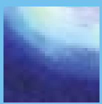
# WHERE DISCOVERIES BEGIN



NSF-funded astronomers are studying the Owl Nebula, the well-known planetary nebula in the Ursa Major constellation.

## Mobilizing to Fight SARS

This spring, grid-computing researchers around the Pacific Rim mobilized to fight the SARS (Severe Acute Respiratory Syndrome) epidemic, helping to establish a cutting-edge communications grid among quarantined hospitals across Taiwan. In addition to linking the hospitals to one another, the grid connected doctors to global sources of health information.

In May 2003, Taiwan's National Center for High-Performance Computing requested help from the members of the Pacific Rim Applications and Grid Middleware Assembly (PRAGMA). Led by the San Diego Supercomputer Center at the University of California–San Diego, offers of assistance poured in within hours from all PRAGMA sites, including Argonne National Laboratory, where the Access Grid was developed.

NSF support for the PRAGMA partnership has led to the development of trust and a cooperative spirit. PRAGMA demonstrated that NSF's investment in cyberinfrastructure will transform not only scientific research and learning, but also the handling of global events such as SARS.

Because quarantine and isolation are the primary means of slowing the spread of the disease, Taiwan's hospitals faced a communications logjam. Physicians in quarantined hospitals could not consult with specialists at other institutions, and on a more personal level, staff and patients had only limited contact with their families.

The Access Grid, a network-based collaboration that goes beyond standard video- and teleconferencing, allowed physicians to share detailed x-ray images, patient data, and other information in online meetings involving several sites.

During a speech given at the Central Intelligence Agency's Strategic Assessments Group workshop in June 2003, NSF Director Rita Colwell said, "SARS is a vivid reminder of the dangers posed by infectious agents in our increasingly interconnected world. At the same time, our capacity to anticipate and prevent harm has never been greater than it is today."

## Cleaner Fuel One Step Closer

NSF-funded scientists working on extracting hydrogen from common renewable plant sources have developed a hydrogen-making catalyst that uses cheaper materials and yields fewer contaminants than current processes do. Further, this catalyst lies at the heart of a chemical process that is said to constitute a significant advance in producing alternate fuels from domestic sources.

Researchers from the University of Wisconsin–Madison created the catalyst from nickel, tin, and aluminum and used it in a process called aqueous-phase reforming (APR), which converts plant byproducts into hydrogen. Although this process is as effective as current methods that use precious metals such as platinum, it is less expensive, runs at lower temperatures, and is much cleaner.

Hydrogen is a "clean" fuel because unlike fossil fuels, it combines with oxygen when it burns to form water instead of toxic byproducts or greenhouse gases. The APR process extracts hydrogen from a variety of biological sources, especially simple carbohydrates and sugars produced by common plants.

This process can be used on a small scale to generate fuel for portable devices such as cars, batteries, and military equipment. It can also be scaled up to provide a hydrogen source for industrial applications such as manufacturing fertilizers or to remove sulfur from petroleum products.

According to the U.S. Environmental Protection Agency, the fossil fuels that are burned to run cars and trucks, to heat homes and businesses, and to power factories are responsible for about 98 percent of carbon dioxide emissions, 24 percent of methane emissions, and 18 percent of nitrous oxide emissions in the United States. Hydrogen-based fuels may eventually reduce the use of these fuels, thus lowering the emissions linked to greenhouse gases and global climate change.

## Breathing Easier

Asthma is a major public health problem that affects some 15 million people in the United States, nearly 5 million of them under 18. It is estimated that people with asthma experience well over 100 million days of restricted activity every year.

To address the growing epidemic of asthma in this country, NSF-supported researchers at the University of Oklahoma have found a novel way of using a laser to analyze exhalations, thus opening the door to more accurate diagnosis and treatment of asthma.

**"Discovery and innovation will be twin pillars of 21st century progress."**

Dr. Joseph Bordogna
Deputy Director

Scientist Patrick McCann coupled a laser spectroscopy system to a tunable laser to create a device that accurately and simultaneously measures both carbon dioxide and nitric oxide levels in a single exhalation of breath. The precise measurements provided by McCann's instrument could help doctors evaluate airway inflammation and target medications to reduce inflammation and enable patients to breathe easier.

The device, which is undergoing clinical trials, promises more accurate diagnosis, which can lead to more effective treatment and reduce medical costs and lost productivity.

## Chasing Storms

Sailplane pilot Bruce Miller guides the National Center for Atmospheric Research (NCAR)-operated Schweizer SGS 2-32 aircraft in search of storm electricity. NSF-funded researchers at NCAR are using the sailplane and other equipment to study and better predict events such as tropical cyclones, hurricanes, flash floods, tornadoes, and thunderstorms.

## Zeroing In on Microbes

Although we live in the age of biotechnology, certain basic questions remain unanswered. For example, which microbes live in lakes and can they benefit humanity? In probing lakes in Wisconsin, researchers are discovering new organisms with as yet unknown traits and learning how microbe communities react to changes in their environment.

These discoveries could be invaluable, since microbes have provided us with important drugs like streptomycin (the first antibiotic to successfully treat tuberculosis), as well as the polymerase chain reaction, a technique critical for studying DNA.

According to Eric Triplett, a biologist at the University of Wisconsin–Madison, scientists understand very little about the bacteria that play a major role in lake processes such as nutrient and carbon cycling. Scientists would like to know how bacterial communities in lakes respond to changes in the environment, including water chemistry and weather. Recent changes in Earth's climate and the invasion of exotic species such as the zebra mussel make this a very interesting time to study a lake's microbial community.

Triplett's research, which is part of the NSF Microbial Observatories program, involves studies of Crystal Bog and Crystal Lake in northern Wisconsin, and Lake Mendota in Madison. Water samples he and his colleagues have collected from these lakes contain dozens of new species of bacteria. Even over as short a period as a week, Triplett and his colleagues have observed significant changes in these microbe communities related to changes in their environment.

Preliminary findings show that water temperature plays a role in determining the structure of a bacterial community and that changes correspond to changes in other communities such as algae. Findings also suggest that geographic location and water chemistry lead to significant differences among the bacterial communities in specific lakes.

## Panda Challenges

A panda walks through the China Research and Conservation Center for the Giant Panda in the Wolong Nature Reserve in Sichuan Province in southwest China. Pandas are rare in the wild; it is estimated that less than 1,000 of them live in China's shrinking and fragmented habitats. NSF-funded researchers like Jack Liu, assistant professor of fisheries and wildlife at Michigan State University, work in conjunction with the Chinese to better understand challenges to the pandas' habitat and the impact of human interaction on biodiverse areas such as Wolong.

## Building Mountains

From volcanic eruptions to earthquakes to catastrophic mudslides, the geologic processes active in mountain belts affect people every day. However, even though mountains are found on every continent and in every ocean basin, scientists still understand relatively little about the forces that interact to form and destroy mountains, the ways they change over time, and the relationship between mountains and climate.

To better understand these dynamics, scientists are now integrating studies across traditional disciplines. In NSF-funded research on a mountain belt located in Fiordland, South Island, New Zealand, a team of scientists has demonstrated a new way to integrate results from observations collected in the field with laboratory and experimental techniques.

This integrated approach has allowed us to better understand the processes behind mountain building. In Fiordland, where rocks from early mountain-building are exposed at the Earth's surface, research has revealed the mechanisms by which magma was generated and transported through the lower continental crust and the ways these processes affected the formation of mountains over millions of years.

Mountains are the surface expression of plate tectonic forces, which constitute the dynamic link between processes active in the deep Earth, processes that change Earth's surface, and the atmosphere that drives the hydrologic cycle and fosters life. Tectonic forces make our planet different from the others in the solar system. Towering mountain ranges such as the Himalayas exist because rock is uplifted so quickly that erosion cannot strip it away fast enough. Understanding tectonic forces is important, say geologists, because ultimately it will allow us to more accurately predict the Earth's behavior and prepare for natural disasters such as volcanoes and earthquakes.

## Vivísimo Delivers Outstanding Results

Vivísimo—a meta-search engine with the potential to revolutionize the way we obtain information from the World Wide Web—was recently recognized by industry experts at Search Engine Watch for its outstanding performance in providing a single source for gathering results from many search engines.

The software that powers Vivísimo filters and automatically categorizes responses to search requests. Getting answers to broad, exploratory questions can leave searchers, especially searchers whose knowledge about a topic is limited, slogging through a morass of information. For example, searching for "Iraq" among the stories on any Web news source will result in a long list of articles on global politics. Searching the entire Web can produce a similar, mostly undifferentiated list of sites about Iraq.

Vivísimo's Clustering Engine does a quick statistical, linguistic, and knowledge-based analysis of the search results, which it then clusters into themes. For example, using Vivísimo to search news sites for "Iraq" might produce clusters of articles under categories such as "weapons inspectors" and "missiles." Vivísimo thereby helps identify trends and fine-tune searches without requiring users to know the correct terminology.

Vivísimo is supported by NSF's Small Business Innovation Research (SBIR) program, which emphasizes high-risk, high-payback innovations that are tied to NSF's mission. All research and development proposals are evaluated on their technical merit, as well as their impact on technology. NSF was the first of 10 federal agencies required to reserve a portion of their research and development funds for the SBIR program.

## Lighting Up the Nanoscale

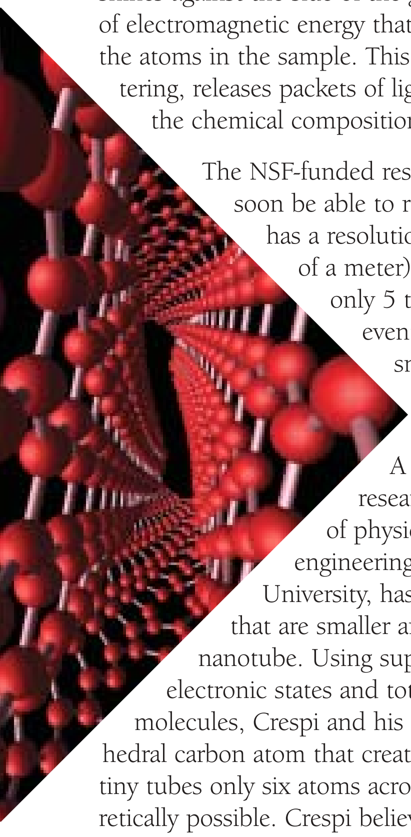
Researchers at the University of Rochester, Portland State University, and Harvard University have recently created the highest resolution optical image ever, revealing structures as small as carbon nanotubes just a few billionths of an inch across.

This new technique, called near-field Raman microscopy, will shed light on previously inaccessible chemical and structural information in samples as small as the proteins in a cell's membrane. Other ultra-high-resolution imaging techniques, such as atomic force microscopes, detect the presence of objects and image them but cannot directly view the light bouncing off them.

Using this technique, researchers can determine a material's composition as well as its structure. The ultimate aim is to use light to gather information on the proteins on a membrane; such information opens the door to designer drugs that could kill harmful cells or repair damaged cells, or even identify strains of disease never imagined before.

To light up the nanoscale, scientists sharpen a gold wire to a point just a few billionths of an inch across. A laser then shines against the side of the gold tip, creating a tiny bubble of electromagnetic energy that interacts with the vibrations of the atoms in the sample. This interaction, called Raman scattering, releases packets of light that can be used to identify the chemical composition of the sample.

The NSF-funded researchers anticipate that they will soon be able to refine the system, which already has a resolution of 20 nanometers (billionths of a meter), to image proteins, which are only 5 to 20 nanometers wide, with eventual resolutions revealing much smaller molecules.

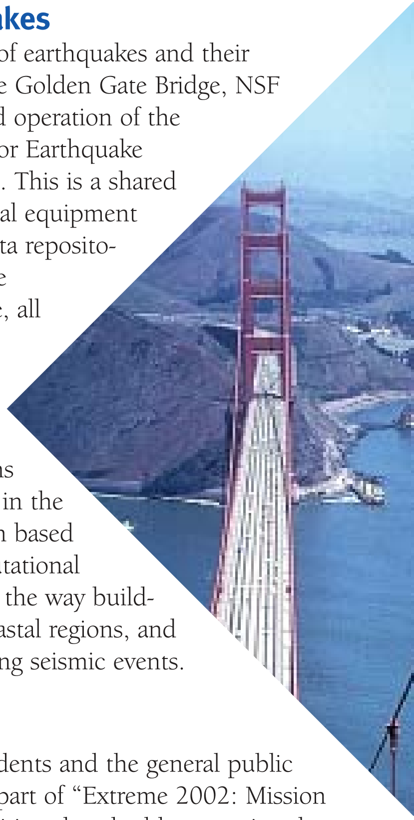


## Tiny But Powerful

A team led by NSF-funded researcher Vincent Crespi, professor of physics and materials science and engineering at Pennsylvania State University, has simulated carbon nanotubes that are smaller and stronger than any other nanotube. Using supercomputers to model the electronic states and total energies of various carbon molecules, Crespi and his colleagues discovered a tetrahedral carbon atom that creates tight, stable bonds to form tiny tubes only six atoms across—the smallest diameter theoretically possible. Crespi believes that these tubes may prove very useful in a variety of nanotechnology applications.

## Understanding Earthquakes

To improve our understanding of earthquakes and their effects on structures such as the Golden Gate Bridge, NSF is funding the development and operation of the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES). This is a shared national network of experimental equipment sites and tools, a centralized data repository, and an archive of earthquake engineering simulation software, all linked together by ultra-high-speed Internet2 connections. When NEES becomes fully operational in 2004, these resources will provide the means for collaboration and discovery in the form of more advanced research based on experimentation and computational simulations of earthquakes and the way buildings, bridges, infrastructure, coastal regions, and geologic materials perform during seismic events.



## Finding the Abyss

Marine scientists are taking students and the general public deep into the Pacific Ocean as part of "Extreme 2002: Mission to the Abyss," a research expedition that doubles as a virtual field trip to hydrothermal vents at the bottom of the sea.

Led by University of Delaware marine biologist Craig Cary, the 23-member team sailed to the site along the East Pacific Rise, more than 1,000 miles west of Costa Rica. There, scientists used the submersible *Alvin* to descend nearly two miles to one of the most demanding environments on Earth. In addition to studying hydrothermal vents, researchers also studied the creatures that inhabit them, including the Pompeii worm, known as the world's hottest animal for its ability to withstand temperatures up to 176° Fahrenheit (80° Celsius).

Participating in Extreme 2002 were 41,000 students from more than 500 schools, representing 49 states as well as countries such as England, South Africa, Canada, Australia, and New Zealand. Students were kept abreast of scientists' progress by video clips, photos, interviews, and journals relayed back to shore every day.

This project yielded more than new knowledge about extreme ocean environments. It also succeeded in getting students excited about science. Extreme 2002 may have created future scientists by introducing students to one of the most fascinating habitats on the planet and engaging them in the process of scientific research and discovery.