Activity 1.
SCoPE Site Lesson Plan
Long Ago, in a Galaxy Far Away

Abstract
Students look at the size of solar systems, galaxies, and the universe and explore the capacity of the Hubble Space Telescope.

National Science Education Standards: Earth and Space Science

CONTENT STANDARD D:
As a result of their activities in grades 5-8, all students should develop an understanding of

- Structure of the earth system
- Earth's history
- Earth in the solar system

Key Concepts
big bang
coalescence
fusion energy
galaxy
nebula
red shift

Instructional Resources
Equipment/Manipulative
Graphing paper
Map (large, pull-down of world with kilometer scale, or Internet map)
Markers for scaled model (may be posters)
Poster board (1 per group)

Student Resource
Chrismer, Melanie. *Highlights from the Hubble Telescope: Postcards from Space.* Berkeley Heights, NJ: Enslow, 2004.

The Hubble Project. NASA. 23 March 2004 <http://hubble.nasa.gov/>.

Texley, Juliana. *Unit 5 Lesson 6 Student Pages*. Teacher-made material. Lansing, MI: Michigan Department of Treasury, 2004.

Ware, Don. *Binary Stars.* 1994-2004. Peoria Astronomical Society. 23 March 2004 <http://www.astronomical.org/astbook/binary.html>.

Teacher Resource

Texley, Juliana. *Grade 8 Unit 5 Teacher Background.* Teacher-made material. Lansing, MI: Michigan Department of Treasury, 2004.

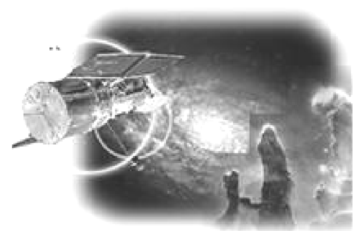
Sequence of Activities
Advanced Preparation: If you will not have access online during the student project, print off selected images from the Hubble Image Gallery at the NASA site (above). Examples:

- Global star cluster NGC 6397 at 8200 light years away http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/21/
- Young star HD141569A at 320 light years away http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/02/
- Stars in Casseopeia at10,000 light years away http://hubblesite.org/newscenter/newsdesk/archive/releases/2002/15/
- Oldest known planet at 5600 light years away http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/19/
- Stars from the center of the galaxy 25,000 light years away at http://hubblesite.org/newscenter/newsdesk/archive/releases/1999/08/

These photos are contained as thumbprints on the Student Pages and in page sizes in the Teacher Background. Further examples can be found in the book by Chrismer cited above. Set aside 1.2 m of bulletin board space for a scale model of the solar system.

1. Review the idea of a satellite—a man-made object circling the Earth. Ask students to describe satellites they know. [Very few will understand that CNN or some cell phones use satellites. NASA EarthShots and SeaWIFS have great satellite photos of areas including Michigan and Orlando, Florida online for students to understand the uses of satellites.]

2. Explain that the Hubble Space Telescope orbits 600 kilometers above Earth, working to unlock the secrets of the universe. It uses excellent pointing precision, powerful optics, and state-of-the-art instruments to provide stunning views of the universe that cannot be made using ground-based telescopes or other satellites. The satellite is roughly the size of a school bus, and weighs 12 tons. It was placed into orbit in 1990, but structural problems with its lenses made its photos blurry. In 1995 Hubble was repaired. The primary mirror is 2.4 meters across. It is a special tool because it can observe the skies without the interference of the atmosphere.



3. As of March 2000, Hubble has already made over 330,000 observations of 25,000 targets, provided data for 26,000 papers and provided glimpses of things never before seen. These photos are confirming astronomical theories and raising new questions. For example, we always thought other stars must have planets, but until Hubble none were seen. Explain to students that their lesson today would not have been possible without Hubble.

4. Ask students if they remember making a scale model of the solar system. (Most will have done this in the middle elementary grades. However, it is usually done wrong. For practical purposes, teachers often use a different scale for the planets than they do for the distances

between the planets. This creates lasting misconceptions in students.) Tell them you want to make a scale model of the solar system and nearby stars. The solar system will be placed on about a meter of your bulletin board. (Solicit suggestions. While you may be tempted to ask the best artists to help, a close analysis should convince students that on this scale there is not much to draw!) Using a scale where the solar system fit inside a little over a meter ellipse, then Mercury, Venus, and Earth would be within a centimeter of the Sun. Their diameters would be less than a millimeter—pencil points. (A spreadsheet of this scale is available below and an Excel worksheet available online so that you can expand your modeling.)

5. Next, let students know that you would like to share some of Hubble's discoveries with the community, using the same scale as your classroom solar system. Assign student groups to prepare posters on some of the Hubble discoveries. (Any can be used; this outline will use the six listed above for purposes of illustration.) Students can enlarge printouts and make posters from them or draw the astronomical observations freehand, adding information for lay people. Then ask: "Using the same scale, where would we put the posters?"

6. When students are done, tell them that you want to determine where to put their posters. Of course, for consistency, you want to use the same scale as the solar system you made. Since the total solar system is about 1/1000 of a light year in diameter, the scale is 1 km = 1 light year. That means that the poster for Global star cluster NGC 6397 should be placed 8200 km away (in Europe!), and the center of our own galaxy would be 25000 km away. Challenge students to discover where Alpha Centauri would be (about 1500 km away, roughly the distance from Houghton, Mi to Detroit.) Ask them to use a world map to envision where they would have to place their posters to maintain the scale. The Sagitarrius dwarf galaxy, our nearest neighbor, is 75,000 light years away—75 km on our scale.

7. Remind students that Hubble is not showing us what *is,* but what *was.* Since it takes light 1500 years to travel to Hubble from Alpha Centauri, we see it as it was 1500 years ago. When we look at the outer edges of the universe, we literally look back in time.

8. Using a computer or projector, take time to browse the Hubble gallery. These images will provide a good basis for understanding the information on stars in Lessons 9 and 10. The Student Pages offer a scavenger hunt of amazing phenomena for students to research in print or Internet.

Assessment
Students should be able to distinguish objects within our solar system from those in our galaxy and those beyond the Milky Way.

Application outside of School
Funding for the Hubble is a highly political issue. In winter, 2004, NASA proposed ending its mission to provide funding for a return to the moon. After protests from scientists, the action is now being reconsidered. Students should understand the uncertain funding for theoretical science.

Connections

Mathematics

Students build scale models of celestial objects.

Spreadsheet of Solar System Scale

Body	Orbit KM	Scale in km (1 km = 1 ly)	Scale in Meters	Diameter	Scale in Km (1 km = 1 ly)	Scale in mm
Pluto	5.914E+09	0.000625106	0.625105708	2300	2.4313E-10	0.000243129
Neptune	4.497E+09	0.000475381	0.47538055	49528	5.2355E-09	0.005235518
Uranus	2.871E+09	0.000303488	0.303488372	51118	5.4036E-09	0.005403594
Saturn	1.427E+09	0.000150846	0.150845666	120536	1.2742E-08	0.012741649
Jupiter	778300000	8.22727E-05	0.082272727	142984	1.5115E-08	0.015114588
Ceres/Asteroids	413700000	4.37315E-05	0.043731501		0	0
Mars	227900000	2.40909E-05	0.024090909	6786	7.1734E-10	0.000717336
Earth	149600000	1.5814E-05	0.015813953	12756	1.3484E-09	0.001348414
Venus	108200000	1.14376E-05	0.011437632	12102	1.2793E-09	0.001279281
Mercury	57900000	6.12051E-06	0.006120507	4878	5.1564E-10	0.000515645
					0	0
Sun				1392000	1.4715E-07	0.147145877

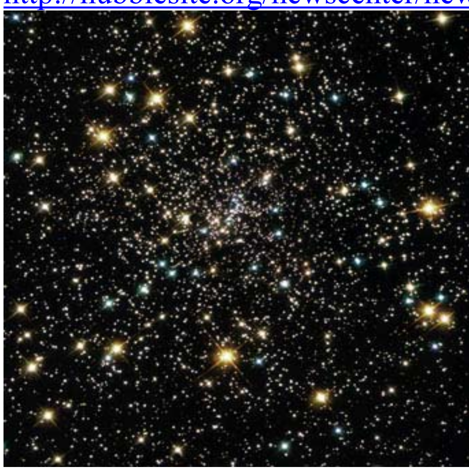
Star	Distance in KM	Scale in km (1 km = 1 ly)
Alpha Centauri	4.068E+13	4.3
Sirius	8.703E+13	9.2
Regulus	8.041E+14	85
Betelgeuse	4.825E+15	510
Deneb	1.703E+16	1800
Center of Galaxy	2.365E+17	25000
NGC 6397	7.757E+16	8200
HD141569A	3.027E+15	320
Cassiopeia	9.46E+16	10000
Oldest known planet	5.298E+16	5600

Name ________________________

Long Ago in a Galaxy Far, Far Away

Can you see what Hubble sees? Here are some of its views. Use the hyperlinks or information from your teacher to describe what you see:

http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/21/



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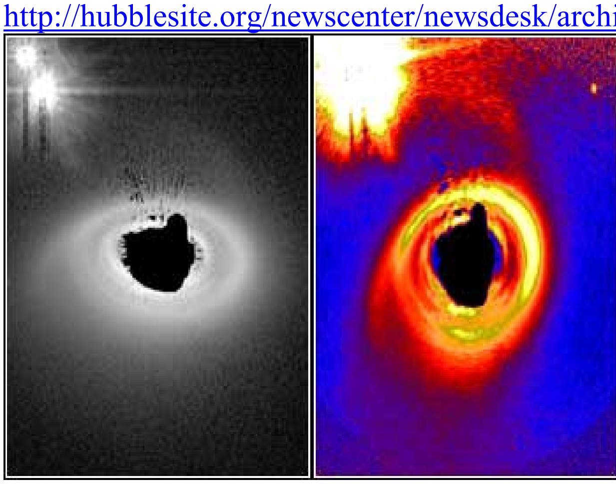
http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/02/



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http://hubblesite.org/newscenter/newsdesk/archive/releases/2002/15/

http://hubblesite.org/newscenter/newsdesk/archive/releases/2003/19/

http://hubblesite.org/newscenter/newsdesk/archive/releases/1999/08/

Build A Scale Model (Use 1 km = 1 light year)

Planet	Orbit Radius in km	Scale	Diameter-- km	Scale
Pluto	5.914E+09		2300	
Neptune	4.497E+09		49528	
Uranus	2.871E+09		51118	
Saturn	1.427E+09		120536	
Jupiter	778300000		142984	
Ceres/Asteroids	413700000			
Mars	227900000		6786	
Earth	149600000		12756	
Venus	108200000		12102	
Mercury	57900000		4878	

Star	**Distance in KM**	**Scale in km (1 km = 1 ly)**
Alpha Centauri	4.068E+13	
Sirius	8.703E+13	
Regulus	8.041E+14	
Betelgeuse	4.825E+15	
Deneb	1.703E+16	
Center of Galaxy	2.365E+17	
NGC 6397	7.757E+16	
HD141569A	3.027E+15	
Cassiopeia	9.46E+16	
Oldest known planet	5.298E+16	

Activity 2.
SCoPE Site Lesson Plan
Math Rules

Abstract
Students examine the value of mathematical analysis to develop models in astronomy, by emulating the work of Johannes Kepler and then analyzing astronomical data.

National Science Education Standards: Earth and Space Science

CONTENT STANDARD D:
As a result of their activities in grades 5-8, all students should develop an understanding of

- Structure of the earth system
- Earth's history
- Earth in the solar system

Key Concept
galaxy

Instructional Resources
Equipment/Manipulative
Cardboard (from stationery 8.5 x 11, 1 per group)
Metric ruler (cm, 1 per group)
Paper (1 8.5 x 11 per group)
Pencils
Push pins (or dissecting pins), 2 per group.
String (~35 cm per group)

Student Resource

Gow, Mary. Great Minds of Science: Johannes Kepler. *Berkeley Heights, NJ: Enslow, 2003.*

Hawking, Stephen. *On the Shoulders of Giants.* Philadelphia: Running Press, 2004.

Living with a Star. 10 March 2004. NASA. 22 March 2004 <http://lws.gsfc.nasa.gov/>.

Texley, Juliana. *Unit 5 Lesson 3 Student Pages.* Teacher-made material. Lansing, MI: Michigan Department of Treasury, 2004.

Teacher Resource

Gene Smith's Astronomy Tutorial: A Brief History of Astronomy. University of California, San Diego Center for Astrophysics and Space Sciences. 22 March 2004 <http://cassfos02.ucsd.edu/public/tutorial/History.html>.

Texley, Juliana. *Grade 8 Unit 5 Teacher Background*. Teacher-made material. Lansing, MI: Michigan Department of Treasury, 2004.

Sequence of Activities

Safety Precaution: Do not use sharp compasses or push pins unless discipline is assured.

9. Remind students that over the thousands of years of human history, there were many careful observers of the skies. However, it took not only data but also understanding in order to build models from those observations: "One of the greatest observers of the l7th Century was Tyge Brahe, who had an entire island and a staff for his observatory. Unfortunately, both Brahe and his patron died before that data could be truly understood. The data fell into the hands of a protégée, Johannes Kepler (1571-1630) whose brilliant mathematical mind was able to "crunch" all that data long before we had computers to do it for us. Kepler did not actually think of himself as a scientist, but rather as a mystic." Students may know something of the pseudoscience called *numerology* that encourages people to think of some numbers as magic or lucky. "Kepler tried to draw a model of the solar system that was like Kopernig's model, and match Brahe's observations to it. But it did not work! In his day, most people would have just thrown out the data. It was not common to rely on it for information. But Kepler believed the data was right and the model was wrong, so he tried to think of a different model that would work. Here are the assumptions he used, to create a model that would match Brahe's data:
   a. The orbits of the planets are ellipses with the Sun at one focus.
   b. The planets sweep out equal areas during equal times of the orbit.
   c. The square of the orbital period is proportional to the cube of the planet's distance from the Sun. (If you measure the period in Earth years and the distance in Astronomical Units (1 A.U.= the average distance of the Earth from the Sun), then $\text{Period}^2 = \text{Distance}^3$."

2. First, ask students to practice drawing ellipses on their Student Pages with these directions: "First, make an ellipse: Turn your cardboard 'landscape.' Lay a piece of paper over the cardboard. Mark the exact center of the paper/cardboard with a pen. Put two pushpins into the cardboard to represent the foci of the ellipse exactly five cm on either side of the center. Make a loop with your string so that it measures exactly 16 cm from side to side when pulled taut. (That means the entire length of the string, minus the knot, is 32 cm.) With your pen/pencil tip also inside the loop and held vertically, pull the loop taut and trace an ellipse on your paper by slowly stretching the string with your pencil tip and moving around the two push pins. Now you have an ellipse. The longest distance you can measure inside this ellipse is its *major axis.* Then measure the distance between the foci. Finally calculate the eccentricity of the ellipse by this formula: Eccentricity – distance between foci/major axis."

3. Next, ask students to put themselves in the position of Johannes Kepler, just as a scientist would do. A scientific model or hypothesis must be tested by data. Have students program

the following chart into an Excel worksheet or calculator. Ask: "Does your result indicate that Kepler was right? What part of his law is confirmed?" [Third part.]

Planet	Orbital period	Semi-major axis	p^2	a^3	p^2/a^3
	(years)	(A.U.'s)			
Mercury	0.241	0.387	0.058081	0.057961	1.002
Venus	0.615	0.723	0.378225	0.377933	1.000
Earth	1	1	1	1	1.000
Mars	1.881	1.524	3.538161	3.539606	0.999
Jupiter	11.86	5.203	140.6596	140.8515	0.999
Saturn	29.46	9.539	867.8916	867.9777	0.999
Uranus	84.01	19.19	7057.68	7066.835	0.999
Neptune	164.8	30.06	27159.04	27162.32	0.999
Pluto	248.6	39.53	61801.96	61770.4	1.000

(Chart from NASA *Living with a Star*)

Note: Remind students the distances are in *astronomical units,* so that Earth is "1" by definition.

4. Share the chart below with students and ask them to summarize in words how it verifies the second part of Kepler's postulates. **Note:** Some students may need to review the formulas for area.

Planet	P (yr)	a (AU)	T^2	R^3
Mercury	0.24	0.39	0.06	0.06
Venus	0.62	0.72	0.39	0.37
Earth	1.00	1.00	1.00	1.00
Mars	1.88	1.52	3.53	3.51
Jupiter	11.9	5.20	142	141
Saturn	29.5	9.54	870	868

5. Discuss with students the scientific process of mathematical modeling. Then share a bit more of Kepler's own life. (Quote from Stephen Hawking, *On the Shoulders of Giants*.)
   If an award were ever given to the person in history who was the most dedicated to the pursuit of absolute precision, the German astronomer Johannes Kepler might well be the recipient. Kepler was so obsessed with measurements that he even calculated his own gestational period to the minute…So it is no surprise that he toiled over his astronomical research to such a degree that he ultimately produced the most exact

astronomical tables of his time, leading to the eventual acceptance of the sun-centered (heliocentric) universe…Kepler believed that he had discovered God's logic in designing the universe, and he was unable to hide his ecstasy.

6. Ask students to brainstorm other mathematical models that have been verified by accurate observations. [The acceleration of gravity, $E = MC^2$, etc.] Ask: "What happens if a model is not verified by observation?" [It must be discarded and a new model sought.]

Assessment
Ask students to imagine a tenth planet that had a semi-major axis of 40 AUs. How long would the year be on that planet?

Applications beyond School
Students can continue to explore other mathematical models such as those that are used to predict the weather and elections.

Connections
<u>Mathematics</u>
While studying the solar system, students use a mathematical model.

Name ___________________

Math Rules

Over the thousands of years of human history, there were many careful observers of the skies. One of the greatest observers of the 17th Century was Tyge Brahe, who had an entire island and a staff for his observatory. Unfortunately, both Brahe and his patron died before that data could be truly understood.

The data fell into the hands of a protégée, Johannes Kepler (1571-1630) whose brilliant mathematical mind was able to "crunch" all that data long before we had computers to do it for us. Kepler did not actually think of himself as a scientist, but rather as a mystic. Kepler tried to draw a model of the solar system that was like Kopernig's model, and match Brahe's observations to it. But it did not work!

In his day, most people would have just thrown out the data. It was not common to rely on it for information. But Kepler believed the data was right and the model was wrong, so he tried to think of a different model that would work. Here are his hypotheses (called postulates in math):

a. The orbits of the planets are ellipses with the Sun at one focus.
b. The planets sweep out equal areas during equal times of the orbit.
c. The square of the orbital period is proportional to the cube of the planet's distance from the Sun. (If you measure the period in Earth years and the distance in Astronomical Units (1 A.U.= the average distance of the Earth from the Sun), then $\text{Period}^2 = \text{Distance}^3$.

First, Let us Find an Ellipse:
Follow these steps:

- Turn your cardboard 'landscape.'
- Lay a piece of paper over the cardboard.
- Mark the exact center of the paper/cardboard with a pen.
- Put two pushpins into the cardboard to represent the foci of the ellipse exactly five cm on either side of the center.
- Make a loop with your string so that it measures exactly 16 cm from side to side when pulled taut. (That means the entire length of the string, minus the knot, is 32 cm.)
- With your pen/pencil tip also inside the loop and held vertically, pull the loop taut and trace an ellipse on your paper by slowly stretching the string with your pencil tip and moving around the two push pins.
- Now you have an ellipse.

The longest distance you can measure inside this ellipse is its *major axis.*
Then measure the distance between the foci.___________________

Now calculate the eccentricity of the ellipse by this formula:

Eccentricity = distance between foci/major axis.

Your answer____________________

You Be the Astronomer
Put yourself in the position of Johannes Kepler. Test your third postulate by filling out the chart:

Planet	**Orbital period**	**Semi-major axis**	p^2	a^3	p^2/a^3
	(years)	(A.U.'s)			
Mercury	0.241	0.387			
Venus	0.615	0.723			
Earth	1	1			
Mars	1.881	1.524			
Jupiter	11.86	5.203			
Saturn	29.46	9.539			
Uranus	84.01	19.19			
Neptune	164.8	30.06			
Pluto	248.6	39.53			

(Chart from NASA *Living with a Star*)

Remember: the distances are in *astronomical units,* so that Earth is "1" by definition.

Here is another chart. Can you tell what it means in your own words?________________________

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Planet	**P (yr)**	**a (AU)**	T^2	R^3
Mercury	0.24	0.39	0.06	0.06
Venus	0.62	0.72	0.39	0.37
Earth	1.00	1.00	1.00	1.00
Mars	1.88	1.52	3.53	3.51
Jupiter	11.9	5.20	142	141
Saturn	29.5	9.54	870	868

Can you think of other scientific ideas that were first mathematical models?__________________

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Activity 3.
SCoPE Site Lesson Plan
Out of Darkness, a New Night Sky

Abstract
Students explore the advances made with the optical telescope, from Galileo to Kepler. They use their own powers of observations to make deductions about the surface of Mars from visual imagery, and formulate research questions for explorers on the surface of Mars.

Subject Area: Science

National Science Education Standards: Earth and Space Science

CONTENT STANDARD D:
As a result of their activities in grades 5-8, all students should develop an understanding of

- Structure of the earth system
- Earth's history
- Earth in the solar system

Key Concepts
galaxy

Instructional Resources
Equipment/Manipulative
Enlarged photos of Mars (from NASA or Teacher Background)
Transparency sheets (blank, per group)
Water-soluble transparency marker pens

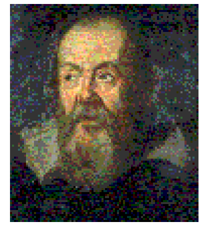
Student Resource
Texley, Juliana. *Unit 5 Lesson 2 Student Pages*. Teacher-made material. Lansing, MI: Michigan Department of Treasury, 2004. (See Below)

Teacher Resources
Gene Smith's Astronomy Tutorial: A Brief History of Astronomy. University of California San Diego Center for Astrophysics and Space Sciences. 22 March 2004 <http://cassfos02.ucsd.edu/public/tutorial/History.html>.

Texley, Juliana. *Grade 8 Unit 5 Teacher Background*. Teacher-made material. Lansing, MI: Michigan Department of Treasury, 2004.

Sequence of Activities

Advanced Preparation: Enlarge the photos of classical astronomers and the images of Mars (one of each per group). Make images of Earth features (from Teacher Background) available to groups either by enlarging them or duplicating them.


10. Review the history of the first Renaissance European astronomers: "These pioneers used minimal instrumentation and great patience to move beyond superstition and guesswork to make inferences about the movement of the objects in the solar system. Nikolas Kopernig (1473-1543) was a Polish mathematician. By his time, most observers realized that the traditional view of the universe first described by Ptolemy could not correspond with careful observations of the universe. The planets and the sun could not be revolving around the Earth and still appear where they did!" (Emphasize to students that to come to these conclusions, contradicting classical models such as that proposed by Ptolemy, required considerable courage.) "Kopernig, who was called Copernicus in Latin, developed a model in 1543 *De Revolutionibus Orbium Celestium* which showed the Earth and planets moving around the sun. Tyge Brahe (1546-1601) was a wealthy and well-respected Danish scientist who made meticulous observations with instruments he designed himself before the optical telescope was ever used. He measured the movement of objects by *parallax* and demonstrated that a supernova that he saw was much farther away than the moon or the planets."

11. Explain *parallax* to students by having them hold a pencil or pen out .25 m in front of their nose. Ask students to describe how the appearance of the pencil or pen changes when they open one eye, then the other. Next, have them extend their arms as far as possible (about .5 m) and again open one eye at a time. [The side-to-side movement of the pencil changes.] "Brahe realized that the farther an object was from Earth, the less its appearance would change from various positions on the planet. Brahe's observations were passed on to Johannes Kepler, who will be discussed in the next lesson."

12. Using classroom instruments as examples, emphasize to students that technology often drives science, and vice versa: "The first modern scientist to use a telescope to observe a celestial object and describe it was Galileo Galilei (1564-1642). Through his telescope, Galileo found sunspots, craters, and mountains on the moon. He also named the first four satellites of Jupiter."

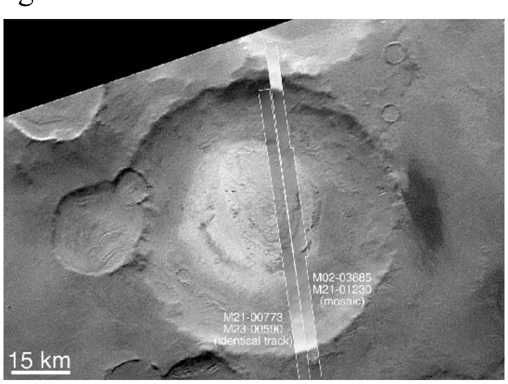
13. Ask students to look at the map of the moon on their Student Pages. Most of the larger features named after ancient or classical scientists received their names from Galileo. Galileo became convinced that Copernicus' view (not Ptolemy's) was the valid one, and published his views in Italian in *Dialogues Concerning the Two Chief World Systems* in 1632. (See the diagram of the two competing views in the Teacher Background.) "This got him in trouble with the Italian Inquisition and he was placed under house arrest for the rest of his life." Ask students why such discoveries are often met with so much resistance. [While this is often

misidentified as a religious issue, in fact the authorities were afraid that challenging one type of authority would "domino" into challenges of another type.]

14. Ask students to think about the perspective of each of the three scientists pictured on the Student Pages, and to imagine what they might say if they could observe the moon today. [Copernicus might say that it moves around the sun, Galileo might still believe that it has lakes and hills, while Brahe might suggest that it is closer to Earth than Mars or other planets.] **Note:** We have listed the names of the scientists in their native language, rather than the tradition of Latinizing their names that began later in history.

15. Stop as you discuss these conflicting views and ask students to sketch the solar system as Ptolemy thought it was, and the solar system as Galileo believed it was. (Classic drawings are shown in the Teacher Background for comparison.) Then ask them to come up with one observation that might convince someone that one was more accurate than another. (This will be difficult at first. Students must imagine various observations, and then think about how they might have been interpreted, requiring significant understanding of geometry. Ask students to discuss your challenge in groups.) [Possible answers might include the rising of Sirius and the Sun, or eclipses of the Sun and Jupiter (by its own moons). Probably the clearest evidence at that time would have come from parallax measurements, which indicated that the stars were much farther from Earth than the planets.] Explain that without a model to which an observer could refer—like their sketches—these isolated observations would not be very useful. Scientists use models to make predictions and to test predictions, as well. Explain to students that careful visual observations (combined with models or information from other sources) are still very valuable to scientists.

16. Show students the two visual images of Mars on their Student Pages. Ask them to brainstorm in groups what they see, then on the board or on a transparency list in two columns their naïve observations for Image 1 and Image 2. At this point no reasonable suggestion should be rejected. Then offer students transparencies and pens, to cover the images so that they can mark on them as they discuss their *hypotheses.* Explain to students that they are to formulate at least one "If…Then…"statement for each image, and then to list observations that support or refute their hypotheses. [For example, for Image 1: "If the large crater was formed before the smaller crater, then we should see places where the second crater wiped out some of the splashes (ejecta) from the first" and for Image 2 "If the features were formed by a fluid like water or wind, some of them should be lined up parallel and should be streamlined."] As students make their hypotheses, it is very difficult for them to ignore what they already know about Mars. Challenge them to think of what they see in a naïve way: "Would it have been logical for Galileo to think this was a lake or a canal?"



17. After students have struggled a bit with their observations, offer them samples of photos of impact, water and wind features from Earth to compare. Ask: "How does a scientist's database of observations make new observations easier to understand?"

18. Finally, explain to students that these photos were made prior to the landing of Mars Exploration vehicles Spirit and Opportunity, and helped NASA design experiments on the surface. Ask them to formulate in groups at least two specific scientific questions that they would like to see investigated in the terrains that they can see in Images 1 and 2. [Emphasize "specific." For example, for the left hand images on Mars and Earth: "How deep is the impact crater? What force would have been necessary to form it?" or for the right hand images of Mars and Earth: "Is there a general pattern of parallel fluid-formed features outside of the area of this photo?" "Is the soil packed harder inside the features than outside?"]

19. Remind students that qualitative observations have great value, but scientists usually combine them with a more careful quantitative analysis using mathematics. In the next lesson, they will return to the Renaissance to see how Johannes Kepler used math to understand the solar system.

Assessment
Students should be able to classify photos of features on Mars and Earth as formed by a) impact or b) fluid action.

Applications beyond School
Students can apply their understanding of various surface features to erosion, which is a common problem in communities. Features only found on Earth (specifically, plant life) prevent erosion here.

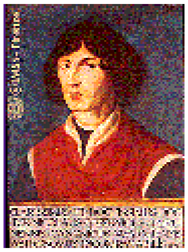
Connections

Arts
Many early scientists (like Leonardo da Vinci) were also artists. Students may wish to explore why Leonardo's natural curiosity about the chemistry of paints and the anatomy of the body made him a better artist.

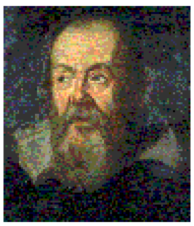
STUDENT PAGES
Name__________________________

Out of Darkness, a New Night Sky

Meet the Masters: *Imagine what they would say if they were looking at the moon with you.*



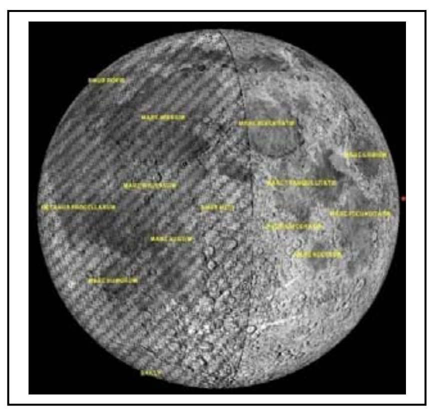
*Pan Kopernig*______________________________________



*Signori Galilei*_______________________________

*Herr Brahe*____

Circle several features of the moon that you believe were observed and named by Galileo:

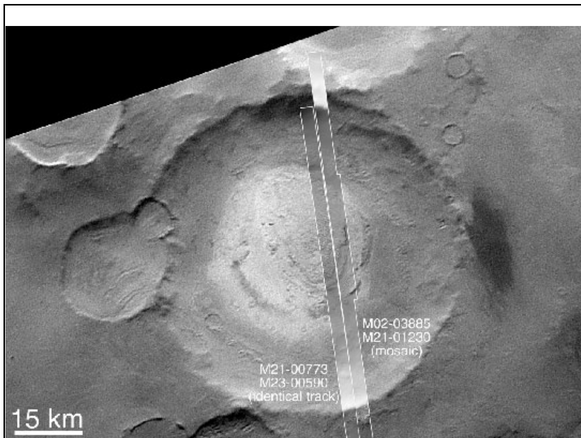


Now imagine you are speaking to a contemporary of Galileo's who believes that the Sun goes around the Earth. Think of one observation that you could share with that person to convince them that Galileo was right and that they were wrong:_____________________________________

____

____

Mars Watching:
Look at the two images of Mars your teacher supplies. (Here are small versions of those images.) Make a list of the observations you can make from these images. Then for each set of observations, think of one "If…Then…" statement that could guide a scientist to explain what you see.

<table>
<tr>
<td>
</td>
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<tr>
<td>Observations:_</td>
<td>Observations:</td>
</tr>
<tr>
<td>If__________________________then______
_____________________</td>
<td>If__________________________then________
___________________</td>
</tr>
</table>

Spirit and Opportunity
These images were made to guide the scientists who program unmanned Martian exploration vehicles. If you could design a task for one of these vehicles, what would it be? Which one of your observations could you test with such a vehicle? What would you find out?______________

____

____

The Star in Our Neighborhood

Abstract

Students study the structure of the Sun and then explore the potential relationship between Sunspots and climate by analyzing historical data. They experiment on ways to block ultraviolet solar radiation from skin.

National Science Education Standards: Earth and Space Science

CONTENT STANDARD D:
As a result of their activities in grades 5-8, all students should develop an understanding of

- Structure of the earth system
- Earth's history
- Earth in the solar system

Key Concept
fusion energy

Instructional Resources
Equipment/Manipulative
Baby oil
Microchemistry well plates or dose cups
Paper plates
Prism
Sunblocks with SPF 15, 30, and 45
UV-sensitive beads

Student Resource

Little Ice Age in Europe. *Ed. Scott Mandia. 22 March 2004* <http://www2.Sunysuffolk.edu/mandias/lia/little_ice_age.html>.

Solar Reports and Models. *NOAA. 22 March 2004* <http://www.sec.noaa.gov/Data/solar.html#models>.

Solar Physics: The Sunspot Cycle. 2 March 2004. NASA. 22 March 2004 <http://science.msfc.nasa.gov/ssl/pad/solar/Sunspots.htm>.

Texley, Juliana. *Unit 5 Lesson 8 Student Pages*. Teacher-made material. Lansing, MI: Michigan Department of Treasury, 2004.

What Lies Beneath a Sunset. *NASA. 22 March 2004* <*http://science.nasa.gov/headlines/y2001/ast07nov_1.htm*>.

Teacher Resource
Exploring the Sun. NASA. 24 March 2004 <http://pcsinspace.hst.nasa.gov/Sun.htm>.

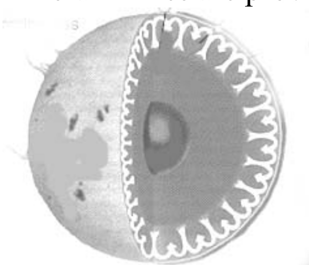
Texley, Juliana. *Grade 8 Unit 5 Teacher Background.* Teacher-made material. Lansing, MI: Michigan Department of Treasury, 2004.

Sequence of Activities

Advanced Preparation: Download the software at http://pcsinspace.hst.nasa.gov/Sun.htm if you would like extra computer tutorials. Order UV Beads from Educational Innovations, Inc.
151 River Road, Cos Cob, CT 06807 or Arbor Scientific, PO Box 2750, Ann Arbor MI 48106-2750. There are several ways to distribute oils; you can pass around the stock bottles, put small amounts in the wells of microchemistry plates or use dose cups.

Safety Precautions: Remind students never to look at the sun directly.

20. Begin by reviewing the spectral nature of sunlight. Ask students to describe the energy of the sun. [Accept brainstormed answers.] Then help students review some basic facts about the sun. (Recall the information on fusion from Lesson 7 as well.) A diagram of the sun and blank lines are provided on the Student Pages for note taking:

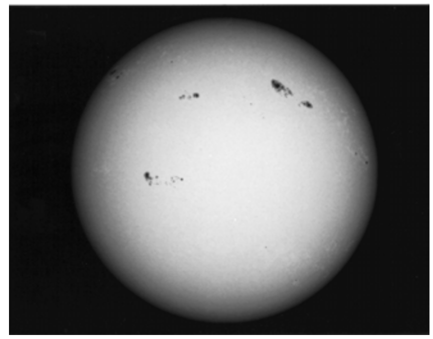


"The sun's volume is 1,412,000 10^{12} km^3 compared to 1,083 10^{12} km^3 for the earth. Its diameter is ~14 x 10^5 km compared to 12 x 10^3 km for the earth. Can you draw an earth to scale on your notepaper for comparison?" [The earth is 1/100 of the diameter, about a mm on the worksheet.]

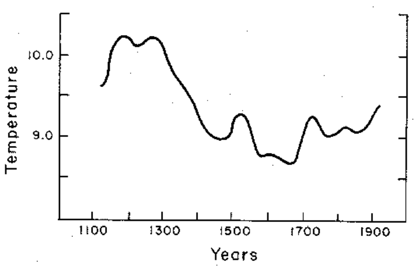
"The sun's interior is where hydrogen fusion occurs. (Review Lesson 7) $4H \rightarrow {}^4He$
Photons slowly move from the inner core toward the outside, producing an energy current that counters the gravitation of the sun and keeps it from collapsing into a white dwarf. (This could happen if a star ran out of hydrogen fuel.) Our sun is middle aged. The temperature at the core is estimated at 15 x 10^6 K."

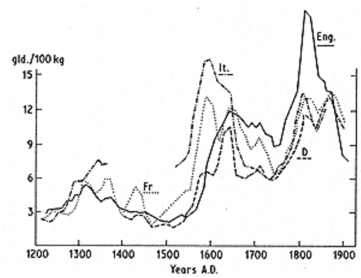
"The outer surface of the sun includes the photosphere. It is the lowest of the three surface layers of the sun. The surface temperature of the sun is about 5800 K. Most of the sun's light comes from this layer, even though it is only about 400 km thick. Just above the photosphere is the chromosphere, which is visible only when the bright photosphere is blocked by an eclipse. It includes spikes of gas called spicules that can rise for a minute or two to height of 10,000 km. Some of the gas and energy from the corona escapes the sun's gravitation to form solar wind."

21. Continue by introducing Sunspots as a visual measure of solar activity. "Sunspots are slightly cooler areas of the sun's surface. They may occur alone or in groups. The Sunspot is relatively cool because convective motion of the gas, which brings new, hot, gas to the surface, is slowed down. It may be 10,000 km across and can last between a few hours and a few months. Some are so large they could be seen with the naked eye *but never look at the sun directly.* Galileo was the first to describe sunspots, but destroyed much of his vision by doing so. Sunspots vary over time. Watching them can help scientists track the sun's rotation about once every four weeks. Some scientists believe that Sunspots are related to earth climate." Ask students to count the number of Sunspots visible on the NASA photo on the Student Pages. Solar flares are magnetic storms on the surface of the sun.

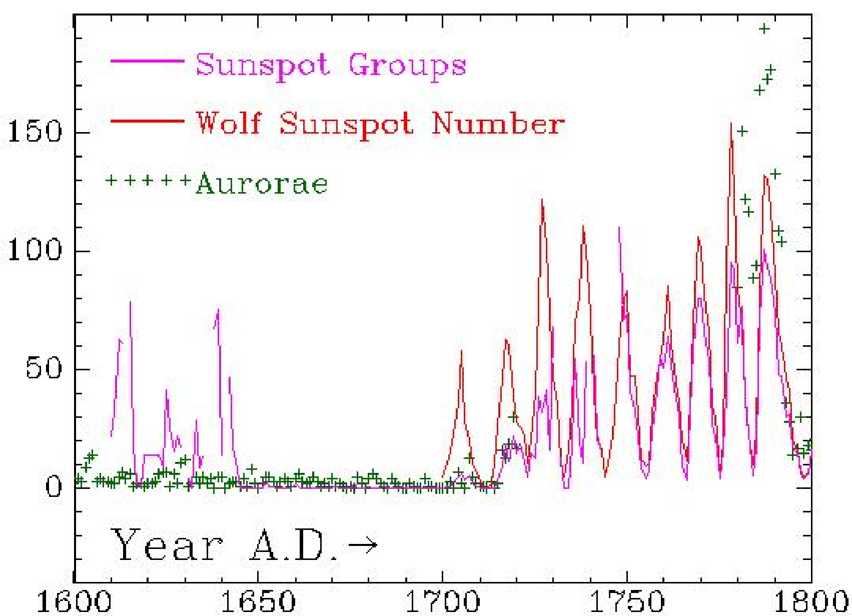


22. Ask students to help analyze a historical mystery about climate. Astronomers believe that during the 17th Century there was a period of about 70 years when there were almost no Sunspots visible. This period is called the "Maunder Minimum." Historians report that there were several strange anomalies on Earth during this period. Look at these graphs:

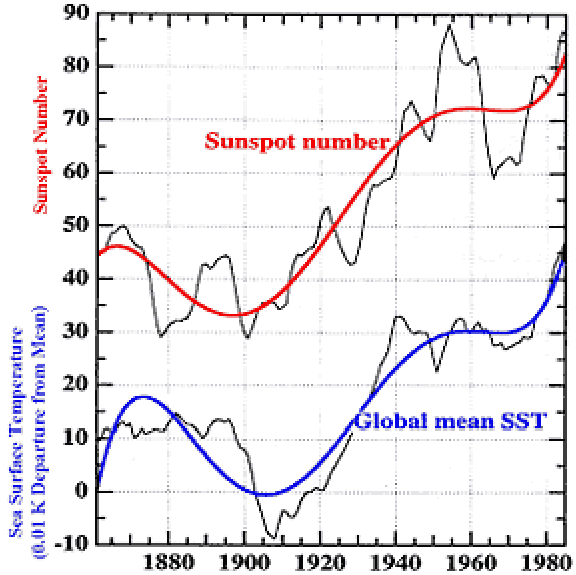




Graph below from http://www.hao.ucar.edu/public/education/sp/great_moments.2.html



23. Ask: "Why would a scientist use the price of Rye Flour as an indicator of climate?" [It indicates rain and length of growing system.] "Is there evidence of a Little Ice Age here?"[Yes.] Introduce another graph. " Is there evidence that there is a correlation between Sunspots and climate? [Visually, yes.] Invite students to look at more NASA data.



Source NOAA
http://www.oar.noaa.gov/spotlite/archive/spot_Sunclimate.html

Ask students to graph the data provided which predicts Sunspots over four years. Then ask them, based upon their graph, whether they would predict warmer or cooler weather? [Predictions will vary, but in general lower temperatures.] Then ask: "What other factors could affect climate?" [Global warming, greenhouse effect.] "What does this tell you about climate predictions?" [They are very complex and involve many factors.]

Data by months:

2003 08	60.0
2003 09	58.7
2003 10	56.6
2003 11	54.6
2003 12	51.8
2004 01	47.6
2004 02	43.4
2004 03	40.7
2004 04	38.0
2004 05	34.5
2004 06	31.7
2004 07	30.0
2004 08	28.1
2004 09	26.6
2004 10	25.1
2004 11	23.6
2004 12	22.2
2005 01	20.9
2005 02	19.6
2005 03	18.4
2005 04	17.2
2005 05	16.1
2005 06	15.1
2005 07	14.1
2005 08	13.2
2005 09	12.4
2005 10	11.7
2005 11	11.0
2005 12	10.3
2006 01	9.6
2006 02	9.0
2006 03	8.4
2006 04	7.9
2006 05	7.5
2006 06	7.3
2006 07	7.1
2006 08	6.7
2006 09	6.5
2006 10	6.3
2006 11	6.1
2006 12	5.1
2007 01	5.4
2007 02	5.6
2007 03	6.0
2007 04	6.4

2007 05	7.1	2007 09	13.3
2007 06	8.2	2007 10	15.6
2007 07	9.5	2007 11	18.3
2007 08	11.2	2007 12	21.3

24. Finally, ask students: "Have you ever felt the solar wind?" [Accept speculation. Solar wind includes radiation, so of course the answer is "yes."] "Does it hurt or harm you?" [Both.] "We need sunlight to help our bodies make Vitamin D, but we also can be harmed because ultraviolet light can cause mutations which result in skin cancer."

25. Introduce an experiment by asking students: "Do sunblocks really work?" Show students the product "UV Beads" and show how they change color in sunlight but not in incandescent light. Ask: "Can you get a tan with a regular light bulb?" [No.] Then distribute to each group paper plates and 10 beads. Students should make circles on their paper plates to identify beads with no covering, each of the sunblocks and baby oil. Then they should place the plates in the sun and observe the effects on the beads. [Baby oil does not block UV rays; sunblocks have varying abilities to block UV rays.]

26. Review the material from the previous lesson, so that students can integrate their understanding of the sun with previous information on stars. "The sun is a middle aged star. Its radiation is not too great or too low. We are shielded by the worst of it by our ozone layer and atmosphere. That is why life can exist on earth."

Assessment
Students graphs of the sunspot data can be used as an assessment for this lesson.

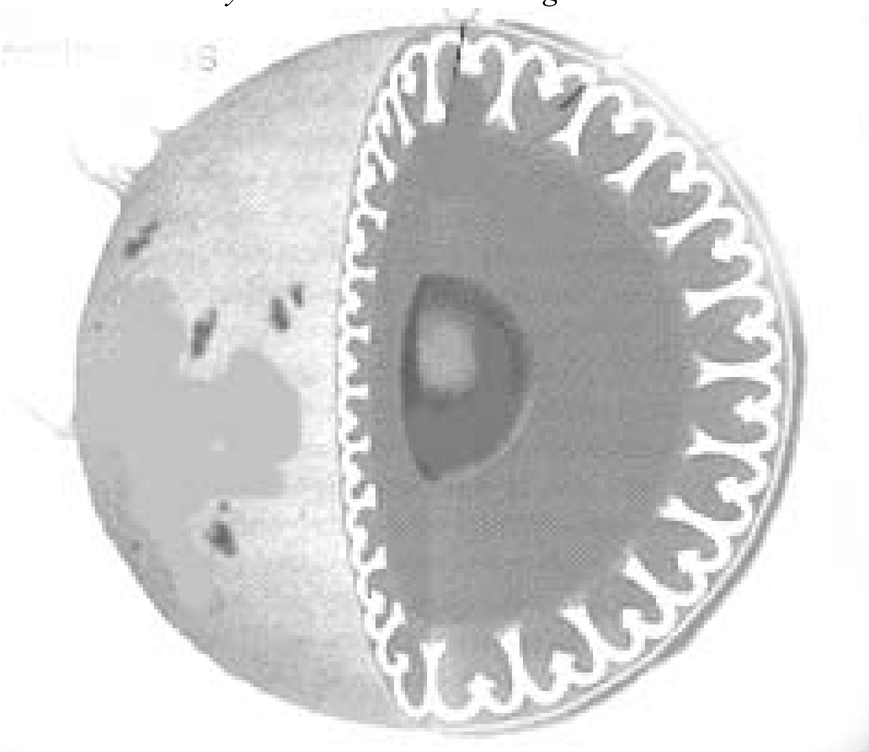
Application Beyond School
After learning about the sun, students can further explore how sunblocks are important tools in preventing skin cancer. Students should avoid getting a sunburn or over-tanning.

Connections
Social Studies

While learning about the sun, students can investigate how certain areas of the globe (i.e., Australia) have more serious problems with ultraviolet radiation than others.

Activity 4.
SCoPE Site Lesson Plan
The Star in Our Neighborhood

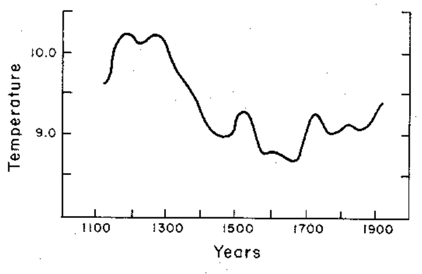
Let me introduce you to the star in our neighborhood:

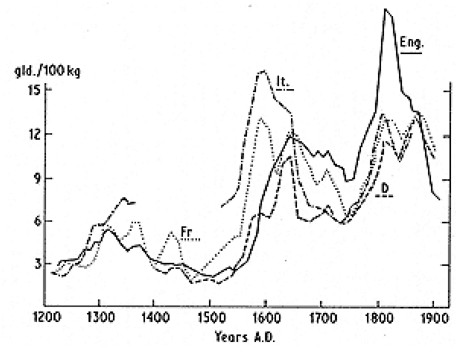


Your Notes

A Middle Age Mystery

Astronomers believe that during the 17th Century there was a period of about 70 years when there were almost no sunspots visible. This period is called the "Maunder Minimum." Historians report that there were several strange anomalies on Earth during this period. Look at these graphs:

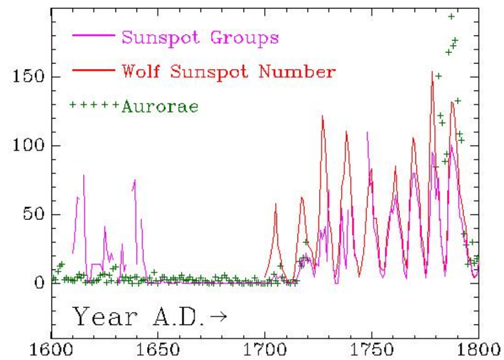




Price of Rye Flour in Europe

Sunspot Data

Graph below from http://www.hao.ucar.edu/public/education/sp/great_moments.2.html



27. Why would a scientist use the price of Rye Flour as an indicator of climate?_______________

____

28. Is there evidence of a Little Ice Age here?____

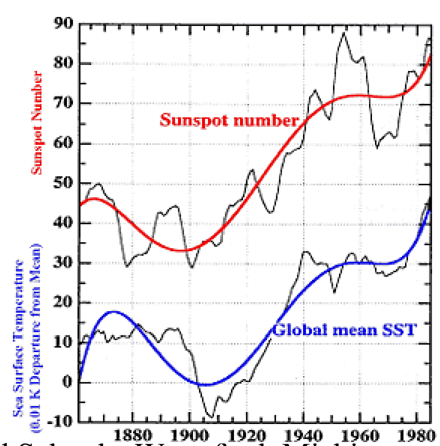
____

29. Here is another graph from NASA. Is there evidence that there is a correlation between sunspots and climate? ___

____

____

Source: NOAA
http://www.oar.noaa.gov/spotlite/archive/spot_sunclimate.html



Make Your Own Prediction:

Graph this data, and then write a conclusion:

Data by months:

2003 08	60.0
2003 09	58.7
2003 10	56.6
2003 11	54.6
2003 12	51.8
2004 01	47.6
2004 02	43.4
2004 03	40.7
2004 04	38.0
2004 05	34.5
2004 06	31.7
2004 07	30.0
2004 08	28.1
2004 09	26.6
2004 10	25.1
2004 11	23.6
2004 12	22.2
2005 01	20.9
2005 02	19.6
2005 03	18.4
2005 04	17.2
2005 05	16.1
2005 06	15.1
2005 07	14.1
2005 08	13.2
2005 09	12.4
2005 10	11.7
2005 11	11.0
2005 12	10.3
2006 01	9.6
2006 02	9.0
2006 03	8.4
2006 04	7.9
2006 05	7.5
2006 06	7.3
2006 07	7.1
2006 08	6.7
2006 09	6.5
2006 10	6.3
2006 11	6.1
2006 12	5.1
2007 01	5.4
2007 02	5.6
2007 03	6.0
2007 04	6.4
2007 05	7.1
2007 06	8.2
2007 07	9.5
2007 08	11.2
2007 09	13.3
2007 10	15.6
2007 11	18.3
2007 12	21.3

http://www.sec.noaa.gov/ftpdir/weekly/Predict.txt

Your Prediction:

How Can We Block Solar Radiation?

Problem: What materials are most effective to block solar radiation?

Procedure:

a) Obtain from your teacher 10 UV sensitive beads and a paper plate.
b) Mark circles on the plate to identify the treatments you will give pairs of beads.
c) Leave two beads without treatment. Use a variety of sunblocks on other pairs of beads.
d) Label carefully.
e) Leave all of your beads in full sunlight for 15 minutes.

Results:

Conclusion: