by discovering how the insect repellent DEET works, answering a scientific question that had persisted for decades. The new work was published in the *Proceedings of the National Academy of Sciences*; read more about it here.

Did You Know?

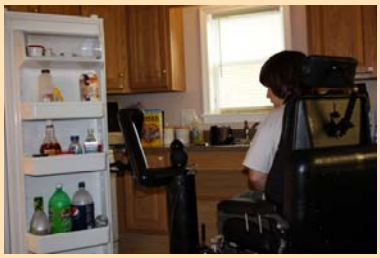
In July 2009, the White House Office of Science and Technology Policy announced the names of the 87 winners of this year's Presidential Awards for Excellence in Mathematics and Science Teaching, or PAEMST. The program is administered by NSF's Directorate for Education and Human Resources.

The 2009 awardees were selected from kindergarten through 6th grade teachers across the nation for their outstanding contributions to teaching and learning and their ability to help students make progress in math and science. These teachers will be honored January 4-7, 2010 through a series of professional development activities—including a full day at NSF—and an awards ceremony in Washington, D.C. Further information about the 2009 PAEMST awardees is available here.

Faces of NSF Research

Using Robots to Assist Those With Disabilities

Rory Cooper, co-director of NSF's Quality of Life Technology Center located at Carnegie Mellon University and the University of Pittsburgh, is devoted to applying his knowledge of robotics to helping people with disabilities. Cooper, who is with the Department of Veterans Affairs and also distinguished professor in the Department of Rehabilitation Science and Technology and professor of bioengineering and mechanical engineering at the University of Pittsburgh, says: "I have focused my entire professional work toward improving the lives of people with disabilities, their families, and the people who assist them. Much of my work has been focused on providing mobility, but I have also made excursions into accessibility and assistive technology policy."



A new robotics system used in food preparation assistance. Credit: Rory Cooper

A component of Cooper's research involves computer modeling, rapid prototyping and robotics applied to the creation of electric-powered mobility and manipulation devices. One such device is shown here: a robotic arm that can be attached to a wheelchair and used by a disabled individual to retrieve and prepare food. Computer modeling has allowed Cooper and his group of engineers to design and simulate such systems before they are ever tried out with human subjects.

"One of the greatest challenges," writes Cooper in a recent NSF Discovery article, "is ensuring that the powered mobility and manipulation device actually meets the user's needs and that the science is guided by problems facing people with disabilities." Cooper explains that it can be equally challenging for a person with a disability to make a sandwich as it is for them to navigate a wheelchair on snowy days. To address the real-life problems faced by those who use assistive devices, Cooper and his team include individuals with disabilities as equal partners in their research team.

Robotics research has traditionally focused on replacing humans with operators, but the type of research going on in the Quality of Life Technology Center uses a different philosophy—to find ways that a person and robot can work together using a technique called "cooperative control." This method involves three components: the pilot, who is the person with the disability, a remote human assistant and the robotic system. The three units work in unison to achieve what the pilot desires. Cooper believes that this approach speeds deployment from the laboratory setting into the real world where it is most needed. Visit the Technology Center's Web site for more information.

NSF in the News

Scientists Unravel Corn Genome (*Chicago Tribune*) The complete genome sequence of corn, one of the world's most important crops, has been determined by a group funded by the U. S. departments of agriculture and energy and by NSF.

Warning Signs (*MSNBC*) New research, partially funded by NSF, shows that daily record high temperatures across the continental U. S. occurred twice as often as record lows over the last decade.

The Botany of Desire (*The Wall Street Journal*) A new PBS documentary, produced with partial financial support from NSF, argues that while we humans think of ourselves as the ones who use plants to serve our needs, plants have been even more successful in using us to meet theirs.

Headphones Can Disrupt Implanted Cardiac Devices (*NPR*) New research, funded partially by NSF, shows that magnets used in headphones are more than strong enough to interfere with the proper function of cardiac pacemakers and implanted defibrillators.

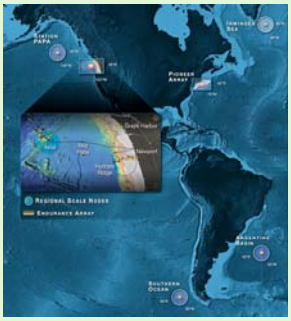
Seeing Invisible Molecules (*Medical News Today*) A team of researchers has developed a new microscopic technique for visualizing, in color, previously undetectable molecules. This new imaging technique offers broad applications in medicine. The work was partially funded by NSF.

Number of Doctorates Increases Again

The number of U. S. doctorates awarded has risen for the sixth year in a row, as reported in a recent NSF study. According to Mark Fiegener of NSF's Human Resources Statistics Program and author of the report, "U.S. academic institutions awarded 48,802 research doctorate degrees in 2008, the sixth consecutive annual increase in U.S. doctoral awards and the highest number ever reported by the Survey of Earned Doctorates (SED). This number represents an increase of 1.4 percent over the 2007 total (48,112), the smallest annual increase over the 6-year span. Doctorates awarded in science and engineering (S&E) fields of study accounted for the overall growth in 2008." More information about this most recent study can be found here.

Part of NSF's mission is gathering, analyzing and making available data about the nation's scientific and engineering enterprise. Extensive information on a wide variety of science and engineering-related work-force issues is available from NSF's Division of Science Resources Statistics.

New Sensor Array Will Provide Data About Oceans



Geographic locations of OOI components. Credit: University of Washington

The Consortium for Ocean Leadership and NSF have signed a new cooperative agreement to begin construction and initial operation of a vast network of undersea sensors. The project, known as the Ocean Observatories Initiative, OOI, will deploy sensors throughout the oceans to gather a variety of data on such phenomena as circulation patterns, acidification and processes related to climate variability. NSF Director Arden L. Bement, Jr., explains: "The oceans drive an incredible range of natural phenomena, including our climate, and directly impact society in myriad ways. New approaches are crucial to our understanding of changes now happening in the world's oceans. OOI will install the latest technologies where they can best serve scientists, policymakers and the public." Data gathered from OOI sensors will be integrated using a sophisticated computing network and will be freely available to the public. Initial construction began in October of this year and is expected to continue for five years. Read more about this project here.

New Education Technology Projects Featured at Recent Hill Event

A T-shirt launcher elicits reactions from participants at the recent technology showcase. Credit: Sandy Schaeffer, NSF

On November 4th, 2009, NSF presented 17 exhibits at an Education Technology showcase on Capitol Hill that was sponsored by the State Education Technology Directors Association, or SETDA. The exhibits highlighted NSF-funded research projects on education technology from several NSF directorates.

Interactive exhibits at the showcase included shooting a T-shirt into the air using a device developed by the PBS show "Design Squad", engaging with robots, observing the impact of earthquakes and trying out educational computer games. Over 450 people attended the showcase including Senate Majority Leader Harry Reid, Senators Jeff Bingaman, Kay Hagan, Ted Kaufman and Patty Murray, and Representatives Peter Welch and Harry Teague. Read more about the showcase here.