Name _____ Class _____ Date _____

CHAPTER 20 Formation of the Solar System

SECTION 2

The Sun: Our Very Own Star

BEFORE YOU READ

After you read this section, you should be able to answer these questions:

- Where does the sun's energy come from?
- How do sunspots and solar flares affect Earth?

National Science Education Standards

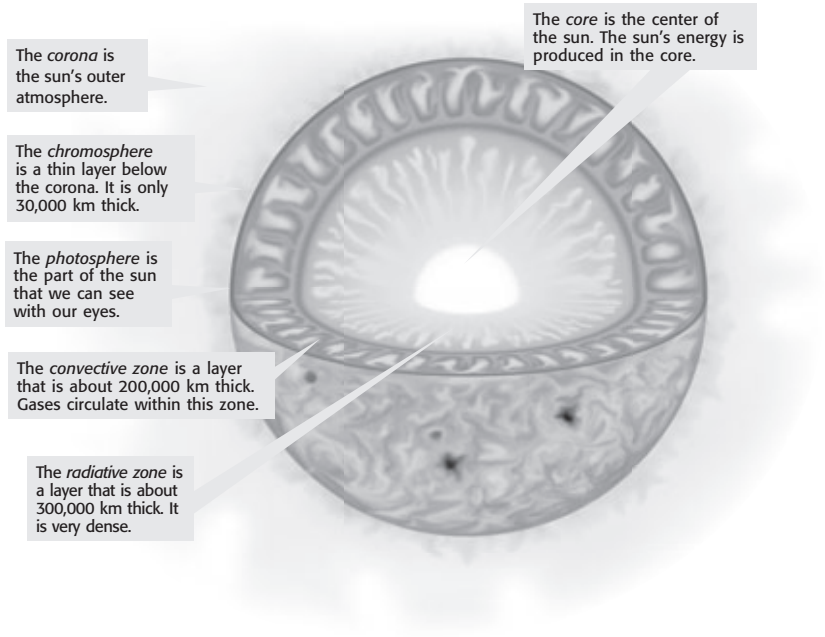
ES 3a

What Is the Structure of the Sun?

The sun is the largest part of our solar system. Ninety-nine percent of the matter in our solar system is found in the sun. Although the sun may look like a solid ball in the sky, it is actually made of gas. The gas is held together by gravity. The figure below shows the structure of the inside of the sun.

STUDY TIP

Ask Questions As you read, write down any questions you have. When you finish reading, discuss your questions with a partner or in a small group. Together, try to figure out the answers to your questions.



TAKE A LOOK

1. Identify What is the corona?

Energy is produced in the core of the sun. The energy produced in the core takes millions of years to move to the photosphere. First, the energy passes from the core into the radiative zone. Next, the energy reaches the convective zone. Within the convective zone, hot gases carry energy to the photosphere. Energy leaves the sun as light. It takes about 8.3 min for light to travel from the sun to Earth.

Where Does the Sun's Energy Come From?

Our sun has existed for about 4.6 billion years. Scientists have developed many theories about why the sun shines. For example, scientists used to think that the sun burns fuel, like a campfire. However, new observations about the age of the sun showed that this theory could not be correct. A sun that burns fuel could not last for more than about 10,000 years. ☑

READING CHECK

2. Identify About how long has the sun been shining?

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Scientists now know that nuclear fusion is the process that powers our sun and most other stars. To understand nuclear fusion, you must know a little bit about the structure of atoms.

Remember that all matter is made of atoms. Atoms, in turn, are made of even smaller particles called electrons, protons, and neutrons. Protons and neutrons make up the *nucleus* (plural, *nuclei*) of the atom. The electrons move around the nucleus. The figure below shows a model of an atom of the element helium. ☑

READING CHECK

3. List What are three particles that make up atoms?

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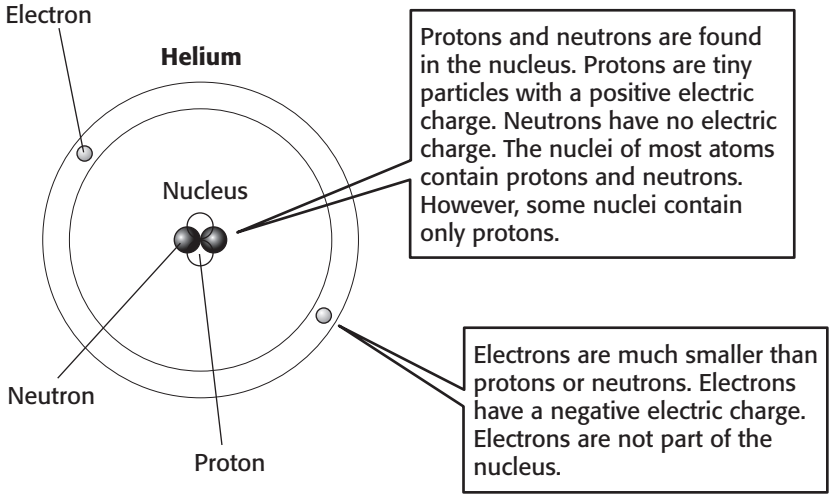

TAKE A LOOK

4. Identify Which kind of particle do all nuclei contain?

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The number of protons in an atom determines which element the atom is. For example, all atoms with only one proton are atoms of the element hydrogen. However, atoms of an element can contain different numbers of neutrons. For example, most hydrogen atoms contain no neutrons, but some contain one neutron. An atom with one proton and one neutron is still hydrogen. It is simply a different form of hydrogen.

Critical Thinking

5. Apply Concepts Atom A has three protons and three neutrons. Atom B has four protons and three neutrons. Are atom A and atom B atoms of the same element? Explain your answer.

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During **nuclear fusion**, two or more nuclei *fuse*, or join together, to form a new nucleus. This process releases a huge amount of energy. Within stars, nuclei of hydrogen fuse to form nuclei of helium. ☑

FUSION IN OUR SUN

Normally, hydrogen nuclei never get close enough to each other to fuse into helium. However, the pressure in the center of the sun is very high. This high pressure forces hydrogen nuclei together, so they can fuse. The figure below shows how hydrogen nuclei in the sun fuse to form helium. ☑

READING CHECK

6. Define What is nuclear fusion?

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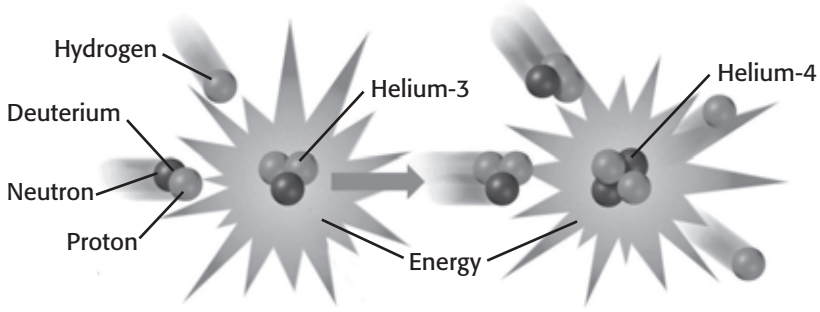

Deuterium is a form of hydrogen that contains one proton and one neutron in its nucleus. Within the sun, a nucleus of deuterium can collide with a nucleus of hydrogen, which contains only one proton. This releases a large amount of energy. It also forms a nucleus of a form of helium called *helium-3*. A nucleus of helium-3 contains two protons and one neutron.

Two helium-3 nuclei collide. This forms a nucleus of *helium-4*, which contains two protons and two neutrons. Two protons are released, along with a large amount of energy.

TAKE A LOOK

7. Compare How is helium-3 different from helium-4?

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How Does Solar Activity Affect Earth?

The movement of energy in the photosphere causes the gases to churn. The circulation of gases and the sun's rotation produce magnetic fields. These magnetic fields reach far into space. They can cause changes in the photosphere. These changes can also affect the Earth.

SUNSPOTS

The sun's magnetic fields slow the movement of gases in the convective zone. This causes certain areas of the photosphere to become cooler than others. The cooler areas show up as sunspots. **Sunspots** are cooler, dark spots on the photosphere. They vary in size and shape. Some sunspots are as large as 80,000 km in diameter. ☑

READING CHECK

8. Define What are sunspots?

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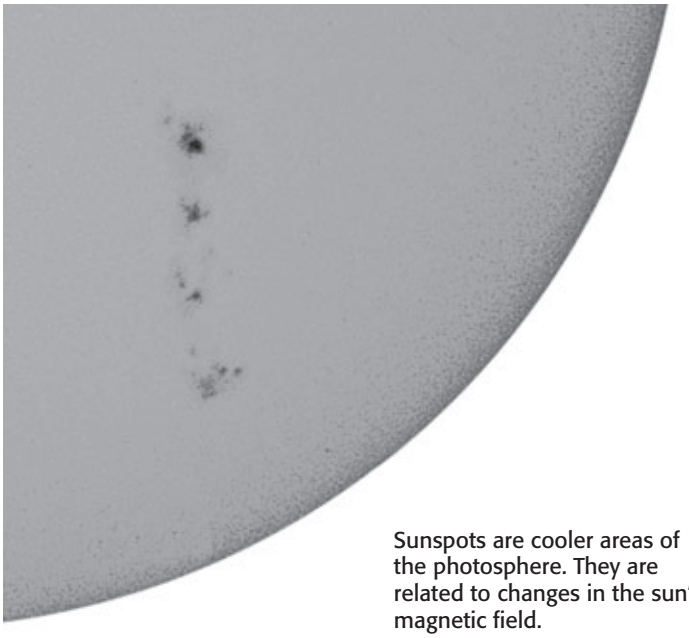

Sunspots are cooler areas of the photosphere. They are related to changes in the sun's magnetic field.

TAKE A LOOK

9. Identify What causes sunspots?

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THE SUNSPOT CYCLE

The Italian scientist Galileo was one of the first to study sunspots. Using a telescope, he observed the numbers, sizes, and locations of sunspots over time. He found that the numbers and locations of sunspots change in a predictable pattern. This pattern is called the *sunspot cycle*.

Today, scientists know that the sunspot cycle is about 11 years long. Every 11 years, the number of sunspots reaches a peak. Then it declines. The graph below shows how the number of sunspots has changed over time.

Math Focus

10. Read a Graph In about what decade was the maximum number of sunspots observed?

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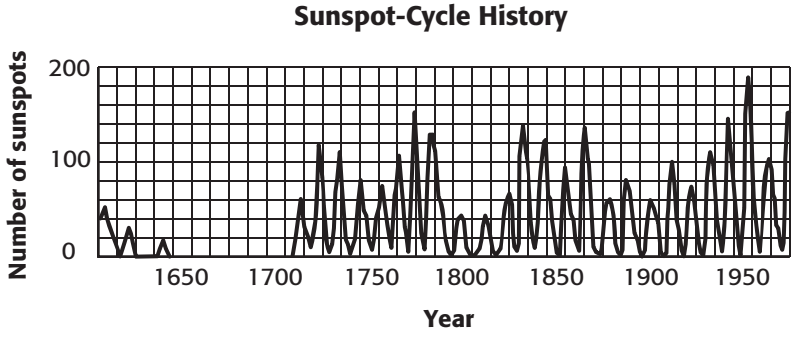

This graph shows the number of sunspots observed in different years. Notice that the number of sunspots changes in a regular way.

EFFECTS OF SUNSPOTS ON CLIMATE

Scientists think that sunspot activity may affect Earth's weather. For example, there were few sunspots between the years of 1645 and 1715. During this time, Europe's climate was much colder than usual. In fact, the climate was so cold that this period is sometimes called the "Little Ice Age." However, scientists do not understand how a small number of sunspots may change the Earth's climate.

Most scientists agree that sunspots may affect the Earth's climate. However, the connection between sunspots and the climate on Earth is not clear. More research is needed in order for us to fully understand how sunspots can affect our climate.

Say It

Hypothesize What kinds of evidence could support the hypothesis that sunspots affect the Earth's climate? By yourself, think about some answers to this question. Then, talk about your answers with a partner or in a small group.

SOLAR FLARES

The magnetic fields that cause sunspots can also cause solar flares. *Solar flares* are extremely hot, bright regions on the sun's surface. They send huge streams of electrical particles throughout the solar system. Solar flares can extend up to several thousand kilometers within only a few minutes. ☑

Scientists do not know exactly what causes solar flares. However, they do know that most solar flares are associated with sunspots.

Solar flares can have significant effects on the Earth. The streams of charged particles solar flares emit can interact with the Earth's atmosphere. They can interfere with radio and television transmissions. Therefore, scientists are trying to find ways to predict solar flares.

READING CHECK

11. Define What is a solar flare?

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Type of solar activity	Description	How can it affect the Earth?
Sunspots		may cause climate change, but the connection is not clear
Solar flares		

TAKE A LOOK

12. Describe Fill in the blank spaces in the table.

Name _____ Class _____ Date _____

Section 2 Review

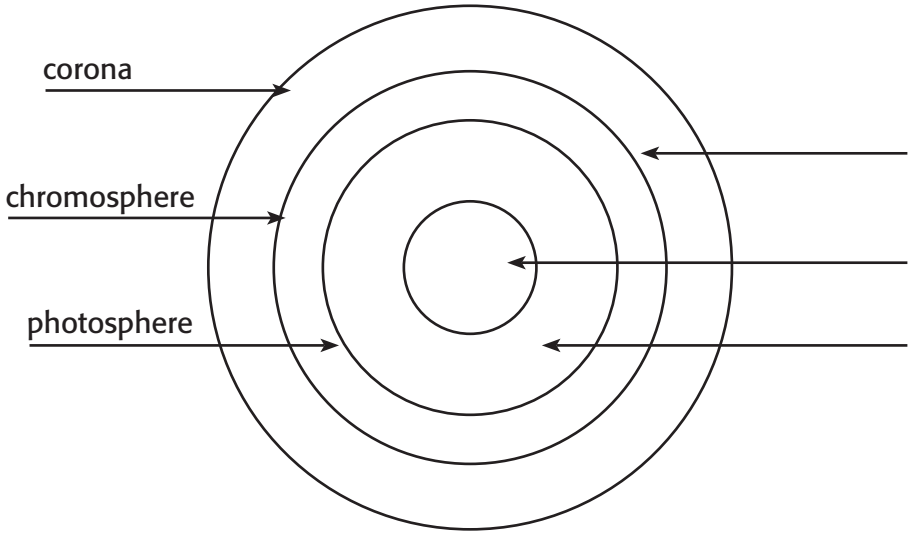
NSES ES 3a

SECTION VOCABULARY

nuclear fusion the process by which nuclei of small atoms combine to form a new, more massive nucleus; the process releases energy	**sunspot** a dark area of the photosphere of the sun that is cooler than the surrounding areas and that has a strong magnetic field

1. Identify What process powers most stars, including our sun?

2. Describe Label the layers of the sun that are missing from this diagram.



3. Explain Describe the process of nuclear fusion in our sun.

4. Identify What produces the sun's magnetic fields?

5. List What are two effects that are caused by changes in the sun's magnetic fields?

6. Describe How do solar flares affect the Earth?