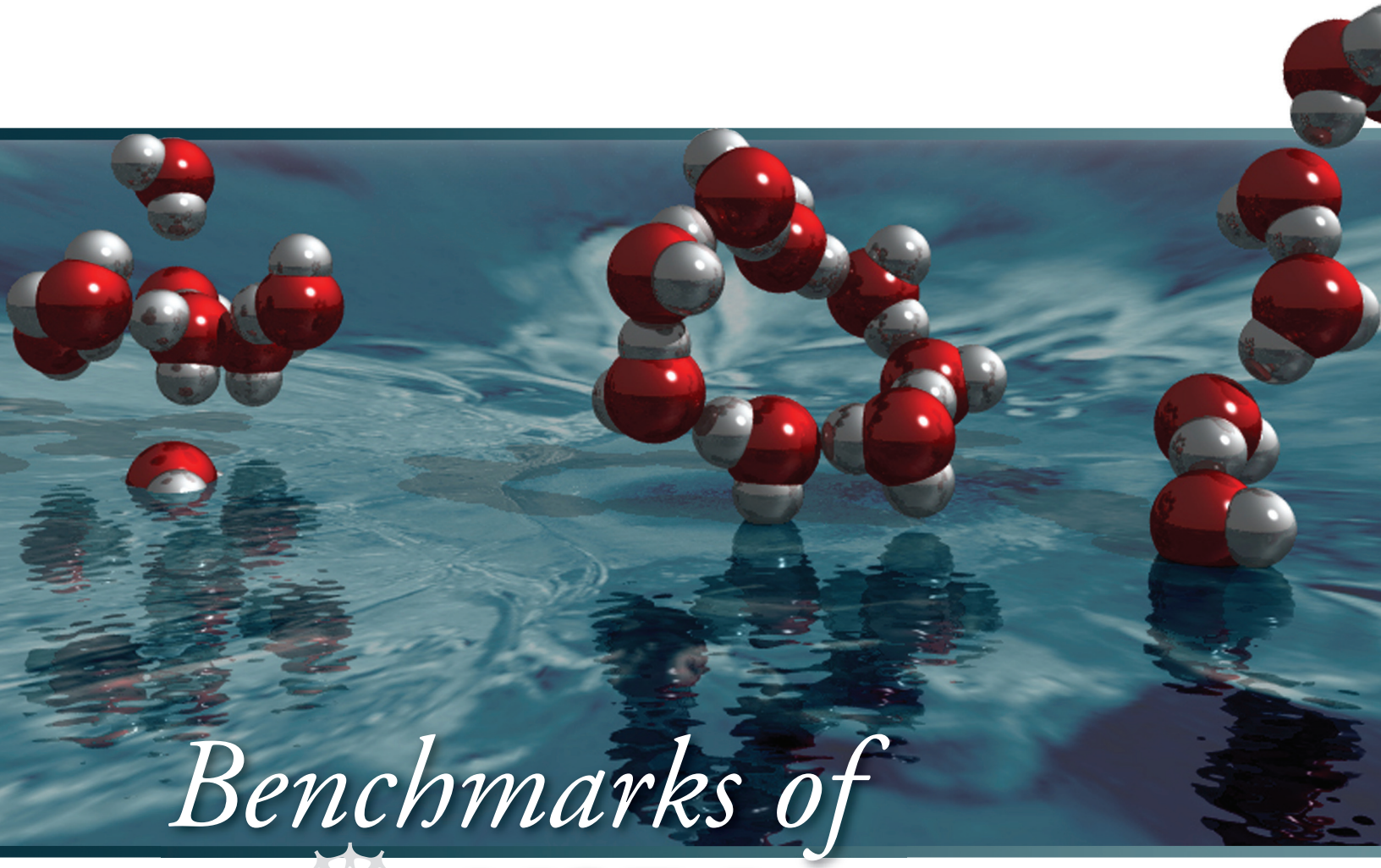


Benchmarks of NSF Innovation

Support from the National Science Foundation (NSF) has been the backbone of America's science and engineering research enterprise for more than fifty years. In fact, NSF is the only federal agency that supports all fields of fundamental science and engineering research and education. NSF-supported research has underpinned multitudinous discoveries—the Internet, Web browsers, Doppler radar, Magnetic Resonance Imaging, DNA fingerprinting, and bar codes—to name a few. These diverse examples underscore NSF's significant contributions to American innovation, and illustrate the agency's critical role in the President's American Competitiveness Initiative.

Executive Summary

Facilitated by competitive merit review, NSF supports cutting-edge research projects—many of which serve as bellwethers for solutions to the myriad complex issues facing society. For example, *implantable generators* and *advanced drug delivery systems* illustrate nanotechnology's increasing contribution to understanding and treating disease. *An injectable gel to treat spinal cord injuries* is the result of NSF-supported polymer research. The *LASIK eye-correction procedure* has emerged from high-precision laser research funded by NSF.

On the environmental front, *thin-film technologies* and *'power plastics'* efficiently generate power from light, offering viable renewable energy sources. Meanwhile, the *production of plastics from atmospheric carbon dioxide* puts the damaging greenhouse gas to good use, helping to sustain the environment.

The *IntelliOne Roadway Speed Management System* will also improve our environment, as well as our daily commutes. The system pinpoints traffic jams in their infancy in real-time. In yet another development, the *Globus Toolkit* integrates geographically distributed computing systems, providing scientists with the necessary horsepower to conduct data-intensive analyses.

Fundamental research can also lead to unpredictable discoveries with immense potential: *the world's strongest natural adhesive* is an outstanding example that resulted from materials science research. Produced by aquatic bacteria, this glue is stronger than the superglues currently sold in stores.

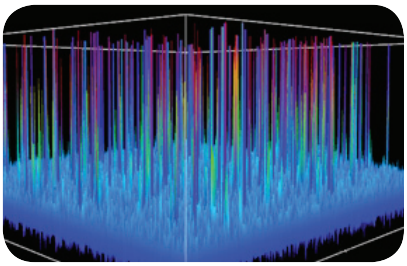
This selective list of discoveries illustrates the Foundation's contribution to the larger science and engineering enterprise. In addition to research, education is also a critical component in the global-innovation-race equation. Knowledge has become the "coin of the realm." Thus, the training of the next generation of researchers and innovators is key to a prosperous future.

NSF programs traditionally integrate research and education, fast tracking innovation excellence via hands-on learning. For example, NSF supported *Advanced Technology Education Centers* offer industry-sanctioned technician education programs. The centers respond directly to industry's workforce needs and graduate technicians who immediately enter the high-tech workforce.

Perhaps the best evidence of the success of NSF is the repeated replication of its model for discovery, education and innovation in nations around the globe.

Nanotechnology Powered by Your Body

Medical devices implanted in the human body are normally battery operated. But, a promising new approach may enable humans to tap into the body's own energy via a "nanogenerator."



Output voltage (vertical scale) of a nano-wire array. Researchers are using nano-wire arrays to create nanogenerators to power implantable medical devices. Credit: Z. L. Wang, Georgia Tech.

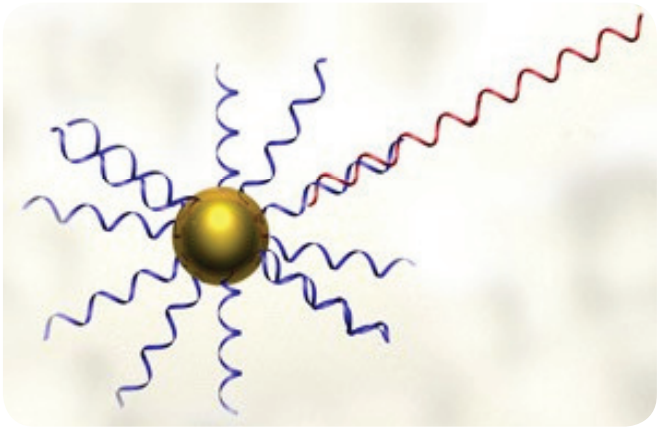
Developed by NSF-funded researchers at the Georgia Institute of Technology, nanogenerators convert mechanical energy from body movement, muscle stretching or water flow into electrical energy.

This technique could open up tremendous possibilities for self-powered, implantable biomedical devices, as well as wireless sensors, portable electronics and other applications.

The nanogenerators produce electricity by bending and then releasing zinc oxide nanowires. By creating interconnected groups of arrays containing millions of wires, researchers can potentially produce enough current to power nanoscale devices, eliminating the need for bulky power sources.

DNA "Strikes It Rich" in Rush to Fight Cancer

By attaching strands of "antisense" DNA to nanometer-scale gold particles, NSF-funded scientists at Northwestern University have significantly enhanced the strands' ability to suppress the production of proteins that cause cancer.



Researchers have significantly enhanced "antisense" DNA's ability to suppress the production of proteins that cause cancer by attaching it to nanometer-scale gold particles. The DNA strands (purple) then sequester RNA molecules (red) before they have the chance to result in disease-causing proteins. Credit: F. Tsuyohiko, N. Rosi, and D. Giljohann, Northwestern Univ.

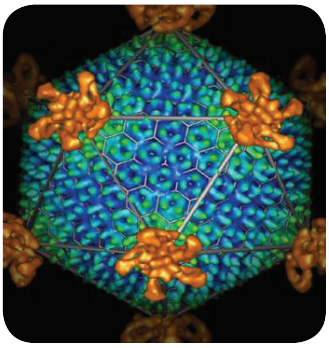
Antisense DNA, a kind of molecular mirror image of ordinary DNA, can be tailored to disrupt the production of specific protein molecules in the cell. Researchers have long believed that antisense DNA could be more effective than conventional drugs at fighting cancer and other diseases with a genetic basis, but the strands tend to break down in biological systems.

Now, the Northwestern group has shown that attaching antisense DNA strands to the surface of gold nanoparticles makes the strands both more stable and more effective in their protein-suppression role.

From Boiling Acid to Nanotechnology

Newly discovered viruses isolated from microorganisms living in boiling acid pools in Yellowstone National Park are serving as raw materials for amazingly diverse new products, from nanoelectronics to drug delivery systems for cancer treatment.

With NSF support, researchers at Montana State University isolated these viruses and studied their practically indestructible protein shells, or "cages." The researchers have now artificially replicated the cages for new applications in nanotechnology.



The structure of a virus from a boiling acid pool in Yellowstone National Park. The virus protein coat is practically indestructible and is finding many uses. Credit: Mark Young, Montana State University.

The team has used the cages as bases for new platinum catalysts to efficiently produce hydrogen and made advanced magnetic materials for use in memory devices now in development with Panasonic.

The researchers also established SpeciGen, a biotech company, which has exclusive rights to the patented protein cage technology. The company is developing targeted drug delivery and imaging agents, and reports that it has more than $11 million of funding.

New Gel Solidifies Spinal Cord Injuries

NSF-funded researchers at the Georgia Tech/Emory Center for the Engineering of Living Tissues have developed a new injectable polymer that shows promise for repairing bone defects, soft tissue injuries and severe spinal cord injuries that are now largely untreatable.

The new polymer can be directly injected into the injured area, where the material rapidly turns to a semi-solid gel bridging gaps and stabilizing damage.

In addition, cells and bioactive agents, such as proteins, can be embedded in the gel to promote enhanced regeneration of bone and nerve cells.

Gel insertion is minimally invasive, and the polymer can fill a wide range of gaps, eliminating the need for specially fabricated inserts.

High-precision Lasers for Eye Surgery

Laser systems developed to study ultra-short reactions at the atomic and molecular levels have now found novel applications in areas as diverse as manufacturing and medicine—including the popular vision-correction surgery known as LASIK.

A team of scientists from the NSF Science and Technology Center for Ultrafast Optical Science and the University of Michigan's Kellogg Eye Center developed a high-precision laser for eye surgery.

The laser developed by the team can perform surgical procedures within the transparent cornea of the eye. This work was not possible with previous laser technology and is considered more precise, faster and less invasive than current procedures.

The IntraLase Corporation was founded to extend ultra-fast laser applications into medical areas, such as ophthalmology and dermatology. IntraLase Corporation reported revenues of $94.5 million for the first nine months of 2006. From July to September of 2006, more than 132,000 IntraLase procedures were performed worldwide.

Using the Sun to Heat and Cool

Researchers are developing a thin-film technology that adheres both solar cells and heat pumps onto surfaces, ultimately turning walls and windows into climate control systems — and harvesting the sun's energy to both heat and cool.

NSF-funded researchers at Rensselaer Polytechnic Institute have built a prototype Active Building Envelope system. Made of solar panels, thermoelectric heat pumps, and a storage device to provide energy on rainy days, the system silently cools and heats with no moving parts.

Thin-film advances could make it possible to seamlessly attach the system to various building surfaces, possibly rendering conventional air conditioning and heating equipment obsolete.

The researchers hope the system's thin-film version will be used in a range of industries, from aerospace to the automotive industries. If applied to automobile windshields and sun roofs, the technology could heat or cool a car's interior.

'Power Plastic:' Bright in Any Light

Through decades of materials science research funding from NSF, followed by support from NSF's Small Business Innovation Research program, Konarka Technologies, Inc. developed a flexible photovoltaic technology, or 'Power Plastic®,' that efficiently generates electricity from light.

Power Plastic is flexible, lightweight, lower in cost and more versatile in application than traditional silicon-based solar cells. The technology, which embeds nanoparticles in a film, enables applications to have their own integrated sources of renewable power.

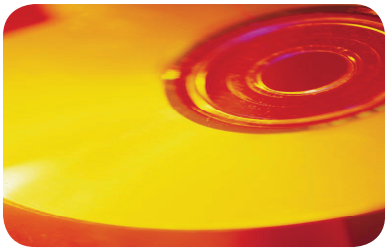
Konarka's 'Power Plastics' are more versatile than conventional solar cells and can efficiently generate electricity from sunlight and artificial light. Credit: Konarka Technologies, Inc.

The company is commercializing its solar cells, and they are being integrated into consumer products, such as mobile electronic devices and laptops. Military applications include battery charging on the battlefield and remote power for unmanned vehicles. As of February 2006, Konarka had $20 million of venture capital funding.

The company's headquarters are in Lowell, Massachusettes, and Nuremburg, Germany. Its research and development facilities are in Austria and Switzerland. One of the company's founders earned a Nobel Prize in chemistry for his work with this technology. Konarka's global intellectual property position includes more than 280 patent applications for materials, manufacturing, manufacturing processes, architecture and devices.

Biodegradable Plastics from Carbon Dioxide

NSF-funded researchers from Texas A&M University have pioneered a method to accelerate the conversion of carbon dioxide (CO_2) gas into the biodegradable thermoplastics used in eyeglass lenses, shatterproof glass, baby bottles, and CDs and DVDs.



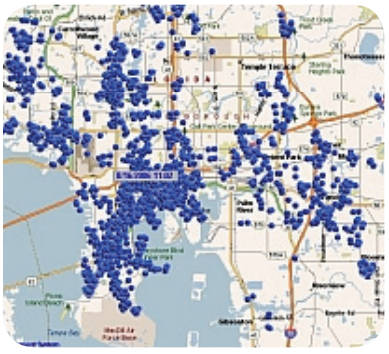
Researchers have pioneered a method to speed the up production of biodegradable plastic products manufactured using atmospheric carbon dioxide, providing a productive use for the greenhouse gas.

Current methods for making thermoplastics generally require petroleum. However, researchers have pioneered a method to produce biodegradable plastic products using atmospheric CO_2—a productive use for the greenhouse gas.

Researchers are now working to develop effective non-toxic metal catalysts for producing another extremely useful plastic, polycarbonate, from CO_2 and other compounds. This plastic can be made into biodegradable rubber-like substances that have potential biomedical applications, such as surgical sutures, drug delivery devices, and body or dental implants.

Untangling Traffic with Cell Phones

Engineers have developed a system that takes anonymous cell-phone location information and turns it into an illuminated traffic map that identifies congestion in real time.



The IntelliOne Roadway Speed Measurement System uses cell phone signals to map roadway speeds for all highways and surface streets where mobile phone coverage exists. The blue dots represent a snapshot of all active mobile phones from a single carrier's network in Tampa, Fla. Credit: IntelliOne Technologies Corporation.

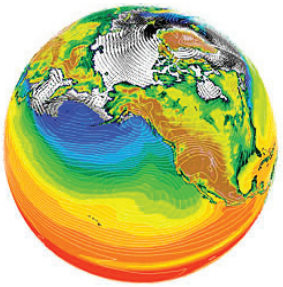
The system takes advantage of the steady stream of positioning cues, untraced signals all cell phones produce whether in use or not, as they seek towers. It is the first traffic-solution technology that monitors patterns on rural roads and city streets as easily as on highways.

Developed by IntelliOne of Atlanta, Ga., the TrafficAid system could not only help guide drivers around tie-ups, but also tell emergency responders where accidents are or how effectively an evacuation is unfolding by pinpointing clusters of cell phones.

Unlike sensors and other equipment along major freeways that are expensive and take years to deploy, this system takes advantage of existing cellular networks in which wireless carriers have already invested billions of dollars, according to NSF awardee and IntelliOne Chief Executive Officer Ron Herman.

Expanding the Computational Grid Frontier

The Globus Toolkit—an open-source library of gridding middleware and software used to integrate geographically distributed computing systems—is the *de facto* standard for building grids.



Scientists in the Earth System Grid—who use Globus software for security, data movement and system monitoring—are providing access to climate data. This image shows sea ice extent (white/gray), sea ice motion, sea surface temperatures (colors) and atmospheric sea level pressure (contours). Credit: UCAR.

IBM promotes Globus as its standard open source grid platform. Several prominent companies also rely on Globus-related applications, e.g., Intel for internal grids and Cisco for network management. The National Cancer Institute's $100-million Globus-based cancer Biomedical Informatics Grid program engages companies at multiple levels.

Globus' indirect impacts are also significant. Virtually every major computer vendor has a "grid product," and most of the Fortune 500 have a "grid strategy." All are influenced by the work on Globus even if they do not use Globus software directly. Globus development is in part supported by NSF.

Nature's Super-Glue

NSF-funded researchers at Indiana and Brown Universities have been studying the strongest natural adhesive known to science.

The super-sticky substance is what one species of water-loving bacteria uses to grip its surroundings with a force of roughly five tons per square inch—equivalent to the downward force exerted by three cars balancing on a spot the size of a quarter.

Aquatic bacteria attach to each other by their glue-secreting holdfasts, structures at the tip of their stalks. Engineers are trying to mass produce the glue. Credit: Yves V. Brun, Indiana University.

This holding power makes the natural glue stronger than superglues found on store shelves and is rivaled by only a few synthetics.

If engineers can find a way to mass-produce the material, it could have uses in medicine, marine technology and a range of other applications.

Technician Education: Intellectual Capital for the Process Technology Sector

The Center for the Advancement of Process Technology (CAPT) in Texas City, Texas, was formed as a response to industry's increasing need for a diverse, highly skilled process-technician workforce. Funded by NSF's Advanced Technology Education (ATE) program, CAPT develops and enhances two-year degree programs based on industry-established standards; provides professional development opportunities for faculty; and promotes career pathways through job-placement initiatives, retention activities and student internships.

For example, 87 students from CAPT partner colleges completed internships at BP and Shell from 2003 to 2005. All of their former supervisors now recommend that other companies support such internships. Such opportunities, supervisors say, help students better understand the real world; develop job skills; and lead them to permanent employment.

Moreover, CAPT has 42 national education partners in 19 states and the Virgin Islands. The center works closely with nine regional process technology alliances—representing the chemical, refining, exploration, production and pharmaceutical sectors—to ensure that its programs and products are based on the latest industrial standards.

To date, CAPT's partner colleges have graduated 5,726 highly-skilled technicians with associate degrees, certificates or both in process technology. The graduates are now working in companies vital to the U.S. economy such as BP, Conoco-Phillips, Dow Chemical, Shell and Exxon Mobil. Three-fourths of these students were hired by industry as full-time employees within six months after graduation with annual salaries ranging from $40,000 to $60,000.

The National Science Foundation (NSF) is an independent federal agency that supports fundamental research and education across all fields of science and engineering, with an annual budget of $5.9 billion. NSF funds reach all 50 states through grants to nearly 1,700 universities and institutions. Each year, NSF receives about 40,000 competitive requests for funding, and makes nearly 11,000 new funding awards. The NSF also awards over $400 million in professional and service contracts yearly.