Section 2 The Sun

Objectives

After this lesson, students will be able to

J.3.2.1 Name the three layers of the sun's interior.

J.3.2.2 Identify the three layers of the sun's atmosphere.

J.3.2.3 Describe features that form on or above the sun's surface.

Target Reading Skill

Outlining Explain that using an outline format helps students organize information by main topic, subtopic, and details.

Answers

The Sun
- I. The Sun's Interior
  - A. The Core
  - B. The Radiation Zone
  - C. The Convection Zone
- II. The Sun's Atmosphere
  - A. The Photosphere
  - B. The Chromosphere
  - C. The Corona
- III. Features on the Sun
  - A. Sunspots
  - B. Prominences
  - C. Solar Flares
  - D. Solar Wind

All in One Teaching Resources

- Transparency J23

Preteach

Build Background Knowledge L2

Solar Radiation

Invite students who have been sunburned to tell about their experiences. Encourage all students to imagine going outside on a clear, hot day and feeling the warmth of the sun. Ask: **What do we receive from the sun?** *(Possible answers: Light, heat)*

Section 2 The Sun

Reading Preview

Key Concepts

- What are the three layers of the sun's interior?
- What are the three layers of the sun's atmosphere?
- What features form on or above the sun's surface?

Key Terms

- core
- nuclear fusion
- radiation zone
- convection zone
- photosphere
- chromosphere
- corona
- solar wind
- sunspot
- prominence
- solar flare

Target Reading Skill

Outlining As you read, make an outline about the sun that you can use for review. Use the red headings for main topics and the blue headings for subtopics.

The Sun

I. The sun's interior
  A. The core
  B.
  C.
II. The sun's atmosphere
  A. The photosphere

Lab Zone Discover Activity

How Can You Safely Observe the Sun?

1. Clamp a pair of binoculars to a ring stand as shown in the photo.
2. Cut a hole in a 20-cm by 28-cm sheet of thin cardboard so that it will fit over the binoculars, as shown in the photo. The cardboard should cover one lens, but allow light through the other lens. Tape the cardboard on securely.
3. Use the binoculars to project an image of the sun onto a sheet of white paper. The cardboard will shade the white paper. Change the focus and move the paper back and forth until you get a sharp image. **CAUTION:** *Never look directly at the sun. You will hurt your eyes if you do. Do not look up through the binoculars.*

Think It Over

Observing Draw what you see on the paper. What do you see on the surface of the sun?

Suppose you are aboard a spaceship approaching the solar system from afar. Your first impression of the solar system might be that it consists of a single star with a few tiny objects orbiting around it. Your first impression wouldn't be that far off. In fact, the sun accounts for 99.8 percent of the solar system's total mass. As a result of its huge mass, the sun exerts a powerful gravitational force throughout the solar system. Although this force decreases rapidly with distance, it is strong enough to hold all the planets and other distant objects in orbit.

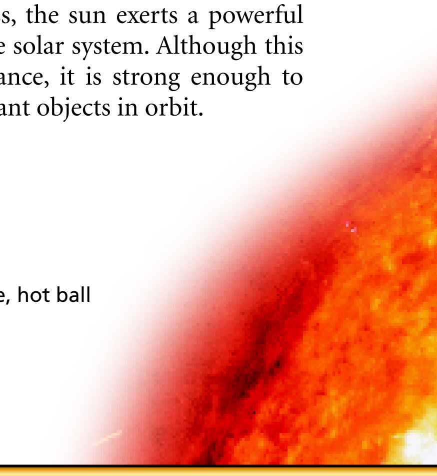


FIGURE 6
Active Sun
The sun is a huge, hot ball of glowing gas.

Lab Zone Discover Activity

Skills Focus observing L2

Materials binoculars, ring stand, ruler, thin cardboard, scissors, masking tape, white paper

Time 15 minutes

Tips If binoculars are not available, make a pinhole in a sheet of cardboard and project the sun's image through the hole onto the white paper. A small telescope can also be used to project the image. **CAUTION:** *The image of the sun focused to a point can cause burns and ignite paper.*

Expected Outcome Students will see an image of the sun and perhaps sunspots.

Think It Over A large bright circle will appear on the paper. Sunspots may also be visible.

The Sun's Interior

Unlike Earth, the sun does not have a solid surface. Rather, the sun is a ball of glowing gas through and through. About three fourths of the sun's mass is hydrogen and one fourth is helium. There are also small amounts of other elements. Like Earth, the sun has an interior and an atmosphere. **The sun's interior consists of the core, the radiation zone, and the convection zone.**

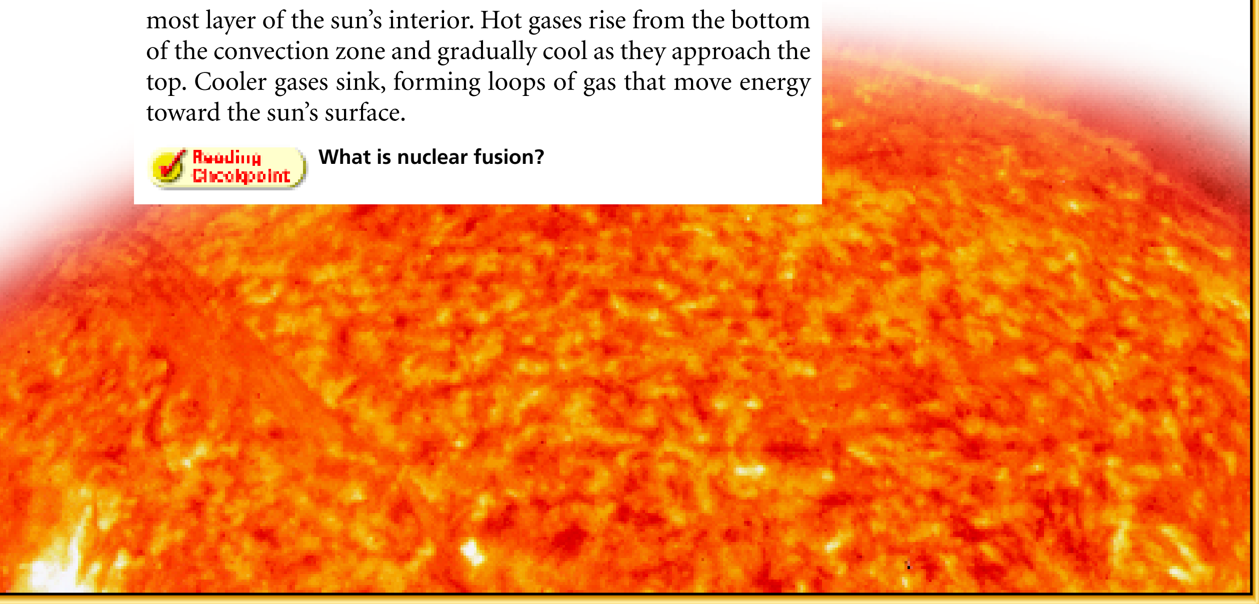
The Core The sun produces an enormous amount of energy in its **core,** or central region. This energy is not produced by burning fuel. Rather, the sun's energy comes from nuclear fusion. In the process of **nuclear fusion,** hydrogen atoms join together to form helium. Nuclear fusion occurs only under conditions of extremely high temperature and pressure. The temperature inside the sun's core reaches about 15 million degrees Celsius, high enough for nuclear fusion to take place.

The total mass of the helium produced by nuclear fusion is slightly less than the total mass of the hydrogen that goes into it. What happens to this mass? It is changed into energy. This energy slowly moves outward from the core, eventually escaping into space.

The Radiation Zone The energy produced in the sun's core moves outward through the middle layer of the sun's interior, the radiation zone. The **radiation zone** is a region of very tightly packed gas where energy is transferred mainly in the form of electromagnetic radiation. Because the radiation zone is so dense, energy can take more than 100,000 years to move through it.

The Convection Zone The **convection zone** is the outermost layer of the sun's interior. Hot gases rise from the bottom of the convection zone and gradually cool as they approach the top. Cooler gases sink, forming loops of gas that move energy toward the sun's surface.

Reading Checkpoint **What is nuclear fusion?**



Go Online PLANET DIARY

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Students can review the sun in an online interactivity.

Instruct

The Sun's Interior

Teach Key Concepts L2

Properties of the Sun's Interior Layers

Focus Remind students that the sun does not have a solid surface.

Teach Ask: **In what layer does nuclear fusion occur?** *(The core)* **How is energy transferred in the radiation zone?** *(Mainly in the form of electromagnetic radiation)* **What happens to the temperature of gases as they reach the top of the convection zone?** *(It becomes lower.)*

Apply Ask: **Why do you think that nuclear fusion is not used as an energy source on Earth?** *(Nuclear fusion occurs only under conditions of extremely high temperature and pressure. We do not currently have the technology to produce electricity by fusion.)* **learning modality: logical/mathematical**

Help Students Read

Relate Cause and Effect Cause-and-effect relationships are integral to scientific discovery. Ask: **What causes sunspots to look darker than surrounding areas on the sun's surface?** *(Sunspots are areas of cooler gases, which don't give off as much light as hotter gases.)*

Independent Practice L2

All in One **Teaching Resources**

- Guided Reading and Study Worksheet: *The Sun*

Student Edition on Audio CD

Differentiated Instruction

Special Needs L1

Interpreting Diagrams Show students color photographs of the sun at various stages of an eclipse. Point out the photosphere, the chromosphere, and the corona. Using the photographs as a guide, have students draw their own diagrams and label them appropriately. **learning modality: visual**

Less Proficient Readers L1

Understanding Key Ideas Have students look up the meanings of the word *corona* and the prefixes *chromo-* and *photo-*. Ask: **Why is the core called a core?** *(Because it's at the center)* Explain to students that the chromosphere lies just above the photosphere and has an intense red color when seen during an eclipse. **learning modality: verbal**

Monitor Progress L2

Drawing Have students diagram the sun's interior and atmosphere.

Answer

Reading Checkpoint A process in the sun's core in which hydrogen joins to form helium, releasing energy in the process

The Sun's Atmosphere

Teach Key Concepts L1

Layers of the Sun's Atmosphere

Focus Remind students that Earth's atmosphere is divided into layers.

Teach Ask: **What are the layers of the sun's atmosphere from innermost to outermost?** *(The photosphere, the chromosphere, and the corona)*

Apply Ask: **If you look at a typical image of the sun, which layer do you see?** *(The photosphere)* **learning modality: logical/mathematical**

Lab zone Teacher Demo

Energy From the Sun L1

Materials 2 glass jars with lids, 2 plastic thermometers, black plastic, waterproof glue (hot glue works well)

Time 45 minutes

Focus Remind students that most energy on Earth comes from the sun.

Teach Glue black plastic on one-half of the *inside* of each jar. Glue a plastic thermometer to the inside of each jar so that it can be read without opening the jar. Fill the jars with cold water, leaving 1.0 cm for expansion, and cap tightly. Take the class outside and place one jar in a shady spot and the other in direct sun, propped up so that sunlight fully illuminates the inside of the jar. Read the temperature of each jar every five minutes for thirty minutes. Back in the classroom, have students graph the temperature versus time for each container.

Apply Ask: **What happened to the temperature of the jars?** *(Shady jar may have gone up or down slightly; sunny jar rose several degrees)* **What caused the temperature to rise?** *(Energy from the sun)* **learning modality: logical/mathematical**

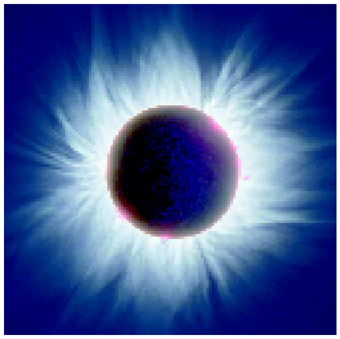


FIGURE 7
The Sun's Corona
During a total solar eclipse, you can see light from the corona, the outer layer of the sun's atmosphere around the dark disk of the moon.

The Sun's Atmosphere

The sun's atmosphere includes the photosphere, the chromosphere, and the corona. Each layer has unique properties.

The Photosphere The inner layer of the sun's atmosphere is called the **photosphere** (FOH tuh sfeer). The Greek word *photos* means "light," so *photosphere* means the sphere that gives off visible light. The sun does not have a solid surface, but the gases of the photosphere are thick enough to be visible. When you look at an image of the sun, you are looking at the photosphere. It is considered to be the sun's surface layer.

The Chromosphere During a total solar eclipse, the moon blocks light from the photosphere. The photosphere no longer produces the glare that keeps you from seeing the sun's faint, outer layers. At the start and end of a total eclipse, a reddish glow is visible just around the photosphere. This glow comes from the middle layer of the sun's atmosphere, the **chromosphere** (KROH muh sfeer). The Greek word *chroma* means "color," so the chromosphere is the "color sphere."

The Corona During a total solar eclipse an even fainter layer of the sun becomes visible, as you can see in Figure 7. This outer layer, which looks like a white halo around the sun, is called the **corona,** which means "crown" in Latin. The corona extends into space for millions of kilometers. It gradually thins into streams of electrically charged particles called the **solar wind.**

Reading Checkpoint **During what event could you see the sun's corona?**

Lab zone Try This Activity

Viewing Sunspots

You can observe changes in the number of sunspots.

1. Make a data table to record the number of sunspots you see each day.
2. Decide on a time to study sunspots each day.
3. View the sun's image in the way described in the Discover activity on page 78. **CAUTION:** *Never look directly at the sun. You will hurt your eyes if you do.*
4. Make and record your observations.

Interpreting Data How much did the number of sunspots change from day to day?

Features on the Sun

For hundreds of years, scientists have used telescopes to study the sun. They have spotted a variety of features on the sun's surface. **Features on or just above the sun's surface include sunspots, prominences, and solar flares.**

Sunspots Early observers noticed dark spots on the sun's surface. These became known as sunspots. Sunspots look small. But in fact, they can be larger than Earth. **Sunspots** are areas of gas on the sun's surface that are cooler than the gases around them. Cooler gases don't give off as much light as hotter gases, which is why sunspots look darker than the rest of the photosphere. Sunspots seem to move across the sun's surface, showing that the sun rotates on its axis, just as Earth does. The number of sunspots on the sun varies over a period of about 11 years.

Lab zone Try This Activity

Skills Focus interpreting data L3

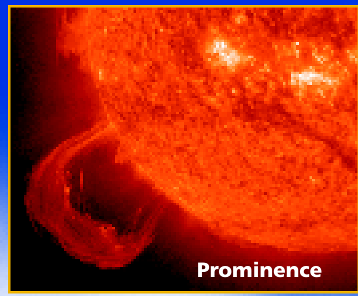
Materials binoculars, ring stand, ruler, thin cardboard, scissors, masking tape, white paper

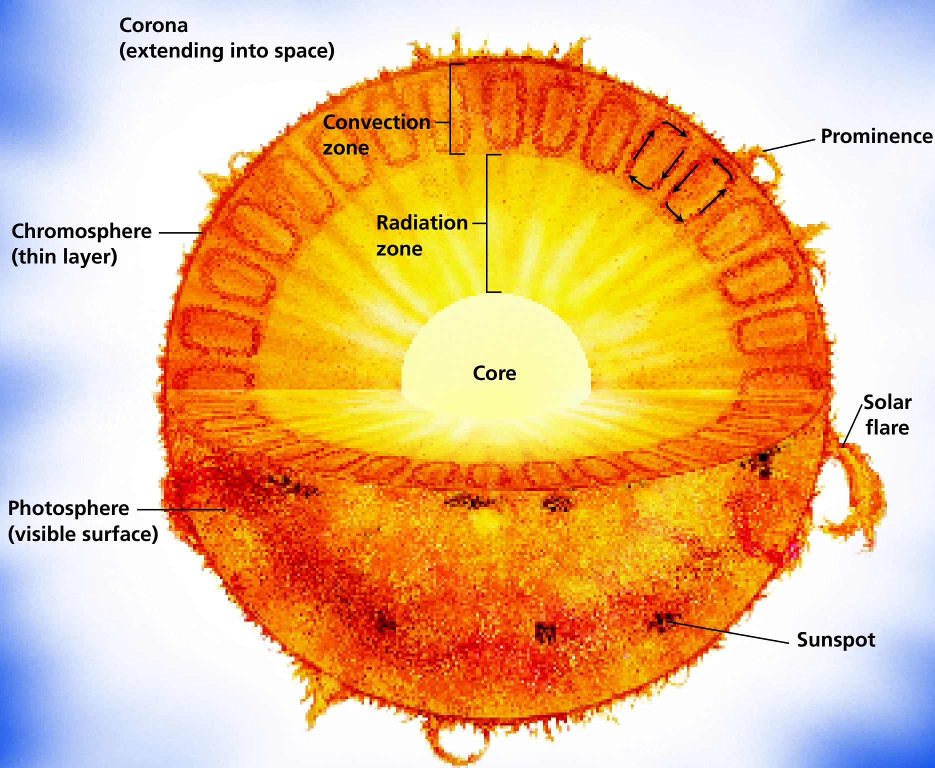
Time 10 minutes per day for 10 days

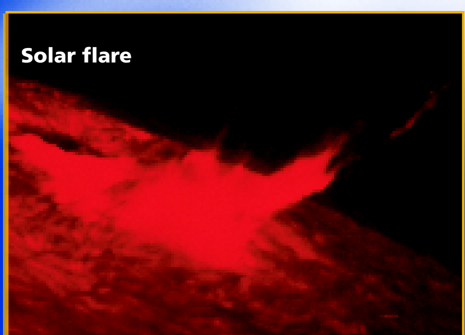
Tips Suggest that students look for sunspots two or three times per day for ten days. Their data tables should include the number of sunspots recorded at each interval as well as the average number of sunspots per day.

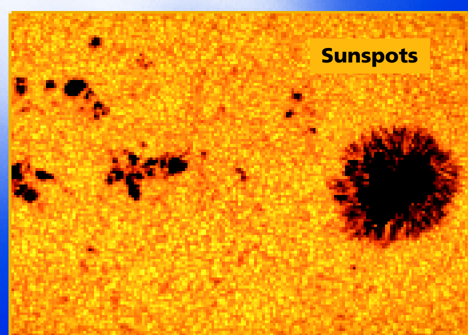
Extend Have students compile class results and evaluate the class average for the number of sunspots observed in a ten-day period. If findings vary, ask students to infer why. **learning modality: visual**

FIGURE 8
The Layers of the Sun
The sun has an interior and an atmosphere, each of which consists of several layers. The diameter of the sun (not including the chromosphere and the corona) is about 1.4 million kilometers. **Interpreting Diagrams** *Name the layers of the sun's interior, beginning at its center.*









Features on the Sun

Teach Key Concepts L2

Sunspots, Prominences, and Solar Flares

Focus Show students images or illustrations of the sun. Features such as sunspots, prominences, and solar flares should be visible.

Teach Ask students to make a table that compares and contrasts sunspots, prominences, and solar flares.

Apply Have students identify the features they saw on the sun's image from the results of the Discover activity. *(Sunspots)* **learning modality: visual**

Use Visuals: Figure 8 L2

The Layers of the Sun

Focus Have students look up the meanings of the word *corona* and the prefixes *chromo-* and *photo-*.

Teach As students examine Figure 8, ask: **Why is the corona called a corona?** *(It surrounds the sun like a crown.)* **Why is the core called a core?** *(Because it's at the center)* **What is the source of light that reaches Earth from the sun?** *(The photosphere)* **What is the source of energy for the energy produced by the sun?** *(Nuclear fusion)*

Apply Explain to students that the chromosphere lies just above the photosphere and has an intense red color when seen during an eclipse. **learning modality: visual**

All in One Teaching Resources

- Transparency J24

Differentiated Instruction

Less Proficient Readers L1

Analyzing Words The words used to describe the sun's features may be unfamiliar to some students. Point out that terms such as *sunspot* and *solar flare* are descriptive. Have students separate these terms into their parts. *(sun + spot; solar + flare)* Tell students to look up the words and word parts in the dictionary. Encourage students to explain how the terms help describe the features of the sun. *(A sunspot is a spot on the sun. A solar flare is a flare or an explosion on the sun.)* **learning modality: verbal**

Monitor Progress L2

Drawing Have students draw and label a diagram of the surface of the sun.

Answers

Figure 8 Core, radiation zone, convection zone

Reading Checkpoint Total solar eclipse

Monitor Progress L2

Answer

Reading Checkpoint A huge, reddish loop of gas on the sun's surface

Assess

Reviewing Key Concepts

1. a. Core, radiation zone, convection zone **b.** In the core **c.** In the radiation zone, energy is transferred mainly in the form of electromagnetic radiation. In the convection zone, hot gases transport energy toward the sun's surface.

2. a. Photosphere, chromosphere, and corona **b.** Photosphere **c.** The glare from the photosphere blocks out the fainter corona.

3. a. Sunspots: cooler, darker areas on sun's surface; prominences: reddish loops of gas that sometimes connect sunspots; and solar flares: gas eruptions reaching into space **b.** Sunspots are cooler than the surrounding photosphere.

Reteach L1

Use the diagrams in this section to review key terms.

Performance Assessment L3

Writing Have students create a travel brochure for an imaginary vacation to the sun. The brochure should include sites to visit, a map, and travel tips.

All in One Teaching Resources

- Section Summary: *The Sun*
- Review and Reinforce: *The Sun*
- Enrich: *The Sun*

FIGURE 9
Auroras
Auroras such as this can occur near Earth's poles when particles of the solar wind strike gas molecules in Earth's upper atmosphere.

Prominences Sunspots usually occur in groups. Huge, reddish loops of gas called **prominences** often link different parts of sunspot regions. When a group of sunspots is near the edge of the sun as seen from Earth, these loops can be seen extending over the edge of the sun.

Solar Flares Sometimes the loops in sunspot regions suddenly connect, releasing large amounts of magnetic energy. The energy heats gas on the sun to millions of degrees Celsius, causing the gas to erupt into space. These eruptions are called **solar flares.**

Solar Wind Solar flares can greatly increase the solar wind from the corona, resulting in an increase in the number of particles reaching Earth's upper atmosphere. Normally, Earth's atmosphere and magnetic field block these particles. However, near the North and South poles, the particles can enter Earth's atmosphere, where they create powerful electric currents that cause gas molecules in the atmosphere to glow. The result is rippling sheets of light in the sky called auroras.

Solar wind particles can also affect Earth's magnetic field, causing magnetic storms. Magnetic storms sometimes disrupt radio, telephone, and television signals. Magnetic storms can also cause electrical power problems.

Reading Checkpoint **What is a prominence?**

Section 2 Assessment

Target Reading Skill Outlining Use your outline to help answer the questions below.

Reviewing Key Concepts

1. a. Listing List the three layers of the sun's interior, starting from the center.
b. Explaining Where is the sun's energy produced?
c. Comparing and Contrasting Compare how energy moves through the radiation zone and the convection zone.

2. a. Listing What three layers make up the sun's atmosphere?
b. Identifying Which of the sun's layers produces its visible light?
c. Relating Cause and Effect Why is it usually impossible to see the sun's corona from Earth?

3. a. Describing Describe three features found on or just above the sun's surface.
b. Relating Cause and Effect Why do sunspots look darker than the rest of the sun's photosphere?

Lab zone At-Home Activity

Sun Symbols As the source of heat and light, the sun is an important symbol in many cultures. With family members, look around your home and neighborhood for illustrations of the sun on signs, flags, clothing, and in artwork. Which parts of the sun's atmosphere do the illustrations show?

Lab zone At-Home Activity

Sun Symbols L1 Suggest that students prepare photo essays or sketchbook collections of the items identified by their families. Some places to look for sun imagery include watches and clocks, artwork, product labels, and book illustrations.

Skills Lab

Stormy Sunspots

Problem

How are magnetic storms on Earth related to sunspot activity?

Skills Focus

graphing, interpreting data

Materials

- graph paper
- ruler

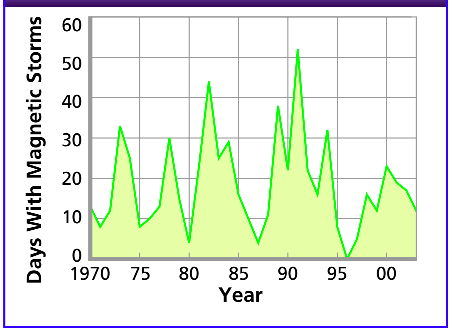
Procedure

1. Use the data in the table of Annual Sunspot Numbers to make a line graph of sunspot activity between 1972 and 2002.
2. On the graph, label the *x*-axis "Year." Use a scale with 2-year intervals, from 1972 to 2002.
3. Label the *y*-axis "Sunspot Number." Use a scale of 0 through 160 in intervals of 10.
4. Graph a point for the Sunspot Number for each year.
5. Complete your graph by drawing lines to connect the points.

Annual Sunspot Numbers

Year	Sunspot Number	Year	Sunspot Number
1972	68.9	1988	100.2
1974	34.5	1990	142.6
1976	12.6	1992	94.3
1978	92.5	1994	29.9
1980	154.6	1996	8.6
1982	115.9	1998	64.3
1984	45.9	2000	119.6
1986	13.4	2002	104.0

Magnetic Storm Days



Analyze and Conclude

1. **Graphing** Based on your graph, which years had the highest Sunspot Number? The lowest Sunspot Number?
2. **Interpreting Data** How often does the cycle of maximum and minimum activity repeat?
3. **Interpreting Data** When was the most recent maximum sunspot activity? The most recent minimum sunspot activity?
4. **Inferring** Compare your sunspot graph with the magnetic storms graph. What relationship can you infer between periods of high sunspot activity and magnetic storms? Explain.
5. **Communicating** Suppose you are an engineer working for an electric power company. Write a brief summary of your analysis of sunspot data. Explain the relationship between sunspot number and electrical disturbances on Earth.

More to Explore

Using the pattern of sunspot activity you found, predict the number of peaks you would expect in the next 30 years. Around which years would you expect the peaks to occur?

Skills Lab

Stormy Sunspots

L2

Prepare for Inquiry

Skills Objectives

After this lab, students will be able to

- Make a graph showing the average sunspot number per year
- Compare a graph of sunspot activity to a graph of number of magnetic storms on Earth during the same period

Class Time 30 minutes

All in One Teaching Resources

- Lab Worksheet: *Stormy Sunspots*

Guide Inquiry

Invitation

Tell students that a magnetic storm is defined as a brief disturbance in Earth's magnetic field.

Introduce the Procedure

Explain that *sunspot number* is a technical term that takes into account both the number of sunspot groups and the number of individual sunspots.

Expected Outcome

- Students will draw a graph that shows three peaks and three valleys in sunspot activity from 1972 to 2002.
- The sunspot activity valleys seem to coincide with valleys in the magnetic storm data.

Analyze and Conclude

1. Highest: 1980, 1990, and 2000; lowest: 1976, 1986, and 1996

2. Every 10–11 years

3. Most recent maximum sunspot activity: 2000; most recent minimum sunspot activity: 1996

4. Periods of high sunspot activity correspond to an increase in magnetic storms. Periods of low sunspot activity correspond to a decrease in magnetic storms.

5. Each summary should include examples and a clear explanation of the relationship among the sunspot number for the year, the number of days in that year with magnetic storms, and the occurrence of electrical disturbances.

Extend Inquiry

More to Explore Three more peaks should occur over the next 30 years. They should occur around 2010–2012, 2020–2023, and 2030–2033.