10.3

Humans in Space

One of the biggest challenges of space travel is the feeling of weightlessness that astronauts experience. In space, astronauts may experience a range of health issues. They also face hazards that do not exist anywhere on Earth.

A Feeling of Weightlessness

Have you ever been on a roller coaster and at one point in the ride felt that you were off your seat? For a moment, you may have experienced the feeling of weightlessness.

Some people think that weightlessness in orbit is caused by lack of gravity. That is not true—there is gravity. The force of gravity 100 km from Earth's surface is 97 % of the force of gravity at Earth's surface. The feeling of weightlessness occurs because orbiting objects are constantly falling toward Earth. Astronauts feel weightless because they are falling toward Earth at the same rate as their spacecraft. This explains why astronauts in the space shuttle or space station appear to be floating. Both the astronauts and the spacecraft are travelling forward, but they are also falling at the same time (**Figure 1**).

The feeling of weightlessness in spacecraft affects the human body in several ways. Together, the effects are known as Space Adaptation Syndrome (SAS).

Figure 1 Julie Payette and Robert Thirsk float in the Destiny laboratory of the International Space Station.

Dizziness

About two-thirds of all astronauts experience dizziness, disorientation, and nausea during their first few days in space because they are constantly falling. The important tasks during a space mission, such as spacewalks and linking up with the ISS, often do not take place during the first few days in space. This way, the astronauts have time to adapt to space conditions.

Puffy Face and Skinny Legs

On Earth, blood and other body fluids tend to distribute themselves evenly throughout the body. When astronauts are in orbit, these fluids collect in the upper part of their bodies. This occurs because of the constant falling toward Earth the body experiences when it is in orbit. This causes puffy face, stuffy nose, and headaches. It also causes their legs to become skinnier than their upper bodies, as there is less blood pooled there (**Figure 2**). Space travel also affects the body's ability to use water properly and can cause dehydration.

Figure 2 (a) Person on Earth; (b) The same person in space. This effect is sometimes called the "puffy-face, bird-leg look."

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Did You Know?

Seasickness in Space

Researchers hypothesize that balance organs in the inner ear do not function properly in space, where there is less exposure to the force of gravity. This produces a sensation similar to seasickness on Earth.

Bone and Muscle Loss

Astronauts can lose up to 2 % of their bone mass for each month they spend in space. This is because in an apparently weightless environment, their skeletal systems do not have to hold up their bodies. As a result, calcium and phosphorus, which are usually used for this purpose, are excreted instead of being retained in bones. This is not a very big problem on short missions of a week or two. However, astronauts who spend months at a time on the ISS have to be monitored carefully (**Figure 3**). The effect is similar to a bone loss condition known as osteoporosis.

Figure 3 Canadian astronaut Robert Thirsk stayed on the ISS for 6 months, from May 27, 2009, to December 1, 2009. Thirsk, age 55, was monitored closely so that scientists could learn more about the endurance of the human body in space.

While in space, muscles also weaken. To counter both bone loss and weakened muscles, astronauts must use a treadmill onboard the space station at least 2 hours a day. Apparent weightlessness also causes astronauts to grow taller by 2 cm to 4 cm while in orbit. This is because gravity in space does not compress the backbone as much. Some astronauts (typically taller men) experience back pain when their backbones expand. Re-adapting to Earth takes about as long as the astronaut was in space. Some bone mass is probably lost for good.

Hazards in Space

While in space, dangerous conditions exist both inside and outside the spacecraft. Astronauts may face hazards that do not exist anywhere on Earth.

Radiation

Earth's atmosphere and magnetic field help protect us from the Sun's radiation. Low Earth orbit is within the magnetic field, so missions there are somewhat protected from radiation. But astronauts can still be exposed to harmful radiation. Shields on spacecraft provide some protection from harmful radiation. Spacesuits are also specially designed to protect astronauts from radiation during spacewalks.

Astronauts on missions outside of Earth's magnetic field—such as those to the Moon or farther—face even greater risks from the Sun's radiation. Mission planners must be able to monitor radiation levels and may have to consider cancelling missions when radiation levels are too high. If a base on the Moon is constructed, it would have to be almost completely shielded against radiation.

Equipment Failure

A spacecraft is an artificial environment that protects astronauts from the harsh conditions of space. This environment is operated by machines and computers. There are usually backup systems in case these fail. Equipment failure can cause life-threatening situations for crew members. If systems fail, there may not be enough air to breathe, food to eat, or water to drink.

Environmental System Failure

- The environmental system provides breathable air to astronauts. This system is critical to their survival.
- Returning to Earth from a low-orbit mission involves many difficult tasks. If the environmental system were to fail during re-entry, astronauts would not be able to respond quickly or perform their tasks.
- Backup systems provide emergency oxygen in case of environmental system failure. The orange suits that astronauts wear during launch and re-entry have built-in survival gear (**Figure 4**).

Figure 4 These suits contain a helmet with communication gear and oxygen, as well as a parachute pack, life raft, and life preserver in case of a re-entry emergency.

Computer Failure

- Computer failure may result in an inability to control the spacecraft.
- The space shuttle has five computers to control the main engines and other systems. For critical functions, the computers "vote" to make sure that they are making the correct "decision." These computers form a backup system to ensure against any system failures.

Loss of Communication

- A spacecraft cannot operate without guidance from the Mission Control Center when it is time for re-entry. Re-entry is controlled by ground computers.
- During shuttle missions, Mission Control Center (**Figure 5**) updates the crew each morning with a "go home plan." If communication with ground control on Earth is lost, then the craft must return following this plan.

Figure 5 NASA Mission Control Center in Houston. Here, the flight director manages the flight, the safety of the crew, the experiments conducted on the mission, and all the people at Mission Control.

Illness of Crew

Astronauts have had the flu, head colds, and aches and pains during a mission. They are in direct contact with Mission Control and can request a private medical conference that will allow them to speak to a NASA medical doctor. Several astronauts have also been doctors themselves. On longer missions, astronauts have regular conferences with NASA doctors to maintain good health.

Space Junk

Human-made satellites may remain in orbit once they are no longer useful, perhaps for hundreds of years. As they deteriorate or collide with other objects, this space technology becomes waste, or **space junk**. Space junk can also be tools or other materials that astronauts accidentally lose as they work in space (**Figure 6**). For example, in November 2008, an astronaut working on the ISS let go of a backpack-sized toolbag. The orbiting toolbag can still be seen in the night sky. Even small items such as nuts and bolts travelling at a few kilometres per second could heavily damage a shuttle or a working satellite.

▶ **space junk:** wreckage from artificial objects orbiting Earth

Scientists are trying to determine how to get rid of space junk. In the meantime, space agencies and astronauts are making great efforts to minimize the amount of useless material left in space.

Figure 6 This drawing shows some of the many objects—from satellites to old rocket parts—orbiting Earth. Space junk is a threat for all spacecraft.

Working in Space

The ability to work safely in space is very important. Space has no oxygen, very little air pressure, extreme temperatures, and radiation. Astronauts wear pressurized spacesuits that provide them with oxygen and protection from lack of air pressure in space. The spacesuit also protects them from temperature extremes and small meteoroids or tools that are not secured.

Features of a Spacesuit and Helmet

The main purpose of the spacesuit and helmet is to protect astronauts while they are outside the spacecraft. Temperatures change very quickly between the sunlit side of a celestial object and the side in shade. The temperatures outside a spacecraft vary between 120 °C in sunlight and –100 °C in the shade. A spacesuit is insulated to protect astronauts from these extreme temperatures. A spacesuit must also be flexible so that an astronaut can perform tasks in a space environment (**Figure 7**). Imagine trying to perform a simple task like tightening a screw while wearing hockey gloves!

The helmet is made of a material that can withstand impacts, similar to helmets worn by athletes. **Figure 8** shows some of the features and safeguards of a helmet and spacesuit.

Figure 7 Spacesuit gloves must be flexible so that astronauts are able to carry out their tasks during missions.

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Web Link

To learn more about the spacesuits of astronauts,

GO TO NELSON SCIENCE

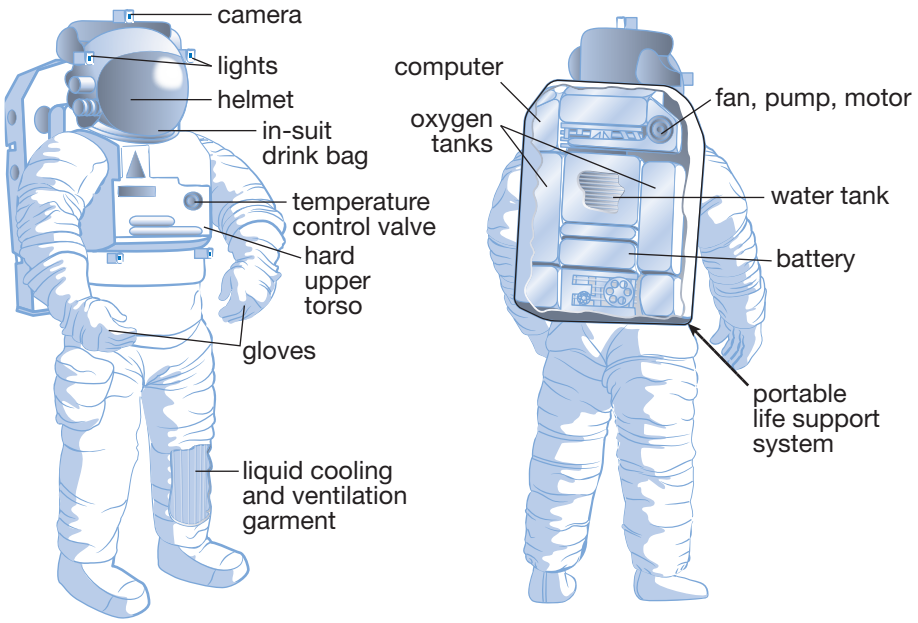

Figure 8 A spacesuit must be pressurized; supply oxygen; regulate temperature, so the astronaut does not get too hot or too cold; and offer reasonable protection against radiation.

Living in Space

Think about what you would need to pack for a camping trip. You would need to bring water, food, clothing, and something to sleep on, or in. Astronauts need to bring all of those items into space, plus one more important item—oxygen.

Life Support on the Space Station

The International Space Station's primary source of oxygen comes through electrolysis of water. In Chapter 7 you read that, in the process of electrolysis, electricity is used to break down water molecules into hydrogen molecules and oxygen molecules. On the ISS, electricity is generated using solar panels. The ISS also has solid oxygen in canisters as a backup supply. The space station recycles water in two ways:

- **Condensing water from humidity:** This is a process similar to what happens in the water cycle. The difference is that the humidity comes from the astronauts breathing and sweating.
- **Reclaiming and recycling wash water and urine:** First, urine is passed through a distillation process that separates the liquid and the gases. Then, along with other liquid wastes, the urine goes through several purification processes. It may sound surprising, but the purified water is cleaner than most of the water we drink on Earth.

Daily Living in Space

Astronauts in space have the same needs as people do on Earth. These are some of the ways astronauts adapt to life in space.

Eating

Many foods and beverages consumed on Earth are not permitted on spacecraft. For example, precautions are made to keep drinks from spilling. Spilled liquid might get into electrical equipment and damage it. Many of the foods astronauts eat are dehydrated (dried out) to preserve them. The food is then rehydrated (water is added back) and heated in microwave ovens. A typical meal could include beef stew, macaroni and cheese, pears, and a beverage.

Many of the freeze-dried foods like fruits or pasta we eat today were developed for travel in space. Take a look in your kitchen cabinets and refrigerator. You might be eating meals very similar to those astronauts eat in space!

Sleeping

Astronauts use sleeping bags that are attached to the walls, ceiling, or floor of the spacecraft to keep from floating into other areas (**Figure 9**). There is no feeling of what is up or down, so sleeping on the ceiling is the same as sleeping on the floor. Many crew members miss the feeling of resting their head on a pillow. The sheets and materials of the sleeping bag are not very soft, as they have to be made of a fireproof material.

Personal Hygiene

Because of the feeling of weightlessness in space, astronauts cannot use water to shower or bathe. Instead, they use rinseless shampoos that were originally developed for hospital patients. Rinseless shampoos are applied and then rubbed off, without using water. Astronauts use wipes, similar to those used for infants on Earth, to clean themselves. In space, everything floats. Special toilets work like vacuums with devices that direct urine and waste into a storage container.

Figure 9 This wall-mounted sleeping bag has arm restraints to keep arms from floating around while astronauts sleep.

TRY THIS WORKING IN SPACE

SKILLS HANDBOOK 3.B.6.–3.B.9.

SKILLS: Observing, Analyzing, Evaluating, Communicating

In this activity, you will simulate what it is like to work in space.

Equipment and Materials: stopwatch; coat; helmet; gloves; a nut; a bolt

1. Work in pairs. While one person unscrews the nut from the bolt, the other person should use the stopwatch to measure how long this takes. Record the time in your notebook.
2. Have one person put on the coat, helmet, and gloves to simulate the weight of a spacesuit. Repeat Step 1, making sure to record the time in your notebook again.
3. Brainstorm three other tasks or activities that astronauts might carry out while in space. Take turns carrying out these tasks or activities with your simulated spacesuit.

A. Compare the time it took to perform each task with your bare hands with the time it took to perform the same task in your simulated spacesuit. C

B. Imagine you had to work like this for 7 hours with only water to drink, and no food. Write a journal entry about what the experience would be like. C A

C. How would you make sure that you did not lose anything such as tools or small bolts? T/I

D. How might you simulate a microgravity environment on Earth? T/I

E. How do you think the feeling of weightlessness would affect your ability to perform each task? A

UNIT TASK

Bookmark

You can apply what you learned about working in space to the Unit Task described on p. 404.

10.3 Wrap Up

- The long-term effect of weightlessness in space can cause serious health problems for astronauts.
- Extreme environmental conditions in space require that astronauts take a life-sustaining environment with them.
- Equipment failure in space could cause loss of air for breathing, computer failure, and loss of communication.
- Spacesuits are constructed to protect astronauts from the extremes of the space environment and to enable them to perform their tasks.
- Astronauts must use special foods, sleeping bags, and personal hygiene items that are adapted for weightlessness.

CHECK YOUR LEARNING

1. What are three ways that space missions can affect the body? K/U
2. What are two potential hazards for astronauts during a spacewalk? K/U
3. What is space junk? Give two examples and describe why these materials pose hazards to an astronaut or spacecraft. K/U
4. Suppose you are on a two-week trip to the ISS. Write a letter to a friend that describes how you are adapting to daily routines such as eating, sleeping, and personal hygiene. C A
5. How is water recycling on the space station similar to the water cycle on Earth? K/U
6. What might humans learn by studying the health effects experienced by astronauts in space? A