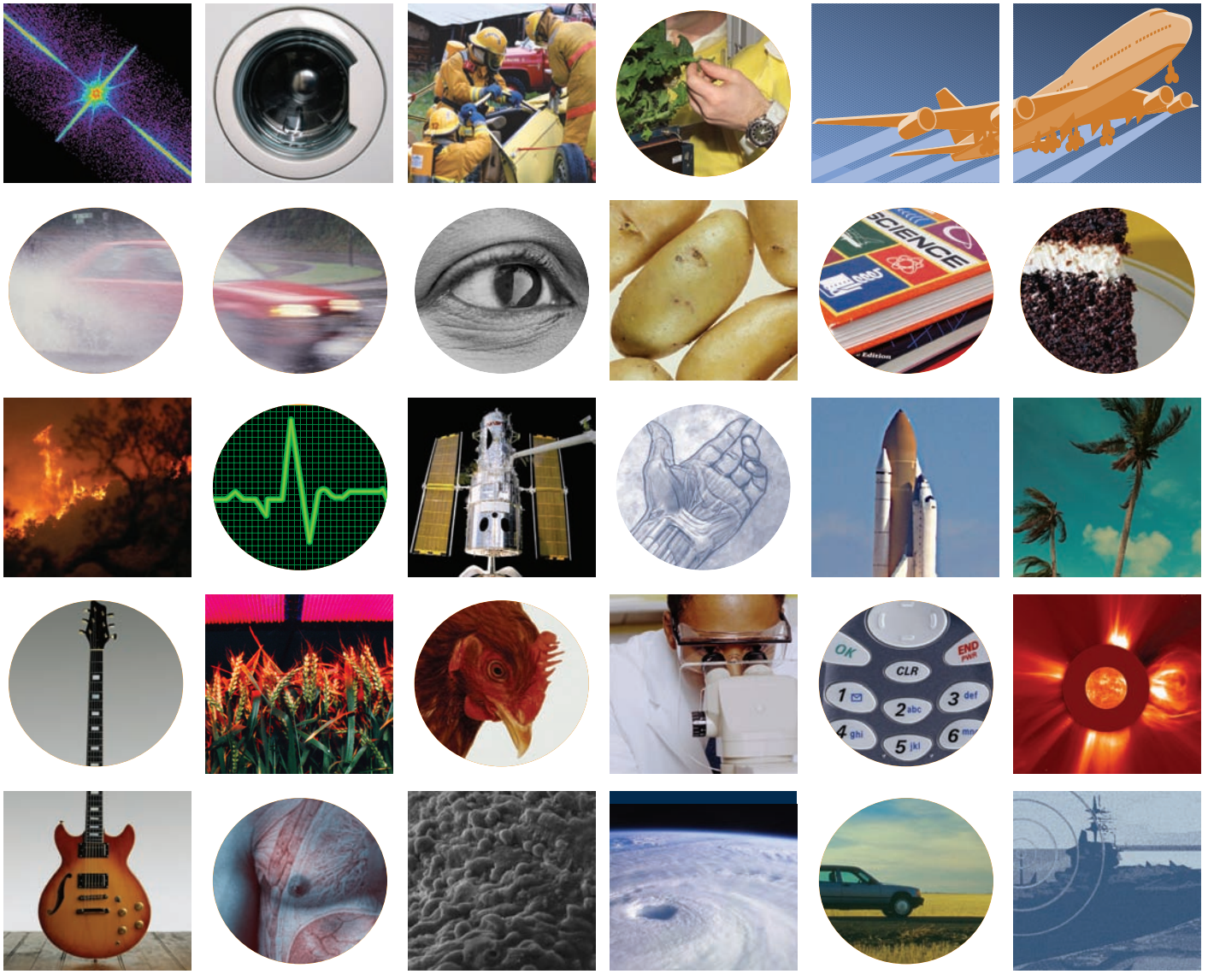
Rewards from Space

NASA hits

HOW NASA IMPROVES OUR QUALITY OF **LIFE**



From the NASA Administrator:

Americans are touched by the legacy of space flight each day. NASA's historic achievements and revolutionary discoveries are recognized around the world. The creativity required to meet the unusual challenges of human space flight repeatedly yields unusual, productive applications. This publication highlights a few of the practical benefits to society derived from NASA's space flight, space science, Earth science, and aeronautics research and technology development. Please use this publication as a resource for responding to questions regarding the rewards and values of human space flight. These achievements resulted from management excellence, technical innovation, and solid science and research, a foundation for success that continues at NASA today.

Sean O'Keefe

practical benefits today

Linking the World's Telephones

When friends and family call from other parts of the country or overseas, they sound as if they are right around the corner. The scope, clarity, and reliability of our long-distance telephone system is the result of communications-satellite technology developed by NASA over a 30-year period.

Vital Signs for Critical Moments

The monitoring systems used in intensive care units and heart rehabilitation wards were developed from the systems used to monitor astronauts during the first space missions in the early 1960s. A single nurse can now monitor several patients in critical care situations.

Countless Americans recovering from heart attacks and other serious illnesses or injuries owe their lives to this technology, a direct result of NASA's space program.

Food Safety for Astronauts Sets the Standard

The Food and Drug Administration and the U.S. Department of Agriculture credit NASA with developing the comprehensive food safety system, referred to as Hazard Analysis and Critical Control Point (HACCP) that the nation uses today. This system, originally developed for astronauts, includes principles for preventative food safety such as minimum cooking temperatures to kill bacteria and methods of dealing with food safety hazards. HACCP has become the accepted safety standard for the food industry worldwide.

S.O.S. to Space Provides Global Rescue Capability

NASA's research in developing and demonstrating space-based beacon locators was used to create an international, satellite-based search and rescue system that has helped save almost 13,000 lives worldwide (as of January 2002). The system automatically detects and locates transmissions from emergency beacons carried by ships, aircraft or individuals. The system then alerts appropriate rescue authorities. A total of 30 nations participate in the system, which operates 24 hours a day year-round.

Getting the Groove on Airport and Highway Safety

NASA researchers determined that cutting thin grooves across concrete runways reduces the risk of hydroplaning. The grooves, which create channels for excess water to drain, have been shown to improve aircraft tire friction performance in wet conditions by 200 to 300 percent. As a result, hundreds of commercial airports around the world have had their runways grooved. This technique is now used nationwide on highway curves and overpasses; pedestrian walkways, ramps and steps; and food processing plants and cattle holding pens. The use of grooves on highways has contributed to an 85 percent reduction in highway accidents.

This could be NASA's most successful technology in terms of lives saved and injuries and accidents avoided.

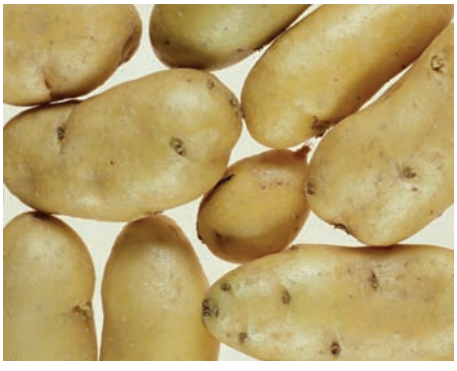
Planes, Trains, and Guitars

The NASA Structural Analysis program, better known as NASTRAN, is a computer that saves time and money by using a computerized design process to identify the strengths and deficiencies of a product before it is manufactured. NASTRAN was originally developed by NASA for human space flight and aeronautics. Private-sector versions of this software are now used to design everything from chemical plants, refineries and trains to next-generation fighter aircraft, cars, acoustic speakers, electric guitars and skyscrapers. The software generates over $1 billion of revenue annually and affects hundreds of billions of dollars worth of consumer products.

New "Fields" and Better Yields for Agriculture

NASA-sponsored researchers working on methods to grow plants in space have produced world-record crops on Earth using hydroponics, a technique that uses intense lighting and high levels of carbon dioxide to grow crops in water. The researchers produced a laboratory wheat crop that yielded five times more grain than a typical field-grown crop. Several growers and large corporations are using NASA's techniques to increase potato production.

Commander Sergei Zalyotin looks at a plant growth experiment in the Zvezda Service Module on the ISS. In optimizing plant growth facilities for flight, NASA has achieved record crop yields.



This view of Hurricane Isabel was taken in the fall of 2003 by one of the Expedition 7 crewmembers onboard the International Space Station (ISS).

Space-Observation Keeps Hurricanes in Clear View

NASA and the National Oceanic and Atmospheric Administration (NOAA) are now able to monitor weather patterns from space to enhance hurricane track, landfall and intensity forecasts. Measurements from NASA's Tropical Rainfall Measuring Mission (TRMM) and Quick Scatterometer (QuikSCAT) Earth-observing satellites help to improve predictions about hurricanes and other tropical systems as they move from the open ocean toward coastal regions. Improved hurricane forecasting reduces property damage and saves lives by giving local residents and municipalities advanced warning to prepare and evacuate as needed prior to a hurricane's landfall.

Big Functions in a Small Package

Microelectromechanical systems (MEMS) are extremely small devices and sensors (comparable to the size of a human hair). MEMS applications are directly traceable to the miniature accelerometers NASA developed in the 1970s to measure changes in speed of small objects or activity levels of people or animals during human space flight. MEMS technology is used now in consumer products to trigger automobile airbags, regulate pacemakers and even keep washers and dryers balanced. MEMS-based products have grown into a $3 billion per year industry. The original NASA-sponsored work on an MEMS accelerometer is referenced in 83 patents; the earliest reference was made in 1975 and the latest in 2003.

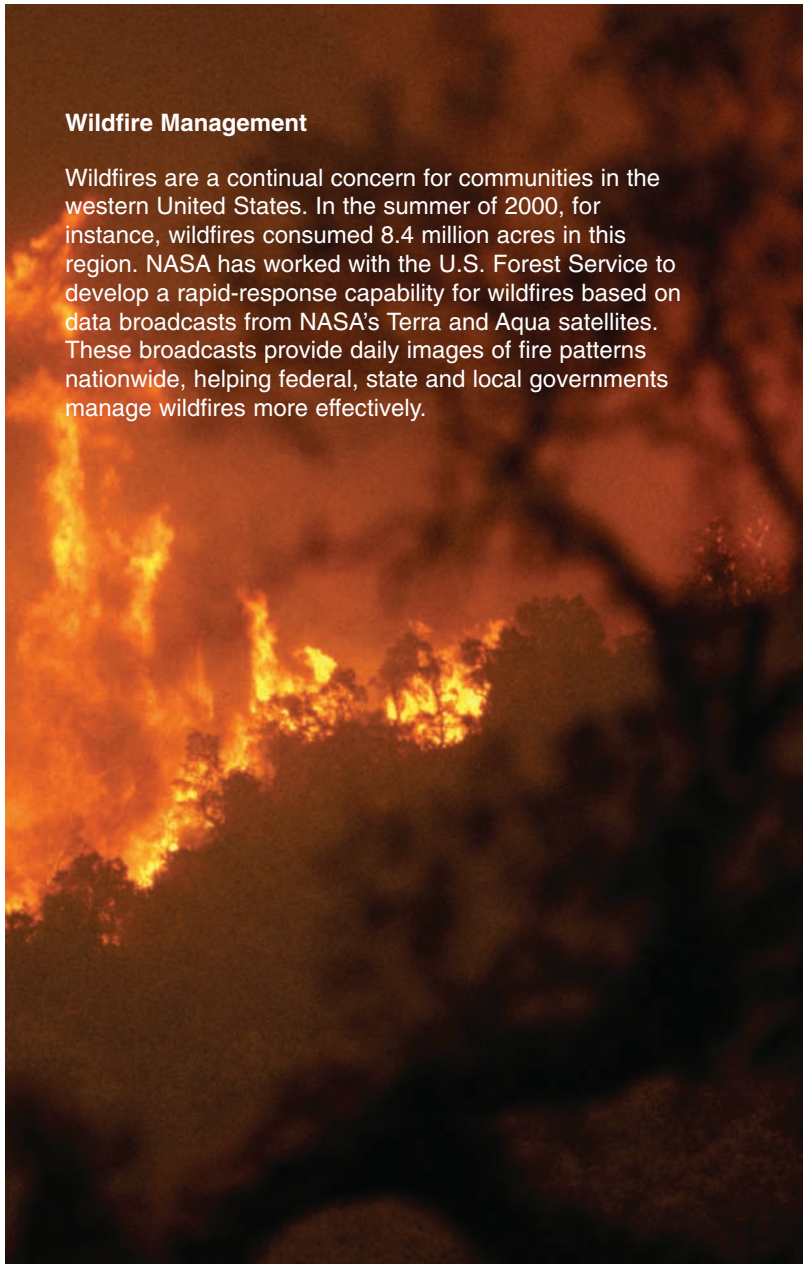
NASA Technique Benefits Animal Research

NASA developed the hind limb suspension technique to simulate the effects of weightlessness on astronauts' physiology. Variations of this technique have been used for almost 25 years by animal researchers to study bone, muscle and cardiovascular atrophy. The technique is the model of choice for independent medical experts and researchers worldwide.

Attached to the "robot arm," the Hubble Space Telescope is unberthed and lifted up into the sunlight during the telescope's second servicing mission.

Breast Cancer Diagnosis

Breast biopsies (mammographies) are essential for the detection and treatment of breast cancer. As a result of technology developed through the Hubble Space Telescope program, biopsies can be performed with a needle instead of a scalpel. The needle biopsies benefit patients by leaving only a small mark rather than a large scar and by costing significantly less—an average of $850 compared to $3,500 for a traditional biopsy.



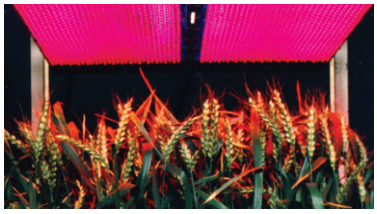
Wildfire Management

Wildfires are a continual concern for communities in the western United States. In the summer of 2000, for instance, wildfires consumed 8.4 million acres in this region. NASA has worked with the U.S. Forest Service to develop a rapid-response capability for wildfires based on data broadcasts from NASA's Terra and Aqua satellites. These broadcasts provide daily images of fire patterns nationwide, helping federal, state and local governments manage wildfires more effectively.

other recent applications

Lifeshears

This powerful hand-held rescue tool can quickly cut through cars or other enclosures to free persons involved in an accident or other dangerous situation. Lifeshears were used by rescue workers searching for survivors at the Oklahoma City Federal building in 1995 and the World Trade Center in 2001. The tool, which was developed through the joint efforts of the Hi-Shear Technology Corporation, firefighters and NASA, uses the same power source used to separate solid rocket boosters from Space Shuttles. Lifeshears are lighter, cheaper and easier to use than traditional rescue equipment.



A first-generation ethylene scrubber, which used the same technology as the Anthrax-killing device, removed ethylene inside the ADVANCED ASTROCULTURE.™

Shedding New Light on Cancer Treatment

New lighting technology originally developed by NASA for plant growth experiments in space is improving the treatment of brain and skin tumors and other medical problems such as wounds. Doctors at the Medical College of Wisconsin are using the technology to improve a chemotherapy technique called photodynamic therapy. This technique uses focused light to activate medicines that kill cancerous tumors. In the past, photodynamic therapy has used a laser light source; the new light source is more efficient, versatile, accurate and less costly. NASA and medical practitioners also are investigating the use of this technique to accelerate the healing of wounds both in space and on the ground.

continuing benefits

Age of the Universe

In February 2003, NASA released the results of a one-year observation of the cosmos by the Wilkinson Microwave Anisotropy Probe (WMAP) Explorer satellite.

The results showed the afterglow or cosmic microwave background of the universe 380,000 years after the Big Bang. Surprisingly, the data revealed that the first generation of stars in the universe ignited only 200 million years after the Big Bang, much earlier than many scientists had expected. Using the WMAP portrait, scientists have estimated that the universe is 13.7 billion years old, with a remarkably small 1 percent margin of error.

Dr. Ansari and an ophthalmologist perform a clinical test using a Dynamic Light Scattering Device that determines molecular interactions that occur in the human lens.

Inspiration and Innovation—A NASA Story

At NASA, extraordinary goals inspire exceptional minds. As a boy in Pakistan, Dr. Rafat Ansari was first inspired to pursue scientific research when he saw astronauts walk on the moon. This inspiration eventually led Dr. Ansari to become a researcher at NASA, where his work with fluid physics has produced an unexpected and valuable medical care innovation.

Dr. Ansari was conducting experiments to study the effects of space on colloidal systems (small particles suspended in liquids) when he realized that his work could relate to cataracts, the degenerative eye condition affecting his father. Dr. Ansari concluded that the NASA instrument being developed as part of his colloids experiment might be able to detect cataracts—possibly earlier than ever before. This research device is now planned to be used to assess the effectiveness of new, non-surgical therapies for early stages of cataract development. The instrument is also being adapted as a pain-free way to try to identify other eye diseases, diabetes and possibly even Alzheimer's. Dr. Ansari's discovery has important applications for NASA, since astronauts face the risk of developing cataracts as a side effect from radiation exposure during long-duration space flights.

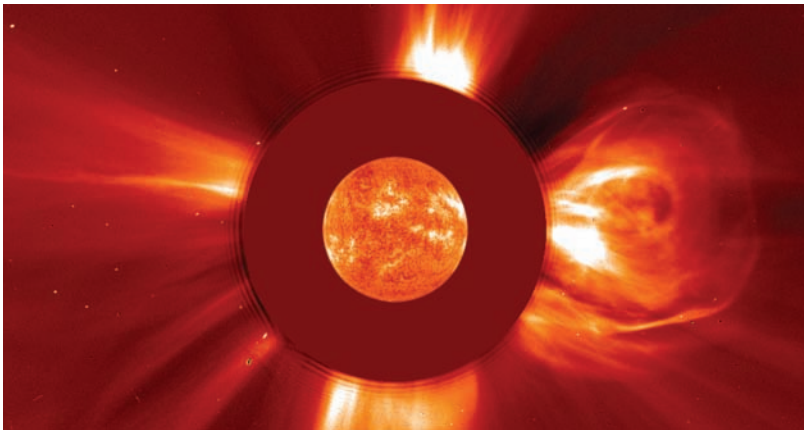
Expanding Evidence for Dark Energy

In 2001, NASA announced that the Hubble Space Telescope had detected a burst of light from an exploding star at an unprecedented distance from Earth. According to scientists, this stellar explosion strengthens the case for the existence of a mysterious form of "dark energy" pervading the universe. The concept of dark energy, which is believed to push galaxies away from each other at continually increasing speeds, was first proposed and then discarded by Albert Einstein early in the 20th century. The recent Hubble discovery reinforces the startling idea that the expansion of the universe is "speeding up." The discovery provides the first observational evidence that gravity began slowing down the expansion of the universe after the Big Bang, and only later did dark energy surpass gravity and begin accelerating the expansion of the universe.

First Complete Recording of a Solar Eruption

In 1997, for the first time, instruments on board the NASA WIND and the European SOHO spacecraft captured the full duration of an interplanetary weather event that carried a blast of high-energy particles from the sun to Earth. The particles from the blast, known as a coronal mass ejection, took four days to reach Earth. The blast pumped vast amounts of energy into the Earth's environment, triggering auroral displays and disrupting radio communications. This was the first solar eruption recorded from start to finish.

The sun has profound effects throughout the solar system, on each planet and the space between them. To explain these effects, we need to understand both the inherent characteristics of the sun and how its emissions interact with the rest of the solar system. On Earth these emissions can have short-term effects, such as interference with satellite communications, as well as possible long-term implications, such as changes to the Earth's climate.

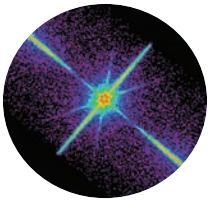


One of the largest solar flares ever recorded occurred at 4:51 p.m. EDT, on Monday, April 2, 2001, as observed by the Solar and Heliospheric Observatory (SOHO) satellite.

NASA Develops Science Curricula with Educational Publisher

NASA and Pearson Education, the world's largest educational publisher, have reached an agreement to develop new science curricula for 100 million elementary and middle school students. The new curricula will be designed to increase student interest in science, technology, engineering, mathematics and space exploration. Content will be supplemented by data from NASA's latest discoveries and technologies.

NASA's contributions to curriculum development continue to increase. For example, in the year 2000, over one-third of astronomy textbook material was based on discoveries made through NASA's space science research.



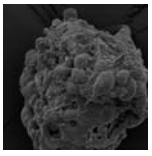
An X-ray image of black hole candidate XTE J1118+480.

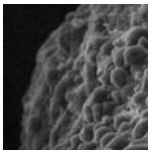
Nobel Prizes

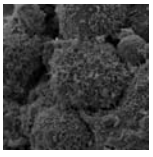
Black Holes—Riccardo Giacconi received the 2002 Nobel Prize in physics for "pioneering contributions to astrophysics" which have led to the discovery of cosmic X-ray sources. Giacconi discovered the first X-ray stars and the X-ray background in the 1960s. With funding from NASA, he also has detected sources of X-rays that most astronomers now believe contain black holes. His continued research with the Chandra X-ray Observatory has led to the discovery that the universe is teeming with black holes, with a super massive black hole existing at the center of the Milky Way Galaxy.

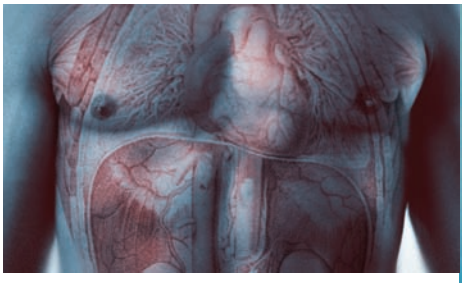
Atom Lasers—The 2001 Nobel Prize for physics was awarded to three scientists, including a Massachusetts Institute of Technology physicist whose NASA-funded research uses ultra-cold atoms that form a new type of matter. The Royal Swedish Academy of Sciences said Dr. Wolfgang Ketterle and two other scientists caused atoms to "sing in unison." Through their research, atomic particles were induced to have the same energy and to oscillate together in a controlled fashion. Laser light has these qualities, but researchers have struggled for decades to make matter behave this way. The breakthrough research has potential uses for extremely precise measurements. The discoveries may lead to microscopic computers and ultra-precise gyroscopes that could dramatically improve aircraft guidance and spacecraft navigation.

space shuttle columbia's legacy









The heart of the Bioreactor Demonstration System (BDMS) is the rotating wall vessel, shown here without its support equipment. During the mission, astronauts studied the interaction of prostate cancer cells and bone cells by using a BDMS to form large samples for research.

Keeping Cells in Suspense

On the Space Shuttle Columbia's final mission, astronauts helped scientists study how prostate cancer cells and bone cells group together or self-assemble. The goal was to learn how the cells interact in the early stages of cancer when the disease begins to spread. Columbia's astronauts used a device invented by NASA called a bioreactor. The bioreactor helps researchers turn cell cultures into functional tissue that can be used for experiments, transplants and drug development. Without a bioreactor, cells fall to the bottom of a Petri dish and grow as a sheet one cell layer thick—thinner than a human hair. In NASA's space bioreactor, the cells stay suspended and form the kind of large samples researchers need. During the Columbia mission, the cell "assembly" grew to the size of a roll of pennies, which is much larger than anything researchers have seen before. The Columbia experiment was so successful that NASA plans to fly similar, longer-term experiments on the International Space Station.

NASA's bioreactor has yielded 25 patents and more than 20 licenses. Over 6,000 bioreactor units are now in hundreds of universities, medical centers and government research agencies such as the National Institutes of Health, the Centers for Disease Control and Prevention and the Navy.

Cleaner Cars

Space flight research is changing our understanding of how and why things burn, a scientific area scientists thought was relatively well established decades ago. A hydrogen experiment on board Columbia's final mission produced the weakest flames ever created—100 times weaker than a birthday candle. This research could lead to cleaner-burning cars in the future by helping scientists improve the burning of hydrogen and other fuels in engines and furnaces. Two corporations, Pratt and Whitney and General Electric, have already used space flight combustion research to improve their jet engines.

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