

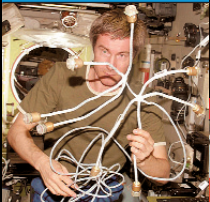
# LIVING & WORKING IN SPACE



EXERCISING



WORKING



SLEEPING



PREPARING FOOD



WASHING HAIR



Smithsonian  
National Air and Space Museum



# LIVING AND WORKING IN SPACE

## OVERVIEW

This introduction to space exploration provides activities that increase students' awareness of the environmental conditions of space, the challenges that must be overcome to live and work there, and advances in spacesuit technology. Students consider various reasons for going to space and compare conditions in space with those on Earth. As a culminating activity, they analyze how a modern spacesuit enables astronauts to live and work under extremely hostile conditions.

The poster is designed as a flexible teaching tool. The activity is written for fifth- through eighth-grade students who are studying space, but older students also can benefit from the activities and extensions. You are encouraged to visit the Smithsonian's National Air and Space Museum in person or on the Web in order to give students the opportunity to see historic spaceflight artifacts. However, if you and your students are unable to visit the Museum, you can still use the poster and activity as a worthwhile part of your science program.

**GRADE LEVEL: 5 THROUGH 8**

**TIME REQUIRED: ONE TO THREE CLASS PERIODS (50 MINUTES EACH)**

## OBJECTIVES

- List several major reasons why humans travel to space
- Compare environmental conditions in space with those on Earth
- Explain how spacesuits enable humans to survive in space

## EDUCATION STANDARDS ADDRESSED IN THIS ACTIVITY

### National Science Education Standards

Science and Technology

Content Standard E:

As a result of activities in grades 5–8, all students should develop

- Understandings about science and technology



# BACKGROUND INFORMATION FOR

Only in the past four decades—after centuries of studying the Solar System from Earth—have humans developed the technology to travel to space and to experience and explore it firsthand. Humans have walked in space and on the Moon. We have launched giant telescopes into space and sent people there to service them. We are building a permanent space station 322 kilometers (200 miles) above the Earth. Today, people live and work in space for months at a time. But the everyday experience of living and working in space is very different from that on Earth.

## EARTH VS. SPACE

Beyond Earth's atmosphere, space becomes a hostile environment that cannot sustain human life. The following chart shows why by comparing environmental conditions on Earth with those in space.

	EARTH	SPACE
OXYGEN	Our atmosphere contains sufficient oxygen to support human life.	The level of oxygen is too low for humans; without protection, they would quickly perish.
AIR PRESSURE	Atmospheric gases push on our bodies from all directions. This pressure counterbalances the pressure of air and fluids pushing out from inside our bodies.	Space is a vacuum with virtually no gases or air pressure. The air inside an unprotected human being's lungs would expand, leading to unconsciousness within 15 seconds.
GRAVITY	Gravity holds humans securely to the Earth.	In the reduced gravity—or microgravity—of space, humans feel weightless. They are in a state of free fall—similar to the feeling of racing down from the top of a roller coaster.
TEMPERATURE	Atmospheric gases distribute heat from the Sun and balance global temperatures.	With no protective atmosphere, the temperature of objects in space varies widely. Near the Earth and Moon, it ranges from -156°C (-250°F) in the shade to 121°C (250°F) in sunlight.
RADIATION	The atmosphere filters out harmful radiation.	With no protective atmosphere, electrically charged particles and high energy radiation from the Sun pose a major danger to humans.
METEORIODS	The atmosphere slows down meteoroids and disintegrates all but the largest.	With no atmosphere to slow them down, meteoroids are a hazard. Even tiny ones (micrometeoroids) can easily penetrate a spacecraft, spacesuit, or human skin.
FOOD AND WATER	Both occur naturally and in abundance on Earth.	There is no evidence of either in space.

# TEACHERS

## SURVIVING IN SPACE

### INSIDE A SPACECRAFT

While in space, humans must protect themselves against the extreme conditions described to the left, and they must bring with them everything they need to survive. Spacecraft like the Space Shuttle have a shell that provides protection from temperature extremes, solar radiation, and micrometeoroids. Inside the Shuttle, the air pressure and oxygen levels are controlled, just like on an airplane, and there are supplies of food and water. Astronauts wear regular clothes—including shorts and t-shirts. The only major environmental condition to which they must adapt is microgravity. Here are several ways astronauts meet the challenge of microgravity while inside the Space Shuttle:

- **Eating:** Astronauts eat most food directly from sealed packages, not from open plates or bowls. Velcro attaches the packages to trays and keeps them from floating away. Silverware has magnets to keep it in place.
- **Sleeping:** Astronauts spend the night in sleeping bags strapped to the wall so they don't float around.
- **Bathing:** Astronauts take sponge baths using wipes, or soap and wet cloths.
- **Working:** Space tools are specially designed to attach to astronaut clothing and equipment with Velcro or cords.
- **Going to the bathroom:** Special toilets with funnels and suction ensure that what comes out goes down, not up.

### OUTSIDE A SPACECRAFT

Today astronauts travel to space to service the Hubble Space Telescope (which orbits the Earth more than 480 kilometers, or 300 miles, away) and to help assemble the International Space Station (located 322 kilometers, or 200 miles, above Earth). Both of these missions require astronauts to leave the shuttle and work in the vacuum of space. These spacewalks are called EVAs—or Extravehicular Activities. They require a spacesuit specifically designed for this purpose. With its protective layers enabling humans to survive in an otherwise hostile environment, a spacesuit is like a personal spacecraft. It provides everything needed for human survival for about eight hours. Without one, astronauts would quickly die.

Spacesuits are complex devices. Technically known as Extravehicular Mobility Units (or EMUs), they are usually made up of 11 layers—each of which serves a different purpose. Here are some major features:

- **Maximum Absorption Garment (MAG):** The first item astronauts put on is this adult-size diaper. When astronauts have to “go” when they’re outside in space, they can just “go” in their MAG.
- **Liquid Cooling and Ventilation Garment:** This long underwear-like garment contains 91.5 meters (267 feet) of plastic tubing. Cooling water circulates through the tubing to keep the astronaut at a comfortable temperature.
- **Pressure Bladder Layers:** Two layers contain the spacesuit’s atmosphere and provide air pressure. The inner layer seals in the air. The outer layer prevents the suit from ballooning.
- **Thermal Micrometeoroid Layers:** Nine layers of foil, mesh, and durable rip-stop cloth provide temperature insulation and protect against micrometeoroid penetration.
- **Life-Support System:** This backpack contains oxygen, equipment to remove carbon dioxide, electrical power, and other life-support needs.
- **Helmet:** The helmet itself is a clear bubble that encloses the astronaut’s supply of air. A visor covered with 14K gold reflects sunlight. Under the helmet, the astronaut wears a cap with earphones and a microphone.
- **Headlights:** Located high on the astronaut’s backpack, they provide light during the dark half of every 90-minute orbit.
- **Gloves:** These are the only component of modern spacesuits custom-made to fit each astronaut.
- **Boots:** Since astronauts in orbit never set foot on land, the boots don’t need treads.
- **Drink Bag:** A water-filled plastic pouch—with a straw—is mounted inside the upper part of the suit.
- **Food:** A high-nutrient food bar, with an edible rice paper cover, is located in the helmet—right near the mouth.
- **Tether:** Attached to the spacecraft is a retractable cord, somewhat like a leash, that prevents the astronaut from floating away. (visible in poster image)

## ABOUT THE POSTER

The large image on the front shows Astronaut Rex J. Walheim during a 2002 extravehicular activity outside the International Space Station (ISS). It lasted 6 hours and 20 minutes. He is wearing a toolkit and the tether is visible. The United States is one of 16 countries helping to build the ISS, located 322 kilometers (200 miles) above Earth. It has been continuously inhabited since November 2000. The completed station will be a laboratory where astronauts conduct research in microgravity and examine how the human body adapts to spaceflight. It may also serve as a training ground for longer missions and a stop for humans traveling to the Moon or Mars. The smaller images show daily activities inside the ISS or the Shuttle that carries astronauts there.

- **Exercising:** A harness keeps astronaut Leroy Chiao in place as he runs on a treadmill (ISS, 2005).
- **Working:** Russian cosmonaut Sergei K. Krikalev works with communications equipment (ISS, 2005).
- **Sleeping:** Canadian payload specialist Bjarni V. Tryggvason sleeps without a pillow—allowing his head to float freely in microgravity (Space Shuttle, 1997).
- **Preparing Food:** Astronaut Richard Searfoss uses Velcro to attach food packets to trays (Space Shuttle, 1998).
- **Washing Hair:** Microgravity causes Astronaut Sandra H. Magnus's hair to stand on end during a shampoo (Space Shuttle, 2002).

## VOCABULARY

air pressure

atmosphere

Extravehicular Activity (EVA)

Extravehicular Mobility Unit (EMU)

gravity

International Space Station (ISS)

meteoroid

microgravity

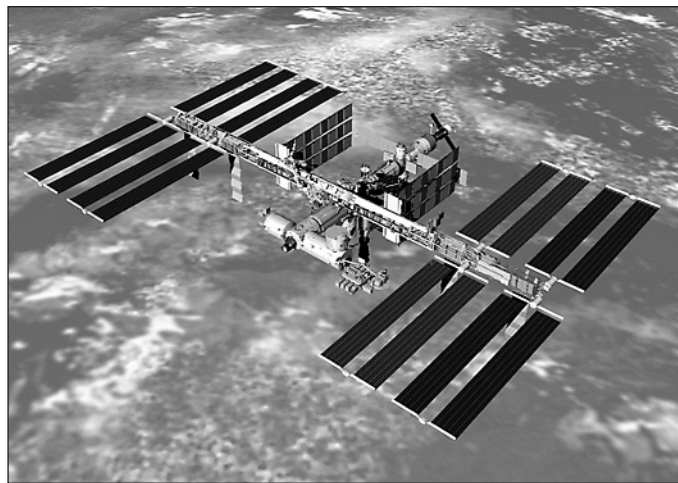
micrometeoroid

radiation

Space Shuttle

spacecraft

spacewalk



COMPLETED INTERNATIONAL SPACE STATION (ISS)

## MATERIALS

**For each team of students:**

- one copy of each Blackline Master
- pencils

**For the class:**

- poster

## MATERIALS FOR MUSEUM VISIT (OPTIONAL)

**For each student:**

- “Exploring Space” self-guide

## PREPARATION

Copy the two Blackline Masters for each team of students. A few days before beginning the activity, display the poster and encourage students to take a close look at it.

## PROCEDURE

- 1 Ask students to think about why humans choose to live and work in space. Going to space is risky and expensive. It's safer and cheaper to study space from right here on Earth—through powerful telescopes, for example—or to send robot explorers. Why go?

Have students work in small groups. Tell each group to come up with at least three reasons why humans would want to live and work orbiting Earth or in far space—e.g., the Moon and beyond. Encourage them to be thoughtful and to go beyond the obvious answers by considering questions such as these:

- Why would humans choose to spend up to six months in space?
- Why are we building a permanent station in space?
- What can we do in space that we can't do here?
- Why do astronauts take animals and plants to space?

Then have each group share their thoughts with the whole class. Here are some reasons to bring up if students don't think of them:

- To learn how space travel affects the human body
- To find out more about the effects of microgravity
- To study science in ways that aren't possible on Earth
- To increase our knowledge of other planets and the universe
- To put and maintain telescopes and other scientific equipment in space
- To get closer to other planetary bodies and see them close-up, without the distorting effects of Earth's atmosphere (e.g., clouds, air turbulence, city lights)
- To collect samples of soil and rock from other planetary bodies
- To find out if life exists on other planets
- To satisfy our curiosity

You may want to conclude by asking students: Are there any reasons why you think humans should *not* live and work in space? Some possible responses are:

- It's dangerous.
- It's expensive. There are others ways to spend the money.
- Astronauts might bring back alien organisms that could harm life on Earth.

In discussing these issues, it may be helpful to explain that while space travel is expensive, it receives less than 1% of the national budget. Robotic travel would be cheaper, but robots can't do everything humans can do.

Help students understand the challenges of living and working in space by having them compare conditions on Earth with those in space. Have students break up into small groups, and give each group a copy of Blackline Master #1. Ask the groups to discuss each environmental condition listed in the left-hand column and then fill in the two columns on the right, based on what they already know about Earth and space. Tell students that they may not be able to fill in all the blanks equally well. Encourage them to just do the best they can by sharing what everyone in the group knows.

When the students finish, discuss the responses with the entire class, and record the answers on the board. Ask students how they feel about the concept of living and working in space. Do the challenges seem insurmountable? Can students imagine some ways to meet the challenges? Which challenge seems the greatest?

Direct students' attention to the images on the front of the poster. Ask students what's happening in each of the small images. What's different about performing these activities in space rather than on Earth? Emphasize that in all the images the astronauts are coping with the effects of microgravity. Use the information provided in the background information section to discuss how this challenge is met in each activity.

Then ask students why the astronauts are not wearing spacesuits. Are they surprised to see astronauts in regular clothes? Explain how spacecraft provide oxygen and air pressure and protect against temperature extremes, radiation, and micrometeoroids. As long as astronauts stay inside the spacecraft, they do not have to wear a spacesuit.

Now have students focus on the large image of the astronaut working on the International Space Station. What is he doing? Explain what the International Space Station (ISS) is and how astronauts may spend up to 8 hours at a time outside in space building and repairing it. Ask students how they think the astronaut is able to survive under these conditions for such a long time. The spacesuit is the key. Emphasize that it is worn only outside the spacecraft, and that it must provide everything needed for human life. Without it, the astronaut would die.

## EXTENSIONS

Tell students that they are now going to discover some of the major ways in which a spacesuit enables astronauts to survive outside the spacecraft for hours at a time. Have students work in small groups, and give each group a copy of Blackline Master #2. Tell students to compare the spacesuit drawing with the large poster image as they discuss each of the spacesuit's labeled features. Challenge them to fill in the three missing labels using the words at the top left of the Blackline Master. These are the:

- Headlights (located on both sides of the helmet)
- Liquid Cooling and Ventilation Garment (visible through a cutaway on the spacesuit leg)
- Life-Support System (the large backpack)

When students finish, have the groups share their answers with the whole class. Then remind students of the conditions in space that they discussed in step #2 above. Ask students how the spacesuit protects astronauts against each of these conditions:

- Lack of oxygen (oxygen inside backpack)
- Lack of air pressure (pressure layers)
- Microgravity (tether to spacecraft)
- Extreme temperatures (insulating layers)
- Radiation (helmet and gold-plated visor)
- Meteoroids (protective layers)
- No food or water (food and water supplies inside spacesuit)

You might end the activity by sharing with students some basic information about the spacesuit. Ask students:

- How much do you think it weighs? (nothing in space because of microgravity; 112 kilograms, or 295 pounds, on Earth)
- How long do you think it takes an astronaut to put on the suit? (2-3 hours, mainly because of the breathing exercises that help astronauts adjust to the pure oxygen atmosphere inside the suit)
- How long do you think it takes to make a suit? (about 5,000 hours)

Take students on a field trip to the National Air and Space Museum in Washington, D.C., to see a replica of the Space Shuttle spacesuit as well as models of the Space Shuttle and International Space Station. You may also want to visit the display of spacesuits from earlier space programs. You can download a student self-guide to six historic craft (including the Space Shuttle) that carried humans in space: "Exploring Space." Visit the Museum's web site at [http://www.nasm.si.edu/education/resources\\_guides.cfm](http://www.nasm.si.edu/education/resources_guides.cfm).

2 Take students on a field trip to the Udvar-Hazy Center in Chantilly, VA, to see the Space Shuttle *Enterprise* and a quarantine facility for astronauts who returned to Earth from the Moon. You can download a student self-guide to these and some of the other highlights there: "What's Tops at the Udvar-Hazy Center." Visit the Museum's web site at [http://www.nasm.si.edu/education/resources\\_guides.cfm](http://www.nasm.si.edu/education/resources_guides.cfm).

Have students work in teams to design a spacesuit that would enable humans to live and work on Mars. Ask them to research the environmental conditions on Mars: oxygen, air pressure, gravity, temperature, radiation, and presence of food and water. Tell them that the person who wears their spacesuit will be exploring the surface of Mars. The spacesuit must protect the person from the Martian environment, be comfortable enough to wear for up to eight hours, and enable the person to bend and reach for rock and soil samples and to use tools and other equipment. Ask students to draw and label their final spacesuit design, noting what features enable the person inside to survive and carry out work.

Assign students to do research on the other planets to find out about the conditions there. What would humans need to survive on each planet? Are there any planets that would be impossible for humans to visit?



# EARTH VS. SPACE CHART

## BLACKLINE MASTER #1

	EARTH	SPACE
OXYGEN		
AIR PRESSURE		
GRAVITY		
TEMPERATURE		
RADIATION		
METEORIDS		
FOOD AND WATER		

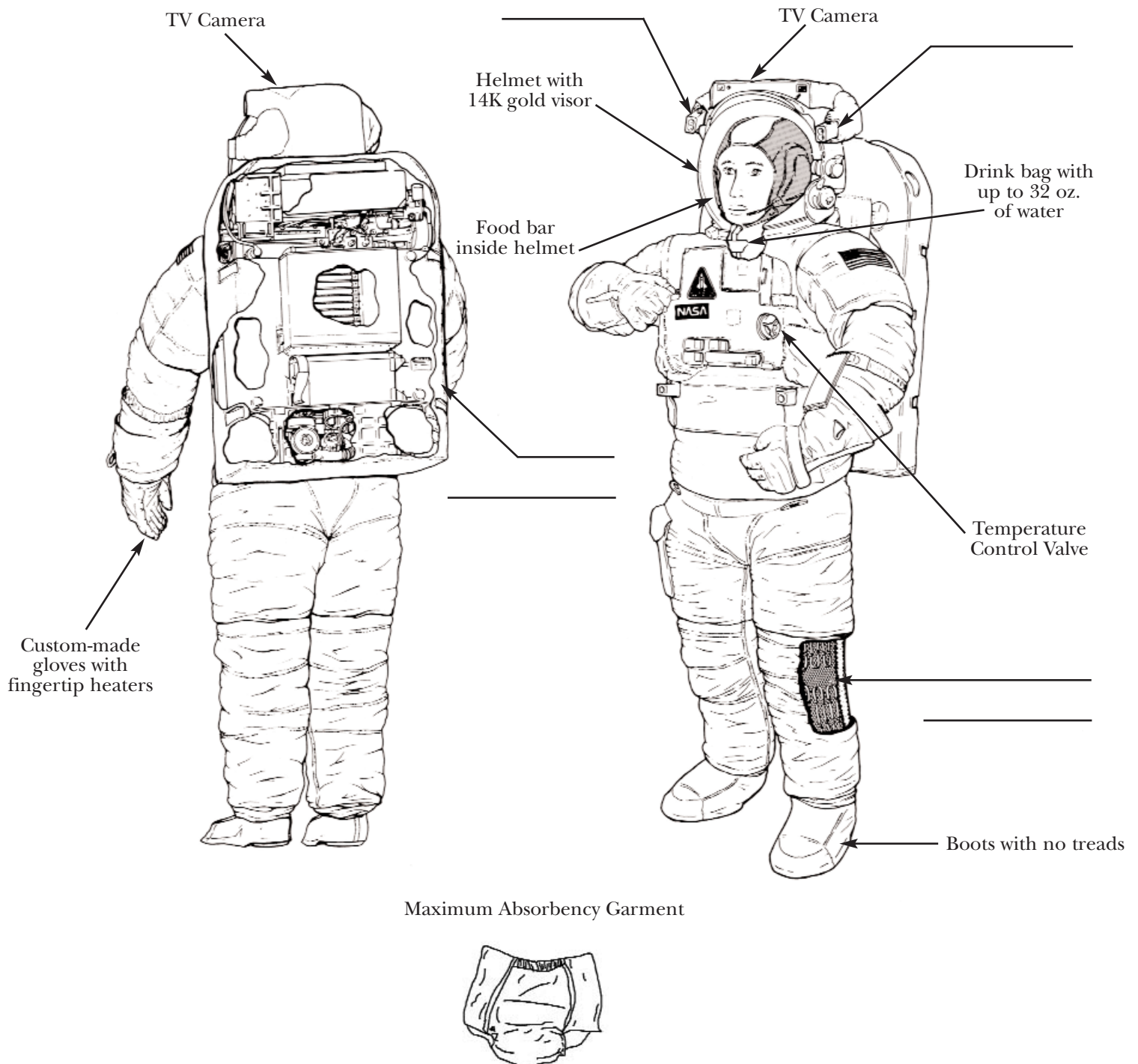


# SPACE SHUTTLE SPACESUIT

## BLACKLINE MASTER #2

### LABEL THESE PARTS:

- Headlights (2 places)
- Liquid Cooling and Ventilation Garment
- Life-Support System



## RESOURCES FOR TEACHERS

### BOOKS:

Butterfield, Moira. *Look Inside Cross-Sections: Space*. London: Dorling-Kindersley Press, 1994.

Joels, Kerry Mark. *The Space Shuttle Operator's Manual*. NY: Ballantine Books, 1988.

Kozloski, Lillian D. *U.S. Space Gear: Outfitting the Astronaut*. Washington, D.C.: Smithsonian Institution Press, 1994.

Vogt, Gregory L. *The Space Shuttle*. NY: Franklin Watts, 1983.

Vogt, Gregory L. *Suited for Spacewalking*. Houston, TX: NASA Johnson Space Center, 1998.

### WEB SITES:

For more information on space, spacecraft, and spacesuits, visit the Web site of the National Air and Space Museum at <http://www.nasm.si.edu>. Navigate to "Exhibitions" and then to the following galleries: *Milestones of Flight*, *Space Race*, *Rocketry and Space Flight*, *Exploring the Planets*, and *Apollo to the Moon*.

For more information on the evolution of the space suit, visit

<http://quest.nasa.gov/space/teachers/suited> or <http://history.nasa.gov/spacesuits.pdf>

For more information on space food, visit

<http://spaceflight1.nasa.gov/spacenews/factsheets/pdfs/food.pdf>

### OTHER NATIONAL AIR AND SPACE MUSEUM TEACHING POSTERS:

*Exploring the Planets*

*Destiny in Space*

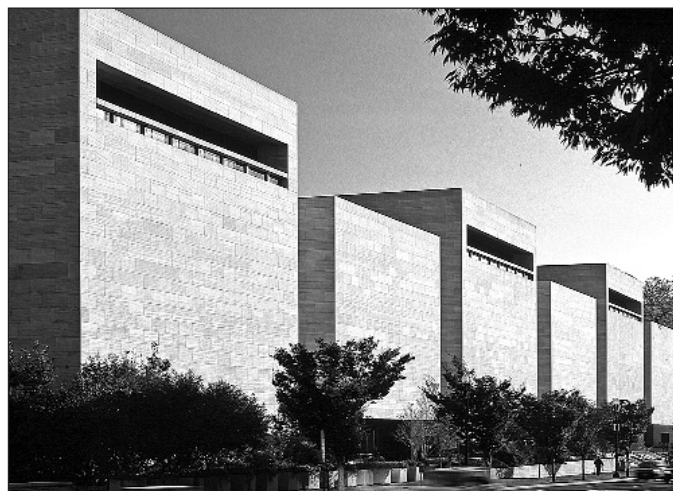
## VISITING THE NATIONAL AIR AND SPACE MUSEUM

The Smithsonian National Air and Space Museum and its companion facility, the Steven F. Udvar-Hazy Center in Virginia, maintain the largest collection of historic aircraft and spacecraft in the world. Both buildings are open from 10:00 a.m. to 5:30 p.m. daily.

A full schedule of guided tours and daily programs for school groups is available on the Museum's Web site <http://www.nasm.si.edu/>. Advance registration is required. For more information on school programs or to schedule a "Living and Working in Space" tour at the National Mall building, visit the Web site.

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