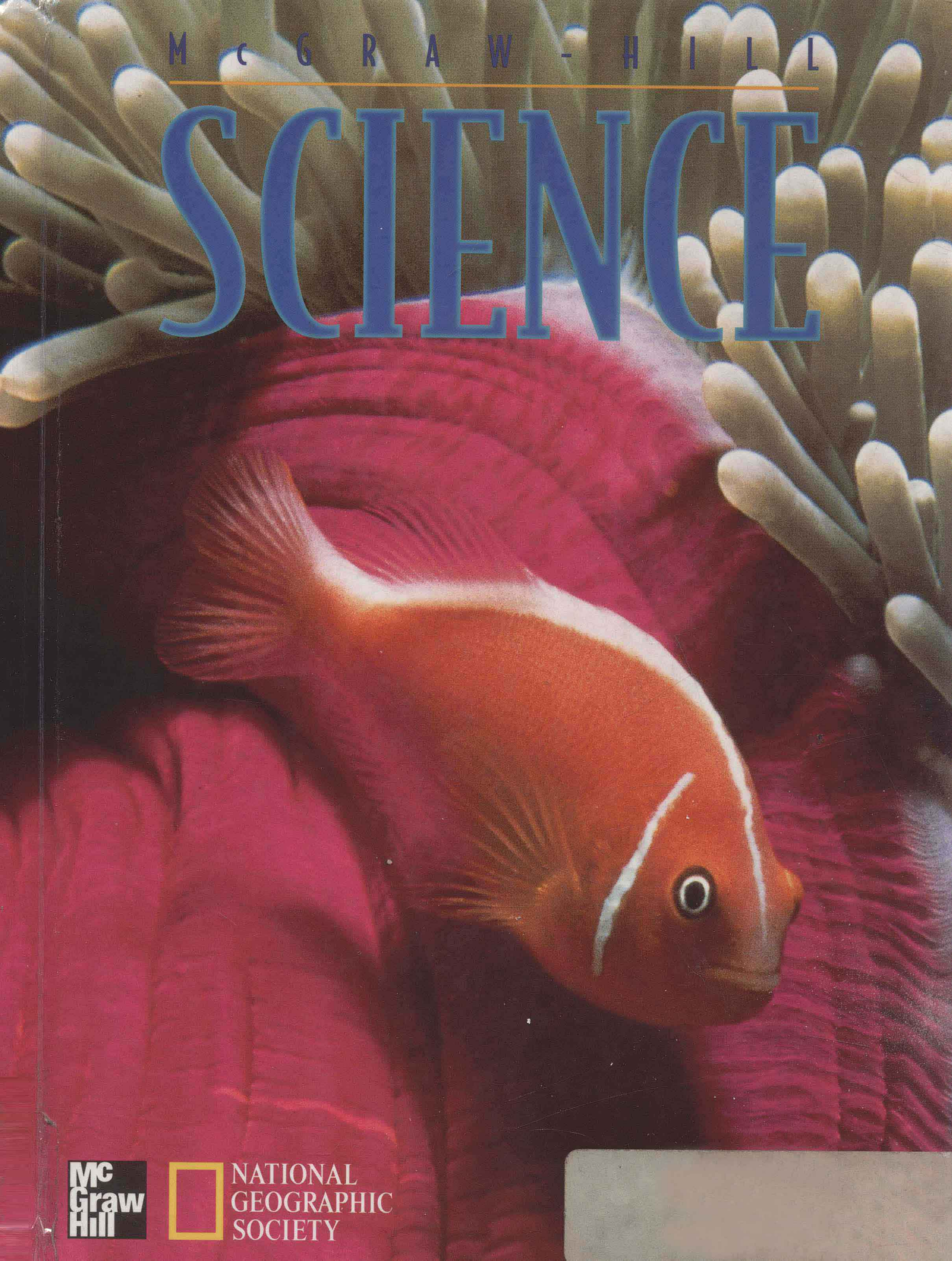
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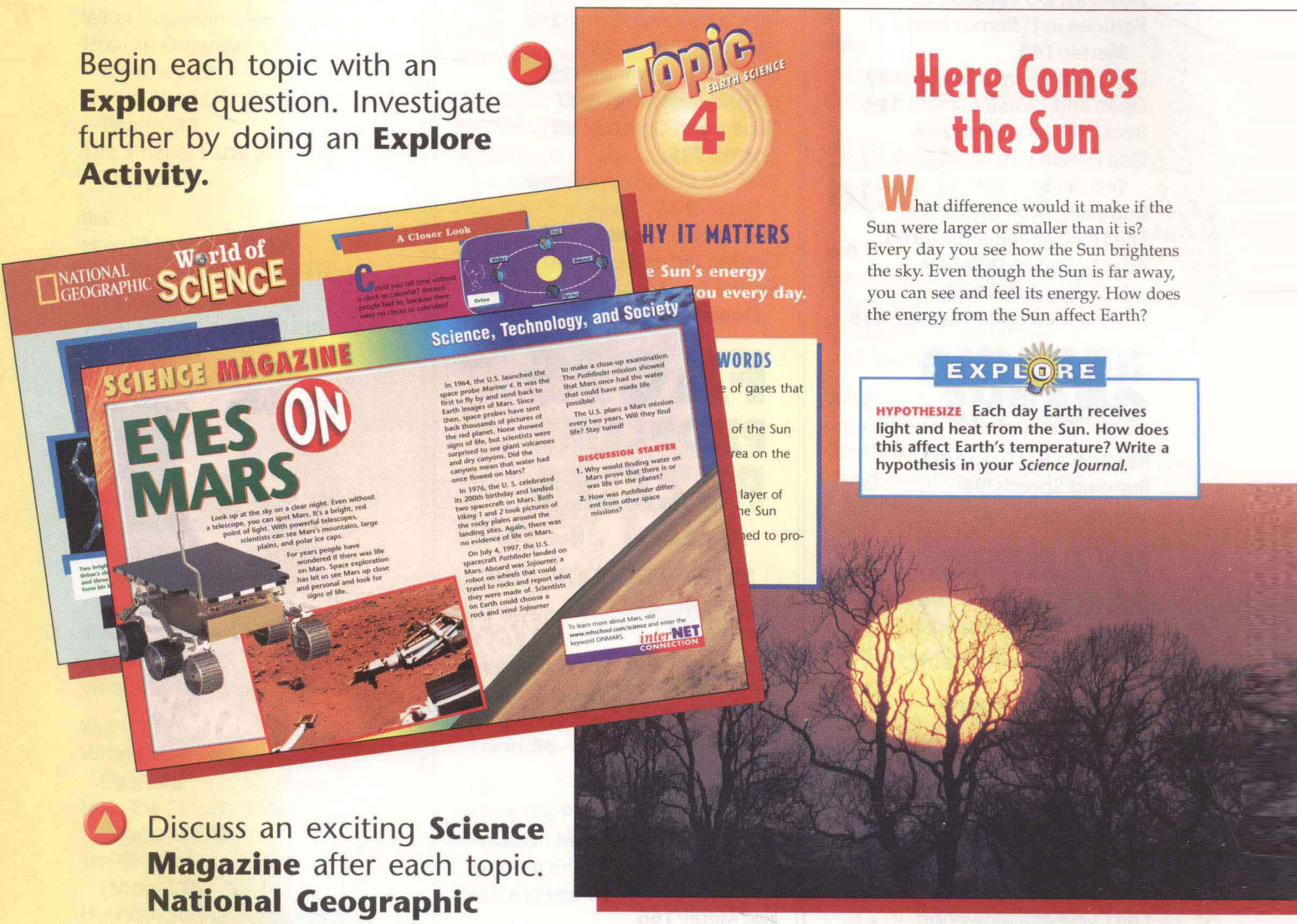
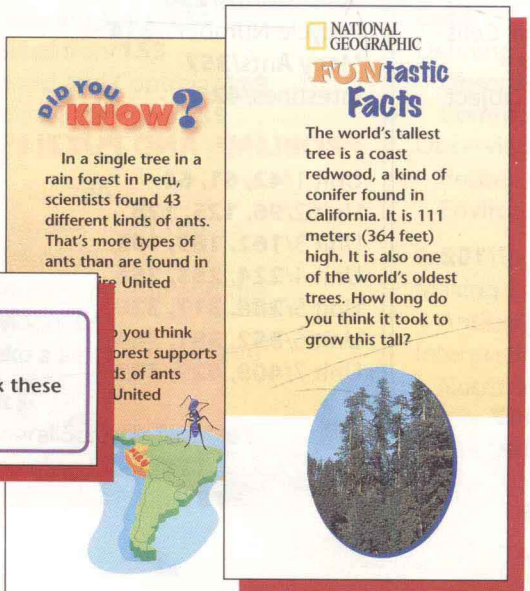
YOUR TEXTBOOK at a Glance

Begin each topic with an **Explore** question. Investigate further by doing an **Explore Activity.**



Discuss an exciting **Science Magazine** after each topic. **National Geographic World of Science** is the first magazine in each unit.



Flex your brain with questions about real-world facts.

EXPLORE ACTIVITY

Investigate How the Sun's Energy Affects Earth

Use a model to explore how the Sun's energy affects Earth's temperature.

MATERIALS
- lamp with light bulb, 60 watt
- aluminum can
- thermometer
- black paper
- meter stick
- tape
- *Science Journal*

PROCEDURES

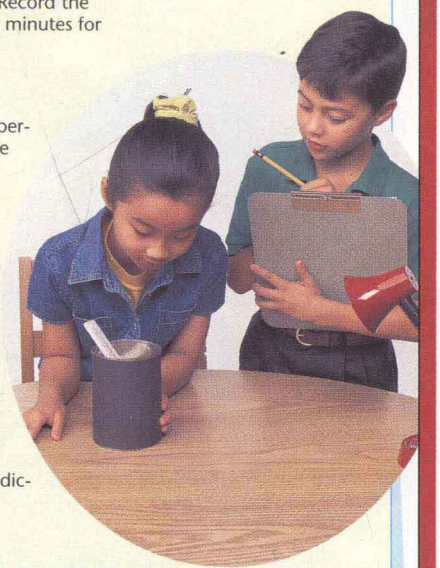
1. **MAKE A MODEL** Cover the can with black paper. The can represents Earth. Place the thermometer in the can, and set the can on a table 20 cm from the lamp. The lamp represents the Sun.
2. **COLLECT DATA** Read the temperature inside the can. Record the number in your *Science Journal*.
3. **COLLECT DATA** Turn on the lamp. Record the temperature of the can every two minutes for 10 minutes.

CONCLUDE AND APPLY

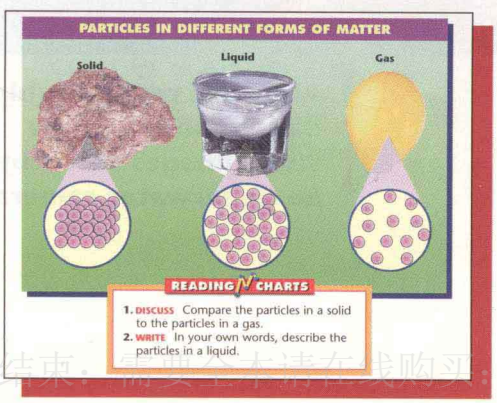
1. **IDENTIFY** What was your first temperature measurement? What was the temperature after 10 minutes?
2. **EXPLAIN** Was the temperature of the can still increasing after 10 minutes? How do you know?
3. **INFER** Why did the temperature of the can stop increasing? Where do you think the energy from the lamp is going?

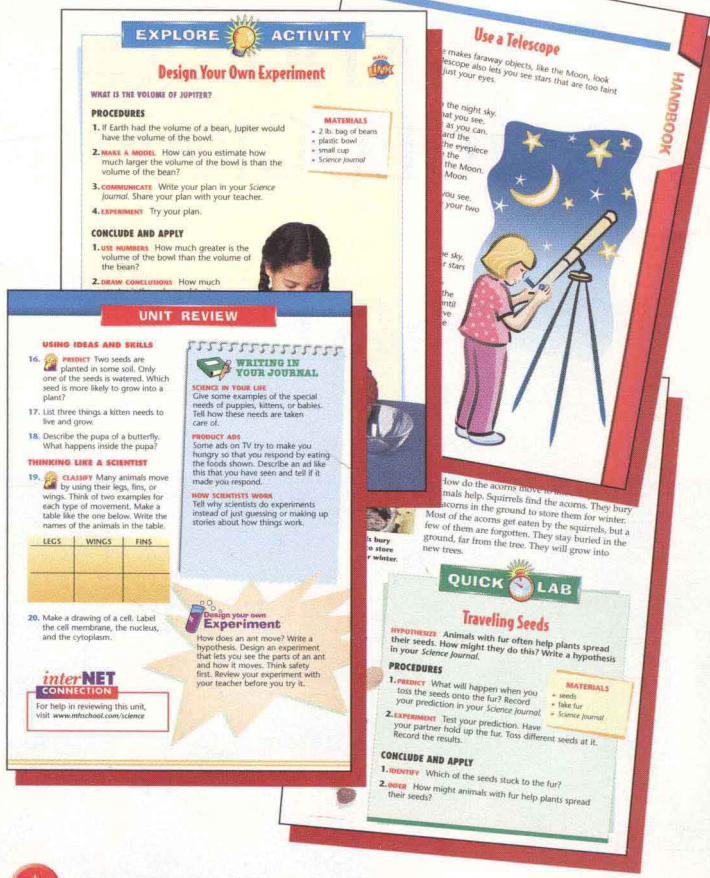
GOING FURTHER: Problem Solving

4. **EXPERIMENT** Suppose the can were twice as far from the lamp. How warm do you think it would get in 10 minutes? Write your prediction. Test it.

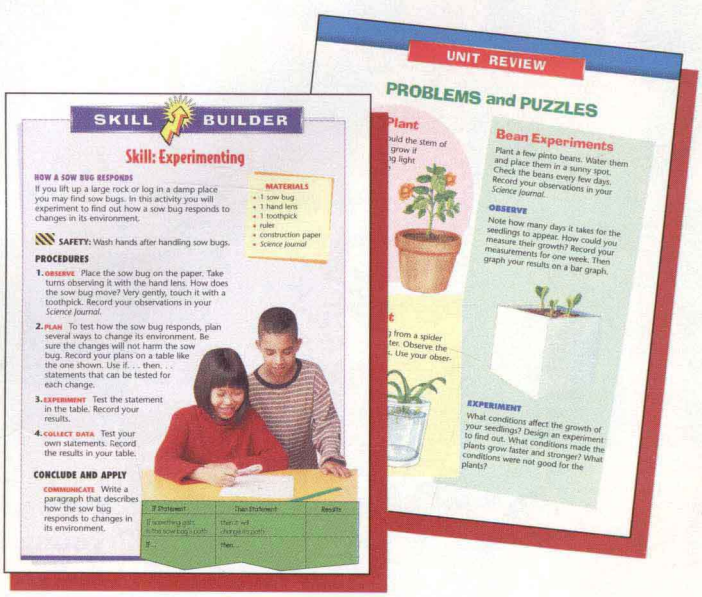


Reading Graphs, Diagrams, Maps, and **Charts** help you learn by using what you see.





Design Your Own Experiments, do **Quick Labs**, use **Internet Connections**, and try **Writing in Your Journal**. Use the **Handbook** for help.



Build your skills with **Skill Builders** and **Problems and Puzzles.**

NATIONAL GEOGRAPHIC

READ ALOUD

INVITATION TO SCIENCE

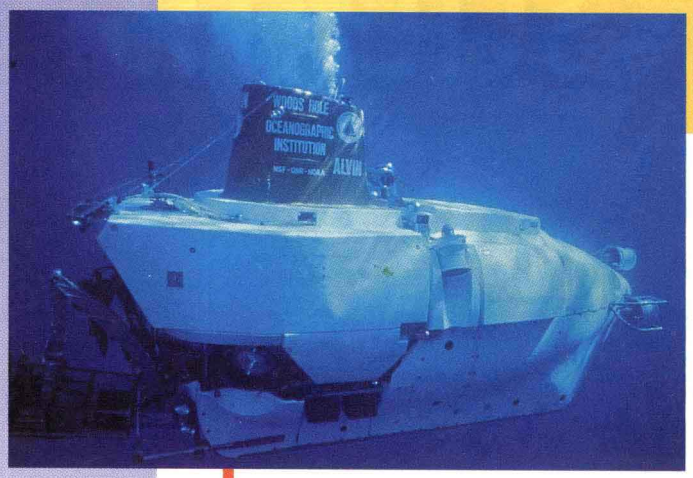
Even as a young boy, Ballard loved the sea!

Aboard a research ship, Ballard and his crew study images taken by an underwater camera.

Robert Ballard

Robert Ballard's love for the sea began when he was a boy in southern California. Other Californians liked to surf the waves, but Ballard was more interested in what lay beneath the ocean's surface.

To explore that world safely, he knew he had to learn as much as possible. He says, "I needed to learn a lot about geography, navigation, meteorology, geology, biology, and many other things."

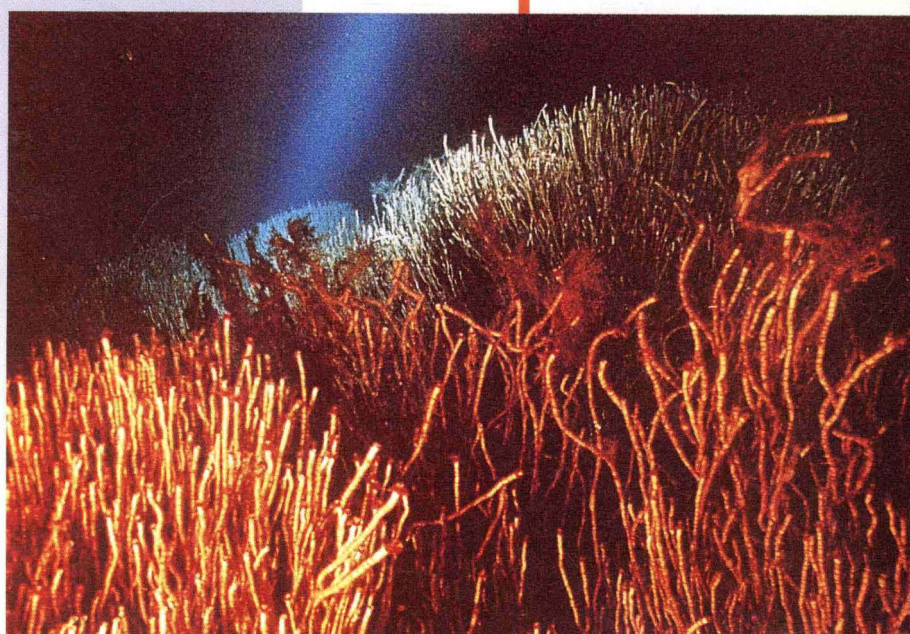


The submersible *Alvin* can carry scientists deep underwater.

His hard work has paid off! Now Ballard leads expeditions to explore the bottom of the sea. He and his crew travel in underwater vehicles called submersibles.

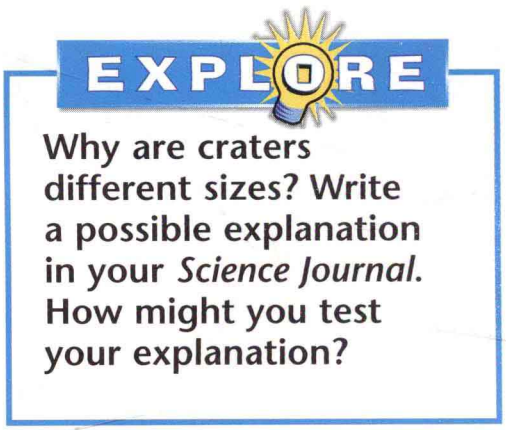
He is most proud of discovering unusual volcanoes on the sea floor. Hot water and minerals flow from the volcanoes, supporting many strange kinds of animals. "Most of the creatures my colleagues and I found," he says, "were completely new to science."

Ballard discovered strange forms of life on the ocean floor.



To help other people enjoy the thrill of discovery, Ballard started the JASON project. It uses satellite broadcasts and Internet connections to let students take part in real scientific expeditions!

Have you ever looked at the Moon through a telescope? The light places you see are mountains and hills. The dark places are flat lands. Can you see parts that look like rings or holes? These are called **craters** (krā'tərz). A crater is a hollow area in the ground. A crater has a flat floor with walls rising around it. Craters are found in different sizes. Some can be smaller than a dime. Others can be miles across. How did they get there?



Why are craters different sizes? Write a possible explanation in your *Science Journal*. How might you test your explanation?

EXPLORE ACTIVITY

Investigate Why Craters Are Different Sizes

How does the size of a falling marble affect the size of the crater it forms? How does the height of a falling marble affect its crater size? Think of a sentence about craters that you can test. Example: A large marble will make a larger crater than a small marble.

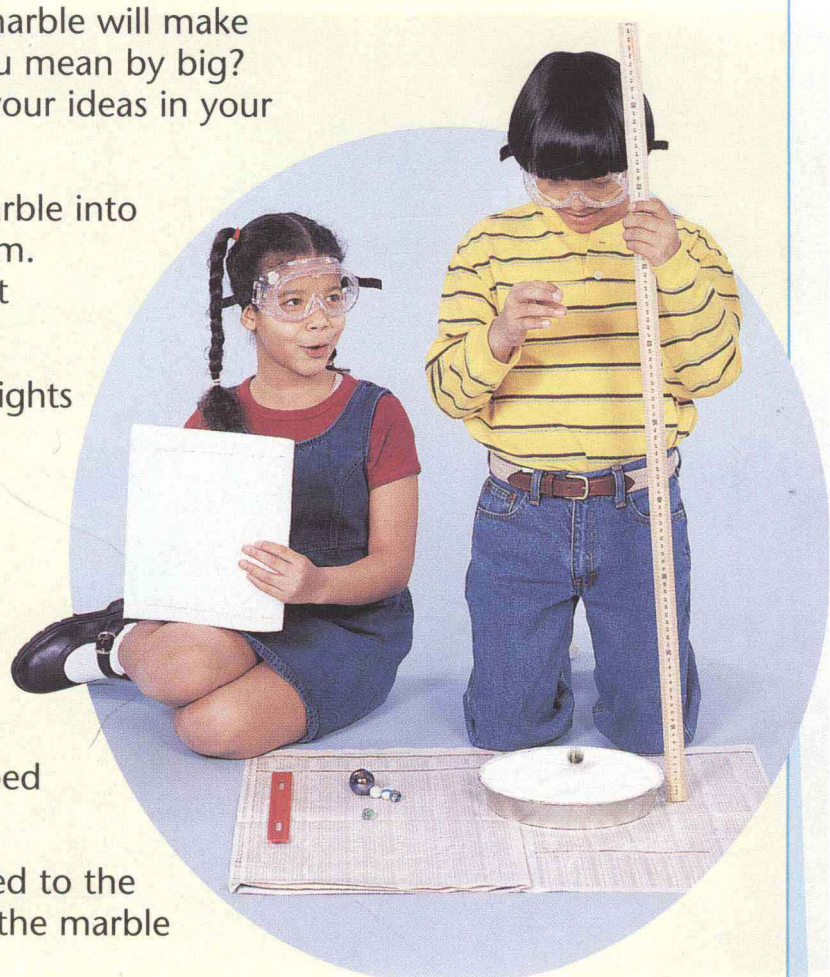
MATERIALS

- flour
- aluminum pie tin
- marbles of different sizes
- newspaper
- meterstick
- ruler
- safety goggles
- *Science Journal*

PROCEDURES

SAFETY: Wear goggles.

1. **MAKE A MODEL** Place newspaper on a flat surface. Fill a pie tin with flour. Smooth the flour's surface.
2. **OBSERVE** Compare the sizes of the marbles. Discuss with a partner which marble will make the biggest crater. What do you mean by big? Deep or wide, or both? Write your ideas in your *Science Journal*.
3. **MEASURE** Drop the smallest marble into the flour from a height of 25 cm. Measure the size of the crater it creates. Record your results.
4. **MEASURE** Repeat step 3 from heights of 50 cm, 75 cm, and 100 cm.
5. **REPEAT** Try the activity again with a large marble.



CONCLUDE AND APPLY

1. **INTERPRET DATA** What happened to the size of the crater as the marble was dropped from greater heights? Why?
2. **INTERPRET DATA** What happened to the size of the crater as the size of the marble increased? Why?
3. **INFER** Why are craters on the Moon different sizes?

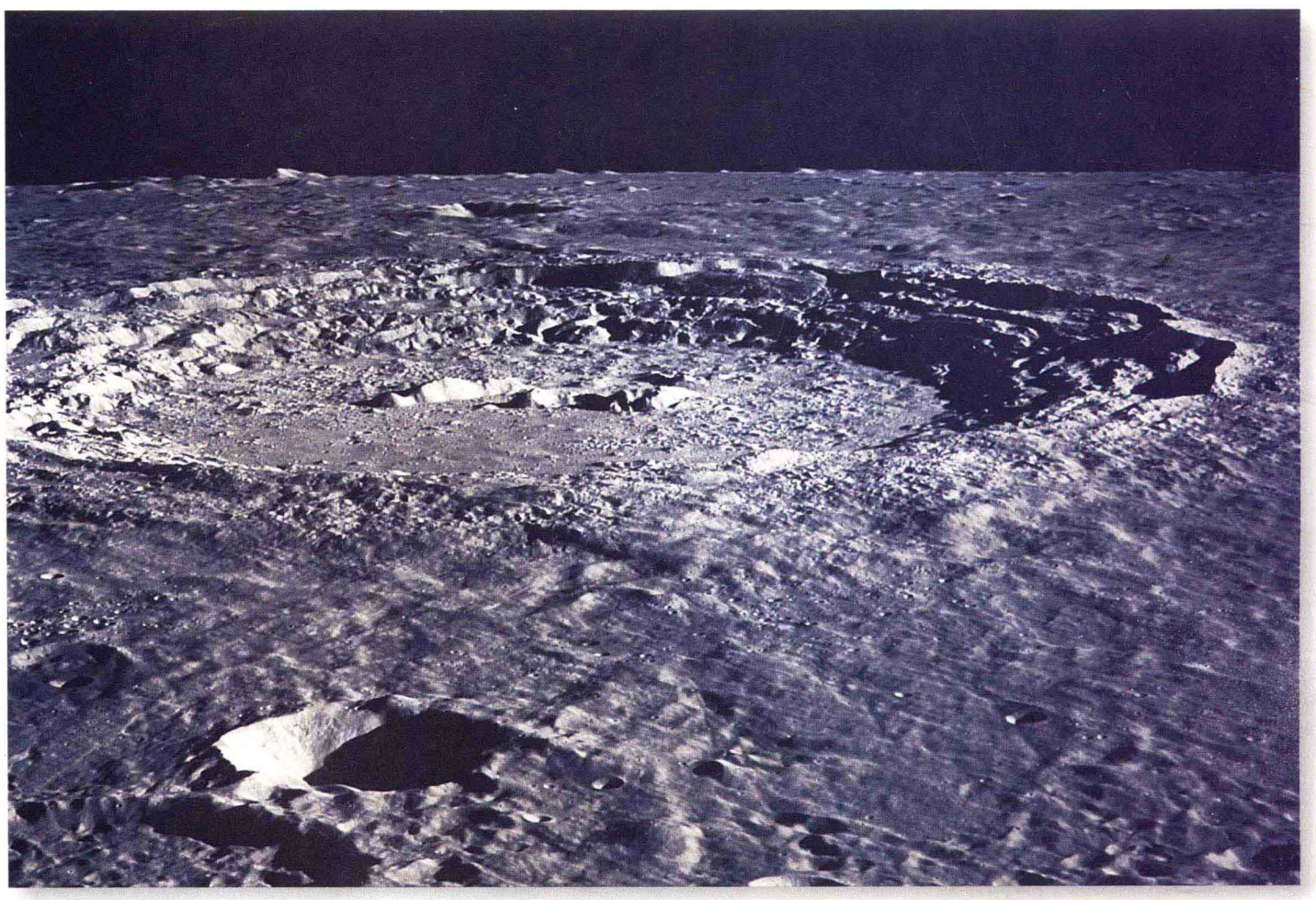
Why Are Craters Different Sizes?

The Explore Activity shows that craters form when an object hits a surface. Scientists call this event an impact. That is why they often call craters *impact craters*.

The Explore Activity also shows that the width of the crater depends on the size of the object hitting the surface. How deep the crater is changes depending on how fast the object is traveling when it hits. The greater the height the marble was dropped from, the greater its speed. Greater speed results in deeper craters.

Did the craters you made in the tin of flour remind you of any other craters you have seen? Could the craters on the Moon be caused by impacts from objects traveling in space?

A large crater on the Moon

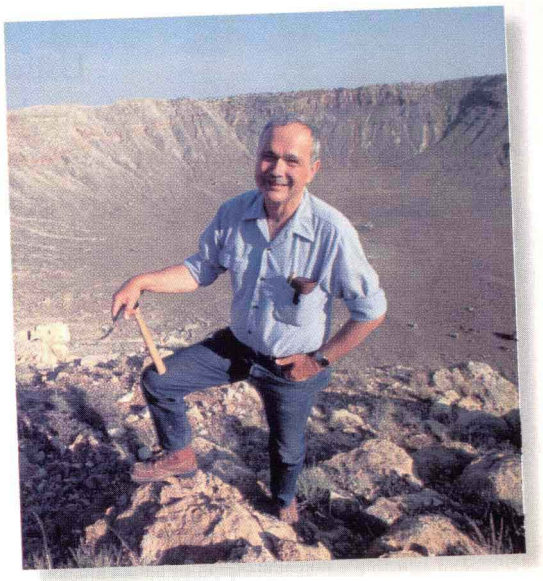


How Do Scientists Work?

One scientist who asked these same questions was **geologist** (jē ol'ə jist) Eugene Shoemaker. A geologist is a scientist who studies the characteristics of rocks to tell how the rocks may have formed. He investigated craters on Earth, and it made him wonder about the craters on the Moon.

Dr. Shoemaker's interest in craters started when he was in school. He saw a crater in Arizona called Meteor Crater and wondered how it formed. He wanted to learn everything he could about it. He studied the crater's shape, and he chipped away at the rock inside it to see what he could learn from it.

The more Dr. Shoemaker studied Meteor Crater, the more he became interested in the craters on the Moon. He was so interested he decided to become an astronaut. He wanted to "bang on the Moon" with his own hammer!



Dr. Eugene Shoemaker was a geologist.

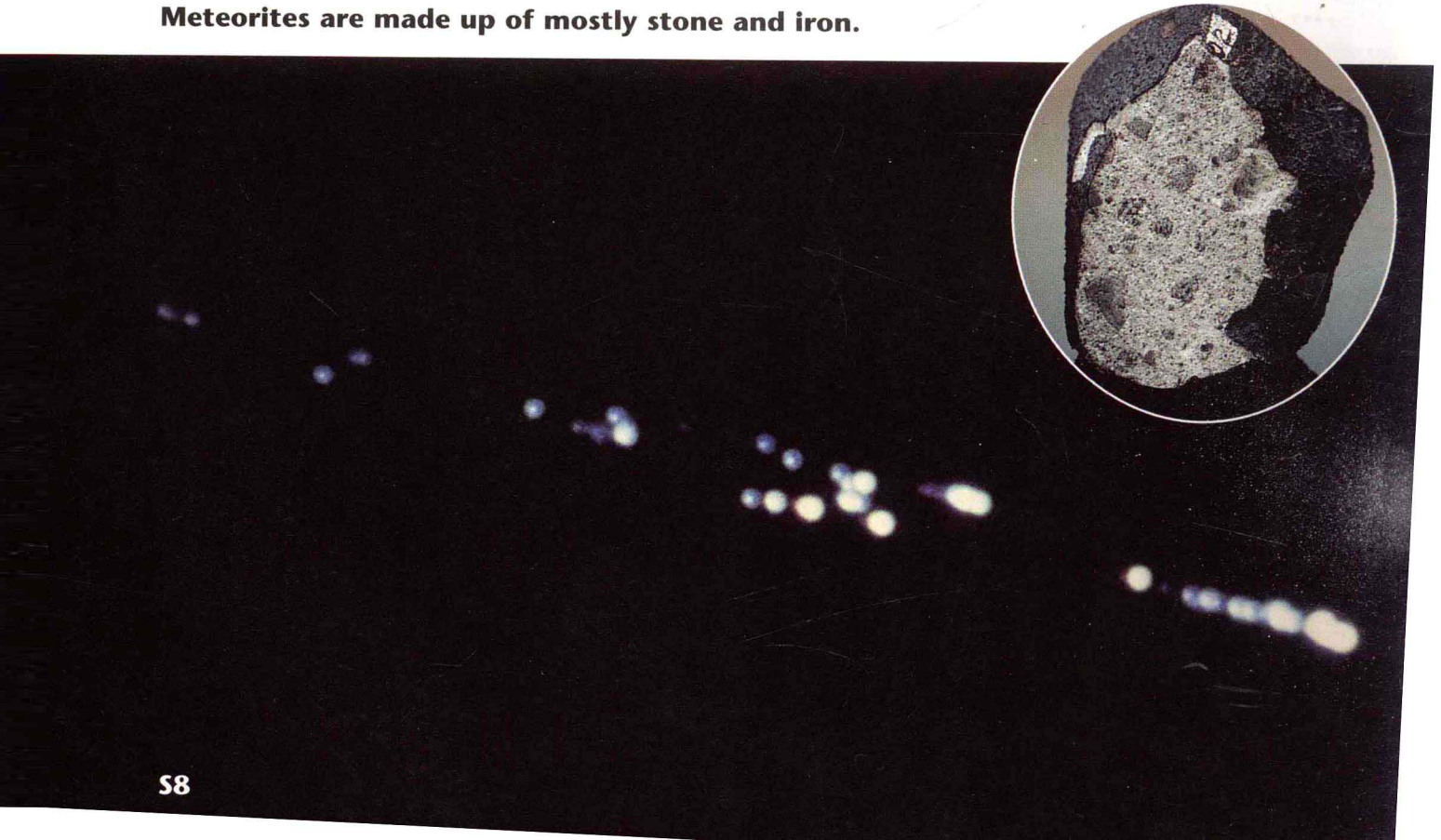
Meteor Crater in Arizona is over one kilometer wide!

Unfortunately, Dr. Shoemaker's health was not good enough for him to be an astronaut. He didn't get a chance to go to the Moon, but he did train astronauts who went into outer space.

He also traveled to craters on every part of Earth. Thanks to his work, scientists now think Meteor Crater was made by a chunk of rock from outer space that hit Earth. The rock was as big as a house! Rocks from outer space enter Earth's **atmosphere** (at'məs fîr'). The atmosphere is the layer of gases that surround the planet. The rocks that enter Earth's atmosphere are called **meteors** (mē'tē ərz). When they hit an object like Earth or the Moon, they are called **meteorites** (mē'tē ə rīts').

Dr. Shoemaker investigated more questions he had about craters. Were all craters the "footprints" of meteorites? Were craters on the Moon formed the same way as craters on Earth? Dr. Shoemaker and other scientists studied many other craters. They found **evidence** (ev'i dəns) of more than 100 large craters on Earth. Evidence is a word for clues used to solve a problem.

Meteorites are made up of mostly stone and iron.



How Do Scientists Use the Work of Other Scientists?

Dr. Shoemaker compared his ideas with what other scientists had discovered. He learned that meteorite craters had several features in common:

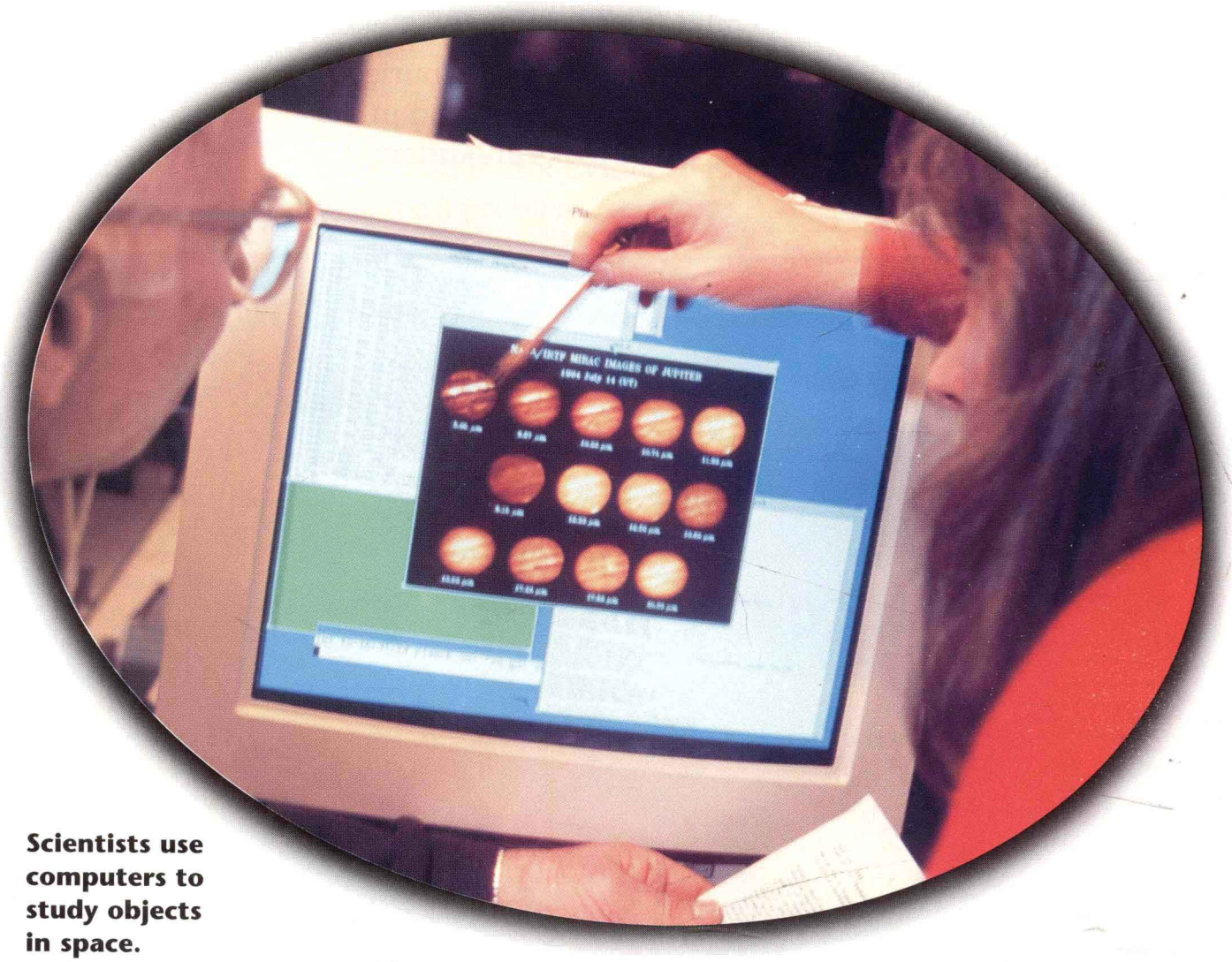
- They are all shaped like circles.
- The floor of the crater is lower than the land around it.
- The rim of the crater is higher than the land around it.
- The rim is made of rock material thrown out of the crater.
- The rocks thrown out of the crater are like those just below Earth's surface around the crater.
- Rock layers under the crater floor have many cracks.
- Pieces of the rock from space may be found buried in the floor of the crater. They also may be found in the ground around the crater. These rocks are different from rocks on Earth.

Henbury Crater is a meteorite crater found in Australia.

How Can a Computer Help Scientists?

Dr. Shoemaker collected evidence about his ideas. He compared craters on Earth to craters on the Moon. He concluded that they were alike. When you **draw conclusions**, you put together in a statement all the facts you have learned.

Dr. Shoemaker used a computer to help answer some of his questions. He made a computer **model** (mod'əl) that showed what it's like when a meteorite hits Earth. A model is something that represents an object or event. In the computer model, the rocks at the center of the spot where the meteorite hit were thrown the farthest away. Rocks around the edges of where the meteorite hit moved only slightly. The rocks now formed the rim of the crater.



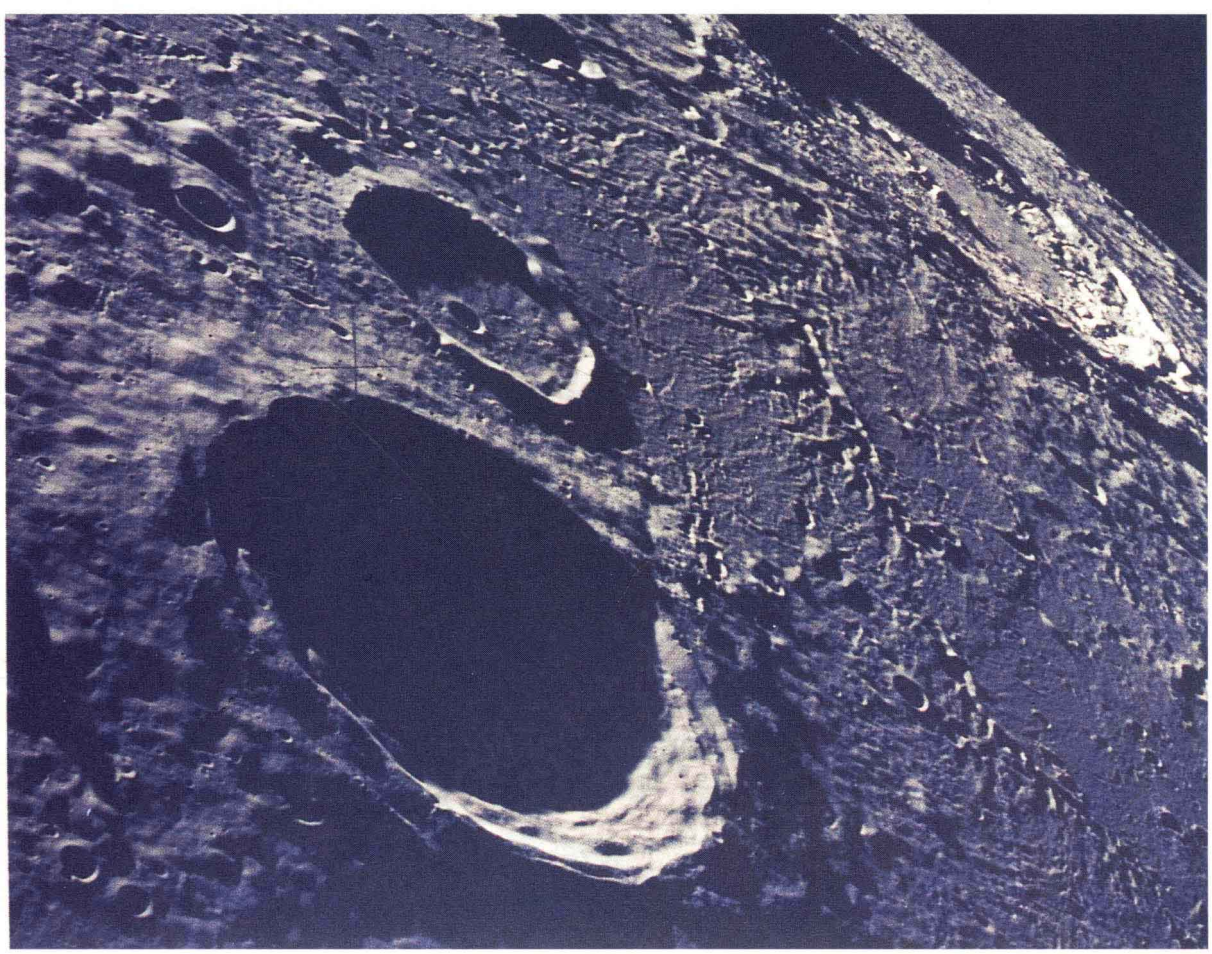
Scientists use computers to study objects in space.

Dr. Shoemaker repeated his **experiment** on the computer using **variables** (vâr′ē ə bəlz). Variables are things in an experiment that can be changed or controlled. Each time he repeated the experiment, Dr. Shoemaker changed the size of the meteorite. The larger the meteorite he used, the larger the crater formed. All of the information he gathered supported his explanation. Earth's craters were formed by meteorites that hit its surface.

Studying Things That Are Far Away

Dr. Shoemaker wanted to learn more about the craters on the Moon. Most scientists agreed that most of the Moon's craters were also formed by meteorites. How could Dr. Shoemaker find out more about how these craters formed? How could he study the Moon's craters without going to the Moon?

Craters cover most of the Moon's surface.



How Can a Scientist Prove His or Her Ideas?

Dr. Shoemaker and other scientists studied photographs of the craters. The pictures were taken through large telescopes. The pictures could be enlarged, making the images much bigger and easier to see. Guess what they found out?

- The Moon's craters are shaped like circles.
- The floors of the Moon's craters are lower than the land around them.
- The rims of the Moon's craters are higher than the land around them.
- The rim around the Moon's Copernicus Crater is much like Meteor Crater's rim in Arizona.

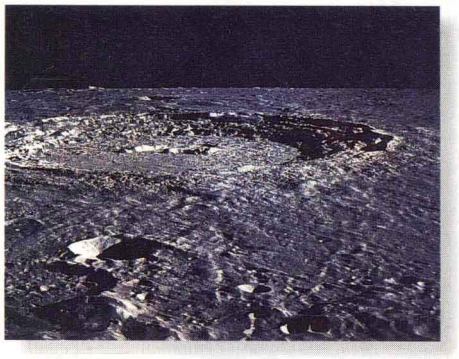
Telescopes are tools used to make faraway objects appear closer.

Based on the evidence, the scientists concluded that Copernicus Crater was made when a large meteorite hit the Moon.

What would it take to make this explanation more certain? Astronauts would have to visit Copernicus Crater and bring back rock samples from it.

The explanation seems correct. Most scientists agree with it. It can be defended using the evidence from photos. The photos can be compared with the evidence collected at Meteor Crater in Arizona.

In the future you may be able to find new evidence as an astronaut or scientist. Maybe you will think of new questions about the Moon's craters. Maybe you will investigate to find the answers.



Copernicus Crater on the Moon

Astronauts have brought rocks from the Moon back to Earth.