EA11

EARTH, MOON, SUN AND SEASONS

TEACHER'S CLASSWORK AGENDA AND CONTENT NOTES

Classwork Agenda for the Week

1. Students will demonstrate that the earth rotates on its axis.
2. Students will explain the cause of earth's seasons.
3. Students will explain the cause of lunar and solar eclipses and calculate the diameter of the sun.
4. Students will show why the moon has phases.

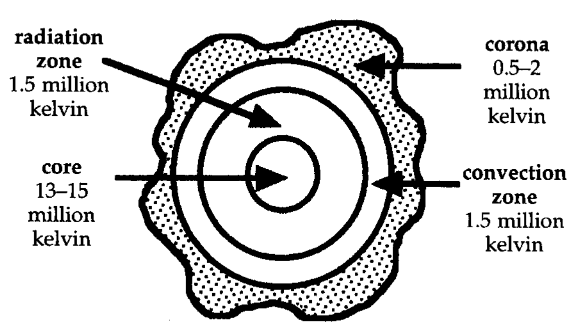
Content Notes for Lecture and Discussion

The Copernican Revolution that began with the publication of **Nicolaus Copernicus**'s (b. 1473; d. 1543) *On the Revolution of the Heavenly Spheres* did not end until the publication of **Sir Isaac Newton**'s (b. 1642; d. 1727) *Principia* in 1687. In his *Principia,* Newton made the final synthesis of the physical and astronomical disciplines by showing the consistency between the laws of **Johannes Kepler** (b. 1571; d. 1630) and the enlightening telescope observations of **Galileo Galilei** (b. 1564; d. 1642). Until Newton put the debate to rest, Copernicus's idea was viewed as little more than a complex mathematical exercise with no basis in physical reality. Newton's definitive incorporation of the properties of mass, inertia, and momentum into the movement of the heavenly bodies made the Heliocentric Theory concrete. What followed was a deluge of new and numerous observations that laid the basis for modern astronomy.

With the invention of photography in the middle of the 19th century, concentration on the features and behavior of the sun and moon led to an increased understanding of the earth and its place in the cosmos. This, combined with Sir Isaac Newton's analysis of the nature of light, resulted in the study of **spectroscopy**. The English scientist **William Wollaston** (b. 1766; d. 1828) recorded the first **solar spectrum** in 1802. His record was interpreted in 1814 by the German physicist **Joseph von Fraunhofer** (b. 1787; d. 1826) who suggested that such spectra might give clues to the chemical composition of the sun. In 1859, the German physicists **Gustav Robert Kirchoff** (b. 1824; d. 1887) and **Robert Wilhelm Bunsen** (b. 1811; d. 1899) recognized the similarity between the solar spectrum and the spectra of burning gases in the laboratory. Together, they built the first **spectroscope** and used it to deduce the chemical composition of light emitted from a variety of sources including the sun and planets.

The **sun** is recognized today to be a medium-sized star of average brightness powered by the nuclear fusion of the element hydrogen into helium. The sun is approximately 1,395,000 kilometers in diameter compared to the 12,756 km diameter of the earth. It is tilted about 7° from the ecliptic (e.g., the path of earth's orbit) and rotates on its axis once in about 9 hours. Figure 1 is a simple diagram of the sun's basic architecture. The sun's surface **photosphere** and outlying **chromosphere** is teeming with violent particle and electromagnetic storms: **sunspots, eruptive prominences, polar plumes,** and **coronal streamers**. About 90% of the energy that flows to the surface is generated at the core which contains nearly 40% of the sun's total mass. Although the sun's volume is nearly

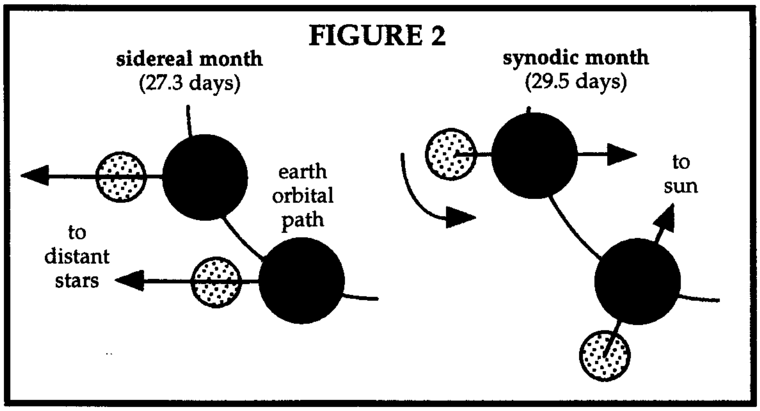
FIGURE 1



1,000,000 times that of earth, it is only about 330,000 times more massive. The sun is, therefore, less dense than earth which is the densest chunk of matter in the Solar System.

The most obvious surface features of the **moon** are its **craters, plains,** and **mountain ranges.** The moon has a diameter of 3,476 km and approximately one-sixth the gravitational attraction of earth at its surface. The moon has an iron core, a molten mantle, and silicate crust much like that of earth. It orbits the earth at an 8° incline with respect to the earth's ecliptic. The incline in the moon's orbit makes the monthly full moon possible when earth is nearer the sun. It is believed that geological action has virtually ceased on the moon since its formation 4.5 billion years ago; although seismometers placed there by Apollo astronauts in the 1970s have registered quakes that are probably the result of gravitational forces exerted at its surface. The moon rotates once on its axis in the same period it takes to revolve around the earth, so the same face of the moon always looks to earth. A **sidereal month** is the time it takes for the moon to make a 360° orbit around the earth until both earth and moon are aligned with the same distant stars (e.g., 27.3 days). A **synodic month** is the time it takes for the moon to realign itself with the earth and sun as it follows our planet in its journey around our star. Figure 2 illustrates the difference between a sidereal and synodic month.

FIGURE 2



The tilt of the earth in its revolution around the sun determines the change of seasons. The changing positions of the earth, moon, and sun with respect to one another results in lunar and solar eclipses as well as the changing phases of the moon.

In Lesson #1, students will demonstrate that the earth rotates on its axis.

In Lesson #2, students will explain the cause of earth's seasons.

In Lesson #3, students will explain the cause of lunar and solar eclipses and calculate the diameter of the sun.

In Lesson #4, students will show why the moon has phases.

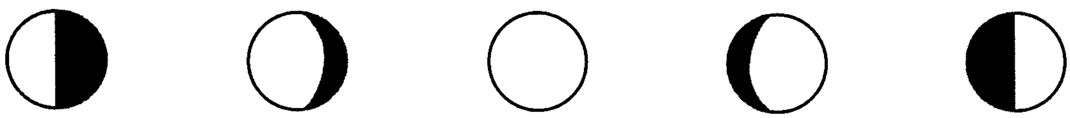
ANSWERS TO THE HOMEWORK PROBLEMS

Students' illustrations should be reproductions of the illustrations they copied in class.

ANSWERS TO THE END-OF-THE-WEEK REVIEW QUIZ

1. true
2. rotates
3. pendulum
4. 27.3 or 29.5
5. were
6. true
7. 390,000
8. true
9. 365.25
10. astronomical
11. true
12. heliopause
13. medium-sized
14. helium
15. true
16. is
17. 11
18. solar wind
19. tilt
20. true

(A) last quarter — (B) waning gibbous — (C) full — (D) waxing gibbous — (E) first quarter



Name: ______________________________ Period:________ Date: ____/____/____

EA11 Fact Sheet

EARTH, MOON, SUN AND SEASONS

CLASSWORK AGENDA FOR THE WEEK

(1) Demonstrate that the earth rotates on its axis.
(2) Explain the cause of earth's seasons.
(3) Explain the cause of lunar and solar eclipses and calculate the diameter of the sun.
(4) Show why the moon has phases.

Nicolaus Copernicus, a Polish-born scientist (b. 1473; d. 1543), changed the way people think about the universe. He proved that the earth **revolves** around the sun at a time when most people believed the earth was the center of the universe. Copernicus's idea was strange to most people because it challenged their direct observations. After all, we wake up every morning, see the sun rise and move across the sky, then dip over the horizon at dusk. At night, we watch the moon move across the sky hour after hour and see the stars travel in counterclockwise circles around the fixed North Star. It appears that the whole univese is revolving around us! In the previous unit—*Mapping the Heavens*—you used some of the same demonstrations Copernicus used to explain his theory. Using those and other demonstrations Copernicus suggested that the earth **rotates** on its **axis** once every 24 hours which causes day and night. But it was not until 1851 that the French physicist **Jean Bernard Léon Foucault** (b. 1819; d. 1868) proved beyond a doubt that the earth does rotate. He did this using a simple swinging pendulum. Copernicus explained that the **moon** was a **satellite** of earth and made one full trip around our planet about once every thirty days. He showed that the sun is the center of our solar system, shedding light on earth and on the other eight distant planets.

Ancient people reasoned that the earth was a sphere long before Columbus sailed to America. They watched ships "sink" beyond the horizon and return home, indicating the earth's surface was curved and not flat. They studied the shadow of the earth that was cast on the moon during lunar eclipses, noting that the shadows were always round. The Greek geographer and mathematician **Eratosthenes** (b. 276 B.C.; d. 194 B.C.) calculated the size of the earth in the third century B.C. and was accurate to within a few hundred miles.

Later astronomers like **Galileo Galilei** (b. 1564; d. 1642) made even more accurate calculations to determine the sizes of the moon, sun, and planets. Galileo discovered that the moon was not smooth but was covered with craters and rugged mountains. Using parallax, astronomers found the average distance to the moon to be **242,000 miles** (or about **390,000 kilometers**). They were able to explain **lunar** and **solar eclipses** as well as the **phases of the moon** (e.g., **crescent**, **quarter**, and **gibbous**) after studying the changing position of the moon relative to the earth and sun. Galileo discovered sunspots moving across the surface of the sun, suggesting that the sun—like earth—rotates on an axis. The earth is about **93,000,000 miles** (or **150,000,000 kilometers**) from the sun and completes one revolution around the sun every **365.25 days** (e.g., 1 year). The average distance from the earth to the sun is called one **astronomical unit** (or **a.u.**). The dimensions of the Solar System can be expressed in astronomical units. The most distant planet, Pluto, orbits at about 39.4 a.u. from the sun. The outer limit of the Solar System at about 100 a.u. from the sun is called the **heliopause**.

The sun is a medium-sized star of average brightness. The sun's **radiation** (e.g., light, heat, and ultraviolet rays) is produced in its dense, hot **core**. In the sun's core **nuclear fusion** combines **hydrogen** atoms to form **helium** atoms at the rate of hundreds of million metric tons per second. Even at this incredible rate of consumption the sun has enough hydrogen to burn for another 6 billion years. As dependable as it is, however, the sun is very active. Dark **sunspots** accompanied by violent **magnetic**

storms appear on the sun's surface in 11 year cycles. These storms give rise to gigantic bursts of energy that cause energetically charged atomic particles to flow out into space. This flow of energetic particles can effect the earth's weather, and radio and television communications. It can knock satellites out of their orbit and injure astronauts working in space. This blizzard of dust, gas, and energy is called the **solar wind.** The solar wind supplies our planet with enough energy to keep all of us alive. It drives the weather and can alter the climate. Today we know that the change of seasons is caused by the shift in the tilt of the earth as it revolves around the sun on its voyage through the storm of solar wind.

Homework Directions

1. Draw and label the positions of the earth, sun, and moon during a lunar and solar eclipse. Label the umbra and penumbra in each diagram.
2. Draw and label the positions of the earth and sun at summer solstice, autumnal equinox, winter solstice, and vernal equinox. Show the correct tilt of the earth in each position.

Assignment due: __________

____________________	____________________	____/____/____
Student's Signature	Parent's Signature	Date