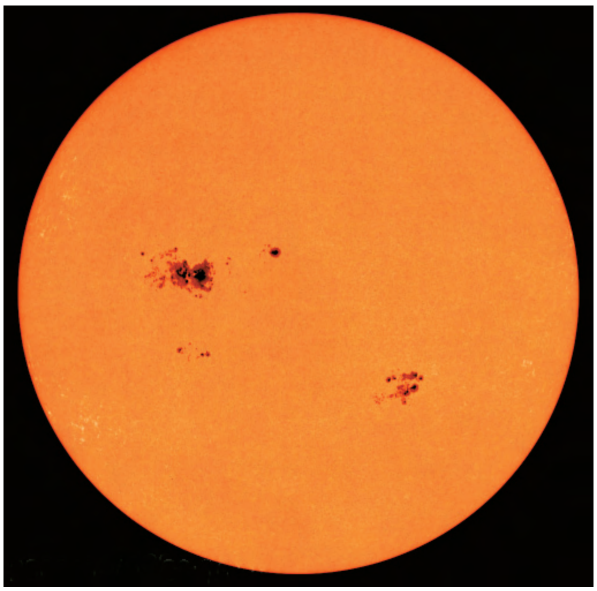
LESSON **8**

Sunspots and Space Weather

COURTESY OF SOHO/MDI (MICHELSON DOPPLER IMAGE) CONSORTIUM. SOHO IS A PROJECT OF INTERNATIONAL COOPERATION BETWEEN ESA (EUROPEAN SPACE AGENCY) AND NATIONAL AERONAUTICS AND SPACE ADMINISTRATION.



Visible-light image of the Sun, showing spots on its surface

INTRODUCTION

In ancient China around 28 B.C., astronomers recorded their observations of what looked like small, changing, dark patches on the surface of the Sun. Some early references to the spots also occur in the writings of Greek philosophers from the fourth century B.C. However, none of those early observers could explain what they saw.

Galileo was one of the first scientists to observe sunspots through a telescope. He made drawings of the changing shapes and watched the spots cross the visible surface of the Sun. These drawings represent the first steps of science toward understanding sunspots. In this lesson, you will observe projected sunspots and track patterns in their movements and occurrences. You also will read about Galileo and his discoveries.

What are sunspots? What do they tell us about the Sun and "weather" in space? In this lesson, you will discover these things for yourself. You also will prepare for Lesson 9, in which you will be assessed on your skills and knowledge about the Sun-Earth-Moon system.

OBJECTIVES FOR THIS LESSON

Examine projected images of the Sun for changes in its surface features.

Analyze patterns in the locations of sunspots.

Graph sunspot data and identify sunspot maximums and minimums.

Read about the effects of sunspots and space weather on Earth.

Getting Started

1. Discuss what you know about the Sun's energy and how it affects Earth as a planet.

2. What do you know about sunspots? How do you think sunspots affect Earth? Share your ideas with the class.

3. Spend a few minutes working with your group's binoculars. Discuss how the binoculars can be used to study the Sun.

4. Look back at the reading selection in Lesson 3, "How To View the Sun Safely." Review the section on safe viewing and projection. How can the binoculars be used to project the Sun's image? Discuss your ideas with your class. Then review the Safety Tips.

SAFETY TIPS

Never look directly at the Sun without special eye protection. Looking at the Sun can cause permanent eye damage or even blindness.

Do not look at the Sun directly through the classroom binoculars. They should be used to project the image of the Sun onto a white screen.

Do not put your hand or anything flammable near the eyepiece of your binoculars.

Give your binoculars a cooling break every 10 minutes by covering the front lens. The eyepiece may become overheated and the lens elements may separate if they are focused on the Sun too long.

MATERIALS FOR LESSON 8

For you

- 1 small square transparency of the Sun
- 1 copy of Student Sheet 8: Sun-Earth-Moon System Review
- 1 colored transparency marker
- 1 sheet of graph paper
- 1 box of colored pencils
- 1 metric ruler, 30 cm (12″)
- 1 pair of solar viewing glasses

For your group

- 1 pair of binoculars
- 1 sheet of fine cardboard
- 1 pair of scissors
- Masking tape
- 1 sheet of white paper
- 1 Sun-Earth-Moon Board™ Side A (from Lesson 3)
- 4 large binder clips
- 1 flashlight (optional)
- 2 D-cell batteries (optional)

Inquiry 8.1
Projecting Images of the Sun

PROCEDURE

1. Trace the size of your large binocular lenses onto your sheet of cardboard. Cut out the two circles in your sheet of cardboard (see Figure 8.1).

2. Tape the sheet of cardboard to the front of the binoculars with the larger lenses sticking through the holes.

3. You only want light to show through one lens. Use one of the cut-out circles to cover one of the larger lenses of the binoculars or tape over the front of the lens with masking tape.

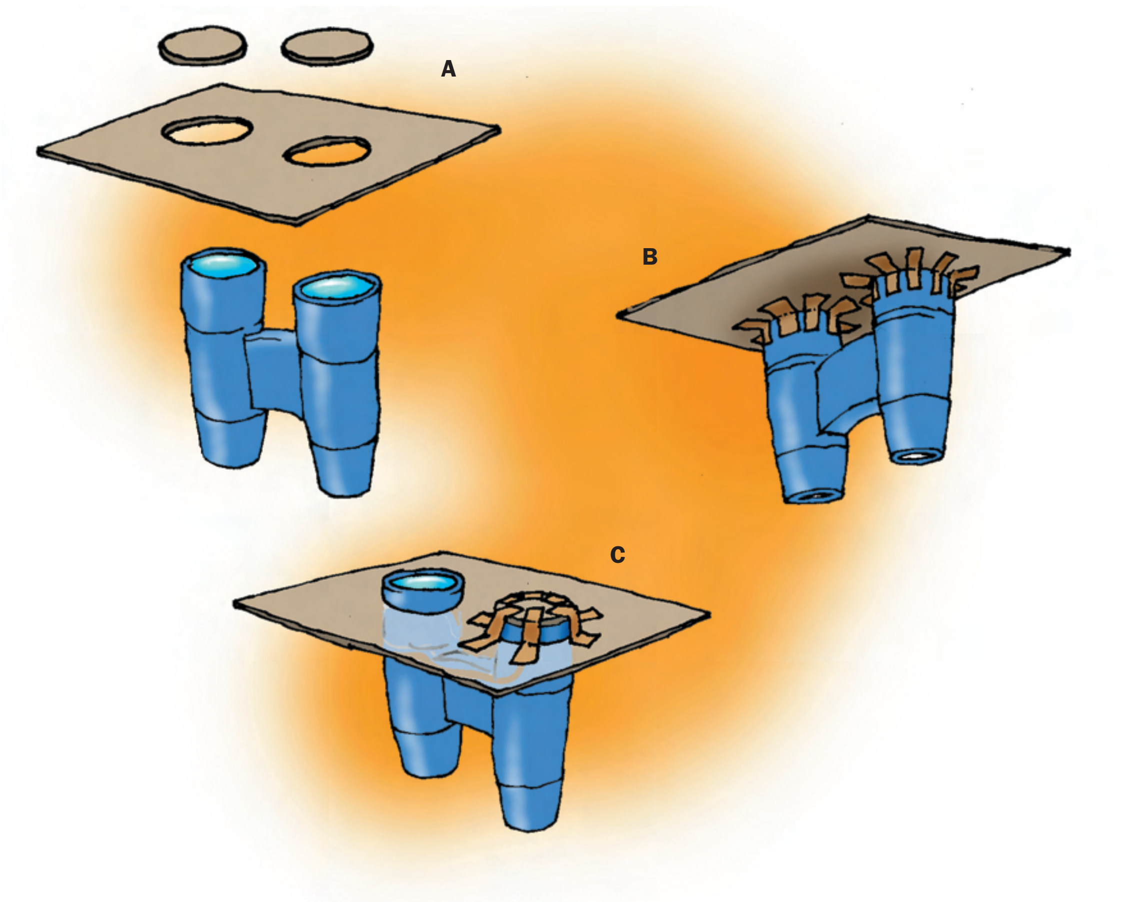


Figure 8.1 *(A) Cut out the two circles from your cardboard sheet. (B) Tape the cardboard sheet to the large lenses of the binoculars. The cardboard will help you to create a shadow around the light's image. (C) Cover one lens with cardboard or tape so that light comes through only one opening.*

4. Use the four binder clips to attach the sheet of white paper to your Sun-Earth-Moon (SEM) Board to keep it in place.

5. With your class, go outside or to a sunny window. Take a pencil, the binoculars, and your SEM Board.

6. Find a sunny location. Have one member of your group hold the SEM Board at an angle against the ground. Face the white paper up, as shown in Figure 8.2.

7. Have another member of your group hold the binoculars about 60 cm from the SEM Board. Point the larger lenses of the binoculars toward the Sun. Try to project the Sun's image onto the board. It will take a little effort to find the Sun.

8. Slowly move the binoculars away from the board. Try to keep the image of the Sun on the board.

Figure 8.2 *Hold the Sun-Earth-Moon Board™ at an angle with the white side facing up. Use the binoculars to project the image of the Sun onto the paper.*

9. Once the binoculars are about 1.5 m from the SEM Board, focus the binoculars to sharpen the Sun's image. (You may want to hold the binoculars on top of your head to keep them steady. See Figure 8.3.) Keep the Sun's image on the board.

10. Examine the projected image of the Sun. What do you observe? Are any spots visible inside the image? If you see sunspots, how many are there? Where are they? Write your observations in your notebook. (Keep in mind that a sunspot on the Sun's surface that is visible by projection can be 200,000 km in diameter—more than 15 times the diameter of Earth! If you can see a spot on your solar image, it is probably a sunspot much larger than Earth.)

11. Put away your binoculars. Do not remove the cardboard sheet.

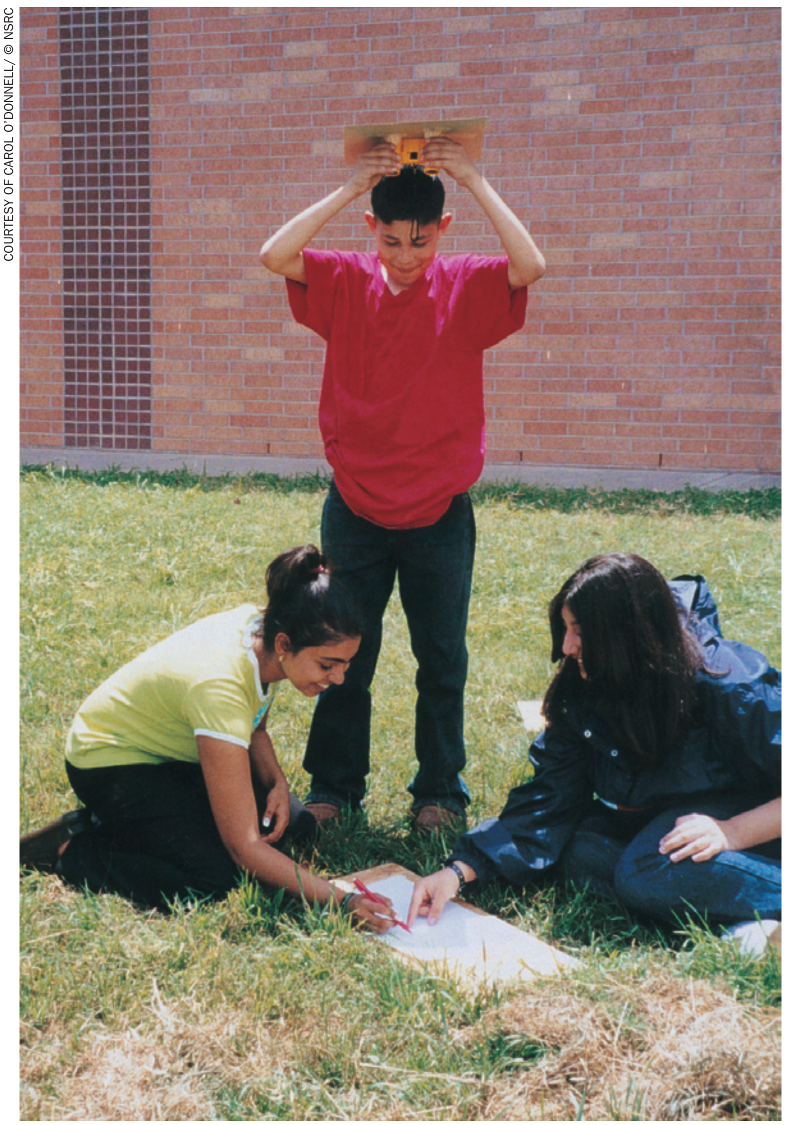


Figure 8.3 *Hold the binoculars about 1.5 m from the board. Steady the binoculars by holding them on top of your head. Keep your image in place on your paper.*

12. Review the Safety Tips. Watch as your teacher demonstrates how to use the solar viewing glasses (see Figure 8.4).

13. Obtain one pair of solar viewing glasses. Can you see sunspots on the Sun's surface?

ANA MORRIS

Figure 8.4 *Students viewing the Sun safely using solar viewing glasses*

SAFETY TIPS

Use solar viewing glasses to safely observe the Sun.

Never use solar viewing glasses with any other optical device, such as cameras, telescopes, or binoculars.

Do not use solar viewing glasses if they are damaged. Before use, check for scratches, pin-holes, or separations from frame. If damaged, cut into small pieces and discard.

Inquiry 8.2
Tracking Sunspots

PROCEDURE

1. Place the small square transparency of the Sun over Figure 8.5 (Day 1). Use your marker(s) to trace the sunspots onto the transparency. Label each group of sunspots with a different capital letter, different color, or different shape, and then create a key.

2. Lift up the transparency and place it over Figure 8.6 (Day 2). Trace the sunspot groups again and label them.

3. Repeat Step 2 with Figure 8.7 (Day 3) and Figure 8.8 (Day 4).

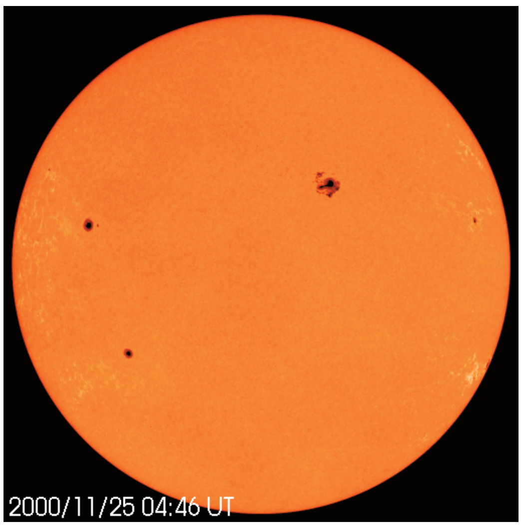


Figure 8.5 *Sunspots Day 1*

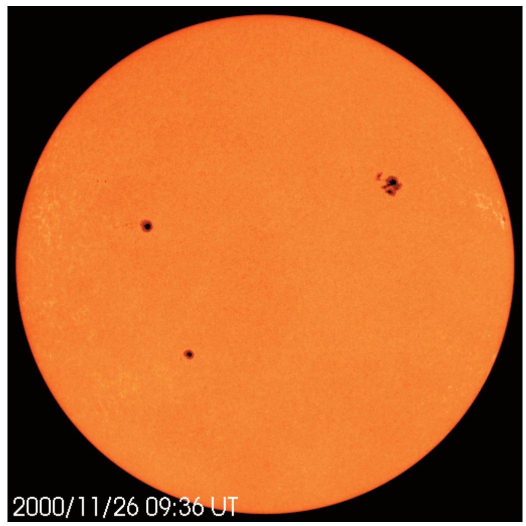


Figure 8.6 *Sunspots Day 2*

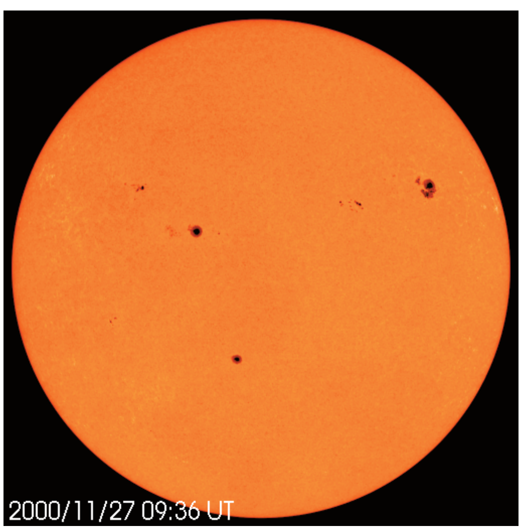


Figure 8.7 *Sunspots Day 3*

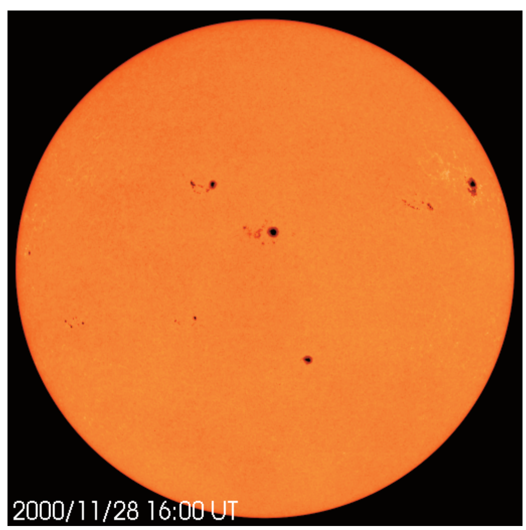


Figure 8.8 *Sunspots Day 4*

4. Create a data table in your notebook. An example is shown in Table 8.1.

5. Select one sunspot group to track. Record that group's longitude and latitude over 4 days.

Table 8.1 Sunspot Data

Sunspot Group: ____________________

Day	Longitude	Latitude
1		
2		
3		
4		

REFLECTING ON WHAT YOU'VE DONE

1. Share your transparency data with the class.

2. Analyze your sunspot data by answering the following questions in your notebook:

   A. How does the position of the sunspot group change over the 4-day period?

   B. What might be happening to cause these results?

3. Read "Galileo's Discoveries." Can you use the movement of sunspots to determine where the rotational axis of the Sun on your transparency is located?

4. Clean off your transparency. Then complete Student Sheet 8 as a review for Lesson 9, which is an assessment for Part 1.

Inquiry 8.3
Analyzing Long-Term Sunspot Data

PROCEDURE

1. What does the term "space weather" mean to you? How do you think it is related to the Sun? How is it related to sunspots? Brainstorm with the class.

2. Read "Space Weather." In your own words, write a definition of "space weather" in your notebook.

SPACE WEATHER

The term "space weather" refers to conditions on the surface of the Sun that ultimately affect Earth and its atmosphere. The Sun emits radiative and particle emissions that flow into space. These emissions and their flow are called "solar wind." Solar wind explodes continuously from the outer region of the Sun's dense atmosphere, called the solar corona.

Space is filled with low-energy charged particles, photons, electric and magnetic fields, dust, and cosmic rays. Solar wind energizes these particles, which affect spacecraft, humans in space, and occasionally human activities on Earth. Solar wind also causes changes in the space environment, which we see as auroras. (See the reading selection "Auroras.")

The radiation from space weather can endanger human life and health. In addition, radiation surges energize particles in the atmosphere and can damage electrical power systems, interfere with telecommunications, ruin high-tech ship navigation systems, and harm astronauts in space. Residents of Quebec, Canada, for example, suffered a blackout in 1989 when many electrical transformers were destroyed by the charged particles from a solar flare. Many of the risks from space weather can be avoided with reliable space weather forecasts and by taking precautions.

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3. Examine Table 8.2: Space Weather Report and Forecast. This information was reported for October 15, 2000, on the NOAA Space Environment Center (SEC) Web site.

Table 8.2 Space Weather Report and Forecast

Solar Data	Solar Forecast
The sunspot number for today [October 15, 2000] is 99. Today's solar wind velocity is 582.9 kilometers per second, and its density is 1.6 protons per cubic centimeter.	Solar activity is expected to be predominantly low for the next 3 days, though there is a chance for isolated moderate-level flare activity from three separate sunspot groups.

4. Use Table 8.2 to answer the following questions:

How many sunspots were reported?

How fast was the solar wind traveling?

How dense was the solar wind?

On the basis of this forecast, do you think the number of sunspots remains the same each day? What evidence do you have to support your answer?

If the number of sunspots changes each day, do you think these changes are predictable? Explain why you think this.

5. Discuss Table 8.3 with your teacher. Your teacher will assign each student a set of data points to graph. Before beginning, discuss with the class how you should standardize the graphing. With your teacher, use the data provided to determine the scale for each axis. Discuss how to label the maximum points (Max or "M") and minimum points (min or "m").

Table 8.3 Sunspot Data (1750–1999)

Year	No. of sunspots	Year	No. of sunspots	Year	No. of sunspots
1750	83	1779	125	1808	8
1751	47	1780	84	1809	2
1752	47	1781	68	1810	0
1753	30	1782	38	1811	1
1754	12	1783	22	1812	5
1755	9	1784	10	1813	12
1756	10	1785	24	1814	13
1757	32	1786	82	1815	35
1758	47	1787	132	1816	45
1759	54	1788	130	1817	41
1760	62	1789	118	1818	30
1761	85	1790	89	1819	23
1762	61	1791	66	1820	15
1763	45	1792	60	1821	6
1764	36	1793	46	1822	4
1765	20	1794	41	1823	1
1766	11	1795	21	1824	8
1767	37	1796	16	1825	16
1768	69	1797	6	1826	36
1769	106	1798	4	1827	49
1770	100	1799	6	1828	62
1771	81	1800	14	1829	67
1772	66	1801	34	1830	71
1773	34	1802	45	1831	47
1774	30	1803	43	1832	27
1775	7	1804	47	1833	8
1776	19	1805	42	1834	13
1777	92	1806	28	1835	56
1778	154	1807	10	1836	121

Year	No. of sunspots	Year	No. of sunspots	Year	No. of sunspots	Year	No. of sunspots	Year	No. of sunspots	Year	No. of sunspots
1837	138	1866	16	1895	64	1924	16	1953	13	1982	116
1838	103	1867	7	1896	41	1925	44	1954	4	1983	67
1839	85	1868	37	1897	26	1926	63	1955	38	1984	46
1840	63	1869	73	1898	26	1927	69	1956	141	1985	118
1841	36	1870	139	1899	12	1928	77	1957	189	1986	13
1842	24	1871	111	1900	9	1929	65	1958	184	1987	29
1843	10	1872	101	1901	2	1930	35	1959	158	1988	100
1844	15	1873	66	1902	5	1931	21	1960	112	1989	148
1845	40	1874	44	1903	24	1932	11	1961	53	1990	143
1846	61	1875	17	1904	42	1933	5	1962	37	1991	149
1847	98	1876	11	1905	63	1934	8	1963	27	1992	94
1848	124	1877	12	1906	53	1935	36	1964	10	1993	55
1849	95	1878	3	1907	62	1936	79	1965	15	1994	30
1850	66	1879	6	1908	48	1937	114	1966	47	1995	18
1851	64	1880	32	1909	43	1938	109	1967	94	1996	9
1852	54	1881	54	1910	18	1939	88	1968	106	1997	22
1853	39	1882	59	1911	5	1940	67	1969	106	1998	64
1854	20	1883	63	1912	3	1941	47	1970	105	1999	93
1855	6	1884	63	1913	1	1942	30	1971	67		
1856	4	1885	52	1914	9	1943	16	1972	69		
1857	22	1886	25	1915	47	1944	11	1973	89		
1858	54	1887	13	1916	57	1945	33	1974	34		
1859	93	1888	6	1917	103	1946	92	1975	16		
1860	95	1889	6	1918	80	1947	151	1976	13		
1861	77	1890	7	1919	63	1948	136	1977	27		
1862	59	1891	35	1920	37	1949	134	1978	93		
1863	44	1892	72	1921	26	1950	83	1979	155		
1864	47	1893	84	1922	14	1951	69	1980	155		
1865	30	1894	78	1923	5	1952	31	1981	140		

SOURCE: NOAA SPACE ENVIRONMENTAL CENTER

6. Graph your assigned data points.

REFLECTING ON WHAT YOU'VE DONE

1. Tape together all four graphs from your group to form a single graph. Analyze the graph. Then answer the following questions in your notebook:

   A. What patterns can you see in the sunspot data?

   B. How many years apart (on average) are the sunspot maximums?

   C. How many years apart (on average) are the sunspot minimums?

   D. Using the graph, predict when you think the next sunspot maximum should have occurred?

   E. On your graph, when might it have been relatively cold on Earth? Explain your answer.

   F. Why might it be important for scientists to determine patterns in sunspot data?

2. Now all groups' graphs will be taped together to form one 200-year graph. What additional observations can you make? Discuss your ideas with the class.

3. Read "Little Ice Age" and "Tree Rings Hold Solar Secrets." Discuss the readings with your class.

4. Are there any questions from the class brainstorming sheet of Lesson 1 that you can now answer? Are there any questions that you want to add? Work with your teacher to do that now.

GALILEO'S DISCOVERIES

Until about 1600, people believed that the universe was a very small place. They thought that Earth was the center of the universe, and that the Sun, Moon, and stars were small, flat disks. People also believed that the other five planets known at that time—Mercury, Venus, Mars, Jupiter, and Saturn—were also flat disks and that all planets and stars moved across the sky while Earth stood still below. This concept of the universe was perfect and precise. People called it "the clockwork universe."

Today, such beliefs seem silly, but centuries ago, many people held those beliefs so strongly that anyone who challenged them could get into terrible trouble. New discoveries that threatened the old, orderly beliefs were considered dangerous.

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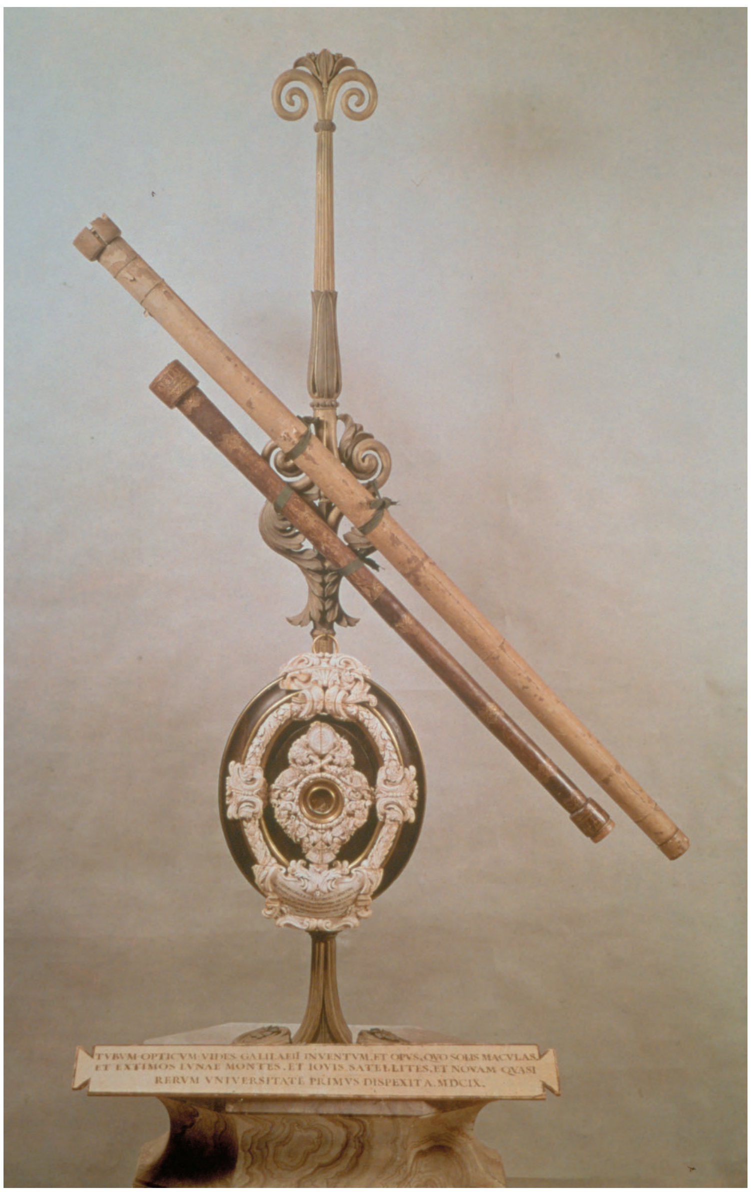

One of the original telescopes

Discovering Through a Telescope

Dutch craftsmen invented the telescope about 1608. The invention of the telescope—which uses lenses and mirrors to make distant objects appear larger and nearer—changed astronomy forever. Suddenly, European astronomers could peer into space and see previously unimagined details on objects such as the Moon, Sun, and planets. They also were able to discover planets and stars that had never been visible.

In 1610, an Italian astronomer named Galileo Galilei aimed one of the first telescopes at the sky. What Galileo saw through the telescope was very different from what could be seen with the naked eye.

One of the things that Galileo discovered was that four small moons

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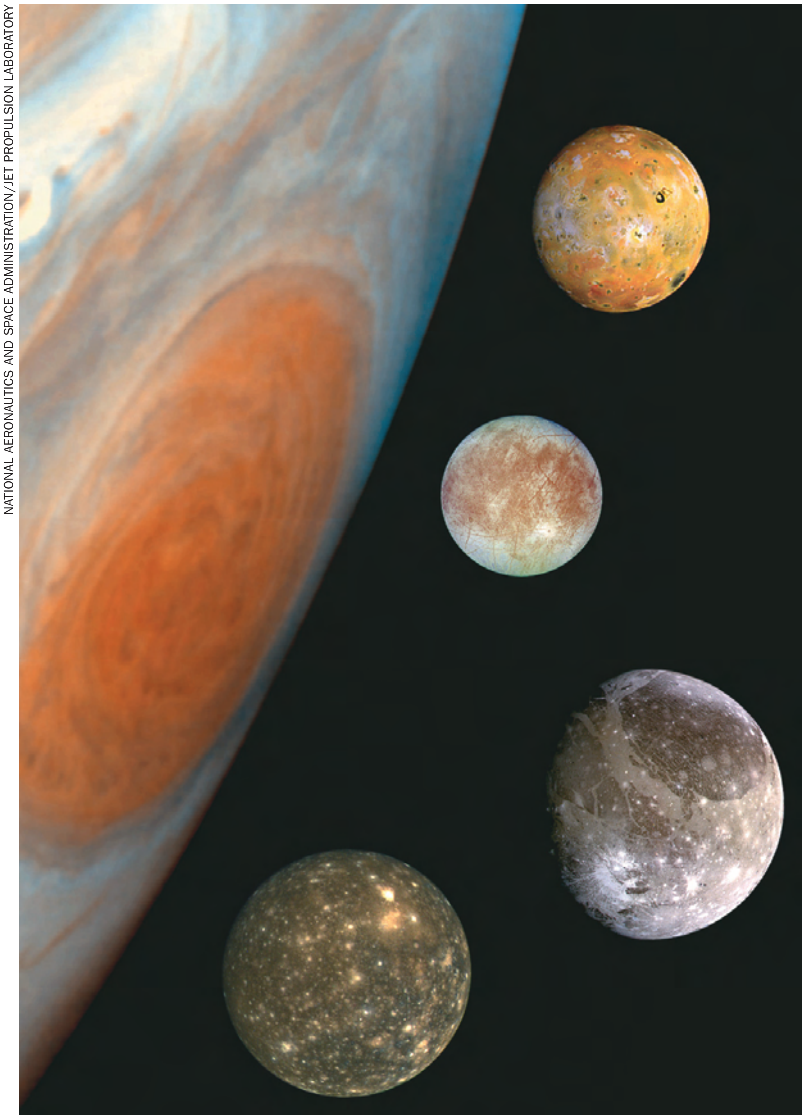


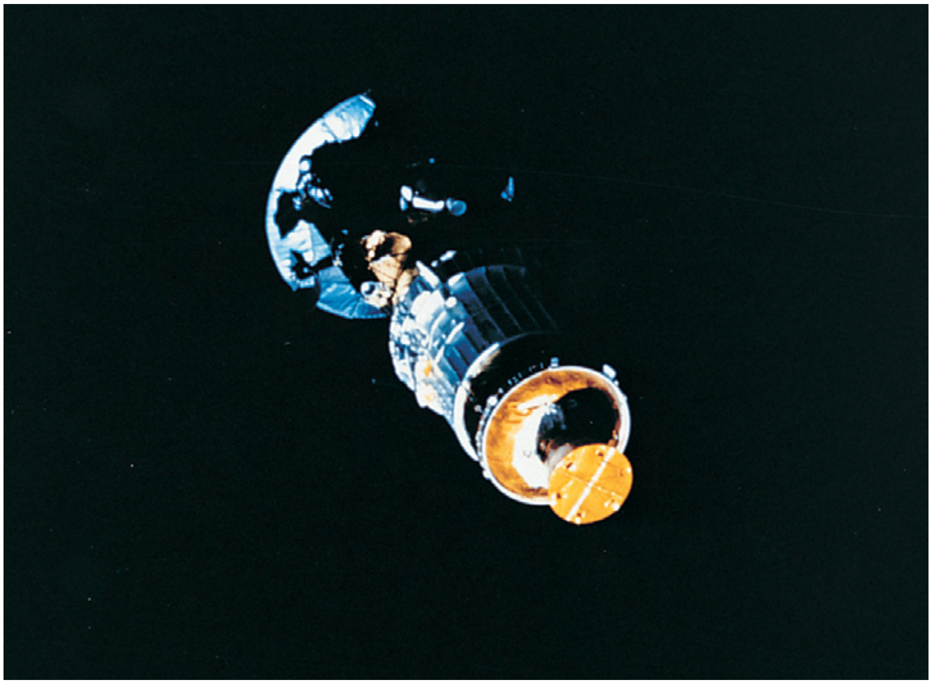
Composite of four of Jupiter's largest moons, known as the Galilean satellites. From top to bottom, the moons shown are Io, Europa, Ganymede, and Callisto. Jupiter's Great Red Spot is in the background. (You would not see the four moons together like this.)

orbit Jupiter. Today, we know that those moons are among the biggest in the solar system. More important to Galileo was that those moons weren't orbiting Earth. If everything orbited Earth, he asked, how could Jupiter have its own moons?

Then Galileo looked at our Moon. Instead of a flat disk, he saw mountains, valleys, and the strange features we now call craters.

Sunspots

Galileo, along with other scientists, made another discovery. When he trained his telescope on the Sun, he saw small, dark spots on its surface. He also observed that the spots appeared to move across the Sun's surface from west to east. Again, Galileo was puzzled. If the universe was perfect, as people claimed,



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The Galileo *space probe was launched in 1989. It sent back pictures of Jupiter and four of its moons, which Galileo first saw in 1609.*

why would the Sun have spots? And if the Sun was a flat disk, why were these spots moving?

Galileo could not explain why these spots existed, but he believed they were part of the Sun itself. Other scientists argued that the spots they were seeing must be planets or moons in front of the Sun.

Galileo noted that all the spots moved at the same speed. They raced across the surface, disappeared, and reappeared. In fact, every spot that Galileo observed took exactly the same amount of time to disappear and reappear in the same place on the Sun's surface. He also noticed that the spots flattened as they neared the Sun's edge, which meant that they had to be a part of the Sun's surface. Galileo concluded that the Sun must rotate. And if it was rotating, it couldn't be a flat disk. It had to be a sphere just like Earth!

New Discoveries Can Be Dangerous

Galileo's discoveries about Jupiter, the Moon, and the Sun were very controversial, especially to leaders of the Church. They put him on trial for heresy (beliefs that were different from accepted beliefs) and threatened him with torture. To keep Galileo from expressing new ideas that contradicted currently held ideas, the Church leaders put him under house arrest. Galileo could not talk or write about his discoveries for the rest of his life, but he remained convinced that his ideas about the solar system were correct.

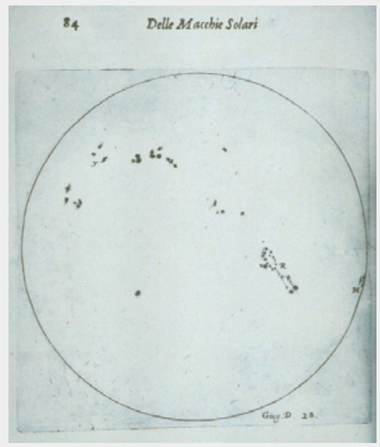
Other scientists at the time also were threatened whenever they announced discoveries that challenged accepted ideas. But over the years, as more and more telescopes were pointed at the skies, scientists realized that Galileo's ideas were true. Eventually Galileo's theories were accepted. Today we honor him for his contributions to science. ☐

Who Saw Them First?

The Aztec Empire existed from about the 14th to the 16th centuries. One Aztec myth of creation tells about a brave god with a scabby, pock-marked face who sacrificed himself by fire to become the Sun.

Observers of long ago could not explain what they were seeing. Today, however, scientists and historians deduce that the blemishes mentioned in these myths must have been the ancients' first observation and record of sunspots.

There is some debate over which European was the first to formally discover sunspots. The credit is usually shared by Galileo Galilei of Italy, Johann Goldsmid (known as Johannes Fabricius) of Holland, Christopher Schiener of Germany, and Thomas Herriot of England, all of whom claimed to have discovered sunspots sometime in 1611. All four men observed sunspots through telescopes. They made drawings of the changing shapes and watched the spots move across the visible surface of the Sun. These drawings were the first steps toward understanding sunspots.



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Sunspot drawing by Christopher Schiener of Germany

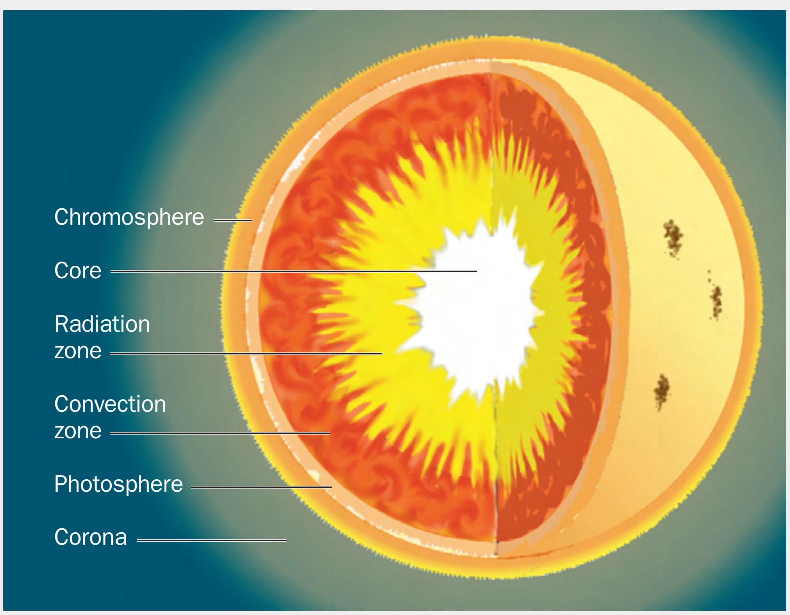
The Aztec myth suggests they had seen spots on the Sun.

What Are Sunspots?

Careful observation from Earth reveals a surprisingly large number of visible features on the Sun. The most obvious and best known is the sunspot. A sunspot is a region in the Sun's photosphere—the visible surface of the Sun—that is relatively cooler than its surroundings and which therefore appears darker. Sunspots are different sizes. They vary in diameter from around 10,000 to 50,000 kilometers. (Earth's diameter is 12,756 kilometers.) Occasionally, sunspots are as wide as about 200,000 km. Planet-sized sunspots can last from a few hours (for the smallest) to a few weeks or months (for the biggest).

Sunspots appear to move across the face of the Sun. In reality, they are moving with the Sun as the Sun rotates on its axis. The rate at which sunspots move indicates the rotational period of the Sun. At the Sun's equator, the rotational period is approximately 25 days. At latitudes around 75 degrees, the rotational period of the Sun is approximately 35 days. The fact that sunspots move at different rates at different latitudes demonstrates that the Sun is not a solid body.

Some scientists theorize that sunspots form because of a process that occurs below the surface of the Sun, in a layer called the convection zone. Convection is the circular movement of a gas or liquid caused by differences in heat. Some scientists think that strong convection in the Sun's convection zone may strengthen the Sun's magnetic field. As an example, think about an electromagnet formed by a wire wrapped around a nail. The more coils in the wire, the stronger the magnetic field around the nail. A stronger magnetic field in the convection zone reduces the convection—or rising—of hotter gases from lower levels. This cools the solar surface area above it. These relatively cooler areas on the Sun's surface are sunspots.



Like Earth, the Sun is made up of layers, including the core, radiation zone, convection zone, photosphere, and chromosphere. The corona is the outer region of the Sun's dense atmosphere.

Little Ice Age

Even if you love winter sports, you may have tired of the cold during the period known as the "Little Ice Age." For about 70 years, from about 1645 to 1715, a severe cold spell gripped Earth. Temperatures dipped and caused glaciers to spread in Greenland, Iceland, Scandinavia, and the Alps. Many springs and summers were cold and wet. As a result, the growing season was shortened, many crops failed, and some people died of starvation.

For many of those 70 cold years, snow covered the northeastern United States from November through mid-April. Many harbors froze. People could even walk or ride sleighs from Staten Island to Manhattan.

What was happening? During the coldest part of this time, astronomers noticed that almost no sunspots appeared on the Sun. Sunspots trigger solar activity that increases the Sun's brightness.

Could Earth experience another Little Ice Age? The answer is—keep your ice skates handy! ☐

ERICH LESSING, ART RESOURCE, NEW YORK

Can you imagine if winter lasted year round?

TREE RINGS HOLD SOLAR SECRETS

Did you know that trees add a ring of new wood each year? Maybe you've seen those rings—light- and dark-colored bands—in a tree stump. And maybe you've heard that you can count the rings to determine a tree's age. But the rings tell us more than a tree's age. They also tell us about the brightness of the Sun!

You might think that the Sun's light is always the same, but it's not. For years at a time, the Sun may shine with a certain degree of brightness, and then it may become somewhat dimmer—or brighter. Sunspots may be the cause.

What does this have to do with tree rings?

Scientists know that when the Sun is very active, its magnetic field makes it harder for cosmic rays to reach Earth. Cosmic rays help form a special carbon element in Earth's atmosphere. When the Sun is at its brightest and most active, less carbon is produced. Trees are able to absorb this natural element from the atmosphere. So when there is less carbon in the air, trees absorb less; when there is more carbon in the air, trees absorb more. And the difference shows up in their rings. Scientists measure the amount of carbon in each tree ring. By dating the tree ring, they can tell how bright the Sun was that year! ☐

IMAGE 235116, 1929, FOREST SERVICE PHOTOGRAPH COLLECTION, SPECIAL COLLECTIONS, NATIONAL AGRICULTURAL LIBRARY

Can this tree's rings tell you how old it is?

AURORAS

Do you like light shows? One of the best shows you could ever see is free, courtesy of nature. It's called an aurora, which is Latin for *dawn*. The aurora—usually red or green—lights up the night sky near the North and South poles. If conditions are right, these auroral storms can be seen thousands of miles away.

In the Northern Hemisphere, this light show is called the aurora borealis. In the Southern Hemisphere, it is called the aurora australis.

Sun Storms Cause Auroras

What causes these beautiful light shows? Scientists have been debating that issue for many years. They have known that there is a connection between activity on the Sun and the appearance of auroras in Earth's atmosphere since 1859. That's when English astronomer Richard Carrington first noticed that auroras often appeared several days after solar storms erupted on the Sun's surface. Now, with advanced space exploration and special space cameras, people are starting to develop a better understanding of this pattern.

How does a solar storm cause a light show on Earth? When a solar storm occurs on the Sun's surface, a very hot, gaseous mixture called "plasma" explodes. Plasma is a mixture of electrons, protons, and ions—very small particles that release tremendous energy.

Streams of this plasma blast through space at very high speeds. The traveling plasma is known as solar wind. The slower solar winds travel at approximately 300 kilometers a second. Faster winds can travel at nearly 800 kilometers a second!

Fortunately, these solar winds never make it to Earth's surface. Earth has a magnetic field that shields it from harm. Most of the solar winds bounce off this magnetic shield. Sometimes, however, solar winds do penetrate the magnetic shield, especially where the magnetic field bends

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This aurora borealis was seen over Alaska in April 2000, during some of the most intense auroral storms of the decade.

inward toward the poles. At the poles, the charged particles from the Sun become trapped, spiral toward Earth's magnetic poles, and collide with the gases in Earth's atmosphere. These collisions give off energy that we see as colored light in the sky.

More Sun Storms Mean More Auroras

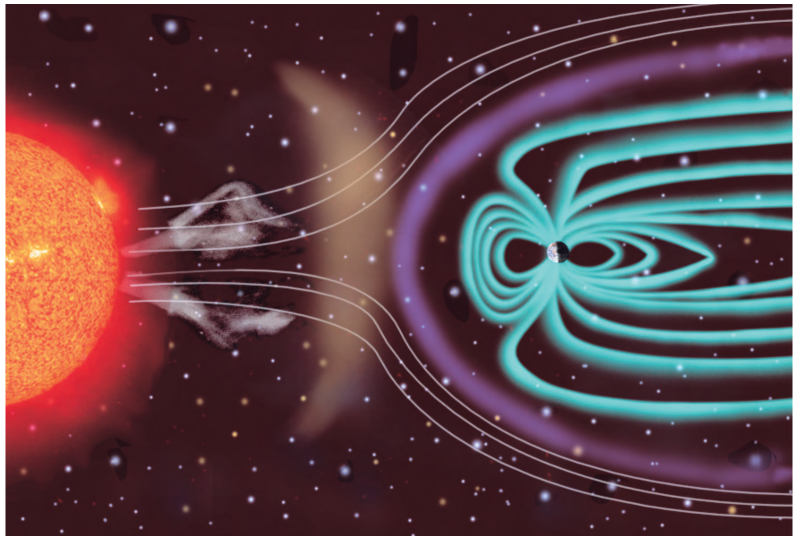
Scientists know that an increase in the number of solar storms—often associated with high sunspot activity—results in more auroras. And the stronger the solar storms, the brighter the auroras.

Sun activity seems to occur in 22-year cycles. The period of greatest solar activity in a 22-year cycle is called the solar maximum. During the solar maximum, we tend to see the most auroras, as well as the brightest ones. This is also when people who live many thousands of miles from the poles get to see auroras.

What Do Auroras Look Like?

Auroras can have many shapes. Some look like flags waving. Others look like arcs or ribbons in the sky. Most auroras are green, although many are red.

The best time to see an aurora is between sunset and midnight. If you live in North America, you have the best chance of seeing an aurora if you live in Canada or Alaska. During a period of solar maximum, however, people in almost every state can view nature's own light show. ☐



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This NASA illustration shows Earth's magnetosphere and its interaction with the Sun. Auroras occur most often where the field curves inward at the poles.

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This aurora was seen over Alaska in the middle of winter.

COURTESY OF DAVID MILLER, NATIONAL GEOPHYSICAL DATA CENTER

Red aurora australis seen over southern Australia.