CHAPTER 17

ACTIVITIES

CROSS-CURRICULAR EXTENSIONS

1. **SCIENCE** Design a method to safely measure the thrust of a model rocket.

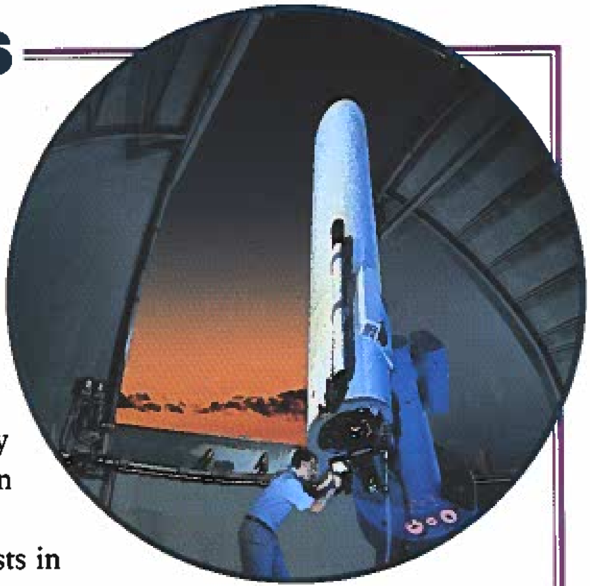
2. **SOCIAL STUDIES** Research space achievements. Make a chart of what you think are major advancements in space technology.

3. **MATHEMATICS** Use the height or altitude gauge to measure how high the tallest part of your school is.

4. **COMMUNICATION** Write a science fiction short story describing a trip to Mars.

EXPLORING CAREERS

Travel between Earth and the moon may become routine in your lifetime. Many believe that vacations on the moon and trips to resorts orbiting Earth are also real possibilities. Work opportunities may exist in the future that we haven't even imagined today.



Aerospace Engineer Aerospace engineers design, develop, and test spacecraft and aircraft. They also develop new products and technologies for use in space exploration, and they may supervise their manufacture. Aerospace engineers have strong interests in mathematics and science and must be willing to continue their education throughout their careers.

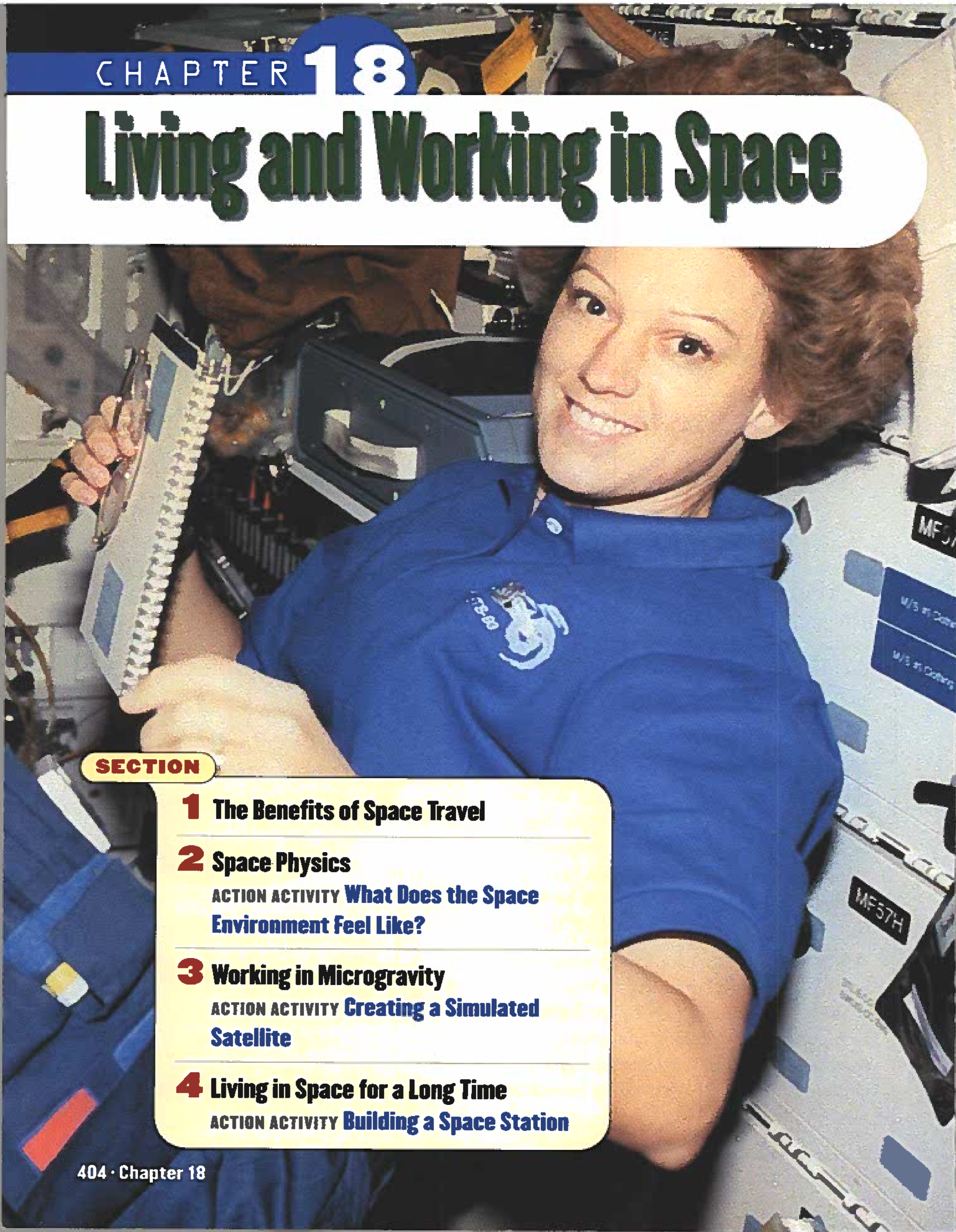
Astronomer Astronomers research the basic nature of the universe and apply that knowledge to problems in navigation and space flight. They may be involved in developing and testing instruments used in flight. Astronomers are imaginative, have curious minds, and have a strong interest in physics.

ACTIVITY

Make a list of three things that you would take with you on a trip into outer space. Explain why you think you will need the items.

CHAPTER 18

Living and Working in Space



SECTION

The Benefits of Space Travel

SECTION 1

THINGS TO EXPLORE

- Explain what a space spinoff is and give examples.
- Evaluate the benefits of space travel.

TechnoTerms

alloy
space spinoff

In the last chapter, you learned about space travel. What are the benefits of space travel for you right now? They probably include new products and processes, as well as increased knowledge.

New Products and Processes

Space spinoffs are new technologies and products developed during a space project that can be used for additional purposes. Fig. 18-1. Battery-powered tools such as drills and screwdrivers came from the Apollo moon program. A new fiber called PBI, used to make spacesuits safer from fire, is now used in airline seat cushions. Even a special mapping system using computers, a satellite, and scanners to detect forest fires is a spinoff from NASA and the Jet Propulsion Laboratory.

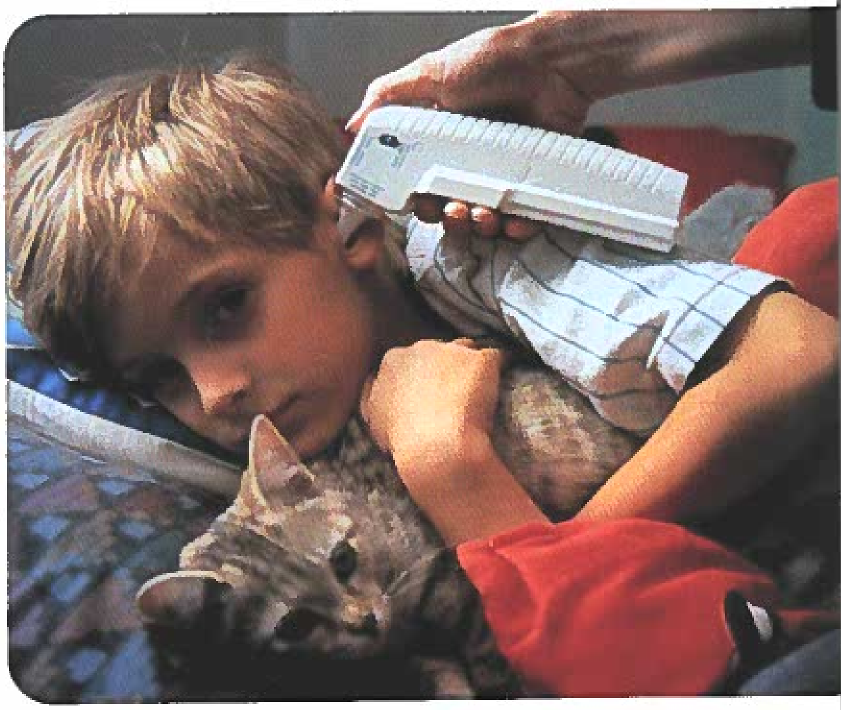


Fig. 18-1. The technology for this digital thermometer was developed for the space program. The temperature sensor contains a thin coating of gold, which provides rapid, accurate results.

OPPOSITE Astronauts float as they work inside a space capsule.

Space is also an ideal place for making certain products that are difficult or impossible to manufacture on Earth. Certain drugs for diabetes and blood diseases are easier to make in space. On Earth, gravity gets in the way but not in space.

New alloys are easier to make in space, too. An **alloy** is a mixture of two or more metals. On Earth, a lighter metal floats on top of a denser one. But the process of making an alloy works best in space because the metals flow together. Once the new alloys are made, they can be used anywhere—even back on Earth. Fig. 18-2. Once the problems of living in space have been solved, people can use the special space environment to make more things we can use in space and on Earth.

TechnoFact

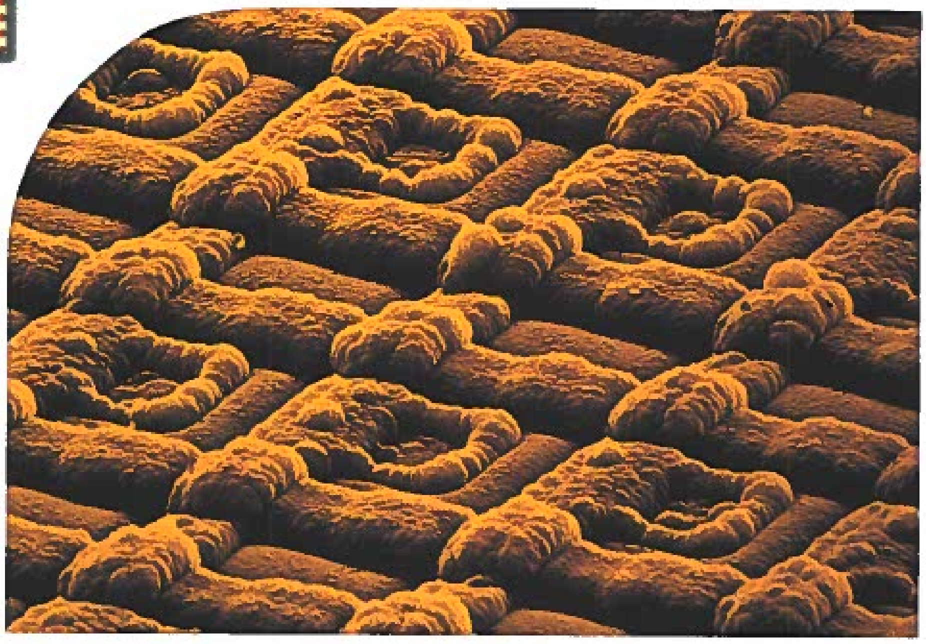
MISSION TO MARS

Where will you be in 2019? If a plan being developed by Russian and U.S. space engineers works, you might be one of the astronauts on Mars. A crew of six would spend a year there. Even before the crew's arrival, prebuilt structures and supplies would be landed at a Martian base site.

Increased Knowledge

Exploring and living in space add to our knowledge of Earth, our own solar system, and the larger universe. How would you like to take a vacation on the moon or Mars? Are you curious to see how things work in space and how people live? What kinds of sports do you think you could play on the moon? The possibilities for the future are very exciting. Fig. 18-3.

Fig. 18-2. This shows a computer chip (magnified) without its protective covering. Semiconductor materials used to create chips may be improved through techniques developed in space. What other materials might be improved in this way?



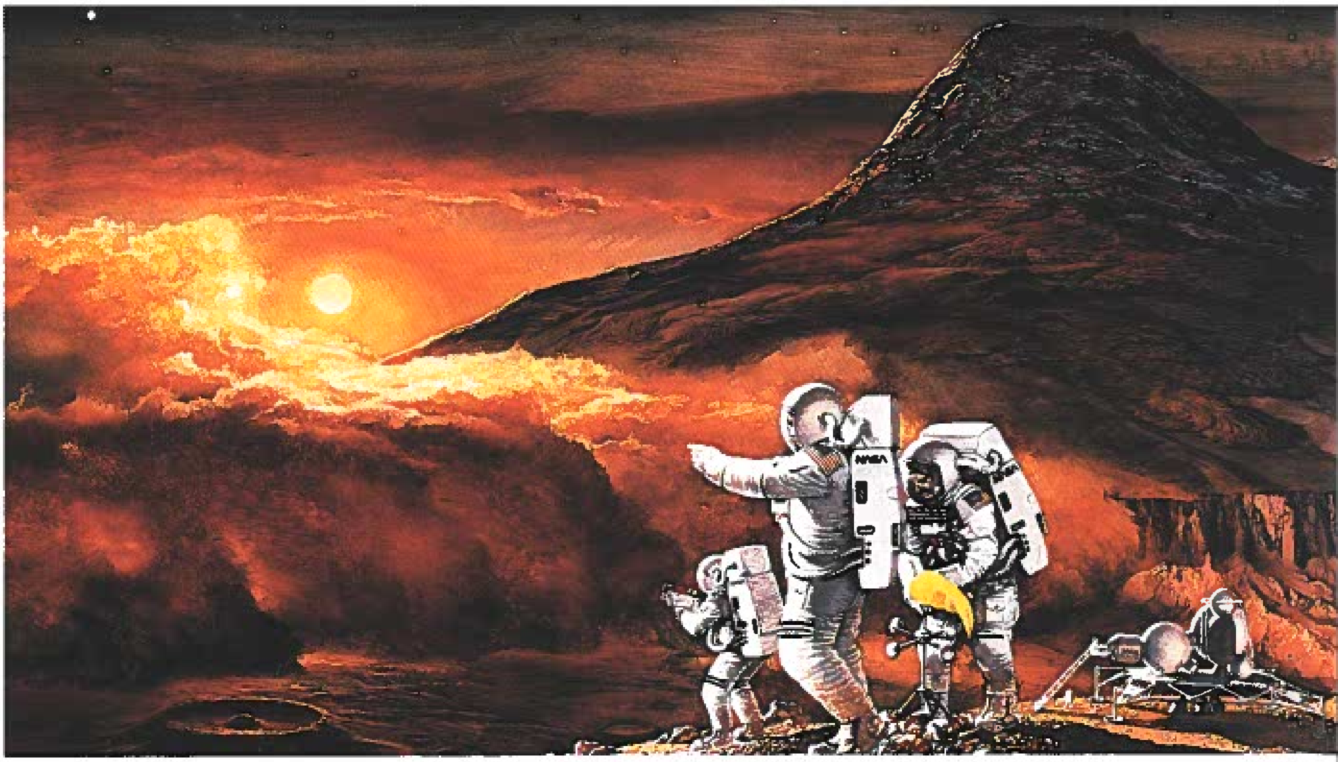


Fig. 18-3. Scientists hope to put astronauts on Mars in the near future. Do some research to learn when they hope to complete the mission.

Is the Space Program Worth It?

Planning for and building things in space is expensive and takes time. Many people feel the space program is worth the price. They can see the benefits to medicine and other industries here on Earth. They see space programs as being valuable in helping us to learn more about Earth from a different viewpoint. Other people do not want their tax dollars spent on space travel when there are many problems on Earth to solve. What do you think the future of space travel should be?

SECTION 1 TechCheck

1. What is a space spinoff? Give three examples.
2. What is an alloy?
3. What are the advantages and disadvantages of the space program?
4. **Apply Your Knowledge.** Research NASA's website to find the current NASA projects. Choose a project and do one of the following:
   - Write a paragraph describing it.
   - Write a script about it for a school radio or TV newscast.
   - Write a story about it for a school newspaper.

SECTION 2

Space Physics

THINGS TO EXPLORE

- Explain how the effects of gravity change when you move away from the Earth.
- Experiment with different materials in a vacuum.
- Create a simulated spacesuit glove.

TechnoTerms

free-fall
microgravity
vacuum

Physics is the science dealing with physical properties and processes. If things worked the same in space as they do on Earth, space physics would be simple. That's just not the case. To understand space physics, you need to understand the effects of gravity and atmosphere.

Gravity in Space

Earth's gravity pulls everything toward the center of the Earth. Things have weight because of gravity. Just how much you weigh depends on how strongly Earth's gravity is pulling on you.

Microgravity In space, people feel the effects of **microgravity**. Some people call microgravity *zero gravity* or *zero-g*. That does not mean there is no gravity. It just means the effects of gravity are reduced compared to what they are on Earth. Fig. 18-4.

Earth's gravity extends for a very long distance out into space because the Earth is so big. The moon is about 240,000 miles from Earth. What do you think holds the moon in orbit around the Earth? The Space Shuttle orbits only a few hundred miles above the Earth. If Earth's gravity holds the moon in orbit, then it affects the Space Shuttle, too.

Fig. 18-4. Astronauts on the moon had to learn how to walk all over again! The pull of gravity there is only one-sixth the pull of gravity on Earth. So you can have the same mass (amount of matter) but weigh only one-sixth as much.

Weightlessness All Earth-orbiting spacecraft are actually falling slowly toward the Earth. Why don't they fall straight down? The answer is in the spacecraft's speed and the shape of the Earth. The spacecraft is traveling forward, and the Earth curves away from it. Fig. 18-5. The astronauts appear to be weightless because they are in **free-fall**. Fig. 18-6. They still have weight, but they can't rest against the floor of the shuttle because the floor is falling at the same speed as they are.

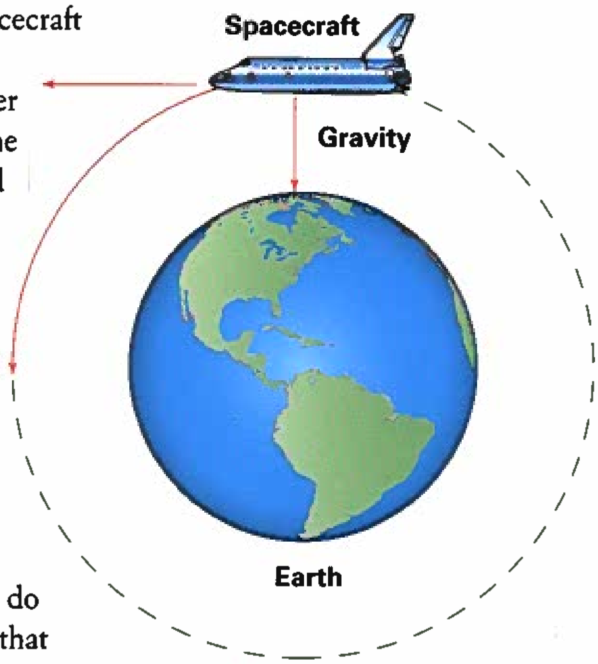


Fig. 18-5. This drawing shows how the speed of the spacecraft, gravity, and the shape of the Earth contribute to weightlessness.

Newton's Laws of Motion explain how things move on Earth. They also work for the space environment. Sometimes the results are different though! You can do tumbling stunts in space that would be impossible to do on Earth—thanks to microgravity. However, it makes living and working in space much harder.

INFOLINK

See Chapter 17 for more information about Newton's Laws of Motion.

Fig. 18-6. Weightless conditions can sometimes cause motion sickness. Have you ever ridden in an elevator that made you feel weightless for an instant? Describe that feeling.

Fig. 18-7. Space suits protect astronauts as they work in space, but the air pressure inside makes it hard to move around. **Can you think of design improvements that would make space suits easier to work in? Explain.**

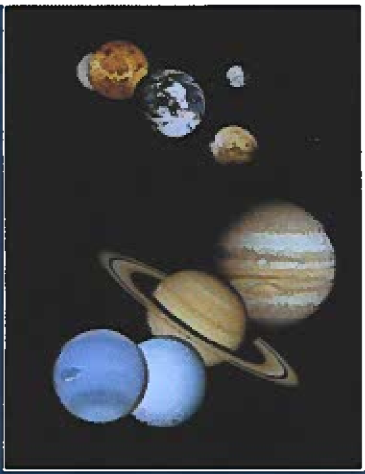
Atmosphere in Space

Gravity pulls on the air in our atmosphere and holds it near the surface of the Earth. If you could weigh the amount of air in the atmosphere at sea level, it would weigh 14.7 pounds for every square inch of the Earth's surface.

Air Molecules The higher you go above sea level the less air there is in the atmosphere. Scientists have measured the number of air molecules at different distances from the Earth. At sea level, there are a million, million, million air molecules in one cubic centimeter. Farther away from Earth the number gets smaller and air pressure is less. At 20 miles

MATHEMATICS CONNECTION

Light as a Feather—or a Brick!



If a person weighs 100 pounds on Earth, what would that person weigh on other planets?

You can use the chart shown here to calculate weights for different planets and even the moon. Simply multiply the weight on Earth by the gravity factor given in the chart.

Example: A 100-pound person on Earth would weigh 16.6 pounds on the moon (100 x 0.166 = 16.6).

above the Earth, the air becomes too thin for jet engines. At 50 to 600 miles away from Earth, there are one million molecules per cubic centimeter. When you reach 1,200 miles in altitude, there is only one air molecule per cubic centimeter.

Living in a Vacuum We live our lives in an ocean of air. Have you ever thought about how things would be different in a vacuum? In a **vacuum**, there is no air to breathe and no air pressure. A vacuum is fatal to people. In outer space there is a near-vacuum. Astronauts must wear specially made space suits for protection. Fig. 18-7.

TechnoFact

DARTS IN SPACE

Like to play darts? In space, playing darts is a bit different than on Earth. When you aim for the target on Earth, you aim a little higher because you know gravity will pull the dart down during its flight. In space, the dart travels in a straight line. And you don't have to throw it hard. In fact, you can just give it a little push and it will actually float toward the bull's-eye. The big challenge is to try playing darts in space without attaching your feet to something!

SECTION 2 TechCheck

1. What are the effects of microgravity?
2. Why do astronauts and objects appear weightless when the Shuttle reaches orbit?
3. What holds the atmosphere around the Earth?
4. **Apply Your Knowledge.** Research how a change in altitude affects the boiling point of water. Make a graph illustrating your findings.

	GRAVITY FACTOR
Mercury	0.284
Venus	0.907
Moon	0.166
Mars	0.38
Jupiter	2.34
Saturn	0.925
Uranus	0.795
Neptune	1.125
Pluto	0.041

ACTIVITY

Figure out what you would weigh on each of the planets and the moon.

SECTION 2

ACTION ACTIVITY

What Does the Space Environment Feel Like?

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

Scientists, astronauts, physicians, engineers, and technicians must understand the space environment in order to design safe equipment that is also comfortable. For example, space suits must be made strong enough to protect the astronaut from temperature extremes, small meteors, radiation, and the vacuum of space.

In this activity, you will work as a research technician to investigate the effects of reduced air and air pressure. Fig. A.

Design Brief

Demonstrate the effects of a vacuum on materials using a vacuum chamber and a vacuum pump. Simulate the feeling of wearing a space suit glove in the vacuum of space.

SAFETY FIRST

Follow all of the general safety rules on pages 42-43. Follow your teacher's instructions on the safe use of power tools. Use power tools only with your teacher's permission and supervision.

Materials/Equipment

- clamp
- hose clamp, 4"
- rubber gasket sheet
- rubber glove
- Styrofoam plastic foam
- vacuum jar
- vacuum pump and tubing
- silicone caulk
- acrylic plastic, 1/8"
- ABS plastic pipe coupling, 4"
- marshmallows
- beaker
- balloon
- tennis ball
- carbonated soda
- battery-operated buzzer

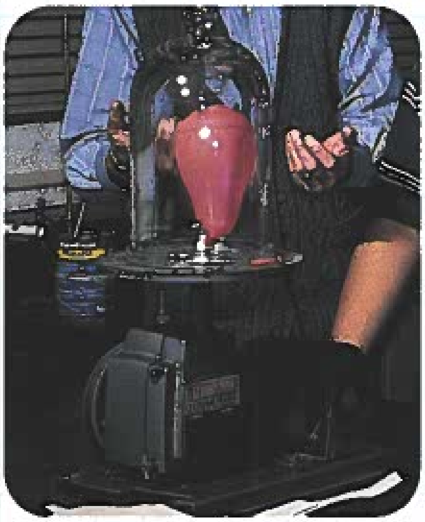


Fig. A. For this activity, your teacher will demonstrate the use of the vacuum pump and vacuum jar.

Procedure

In the first part of this activity, you will test different objects or materials in a vacuum. In the second part, you will simulate the feeling of wearing a glove while working in space.

Part 1 • Testing Materials in a Vacuum

You will work in groups of three or four. Your teacher will demonstrate the proper use of the vacuum pump and vacuum jar.

1. Gather the materials you would like to test under reduced pressure. Ask your teacher to approve your test materials.
2. Make a chart of the materials you are testing, your predictions, and the effects you observe. Your chart might look like the one shown in Fig. B.
3. Place each object in the bell jar and draw a vacuum. Watch and listen for the effects of reduced pressure.

Part 2 • Wearing a Space Suit Glove

The entire class or a large group (8-12 students) can work on this part of the activity.

1. Measure and mark a piece of 1/4" acrylic plastic as shown in Fig. C (page 414).
2. Cut the shape with the help of your instructor.
3. Measure and mark the appropriate size for the rubber gasket. Use scissors to cut the gasket to size.
4. Design and cut a plastic foam stand for the vacuum jar. Check the hole in the acrylic plastic for the proper height.
5. Use silicone caulk to attach the ABS plastic coupling to the hole in the acrylic sheet. Let the caulk dry overnight.
6. Stretch the glove over the coupling and attach it with a hose clamp.
7. Assemble all the parts and use a vacuum pump to remove the air around the glove. Put your hand in the glove and try to make a fist. Fig. D (page 414).

Evaluation

1. What happened to the balloon when you placed it in a vacuum? Explain.
2. What do you think would happen to your body in space if you didn't have the protection of a space suit? Explain.
3. Describe how it felt to use the glove in a vacuum.
4. Why do you think tennis balls are sometimes packaged in pressurized cans?

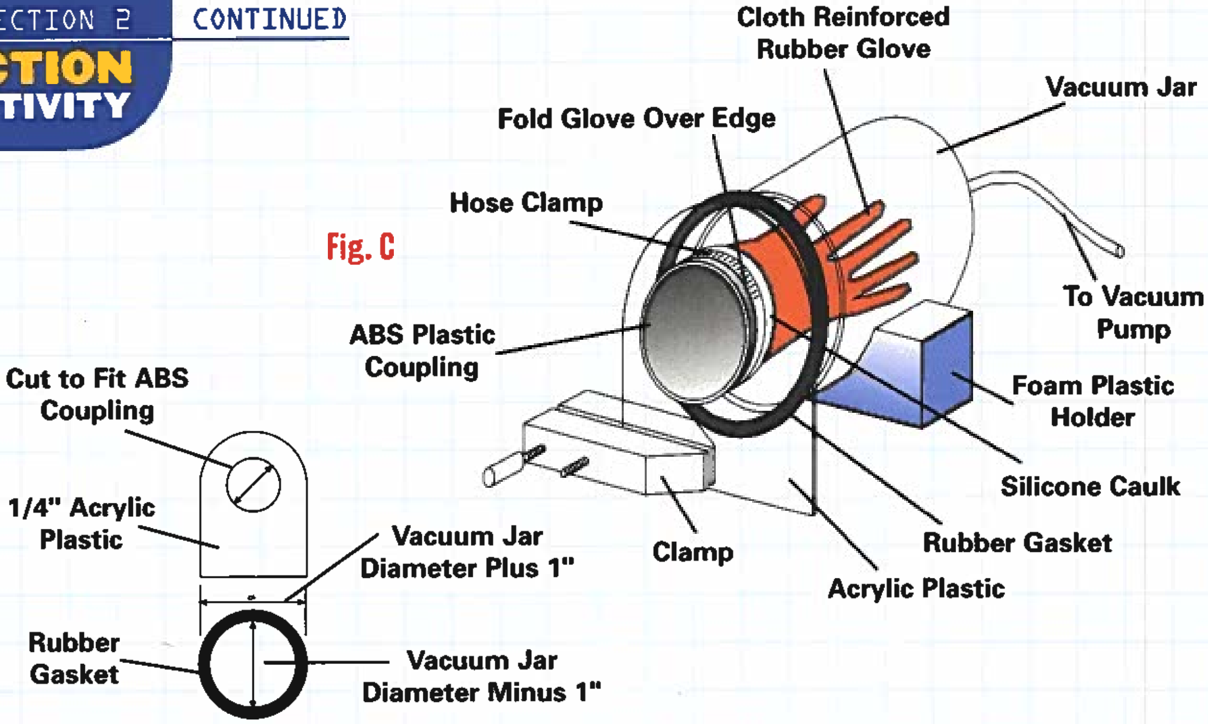
Fig. B

Effects of Vacuum		
Materials	**Prediction**	**Actual**
Marshmallow		
Balloon		
Tennis Ball		
Buzzer		
Soda		

(Continued on next page)

ACTION ACTIVITY

Fig. C



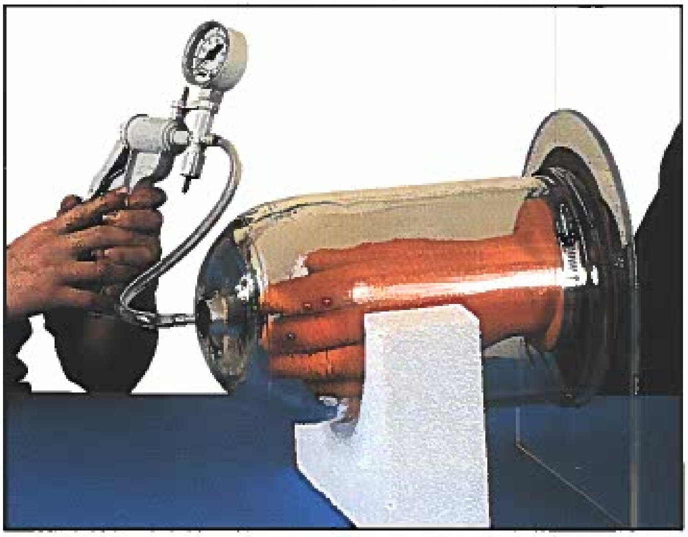
5. Are sonic booms created in space from rapidly moving space vehicles like the Space Shuttle? Explain.

6. **Going Beyond.** Make a list of similarities and differences between space suits and deep sea diving suits.

7. **Going Beyond.** Why do mountain climbers at high altitudes have to boil food longer in order to cook it than they would at sea level? Why does water "boil" at cold temperatures in reduced pressure?

8. **Going Beyond.** NASA researchers have found that metal parts sometimes weld themselves together when they touch in a vacuum. How could this happen? Describe an experiment that would illustrate "cold" welding.

Fig. D



Working in Microgravity

SECTION 3

THINGS TO EXPLORE

- Describe the effects of microgravity on the human body.
- Explain how astronauts train for space.
- Create a simulation of neutral buoyancy.

TechnoTerms
grapple point
neutral buoyancy
Remote Manipulator System (RMS)

Telephone communication and important weather information depend on satellites that work properly. Even space telescopes like the *Hubble* require repair and upgrading. Did you ever think about how equipment might be repaired or replaced in space?

Working in space is a real challenge for astronauts. As you read in Section 2, they must work in a microgravity environment as well as in a near-vacuum. How do you think their bodies are affected?

How Does Space Affect the Body?

Did you know that a microgravity environment will make you taller? You will actually grow an inch or two because gravity isn't compressing (pushing together) the spongy disks between the bones in your backbone. How do you think this affects the design of a spacesuit?

Sometimes your face will get puffy in space because gravity doesn't pull the blood away from your head. Your leg muscles will become smaller because you don't have to work them as much. Doctors have also found you will lose calcium from your bones and they will become weak.

Researchers are working on medicines to help solve some of these problems. But the best thing is exercise—and lots of it! Spacecraft now have equipment such as treadmills and exercise bicycles on board. The astronauts must use the equipment for certain periods daily to keep in shape. Fig. 18-8.

Fig. 18-8. These astronauts are using a treadmill to help counteract the effects of weightlessness. Why do you suppose the astronaut is strapped to the machine?

INFOLINK

See Chapter 17 for more information about Newton's Laws of Motion.

Practicing for Microgravity

Astronauts are expected to perform some specialized jobs while on space walks. Fig. 18-9. They have to think about how microgravity will affect their work. It is sometimes hard to figure out which way is up or down. They and other objects are in free fall and are therefore weightless. They have to be careful how they move. Every time they exert a force their bodies will move in the opposite direction. The wrong move can send them off in a direction in which they might not want to go.

Before they go into orbit, astronauts have to spend many hours practicing how to use special tools and equipment. They train for some special tasks in an underwater facility. Fig. 18-10. Mission specialists also try to simulate the floating effect of neutral buoyancy using *helium* gas. When something floats in air or on water, it is *buoyant*. Positive buoyancy causes something to rise. Negative buoyancy makes it sink. **Neutral buoyancy** means the object doesn't rise *or* sink. It stays where it is.

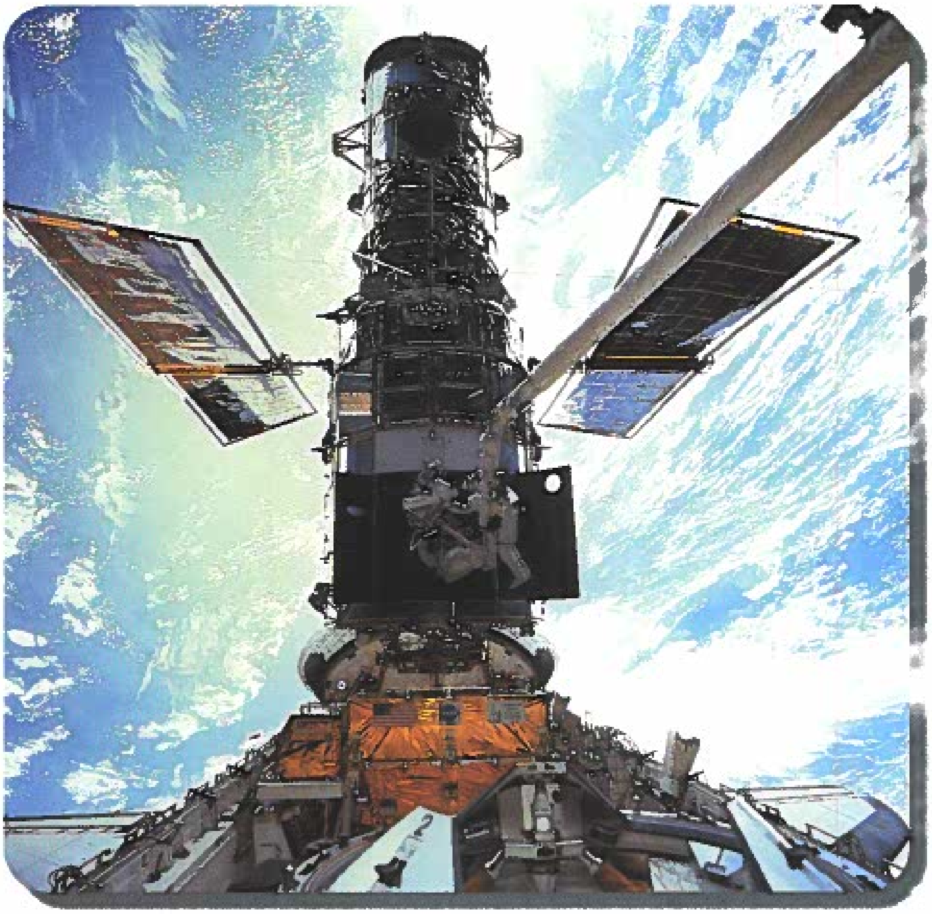


Fig. 18-9. These astronauts are repairing the *Hubble Space Telescope.* Do some research to learn about repairs made to the *Hubble.*

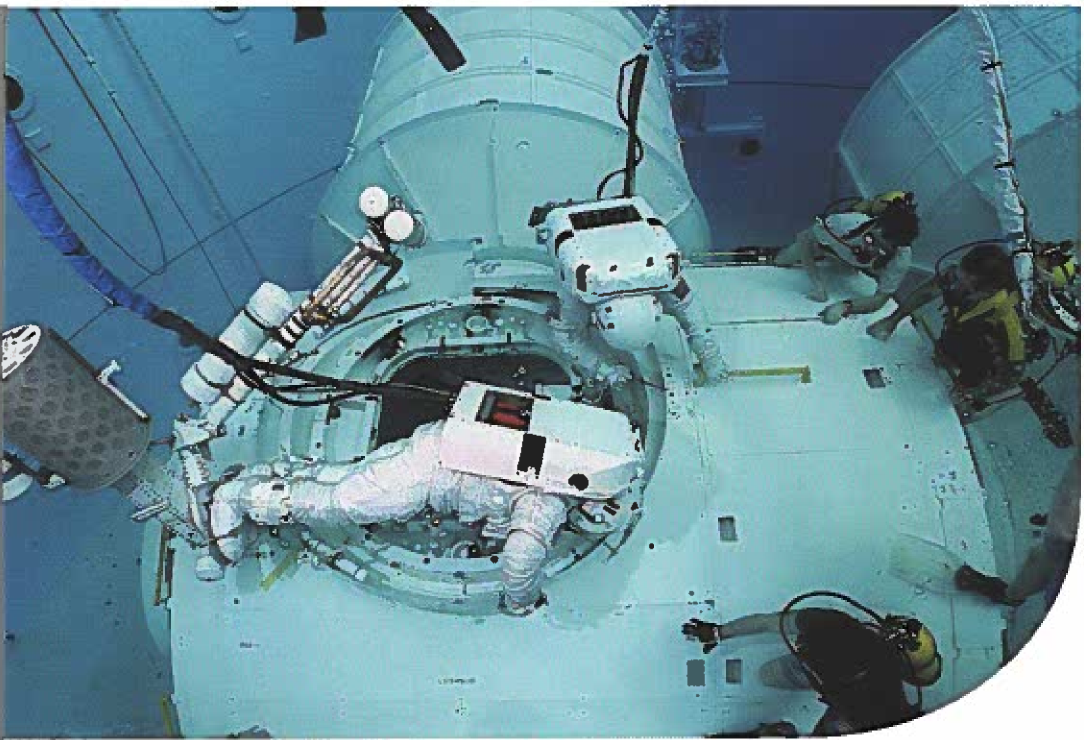


Fig. 18-10. The weightless conditions of space can be simulated in a large water tank. **Why do you suppose the scuba divers are present?**

Special Tools for Work in Space

On the real Space Shuttle, astronauts often have to use a mechanical arm called the **Remote Manipulator System (RMS)**. It is used to move payloads (cargoes) in and out of the cargo bay. Astronauts learn how to use the arm in the Manipulator Development Facility (MDF). Fig. 18-11.

Fig. 18-11. This photo shows the *Discovery* Space Shuttle's manipulator arm (right) being used in space. The arm was built in Canada. The *Discovery* crew is preparing for work on the *Hubble Space Telescope.* The telescope will be pulled into *Discovery's* cargo bay.

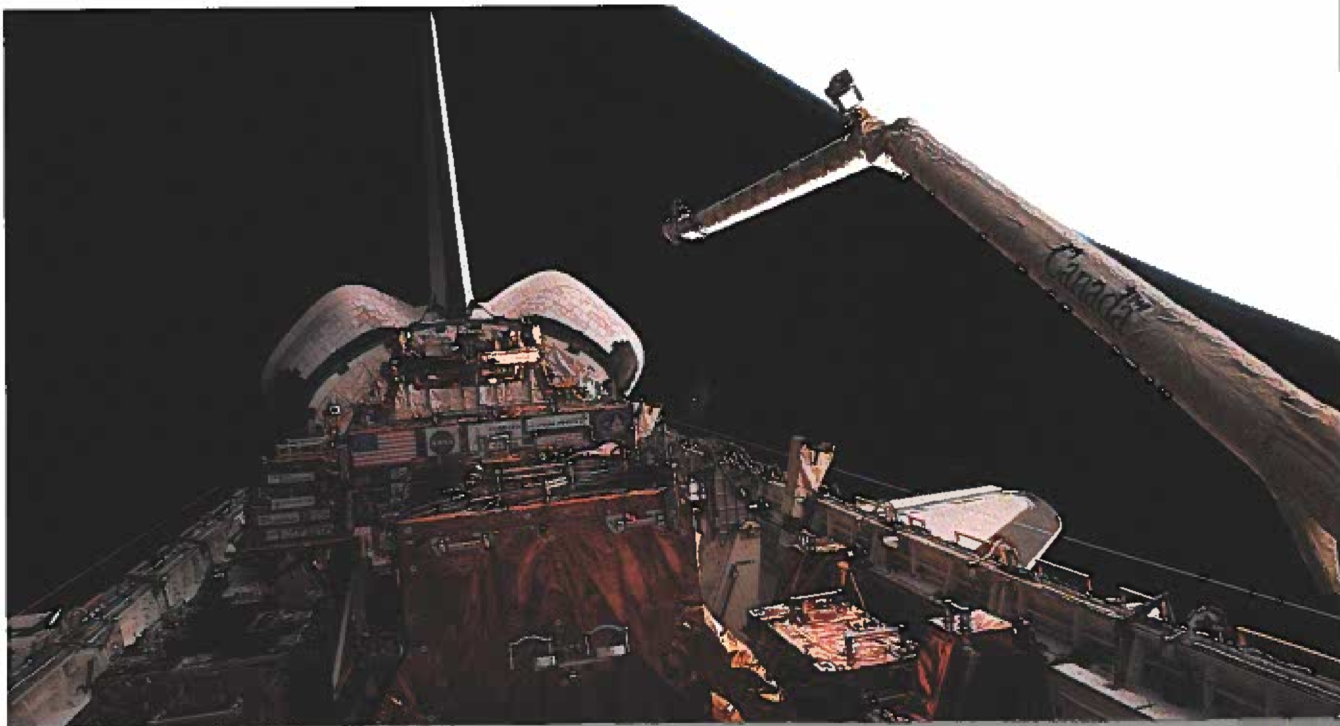


Fig. 18-12. Here the arm is being used for work on the *International Space Station.* Astronaut Tamara E. Jernigan's feet are attached to the *Discovery's* manipulator arm (top) by a mobile foot restraint. She is handling a crane, which was later installed on the space station.

This 50-foot-long robot arm is also used to help launch and retrieve satellites. Astronauts and mission specialists must practice using it to *grapple*, or grab, satellites before they go into orbit. Satellites are built of very lightweight material that could easily be damaged. To make sure no harm is done, strong "handles," called **grapple points**, are designed into the satellite. The RMS is also used for work on the *International Space Station*, which you will learn about in the next section. Fig. 18-12.

SECTION 3 TechCHECK

1. What effects would space have on your body?
2. What is the best way to stay strong in space?
3. How do astronauts train for their jobs?
4. **Apply Your Knowledge.** Choose one of the following:
   - If your school has a robot arm, simulate launching a satellite from a model of the Space Shuttle.
   - Use computer software to simulate movement of a robot arm.
   - Build a working model of a robot arm from scrap materials.

ACTION ACTIVITY

Creating a Simulated Satellite

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

On Earth, NASA specialists use *helium* gas to simulate neutral buoyancy, or the "floating" effect of a microgravity environment.

In this activity, you will design a simulated satellite made from a helium-filled balloon. Fig. A. After you have built your satellite, you will see how long it takes to grapple it as it floats in the air.

SAFETY FIRST

- **Do not inhale helium! Your body cannot use helium. Breathing it can reduce or replace the oxygen in your lungs, and you need oxygen to live.**
- **Read and follow the warnings on the helium tank. Use helium only with your teacher's permission.**
- **Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.**

Design Brief

Design, build, and test a model of a satellite that will float in air. Your simulated satellite should have the following features:

- *Solar array*: A solar array, or panel, is used to change sunlight into electricity to power satellites. In real satellites, the electricity can be used directly or stored in batteries. Your array should be made from lightweight balsa wood and tissue paper. Try to design yours to look like a solar panel on a real satellite.
- *Grapple point*: A grapple point is a type of handle designed to be grabbed by a robot arm. The grapple point prevents damage to the delicate parts of the satellite.

Materials/Equipment

- balloons (12 inch)
- string or thread
- helium
- balsa wood
- tape
- paper
- markers
- straws
- Styrofoam plastic foam
- tissue paper
- markers
- stopwatch or watch

MICROGRAVITY BALLOON

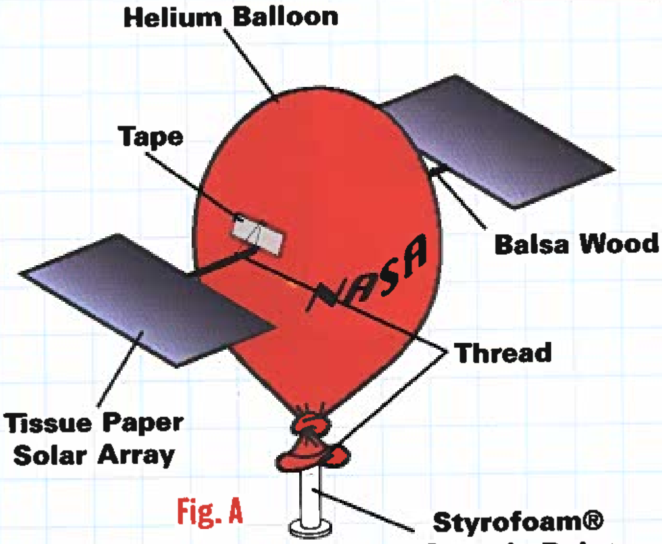


Fig. A

(Continued on next page)

Procedure

Part 1 • Building the Satellite

1. Working in small groups of three or four students, make sketches of how your satellite design might look.
2. Make a list of the materials you will need.
3. With your teacher's help, experiment with the weight of the materials and the lifting ability of helium.
4. Modify your design if needed.
5. Build the final satellite.
6. Test your satellite by adjusting its weight until it floats in air without going up or down.

Part 2 • The Grapple Test

If your school has a robot arm, use it to grapple your satellite. Record the time it takes in your TechNotes. If you do not have a robot arm, follow the steps below to use a human arm instead.

1. Choose a member of your team to be the "robot."
2. Clear an area of the classroom large enough for the robot to stand free of obstacles like desks or chairs.
3. Blindfold the robot. Have members of the group form a circle around him or her at arm's length. Fig. B.
4. Ask your human robot to respond to the verbal commands shown in Fig. C the way a real robot would.
5. Place your satellite near the human robot and time how long it takes the robot to grab the satellite's grapple point. Record your time on your TechNotes.
6. Take turns being the human robot and giving voice commands for directions.

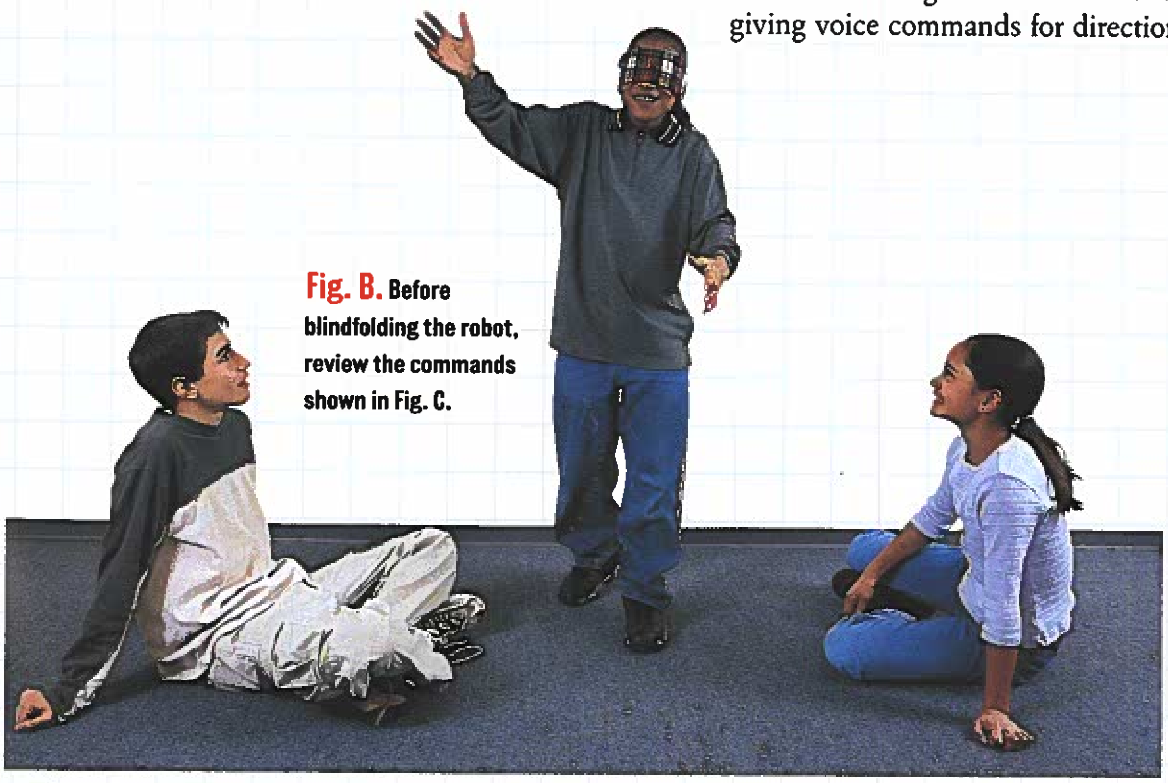


Fig. B. Before blindfolding the robot, review the commands shown in Fig. C.

Evaluation

1. List seven different commands needed to move a robot arm.
2. Why is it important for astronauts to practice things on Earth before going into orbit?
3. What do you think would happen to a real satellite in space if it were bumped accidentally?
4. **Going Beyond.** Use a video camera and monitor to simulate remote telemetry control of your real or human robot.
5. **Going Beyond.** Design, build, and launch a weather balloon that will record temperatures at higher altitudes. Keep the balloon tethered with kite string. Use a maximum/minimum digital thermometer. Graph the relation between altitude and temperature.
6. **Going Beyond.** Research the effect of temperature as it relates to the lifting ability of helium. Find information about Boyle's and Charles' laws and explain the laws to your class.

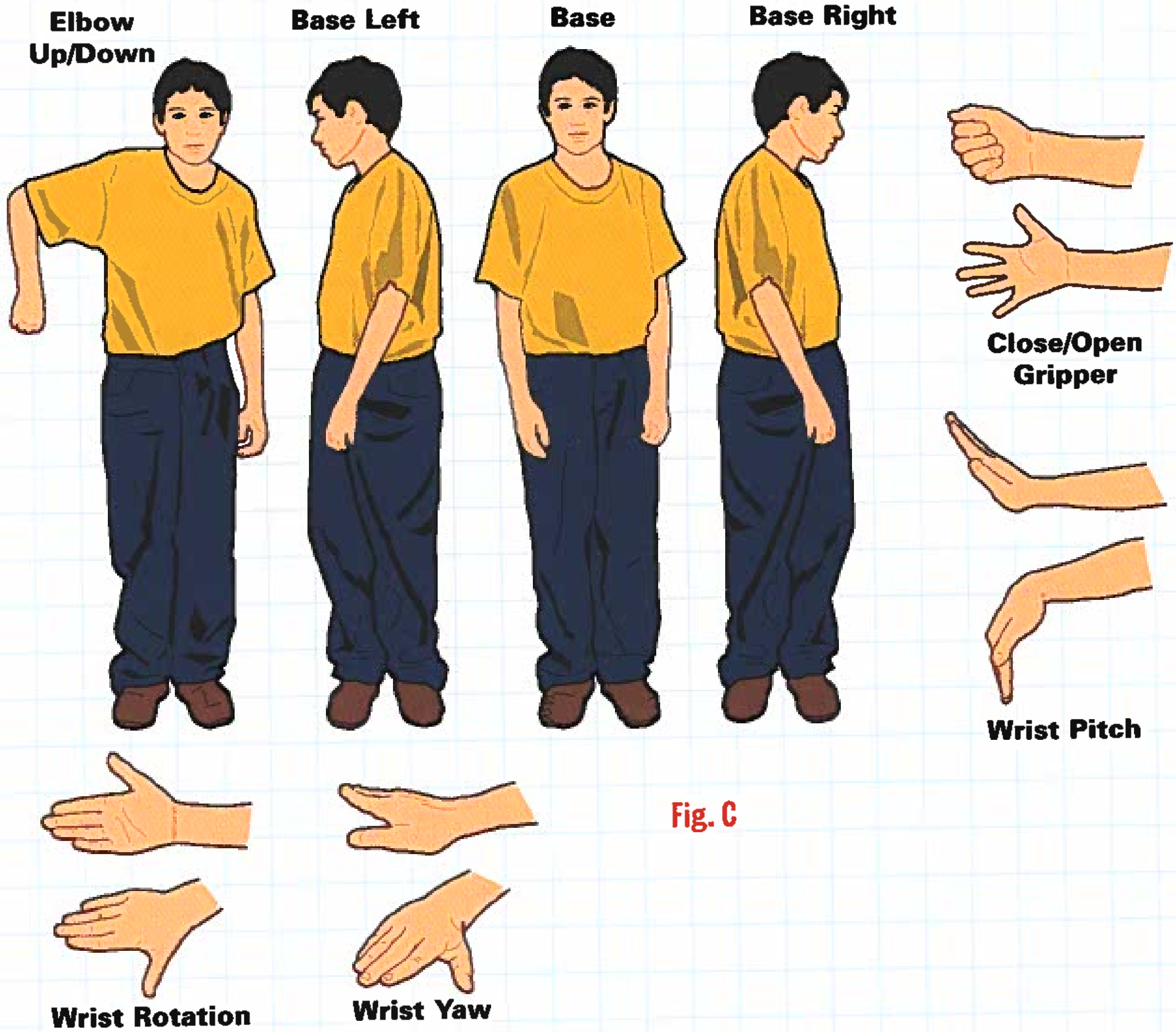


Fig. C

SECTION 4

Living in Space for a Long Time

TechnoTerms

International Space Station
Mir 1
Salyut 1

THINGS TO EXPLORE

- Describe the challenges of living in a space colony.
- Name the first space stations.
- Design and build a simulated space station.

Once you're up in space, what would it be like to live there? What's so different about living in space for a long time?

Space Stations

In order to find out more about living in space, both the United States and the former Soviet Union built space stations where people could stay for longer times. Living in space for long periods brought new challenges to both people and equipment.

Salyut 1, launched by the Soviet Union in 1971, was the first space workstation. *Salyut 1* was about 44 feet long. Though it was used only once, it was the beginning for many other successful *Salyut* missions.

Skylab, launched on May 14, 1973, was America's first space station. It became home for three crews of three people each. *Skylab* was almost 120 feet long, about the size of an average three-bedroom house. On Earth, it weighed about 100 tons.

Then in 1986, the Soviet Union launched the ***Mir 1*** space station. Its computers took over some of the tiresome jobs people once had to do. Cosmonauts on *Mir* proved that people can live in a microgravity environment for over a year!

The *Skylab*, *Salyut*, and *Mir* missions gave us lots of information about ways to make life better for people living and working in space. We want to use this information in building future space stations.

Many countries, working independently and together, already have satellites in orbit above the Earth. In the future, more nations

TechnoFact

SPACE SUIT DESIGN Space suits contain enough water and oxygen to last about 7 hours. The suit has to be able to withstand temperatures from -157°C (-250°F) to +121°C (+250°F). It must also be pressurized, because there is hardly any atmosphere outside the spacecraft or space station. The visor on the helmet is made to protect the wearer's eyes from ultraviolet rays and tiny meteorites.

expect to send people into space. Fig. 18-13. Sixteen nations, including the United States, Russia, and Japan, are now working together to create the ***International Space Station***. Building this space station will be an engineering challenge. Many shuttle trips over a period of three to five years will be needed to assemble, outfit, and get the space station ready. The modules (separate compartments) will be taken up separately and attached to the space station. The modules will be like rooms in a house, only smaller. The idea is for you to be as comfortable as possible during your time in space. Power will come from solar cells and batteries.

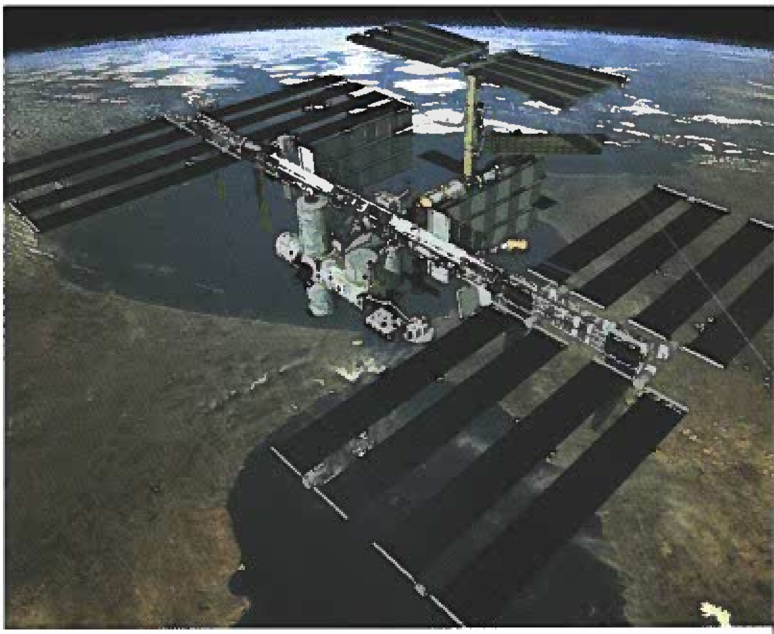


Fig. 18-13. The next space station will provide a platform for conducting experiments in microgravity, materials testing, and water recycling. Find out which nations are involved in creating the *International Space Station.*

Figure 18-14 (page 424) describes life in space as you might find it today. How would you like to be the first student in space?

Space Colonies

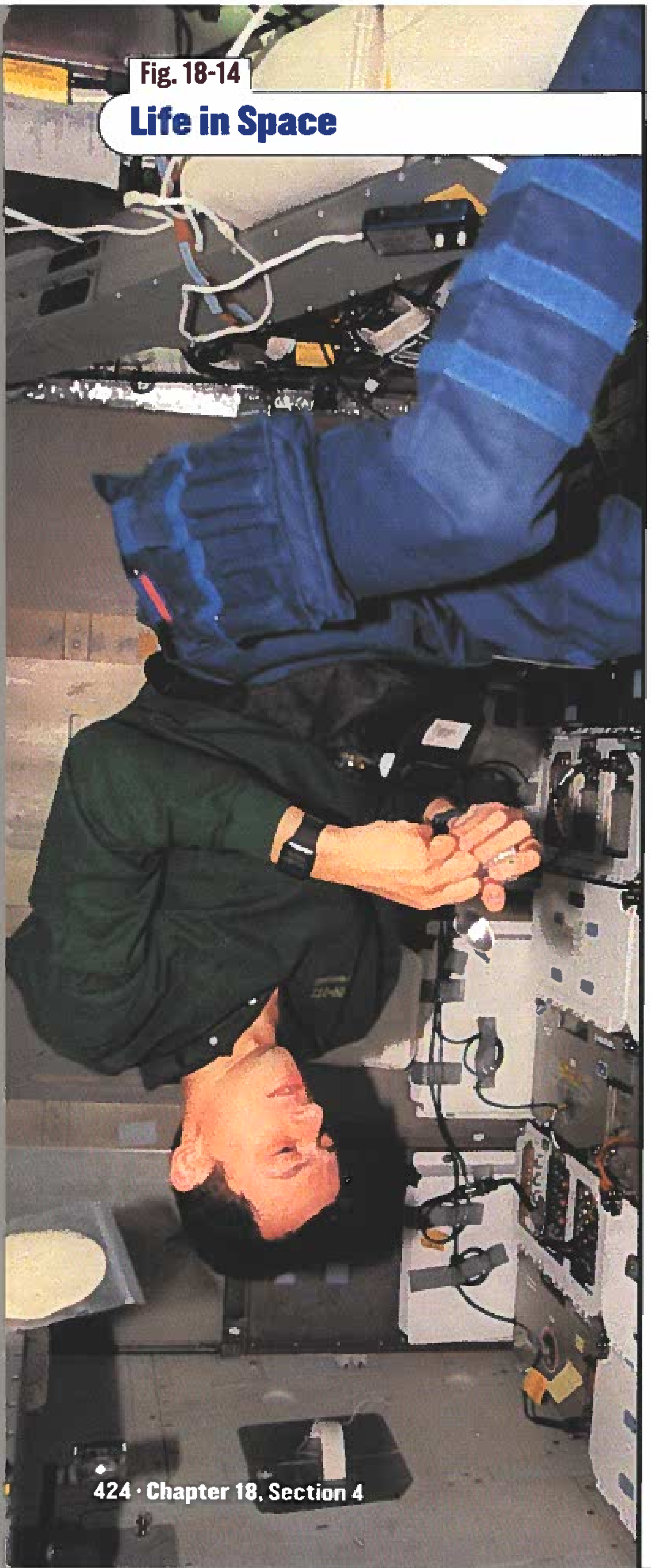
People are also thinking of developing space colonies on the moon or Mars as permanent homes. Living on another world will be different from a short trip in a shuttle or a longer time on a space station. The space colony will be built from materials brought from Earth. It will have an artificial environment that can be controlled for maximum comfort. The colony may have its own farming areas, artificial gravity system, and even shopping centers. Space colonies will have to become almost *self-sufficient*. That means they must produce what they need to survive.

SECTION 4 TechCHECK

1. What were the first space stations called?
2. Why do astronauts have to use liquid salt and pepper?
3. What does it mean to be self-sufficient?
4. **Apply Your Knowledge.** Prepare your favorite meal as if you were planning on eating it in space.

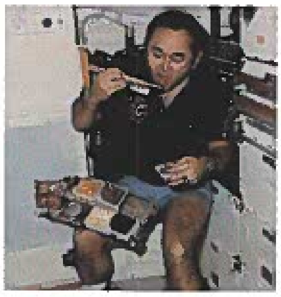
Fig. 18-14

Life in Space



What's for dinner? Breakfasts, lunches, and dinners are packed as meals in containers. Many foods have been vacuum-packed, dehydrated (dried), and deep-frozen. Most drinks, except orange and grapefruit juice, come in powdered form. Luckily some things, such as peanut butter, nuts, and chewing gum, stay in their natural form.

Eating in space. Preparing the food and eating it take special equipment. A punching machine inserts hot or cold water into dehydrated food packs. Velcro tape or magnets hold the food onto your tray. Most food is in a thick gravy or jelly-like substance, so it sticks to your spoon or fork. Salt and pepper must be added in liquid form because crystals would float away.



Sleeping in space. You don't need a bed. You just have to tie your sleeping bag someplace so that you don't float off when you turn over in your sleep. Even your breathing can make you move!

Keeping clean. To take a shower in space, you have to hook your feet to the floor, or you might end up upside down from how you started. Suction devices pick up water so that droplets don't float around. Even to use the toilet you have to strap yourself down with a seat belt!

ACTION ACTIVITY

Building a Space Station

Be sure to fill out your TechNotes and place them in your portfolio.

Real World Connection

Space stations provide a place for astronomy, for doing long-term experiments on materials, and for testing the effects of microgravity on people. They also provide a place for careful observation of the Earth. They might even help us locate and fight the harmful effects of air or water pollution.

In this activity, you will work as engineers, drafters, and technicians to design and build a simulated space station. Fig. A.

Design Brief

Design and build a simulated space station that is large enough to hold four student astronauts. At least two exits must be provided. Include a mission control center and a communications system that will connect to the space station. Consider the following:

- Your space station must be strong enough to support the weight of the building materials used and the equipment you put in it.
- The design of your space station must provide for easy entry and exit in an emergency. The exits should not be able to be locked or blocked.
- The design of your space station must provide for electrical safety. Any use of extension cords must be approved by your teacher.
- Your space station will be used to simulate experiments that astronauts would perform in space. Plan what kind of experiments you could do, and make a list of the equipment that you might put into the space station.

Fig. A

Materials/Equipment

- plywood, prefinished hardboard, particleboard
- electrical components: wire, switches, etc. (12-volt DC)
- nails, wood screws, panel adhesive
- band saw, scroll saw, saber saw
- electric soldering gun
- CAD software

(Continued on next page)

ACTION ACTIVITY

Procedure

This is a long-term activity that will require the help of all students in each class. You may work in groups to make different parts.

1. Brainstorm ideas for the shape of your space station. The space and materials available may be factors to consider.

SAFETY FIRST

Follow your teacher's instructions on the safe use of electricity. You must get the approval of your teacher before any electrical connections are made. Follow the safety rules listed on pages 42-43 and the specific rules provided by your teacher for tools and machines.

2. Use CAD software to design the shape of your space station. Keep the design specifications in mind.
3. Choose the design that best suits your needs. Plan the structural skeleton that will support the station. Your design might look like the one shown in Fig. B.
4. When the skeleton is complete, create the inside walls of the space station. Leave the outside uncovered for now so you can easily run wires and connect equipment.
5. Design and install the electrical circuits so they will run on 12 volts DC or less. Put a fuse in each circuit to prevent possible fires. Ask your teacher for help.

INFOLINK

See Chapter 5 for more information about CAD.

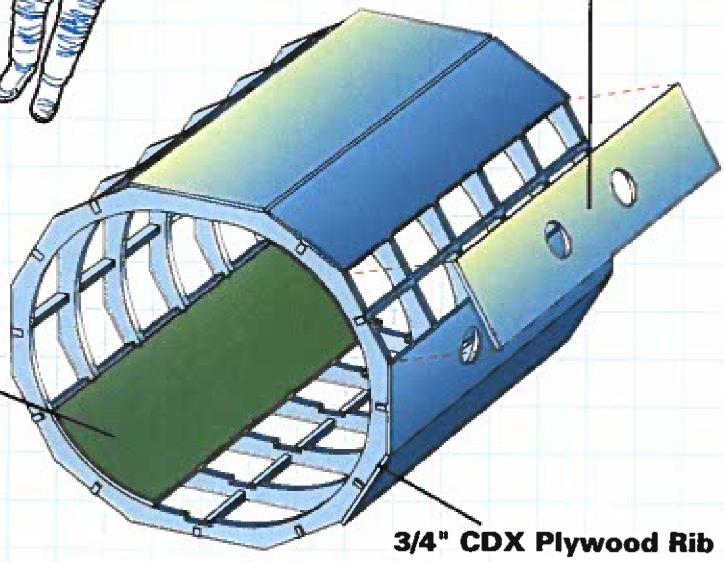


Fig. B

6. Complete the outside "skin" of your space station. Keep in mind that you may want to remodel your design or add more equipment in the future. Each outside panel should be removable to give easy access.
7. Use your imagination to think of ways equipment might be used in the simulation of space station experiments. Make a list of the equipment and its use in the space station. Your list might include:
   - *Computer.* Can your computer be connected to a modem or a network so you could communicate with other student astronauts?
   - *Laser.* Could a laser be used to simulate the alignment of your space station with the Space Shuttle for docking?
   - *Video phone.* Can you use video cameras and monitors to let student astronauts see and talk with mission control in another classroom?
   - *Cooking equipment.* How would food preparation be different in space? What would it be like to eat in microgravity?
   - *Exercise equipment.* Astronauts must exercise in space to keep their muscle tone. How could you simulate exercise activities in your space station?
8. Work in groups to perform space-related experiments in the space station. Switch groups so that everyone has a chance to be at mission control and "in space."

Evaluation

1. List the features that your simulated space station has in common with a real space station.
2. If you could add one more piece of equipment to your space station, what would it be and how would it be used?
3. How could space station research help us on a mission to Mars?
4. Why would it be important to recycle materials on a space station? How would recycling in space be different from recycling on Earth?
5. **Going Beyond.** Research real space stations and those in science fiction. What do the two have in common? How are they different?
6. **Going Beyond.** Contact other schools that have simulated space stations. Communicate with them using a modem or fax machine while you are simulating a space mission.
7. **Going Beyond.** Write to NASA requesting information on space stations. Ask NASA if you could set up a phone call to an astronaut or mission specialist.
8. **Going Beyond.** Download information from SpaceLink (available from NASA) or other space-related bulletin board services. Downlink information related to space from a satellite dish receiving system, such as NASA Select television.
9. **Going Beyond.** Research the design and construction of simulations conducted by NASA to prepare for the building of a space station. Research the former Soviet Union's *Mir* space station.

CHAPTER 18 REVIEW &

CHAPTER SUMMARY

SECTION 1

- Space spinoffs are products, medicines, or other items that can be used on Earth.
- The future of space exploration will be determined by how people want their tax money spent.

SECTION 2

- In a microgravity environment, the effects of gravity are reduced compared to gravity at Earth's surface.
- All orbiting spacecraft are actually falling toward the Earth.
- In a vacuum, there is not enough air to breathe and a lack of air pressure; both are fatal to humans.

SECTION 3

- Daily exercise is needed to reduce the effects of microgravity on the body.
- Mission specialists simulate the floating effect of a microgravity environment using neutral buoyancy.

SECTION 4

- The *Skylab*, *Salyut*, and *Mir* missions gave us information about living and working in space.
- Many nations are working together to build the *International Space Station*.

REVIEW QUESTIONS

1. What is microgravity?
2. Explain why spacecraft are really falling toward the Earth when they are in orbit.
3. What are space spinoffs? Give examples.
4. Describe how eating in a microgravity environment would be different from eating on Earth.
5. How did the first space stations help with plans for the *International Space Station*?

CRITICAL THINKING

1. Do you think tax money should be spent on space exploration? Explain.
2. What would happen if you spilled water in the vacuum of space?
3. Do you think it is possible to swallow while standing on your head? How does this relate to eating in microgravity?
4. Explain how hot air balloons and dirigibles are made neutrally buoyant.
5. What would happen if you tried to throw a ball while walking in space?
6. Why do you think the *International Space Station* is made up of modules rather than one large piece?