Accommodations for Space Exploration

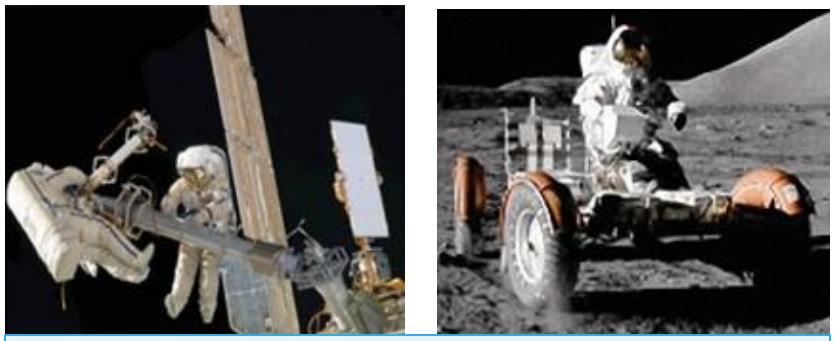
Reflect

Human beings are adapted to conditions found on Earth. The conditions in space and on the Moon are very different from those on Earth. For example, in space there is no air to breathe or gravity to keep an astronaut from floating away. Can you think of other ways in which conditions in space and on the Moon differ from those on Earth? How do you think these conditions threaten the health and lives of astronauts?

To survive in space, humans must account for several environmental factors. The human exploration of space began in the 1960s. Astronauts from all over the world have been traveling into space ever since. Some have traveled as far as Earth's moon, walking and riding over its surface. Others have lived for months at a time aboard the International Space Station, which floats in orbit about 200 miles above the planet's surface. However, no matter how they make the journey, astronauts always are exposed to a hostile and potentially deadly environment.

Temperatures in space plummet far below 0˚C, the freezing point of water. At the bottom of some craters on the Moon, temperatures have been measured at less than −238˚C (−397˚F). Oxygen, which sustains life on Earth, is absent in space and on the Moon. Harmful radiation from the Sun and other parts of the galaxy shoots through space. This radiation has so much energy that it can destroy living tissue that is not protected by special suits. Without gravity to support them, human bones and muscles can become extremely weak.

Yet, astronauts have survived being exposed to this environment, and they have returned to Earth in good shape. How is this possible? Engineers have designed life support systems for astronauts. These include space suits, space capsules, space vehicles, and space habitats that protect humans against the harmful effects of the space environment.



Life support systems have allowed astronauts to work outside the International Space Station (left) and to ride on the Moon's surface (right) without being harmed.

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Look Out!

If you've ever seen an action movie set in space, you may have noticed that astronauts in the story can hear explosions, gunfire, and other sounds. This makes for a more exciting movie; yet, in real life, people cannot hear sounds in space. Space is a *vacuum*. This means it is nearly empty of particles. You have learned that sound is a form of energy caused by vibrating particles. Without particles to vibrate, sound waves cannot exist in a vacuum.

Sound cannot travel through the vacuum of space.

Inside the International Space Station, machines create an artificial environment that contains air particles. This is how astronauts there can talk to each other—and breathe!—as they would on Earth. However, astronauts working outside the space station require special radios, video devices, and computers to communicate with each other and with scientists on Earth. These devices transform the sounds the astronauts make into forms of energy that can be transmitted through space.

Spacesuits enable humans to survive and work in space.
Many of the dangers of living and working in space result from the lack of an atmosphere. Earth's atmosphere gives us air to breathe and protects us from harmful radiation. It provides a medium through which sound can travel, and it warms the planet by trapping heat at Earth's surface. None of these protections are available in space. To survive there, astronauts must wear an extravehicular mobility unit (EMU)—commonly called a spacesuit.

An astronaut's spacesuit contains many different parts. Each part plays a crucial role in the astronaut's survival, and all the parts must fit together perfectly. Any gaps or tears in a spacesuit pose immediate threats to an astronaut's life. Let's take a look at some of the most important parts.

- **Helmet:** The hard helmet of a spacesuit performs a number of functions. Astronauts see through a clear visor that contains an extremely thin layer of gold, which filters out harmful radiation. The helmet also protects the astronaut from debris and other small objects whizzing through space. It contains earphones and a microphone for communicating with other astronauts.

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- **EVA Gloves:** To work in space, astronauts must be able to easily move their fingers without exposing them to radiation and freezing temperatures. To do this, they wear EVA gloves. (*EVA* stands for "extravehicular activity," or activity outside a space vehicle.) The fingers of these gloves are very flexible and equipped with heaters. The gloves are connected to the suit's arms in a way that allows astronauts to turn their wrists.

- **Liquid Cooling and Ventilating Garment (LCVG):** To keep warm on a cold day, you might pull on long underwear. Unfortunately, if you work up a sweat outside you might soak your underwear. Astronauts wear something similar to long underwear. However, the LCVG helps to keep them cool and dry as they work in space. It is webbed with over 90 meters of narrow tubing. Water is pumped from a special backpack through the tubes to cool the astronaut's body. Vents in the underwear move any sweat the astronaut produces while working away from the astronaut's skin.

- **Additional Layers:** The inner three layers of an astronaut's spacesuit make up the LCVG. However, a spacesuit contains eleven more layers! The vacuum of space applies almost no pressure to an astronaut's body. A bladder layer directly above the LCVG is designed to apply the pressure the human body needs to function properly. Among the remaining layers are seven made of a special plastic that acts like insulation. These layers keep temperatures stable near the astronaut's body. The outer layer of a spacesuit is made of three materials. They form a fire- resistant, waterproof barrier against space objects.

Design accommodations enable humans to complete ordinary tasks and exercise in space.

Normally, your everyday activities provide the exercise you need to stay healthy. You walk, you run, and you play sports. As you move on Earth, your muscles and bones work against the downward pull of gravity. Your body is adapted to a world that contains gravity. Working against gravity helps to produce strong muscles and bones.

In space, astronauts experience practically no gravity. (This is called a *microgravity environment*.)

Regular exercise on specialized equipment keeps astronauts' muscles and bones from weakening in space.

Accommodations for Space Exploration

Look Out!

Astronauts in space vehicles or aboard the International Space Station float weightlessly. Their muscles and bones no longer have to work against the force of gravity. If astronauts do nothing but float, they will lose bone and muscle tissue. They will lose fluids and red cells from their blood, and less oxygen will move through their bodies.

Fortunately, scientists have found ways to keep astronauts healthy in microgravity environments. Astronauts aboard the space station spend several hours a day exercising using stationary bicycles, treadmills, and a piece of equipment called a Resistance Exercise Device (RED). The RED is like a weight-lifting machine equipped with rubber cords. Astronauts use their hands, arms, legs, feet, and other body parts to pull the cords. Straps and harnesses keep the astronauts from floating away as they exercise!

What Do You Think?

How do you think astronauts move around their spacecrafts in a microgravity environment? How do you think they sleep without floating out of bed? What are some other challenges of living without gravity that the astronauts deal with?

Getting Technical: SAFER
When astronauts move or work outside a space vehicle, they use strong cords to attach themselves to the vehicle. If this cord were to break or come loose, the astronaut would be in danger of floating away. As an additional safeguard, space scientists and engineers designed a kind of life preserver called SAFER. *SAFER* stands for Simplified Aid for EVA Rescue. (Remember, *EVA* refers to activity outside of a space vehicle.)

You might think of SAFER as a life preserver that is worn like a backpack. SAFER is equipped with containers of compressed nitrogen gas. An astronaut floating away from a space vehicle releases jets of nitrogen from ports located around the backpack. This thrusts the astronaut in the direction opposite to where the gas is flowing. Astronauts use a kind of joystick to control which ports release nitrogen. This allows astronauts to maneuver themselves safely back to their vehicle.

The SAFER backpack allows astronauts to control the direction in which they float.

Try Now

What do you know?
Astronauts in space require life support systems they don't need on Earth. These systems are necessary because conditions in space are very different from conditions on Earth.

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Try Now

Complete the chart below by describing whether each condition is present or absent in each environment. In addition, explain how astronauts are protected from dangerous conditions.

Condition	Present on Earth?	Present in Space?	What Protects Astronauts?
Gravity			
Atmosphere			
Radiation from the Sun			
Extreme temperatures			

Connecting With Your Child

Experimenting with Temperature Changes

In space, an astronaut's body temperature must be kept as constant as possible. For an astronaut working outside a space vehicle, the spacesuit is the primary tool for maintaining body temperature. You and your child can investigate how different materials affect temperature loss over time. All you need is a thermometer, a clear plastic container, cold water, and various materials to wrap the container in (e.g., aluminum foil, paper towels, various kinds of cloth, plastic wrap). Follow this procedure:

1. Fill the container with warm water.
2. Place the thermometer in the water.
3. Wrap the container with a material of your choice. Be sure to place the wrap over the top of the container and tightly around the thermometer. The material should cover all surfaces of the container. (You may need to use rubber bands to keep the material tightly in place.) Record the material you are using and the number of layers of the wrap.
4. Check and record the temperature of the water at five-minute intervals.
5. Repeat the experiment, varying the kinds of materials or the number of layers of wrap. You may mix materials: that is, wrap the container in more than one kind of material.
6. The purpose of your investigation is to determine which material, combination of materials, or number of layers best insulates—or maintains the temperature of—the water in the container.
7. Write a brief report of your results, explaining how they might relate to the design of a spacesuit.

Here are some questions to discuss with your child:

- Which materials were most effective at maintaining the water's temperature? Which materials were least effective?
- Why do you think some materials are more effective insulators?
- How might the results of your investigation relate to the design of a spacesuit? (This question is not intended to imply that any of the materials in your home might be appropriate for constructing a spacesuit. Rather, students should consider how different materials have different properties that make them more or less suitable for certain purposes.)