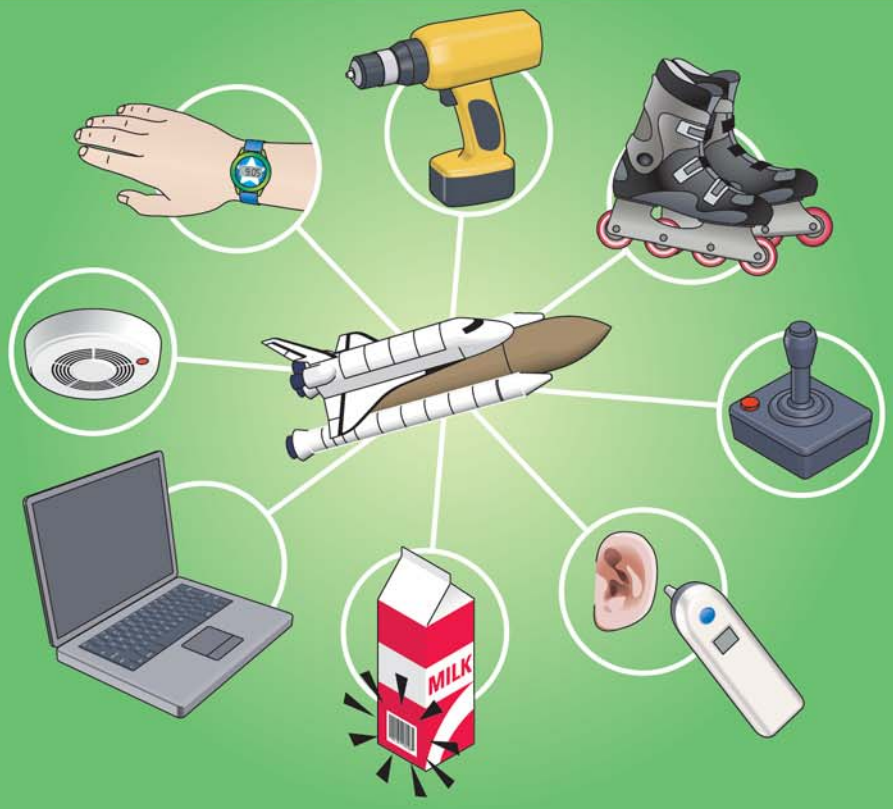
CHAPTER 12

Exploring extreme environments has both benefits and costs.



KEY IDEAS

- The exploration of extreme environments produces spinoffs and other benefits.
- The exploration of extreme environments has drawbacks and costs.

Did you know that the joystick you use to play video games is modelled on the controls that astronauts use to practise shuttle landings? Exploration technology is all around you. Many inventions created for exploring extreme environments find their way into everyday life.

Exploration provides knowledge about the world you live in. New species of plants and animals discovered deep in the oceans may lead to new medicines. Satellites in space are used to predict the weather on Earth. Information sent from sensors on the ocean floor may help predict earthquakes.

But there are costs to exploring extreme environments, too. Deciding whether the benefits of exploration outweigh the costs is an important issue, not just for scientists, but for everyone.

Exploration Spinoffs

12.1

What do the bar codes you see on many products have in common with space technology? National Aeronautics and Space Agency (NASA) developed bar code technology to keep track of millions of spacecraft parts. Today, grocery stores and department stores use bar codes to keep track of their products (**Figure 1**). Bar code technology is an example of a **spinoff** —an everyday use of a technology that was first developed for exploration.

Figure 1
Scanning bar codes is just one example of space technology.

Space exploration, in particular, has given us many spinoffs. Smoke detectors, like the ones used in your home, were originally developed to detect deadly gases on *Skylab*, the first space station. Cordless tools were originally developed for astronauts to use on the Moon to collect rock samples. Even portable laptop computers were first used on space shuttle missions. Other examples of spinoffs are shown in **Figure 2**.

Figure 2
A type of fetal heart monitor (left) and industrial robots that put cars together (right) are two spinoffs from space technology.

LEARNING TIP

Before you read a table, look at its title. The title will help you focus on what the table shows. Then read the column headings to see how the information is organized.

Spinoffs from space and ocean exploration are listed in **Table 1**.

Table 1 Spinoffs from Space and Ocean Exploration

Exploration technology	Examples
microelectronics	digital watches, computers, heart pacemakers, calculators, cordless tools
new materials	waterproof materials, flame-resistant materials, nonstick coating
ceramic materials	dental braces
plastics	safety helmets, in-line skates
space food	freeze-dried foods
robotics	building cars, mining, oil exploration
medicine	motion sickness patches, scanning equipment, fetal heart monitor, heart pump, kidney dialysis, insulin pumps, temperature pill, surgical probe

TRY THIS: RESEARCH A SPINOFF

Skills Focus: questioning, inferring

Look at the spinoff technologies listed in **Table 1**. Choose one technology and research how it was developed. For example, you could research the development of in-line skates or safety helmets (**Figure 3**). Make a time line for the technology. How is this technology used in daily life?

Figure 3
Helmets and in-line skates are spinoffs of exploration technology.

CHECK YOUR UNDERSTANDING

1. What is a spinoff? Why are spinoffs important?
2. What exploration spinoff do you think has the most impact on your life? Explain your choice.

Exploration and Your Health

12.2

The technology developed for space exploration has produced many medical spinoffs. For example, heart pacemakers, laser surgery, and medical imaging systems are three important spinoffs from space exploration.

We also benefit from medical experiments done in space. In space, substances mix together more easily, and crystals grow differently because of the microgravity environment. These conditions allow scientists to develop new medicines. Space medicines have been used to treat people on Earth who have diabetes, burns, and blood diseases. Research is also being done on producing medicines that are made with "space-grown" crystals.

Three Canadian astronauts—Dr. Roberta Bondar (**Figure 1**), Dr. Robert Thirsk, and Dr. Dave Williams (**Figure 2**)—are medical doctors who specialize in space medicine. They study the impact of working and living in space. As well, they experiment to find ways to apply what they have learned to help people on Earth. For example, astronauts are given medication to stop them from feeling dizzy during landing. This medication is now being used to treat heart patients on Earth.

Figure 1
Roberta Bondar flew on the space shuttle *Discovery* in 1992. The crew looked at how microgravity affects shrimp eggs, lentil seedlings, and bacteria. Dr. Bondar also investigated how humans adapt to weightlessness.

Figure 2
Dave Williams flew on the space shuttle *Columbia* in 1998. During the 17-day mission, the crew studied the effects of weightlessness on the nervous system. They also looked at how the inner ear, cardiovascular system, and muscles cope without gravity.

CHECK YOUR UNDERSTANDING

1. Give two reasons why scientists do medical experiments in space.
2. Why is it important to study the effects that living in space has on astronauts?

12.3 The Drawbacks of Exploration

The discovery of new species, spinoffs, knowledge about the world and the universe, and new energy sources are just some of the benefits of exploring extreme environments. However, there are also drawbacks to explorations.

Figure 1
The space shuttle *Columbia*

Space exploration, for example, is costly and dangerous. Since space exploration began, 18 astronauts have been killed on missions. The most recent space disaster occurred on February 2003, when the space shuttle *Columbia* (**Figure 1**) disintegrated upon re-entry to Earth's atmosphere. All seven of the astronauts on board were killed. Even training for space missions can be deadly. Ten astronauts have been killed in training accidents on the ground.

What orbits Earth, is found on the surfaces of the Moon, Venus, and Mars, and is greatly feared by space explorers? Space junk! Space junk includes broken satellites, discarded pieces of rockets, and even nuts and bolts from spacecraft. All human-made objects that remain in orbit and serve no useful purpose are called space junk. Space scientists estimate that there are millions of pieces of space junk floating around Earth (**Figure 2**).

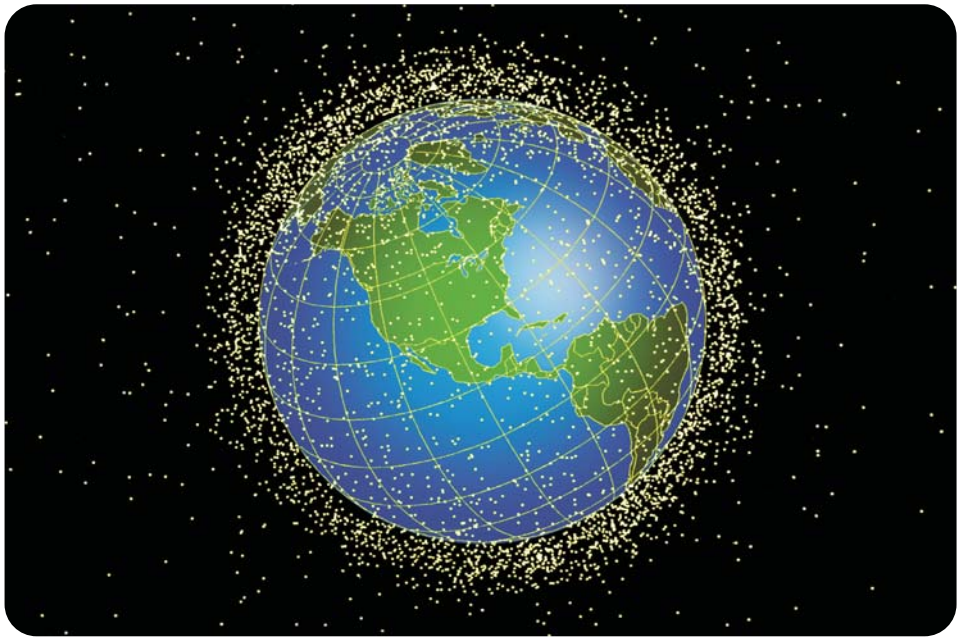


Figure 2
Space junk orbits Earth and poses a hazard to the International Space Station and to spacecraft.

Space junk comes in different sizes and shapes. Some pieces are as large as trucks. Others are smaller than a flake of paint. There's even a glove that floated away from the crew of *Gemini 4* during the first spacewalk and a camera lost by an astronaut during the *Gemini 10* mission. All this space junk zooms around Earth at speeds of up to 36 000 km/h.

Space junk poses a danger to working satellites and spacecraft because it travels at great speeds. Even small pieces can damage a spacecraft in a collision (**Figure 3**).

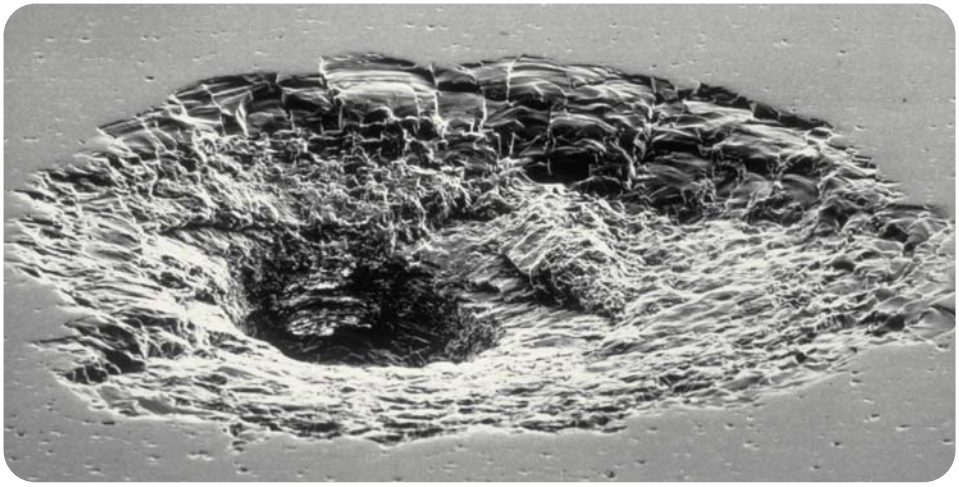


Figure 3
This tiny crater in the window of the space shuttle *Challenger* may have been caused by a flake of paint.

Ground stations track large pieces of space junk so that collisions with working satellites, spacecraft, and the International Space Station can be avoided. Different countries are also working on plans to stop the creation of space junk and to clean up what is already there. Perhaps a future job may be space junk collector!

Another drawback to exploration is cost. Billions of dollars are spent designing and testing vehicles for space and ocean exploration. This money could, perhaps, be better spent elsewhere. Or could it? In the next section, you will look at whether exploration is worth the cost.

CHECK YOUR UNDERSTANDING

1. What are some of the drawbacks of space exploration?
2. What is space junk? Where does space junk come from?
3. What drawbacks do you think are associated with exploring volcanoes or oceans?

12.4 Explore an Issue

LEARNING TIP

Before you begin this activity, read the section "Exploring an Issue" in the Skills Handbook.

Is Exploration Worth the Cost?

Exploration benefits us in many ways, from the spinoff technologies that we use in daily life to the discovery of new resources. However, the exploration of extreme environments is costly, and scientists don't always know whether an exploration will prove worthwhile.

The Issue

Some people believe that exploration, especially space exploration, costs too much. They would prefer to see the money used to deal with problems that are closer to home, such as social problems and pollution (**Figure 1**).

Figure 1
Some people believe that the money spent on exploring space should be spent on cleaning up polluted rivers and lakes.

Background to the Issue

Designing and developing the technology needed to explore extreme environments is very costly. For example, Canada's space program receives about $300 million from the federal government. Even though this is only a small amount of Canada's national budget, it represents a lot of money. People who support space and ocean exploration believe that the spinoffs and benefits outweigh the cost. What do you think? Is the exploration of extreme environments worth the cost?

Identify Perspectives

To decide whether the exploration of extreme environments is worth the cost, you must look at the issue from different perspectives. This means that you have to look at both the positive aspects and the negative aspects of exploration.

Working in groups of three, choose one of the extreme environments that you have learned about in this unit: polar regions, deserts, oceans, volcanoes, or space.

Use the Internet and the library to research your topic. Start by looking for information on recent expeditions to study the extreme environment that you have chosen. Make sure that you look at both the benefits and drawbacks of your topic. Use questions, such as the following, to help identify the information you need:

- What were the goals of the expeditions?
- What benefits could the expeditions provide?
- What technology did the exploration require?
- What were the problems, dangers, and costs of the exploration?

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How do you feel about about your topic after assessing the information that you found? Can you conclude whether this type of exploration is worth the cost?

LEARNING TIP

When you look at the benefits and drawbacks of something, you are looking at the pros and cons. What other topics have you learned about that were organized into pros and cons?

Communicate Your Ideas

Share what you have learned with your class. You can make a presentation, design a poster, act out a scene, give a speech about your topic, or use a graphic organizer to present what you have learned.

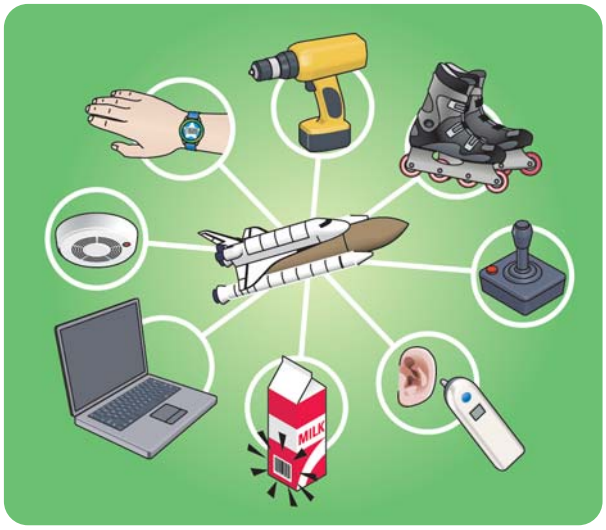
CHECK YOUR UNDERSTANDING

1. Why is it important to consider both the benefits and costs of exploration?
2. What difficulties did you encounter in trying to weigh the benefits and the costs of exploration?

12 Chapter Review

Exploring extreme environments has both benefits and costs.

Key Idea: **The exploration of extreme environments produces spinoffs and other benefits.**

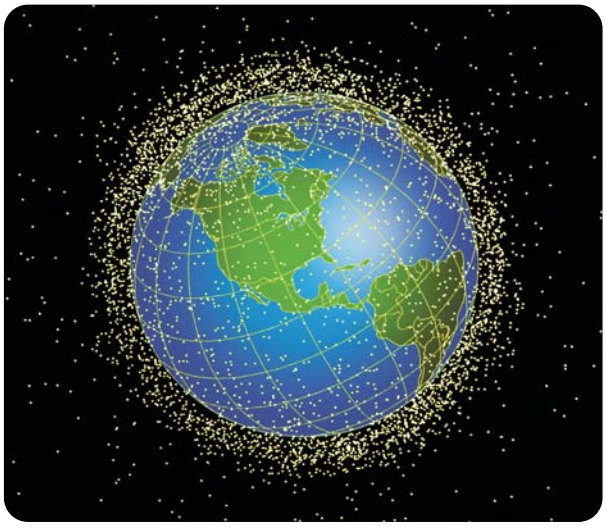


Many things that were created for exploring space are used in everyday life.

Vocabulary

spinoff **p. 229**

Key Idea: **The exploration of extreme environments has drawbacks and costs.**



There are millions of pieces of space junk floating around Earth.

Review Key Ideas and Vocabulary

When answering the questions, remember to use the chapter vocabulary.

1. What are some of the benefits of exploring extreme environments?
2. How are spinoffs related to space exploration? Give an example of a spinoff.
3. What are some of the drawbacks of exploring extreme environments?

Use What You've Learned

4. Think about different careers that are related to a spinoff of science exploration. Which career most interests you?
5. Look at **Figure 1**. What space missions are taking place right now? Do an Internet search to find out. Select one mission, and write a short description of its purpose.

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Figure 1
The Cassini-Huygens mission to Saturn began on October 15, 1997. It reached Saturn's rings on June 30, 2004.

6. Name three Canadian astronauts who have conducted health experiments on space shuttle missions. Research one of these astronauts.

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7. New medicines are being created in space. Research and write a paragraph about the work of Canadian astronauts in space health sciences.

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Think Critically

8. Dogs and chimpanzees were launched into space before humans. Many of the experiments done in the International Space Station involve fish, birds, snakes, frogs, rats, jellyfish, and insects. Why are animals sent into space? Does the benefit to humans outweigh the risk to animals? Discuss your answers in a small group.

Reflect on Your Learning

9. What spinoffs of exploration technology most surprised you? Why?
10. It is hard to believe that 50 years ago, video games did not exist and no one imagined working as a video-game programmer. Invent a career that you think will exist as a result of exploration technology when you are an adult.

Making Connections

Design an Exploration Vehicle

Looking Back

In this unit, you learned about extreme environments and the obstacles they present for human survival. You learned that technology allows people to travel to and survive in extreme conditions, like those found in space and in the oceans (**Figure 1**).

For this project, you will work with a partner to design and build a 3-D model of an exploration vehicle to travel to and investigate an extreme environment.

Demonstrate Your Learning

Part 1: Research an extreme environment

Which extreme environment would you like to explore? Choose one of the environments discussed in this chapter: polar regions, deserts, oceans, volcanoes, or space. Research the challenges that this environment would pose for an exploration vehicle. Also research the scientific principles that need to be incorporated into your design to overcome these challenges. For example, a submersible

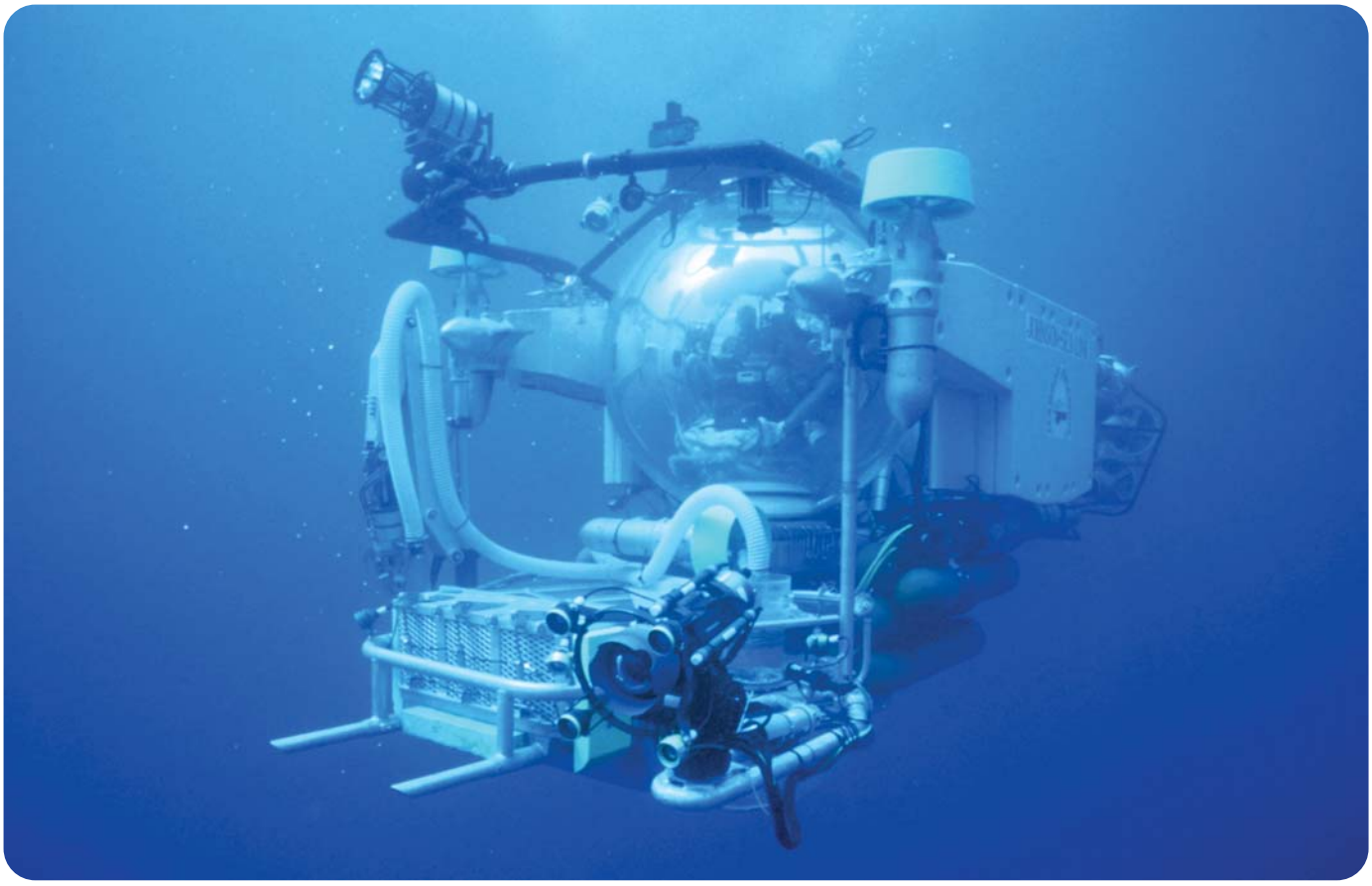

Figure 1

The *Johnson Sea-Link* is a submersible used to study life in deep water, perform search and recovery tasks, and conduct underwater archeological missions.

would need to have a pressurized hull to withstand the immense water pressure. A vehicle that is travelling over rough terrain would need large wheels (**Figure 2**).

Figure 2
NASA is developing Big Wheels, an inflatable robot rover, for future missions to Mars. Its large wheels will allow it to travel over rocky terrain.

Part 2: Brainstorm the design of an exploration vehicle

Brainstorm different ideas for the design of your exploration vehicle. Consider the following questions:

- What information do you want to collect about the extreme environment you are exploring?
- How will your vehicle gather this information? (For example, how will it take pictures or collect samples?) What devices and accessories will you need to collect scientific data?
- How is your vehicle controlled and guided? (For example, does it need a driver or is it remote controlled?)
- How will your vehicle move?

Draw a diagram of the model you want to build. Discuss the materials you will need to build your model.

Part 3: Build a model of your exploration vehicle

Build a model of your exploration vehicle. Use your diagram as a guide. Make any adjustments to your design as necessary.

Part 4: Communicate

Prepare a report about your exploration vehicle. Describe the environment in which your vehicle would be used. Also describe the function and purpose of your vehicle.

ASSESSMENT

MODEL

Check to make sure that your model of an exploration vehicle provides evidence that you are able to

- apply appropriate technology
- design a model that meets the conditions of an extreme environment
- work cooperatively with a partner

REPORT

Check to make sure that your report provides evidence that you are able to

- identify the information needed
- find appropriate sources of information
- identify and describe the conditions in an extreme environment
- use appropriate scientific language
- communicate clearly