The Sunspot Cycle

Overview

Students use the Internet to find recent sunspot numbers and sunspot numbers for dates in the past. Students plot 15-year time spans of sunspot data on a line graph and discover the 11-year sunspot cycle over 269 years.

Objectives:

The student will:

- learn about the 11-year sunspot cycle on the sun;
- plot and analyze data on a line graph;
- identify the solar maximum and solar minimum on a line graph;
- describe the significance of sunspot numbers;
- observe changes in the sunspot cycles over a 269-year timespan; and
- represent, analyze, and use mathematical patterns, relations and functions using methods such as tables, equations and graphs.

Materials:

- VISUAL AID: “Sunspots”
- VISUAL AID: “Yearly Mean Sunspot Graph and Data Table”
- STUDENT INFORMATION SHEET: “Yearly Mean Sunspot Numbers”
- STUDENT WORKSHEET: “The Sunspot Cycle”

The Sunspot Cycle

Activity Procedure:

Problem #1: *Internet Search for Daily Sunspot Numbers*

1. Using VISUAL AID: "Sunspots," ask students to identify sunspots on the surface of the sun. Explain a high number of sunspots often indicates a high level of solar activity. Sunspots often are the source of strong solar wind and can be used to help scientists predict the aurora.
2. Distribute the STUDENT WORKSHEET: "The Sunspot Cycle" and ask students to look up the number of sunspots on the surface of the sun for the variety of dates listed in the table.
3. Talk about Johann Rudolph Wolf and explain that today, sunspots are counted in the same way Wolf counted them more than 150 years ago.

Johann Rudolph Wolf (1816-1893)

In 1848, Wolf found a way to count individual spots and groups of spots on the sun. He calculated the number of sunspots by multiplying the number of groups of sunspots by 10, then adding the number of individual spots. Wolf's formula gives reliable numbers even when the observing conditions are not good. Today, sunspots are counted the same way they were more than 150 years ago.

Problem #2: *The Sunspot Cycle*

1. Show VISUAL AID: "Yearly Mean Sunspot Graph and Data Table." Explain the number of sunspots on the sun's surface increases and decreases in a pattern.
2. The greatest number of sunspots occur during a period called the solar maximum (see graph). When the sunspot count is lowest during the solar cycle, the period is called the solar minimum (see graph).
3. Explain that scientists often find the average (or "mean") of a large group of numbers when studying data over a long period of time. Instruct students to use mean numbers over a 15-year period to plot yearly sunspot totals on a line graph. Using the same VISUAL AID, show students how numbers from the "Data Table" were plotted on the "Yearly Mean Sunspot Graph."
4. Hand out the STUDENT INFORMATION SHEET: "Yearly Mean Sunspot Numbers." Break students into pairs and assign a different 15-year time span to each pair. For the best results, assign students consecutive 15-year time spans. Ask students to use data on the student information sheet to fill in the "Sunspot Data Table" on their worksheet for the years they have been assigned. Then, ask students to plot data from their tables on the "Yearly Sunspot Mean Graph" and to label the solar minimum and solar maximum.
5. Ask the class to assemble their graphs in chronological order and tape them to the wall. This will give the class a long-term (100+ years) look at sunspot cycles.
6. Students should work with their partners to analyze the data collected. Assist the groups initially to ensure they are recording the actual solar minimums. In the data for Group #1, students can use either 1711 or 1712. Once students have mathematically determined the length of the cycle to be about 10.9 years, ask them to round their data to the nearest whole year.

The Sunspot Cycle

Answers to Student Worksheet:

Problem #1: *Internet Search for Daily Sunspot Numbers*

Date	Sunspot #
Exactly one month ago today (write date)	*Answers will vary*
Your Birthday (write date)	*Answers will vary*
April 12, 1961	*42*
January 3, 1959	*229*
March 16, 1926	*110*
December 17, 1903	*58*

Problem #2: *The Sunspot Cycle*

Data:

Sunspot Data Table answers will vary.

Yearly Sunspot Mean Graph answers will vary.

Analysis of Data:

Group	Year	Time Passed
#1	1701	
	1711 / 1712	10 / 11
#2	1723	12/ 11
#3	1733	10
	1744	11
#4	1755	11
#5	1766	11
	1775	9
#6	1784	9
#7	1798	14
#8	1810	12
#9	1823	13
	1833	10
#10	1843	10

Group	Year	Time Passed
#11	1856	13
#12	1867	11
	1878	9
#13	1889	13
#14	1901	12
#15	1913	12
	1923	10
#16	1933	10
#17	1944	11
	1954	10
#18	1964	10
#19	1976	12
#20	1986	10
	1996	10

Conclusion: *1. The average sunspot cycle lasts 11 years. Answers 2.-3. will vary.*

Further Questions:

1. Yes, rest of answer will vary.

2. Yes, rest of answer will vary.

3. Solar minimum: 2007, Solar maximum: about 2001

4. Use webpage from Problem #1, or find other resources that list sunspot data.

Yearly Mean Sunspot Numbers

Year	Sunspot Number		Year	Sunspot Number		Year	Sunspot Number		Year	Sunspot Number		Year	Sunspot Number		Year	Sunspot Number		Year	Sunspot Number	
1701	11		1746	22		1791	66.6		1836	121.5		1881	54.3		1926	63.9		1971	66.6	
1702	16		1747	40		1792	60.0		1837	138.3		1882	59.7		1927	69.0		1972	68.9	
1703	23		1748	60		1793	46.9		1838	103.2		1883	63.7		1928	77.8		1973	38.0	
1704	36		1749	80.9		1794	41.0		1839	85.7		1884	63.5		1929	64.9		1974	34.5	
1705	58		1750	83.4		1795	21.3		1840	64.6		1885	52.2		1930	35.7		1975	15.5	
1706	29		1751	47.7		1796	16.0		1841	36.7		1886	25.4		1931	21.2		1976	12.6	
1707	20		1752	47.8		1797	6.4		1842	24.2		1887	13.1		1932	11.1		1977	27.5	
1708	10	Group #1	1753	30.7	Group #4	1798	4.1	Group #7	1843	10.7	Group #10	1888	6.8	Group #13	1933	5.7	Group #16	1978	92.5	Group #19
1709	8		1754	12.2		1799	6.8		1844	15.0		1889	6.3		1934	8.7		1979	155.4	
1710	3		1755	9.6		1800	14.5		1845	40.1		1890	7/1		1935	36.1		1980	154.6	
1711	0		1756	10.2		1801	34.0		1846	61.5		1891	35.6		1936	79.7		1981	140.4	
1712	0		1757	32.4		1802	45.0		1847	98.5		1892	73.0		1937	114.4		1982	115.9	
1713	2		1758	47.6		1803	43.1		1848	124.7		1893	85.1		1938	109.6		1983	66.6	
1714	11		1759	54.0		1804	47.5		1849	96.3		1894	78.0		1939	88.8		1984	45.9	
1715	27		1760	62.9		1805	42.2		1850	66.6		1895	64.0		1940	67.8		1985	17.9	
1716	47		1761	85.9		1806	28.1		1851	64.5		1896	41.8		1941	47.5		1986	13.4	
1717	63		1762	61.2		1807	10.1		1852	54.1		1897	26.2		1942	30.6		1987	29.4	
1718	60		1763	45.1		1808	8.1		1853	39.0		1898	26.7		1943	16.3		1988	100.2	
1719	39		1764	36.4		1809	2.5		1854	20.6		1899	12.1		1944	9.6		1989	157.6	
1720	28		1765	20.9		1810	0.0		1855	6.7		1900	9.5		1945	33.2		1990	142.6	
1721	26		1766	11.4		1811	1.4		1856	4.3		1901	2.7		1946	92.6		1991	145.7	
1722	22		1767	37.8		1812	5.0		1857	22.7		1902	5.0		1947	151.6		1992	94.3	
1723	11	Group #2	1768	69.8	Group #5	1813	12.2	Group #8	1858	54.8	Group #11	1903	24.4	Group #14	1948	136.3	Group #17	1993	54.6	Group #20
1724	21		1769	106.1		1814	13.9		1859	93.8		1904	42.0		1949	134.7		1994	29.9	
1725	40		1770	100.8		1815	35.4		1860	95.8		1905	63.5		1950	83.9		1995	17.5	
1726	78		1771	81.6		1816	45.8		1861	77.2		1906	53.8		1951	69.4		1996	8.6	
1727	122		1772	66.5		1817	41.1		1862	59.1		1907	62.0		1952	31.5		1997	21.5	
1728	103		1773	34.8		1818	30.1		1863	44.0		1908	48.5		1953	13.9		1998	64.3	
1729	73		1774	30.6		1819	23.9		1864	47.0		1909	43.9		1954	4.4		1999	93.3	
1730	47		1775	7.0		1820	15.6		1865	30.5		1910	18.6		1955	38.0				
1731	35		1776	19.8		1821	6.6		1866	16.3		1911	5.7		1956	141.7				
1732	11		1777	92.5		1822	4.0		1867	7.3		1912	3.6		1957	190.2				
1733	5		1778	154.4		1823	1.8		1868	37.6		1913	1.4		1958	184.8				
1734	16		1779	125.9		1824	8.5		1869	74.0		1914	9.6		1959	159.0				
1735	34		1780	84.8		1825	16.6		1870	139.0		1915	47.4		1960	112.3				
1736	70		1781	68.1		1826	36.3		1871	111.2		1916	57.1		1961	53.9				
1737	81		1782	38.5		1827	49.6		1872	101.6		1917	103.9		1962	37.6				
1738	111	Group #3	1783	22.8	Group #6	1828	64.2	Group #9	1873	66.2	Group #12	1918	80.6	Group #15	1963	27.9	Group #18			
1739	101		1784	10.2		1829	67.0		1874	44.7		1919	63.6		1964	10.2				
1740	73		1785	24.1		1830	70.9		1875	17.0		1920	37.6		1965	15.1				
1741	40		1786	82.9		1831	47.8		1876	11.3		1921	26.1		1966	47.0				
1742	20		1787	132.0		1832	27.5		1877	12.4		1922	14.2		1967	93.8				
1743	16		1788	130.9		1833	8.5		1878	3.4		1923	5.8		1968	105.9				
1744	5		1789	118.1		1834	13.2		1879	6.0		1924	16.7		1969	105.5				
1745	11		1790	89.9		1835	56.9		1880	32.3		1925	44.3		1970	104.5				

Name:_____ **Student Worksheet (1 of 5)**

The Sunspot Cycle

Problem #1: *Internet Search for Daily Sunspot Numbers*

1. Use the Internet to find the number of sunspots for each day listed in the Daily Sunspot Table. Record your findings in the column provided.
2. To find today's sunspot total, access the *Space Weather* website: (www.spaceweather.com). Historical data can be found at the *National Oceanic Atmospheric Administration (NOAA) website*: (ftp://ftp.ngdc.noaa.gov/STP/SOLAR_DATA/SUNSPOT_NUMBERS). Click on the year you are looking for, then locate the sunspot information for the date listed.

Date	**Sunspot #**
Today's date (write date)	
Your Birthday (write date)	
April 12, 1961: *Yuri Gagarin became the first human launched into space.*	
January 3, 1959: *The day Alaska officially became the 49th state.*	
March 16, 1926: *The day Robert Goddard launched the first rocket.*	
December 17, 1903: *The day the Wright brothers made the first flight at Kitty Hawk.*	

Problem #2: *The Sunspot Cycle*

Testable Question:

How long is our sun's sunspot cycle?

Background Information:

The number of sunspots on the surface of the sun increases and decreases in a pattern. The greatest number of sunspots occurs during a period called the "solar maximum." When the sunspot count is lowest during the solar cycle, the period is called the "solar minimum."

Hypothesis:

During this activity, you will investigate historical data about the sun to determine the length of the sunspot cycle. Use the background information provided by your teacher or on this worksheet to make a hypothesis (fill in the space below).

I estimate the sunspot cycle to be _____ year(s).

Name:_____ **Student Worksheet (2 of 5)**

The Sunspot Cycle

Activity:

Materials:

- STUDENT INFORMATION SHEET: "Yearly Mean Sunspot Numbers"
- STUDENT WORKSHEET: "The Sunspot Cycle"

Data:

1. Find the mean number of sunspots for each year in the 15-year time span you were assigned.
2. Write the years your group is researching in the left column of the Sunspot Data Table. Then find the sunspot mean number for that year on the STUDENT INFORMATION SHEET: "Yearly Mean Sunspot Numbers." List the sunspot number for each year in the right column.

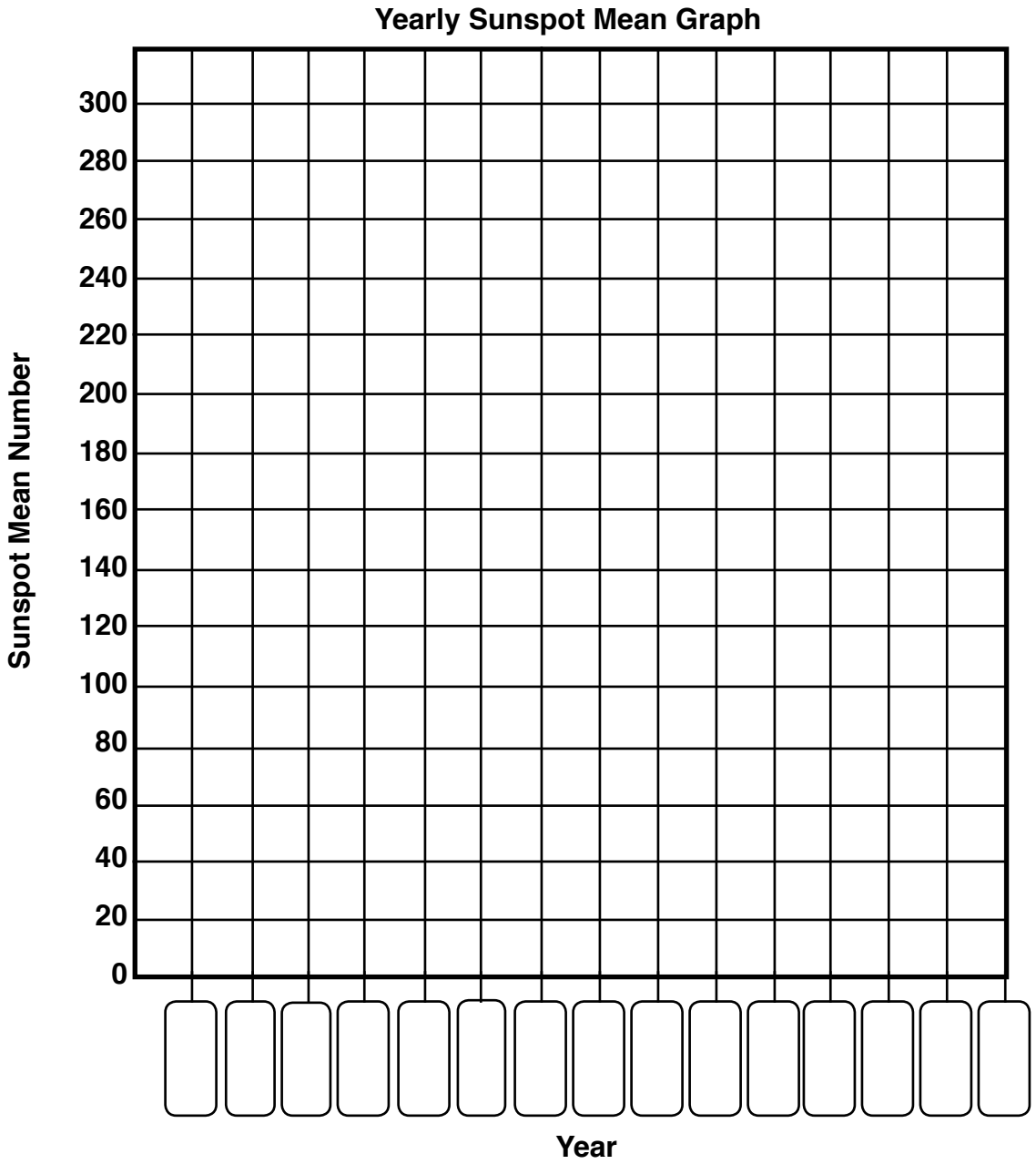
Sunspot Data Table

Year	Sunspot Mean Number

The Sunspot Cycle

Data (continued):

Using the years and sunspot numbers from the Sunspot Data Table, plot the yearly sunspot mean for a 15-year time span on the graph below.



Name:_____ **Student Worksheet (4 of 5)**

The Sunspot Cycle

1. Analyze the data your class has displayed in graph form and record your findings in the chart below. On each graph, find the lowest number and write the year of that "solar minimum" in the chart below. In some cases, there are two solar minimums found within a 15-year time span.

2. After identifying the solar minimums, calculate the length of time between them by subtracting the earlier year from the more recent year. For example, if the first solar minimum is in 1489 and the next on the list is in 1502, do the following calculation: 1502-1489=13. Record that answer under "Time Passed" next to the later date.

Group	Year	Time Passed
#1		
#2		
#3		
#4		
#5		
#6		
#7		
#8		
#9		
#10		

Group	Year	Time Passed
#11		
#12		
#13		
#14		
#15		
#16		
#17		
#18		
#19		
#20		

3. Find the average amount of time between the solar minimums by adding all of the "Time Passed" data and dividing by 27 (this is the number of cycles listed above). Record your calculation below:

_____ ÷ 27 = _____

Total "Time Passed" *Number of cycles* *Average length of cycles*

Name:_____ **Student Worksheet (5 of 5)**

The Sunspot Cycle

Record your conclusion below:

1. An average sunspot cycle lasts _____ year(s).

2. Was your hypothesis proved or disproved? Use complete sentences.

_____

3. Explain what evidence supports your conclusion. Use complete sentences.

_____

_____

Further Questions:

1. Will the length of the sunspot cycle for the solar maximum be similar to the length of the cycle for the solar minimum? Explain your answer with complete sentences.

_____

_____

_____

_____

2. Would a data analysis of the solar maximums have brought to the same conclusion as your analysis of the solar minimums? Explain your answer with complete sentences.

_____

_____

3. The data used for this experiment ended in 1999. Use what you know about the sunspot cycle to estimate when the next solar minimum and the next solar maximum might be.

   Year of the next solar minimum: _____

   Year of the next solar maximum: _____

4. Identify one way to test your answer to Question #3. Answer in complete sentences.

_____

_____

