Earth teems with liquid water, oxygen, and abundant life forms. But it wasn’t always this way. The primitive Earth—like Venus today—had an atmosphere thick in carbon dioxide. This gas caused a greenhouse effect with high surface temperatures on Earth. Earth’s surface was covered with volcanoes, just as Venus’ surface is today. Is Earth unique? Or could Venus be a young Earth?

The presence of life on Earth and its abundant liquid water sets our planet apart from the rest of the planets in our solar system. In this lesson, you and your classmates will present your planetary travel brochures and mission designs. You will compare Earth to the other planets in the solar system and consider how the conditions on each planet—such as distance from the Sun, surface gravity, atmosphere, and temperature—affect our ability to study the planet more closely in the future. You also will consider the delicate balance of conditions on Earth that allow life to exist.

What might life on Earth be like if its conditions were different? What conditions might be necessary for life to exist on other planets? Let’s find out.

OBJECTIVES FOR THIS LESSON

Present your travel brochure and your team’s mission design to the class; explain how a planet’s features affect scientists’ ability to study it.

Compare Earth to other planets in the solar system.

Explore the effects of climate change on Earth.
Getting Started

1. With your group, brainstorm how Earth compares to the other planets in our solar system. How is Earth like other planets? How is it different? List your group’s ideas in your notebook.

2. Examine the list of ideas. What conditions or characteristics allow life to exist on Earth? Identify them in some way on your list.

3. Read “Climate’s Link to Life.” Answer the questions at the end of the selection in your notebook, and then discuss them as a class.

MATERIALS FOR LESSON 19

For you
1 completed copy of Student Sheet
10.1c: Planetary Chart
1 completed planetary travel brochure

For your team
1 completed future mission design
Inquiry 19.1
Comparing the Planets

PROCEDURE

1. Listen as other students present their planetary travel brochures to the class. Compare the data you have recorded on Student Sheet 10.1c with the data presented by each student. Be prepared to ask questions and debate ideas. Revise information on Student Sheet 10.1c if needed.

2. After all the students have presented their brochures, get together with your mission design team. Present to the class your ideas for a future mission to your planet. What features of the planet did you consider when designing your mission? Share your ideas with the class.

REFLECTING ON WHAT YOU’VE DONE

1. With your group, compare the nine planets in each category listed on Student Sheet 10.1c. Look for patterns and exceptions to the patterns. (For example, does the distance of a planet from the Sun relate to its mass? Does the mass of a planet determine how many moons it can have? If a pattern in mass and distance exists, is there a planet that doesn’t follow this pattern?) Decide with your group how to record the patterns you discover.

2. Analyze any patterns or exceptions to the patterns by answering the following in your notebook, then discuss them as a class:

   A. Which categories listed on Student Sheet 10.1c seem to be related? Explain why you think they are related.

   B. Which categories seem to stand alone, with little or no relation to the others?

   C. Which planet breaks a pattern and in which category?

   D. Look back to the Mission reading selections in Lessons 11–17. What patterns do you observe in the planets’ atmospheres? Which categories seem to be related to whether a planet has an atmosphere? Explain your thinking.

3. Read “Little Things Mean a Lot.” Then answer the questions at the end of the reader in your notebook. Discuss your answers with your class.
Earth has a lot going for it—it has the best position of any planet in the solar system. If Earth were much closer to the Sun, all of its water would boil away, as it has on Venus. If our planet were farther from the Sun, Earth’s water would freeze, as it has on Mars.

All the other planets in our solar system are either too hot or too cold to support life as we know it. But on Earth an incredible range of life forms exists, from algae to zebras. No doubt about it—Earth’s position and conditions are just right. That doesn’t mean, however, that Earth’s climate is the same everywhere on the planet, or that it never changes.

Climate Differences in Place and Time
Tour the planet and you’ll find different climates that support different plants and animals. Around the equator, the climate is hot and wet, which is perfect for monkeys, snakes, and orchids. But those life forms wouldn’t last long in the frigid, dry Arctic. And can you imagine a polar bear

(continued)
from the Arctic surviving in the tropics?

Not only does Earth have a wide variety of climates, but over time—a long time—the planet’s climate has changed.

Throughout Earth’s 4.5 billion-year history, there have been many ice ages when snow and ice covered much of the planet for long periods. Eventually, higher temperatures melted most of the ice and put an end to each ice age. But there were losers each time the climate changed.

Different climates support different plants and animals on Earth.
During Earth’s last ice age, woolly mammoths and mastodons thrived. We know this because scientists have found many of their bones and analyzed these fossils to determine their ages. This research makes one thing perfectly clear: These prehistoric giants died out at the end of the last ice age. They did not survive the change in climate. Their disappearance helped make way for newer species of plants and animals that were better suited to the warmer climate.

Thousands of years from now, Earth will likely enter another ice age. But first, the planet is in for some pretty hot times.

Greenhouse Gas
Earth typically experiences a warm period between ice ages, but something else is happening on our planet. Earth is getting even warmer than it usually would between ice ages! For a clue about why this is happening, think about the climate on Venus. It is one of the hottest planets in our solar system because its thick atmosphere is made up of mostly carbon dioxide (CO₂). Carbon dioxide is a “greenhouse gas.” That means that it lets the Sun’s heat in, but it does not let it back out again. This CO₂ traps a planet’s heat like a thick woolen blanket. Earth may be heading for a similar situation.

This prehistoric giant died out at the end of the last ice age.
Gasoline-burning cars, trucks, jet skis, leaf blowers, and lawn mowers release carbon dioxide, a colorless gas, into the air. And this gas, along with other pollutants and water vapor, absorbs the Sun’s heat—heat that would normally escape into space—and traps it in Earth’s atmosphere.

**Global Warming**

Temperatures on Earth appear to be rising. Scientists predict that increased hot spells may cause more drastic changes due to the heat. Numerous frog species already have been wiped out in Central America because of these changing conditions. Some scientists believe that the world’s coral reefs may be gone by 2050 due to global warming. The population of Adelie penguins on the Antarctic dropped 40 percent in the last quarter of the 20th Century. Scientists think that warmer temperatures make it harder for penguins to find food and breed.

Higher temperatures also will melt glaciers and ice sheets, causing oceans to rise. Models indicate that the glaciers in Glacier Park, Montana, may be gone by 2030. Rising sea levels in Maryland’s Blackwater National Wildlife Refuge are driving away many species of birds. Coastal areas around the planet—including places such as Florida in the United States, and countless low-lying countries like the Netherlands—could get buried under water.

It’s true that Earth is the best planet in the solar system to call home. But let’s not forget: The climate has a whole lot to do with it.

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**QUESTIONS**

1. Do you consider that Earth is in a state of balance (or equilibrium)? Explain your answer.
2. Why could Earth’s state of balance be considered “delicate”?
3. Why might Earth’s climate be its “link to life”?
4. Look at the photograph of Venus. How does Earth’s climate compare to other planets?
Throughout this course, you read a series called Missions. The information about Earth’s solar system is very detailed—and perhaps confusing at times.

“Why does this all matter?” you might ask. “Is it really important that Earth is 149.6 million kilometers from the Sun? Or that Earth's surface gravity is much less than that of Jupiter? Or that the Moon is 382,400 kilometers from Earth?”

These details do matter. They matter because it’s the balance of many factors—mass, distance from the Sun, rotation rate, and other factors—that makes life as we know it possible on Earth. These factors also make Earth, its sister planets, and the Sun work together as a whole—as a system.

Two scientists, Stephen Dole and Isaac Asimov, described the importance of little things in Habitable Planets for Man, a book published in the 1960s. In it they speculate about life on Earth if some things were changed. Let’s examine a few.

### What if Earth were twice as massive?
Greater mass would mean a greater surface gravity. This would have a significant effect on plant and animal life. Trees would be shorter and have thicker trunks. Animals would have heavier leg bones and muscles. Mountains would not be as high because they would not have the strength to support their weight. Waves in the ocean would be lower, and erosion would be faster.

### What if Earth were closer to the Sun?
If Earth’s mean distance from the Sun were 10 percent less than it is now, less than 20 percent of Earth’s surface would be habitable. The habitable areas would lie in two bands between latitudes 45 degrees and 64 degrees North and South. A broad area of intolerable heat would separate these two bands. There would be no polar ice, and the level of the oceans would be higher.
As we can see from these examples from *Habitable Planets for Man*, life on Earth is possible only because of a delicate balance that exists in the solar system. Change just one thing and we might be in for trouble. Details do matter! □

**QUESTIONS**

1. Which of Earth’s characteristics allow life to exist on the planet?
2. How might Earth change if any of its conditions were even slightly changed?
3. Examine the planet you studied for your planetary travel brochure. What conditions would you have to change on the planet for life to exist on it?
What kinds of books do you like to read? Many people turn to science fiction. Adults may enjoy writers such as Isaac Asimov and Arthur Clarke, whose works are modern classics. Younger people may prefer a writer like Madeleine L’Engle, who wrote *A Wrinkle in Time* and *A Swiftly Tilting Planet*.

Why is science fiction so popular? One reason is that science fiction tells a good story that removes us from our ordinary surroundings. Authors who make good use of their imaginations can create convincing and inventive worlds.

But science fiction is different from fantasy—it is not based on imagination alone. Real science fiction is based on scientific principles and a solid understanding of the real world and how it works. Some of the best-known authors of science fiction are scientists themselves. Asimov had a Ph.D. in chemistry and he taught in a medical school—whenever he wasn’t writing one of his hundreds of books!

Asimov defined science fiction as writing that is concerned with the “impact of scientific advance on human beings.” He thought science fiction was a good way to make science more accessible to everyone.

Once you know what science fiction is, you can see how something that was once featured in science fiction can become science fact. In 1865, the French author Jules Verne wrote a book, *From the Earth to the Moon*, that described a manned voyage to the Moon. Most French people at the time were probably skeptical—“C’est impossible!” they may have said.
Author Jules Verne surrounded by illustrations of some of his ideas
Science fantasy can be great reading. One of the most famous books of the late 1800s was War of the Worlds by H.G. Wells. In that story, Martians invaded Earth. A radio broadcast based on the book aired on Halloween night in 1938 and caused millions of people to believe that an invasion from Mars was actually taking place. Some people even decided to evacuate their cities!

Scientists doubted Wells’s fantastic theory about Martians. And when Viking I landed on Mars in 1976, people learned that this famous author had indeed been writing science fiction and not science fiction. There were no signs of life on the planet. Wells’s book is good reading—but his tales are not necessarily based on true science.

Science fiction helps shape our vision of how we will live tomorrow. If something can be imagined, has practical applications, and is scientifically possible, chances are it will become a reality. Jules Verne, one of the greatest science fiction writers of all time, was able to imagine the future.

Why don’t you give it a try? Let your imagination soar. Can you think of something that is science fiction today—but may become science fact tomorrow? ☐

QUESTION

1. How would you describe your team’s mission to another planet—science fiction or science fact? Explain your answer.