CHAPTER 10

Technology allows us to explore Earth's extreme environments.

KEY IDEAS

- Technology allows us to navigate Earth's extreme environments.
- Technology allows us to survive extreme temperatures.
- Technology allows us to explore the ocean depths.
- Canadians make important contributions to ocean exploration.

Earth's extreme environments are some of the most fascinating places for humans to explore. But just getting to these places can be difficult and dangerous. Surviving once you're there can be just as challenging, if not impossible.

Humans do not have the adaptations that allow some organisms to survive extreme conditions. Instead, we rely on technology to make possible things that would otherwise be impossible—things like exploring an erupting volcano (as shown in the above photo), living in the frigid cold of Antarctica, or travelling to the deepest ocean depths. In this chapter, you will look at the technology that allows humans to travel to and survive in Earth's extreme environments.

Finding Our Way

10.1

Early peoples and explorers used the Sun and stars to guide them on their journeys. For example, the Inuit relied on their detailed knowledge of the night skies and the position of the Sun to help them navigate. After the compass was invented, explorers used it to find out where they were. Today, people use technology, such as radar, satellites, and sonar, to explore and navigate extreme environments.

TRY THIS: USE RADAR TO "SEE"

Skills Focus: creating models, measuring, inferring

In this activity, you will use the concepts of radar to find out the shape of an object in a box. Your teacher will give you a box that has a grid taped to the top. Inside the box is an object. Working in a group, use a nail to poke a hole through the grid. Then use a wooden skewer to probe for the object. When you feel the skewer touch the object, stop and measure the distance, in centimetres, from the top of the box to the end of the stick as shown in **Figure 1**. Record the distance in a table. Repeat this process until you have recorded all the measurements.

Figure 1

1. Create a graph or contour map of your data. If you have access to a computer, you can use a spreadsheet program to create a surface graph.
2. Based on the picture you created, what object is inside the box?

LEARNING TIP

Pause after each paragraph on this page and see if you can define the highlighted word in the paragraph.

Radar, which stands for **ra**dio **d**etection **a**nd **r**anging, uses radio waves to help people explore. Radio waves are invisible waves that carry voices, music, pictures, and signals through the air. A radar set picks up any echoes that are bounced back off an object and uses the echoes to tell the distance, speed, direction of motion, and shape of the object. Radar systems are used on boats and ships to search for land, ice, and other boats or ships.

Satellites use radar to relay signals for cell phones and television signals. A **satellite** is an object in space that revolves around Earth or any other planet. One of the most important satellite technologies that is used today, for both land and sea navigation, is the Global Positioning System, or GPS. GPS has 24 orbiting satellites that send out radio signals. The boat in **Figure 2** has a GPS receiver that can detect these signals. Signals from three satellites are used to tell exactly where the boat is and how fast the boat is moving. GPS is a good navigation system for environments, such as oceans and deserts, that have few features to use as a reference point. GPS is used in cars, boats, helicopters, ships, submarines, and airplanes, as well as in small handheld receivers that are carried by hikers and explorers.

LEARNING TIP

Look closely at **Figure 2**. Then reread the paragraph above it. Now look again at each part of the diagram and check that you understand what it shows about how GPS works.

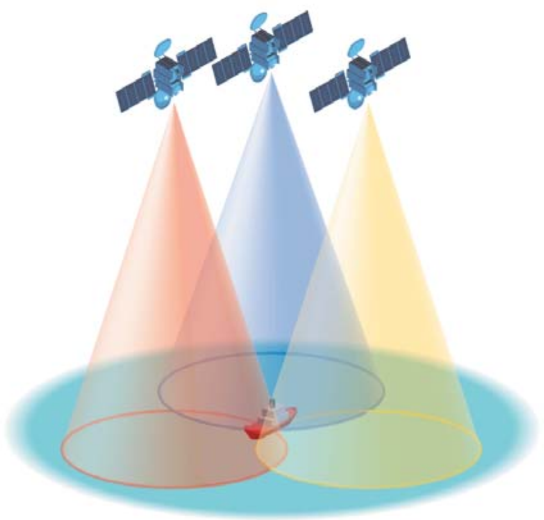


Figure 2
Using radar, GPS satellites can pinpoint the exact location of this boat.

Did you know that ships use sound to chart the depths of the oceans? **Sonar,** which stands for **so**und **na**vigation and **r**anging, works by using the echoes of sound waves. First, a device sends a sound wave into the ocean. The sound wave bounces off the ocean floor. This creates an echo, just like when you shout into a canyon or an empty room. A receiver on the ship can figure out how far away the ocean floor is by measuring the time it takes for the echoes to return to the ship (**Figure 3**).

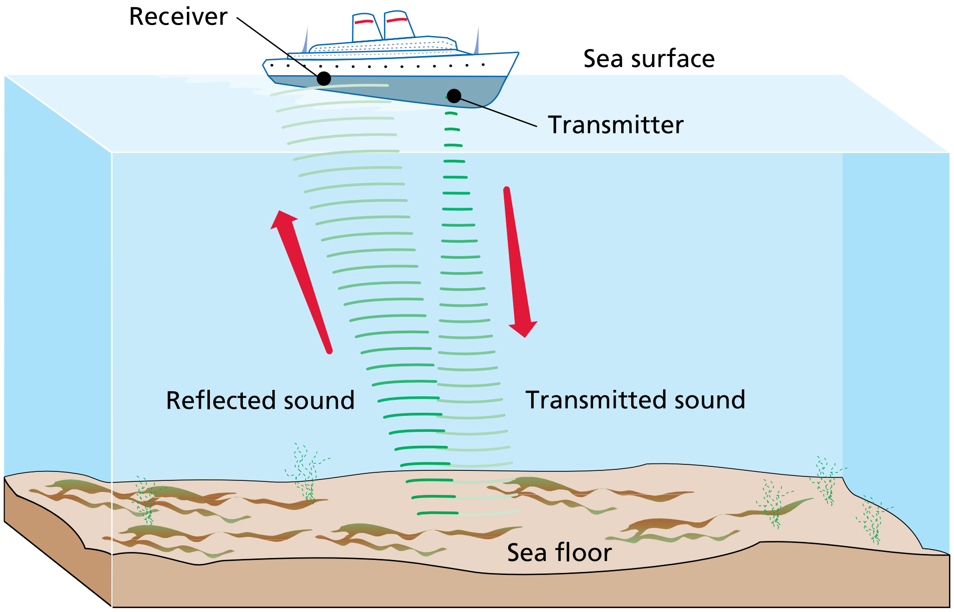


Figure 3
A sonar transmitter underneath a ship sends sound waves down through the water. The time it takes for the sound waves to bounce off the floor and back to a receiver on the ship is used to figure out the depth of the ocean and to create maps of the ocean floor.

Sonar is used to map the ocean floor and to determine the locations of underwater objects—from shipwrecks to submarines. As well, sonar is used to help ships and submarines navigate through shallow and rocky waters.

CHECK YOUR UNDERSTANDING

1. What does the word "radar" stand for? How does radar work?
2. Compare the GPS system with the navigation systems of the Inuit.
3. Why is GPS such a valuable technology for explorers to use?
4. How is GPS used in everyday life?
5. Bats and dolphins use a technique called echolocation to navigate and to locate prey. They emit sounds and listen for the echoes. Explain how echolocation is similar to sonar.

LEARNING TIP

Look at the highlighted words *sonar* and *radar*. They are formed from the first letters of the words they stand for. Words like these are called acronyms. Other examples in this unit include *scuba* and *NASA*.

10.2 Protection from Extreme Temperatures

A polar bear has a nice thick fur coat to keep it warm in extremely cold temperatures (**Figure 1**). But humans do not have natural adaptations to keep them warm. So before humans could travel to and explore very cold or very hot places, they had to develop clothing that would protect them from the extreme temperatures. For example, a winter coat keeps you warm in cold temperatures because it is a good **insulator.** This means that it stops the heat of your body from moving into the surrounding air. Heat is the movement of energy from a warm object to a cool object.

Different materials have different insulating properties. For example, metals are not good insulators because they move heat away from a warm object. Fur is a good insulator because it traps small pockets of air. Trapped air is an excellent insulator because air does not conduct heat very well. Feathers also trap air (**Figure 2**), and so do wool fibres. This is why wool sweaters keep you so warm.

Figure 1
Polar bears keep warm in the cold Arctic temperatures because they have thick fur and a thick layer of fat under their skin. Fur and fat are good insulators because they stop body heat from going into the environment.

Figure 2
The Emperor penguin's feathers provide insulation against the bitter cold of Antarctica. Penguin chicks have fluffy feathers that trap even more air to hold in the heat from the chick's body.

TRY THIS: FEEL HOW BLUBBER WORKS

Skills Focus: observing, inferring

Some animals that live in the Arctic have a thick layer of fat, or blubber, under their skin. To see how well blubber insulates, make a "blubber mitt" by filling a large plastic bag about halfway with vegetable shortening or lard (**Figure 3**). Put an empty plastic bag on your hand so that you are wearing it like a mitten. Slide your hand into the shortening-filled bag. Mush around the shortening until it surrounds your hand. Plunge your other hand (your bare hand) into a bucket of ice water. Be careful not to keep your hand in the ice water for too long. Now plunge your blubber mitt into the ice water. What do you notice about your hands?

Figure 3
A "blubber mitt"

CHECK YOUR UNDERSTANDING

1. How does insulation keep you warm?
2. Explain how polar bears can survive in the extreme cold of the Arctic.
3. Explain how scientists use observations of nature to develop insulating materials.

10.3 Design Your Own Experiment

SKILLS MENU

○ Questioning	● Observing
○ Predicting	● Measuring
● Hypothesizing	○ Classifying
● Designing Experiments	● Inferring
● Controlling Variables	● Interpreting Data
○ Creating Models	● Communicating

Testing Materials for a Polar Suit

Scientists who work in Vostok, Antarctica, experience the world's lowest temperatures. To survive and work in temperatures as low as −88 °C, scientists need clothing that keeps them warm and dry, and protects them from the wind.

In this investigation, you will test different materials that could be used to make a polar suit for scientists who work in Vostok.

Question

What is the best insulating material for a polar suit?

Hypothesis

Write a hypothesis that states which material(s) would make the best insulator(s). Complete your hypothesis with a short explanation of your reasons. Write your hypothesis in the form "If … then … because … ."

Materials

- apron
- 2 or more baby-food jars
- 2 or more lids for baby-food jars, with a hole in the middle large enough for a thermometer to fit
- scraps of fabric or other materials
- hot and cold water
- rubber bands
- thermometer

apron

baby-food jars with cut-out lids

scraps of fabric or other materials

hot and cold water in beakers

rubber bands

thermometer

Thermometers are fragile and expensive. Be careful when handling a thermometer.

Decide what other materials you will need. Check with your teacher to make sure that these materials are safe for you to use.

Procedure

- Design a procedure to test the insulating properties of different fabrics. A procedure is a step-by-step description of how you will conduct your experiment. It must be clear enough for someone else to follow and do the exact same experiment.
- Submit your procedure (including any safety precautions), to your teacher for approval. Also submit a diagram, at least half a page in size, showing how you will set up your equipment.

Data and Observations

Create a data table to record your observations. Record your observations as you carry out your experiment.

LEARNING TIP

For help with your experiment, read the Skills Handbook sections "Designing Your Own Experiment," "Writing a Hypothesis," "Controlling Variables," and "Writing a Lab Report."

Analysis

1. What did you learn about the insulating properties of different materials?
2. Compile the findings of all the groups in your class. Which materials provided the best insulation?
3. Can you use a graph to represent the findings of your class? Try it and see.

Conclusion

Go back to your hypothesis. Did your observations support, partly support, or not support your hypothesis? Write your conclusion.

Applications

1. Most polar suits contain several layers of different materials. Which combinations of materials do you think would produce an even more effective insulator? If there is time, test your ideas.
2. Would the materials you tested be practical for Arctic explorers (for clothing or protective equipment)? Explain.

CHECK YOUR UNDERSTANDING

1. Which variable did you change (your independent variable)?
2. How did you measure the change in temperature (your dependent variable)?
3. Were other groups testing the same hypothesis as your group? How were their results the same or different from yours?

10.4 Exploring Beneath the Ocean

TRY THIS: MAKE A DEEP-SEA DIVER

Skills Focus: observing, communicating

Make a "diver" out of a plastic pen cap by putting a ball of modelling clay on the end of the cap. If there are any holes in the tip of the pen cap, seal them with modelling clay. Put the cap in a glass of water. Add more modelling clay until the cap just floats on the surface.

Fill a 500-mL or a 2-L plastic bottle with water. Gently put the diver into the water bottle as shown in **Figure 1**. Without squeezing the water bottle, put on the lid and tighten it.

1. What happens to the diver when you squeeze the water bottle? Why do you think this happens?
2. What happens to the diver when you release the water bottle? Why does this happen?
3. What happens if you add more modelling clay to your diver?

Figure 1

LEARNING TIP

The first paragraph in this section describes three obstacles to ocean exploration. Turn these into three questions that you should be able to answer after reading the paragraph.

The oceans are the last unexplored place on Earth. Even though most of Earth is covered with water, only a small fraction has been explored. There are many obstacles to ocean exploration. Divers need to be able to breathe underwater and to control their floating and sinking. They also need to be able to overcome the enormous and rapid change in pressure when travelling deep underwater.

The Challenge of Breathing Underwater

The possibility of finding treasure in sunken shipwrecks prompted many inventions that allowed divers to work underwater. In the early 1800s, divers wore a heavy copper helmet attached to a canvas suit. Air was pumped through a long hose that was connected to the helmet. If someone accidentally stepped on the hose, or if the hose got caught on something, the diver's air supply was cut off.

The invention of the **s**elf-**c**ontained **u**nderwater **b**reathing **a**pparatus, better known as **scuba,** allowed divers to carry their air supply on their backs. Ocean explorers Jacques Cousteau and Émile Gagnon improved the scuba system by inventing the Aqua-Lung.

The Aqua-Lung allows a diver to breathe air at a regulated pressure using a mouthpiece. The mouthpiece supplies just the right amount of air from a pressurized tank strapped to the diver's back. With an Aqua-Lung, a diver can safely go down 75 m while breathing compressed air and oxygen (**Figure 2**). Today, anyone can scuba dive and explore underwater areas that were once thought to be impossible to explore.

Figure 2
A scuba diver wears a metal tank that is filled with compressed air. A regulator attaches to the tank. To breathe, the diver inhales air from the regulator, which reduces the pressure of the air to match the surrounding water pressure.

Floating and Sinking—Controlling Buoyancy

Imagine swimming or even floating in a bathtub. The ability to float is called **buoyancy** [BOY-uhn-see]. If you hold your face out of the water and breathe normally, you float at the top of the water. This is because air is lighter, or less dense, than water. The air in your lungs makes you buoyant. If you blow out some of the air, you will sink (**Figure 3**).

Figure 3
When your body has less air and your density is greater than the water, you sink in the water.

A boat floats because its density is less than the density of the water. The water exerts an upward buoyant force on the boat. The boat sinks down into the water until it has displaced, or pushed aside, a volume of water that has the same weight as the boat (**Figure 4**). An object has neutral buoyancy if it neither floats nor sinks.

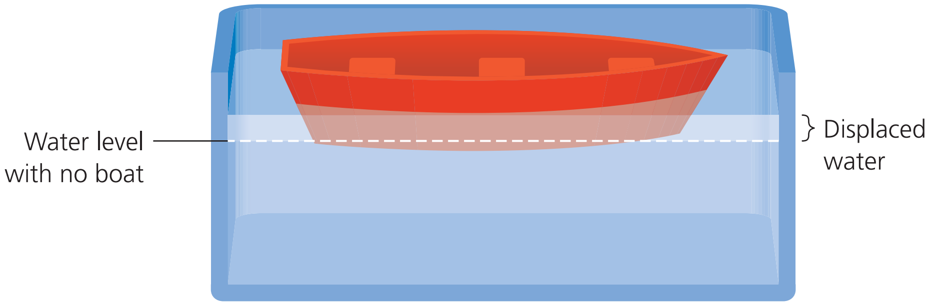


Figure 4
A boat that weighs 1000 kg will sink into the water until it has displaced 1000 kg of water.

TRY THIS: ***WHY DOES IT FLOAT?***

Skills Focus: observing, inferring

Fill a large plastic cup about half full with water. Place the cup on a flat surface, and mark the level of the water. Place a piece of wood in the cup, and again mark the water level.

1. What happens to the water level when the wood is in the cup? Why does this happen?
2. What does this tell you about buoyancy?
3. What would happen to the water level if you used different types of wood of equal volume, such as maple and pine? Try this to find out.

Using Technology to Control Buoyancy

If you want to explore underwater, you have to be able to sink and to come back to the surface. To dive under the water, a scuba diver wears a belt that contains weights. They also wear a buoyancy compensator. A buoyancy compensator is a vest that can hold air. To sink, the diver releases air from the vest. To rise again, the diver blows air from the compressed air tank into the vest, filling it with air. This causes the diver to float back up to the surface.

Submarines sink and rise in the water in a similar way. Special tanks, called ballast [BAL-uhst] tanks, in the outer compartment of a submarine can be filled with water or air (**Figure 5**). When the ballast tanks are filled with water, the submarine sinks. When compressed air is pumped back into the ballast tanks, the submarine floats to the surface.

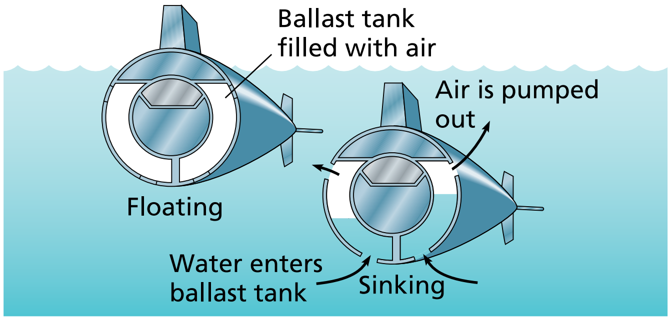


Figure 5
Ballast tanks control a submarine's buoyancy.

Surviving Water Pressure in the Ocean Depths

Have you ever felt your ears pop when you dived underwater or swam to the bottom of a pool? This happens because the water above you presses on your body, squeezing the air out of places such as your ears and sinuses. The **water pressure** increases as you go deeper underwater. At just below 10 m, the pressure of the water on your body is twice what the air pressure, or atmospheric pressure, is at the surface. As you go deeper, the pressure continues to increase.

Underwater vehicles must have very strong bodies, or hulls, to withstand the tremendous water pressure at great depths. Submersibles, such as submarines, are pressurized vehicles that have normal air pressure inside. The outside of a submersible is made of titanium [ti-TAY-knee-um]. Titanium is a very strong metal, which is also used to make spacecraft.

Some submersibles, such as the *Alvin* shown in **Figure 6**, can take scientists to a depth of 4500 m. Other submersibles, called remote operated vehicles, or ROVs, do not carry passengers. An ROV is operated with a joystick by an oceanographer on board a large research vessel.

Figure 6
The *Alvin* carries one pilot and two scientists. It has underwater cameras, lights, a television system, and instruments to collect samples from the water.

Canada's Contributions to Ocean Exploration

Canada has a special interest in ocean exploration because of its access to three oceans: the Atlantic, the Pacific, and the Arctic Oceans. Canada has developed technology for exploring its oceans, including a specialized diving suit called a Newt Suit and a submersible called Deep Worker. Canada, along with the United States, is also developing an underwater observatory called the Neptune Project.

The Newt Suit is built to withstand the pressure of deep water (**Figure 7**). Developed by Vancouver diver Phil Nuytten, it looks like something an astronaut would wear underwater. Two electric thrusters are attached to the suit, to move the diver forward. The suit is very heavy out of the water, but nearly weightless underwater. A person wearing the suit can work at 305 m below the surface for up to 8 h.

Figure 7

The Newt Suit is worn by divers who are drilling for oil or gas, or building pipelines for communication companies.

The Deep Worker is a Canadian-designed one-person submersible used to explore the underwater world (**Figure 8**). The Deep Worker is so small that it has been described as an underwater sports car. Explorers are able to go deeper underwater and spend more time underwater than they can with traditional scuba gear.

Figure 8
The Deep Worker can take photos and collect samples from the bottom of the ocean.

Canadian and American scientists are working together on the Neptune Project, which will give scientists a new understanding of deep ocean activity in the Pacific Ocean (**Figure 9**). This new knowledge can be applied to many global issues, such as predicting earthquakes, tracking marine life, understanding climate change, and discovering new energy sources. One of the goals of the Neptune Project is to become a global centre for ocean research.

Figure 9
The Neptune Project will study the diversity of deep-sea life.

CHECK YOUR UNDERSTANDING

1. What three obstacles make ocean exploration difficult?
2. Why is it important for humans to explore the depths of the oceans?
3. What types of technology have been developed by Canadians to explore the ocean depths?

10.5 Solve a Problem

Figure 1
Giant tube worms can be over 1 m long.

Designing a Sample Collector

One of the most extreme environments on Earth is the ocean floor. In some places, incredibly hot water erupts from cracks, or vents, along the ocean floor. The water can get as hot as 400 °C. Mineral deposits build up around the vents forming stacks. Scientists call these vents black smokers because they look like they are producing black smoke.

Extraordinary creatures, such as giant tube worms (**Figure 1**), live around black smokers. A tube worm has no mouth or gut, but feeds on the bacteria that live inside it. These bacteria can live without oxygen. They do not depend on the Sun for food, since sunlight does not reach the bottom of the ocean. Instead, they break down chemicals from the black smokers to make food for themselves and the tube worms.

Problem

Imagine that you have just joined a team of oceanographers investigating a newly discovered thermal vent ecosystem. You need to design a device for collecting samples from the ocean floor for further study.

Figure 2
ROPOS uses its manipulator arm to collect fluid samples from between rocks on the ocean floor.

Task

Design a device for collecting samples from the area around a thermal vent. Draw a plan for your design and explain how it would work.

Criteria

To be successful, your design must

- show how the device would function under the extreme conditions (such as darkness, and high temperatures and pressures) in and around a thermal vent
- show how a sample would be collected from the ocean floor
- show how the sample would be transported to the surface
- show how the device would be connected to an ROV (**Figure 2**)

Plan and Test

1. Give your device a name.
2. Describe how your device works.
3. Draw a picture of your device, and label all the parts. Describe the function of each part.
4. Decide what samples your device could collect. How would it collect samples in a way that does not disrupt the environment?
5. Describe how the samples would be transported to the surface.
6. Describe any special features you have included to make sure that your device would survive the trip to the bottom of the ocean and back.
7. Explain how your device would be connected to an ROV.

Evaluate

8. Consider the list of criteria. Does your design meet the criteria? Explain.
9. Re-evaluate your design. Are there any changes you would make to your design? Why or why not?

Communicate

10. How will you share your design? You could build a model of your device using simple craft materials or modelling clay. Perhaps you could create a video or computer animation to promote your device.

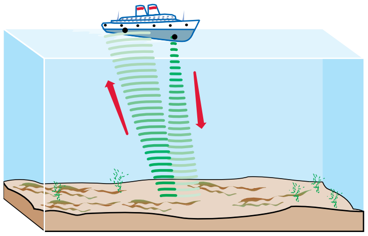
CHECK YOUR UNDERSTANDING

1. Why are the criteria listed important when designing a new device?
2. What questions should scientists ask before they collect live samples of plants or animals?
3. Explain why it is important to test and re-evaluate your design.

10 Chapter Review

Technology allows us to explore Earth's extreme environments.

Key Idea: Technology allows us to navigate Earth's extreme environments.



Sonar is used to map the ocean floor and to help ships navigate through shallow and rocky waters.

Vocabulary

radar p. 186

satellite p. 186

sonar p. 186

Key Idea: Technology allows us to survive extreme temperatures.

Vocabulary

insulator p. 188

Key Idea: Technology allows us to explore the ocean depths.

Scuba gear and submersibles are two types of technology that were developed to explore the oceans.

Vocabulary

scuba p. 192

buoyancy p. 193

water pressure p. 195

Key Idea: Canadians make important contributions to ocean exploration.

The Newt Suit and the Deep Worker are examples of Canadian technology.

Review Key Ideas and Vocabulary

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

1. Describe two technologies that have enabled humans to navigate in extreme environments.
2. Draw and label a diagram to show how sonar is used to map the ocean floor.
3. Think about a very cold winter day. Based on your understanding of insulation, what materials would you wear?
4. Describe two Canadian technologies that allow scientists to explore the ocean depths.
5. What do you think is the most important invention for allowing humans to explore underwater? Explain your choice.

Use What You've Learned

6. What are some of the things that humans hope to discover by exploring the ocean? How will these discoveries help society?
7. What is known about the ocean environment? What are some of the unknowns?

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8. Make a time line of the various types of technology that are used to explore the oceans.

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9. Some Inuit clothing is made from caribou skins. The long, hollow caribou hair is good insulation from the cold. As well, Inuit clothing often has fur on the inside to prevent body heat from escaping into the icy environment. For the same reason, Inuit boots are insulated with fur. Based on what you know about insulation and heat loss, explain why the Inuit use these designs for their clothing and boots.

Think Critically

10. What do you think scientists should consider before they collect living samples from any environment? Explain why.
11. What special features would a deep-ocean collecting device need to have to survive the extreme pressures and temperatures, and to be able to function in the dark?
12. When inventing a new device, it is important for the engineer to know what function the device needs to perform. How was the *form* (the design) of your collection sampler affected by the *function* you wanted it to perform?

Reflect on Your Learning

13. Which of the hands-on activities in this chapter did you find the most interesting? What did the activity help you learn?