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Editor
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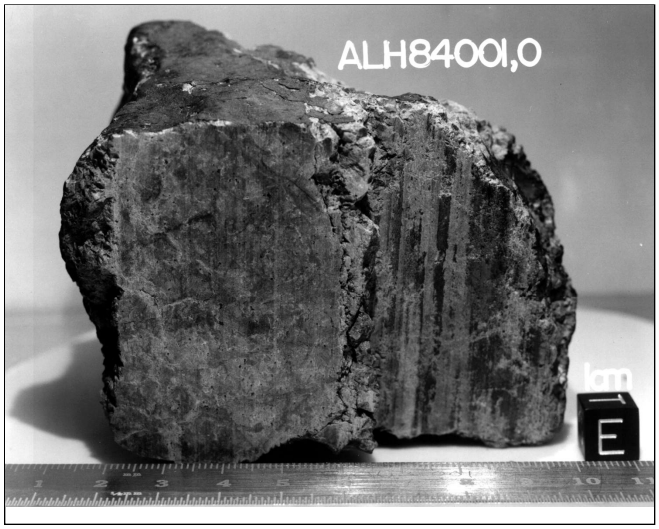
Meteorite Yields Evidence of Primitive Life on Early Mars



A NASA research team of scientists at the Johnson Space Center (JSC), Houston, TX, and at Stanford University, Palo Alto, CA, has found evidence that strongly suggests primitive life may have existed on Mars more than 3.6 billion years ago. The NASA-funded team found the first organic molecules thought to be of Martian origin; several mineral features characteristic of biological activity; and possible microscopic fossils of primitive, bacteria-like organisms inside of an ancient Martian rock that fell to Earth as a meteorite.

The igneous rock in the 4.2-pound, potato-sized meteorite has been age-dated to about 4.5 billion years, the period when the planet Mars formed. The rock is believed to have originated underneath the Martian surface and to have been extensively fractured by impacts as meteorites bombarded the planets in the early inner solar system. Between 3.6 billion and 4 billion years ago, a time when it is generally thought that the planet was warmer and wetter, water is believed to have penetrated fractures in the subsurface rock, possibly forming an underground water system.

Since the water was saturated with carbon dioxide from the Martian atmosphere, carbonate minerals were deposited in the fractures. The team's findings indicate living organisms also may have assisted in the formation of the carbonate, and some remains of the microscopic organisms may have become fossilized, in a fashion similar to the formation of fossils in limestone on Earth. Then, 16 million years ago, a huge comet or asteroid struck Mars, ejecting a piece of the rock from its subsurface location with enough force to escape the planet. For millions of years, the chunk of rock floated through space. It encountered Earth's atmosphere 13,000 years ago and fell in Antarctica as a meteorite.

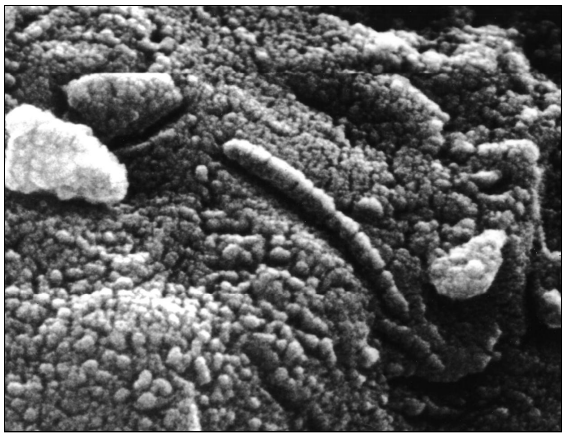
It is in the tiny globs of carbonate that the researchers found a number of features that can be interpreted as suggesting past life. Stanford researchers found easily detectable amounts of organic molecules called polycyclic aromatic hydrocarbons (PAHs) concentrated in the vicinity of the carbonate. Researchers at JSC found mineral compounds commonly associated with microscopic organisms and the possible microscopic fossil structures.

The largest of the possible fossils are less than 1/100 the diameter of a human hair, and most are about 1/1000 the diameter of a human hair—small enough that it would take about a thousand laid end-to-end to span the dot at the end of this sentence. Some are egg-shaped while others are tubular. In appearance and size, the structures are strikingly similar to microscopic fossils of the tiniest bacteria found on Earth.

The meteorite, called ALH84001, was found in 1984 in Allan Hills ice field, Antarctica, by an annual expedition of the National Science Foundation's Antarctic Meteorite Program. It was preserved for study in JSC's Meteorite Processing Laboratory and its possible Martian origin was not recognized until 1993. It is one of only 12 meteorites identified so far that match the unique Martian chemistry measured by the Viking spacecraft that landed on Mars in 1976. ALH84001 is by far the oldest of the 12 Martian meteorites, more than three times as old as any other.

Highlights This Issue:

The unusual tube-like structural form less than 1/100th the width of a human hair in size found in meteorite ALH84001, a meteorite believed to be of Martian origin.



Many of the team's findings were made possible only because of very recent technological advances in high-resolution scanning electron microscopy and laser mass spectrometry. Only a few years ago, many of the features that they report were undetectable. Although previous studies of this meteorite and others of Martian origin failed to detect evidence of past life, they were generally performed using lower levels of magnification, without the benefit of the technology used in this research. The recent discovery of extremely small bacteria on Earth, called nanobacteria, prompted the team to perform this work at a much finer scale than past efforts.

NASA Administrator Daniel Goldin called the evidence "exciting, even compelling, but not conclusive," and declared that "NASA is ready to assist the process of rigorous scientific investigation and lively scientific debate that will follow this discovery."

For more information, visit the following URL: **http://www.jsc.nasa.gov/pao/flash/**

Return to the Red Planet

Mars has inspired wild flights of imagination over the centuries and an intense scientific interest. Fancied to be the source of hostile invaders of Earth, the home of a dying civilization, and a rough-and-tumble mining colony of the future, Mars has proven to be fertile ground for science fiction writers, based on seeds planted by centuries of scientific observation. Mars has shown itself to be most Earth-like of all the planets; it has polar ice caps that grow and recede with the change of seasons, and markings that looked, through 19th century telescopes, to be similar to human-made water canals on Earth, which fueled speculations that Mars was inhabited.

American and Russian orbiters did not disclose any canals on Mars, but did find evidence of surface erosion and dried riverbeds, indicating the planet was once capable of sustaining liquid water. For millions of years, the Martian surface has been barren of water, and not subjected to the volcanism and crustal plate movement that continually resurface Earth. Mars is too cool and its atmosphere is too thin to allow liquid water to exist. It is unlikely that there are extant life forms, but research indicates there may be fossils of life forms from a time when the climate was warmer and there was liquid water.

Mars is a small rocky planet that developed relatively close to the Sun and has been subject to some of the same planetary processes associated with the formation of the other "terrestrial" planets (Mercury, Venus, and Earth), including volcanism, impact events, and erosion. Unlike Earth, Mars retains much of the surface record of its evolution.Layered terrains near the Martian poles suggest that the planet's climate changes have been periodic, perhaps caused by a regular change in the planet's orbit. Martian tectonism—the geological development and alteration of a planet's crust—differs from Earth's. Where Earth tectonics involve sliding plates that grind against each other or spread apart, Martian tectonics seem to be vertical, with hot lava pushing upwards through the crust to the surface. Periodically, great dust storms occur that engulf the entire planet. The effects of these storms are dramatic, and include dunes, wind streaks, and wind carved features.

Mars has some remarkable geological characteristics, including the largest volcano mountain in the solar system, Olympus Mons (27 km high and 600 km across); volcanoes in the northern Tharsis region that are so huge they deformed the planet's sphericity; and a gigantic equatorial rift valley, the Vallis Marineris. This canyon system could easily contain the Grand Canyon and stretches the distance equivalent from New York to Los Angeles.

Mars Exploration

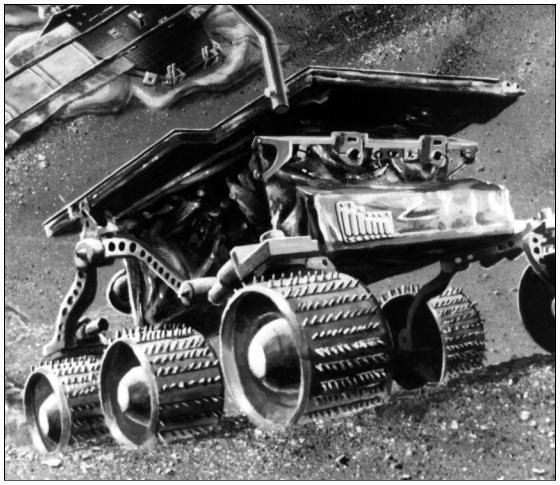
Previous American missions to Mars include *Mariner 4* (1965), which returned close-up pictures of the surface of the planet; *Mariner 6* and *Mariner 7* flybys (1969), which resulted in high-resolution images of the planet's equatorial region and southern hemisphere; *Mariner 9* (1971), which spent nearly two years orbiting and mapping the entire surface of Mars; and *Viking 1* and *Viking 2* (1975), whose landers provided the first sustained surface science.

Mars is named for the Roman God of War. Its maximum distance from the Sun is 249 million km; its minimum distance is 206 million km. Mars' distance from Earth ranges from 56 million km to 399 million km. Its atmosphere is composed mainly of carbon dioxide, with temperature ranges from 295 K (22°C) down to 148 K (–125°C). Mars has two moons, Phobos and Deimos. The *Mariner 9* mission took detailed photos of the two Martian satellites.

Mars Pathfinder

The Mars Pathfinder mission is the second launch in the Discovery Program, a NASA initiative for planetary missions. The mission is primarily an engineering demonstration of key technologies and concepts for eventual use in future missions to Mars employing scientific landers. Pathfinder also delivers science instruments to the surface of Mars to investigate the structure of the Martian atmosphere, surface meteorology, surface geology, form and structure, and the elemental composition of Martian rocks and soil. In addition, a free-ranging surface rover is deployed to conduct technology experiments and to serve as an instrument deployment mechanism.

The flight system will be launched on a Delta launch vehicle from the Cape Canaveral Air Force Station. The mission launch window is a 24-day period beginning on December 2, 1996. After launch, the spacecraft requires six to seven months to reach Mars, depending on the exact launch date. During this phase, a series of four Trajectory Correction Maneuvers (TCMs) will be performed, to fine tune the flight path. Tracking, telemetry, and command operations with the spacecraft will be conducted using the giant dish antennas of the NASA/Jet Propulsion Laboratory (JPL) Deep Space Network (DSN). Upon arrival at Mars on July 4, 1997, the spacecraft will enter the Martian atmosphere, and then deploy the parachute, rocket braking system, and air bag system for a soft, upright landing. At this point the primary data-taking phase begins, and continues for 30 Martian days (the Martian day is equivalent to 24.6 hours).



This artist's rendering shows the Mars Pathfinder rover in operation on the Martian surface in July 1997.

During this time, the microrover is deployed and operated for at least seven sols (Martian days). If the lander and rover continue to perform well at the end of this period, an extended mission may continue for up to one Martian year (1.88 Earth-years) for the lander, and for up to 30 sols for the microrover.

Mars Global Surveyor Mission

With the journey by Mars Global Surveyor (MGS), scheduled to launch in November 1996, NASA continues a program of Mars exploration begun in 1971 by *Mariner 9,* and commencing with a series of missions to the Red Planet every 26 months.

The MGS spacecraft will travel hundreds of millions of kilometers to carry out an extensive study of Mars using its suite of sophisticated remote-sensing instruments. The entire Martian globe will be photographed every day to provide a daily Mars "weather map." The goal is to create a global portrait of Mars by surveying the planet's topography, magnetism, mineral composition, and atmosphere. The MGS mission is expected to make an enormous contribution to the archive of Mars data, giving scientists new perspectives in addressing the many questions about Mars and about the evolution of the planets of the inner solar system. The mission will also help pave the way for the missions of the 21st century that will carry automated rovers, and eventually astronauts, to Mars.

For more information on the Mars Pathfinder and Mars Global Surveyor missions, visit the following URLs:

http://mpfwww.jpl.nasa.gov/

http://mgs-www.jpl.nasa.gov/

The Mars Pathfinder and Mars Global Surveyor Missions are managed for NASA by the Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA.

PLANETFEST

Planetfest '97, a three-day international conference and exhibition, will take place at the Pasadena Convention Center, Pasadena, CA, July 3–6, 1997. Planetfest '97 is a celebration of international cooperative and collaborative planetary exploration, with thousands of attendees witnessing the landing of the Pathfinder on Mars and real-time images of the Red Planet.

Planetfest '97 will host special exhibitions, hands-on activities, interactive technological programs, and a demonstration of the power of the Internet as Planetfest '97 reaches an international audience with a worldwide Internet presence, including presentations, debates, and discussions by some of the most renowned and popular scientists today. Through a variety of interactive exhibitions, seminars, and displays, Planetfest '97 is designed to involve humankind and to open the mind and the senses to the greatest adventure of all—planetary exploration.

Planetfest '97 is presented by The Planetary Society, a nonprofit organization committed to making new ventures in exploration happen around the world through creative research test programs, astronomical observations, student activities, studies, conferences, and workshops. Founded in 1980 by Carl Sagan and Bruce Murray, The Planetary Society is the largest nongovernmental space organization in the world, having a membership of more than 100,000.

For information on Planetfest '97, contact:

Cindy Jalife
The Planetary Society
65 North Catalina Avenue
Pasadena, CA 91106
818-793-5100
818-793-5528 (fax)

Geri Wilson
The Jonathan Group
1407 Rollin Street
South Pasadena, CA 91030
818-799-3505
818-799-3558 (fax)

In 1996 NASA will launch two missions to Mars, and by participating in **Passport to Knowledge**, you and your students can travel along! Passport to Knowledge is a series of electronic field trips to scientific frontiers that uses live interactive television and online computer networks to bring real science, real scientists, and real locations in real time directly into the classroom. In the 1996-97 school year, Passport to Knowledge, in collaboration with the Mars Exploration Directorate of NASA's Jet Propulsion Laboratory, will present ***Live from Mars***. A series of four live broadcasts, combined with extensive online resources and a Teacher's Kit suggesting hands-on discovery activities, will let students follow and simulate both the Mars Global Surveyor and Mars Pathfinder missions. The project also will document the search for life on Mars; connect across the disciplines to mathematics, language arts, social studies, and geography; and provide teachers and students with the most current research available on biology, robotics, geology, and comparisions between the planets of our solar system.

The Broadcasts:November 19, 1996, 1:00 to 2:00 p.m.Eastern, *Countdown*—live from the "pad"at Cape Canaveral;April 24, 1997, 1:00 to 2:00 p.m. Eastern, *Cruising the Planets*—live from NASA's Jet Propulsion Laboratory; July 4–5, 1997, a primetime celebration of the first spacecraft to land on Mars since 1976;and November 1997, time to be announced, *Today on Mars* will conclude with a summary of the mission and its results. All broadcasts are free and available over most PBS stations and NASA-TV. Please check with your local stations for specifics.

ONLINE: an integrated array of online activities will make the experience truly interactive. These include journals from the Mission Team, Q&A, collaborative online activities, the Live from Mars Teacher's Guide, lesson plans, and imaging activities. This part of the project is managed by NASA's K–12 Internet Initiative. To sample our existing online materials on the World Wide Web, point your browser to: **http://quest.arc.nasa.gov**. Under "Interactive Projects," you will find links to all Passport to Knowledge projects.

For additional information on Live from Mars, send e-mail to: *listmanager@quest.arc.nasa.gov*. In the message body write: subscribe updates-lfm, or call the toll-free hotline: 1-800-626-LIVE (626-5483), or write Passport to Knowledge, P.O. Box 1502, Summit, NJ 07901.

Passport to Knowledge is made possible by the National Science Foundation, NASA, PBS Teacher Resource Services, and public television.

SpaceLink

NASA Spacelink is an electronic information system for educators and students containing NASA information and educational materials. The service includes current NASA news, data about America's aerospace program, classroom materials, software, NASA images, and other information useful to teachers and students. Special features available to registered educators include newsgroups, electronic mail, online conferences, and access to other NASA resources available on the Internet.

Spacelink may be accessed by a computer through direct-dial modem or the Internet:

Modem line: (205) 895-0028, VT-100 terminal emulation, 8-N-1 data format

Internet Telnet, Anonymous FTP, Gopher: **spacelink.msfc.nasa.gov** (192.149.89.61)

Internet World Wide Web: **http://spacelink.msfc.nasa.gov**

Need More Space? Watch NASA Television

NASA Television (NTV) features video files highlighting current events, scientific discoveries and technological innovation, and human missions to space. Astronauts, scientists, and other explorers are interviewed live via satellite from space centers around the country as well as on location. NTV also features educational programs and live coverage of special NASA events.

NTV is available on:

SPACENET 2 (C-Band)

69 Degrees West

Transponder 5, Channel 9

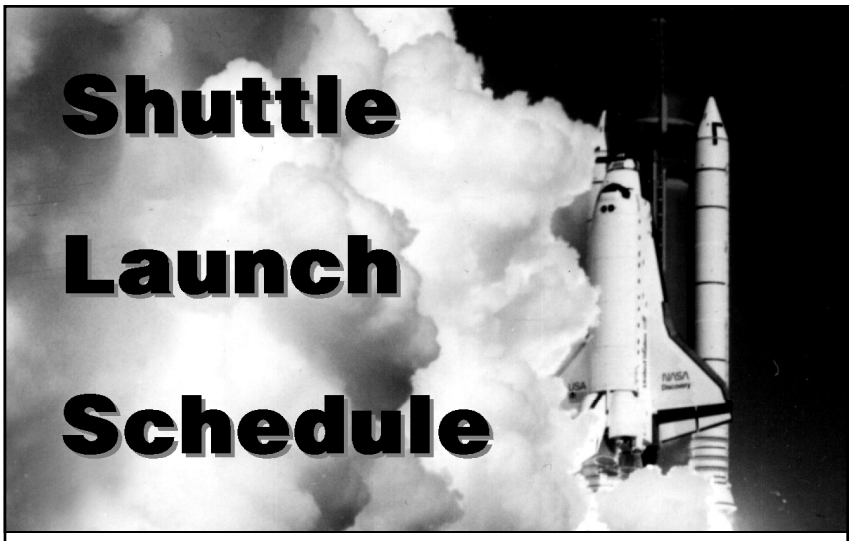
3800 MHz

Audio 6.8 MHz

Horizontal Polarization

Information on NTV's schedule may be obtained by calling the automated phoneline at 202-358-ELSA (3572), or at the following URL:

http://www.hq.nasa.gov/office/pao/Television/ntvtext3.html



STS-80
Columbia
Five-member crew
Payload: ORFEUS-SPAS-2*;WSF-3**
Estimated launch date: October 31, 1996
Estimated duration: 15 days

STS-81
Atlantis
Six-member crew (Mission Specialist Jerry Linenger will switch places with Mission Specialist John Blaha [STS-79] on Mir, during this shuttle/Mir docking.)
Payload: 5th Mir Docking, Spacehab - DM
Estimated launch date: December 5, 1996
Estimated duration: 9 days

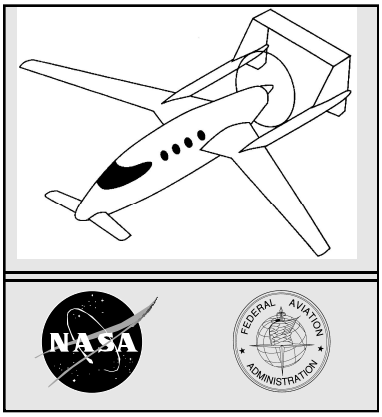
STS-82
Discovery
Seven-member crew
Payload: Hubble Space Telescope Servicing-2
Estimated launch date: February 13, 1997
Estimated duration: 9 days

STS-83
Columbia
Seven-member crew
Payload:MSL-1 +
Estimated launch date: March 20, 1997
Estimated duration: 16 days

STS-84
Atlantis
Crew:TBD
Payload: 6th Mir Docking, Spacehab - DM
Estimated launch date: May 1, 1997
Estimated duration: 9 days

* Orbiting Retrievable Far and Extreme Ultraviolet Spectrometer-Shuttle Pallet Satellite
** Wake Shield Facility
\+ Microgravity Science Lab

Announcing the Third Annual National General Aviation Design Competition



NASA and the Federal Aviation Administration are sponsoring a National General Aviation Design Competition for students at U.S. aeronautical and engineering universities for the 1996–97 academic year. The contest challenges teams of undergraduate and/or graduate students, working with faculty advisors, to address design challenges for a small aircraft transportation system.

This competition, which is in its third year, allows university students to participate in a major national effort to rebuild the U.S. general aviation sector. It is intended to help raise student awareness of the value of general aviation for business and personal use and its economic relevance. Revitalization goals present excellent open-ended design challenges to stimulate engineering students and to provide the basis for a quality educational experience. All design packages will be reviewed by a panel of industry and government experts, and feedback will be provided.

U.S. colleges with at least four-year accredited engineering programs may compete. It is anticipated that this project will be undertaken as part of a formal undergraduate or graduate engineering course.

A letter of intent to participate in the competition must be submitted by the faculty advisor, and letters must be received no later than January 21, 1997. Individuals providing letters of intent will receive additional general aviation background material, which will be helpful in the design process, as well as additional information on evaluation criteria and any other competition updates as they become available. **It is in the team's interest to submit a letter of intent as early as possible.**

Teams should address design challenges in one or more of the following technical areas: Integrated Cockpit Systems; Propulsion, Noise, and Emissions; Integrated Design and Manufacturing; Aerodynamics; Operating Infrastructure; and Unconventional Designs, such as Air-Cars.

Specific engineering objectives for general aviation revitalization are provided in the competition guidelines, which may be obtained from the Virginia Space Grant Consortium, Old Dominion University Peninsula Graduate Engineering Center, 2713-D Magruder Boulevard, Hampton, VA 23666.

At least four cash awards will be announced in July 1997.

1997 NASA Reduced-Gravity Student Flight Opportunities

Students monitor experiments aboard the NASA 931.

Proposals are due November 22, 1997, for NASA Reduced-Gravity Student Flight Opportunities, a NASA-sponsored pilot program administered by the Texas Space Grant Consortium. Teams of undergraduate students from Space Grant-affiliated universities and colleges nationwide are encouraged to submit proposals to fly experiments aboard the NASA 931, Johnson Space Center's (JSC) flying reduced-gravity laboratory.

The 1997 NASA Reduced-Gravity Student Flight Opportunities pilot program provides a unique academic experience for undergraduate students to successfully propose, design, fabricate, fly, and assess a reduced-gravity experiment of their choice over the course of eight months. That experience will include scientific scholarship, hands-on test operations, and education/public outreach activities. The program is designed to encourage teams to participate either as an organized class project or as an independent study project. It is recommended that the participating team's academic institution convey class credit for the successful completion of the program.

The 1997 NASA Reduced-Gravity Student Flight Opportunities pilot program will provide access to NASA's JSC Reduced-Gravity Program to 25 teams. Each team may include up to four undergraduate students, a supervising faculty member, and one journalist.Any two of a team's four students and the journalist will be able to fly on each of two flights, enabling all students to fly at least once and the journalist twice. Only proposals from academic institutions affiliated with National Space Grant College and Fellowship Program consortia will be considered.

Letters of Intent are due October 4, 1996. Proposals are due November 22, 1996. Teams will be announced December 20, 1996. Flights will take place the last week in March and first week in April 1997.

A copy of the Competition Guidelines for the 1997 NASA Reduced-Gravity Student Flight Opportunities pilot program may be obtained at the following URL: **http://www.utexas.edu/tsgc/floatn.html** or from Burke Fort, Texas Space Grant Consortium, at e-mail address *fort@mail.utexas.edu*; telephone 512-471-7225; fax 512-471-3585; or write Burke Fort, 1997 NASA Reduced-Gravity Student Flight Opportunities, Texas Space Grant Consortium, 3925 West Braker Lane, Suite 200, Austin, TX 78759-5321.

1996 SHARP Plus Apprentices Selected

NASA and the Quality Education for Minorities (QEM) Network selected 300 high school students as apprentices to engage in cutting-edge science and engineering research activities as part of NASA's SHARP Plus Research Apprenticeship Program.

The program enables students, under the guidance of industry or university-based mentors, to spend eight weeks in residence at 14 universities that have joined with NASA and QEM to increase the participation and success rates of highly talented students who are underrepresented in mathematics and science courses at the precollege level. Chosen from a pool of 1,000 applicants, the apprentices (179 female and 121 male students) come from 29 states, Puerto Rico, the U.S. Virgin Islands, Washington, D.C., and a U.S. military base in Germany.

SHARP Plus sets high academic standards and seeks to increase, strengthen, and diversify the pool of students for mathematics, science, and engineering college majors and careers. The program is administered by QEM for NASA's Education Division, which is tasked to promote excellence in America's education system by involving the education community in endeavors to inspire American students, create learning opportunities, and enlighten inquisitive minds. The QEM Network is a nonprofit organization dedicated to improving the education of minorities and other underrepresented groups throughout the Nation. It serves as a focal point for the implementation of strategies to help realize the vision and goals set forth in the 1990 QEM Project Report, *Education That Works: An Action Plan for the Education of Minorities*.

Each year, applications for the 300 apprenticeships expected to be available are due at the QEM Network by March 1, and applicants will be notified by May 15. The eight-week program operates from about mid-June to mid-August. Applications may be obtained by contacting: QEM Network, NASA SHARP Plus Program, Suite 350, 1818 N Street, NW, Washington, DC 20036; telephone 202-659-1818; fax 202-659-5408; e-mail *sharpplus@qem.org.*

NASA SSIP Winners Honored in Washington, D.C.

Twenty-seven students from public and private schools across the United States won national recognition in NASA's 16th annual Space Science Student Involvement Program (SSIP) competition. The students were honored along with their teachers in May at the National Space Symposium in Washington, D.C. In addition to their recognition in Washington, the students have the opportunity to intern at a NASA field center for a week and receive a Space Camp scholarship.

The competition, co-sponsored by NASA and the National Science Teachers Association, is an interdisciplinary program designed to address the need for greater literacy in the areas of science, critical and creative thinking, mathematics, and technology. More than 10,000 students in elementary, junior high, and high school competed in five categories, using their skills in mathematics, science, technology, art, and creative writing. Thousands of teachers throughout the United States successfully use SSIP to support curricular goals, spark student interest, encourage creative thinking across disciplines, and involve students in science process skills.

The deadline for entry in SSIP is January 10, 1997. To obtain the official entry form and competition rules, write the National Science Teachers Association, Attention: SSIP Competition, 1840 Wilson Boulevard, Arlington, VA 22201-3000, or e-mail your request to *ssip@nsta.org*.

Teacher Workshops

NASA's Education Workshops for Elementary School Teachers (NEWEST) and NASA's Education Workshops for Mathematics, Science, and Technology Teachers (NEWMAST) provide teachers with an opportunity to observe NASA's state-of-the-art research and development activities through direct interaction with NASA scientists, engineers, technicians, and education specialists at one of NASA's 10 field centers. During the two-week workshop, participants will visit research and applied science facilities; examine topics relating to Mission to Planet Earth, Aeronautics, Human Exploration and Development of Space, Space Science, and Space Technology; collect and review educational materials; and share their teaching experiences and ideas with other participants. Special activities conducted throughout the workshop help teachers translate their new content knowledge, experience, and materials into an educational format specific to their situation.

Applications can be obtained from NASA Teacher Resource Centers or contact the National Science Teachers Association (NSTA) at: NSTA, Space Science and Technology Programs, 1840 Wilson Boulevard, Arlington, VA 22201-3000; fax 703-522-5413; e-mail *nenmrequest@nsta.org.*

Applications must be postmarked no later than February 15, 1997. Travel expenses, housing, and meals are covered under this program.

NEWEST and NEWMAST are sponsored by NASA and are implemented in cooperation with NSTA, the National Council of Teachers of Mathematics, and the International Technology Education Association.

NASA Awards Precollege Grants to Nine Universities

NASA's Office of Equal Opportunity Programs announced the selection of nine minority universities to receive a three-year grant—Precollege Awards for Excellence in Mathematics, Science, Engineering, and Technology (PACE/MSET)—for educational outreach projects. Each university will receive up to $100,000 per year for the three years of the grant based on performance and availability of funds under the program.

The grants are intended to help students who have historically been underrepresented in college-preparatory mathematics and science classes gain the skills necessary to pursue science, engineering, and related fields in college.

The selected universities to receive grants are:

- California State University, Los Angeles, CA
- Elizabeth City State University, Elizabeth City, NC
- Fayetteville State University, Fayetteville, NC
- Hampton University, Hampton, VA
- Lehman College, Bronx, NY
- Northwest Indian College, Bellingham, WA
- Pasadena City College, Pasadena, CA
- Southwestern Indian Polytechnic, Albuquerque, NM
- Saint Augustine's College, Raleigh, NC

The grant program targets institutions of higher education, especially Historically Black Colleges and Universities, Hispanic Serving Institutions, Tribal Colleges, and other minority universities whose student enrollment of underrepresented minorities exceeds 50 percent.

The PACE/MSET grant program is sponsored by the NASA Office of Equal Opportunity Programs, Washington, D.C.

NASA Awards Microgravity Combustion Research Grants

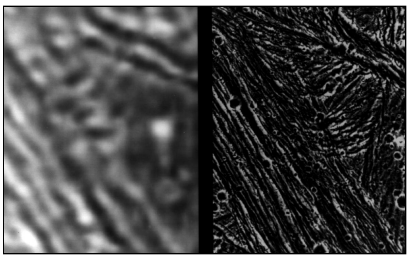
NASA has selected 20 researchers to receive grants totaling more than $7 million for microgravity combustion research. Sponsored by NASA's Office of Life and Microgravity Science and Applications, Washington, D.C., combustion research involves many important technology applications, including fuel-efficient automobiles, pollution control, fire safety, and space propulsion. Combustion researchers use the low-gravity environment of space as a tool to gain new insights into these physical and chemical processes.

Seventeen of the grants are for ground-based research, while the remaining three are for flight-definition projects. Two of these grants are for continuation of work currently being funded by NASA; the remaining 18 programs represent new research efforts.

The investigators will utilize NASA's microgravity research facilities, such as drop tubes, drop towers, aircraft flying parabolic trajectories, and sounding rockets, with the flight-definition investigators working toward experiments on a spaceflight testbed.

NASA received 110 proposals in response to this research announcement. These proposals were all peer-reviewed by scientific and technical experts from academia, government, and industry. In addition, proposals selected for flight definition were reviewed in terms of engineering feasibility by a team from NASA's Lewis Research Center, Cleveland, OH.

Ganymede



These images demonstrate the dramatic improvement in the resolution of pictures that NASA's Galileo spacecraft is returning compared to previous images of the Jupiter system.The frame at left was taken by the Voyager 2 spacecraft in 1979, with a resolution of about 1.3 kilometers (0.8 miles) per pixel.The frame at right showing the same area was captured by Galileo during its first flyby on June 27;it has a resolution of about 74 meters (243 feet) per pixel, more than 17 times better than that of the Voyager image. Ancient impact craters shown in this image testify to the great age of the terrain, dating back several billion years. To learn more about Ganymede, visit **http://www.jpl.nasa.gov/galileo/**

Utah State University Develops Space Crop

The first crop developed specifically for growth in space has been developed at Utah State University, Logan, Utah. A space-age wheat variety, USU-Apogee, produces the equivalent of almost 600 bushels of grain per acre—three times the top yields from most fields.

It took more than a decade to develop a wheat suitable for space farms, where the artificial sun always shines, carbon dioxide levels are high, and space is at a premium. Apogee thrives under those conditions. Its heads emerge 23 days after germination, about a week sooner than some varieties grown in controlled environments. So far, Apogee's baking characteristics pass muster, at least on Earth.Making bread in space is still uncharted territory.

On long-duration space missions, it will be more economical to provide life support supplies by producing food, such as Apogee, potable water, and breathable air by recycling metabolic and other wastes. It is not known whether the new variety will make it to the Moon or Mars, but it is likely to be grown on the International Space Station scheduled for completion in 2002.

Bruce Bugbee, the USU crop physiologist who developed the variety, has worked with NASA for almost 15 years. He heads a NASA-supported university research facility to develop food crops for space in a complex consisting of 30 computer-controlled growth chambers of various sizes, in addition to several greenhouses.

Previously, the only wheat to be grown in space was Superdwarf, a short line (about 10 inches tall) that Bugbee originally found in Mexico. Superdwarf's short height was an attribute, but it grew poorly and produced low yields in the prototype space farms, known as regenerative life support systems.

Apogee, which is the term for the point in orbit farthest from Earth, is a dwarf hard red spring wheat, developed from thousands of segregating lines. It produces few tillers, or branches, which tend to sap energy that a plant devotes to grain production. It fits the bill for space farming—short (about 18 inches tall when mature), producing an unusually large number of seeds, and exhibiting luxuriant green leaves. Other wheat grown in controlled environments tended to develop yellow leaf tips characteristic of calcium deficiency, often killing 30 percent of the leaf.

To boost growth and yields, plants destined for space are always bathed in light, at a constant temperature and in air enriched with carbon dioxide, Bugbee said. Their roots never touch soil. All are grown hydroponically or in a crumbly substrate.

Apogee is not likely to be as popular on Earth as other crop varieties. Its yields are comparable to taller field varieties, but its shortness hampers harvest and limits its ability to compete with weeds.

The USU-Apogee crop

Bugbee provides free samples of Apogee to research laboratories around the world—and to schools. To receive seed of Apogee, contact Bugbee at the Crop Physiology Laboratory, Department of Plants, Soils, and Biometeorology, Utah State University, Logan, UT 84322-4820, or e-mail *bugbee@cc.usu.edu*. For information on USU-Apogee, hydroponics, and other aspects of USU crop research, visit the following URL:

http://wwww.usu.edu/~cpl/index.html

The wheat variety's development was funded by NASA's Office of Life and Microgravity Sciences and Applications and the Utah Agricultural Experiment Station.

NASA Field Centers

NASA is composed of Headquarters operations, located in Washington, D.C., and 10 field centers situated throughout the country. While NASA Headquarters oversees operations at the centers, the centers conduct local and regional programs for teachers, students, and faculty, ranging from workshops to summer internships.

For information on K-12 opportunities, contact personnel listed below.

Residents of Alaska, Arizona, California, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming contact:

Ames Research Center
Mr. Garth A.Hull
Special Assistant:Educational Programs
Mail Stop 204-12
Moffett Field, CA 94035-1000

California cities near Dryden Flight Research Center contact:

Dryden Flight Research Center
Dr. Marianne McCarthy
Education Specialist
PO Box 273, MS D4839A
Edwards, CA 935234-0273

Residents of Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont contact:

Goddard Space Flight Center
Dr. Robert Gabrys
Chief, Education Office
Code 130.3
Greenbelt, MD 20771-0001

Residents of Colorado, Kansas, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, and Texas contact:

Johnson Space Center
Ms. Billie A.Deason
Education Team Leader
Education and Information Services Branch-AP 2
2101 NASA Road One
Houston, TX 77058-3696

Residents of Florida, Georgia, Puerto Rico, and Virgin Islands contact:

Kennedy Space Center
Mr. Steve Dutczak
Chief, Education and Services Branch
Mail Code PA-ESB
Kennedy Space Center, FL 32899-0001

Residents of Kentucky, North Carolina, South Carolina, Virginia, and West Virginia contact:

Langley Research Center
Dr. Marchelle Canright
Center Education Program Officer
Mail Stop 400
Hampton, VA 23681-0001

Residents of Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin contact:

Lewis Research Center
Ms. Jo Ann Charleston
Acting Chief, Office of Educational Programs
Mail Stop 7-4
21000 Brookpark Road
Cleveland, OH 44135-3191

Residents of Alabama, Arkansas, Iowa, Louisiana, Missouri, and Tennessee contact:

Marshall Space Flight Center
Mr. Jim Pruitt
Director, Education Programs Office
Mail Stop CL01
Huntsville, AL 35812-0001

Residents of Mississippi contact:

John C.Stennis Space Center
Dr. David Powe
Manager, Educational Programs
Mail Stop MA00
Stennis Space Center, MS 39529-6000

For inquiries related to planetary exploration, contact:

Jet Propulsion Laboratory
Dr. Fredrick Shair
Manager, Educational Affairs Office
Mail Code 183-900
4800 Oak Grove Drive
Pasadena, CA 91109-8099

For information on programs for university students and faculty, contact personnel listed below:

Ames Research Center
Mr. Aaron Hatch
[Space Grant, EPSCoR*, Minority Programs]
Mail Code 241-3
Moffett Field, CA 94035
Ms. Meredith Moore [SFFP**, GSRP +, RRA++]
Mail Code 241-3
Moffett Field, CA 94035

Dryden Flight Research Center
Mr. Lee Duke
P.O. Box 273, Mail Stop D4839A
Edwards, CA 93523-0273

Goddard Space Flight Center
Dr. Gerald Soffen
Mail Code 160
Greenbelt Road
Greenbelt, MD 20771

Johnson Space Center
Dr. Donn Sickorez
Code AP-2
Houston, TX 77058

Jet Propulsion Laboratory
Ms. Carol Hix
Mail Stop 183-900
4800 Oak Grove Drive
Pasadena, CA 91109
Dr. Fredrick Shair
Mail Stop 183-900
4800 Oak Grove Drive
Pasadena, CA 91109

Kennedy Space Center
Mr. Gregg Buckingham
Attn:HM-CIU
Kennedy Space Center, FL 32899

Langley Research Center
Mr. Edwin Prior
Mail Stop 400
Hampton, VA 23681-0001
Mr. Roger A.Hathaway
Mail Code 400
Hampton, VA 23681-0001

Lewis Research Center
Dr. Francis Montegani
Mail Stop CP-1
21000 Brookpark Road
Cleveland, OH 44135

Marshall Space Flight Center
Dr. Frank Six
Code DS01
MSFC, AL 35812

Stennis Space Center
Dr. Armond Joyce
Science & Technology Branch
Stennis Space Center, MS 39529

* Experimental Program to Stimulate Competitive Research. EPSCoR is designed to strengthen the research capability of states not competitive in space and aeronautical research and development activities.
** Summer Faculty Fellowship Program
\+ Graduate Student Researchers Program
++ Resident Researchers Associateship Program—the National Research Council Post-doctoral Program

NASA Teacher Resource Center Network

Although NASA educational materials relate primarily to mathematics, science, and technology, they can be valuable curriculum supplements for all subjects. To help disseminate these materials to educators, NASA's Education Division established the NASA Teacher Resource Center Network. In addition to the Teacher Resource Centers (TRCs) listed below, NASA has formed partnerships with school systems, planetariums, museums, and other nonprofit organizations to serve as Regional Teacher Resource Centers (RTRCs). A list of RTRCs is available electronically through NASA Spacelink (page 5) or by contacting NASA Central Operation of Resources for Educators (CORE). These facilities are the principal distribution points where educators may copy NASA text, audio, visual, and computer materials.

TRCs are located on or near NASA field centers, and they offer a variety of NASA-related educational materials in several formats: videotapes, slide sets, audio tapes, and publications, including teachers guides with activities. Teachers may preview, copy or receive NASA materials at the sites listed below.

Residents of Alaska, Arizona, Californiia, Hawaii, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming contact the fol - lowing TRC:

NASA Ames Research Center
Teacher Resource Center
Mail Stop T12-A
Moffett Field, CA 94035-1000
(415) 604-3574

Residents of California (mainly cities near Dryden Flight Research Center) contact the following TRC:

NASA Dryden Flight Research Center
Public Affairs Office (Trl.42)
Teacher Research Center
Edwards AFB, CA 93523-0273
(804) 258-3456

Inquiries related to solar system and planetary exploration:

NASA Jet Propulsion Laboratory
Teacher Resource Center
JPL Educational Outreach
4800 Oak Grove Drive
Mail Code CS-530
Pasadena, CA 91109-8099
(818) 354-6916

Residents of Connecticut, Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, and Vermont contact the fol - lowing TRC:

NASA Goddard Space Flight Center
Teacher Resource Laboratory
Mail Code 130.3
Greenbelt, MD 20771-1000
(301) 286-8570

Residents of Virginia's and Maryland's Eastern Shores contact the following TRC:

NASA Goddard Space Flight Center
Wallops Flight Facility
Education Complex, Visitor Center
Teacher Resource Lab
BIdg.J-17
Wallops Island, VA 23337-5099
(804) 824-2297/2298

Residents of Florida, Georgia, Puerto Rico, and Virgin Islands contact the following TRC:

NASA John F. Kennedy Space Center
Educators Resources Laboratory
Mail Code ERL
Kennedy Space Center, FL 32899-0001
(407) 867-4090

Residents of Colorado, Kansas, Nebraska, New Mexico, North Dakota, Oklahoma, South Dakota, and Texas contact the following TRC:

NASA Johnson Space Center
Teacher Resource Center
Mail Code AP 2
2101 NASA Road One
Houston, TX 77058-3696
(713) 483-8696

Residents of Kentucky, North Carolina, South Carolina, Virginia, and West Virginia contact the following TRC:

NASA Teacher Resource Center for Langley Research Center
Virginia Air and Space Center
600 Settler's Landing Road
Hampton, VA 23669-4033
(804) 727-0900 x757 (touch tone)

Residents of Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin contact the following TRC:

NASA Lewis Research Center
Teacher Resource Center
Mail Stop 8-1
21000 Brookpark Road
Cleveland, OH 44135-3191
(216) 433-2017

Residents of Mississippi contact the following TRC:

NASA Stennis Space Center
Teacher Resource Center
Building 1200
Stennis Space Center, MS 39529-6000
(601) 688-3338

Residents of Alabama, Arkansas, Iowa, Louisiana, Missouri, and Tennessee contact the following TRC:

NASA Teacher Resource Center for Marshall Space Flight Center
U.S. Space & Rocket Center
P.O. Box 070015
Huntsville, AL 35807-7015
(205) 544-5812

Complete and mail to NASA, Education Division, Mail Code FE, Washington, DC 20546-0001. Print clearly and give complete address. Please include old mailing label.

Action Required
- ❑ New
- ❑ Name/Address Change
- ❑ Drop From List

NASA Educational Program Interests
- ❑ (A) Teacher/Faculty Preparation and Enhancement Opportunities
- ❑ (B) Student Opportunities
- ❑ (C) Educational Technology
- ❑ (D) Curriculum Support Materials

Name	First	(M.I.)	(Last)
School/Organization			
Street Address			
City	State	ZIP Code	Country

Educational Horizons is available electronically through NASA Spacelink in the Educational Services area. Spacelink can be accessed by computer through direct-dial modem or the Internet. Modem line: (205) 895-0028; Terminal Emulation: VT-100 required; Data format: 8-N-1. Spacelink fully supports the following Internet services: World Wide Web (http://spacelink.msfc.nasa.gov); Telnet, Gopher and Anonymous FTP (spacelink.msfc.nasa.gov); Internet TCP/IP address (192.149.89.61).

Your Position
- ❑ (A) Administrator
- ❑ (B) Teacher/Faculty
- ❑ (C) Counselor/Advisor
- ❑ (D) Planetarium/Museum
- ❑ (E) Librarian
- ❑ (F) Other *(Please Specify)* _____

Grade Level Taught
- ❑ (A) Preschool
- ❑ (B) Grades K–4
- ❑ (C) Grades 5–8
- ❑ (D) Grades 9–12
- ❑ (E) College/University
- ❑ (F) Other *(Please Specify)* _____

Area(s) of Instruction
- ❑ (A) Elementary—All Subjects
- ❑ (B) Physical Science
- ❑ (C) Life Science
- ❑ (D) Earth Science
- ❑ (E) Space Science
- ❑ (F) Mathematics
- ❑ (G) Technology

Area(s) of Instruction (con't.)
- ❑ (H) Engineering
- ❑ (I) Social Studies
- ❑ (J) Art
- ❑ (K) Music
- ❑ (L) Language Arts
- ❑ (M) Other *(Please Specify)* _____

Educational Publications

Educational Resource Publications

Technology Today Magazine (April 1996)

Lithographs

Crew of Space Shuttle Mission STS-77 (JSCLL-151)
Crew of Space Shuttle Mission STS-78 (JSCLL-152)

Posters

Aeronautics Posters (set of three)
- Commercial Aircraft (WED-116)
- Research Aircraft (WED-117)
- General Aviation Aircraft (WED-118)

Videotapes

To obtain the following videotape, contact CORE:

Microgravity (Physical Science Grades 5–12) describes the restrictions that gravity imposes on scientific experimentation and how they can be reduced in the environment of the Space Shuttle. Length: 23:24.

Central Operation of Resources for Educators (CORE)

CORE provides NASA educational audiovisual materials at cost, plus shipping and handling. An educator may request a catalog and an order form from CORE by writing on school letterhead or by telephoning:

NASA CORE
Lorain County Joint Vocational School
15181 Route 58 South
Oberlin, OH 44074
216-774-1051, ext. 293/294

Upcoming Events

Visit NASA personnel and learn more about NASA's education programs at the following events:

• **National Science Teachers Association Western Area Convention**	**Phoenix, AZ**	**October 17–19,1996**
• **National Science Teachers Association Electronic Town Meeting** (for more information, contact *erma.anderson@nsta.org*)		**October 17, 1996**
• **National School Boards Association Technology and Learning Conference**	**Dallas,TX**	**October 23–25,1996**
• **Association of Science-Technology Centers**	**Pittsburgh, PA**	**October 26–29, 1996**
• **National Science Teachers Association Southern Area Regional Convention**	**Atlanta, GA**	**Oct. 31–Nov. 2,1996**
• **TEL*ED and Multimedia International Conference on Telecommunications in Education/Multimedia**	**Tampa, FL**	**December 6–7,1996**
• **National Science Teachers Association Global Summit on Science and Science Education**	**San Francisco, CA**	**December 27–29,1996**

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