Name:_____ Block:_____ Partner:_____

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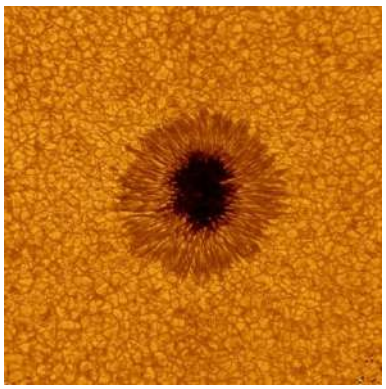
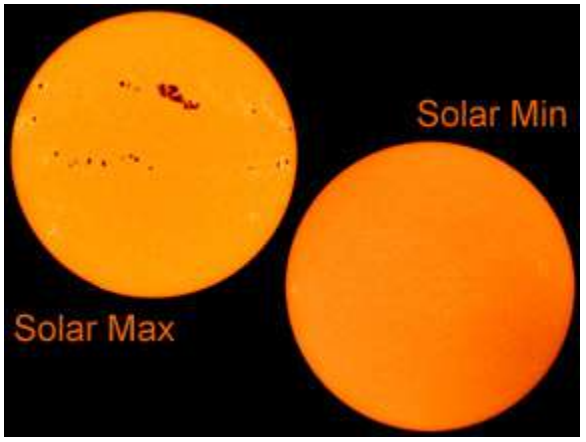
Sunspots and Climate: Analyzing Data/Graphs to Support Conclusions in Science

Background: In the early 1600's Galileo used a telescope to observe dark spots on the sun's surface. He referred to them as sunspots. Although they look like small dark areas on the sun, in reality they are very large, in fact, some are even the size of our own Earth! Sunspots are caused by increased magnetic activity on the sun. These dark, cooler regions of increased magnetic activity block convection currents of energy within the sun, an actually cause an increase in magnetic storms, much like an explosion when you loosen the cap of a soda bottle after shaking it up. Solar storms such as solar flares and coronal mass ejections can erupt in regions surrounding sunspots, releasing vast quantities of radiation/energy into space. This additional radiation can actually increase solar irradiance (total energy output of the sun), and can cause electrical disturbances on earth. In 1859 during a **solar maximum** (the largest number of sunspots on the sun in a cycle), a large geomagnetic storm erupted on the Sun's surface which was later received by earth's magnetosphere. The result: The Aurora Borealis, better known as the "Northern Lights" could be seen as far as Cuba, and telegraph reporters reported sparks flying from their equipment which caused fires. This was dubbed the "Carrington Event." Imagine if a solar storm intercepted Earth today; this could impact countless satellites and thus communications on Earth! Scientists have been keeping track of sunspot activity for over 200 years, and believe that sunspot numbers, and thus solar activity, influence climate on Earth.





Pre-Lab Questions:

1.) What is a sunspot?

2.) Do sunspot numbers change or stay the same over time?

Purpose: The purpose of this lab is to analyze how the number of sunspots have changed over time, and to look for any correlations in solar activity and global temperature with sunspot numbers.

Hypothesis #1:

If the number of sunspots increase, the total energy (irradiance) emitted by the sun will: _____

Hypothesis #2:

If the number of sunspots increase, global temperatures will: _____

Critical Thinking: Do you think a change in earth's temperature could solely be the result of a change in sunspot numbers? What other factors in the environment do you think contribute to earth's temperature change over time?

Materials: Data table, pencils, red and blue colored pencils

Procedure:

1.) On the graph on page 3, label the X axis "Year" and the T-axis "Number of Sunspots"
2.) Use the data table below to make a line graph of sunspot activity between 1970 and 2016. Plot all points, then connect with a smooth curve.
3.) Extend your graph with a dashed line ---- to predict the sunspot number in 2020 (this is just an estimate).
4.) Where the data peaks, this is called a maximum (highest number of sunspots in a cycle. **Circle every data point which is a maximum with a red colored pencil on your graph, write the year overhead**.
5.) Where the data shows a valley, or a decline, this is called a minimum, where the lowest sunspot numbers occur. **Circle these in blue, and write the year overhead on the graph**.

The following data represents yearly averages and was supplied from NOAA.

Data:

Year	Number of Sunspots	Year	Number of Sunspots	Year	Number of Sunspots	Year	Number of Sunspots	Year	Number of Sunspots
1970	109	1981	140	1992	96	2003	64	2014	75
1971	74	1982	116	1993	54	2004	41	2015	46
1972	72	1983	72	1994	36	2005	30	2016	26
1973	39	1984	44	1995	19	2006	15		
1974	35	1985	17	1996	9	2007	8		
1975	15	1986	12	1997	22	2008	3		
1976	14	1987	28	1998	65	2009	4		
1977	30	1988	89	1999	94	2010	16		
1978	103	1989	148	2000	120	2011	50		
1979	156	1990	149	2001	111	2012	53		
1980	141	1991	146	2002	104	2013	61		

Analysis Questions (Use your graph to answer!):

1.) During which four years were there solar maximums? _____ _____ _____ _____

2.) During which four years were there solar minimums? _____ _____ _____ _____

3.) Using your answer to question 1, what is the **average** time span between solar maximums? _____
(you must figure out the time between each solar maximum, add them, and divide by the four you observed)

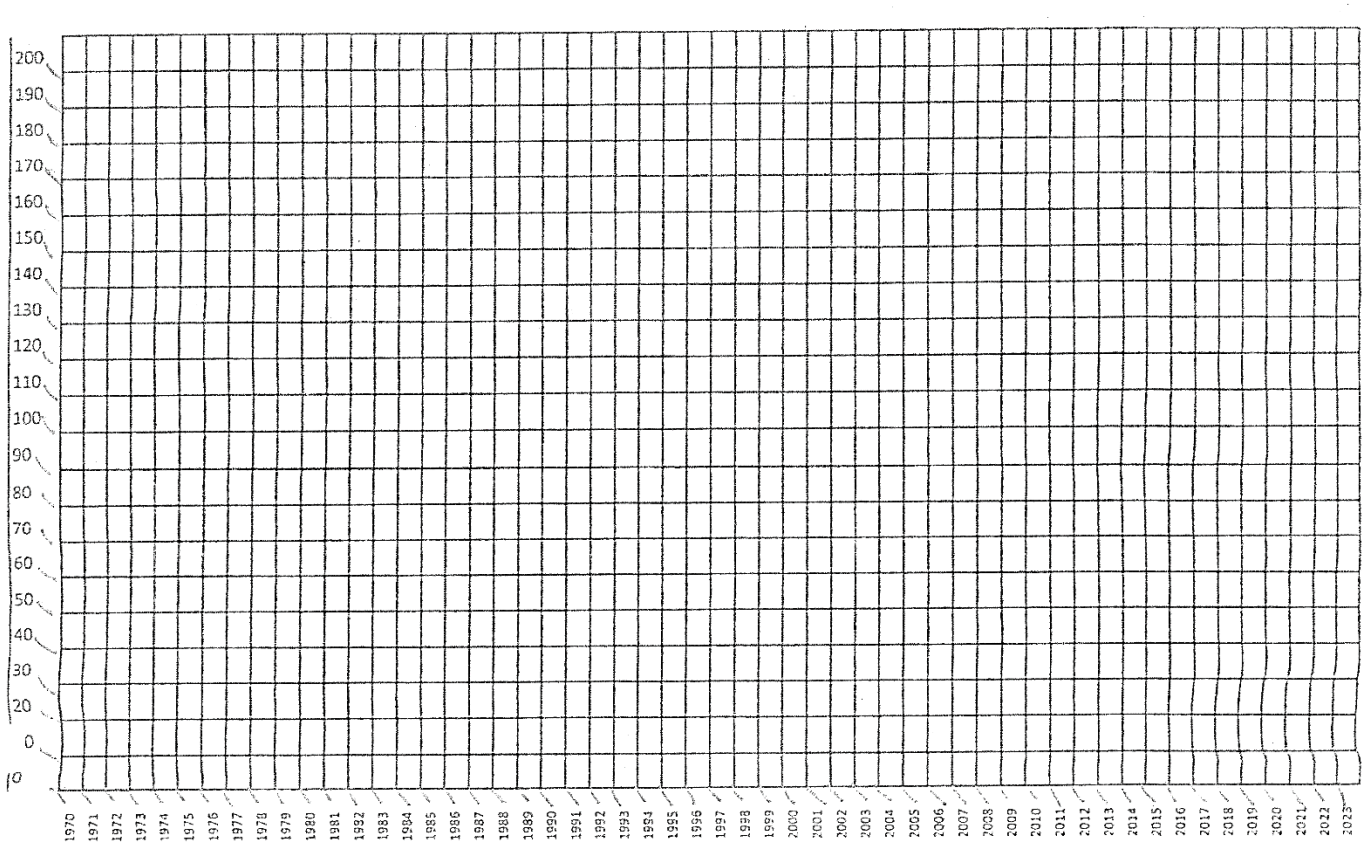
4.) When was the most recent solar maximum? _____

5.) Using your answer to 3 and 4, during **what year** do you predict the **next** solar maximum to be? _____

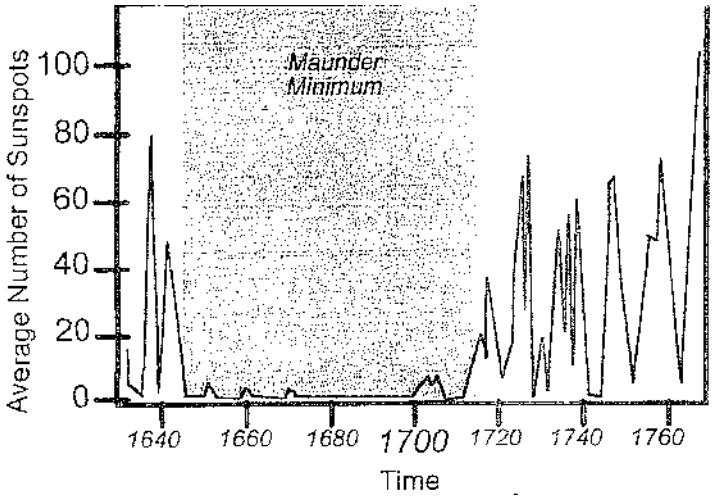
6.) Looking at your graph displaying solar maximums, the numbers of sunspots during each seem to be **increasing/decreasing/staying the same** as time progresses: _____

7.) If sunspot activity alone affected the temperatures on earth, would one expect global temperatures to increase or decrease as time goes on? _____ (hint: go back to your background information)

Graph:



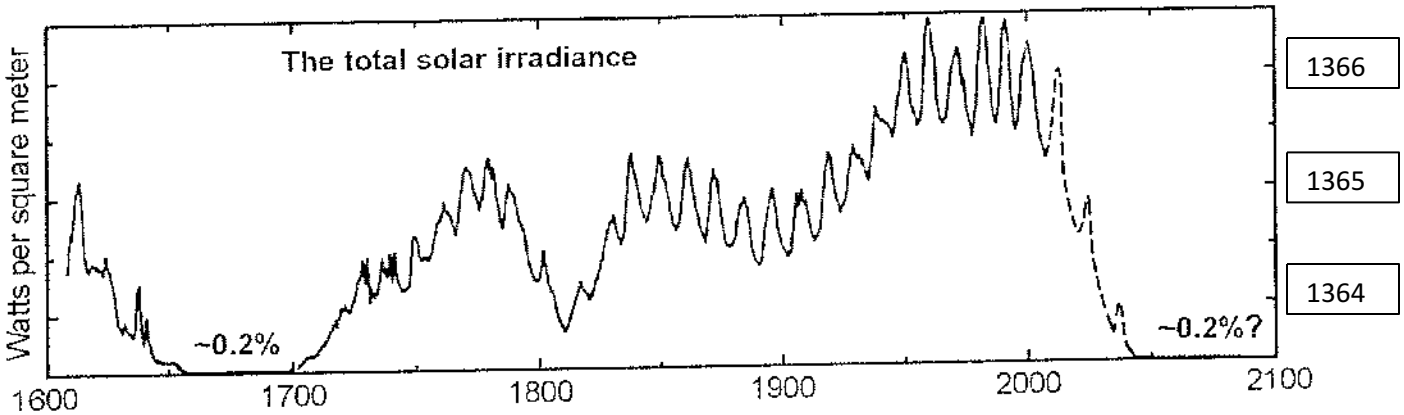
Part II: **The Maunder Minimum** is scientifically known as a time period when the sun produced very little sunspots, even during successive solar maximums. A graph displaying sunspot number data as far back as 1650 is period is pictured below.



8.) Using the graph, approximately how long did the Maunder Minimum last in years? _____

9.) How do you think the earth's global temperature could have been effected by this prolonged period of low sunspot activity?

Below is a graph which displays total solar irradiance (energy released by the Sun) in Watts per square meter.



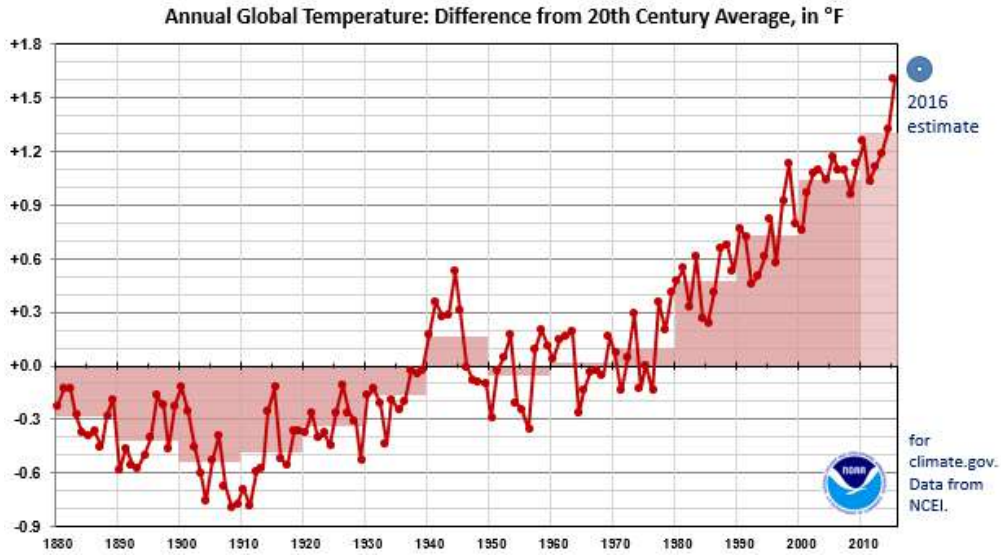
Notice that the graph displays a cyclic relationship in which the solar irradiance increases and decreases with time in a fairly predictable time period. There is a time period however, in which solar irradiance declines anomalously.

10.) Using the graph above during which estimated dates was there a prolonged decline in total solar irradiance?

11.) Does this data correlate (share a connection) to the time of the Maunder Minimum?

12.) Complete the following statement: As sunspot numbers decline, total solar irradiance _____.

Part III: Global warming is among popular talk in scientists and every day global citizens alike. Astronomers have noted that the sun is in fact producing **less sunspots** during our solar maximums as time goes on. Some argue that this could set the world into another "little ice age," just like the one that was experienced during the Maunder Minimum. Here is a graph from NOAA displaying average global temperature change from 1880-2016. + values show an increase in average. temperature and – values show a decline in average temperatures.



Conclusion: Based on the data you saw today, could you use changing sunspot numbers to support the change in global temperatures you see pictured in the graph above? **Why or why not?**