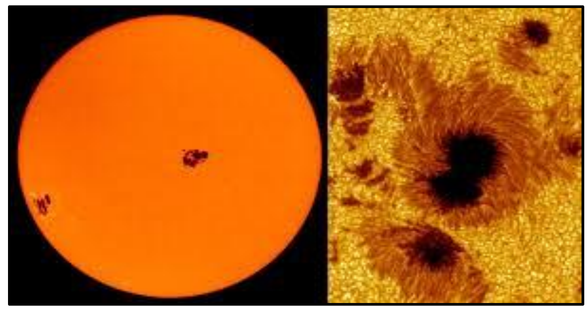
Student Sheet 1

CRITICAL THINKING ACTIVITY: GETTING TO KNOW SUNSPOTS

Our Sun is not a perfect, constant source of heat and light. As early as 28 B.C., astronomers in ancient China recorded observations of the movements of what looked like small, changing dark patches on the surface of the Sun. There are also some early notes about sunspots in the writings of Greek philosophers from the fourth century B.C. However, none of the early observers could explain what they were seeing.



The invention of the telescope by Dutch craftsmen in about 1608 changed astronomy forever. Suddenly, European astronomers could look into space, and see unimagined details on known objects like the moon, sun, and planets, and discovering planets and stars never before visible.

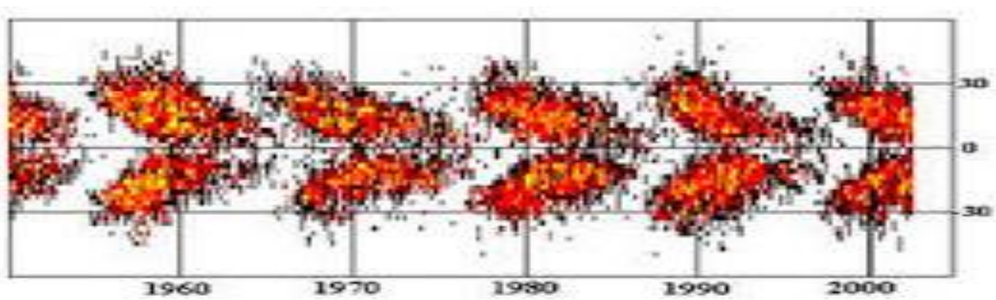
No one is really sure who first discovered sunspots. The credit is usually shared by four scientists, including ***Galileo Galilei*** of Italy, all of who claimed to have noticed sunspots sometime in 1611. All four men observed sunspots through telescopes, and made drawings of the changing shapes by hand, but could not agree on what they were seeing. Some, like Galileo, believed that sunspots were part of the Sun itself, features like spots or clouds. But other scientists, believed the Catholic Church's policy that the heavens were perfect, signifying the perfection of God. To admit that the Sun had spots or blemishes that moved and changed would be to challenge that perfection and the teachings of the Church.

Galileo eventually made a breakthrough. Galileo noticed the shape of the sunspots became reduced as they approached the edge of the visible sun. He realized that this would only happen if the spots were objects on the surface of the Sun, and not if they were planets or moons passing before the Sun. So he concluded that the spots must be on the surface.

Student Sheet 2

Today these areas are called ***sunspots***. Observations have shown sunspots to be relatively "cooler" areas of the Sun's surface or ***photosphere*** connected with disturbances in the ***solar magnetic field***. If seen from the side, they look like deep depressions in the photosphere. Sunspots usually come in pairs and drift from the high latitudes of the Sun toward the equator. The first one that moves across the disc of the Sun has the opposite magnetic charge (+/-) from the one that follows it. Scientists believe that this drifting is caused by the movement of heat within the photosphere, as well as the rotation of the Sun.

In the early years of a sunspot cycle, the sunspots tend to be smaller and to form at the higher latitudes, both north and south of the equator. As the cycle moves toward ***maximum***, spots form at latitudes of 10-15 degrees. As the cycle moves toward ***minimum***, the spots get smaller and look closer to the equator. There is an overlap at the end of one cycle and the start of another, as new sunspots form in the in the higher latitudes, while spots from the present cycle are still visible near the equator. When sunspots are plotted according to their latitude and longitude, a very clear "butterfly pattern" develops within each cycle of approximately 11 years.



The "butterfly pattern" of sunspots

Modern telescopes operate in different wavelengths, so the scientists in Galileo's time had to just use the eye, and just use visible light. Today, people are using instruments to measure the light more precisely than the eye can, and measure it in colors beyond the visible, extending to ultraviolet, infrared, and even x-rays and gamma rays. This gives scientists new ways to examine the sun as well as new ways to contrast and compare results. With these new tools, scientists have begun to unravel the mystery of sunspots.

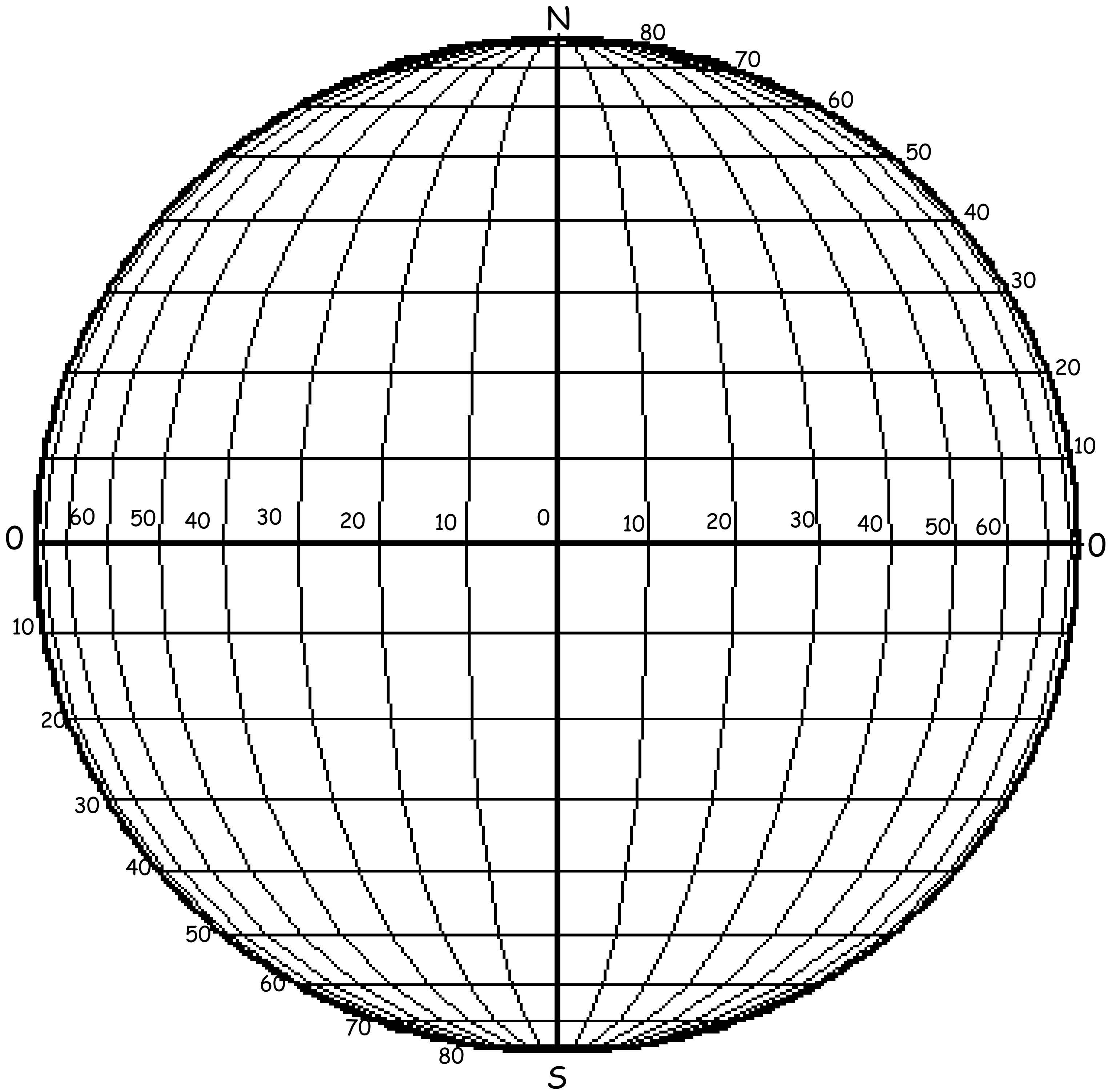
Student Sheet 3

DATA TABLE 1: SUNSPOT LOCATIONS

#	LAT	LONG	#	LAT	LONG
1	0	E5	31	S40	W35
2	N8	0	32	S30	W35
3	N10	W3	33	S27	W30
4	N15	W10	34	S21	W20
5	N19	W20	35	S17	W10
6	N20	W23	36	S10	W2
7	N23	W30	37	S8	0
8	N30	W39	38	S5	E4
9	N35	W40	39	N5	E3
10	N40	W30	40	N12	W8
11	N41	W20	41	N18	W15
12	N41	W10	42	S32	E15
13	N37	0	43	S36	W37
14	N31	E10	44	S23	W25
15	N27	E20	45	S18	W15
16	N20	E30	46	N25	W35
17	N10	E39	47	N38	W36
18	N10	E49	48	N41	W24
19	N4	E51	49	N38	E7
20	S5	E50	50	N34	E15
21	S10	E47	51	N30	E24
22	S17	E40	52	N24	E35
23	S20	E36	53	N15	E45
24	S25	E30	54	S13	E42
25	S30	E21	55	S40	E3
26	S38	E10	56	S13	W8
27	S40	0	57	N40	W4
28	S45	W10	58	S31	E20
29	S46	W20	59	0	E52
30	S44	W30	60	N8	E50

Student Sheet 4

SUNSPOT LOCATION GRID



Student Sheet 5

ANALYSIS/CONCLUSIONS

1. Who was the first scientist to actively describe sunspots?
2. What have modern observations shown sunspots to be?
3. What is their temperature like in comparison to the surrounding area?
4. What creates the "cooler" areas on the Sun's surface?
5. How does sunspot size compare to the size of the Earth?
6. Are all sunspots affected by magnetic fields? Explain.
7. Why were Galileo's ideas about the Sun likely to get him into trouble with the Church?
8. Describe the process of sunspot formation and movement across the surface of the Sun.
9. Why can it be said that sunspots are repetitious or occur in cycles?
10. How are sunspots plotted?
11. From your completed grid, what can you say about sunspot locations in the Southern Hemisphere of the Sun and those in the Northern Hemisphere?
12. Would sunspot (40N, O) be and old or a new sunspot? Explain.
13. Would sunspot (0,5E) be a large or a small sunspot? Explain.