

THE SUN AND THE SOLAR SYSTEM

CHAPTER 26

SECTION 26.1:

THE SUN'S SIZE, HEAT, AND STRUCTURE

Objectives:

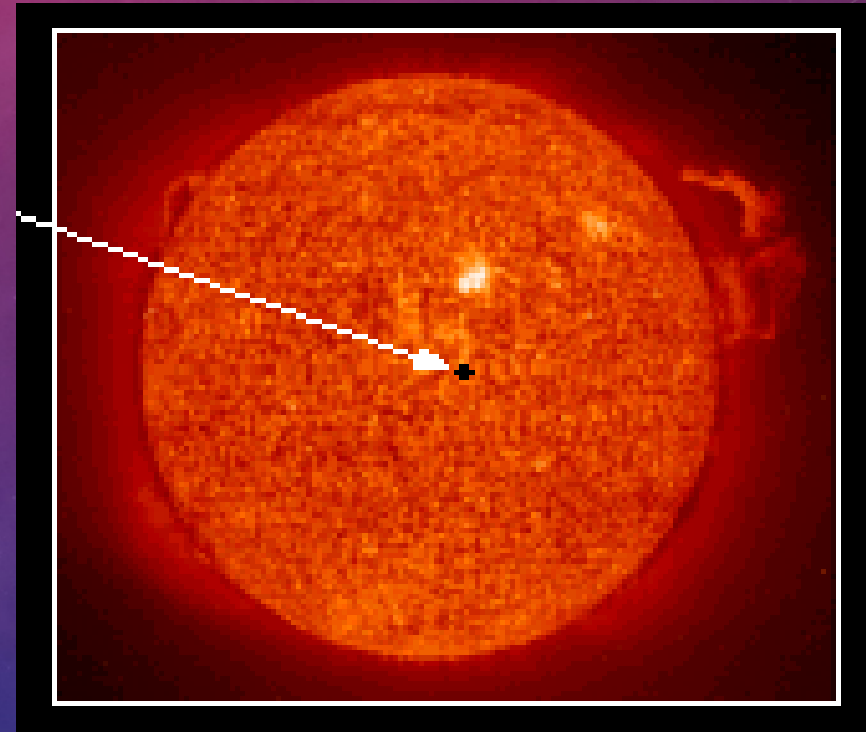
What is the Sun's structure and source of energy?

Key Vocabulary:

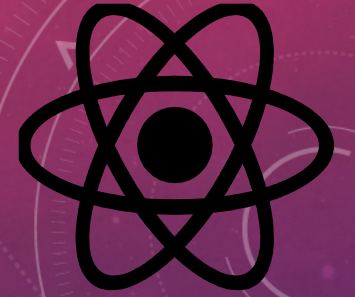
- Fusion
- Photosphere
- Corona
- Solar wind
- Plasma
- Chromosphere
- Sunspot
- Aurora

THE SUN'S SIZE, HEAT, AND STRUCTURE

The black dot represents the approximate size of our Earth when compared to the Sun.



THE SUN'S ENERGY



All stars, including our Sun, get their energy from **fusion**.

Fusion is the **combining** of the nuclei of **lighter elements** to **form** a **heavier element**. Matter is converted into energy during fusion.

THE SUN'S ENERGY

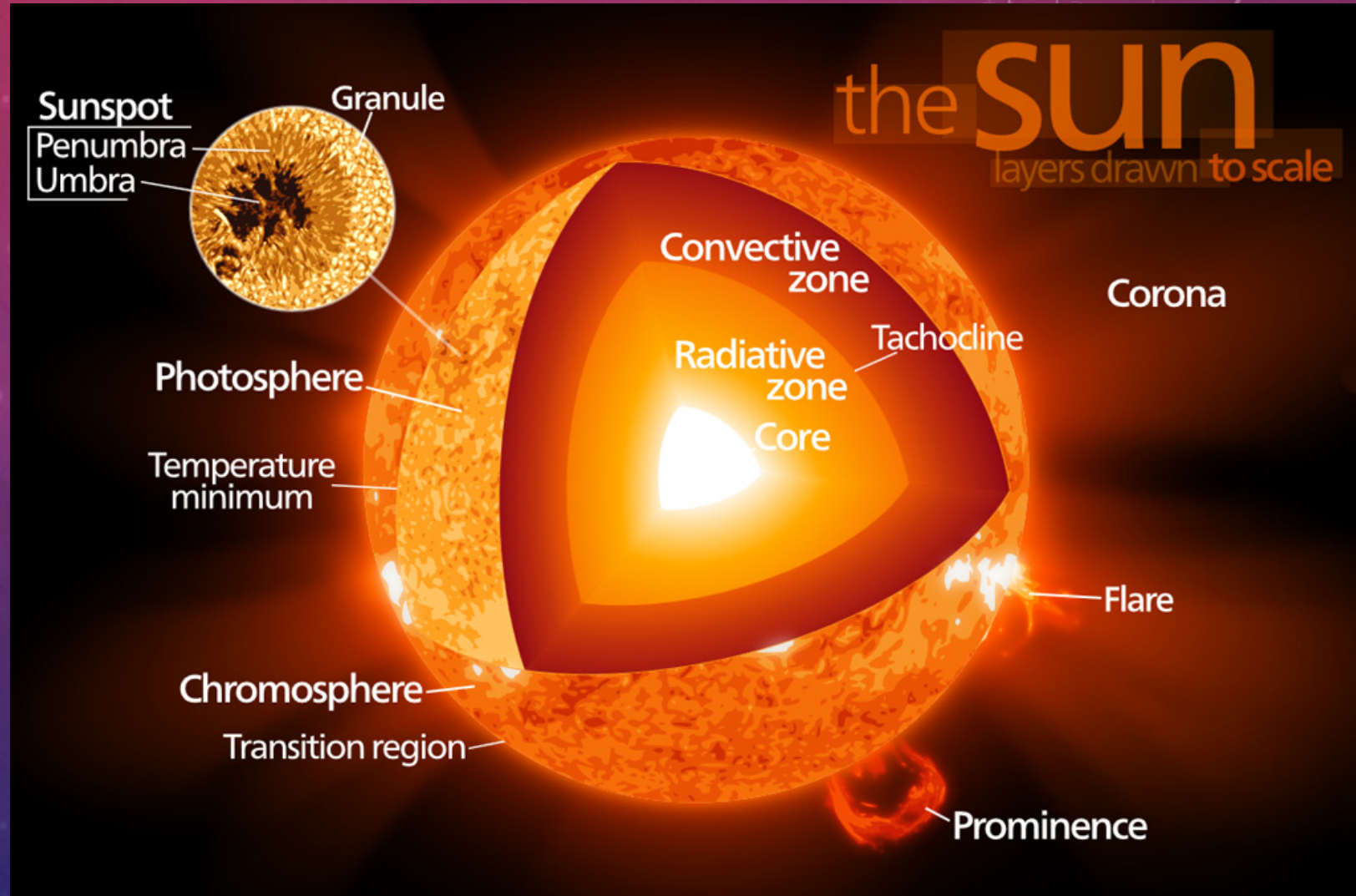
A star has intense heat and pressure – so intense that atoms are torn apart into their component nuclei and electrons. As a result, elements such as hydrogen and helium exist as plasma.

Plasma is a fourth state of matter consisting of charged particles: Nuclei (or ions) that are positively charged and electrons that are negatively charged.

The nuclei normally repel each other. Due to the speed at which they move, and the crowding and heat, nuclei come together and fuse. **

THE SUN'S LAYERS

From the surface of the sun to its center, the temperature can be assumed to steadily increase.**



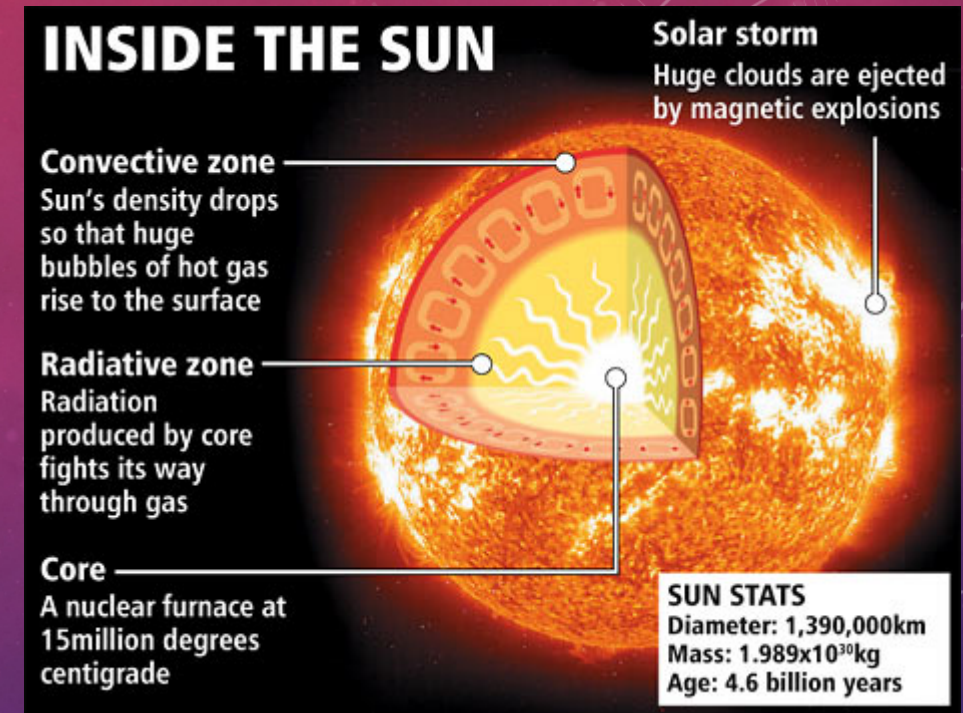
THE SUN'S LAYERS

Energy produced inside the Sun pushes outward. This is balanced by the force of gravity drawing the outer layers inward.

Because the sun is made of gas, no sharp boundaries exist between its various layers. We can divide the sun into four parts: the core; the visible surface, or photosphere; and two atmospheric layers, the chromosphere and corona.

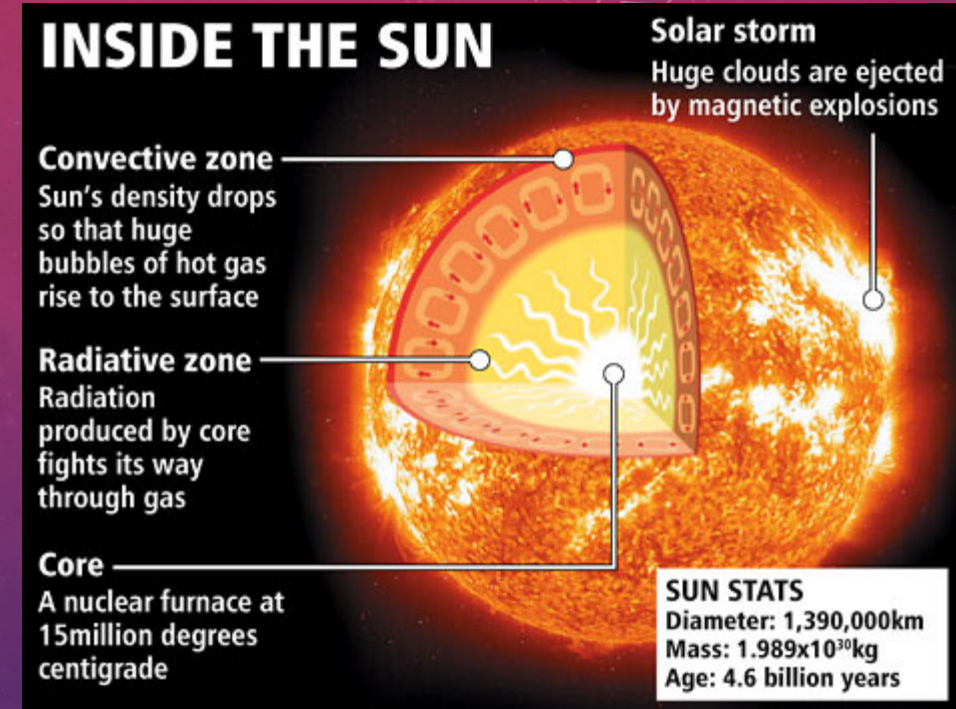
THE CORE – SOLAR INTERIOR

- Consists mostly of hydrogen and helium ions in a plasma state (more than 100 times as dense as water).
- Temperatures reach about 15,600,000° Celsius.
- This is where fusion takes place. **



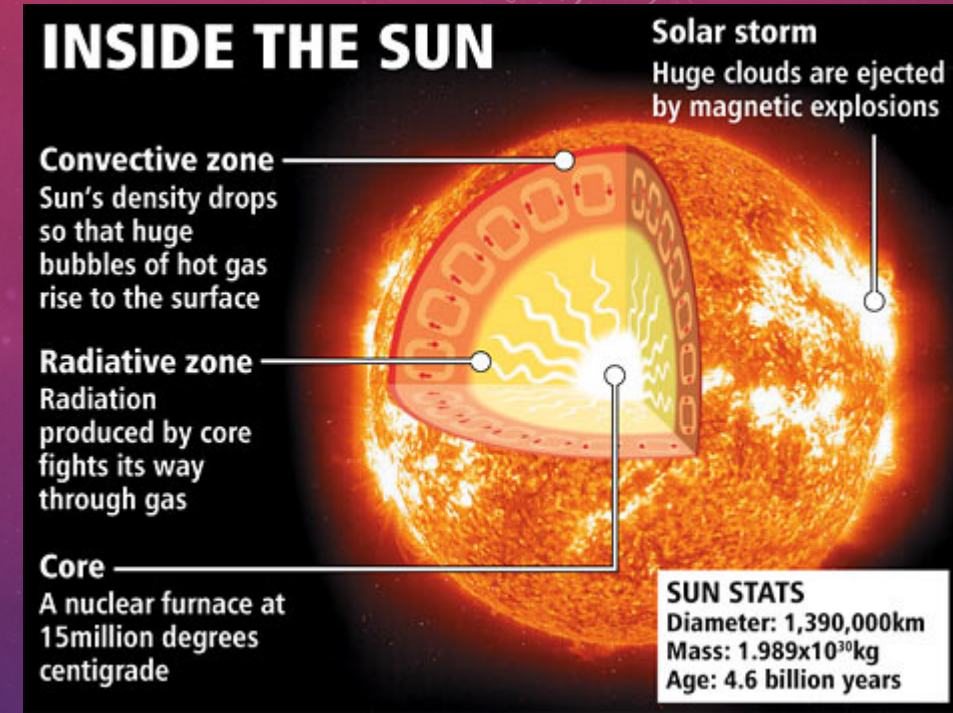
RADIATIVE ZONE

- Another layer of plasma.
- Temperature ranges from about 8,000,000° Celsius near the Core to about 2,000,000° Celsius near the Convection Zone.



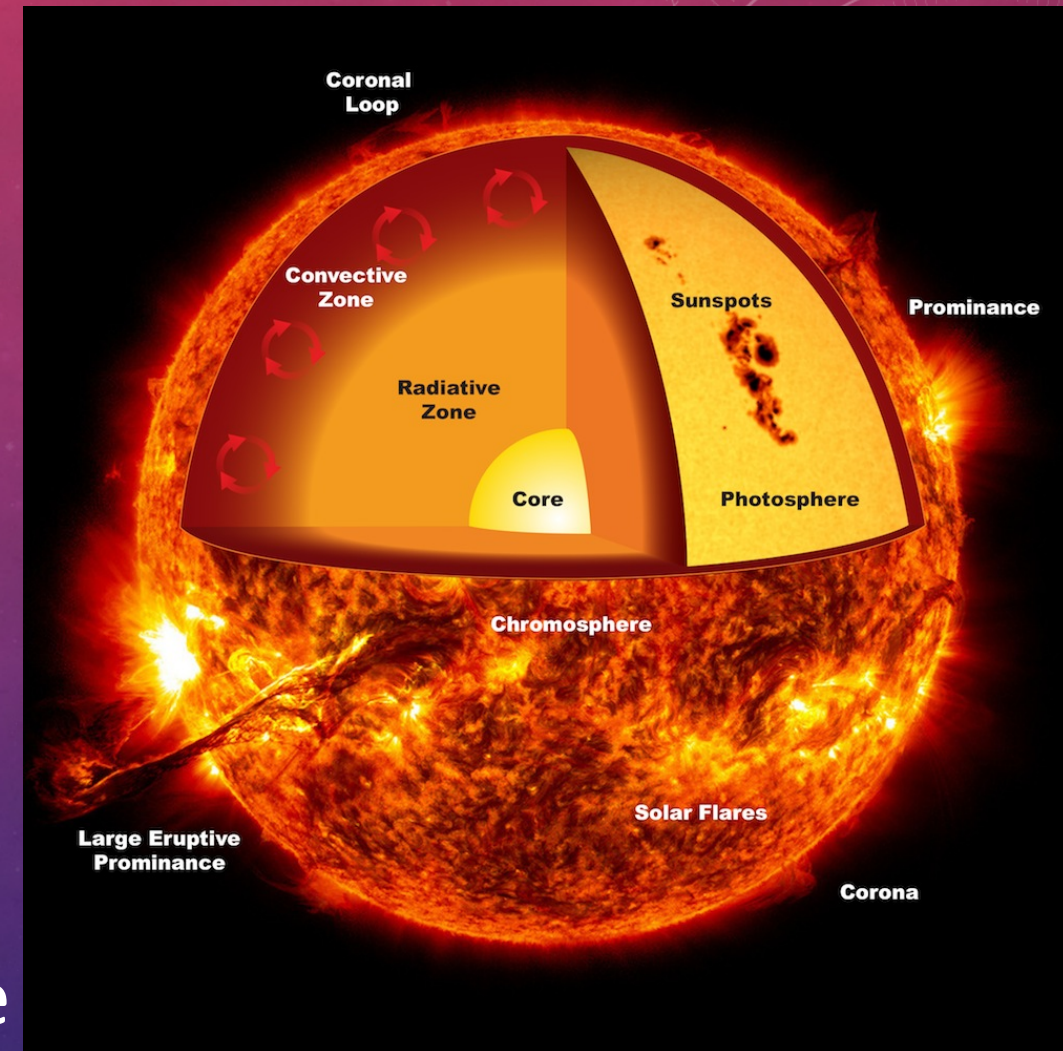
CONVECTION ZONE

- Rising and falling currents of plasma carry energy to the Sun's surface, where it is radiated out into space as sunlight.
- Temperatures reach about 1,500,000° Celsius.



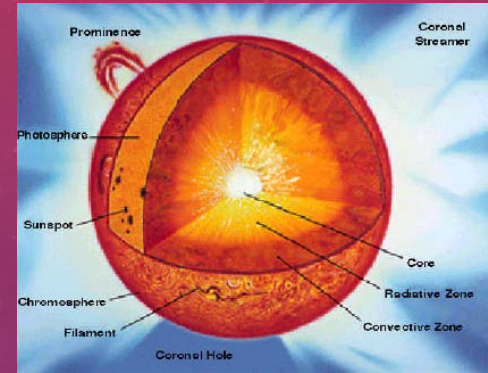
PHOTOSPHERE

- The visible surface of the Sun.**
- The tops of the rising currents from the Convection Zone form structures called granules.
- The temperature is “only” about 6,000° Celsius.
- Energy is radiated out here into space as sunlight.
- Sunspots are found here.

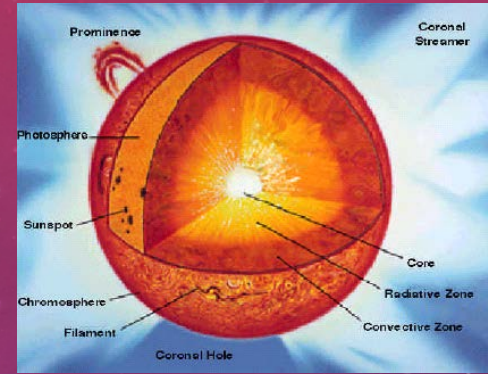


CHROMOSPHERE

- The inner layer of the Sun's atmosphere that extends thousands of kilometers above the Photosphere.
- The 20,000°C Celsius temperature causes the hydrogen to emit light with a distinctive reddish color.
- Solar prominences are found here.



CORONA



- The Sun's thin outer atmosphere.
- The Corona is a million times less bright than the Photosphere.
- The temperature ranges from $1,000,000^{\circ}$ to $3,000,000^{\circ}$ Celsius.

THE SUN'S DISTANCE FROM THE EARTH

The average distance that the Earth is from the Sun is 150,000,000 kilometers.** Astronomers have defined this distance as 1 AU. “AU” stands for Astronomical Unit.



1 AU

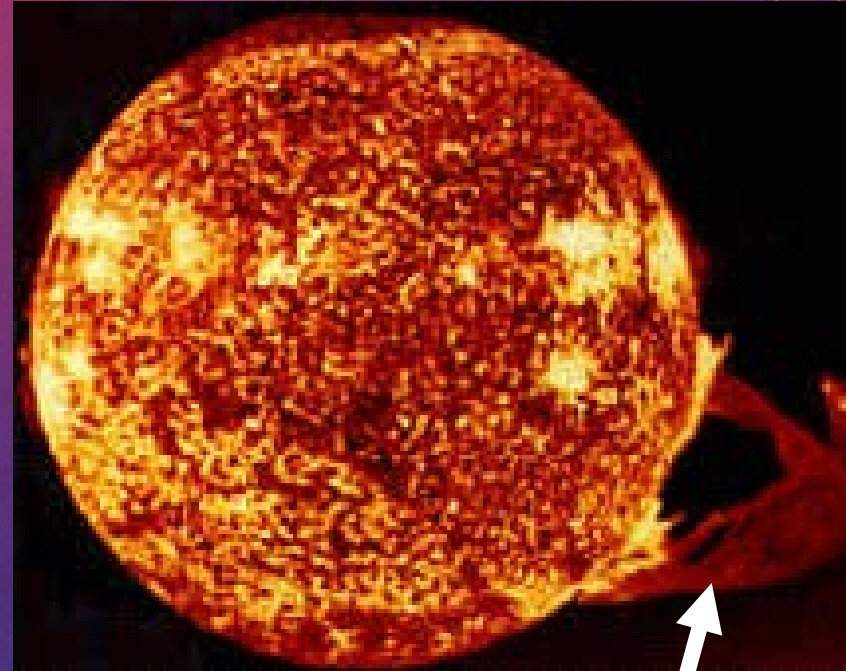


FEATURES ON THE SUN

- Solar prominences
- Sunspots
- Solar wind
- Auroras

SOLAR PROMINENCES

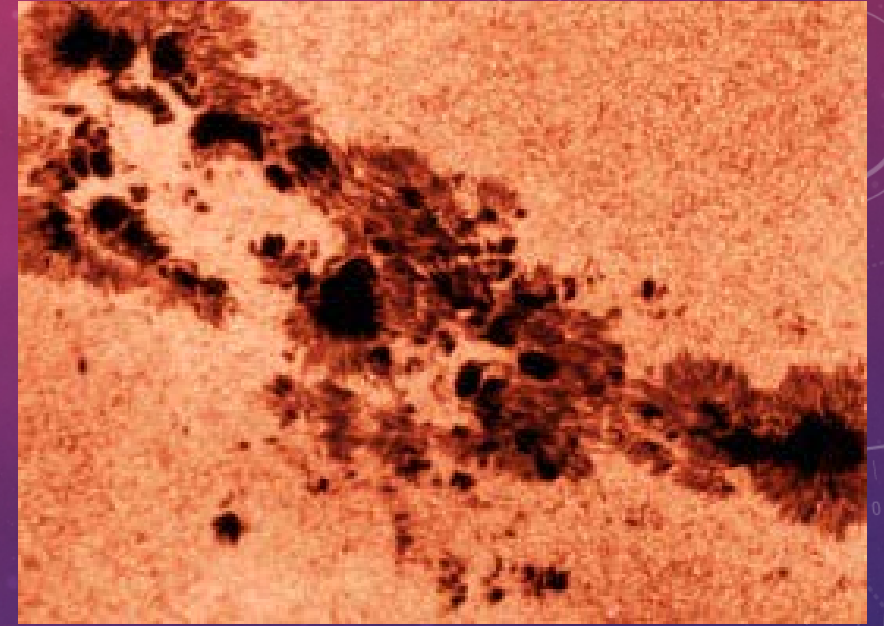
Solar prominences are dense clouds of material suspended above the Sun's surface by magnetic fields. They can erupt off the Sun in just a few minutes or hours, extending thousands of kilometers into space before falling back to the Sun's surface.



SUNSPOTS

Sunspots are dark spots on the Photosphere. Some are barely visible, others are four times larger than Earth's diameter.

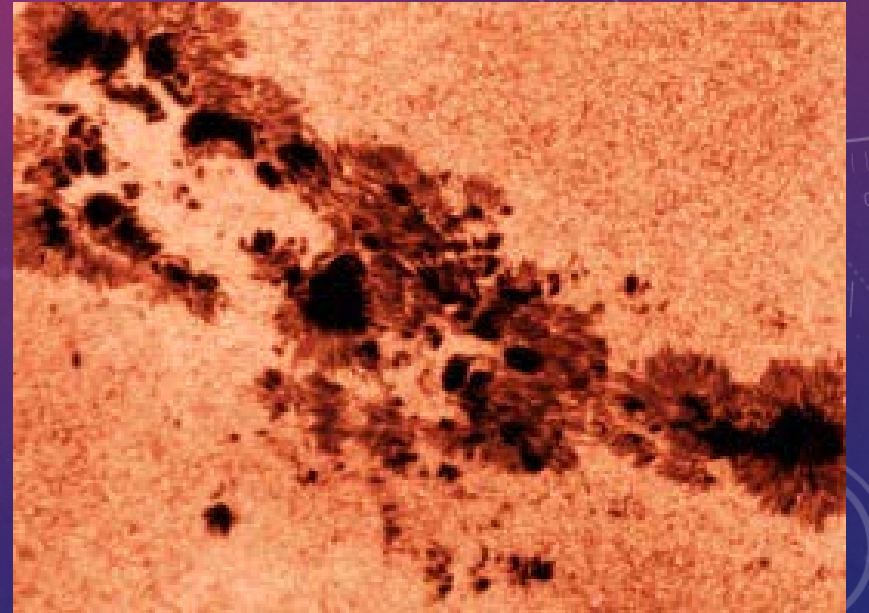
Small sunspots may be visible for a few hours, whereas larger ones may remain visible for a few months.



SUNSPOTS

Sunspots are actually very hot and bright. They look dark in pictures because the surrounding Photosphere is so much hotter and brighter.

The magnetic field associated with a sunspot is about 1,000 times stronger than the magnetic field of the surrounding Photosphere.



SUNSPOTS

We can watch sunspots move from left to right across the Sun's surface. This tells us that the Sun rotates on its axis.

The Sun is not solid, so its rate of rotation varies from place to place. The rate of rotation at the equator is a little over 25 days, while near the poles, the rate is about 34 days. (=faster at the equator than the at the poles).**

SUNSPOTS

The number of visible sunspots varies from day to day. At times of peak solar activity, more than 100 sunspots can be seen. During periods of low solar activity, several days may pass where no sunspots are visible.

The sunspot cycle averages about 11 years from one period of peak activity to the next.

THE SOLAR WIND AND MAGNETIC STORMS

The corona gives off a constant stream of electrically charged particles ** called the solar wind.

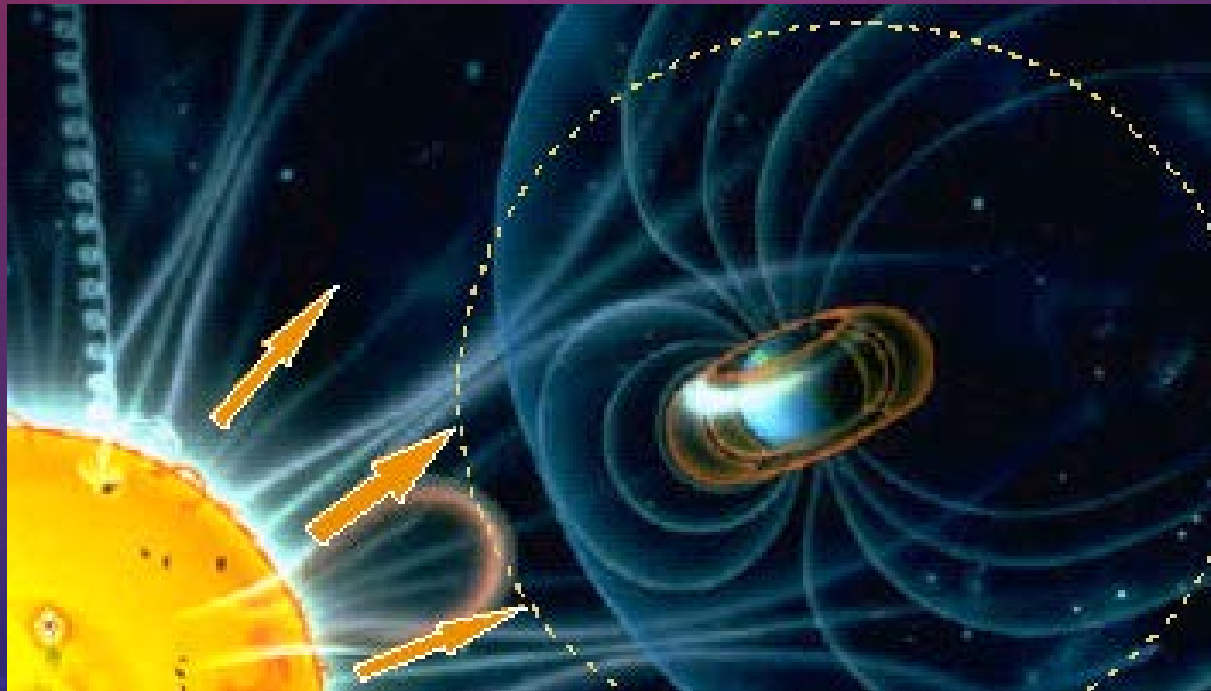
These particles travel in all directions at a speed of about 450 kilometers per second (reaching Earth in a few days).

Earth's magnetic field deflects most of the solar wind particles around the planet.

← Solar flares (outbursts of light that rise up suddenly in areas of sunspot activity) are another source of solar wind bursts.

THE SOLAR WIND AND MAGNETIC STORMS

Earth's magnetic field shields us from solar wind. Without this field, Earth's surface would be bombarded by particles that are very harmful to life.



THE SOLAR WIND AND MAGNETIC STORMS

Some particles (of the solar wind) do interact with the magnetic field and our upper atmosphere. This causes auroras, which are displays of color and light appearing in the upper atmosphere.

Auroras are also called the “northern lights” or the “southern lights”, and are common events in the regions near Earth’s magnetic poles.

TICKET OUT THE DOOR

- 1. Where does fusion take place?
- 2. What is the average distance of the Earth from the Sun?
- 3. Name 4 features of the sun.

SECTION 26.1: REVIEW

1. How does a plasma differ from a gas?
2. Describe how the temperature of the sun changes as you move from the sun's core out to the corona.
3. How does the solar wind affect Earth?
4. Use your knowledge about Earth's magnetic field and solar winds to explain why auroras are not always visible from temperate regions.

SECTION 26.2: OBSERVING THE SOLAR SYSTEM

Objectives:

- Describe the early models of the movements of planets and stars.
- Explain Newton's Law of Gravitation.

Key Vocabulary:

- Geocentric
- Heliocentric
- Gravitation

OBSERVING THE SOLAR SYSTEM: A HISTORY

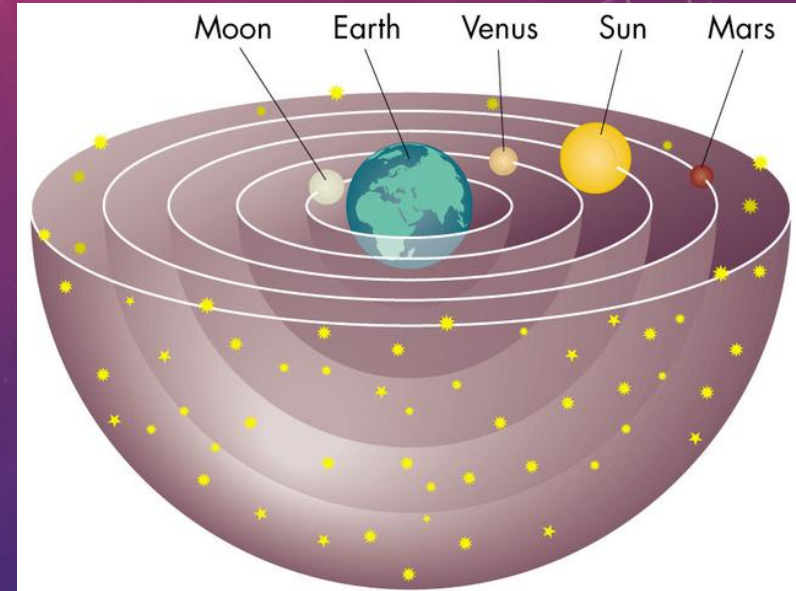
When you look up and notice that the sun has moved from east to west over the course of a few hours, doesn't it seem as though Earth is standing still and the sun is moving across the sky?

This perception – that the Earth is stationary – was the basis of ancient Greek theories that prevailed for over two thousand years.

THE MOVEMENT OF PLANETS AND STARS

For thousands of years, the predominant model of the universe stated that the Earth stood still in the center of the universe.

Such a model of the universe is called a geocentric model —** meaning “Earth-centered”.



THE MOVEMENT OF PLANETS AND STARS

Ancient astronomers (as long as 6000 years ago) noticed that the stars appeared to move across the sky, but they did not move in relation to each other.

To explain this, the astronomers envisioned the stars as holes in a solid celestial sphere that surrounded Earth. Beyond the sphere, they imagined a source of intense light that shone through the holes. They concluded that the stars moved around Earth as the sphere rotated.

THE MOVEMENT OF PLANETS AND STARS

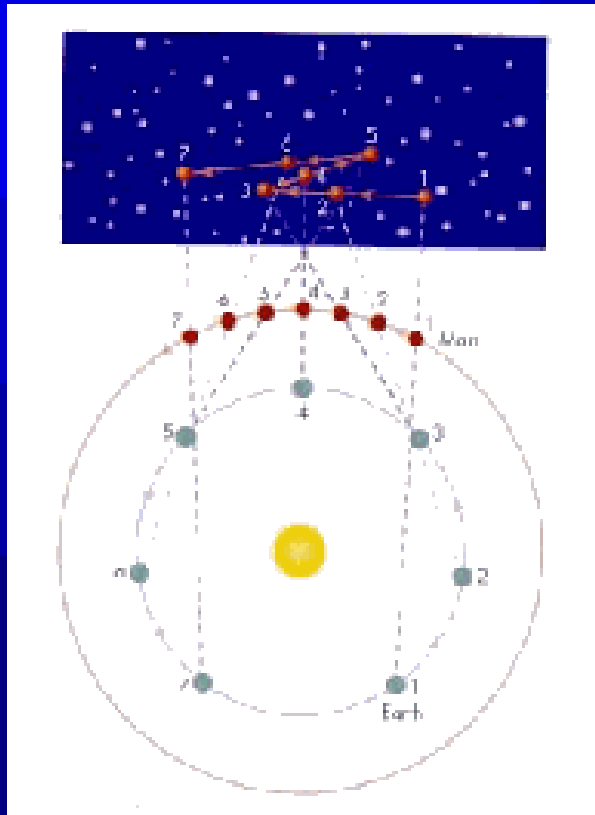
Lights that wandered across the sky were correctly identified as planets.

Early astronomers noticed that most of the time the planets moved eastward in front of the background of constellations. Periodically, the planets stopped moving eastward and moved westward for a few weeks, then resumed their eastward paths.

The pattern of apparent backward motion is called retrograde motion.

THE MOVEMENT OF PLANETS AND STARS

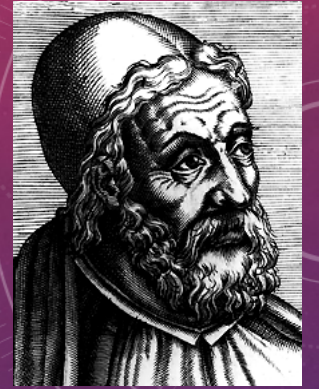
Explaining Retrograde Motion



- ◆ The earth goes around the sun at a faster rate than does Mars.
- ◆ The earth is at position Earth 1 at the same time that Mars is at position Mars 1.
- ◆ An observer on earth sees Mars *against the background of stars* as being at position star 1.
- ◆ Note what happens to what an observer on earth sees as the two planets move to positions 2, 3, 4, 5, 6, and 7.

PTOLEMY'S GEOCENTRIC MODEL

- Real name was Claudius Ptolemaeus.
- **Developed first model used to “predict” location of planets.**
- His model assigned small circular orbits to the planets (epicycles). The center of each small orbit moved around Earth on a larger circular orbit (deferent).
- Even though observations didn't always match his model, it was used by astronomers until the 16th century.



COPERNICUS'S** HELIOCENTRIC MODEL

- Proposed the heliocentric (or “Sun-centered”) model of the universe.
- Suggested that Earth rotated and was a planet that revolved around the Sun just like the other planets.
- Retrograde motion was explained by planets moving at different speeds,** and orbiting at different distances from the sun.

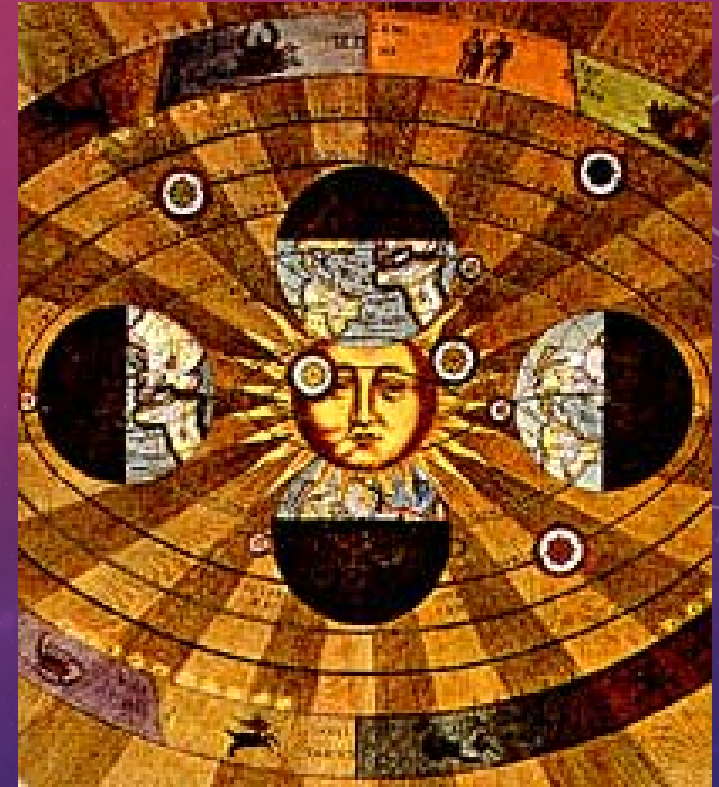


Nicolaus Copernicus

HELIOCENTRIC MODEL

The heliocentric model is the basis for our modern understanding of the universe.

The model is still not completely correct however, as Copernicus still has planets with circular orbits.



Sun-centered model

TYCHO, KEPLER, AND PLANETARY MOTION

Tycho Brahe was an observational astronomer. He studied the stars without the aid of a telescope.

Brahe tracked and measured the movements of the moon, planets, and other celestial objects. These were the most precise measurements taken before the invention of the telescope.



Tycho Brahe

TYCHO, KEPLER, AND PLANETARY MOTION

Johannes Kepler was a mathematician who worked for Tycho Brahe. After Brahe died, he analyzed Brahe's data, which helped him develop his three laws of planetary motion.



Johannes Kepler

KEPLER'S LAWS OF PLANETARY MOTION

- Law #1: The planets move in elliptical orbits (not circular).**
- The Sun is at one focus of the ellipse.
- Because the orbit is elliptical, a planet's distance from the Sun will change throughout its orbit.

KEPLER'S LAWS OF PLANETARY MOTION

- Law #2: The closer a planet comes to the Sun, the more rapidly it moves.**
- Known as the “equal area” law.
- While Kepler thought a planet would not have a constant speed while in orbit, he wasn't able to explain why.

KEPLER'S LAWS OF PLANETARY MOTION

- Law #3: The square of the period (in years) for one revolution equals the cube of the mean distance from the Sun's center.
- Known as the “harmonic” law.
- The formula would let someone find the distance between the sun and a planet (if the period was known), or find the period of a planet (if the distance was known).

ISAAC NEWTON AND THE LAW OF GRAVITATION

Newton's contribution to modern science was enormous.

He invented calculus, studied the composition of light, and established classical physics.

He came up with three laws of motion and the law of gravitation.**



Isaac Newton

NEWTON'S LAWS OF MOTION

- Law #1: An object will move forever in a straight line at the same speed unless some external force changes its direction or speed.
- Law #2: The acceleration of an object multiplied by the mass of the object is equal to the net force acting on the object.
- Law #3: For every action, there is always an equal and opposite reaction.

NEWTON'S** LAW OF GRAVITATION

- Gravitation is a force of attraction between any two objects with mass.
- The strength of the attraction is proportional to their masses (larger objects have a stronger force)** and inversely proportional to the distance between them (the closer the object, the stronger the attraction).
- The force that keeps planets in orbit around the sun is gravity.**

TICKET OUT THE DOOR

- 1. What does the geocentric model refer to or mean?
- 2. What does the heliocentric model refer to or mean?
- 3. Who developed the Law of Gravitation?

SECTION 26.2: REVIEW

1. What is the main difference between geocentric and heliocentric models of the solar system?
2. How did Ptolemy account for retrograde motion in his model of the solar system?
3. Explain how Copernicus's model contributed to modern understanding of the solar system.
4. Draw a diagram to demonstrate why Mars appears to travel westward across the sky most of the time and eastward