Astronomy Regents Review

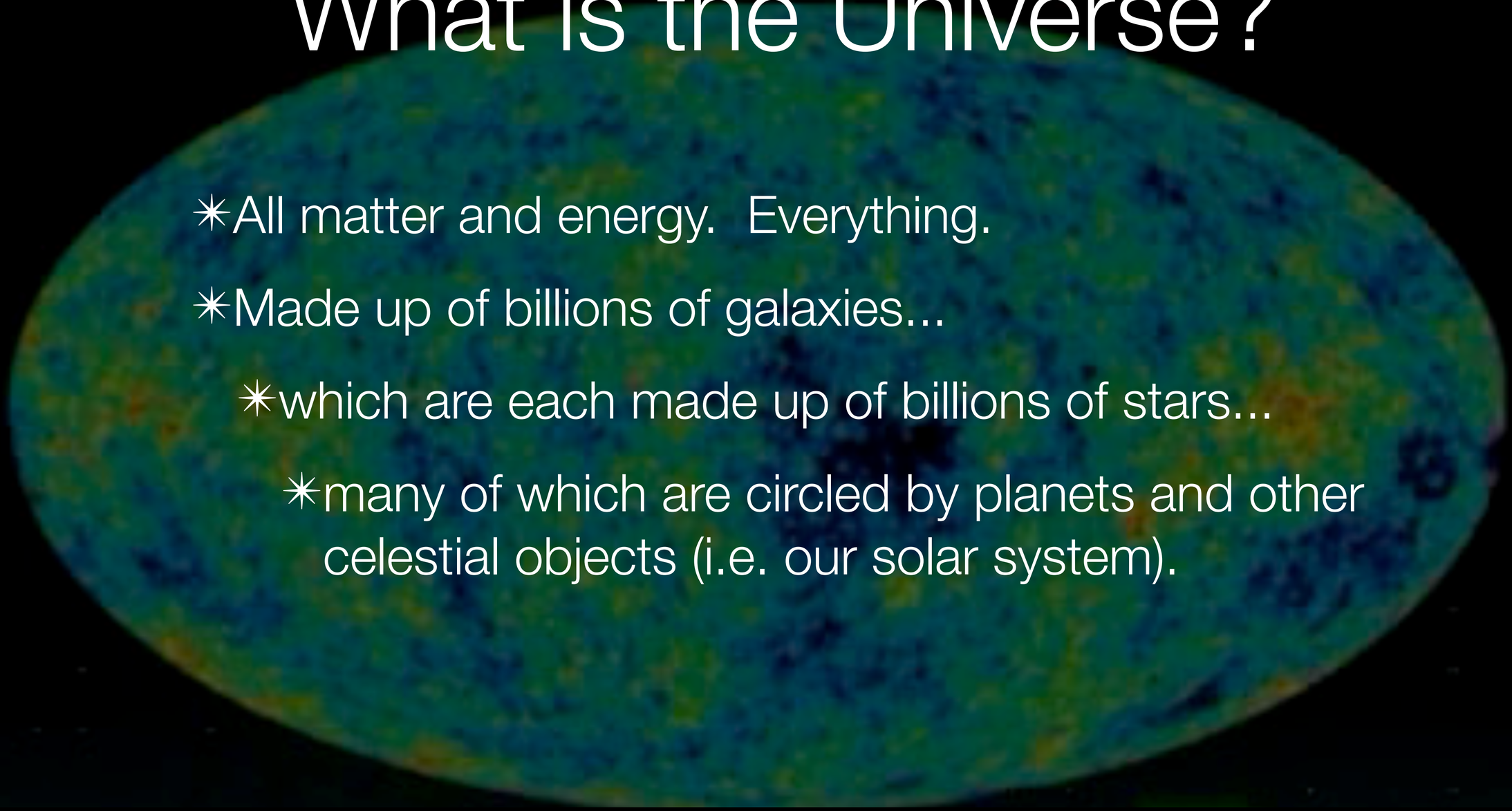



I AM SO READY FOR THIS FINAL!
I'VE STUDIED EVERY NIGHT, REVIEWED THE CHAPTERS, HAD A GOOD NIGHT'S SLEEP...
THIS SHOULD GO VERY WELL.
YOU MAY BEGIN.
HEE-YAAH!

What is Astronomy?

- The study of the Universe, the stars, planets and all other objects in space.

What is the Universe?

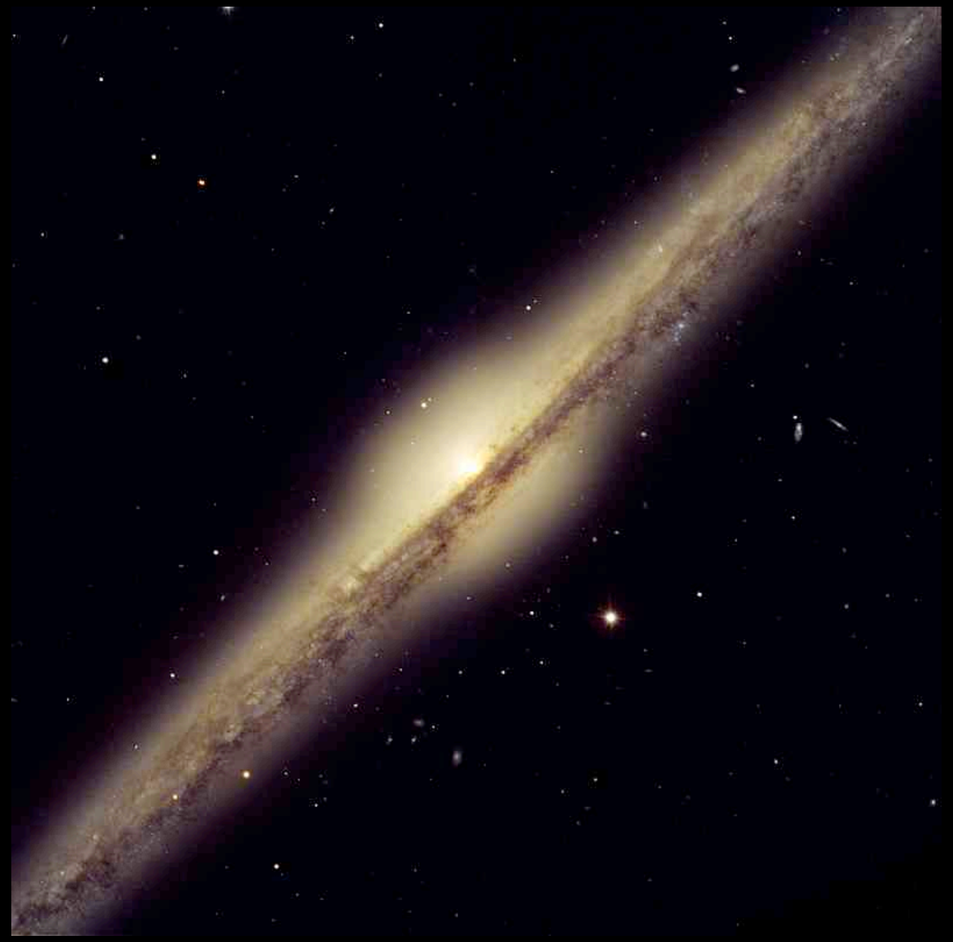


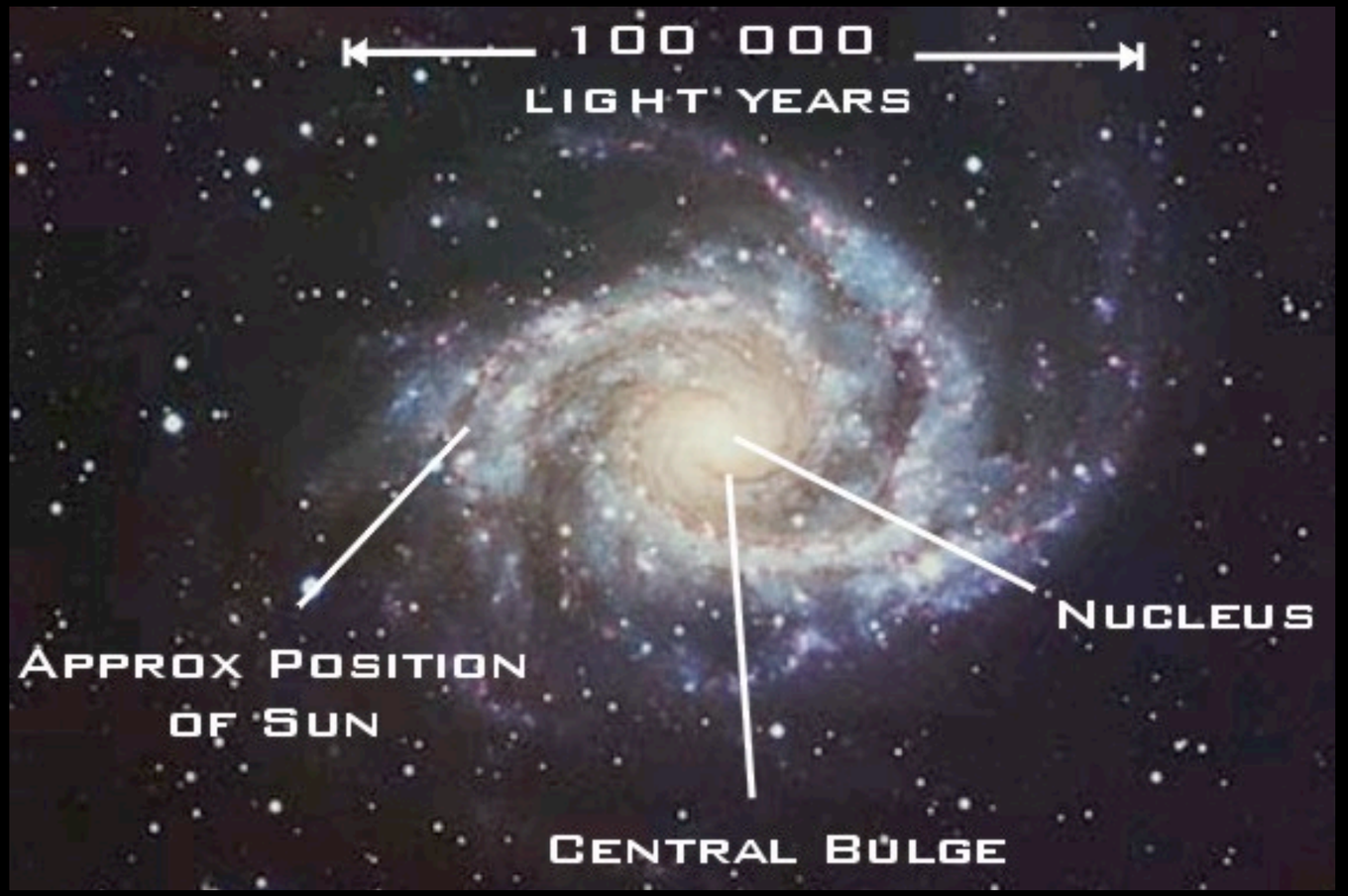
- All matter and energy. Everything.
- Made up of billions of galaxies...
  - which are each made up of billions of stars...
    - many of which are circled by planets and other celestial objects (i.e. our solar system).

What is a Galaxy?

- Types of Galaxies
  - Spiral Galaxies (shaped like pinwheels)
  - Elliptical Galaxies (shaped like flattened blobs)
  - Irregular Galaxies (no definite shape)

Spiral Galaxies

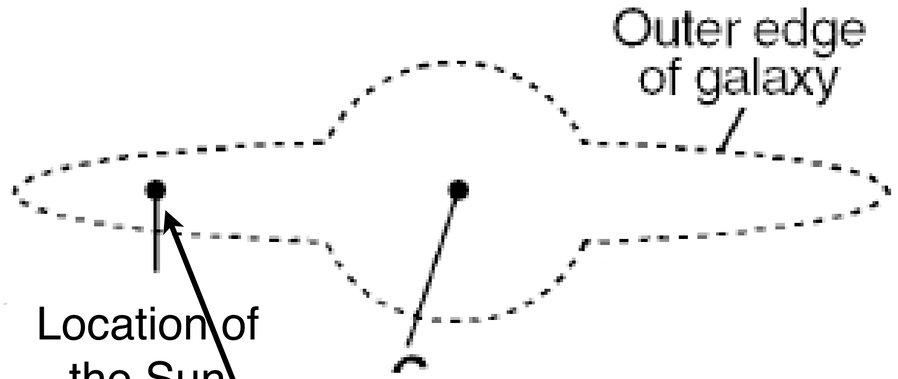




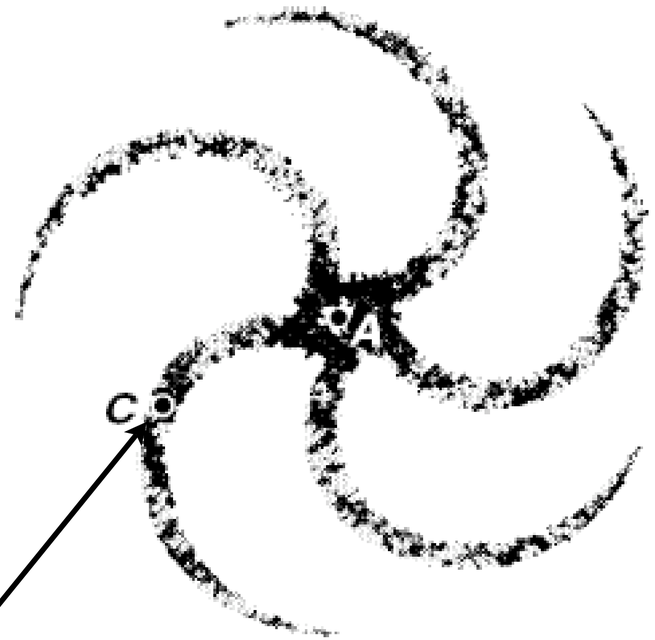
The Milky Way Galaxy looks like this.

The Milky Way Galaxy and Our Solar System

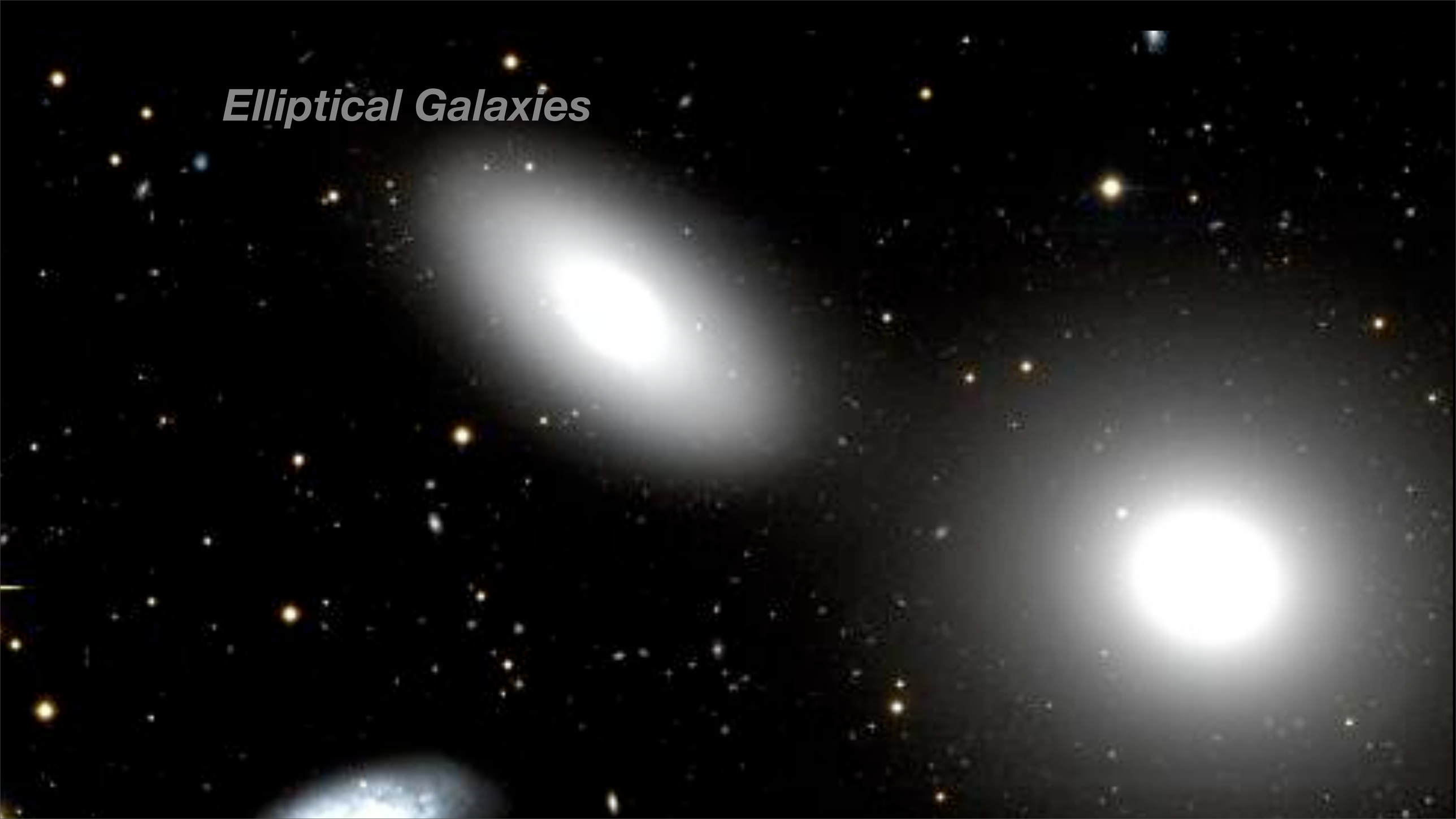
Side-View



Top-View



We are located here.


Elliptical Galaxies

Irregular Galaxies

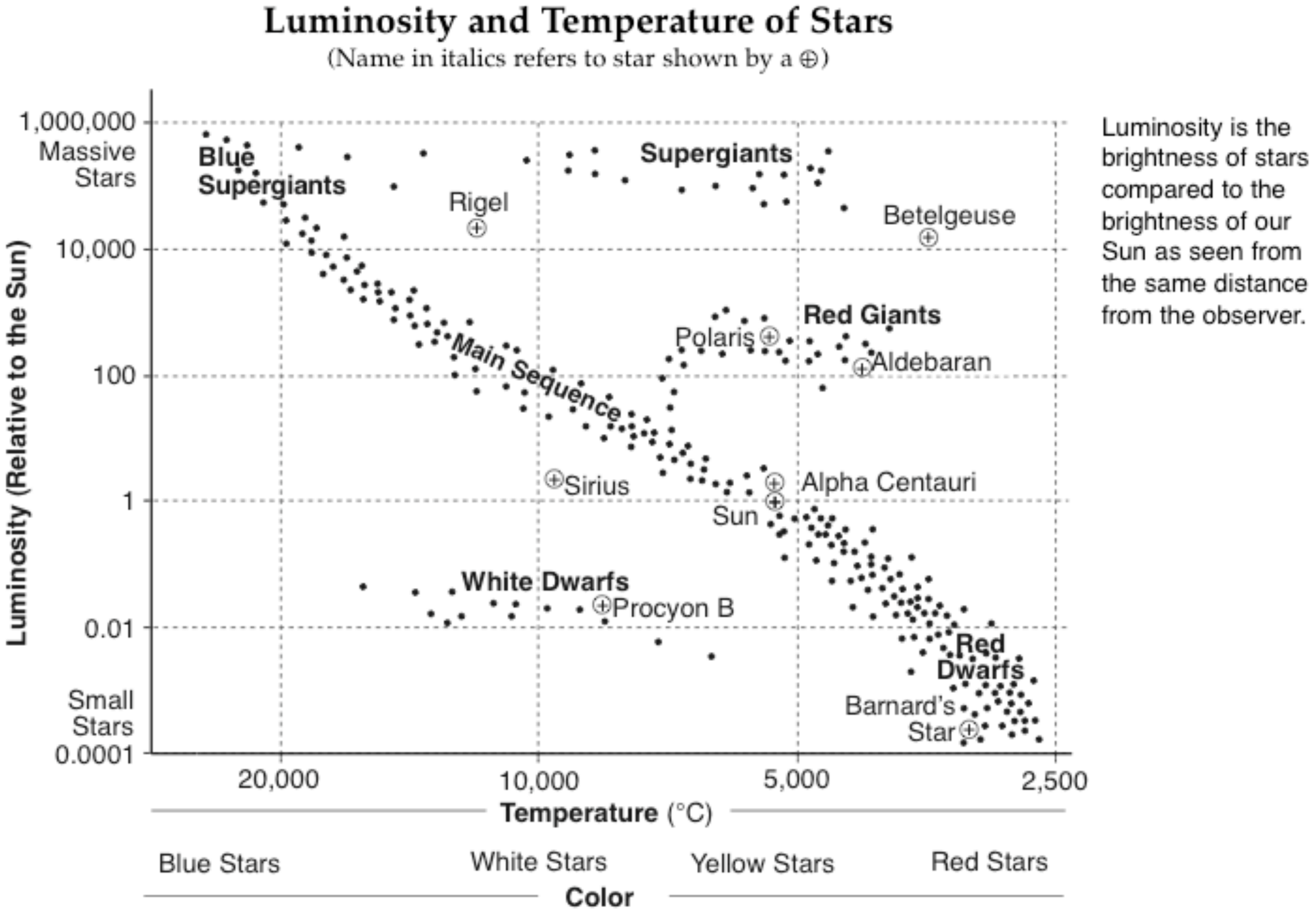




What is a Star?

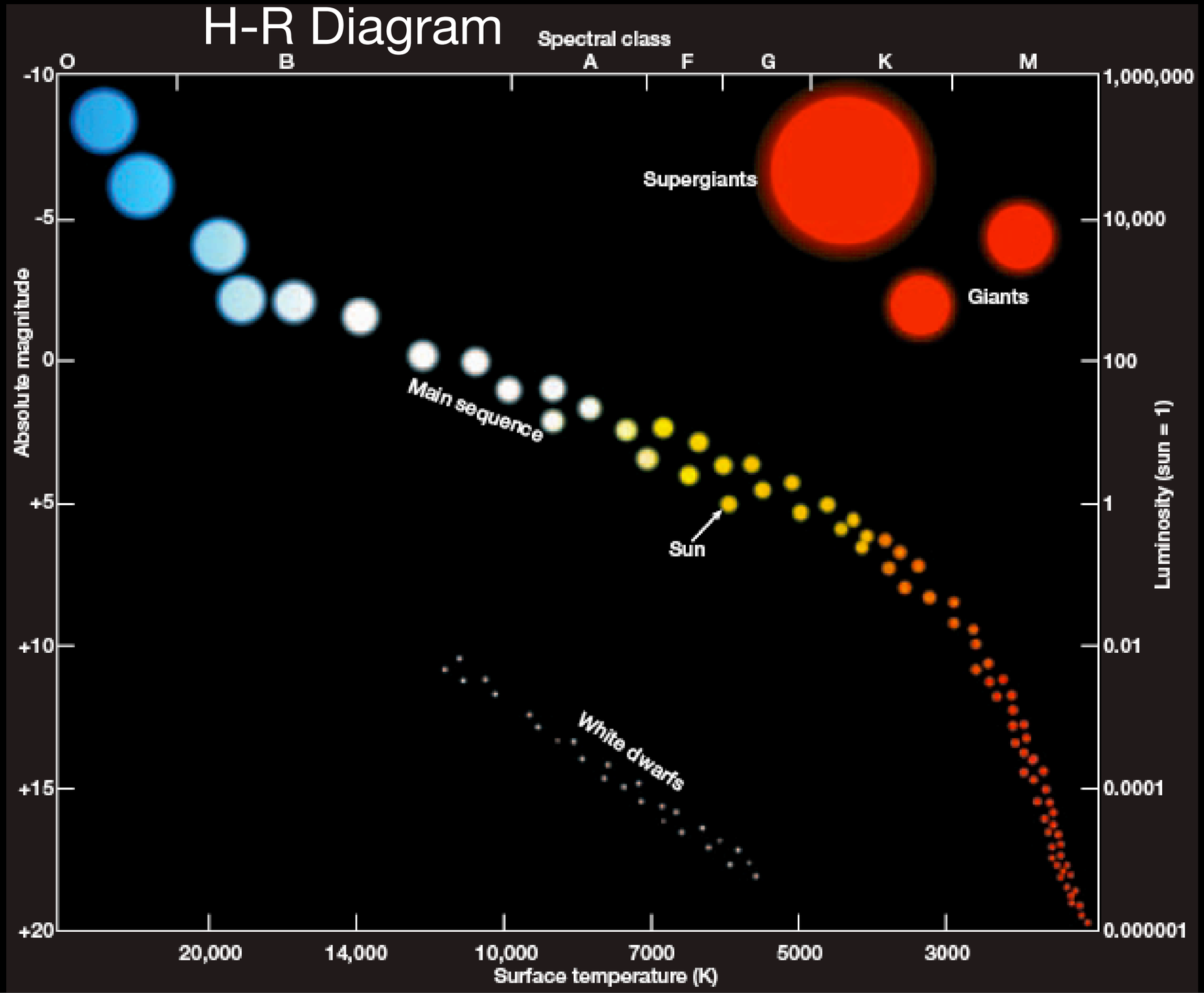
- A very large ball of gas, usually hydrogen and helium, that glows from its own energy.
- Stars are different from planets in that they are “self-luminous”.
- This process, which releases tremendous amounts of energy, is called **fusion**. Where intense heat and pressure within the star actually squeezes the hydrogen atoms together to form helium.
- Stars are not “burning”, rather they are undergoing continuous nuclear reactions.





Luminosity is the brightness of stars compared to the brightness of our Sun as seen from the same distance from the observer.

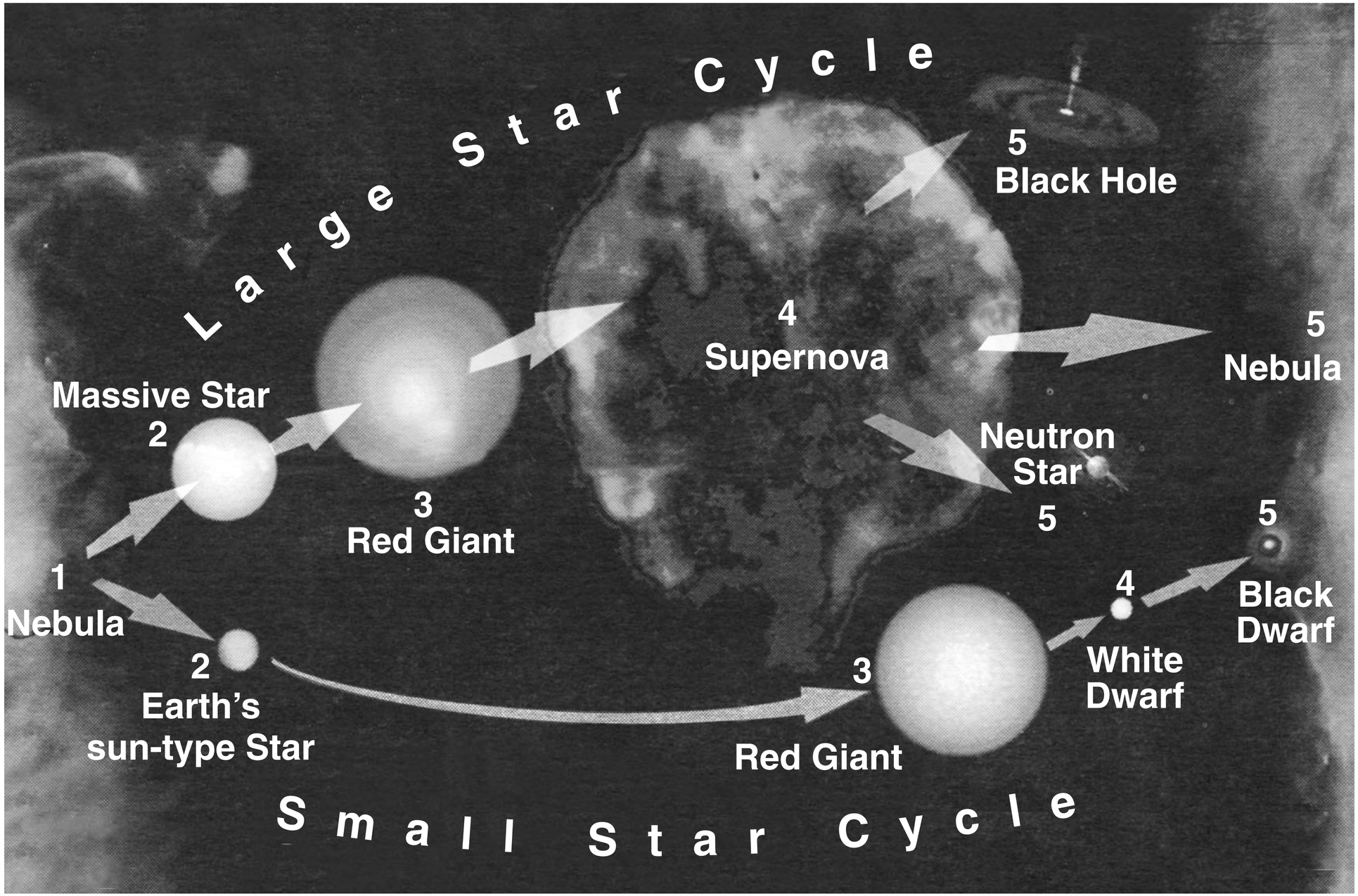
H-R Diagram


Spectral class
O
B
A
F
G
K
M
-10
-5
0
+5
+10
+15
+20
Absolute magnitude
1,000,000
10,000
100
1
0.01
0.0001
0.000001
Luminosity (sun = 1)
Supergiants
Giants
Main sequence
Sun
White dwarfs
20,000
14,000
10,000
7000
5000
3000
Surface temperature (K)

How do Stars form?

- Stars begin their lives as a nebula, a huge cloud of dust and gas in space.
- As gravity pulls the dust and gas together, its temperature rises causing nuclear fusion to begin.
- Fusion turns hydrogen to helium and energy.
- The energy is released as light and the star is born.
- The bigger the star, the shorter its life as it burns its fuel up very quickly.
- Stars will undergo fusion as long as there is enough hydrogen...eventually all stars die.

The Life Cycles of Stars

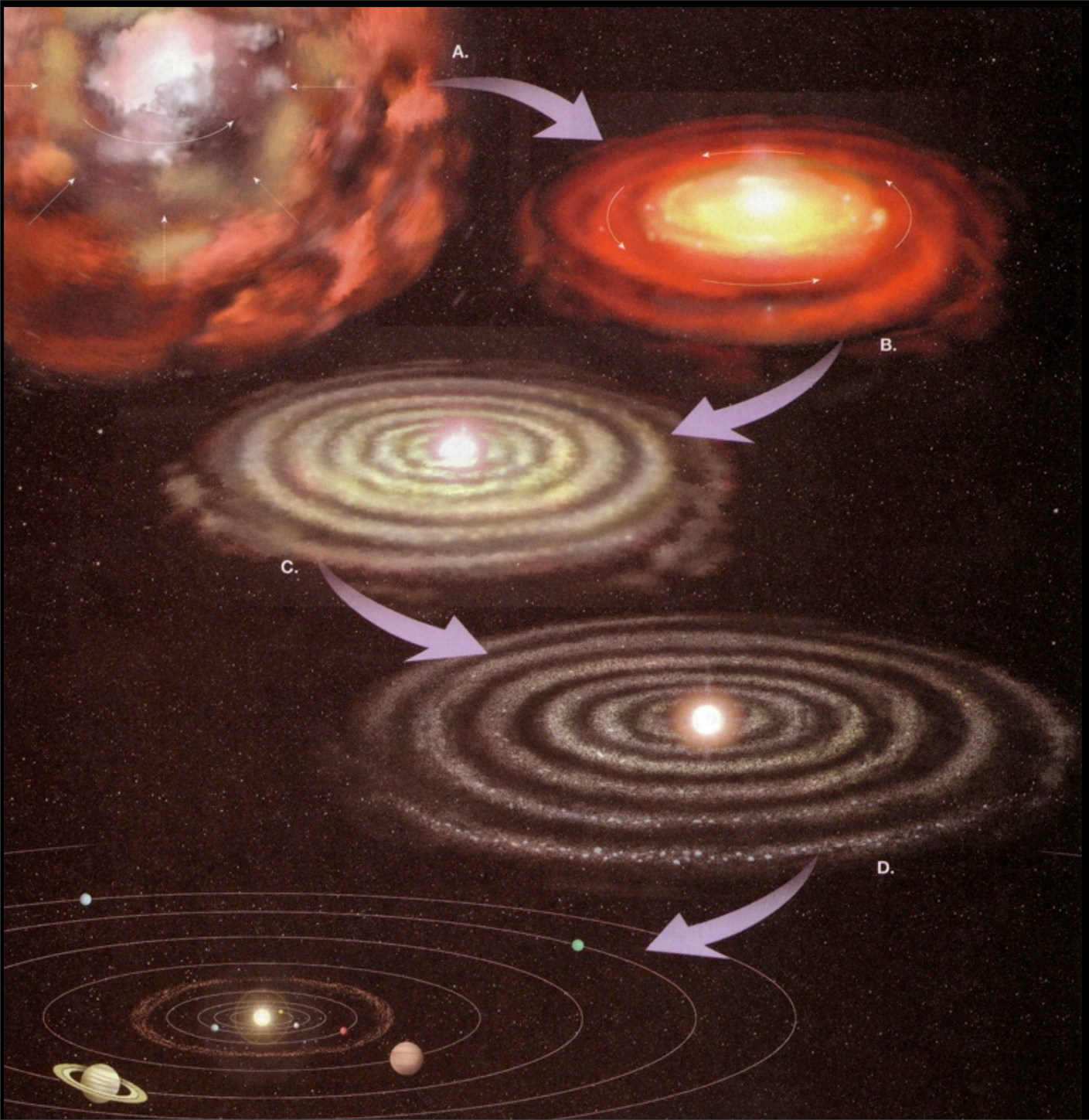


Our Solar System

We believe that our solar system began to form about 5 billion years ago from a vast cloud of gas and dust.



- The giant cloud of dust and gas is called a ***nebula***.
- Nebulae represent the raw material the stars are made of.



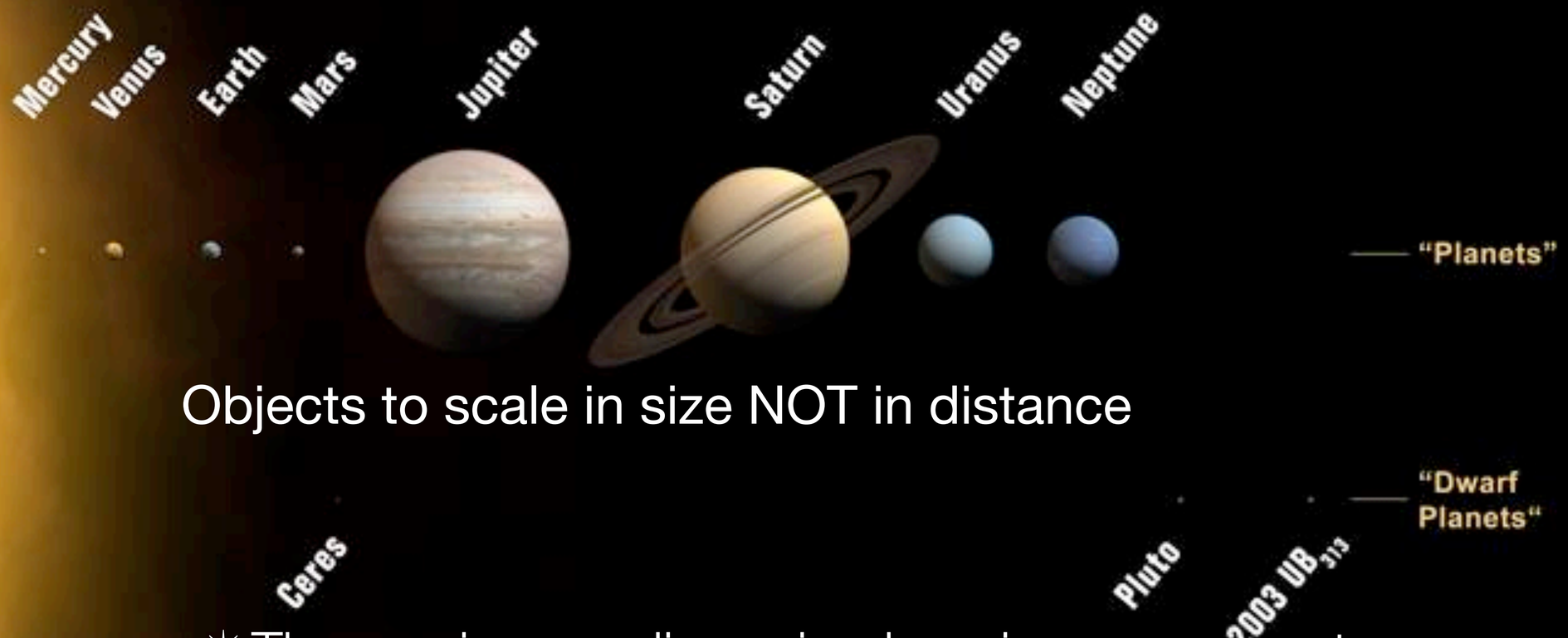
Accretion- The combining of matter to create larger objects. This is how the planets formed.

Our Solar System Today

- Planets
- Moons
- Asteroids
- Meteoroids
- Comets



Our Solar System Today



Objects to scale in size NOT in distance

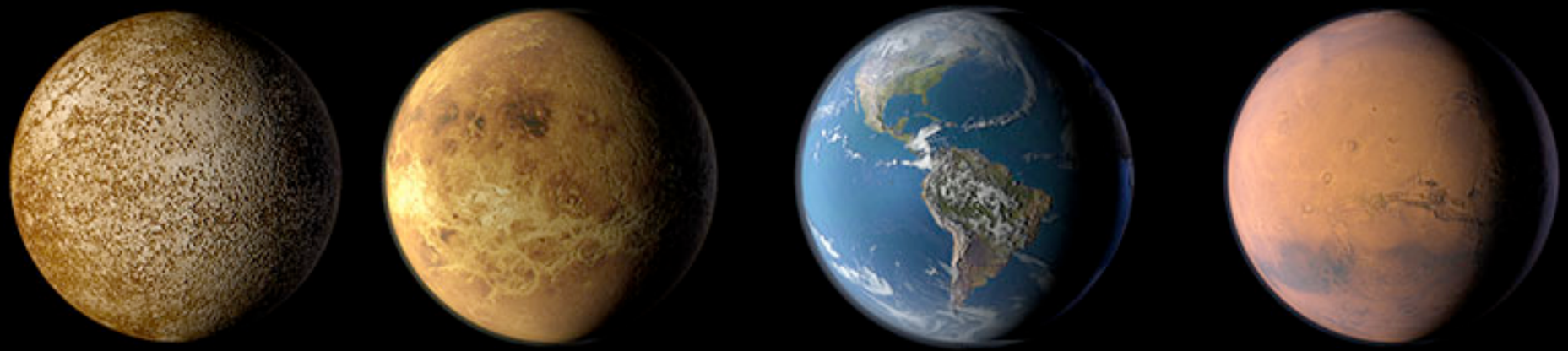
- The sun is a medium-sized, main sequence star about five billion years old.
- The sun is the gravitational center of the solar system.

Planets

- Largest objects that orbit the sun.
- Generally spherical in shape.
- Currently, we classify eight objects in our solar system as planets:
  - Mercury
  - Venus
  - Earth
  - Mars
  - Jupiter
  - Saturn
  - Uranus
  - Neptune

Terrestrial Planets

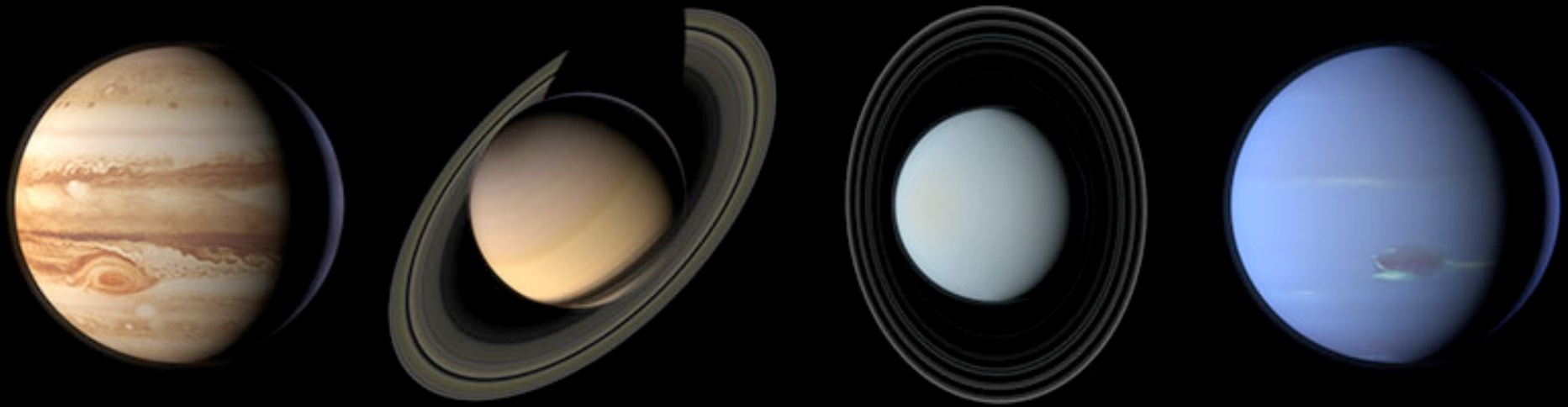
- The inner four planets, Mercury, Venus, Earth and Mars, are called the **terrestrial planets, or Earth-like planets.**
- These planets are small, dense, and rocky.



Objects not to scale

Jovian Planets

- The outer four planets, Jupiter, Saturn, Uranus and Neptune, are called the jovian planets or gas giants.
- These planets are giant, gaseous, and not very dense.

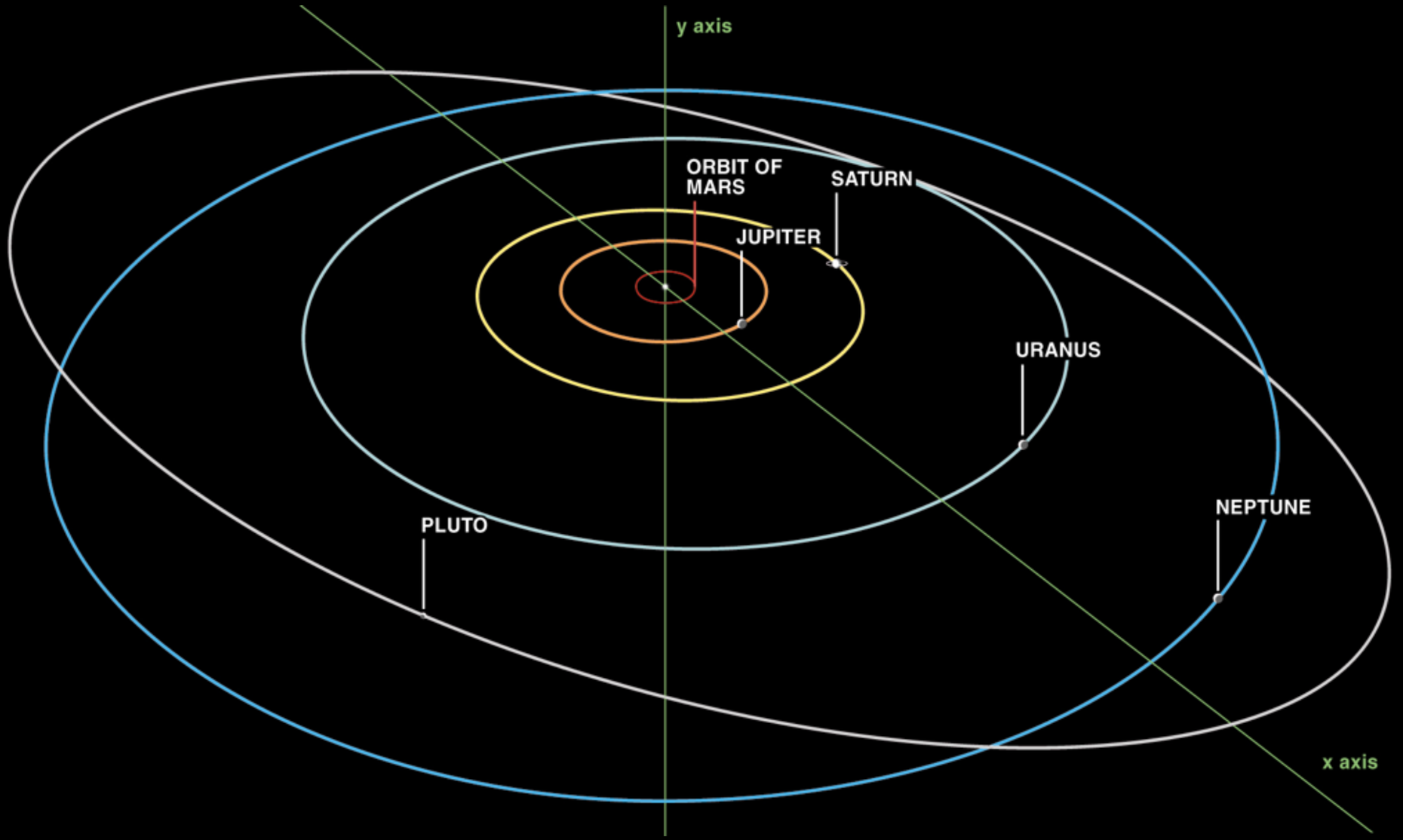


Objects not to scale

Pluto

- Now classified as a **dwarf planet**
- Does not fit with the patterns of the solar system



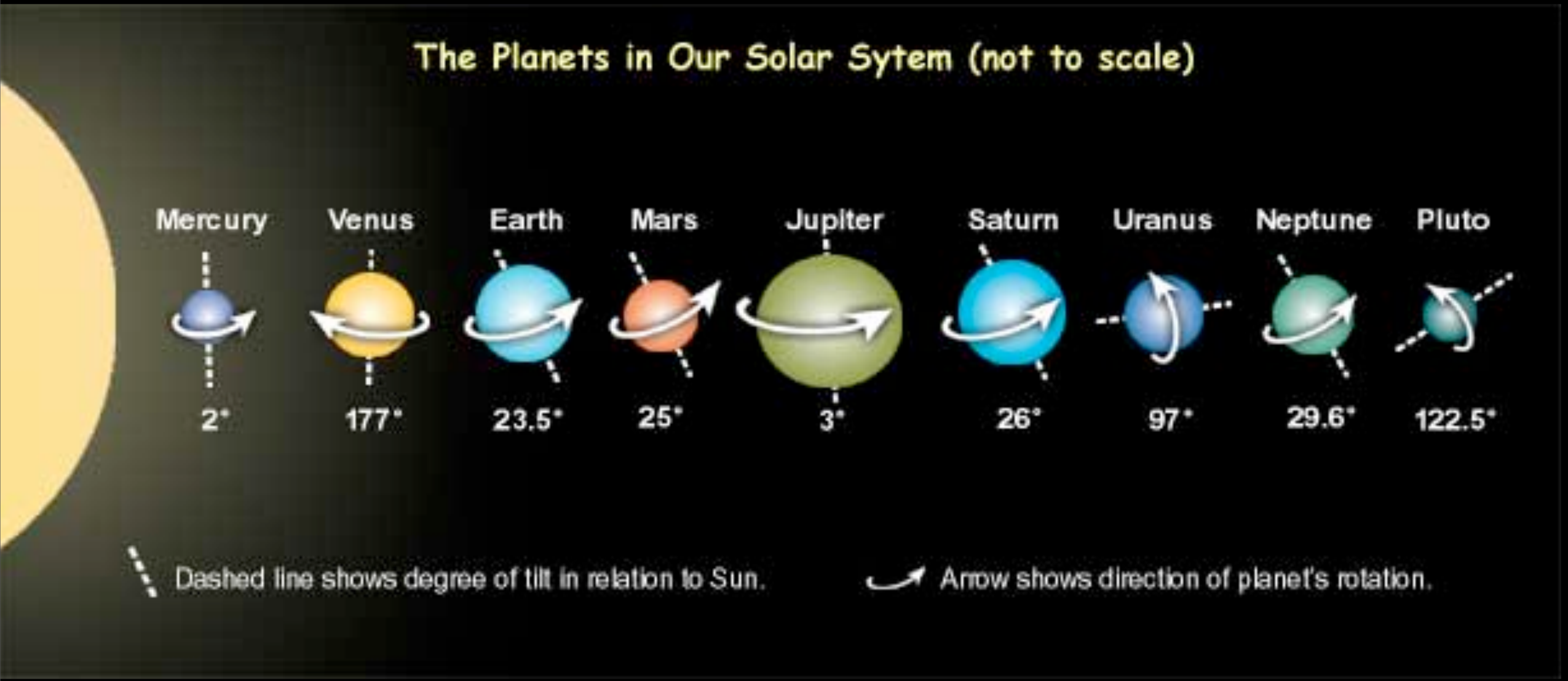

y axis
ORBIT OF MARS
SATURN
JUPITER
URANUS
NEPTUNE
PLUTO
x axis

Solar System Data

Object	Mean Distance from Sun (millions of km)	Period of Revolution	Period of Rotation	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)	Number of Moons
SUN	—	—	27 days	—	1,392,000	333,000.00	1.4	–
MERCURY	57.9	88 days	59 days	0.206	4,880	0.553	5.4	0
VENUS	108.2	224.7 days	243 days	0.007	12,104	0.815	5.2	0
EARTH	149.6	365.26 days	23 hr 56 min 4 sec	0.017	12,756	1.00	5.5	1
MARS	227.9	687 days	24 hr 37 min 23 sec	0.093	6,787	0.1074	3.9	2
JUPITER	778.3	11.86 years	9 hr 50 min 30 sec	0.048	142,800	317.896	1.3	16
SATURN	1,427	29.46 years	10 hr 14 min	0.056	120,000	95.185	0.7	18
URANUS	2,869	84.0 years	17 hr 14 min	0.047	51,800	14.537	1.2	21
NEPTUNE	4,496	164.8 years	16 hr	0.009	49,500	17.151	1.7	8

EARTH'S MOON	149.6 (0.386 from Earth)	27.3 days	27 days 8 hr	0.055	3,476	0.0123	3.3	—

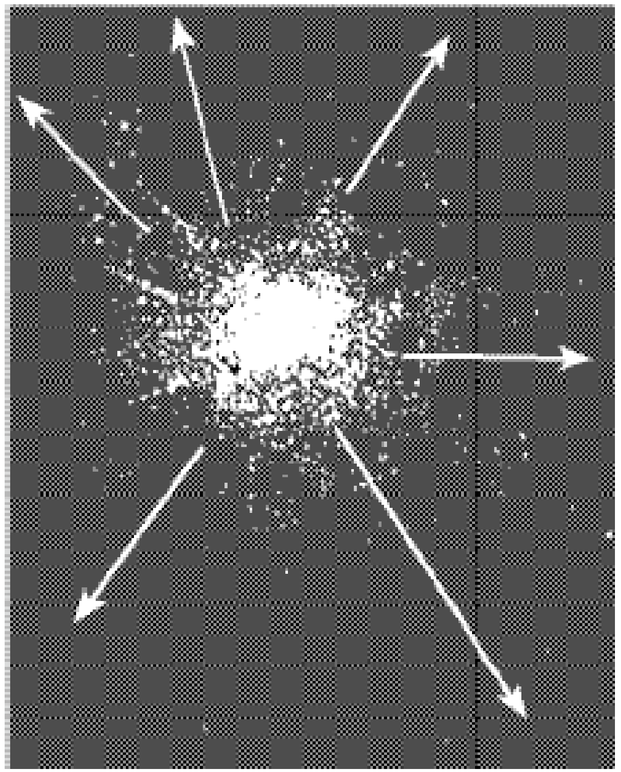
The Planets in Our Solar Sytem (not to scale)




HISTORY.COM

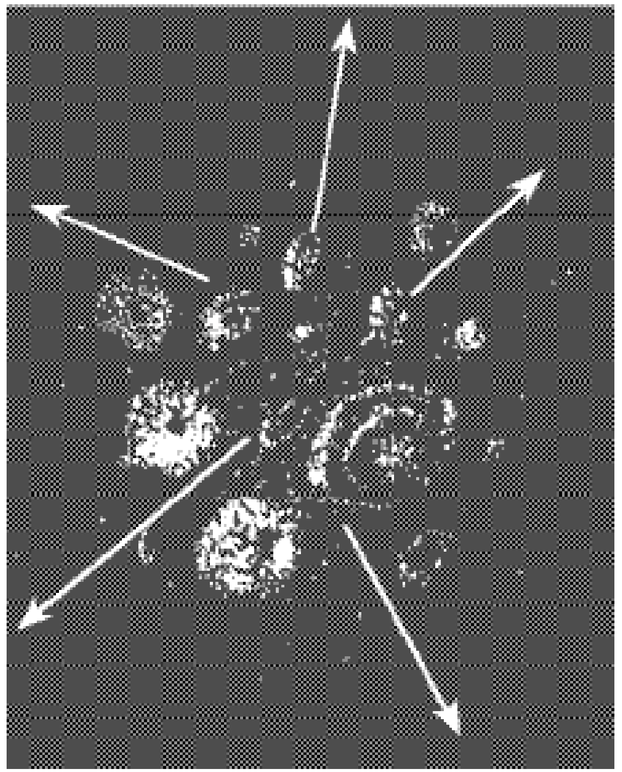
The Big Bang

- A accepted theory that explains the creation of the Universe.
- It states that, for an unknown reason, a point in space exploded about 15 billion years ago.
- All energy and matter, everything, was created during this explosion.
- Ever since this event, the Universe has been expanding in all directions.



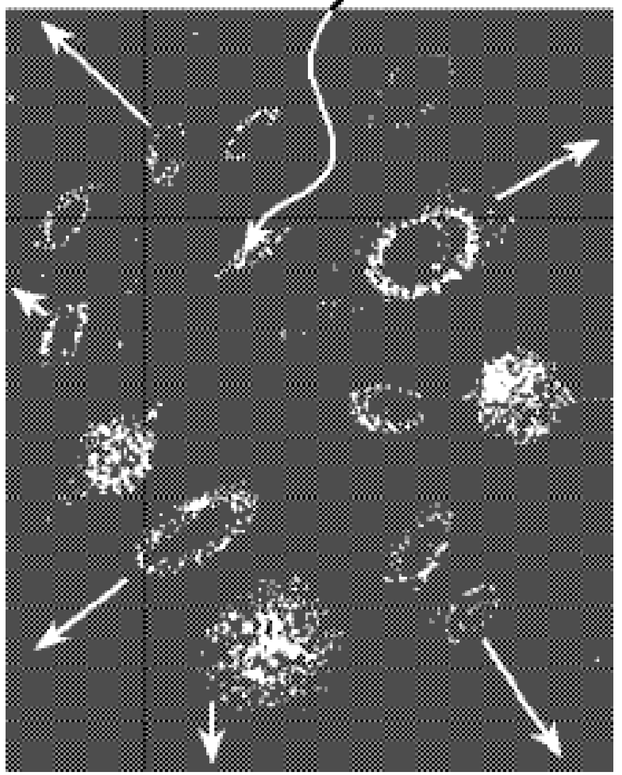
STAGE 1

A ball of hydrogen exploded.



STAGE 2

A huge hydrogen cloud moved outward with cloud parts condensing to form galaxies.



STAGE 3

The galaxies continue to move outward

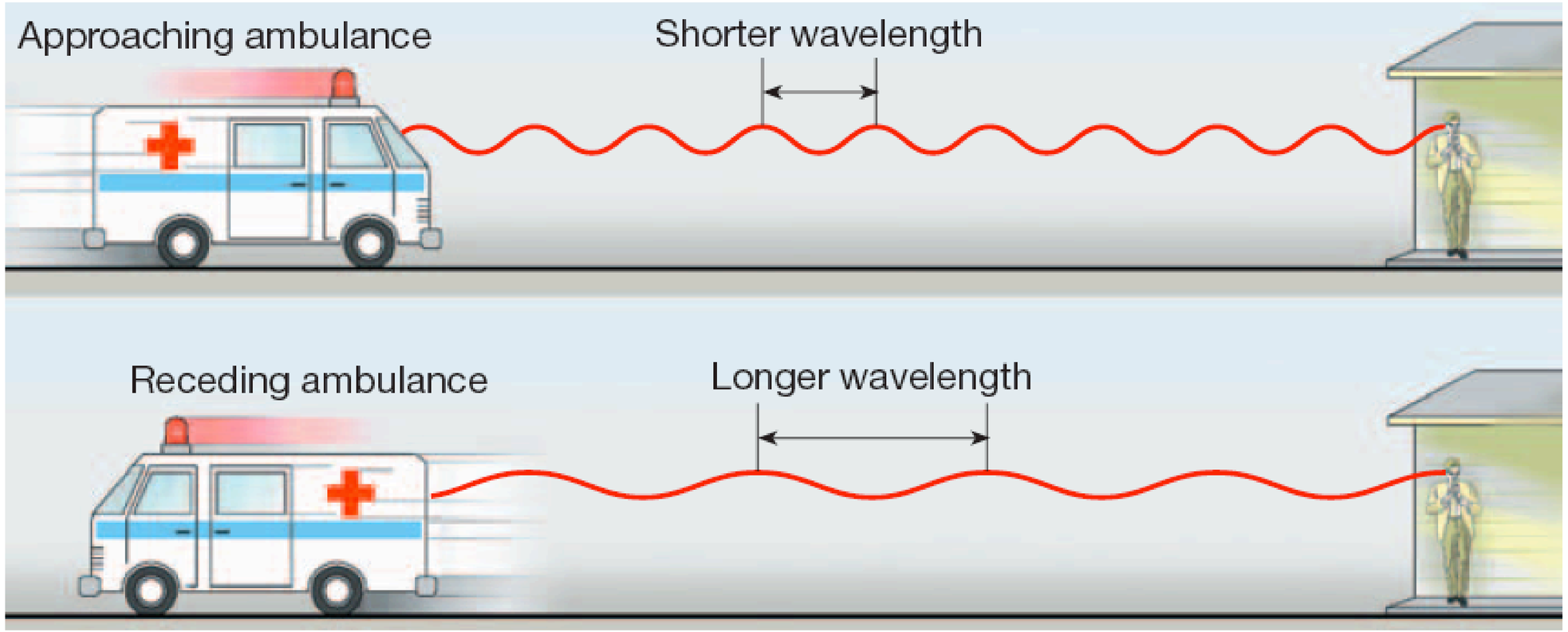
The Doppler Effect

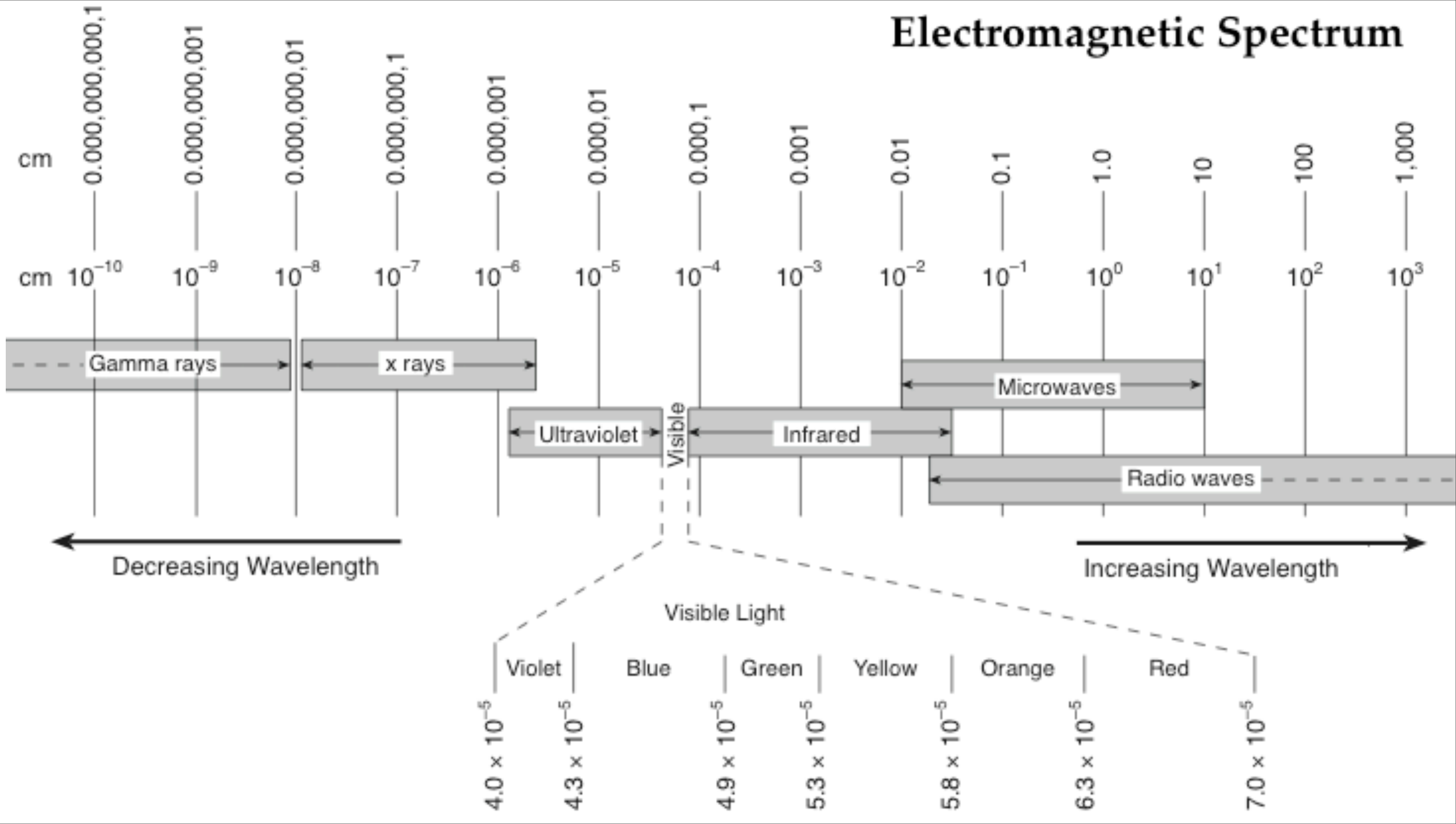


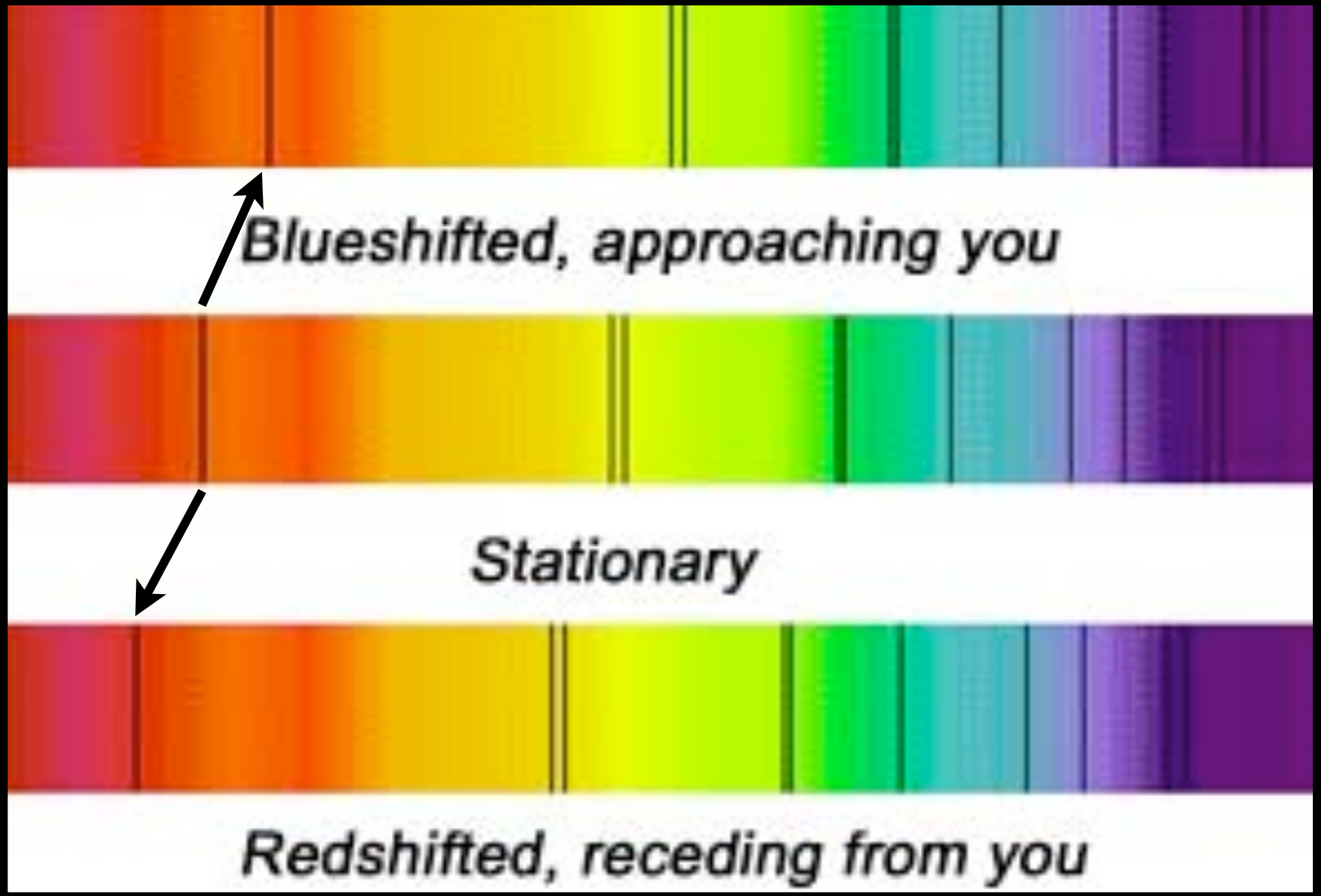
Evidence for the Big Bang

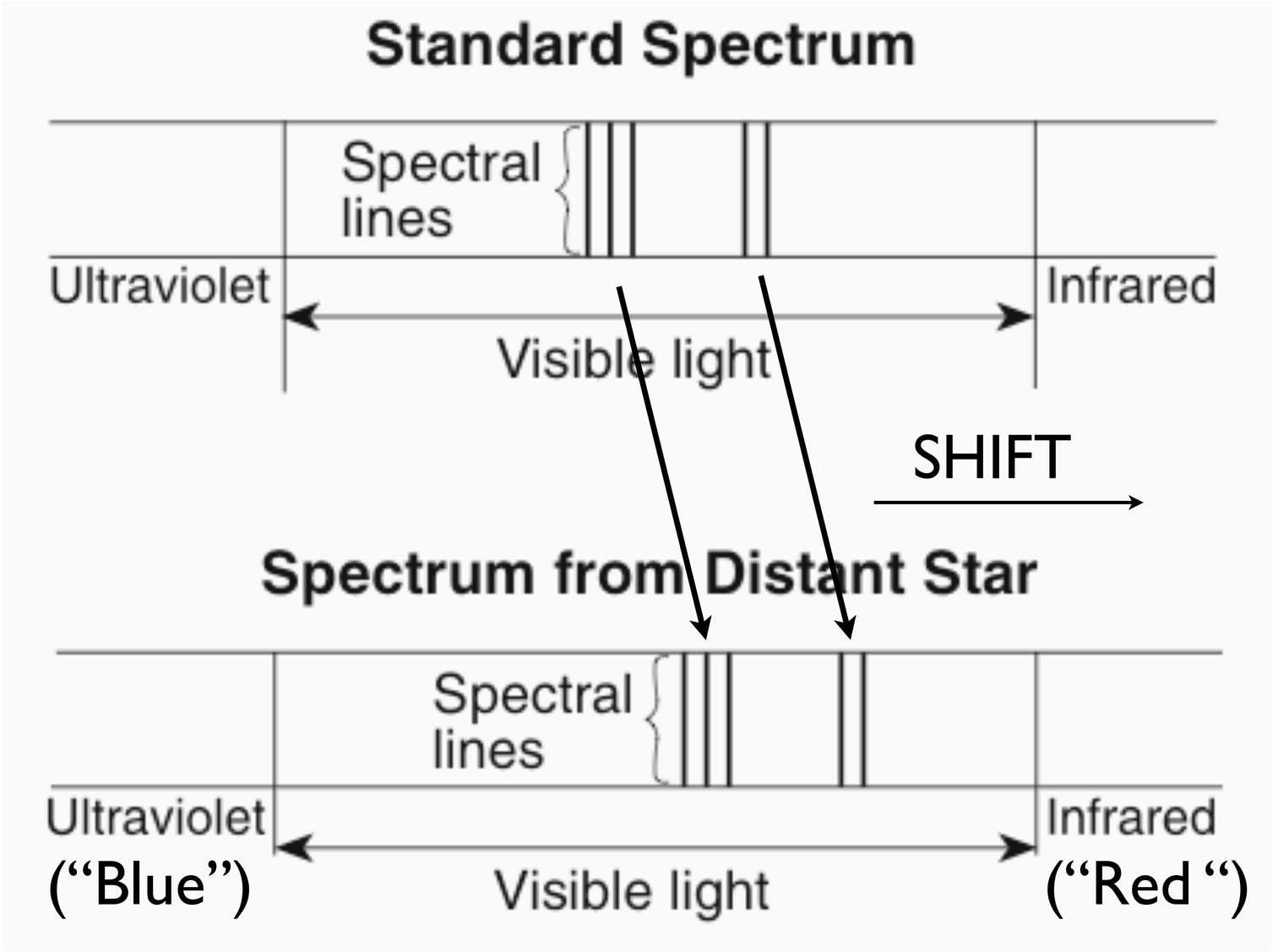
Think of a car speeding past you with the horn honking.

As the car is approaching, the sound waves from the horn get compressed, causing the horn to have a higher pitch. As it drives away from you, the sound waves are stretched out, causing a lower pitch.




Electromagnetic Spectrum
cm
0.000,000,000,1
0.000,000,001
0.000,000,01
0.000,000,1
0.000,001
0.000,01
0.000,1
0.001
0.01
0.1
1.0
10
100
1,000
cm 10^{-10} 10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3}
Gamma rays
x rays
Ultraviolet
Visible
Infrared
Microwaves
Radio waves
Decreasing Wavelength
Increasing Wavelength
Visible Light
Violet
Blue
Green
Yellow
Orange
Red
4.0×10^{-5}
4.3×10^{-5}
4.9×10^{-5}
5.3×10^{-5}
5.8×10^{-5}
6.3×10^{-5}
7.0×10^{-5}


Blueshifted, approaching you
Stationary
Redshifted, receding from you


Standard Spectrum
Spectral lines
Ultraviolet
Infrared
Visible light
SHIFT
Spectrum from Distant Star
Spectral lines
Ultraviolet
("Blue")
Infrared
("Red")
Visible light



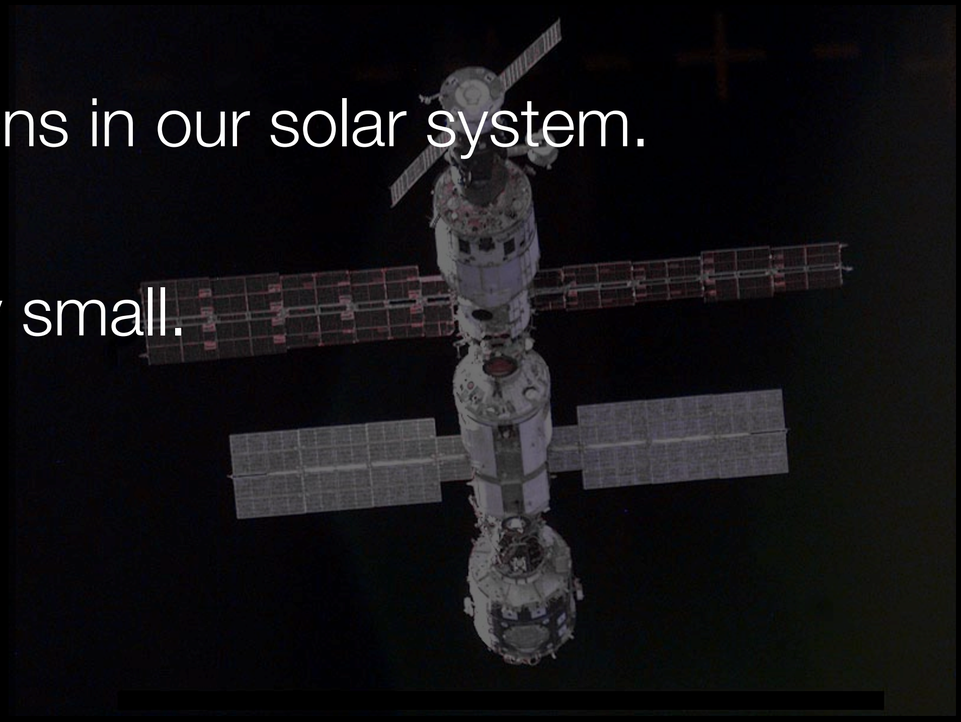
So What Does Red-shifting Mean to Us?

- We have observed that the spectra of every object in the sky is red-shifted.
- ***This means that everything is moving away from everything else and that the Universe is expanding.***
- We have also observed that as objects get further away from each other, they move faster and faster.
- If we run time backwards, the conclusion is that all matter and energy was once together at one point.
- This idea was the basis of the Big Bang hypothesis.

Moons / Satellites

- A body that orbits (revolves around) a planet or asteroid while that object orbits the sun. Can be naturally made or man-made.
- More than 100 known moons in our solar system.
- Can be planet sized to very small.

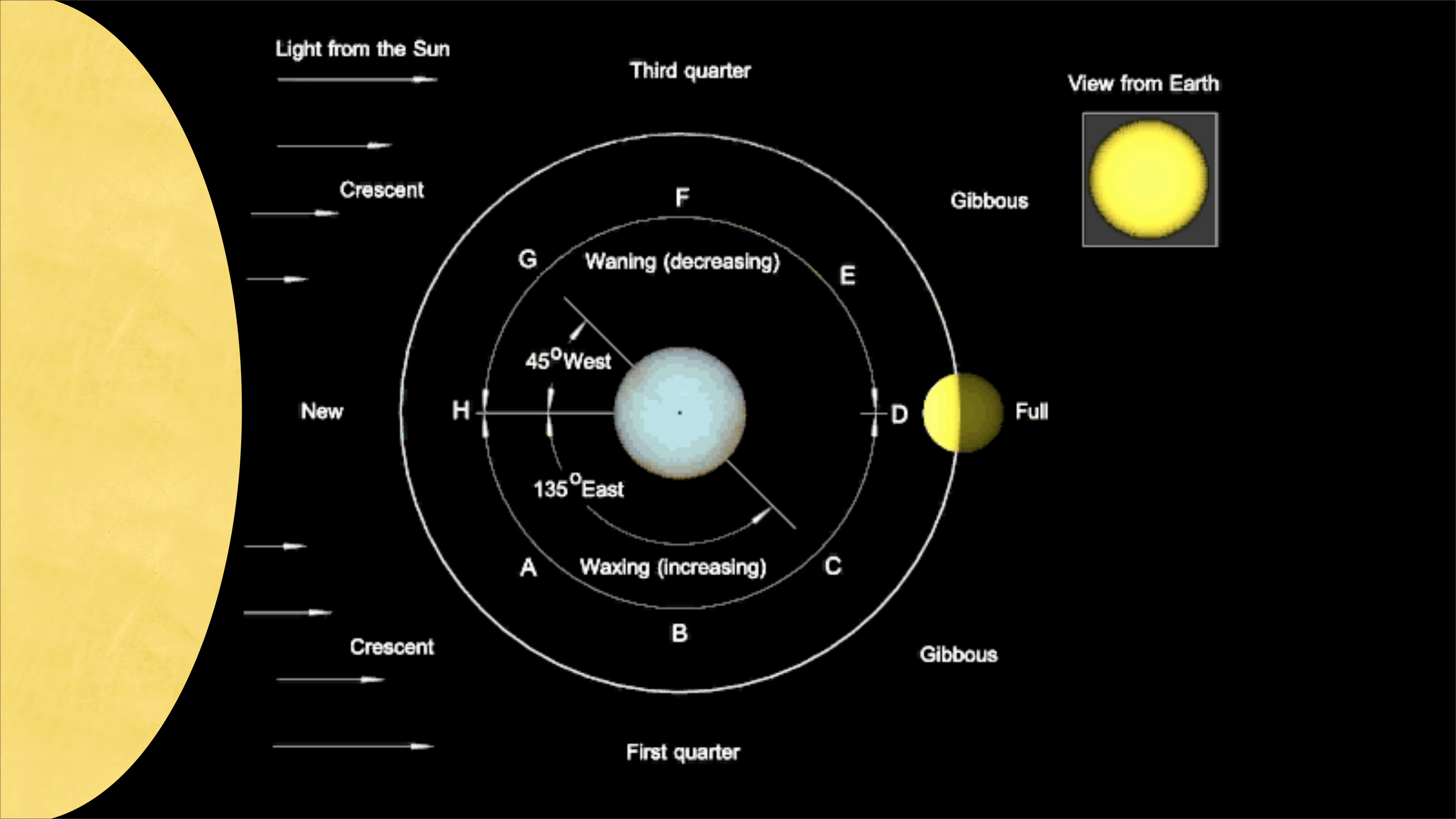




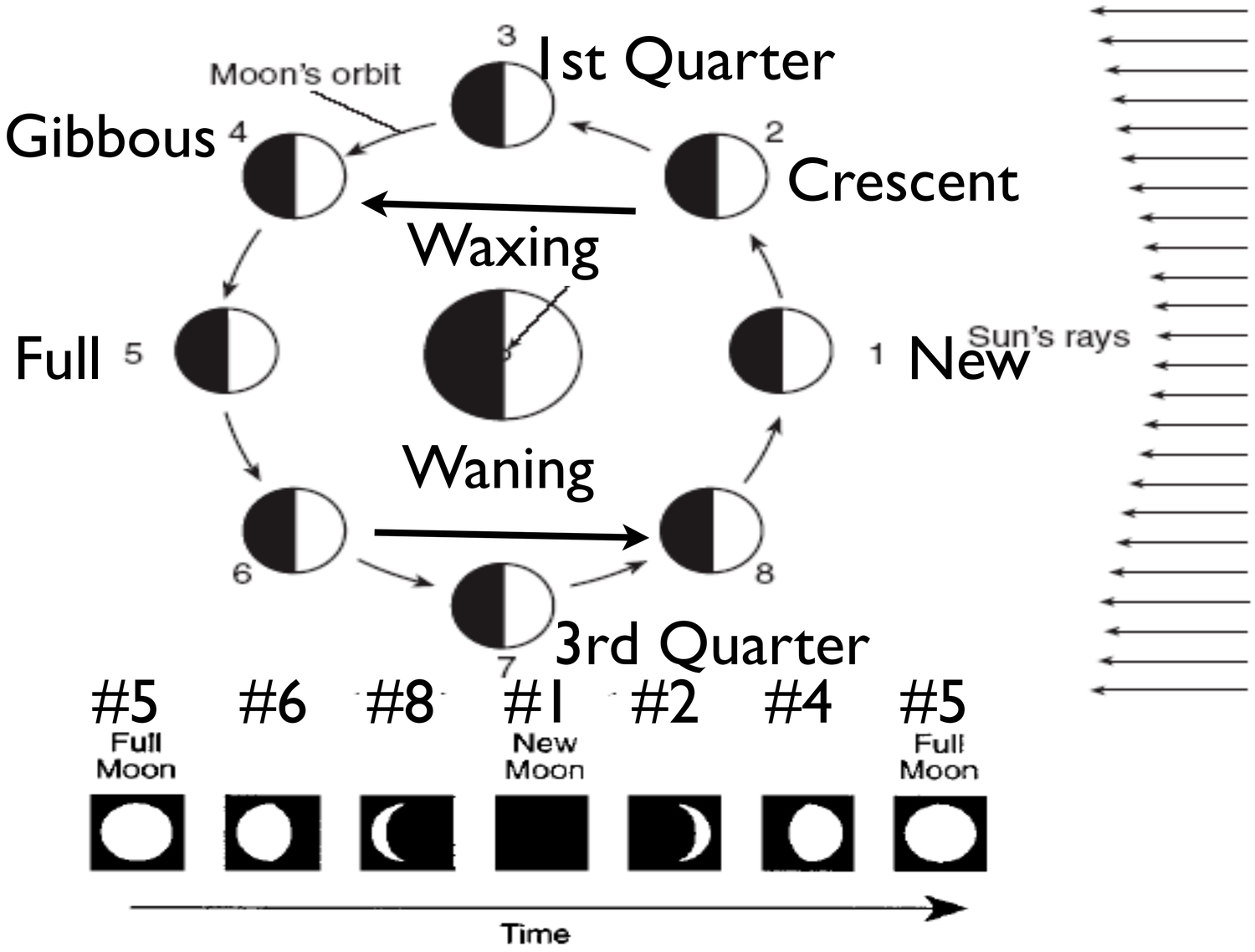
Earth’s Moon

- The same side of the moon always faces the earth.

- Both the rotation of the Moon and its revolution around Earth takes 27 days, 7 hours, and 43 minutes (approximately 27.3 days).

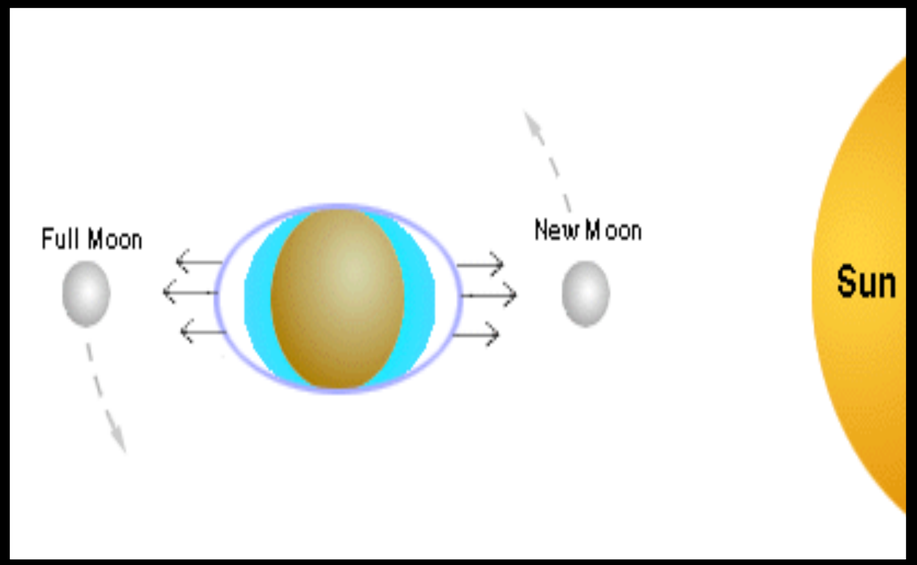

Light from the Sun
Third quarter
View from Earth
Crescent
F
Gibbous
G
Waning (decreasing)
E
45°West
New
H
D
Full
135°East
A
Waxing (increasing)
C
B
Crescent
Gibbous
First quarter

Moon Phases

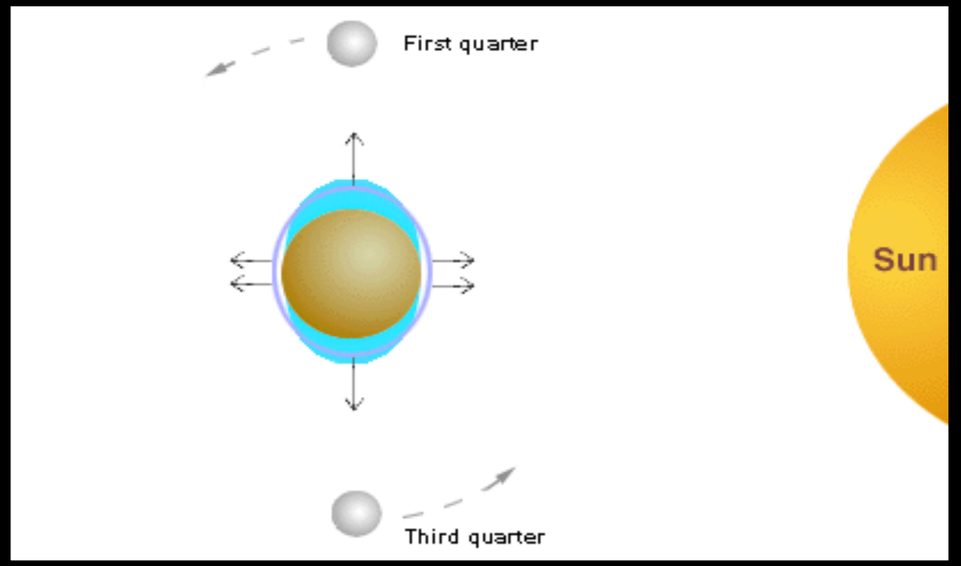

Moon's orbit
3
1st Quarter
Gibbous 4
2
Crescent
Waxing
Full 5
1 New
Sun's rays
Waning
6
8
7
3rd Quarter
#5 Full Moon
#6
#8
#1 New Moon
#2
#4
#5 Full Moon
Time

Tides

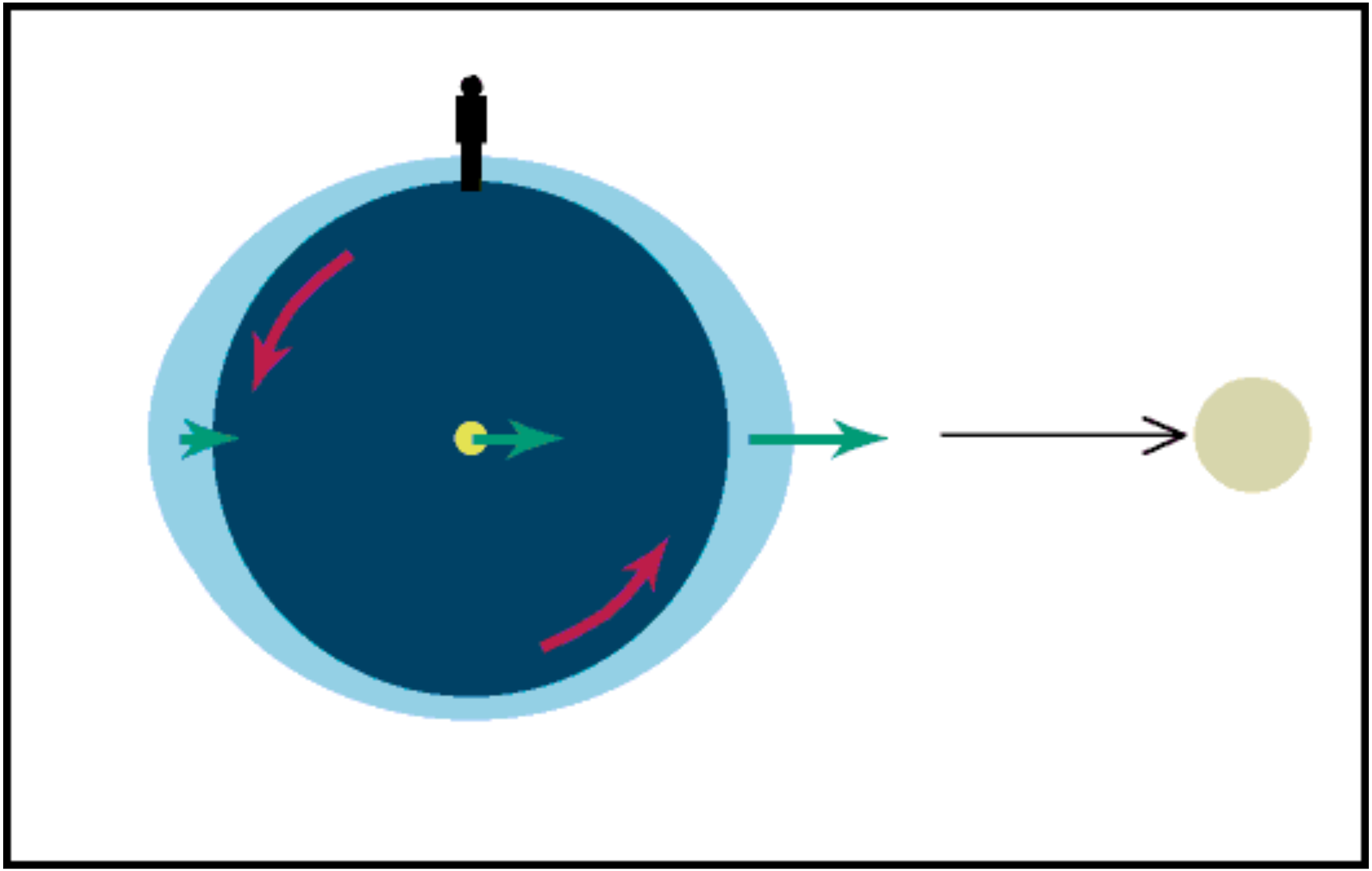
Tides – The earth's ocean tides are caused by the moon's gravity pulling on the ocean's water. Most areas on earth have two high tides and two low tides per day (diurnal tides).



Spring Tides: When the moon and sun are in the same plane of rotation (parallel), their gravity works together to create **extra high tides and extra low tides**. This happens during the full moon and new moons.



Neap Tides: When the sun and moon are perpendicular to each other, their gravity works against each other to create less extreme tides – **low highs and high lows**.



Eclipses

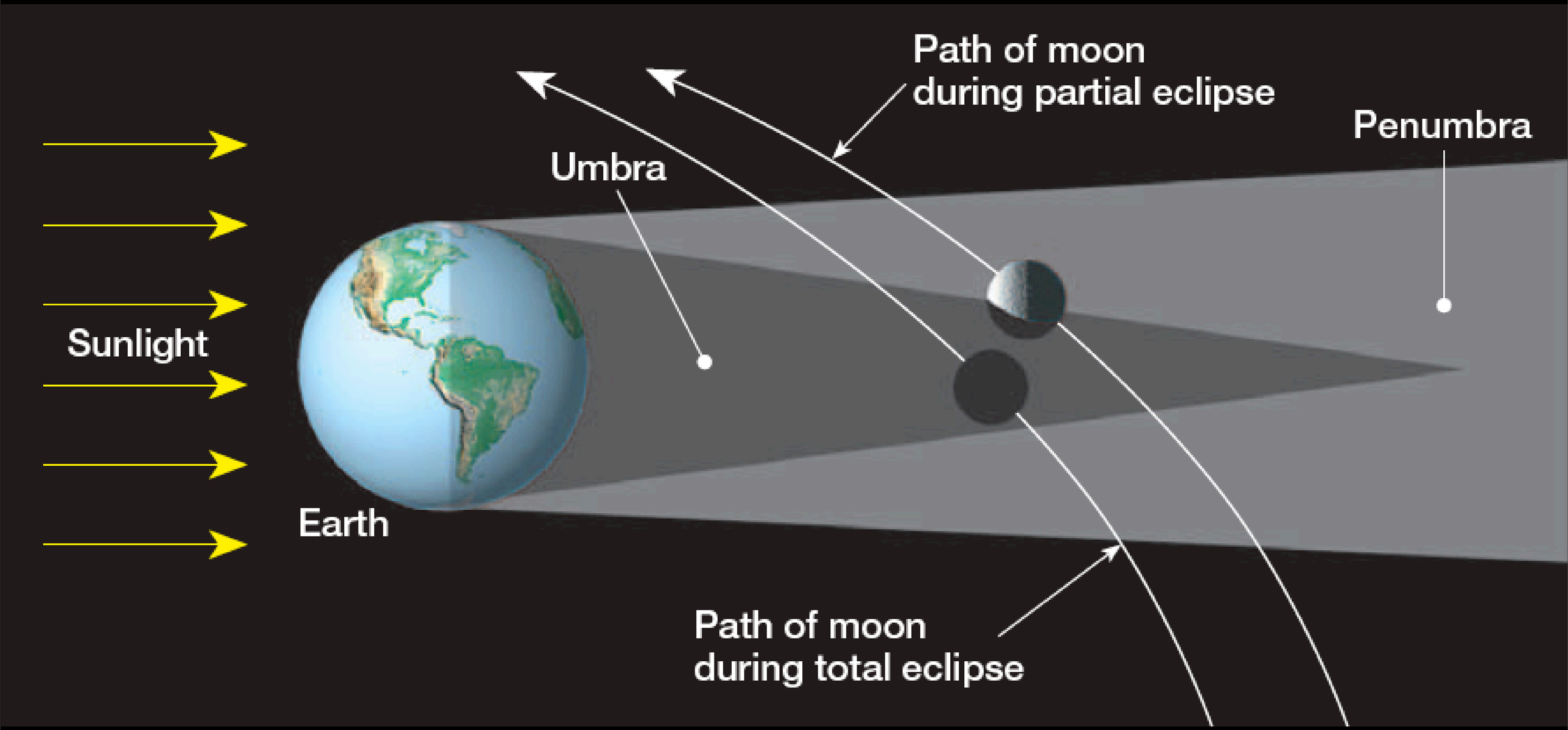
- **Lunar Eclipse** - At the full moon phase the moon moves into the Earth's shadow and is hidden.

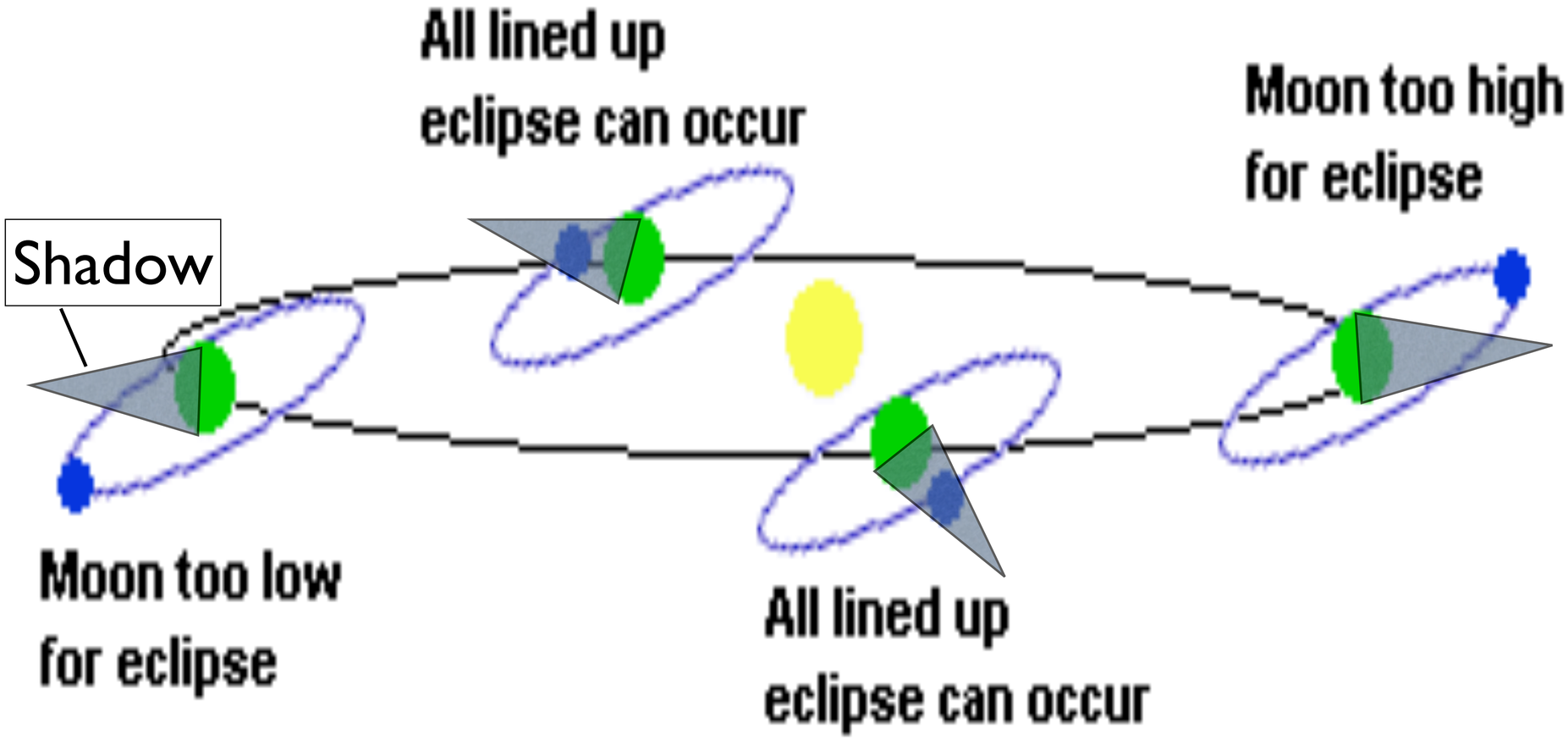


- **Solar Eclipse** - At the new moon phase the moon moves in the way of the Earth's view of the Sun and the Sun is hidden.

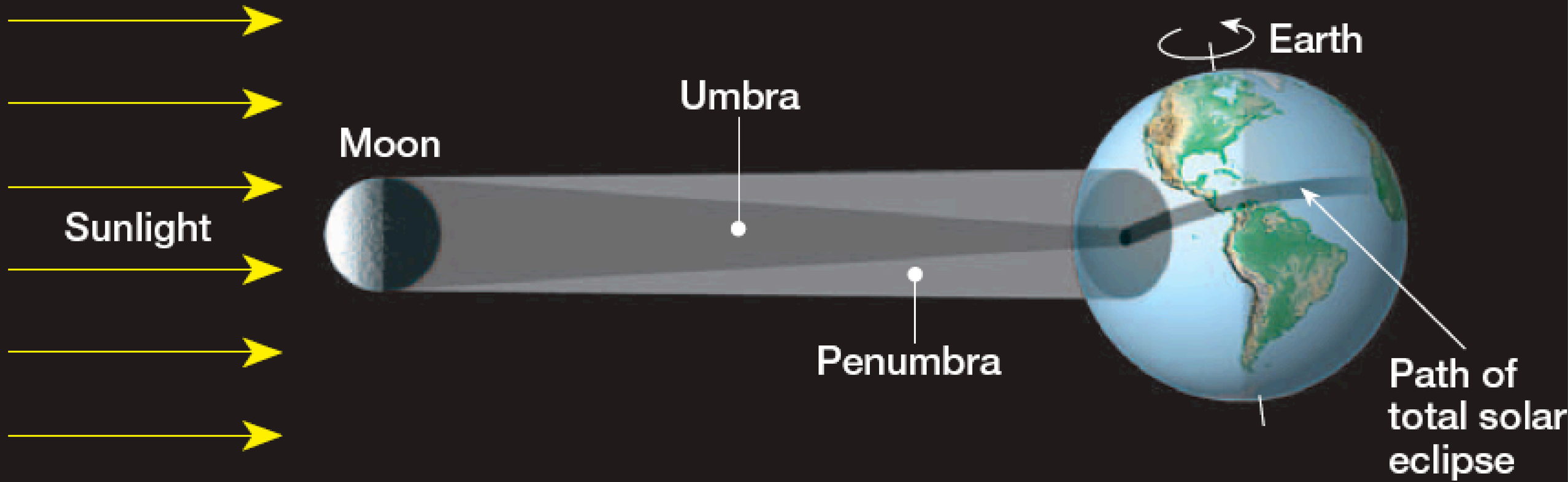


Lunar Eclipse

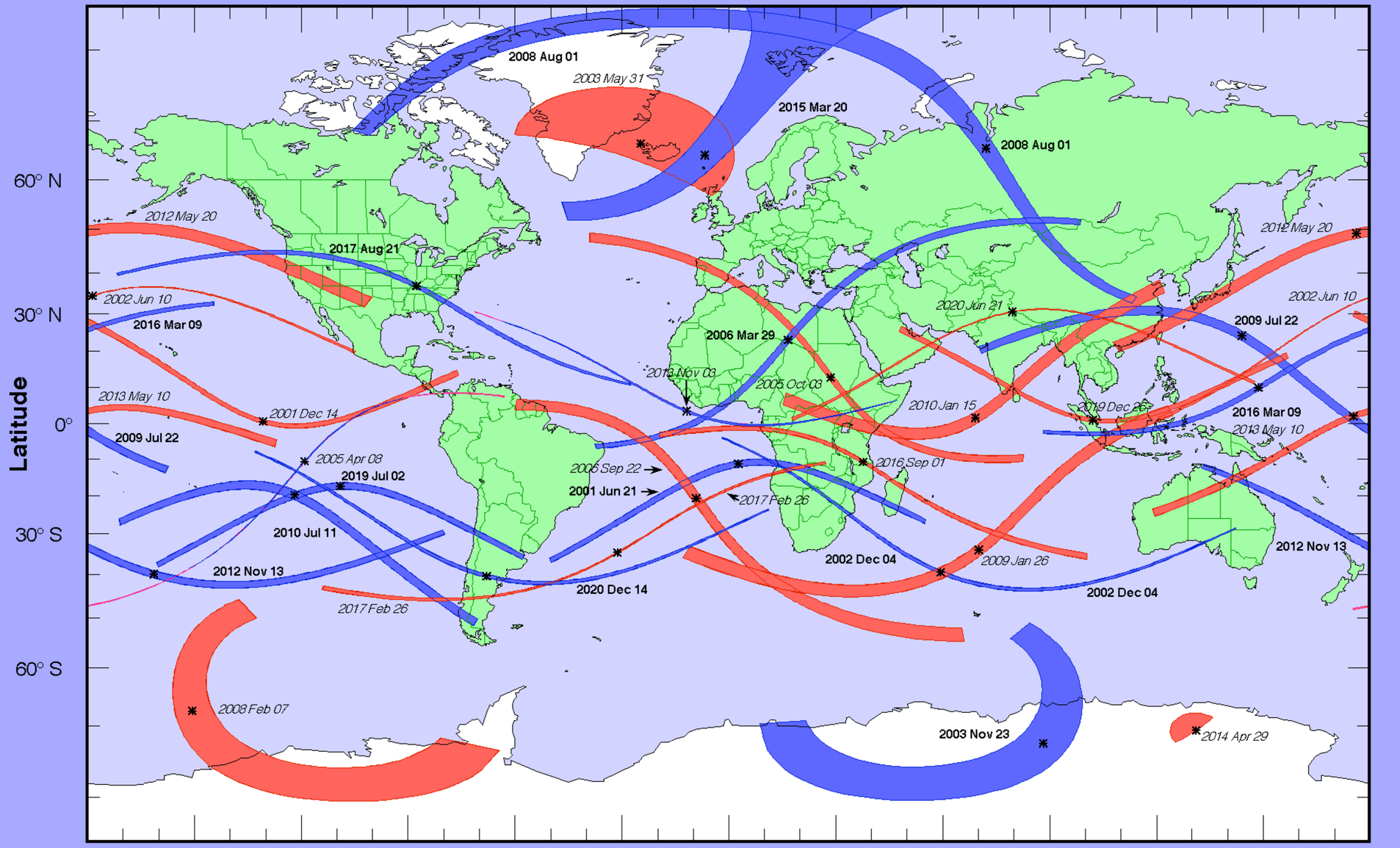



All lined up
eclipse can occur
Moon too high
for eclipse
Shadow
Moon too low
for eclipse
All lined up
eclipse can occur

Solar Eclipse



Total and Annular Solar Eclipse Paths: 2001 – 2020



sunearth.gsfc.nasa.gov/eclipse/eclipse.html

Fred Espenak, NASA/GSFC - 2002 July

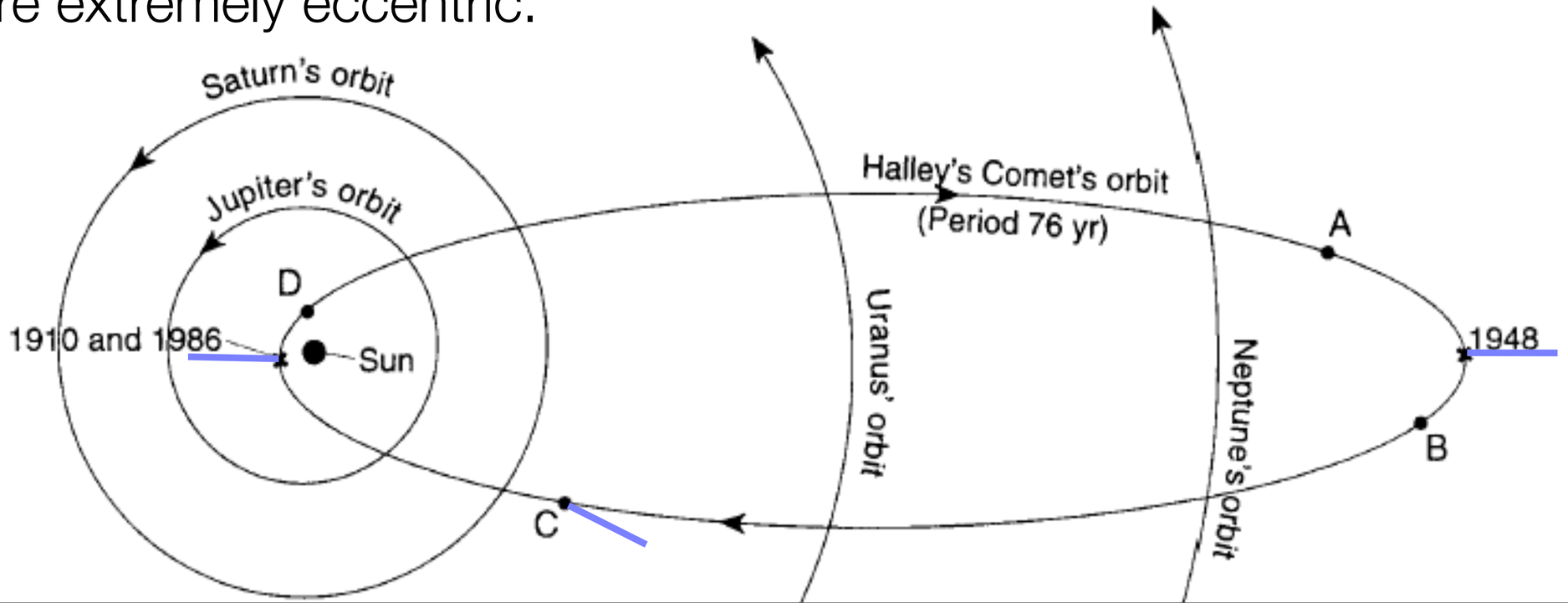

Path of the Total Solar Eclipse
August 21, 2017
Abbotsford
Victoria
Seattle
Spokane
Washington
Tacoma
Portland
Salem
Eugene
Oregon
Boise City
Idaho
Montana
Billings
Gillette
Wyoming
Douglas
Ogden
Fort Collins
Denver
Reno
Nevada
Ely
Utah
Colorado
Pueblo
San Francisco
Sacramento
Stockton
San Jose
California
Las Vegas
Bakersfield
Farmington
Dulce
Santa Fe
Albuquerque
Amarillo
Los Angeles
Riverside
San Diego
Arizona
Phoenix
Tucson
New Mexico
Roswell
Lubbock
Deming
Las Cruces
Artesia
Andrews
El Paso
Texas
San Angelo
Waco
Austin
San Antonio
Laredo
Corpus Christi
Houston
Katy
Beaumont
Louisiana
New Orleans
Mississippi
Jackson
Alabama
Montgomery
Mobile
Tallahassee
Panama City
Georgia
Savannah
Jacksonville
Florida
Orlando
Ocala
St Petersburg
Sarasota
Pompano Beach
Fort
Charleston
South Carolina
Augusta
Atlanta
Birmingham
Chattanooga
Greenville
Charlotte
Fayetteville
Wilmington
North Carolina
Knoxville
Tennessee
Memphis
Arkansas
Oklahoma
Tulsa
McKinney
Dallas
Weatherford
Shreveport
Tyler
Kansas
Wichita
Topeka
Kansas City
Missouri
St Louis
Springfield
Nebraska
Omaha
Lincoln
Iowa
Des Moines
Minnesota
Minneapolis
Thunder Bay
North Dakota
South Dakota
Wisconsin
Madison
Milwaukee
Chicago
Illinois
Michigan
Grand Rapids
Fort Wayne
Indiana
Indianapolis
Louisville
Evansville
Kentucky
Lexington-Fayette
Cincinnati
Dayton
Ohio
Toledo
Cleveland
Detroit
Flint
Canton
Pittsburgh
West Virginia
Virginia
Richmond
Alexandria
Maryland
Delaware
District of Columbia
Pennsylvania
New York
New Jersey
Philadelphia
York
Chesapeake
Greeneville
Clarksville
Lebanon
Hamilton
London
Toronto
Kitchener
Kingston
Ottawa
Montréal
North Bay
Sudbury
Val-d'Or
"eEclipser by Xavier Jubier (http://http://xjubier.free.fr/en/site_pages/solar_eclipses/5MCSEIxSE_Five_Millennium_Canon.php)"

Comets

- "Dirty snowballs"
- Often appear to have **tails** which are made of gases that have evaporated from ice and always **point away from the Sun**.
- Rocky/metallic solids mixed with frozen water or methane.
- Orbits are extremely eccentric.



— = tail

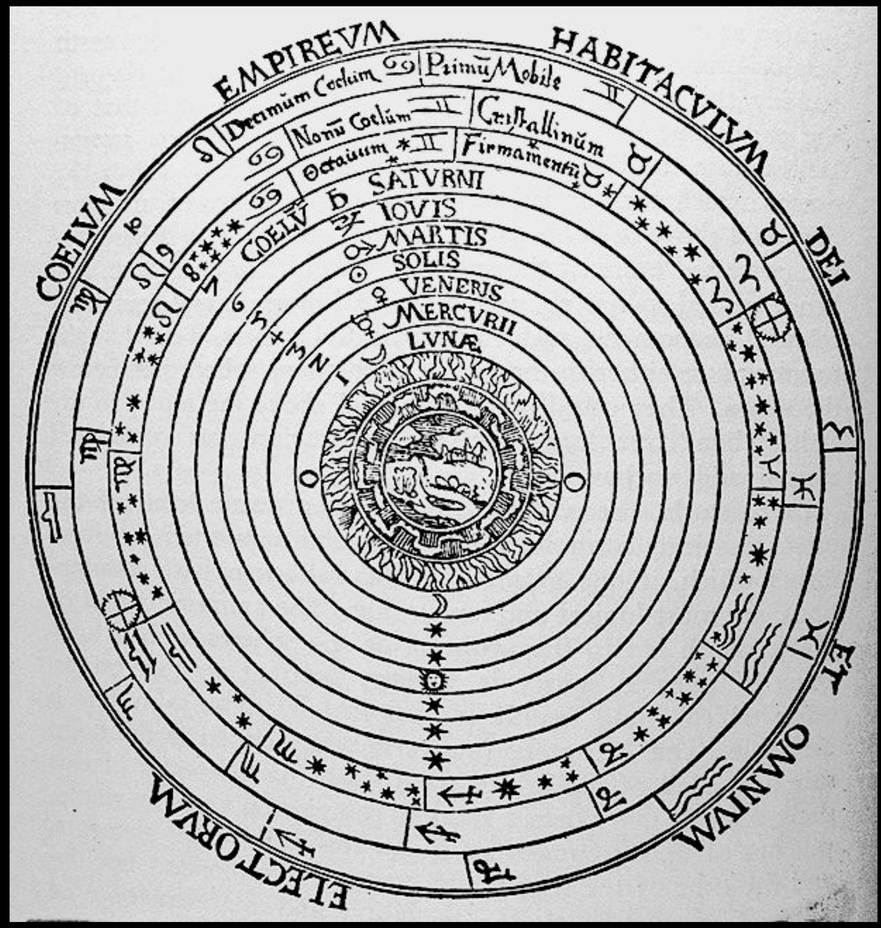


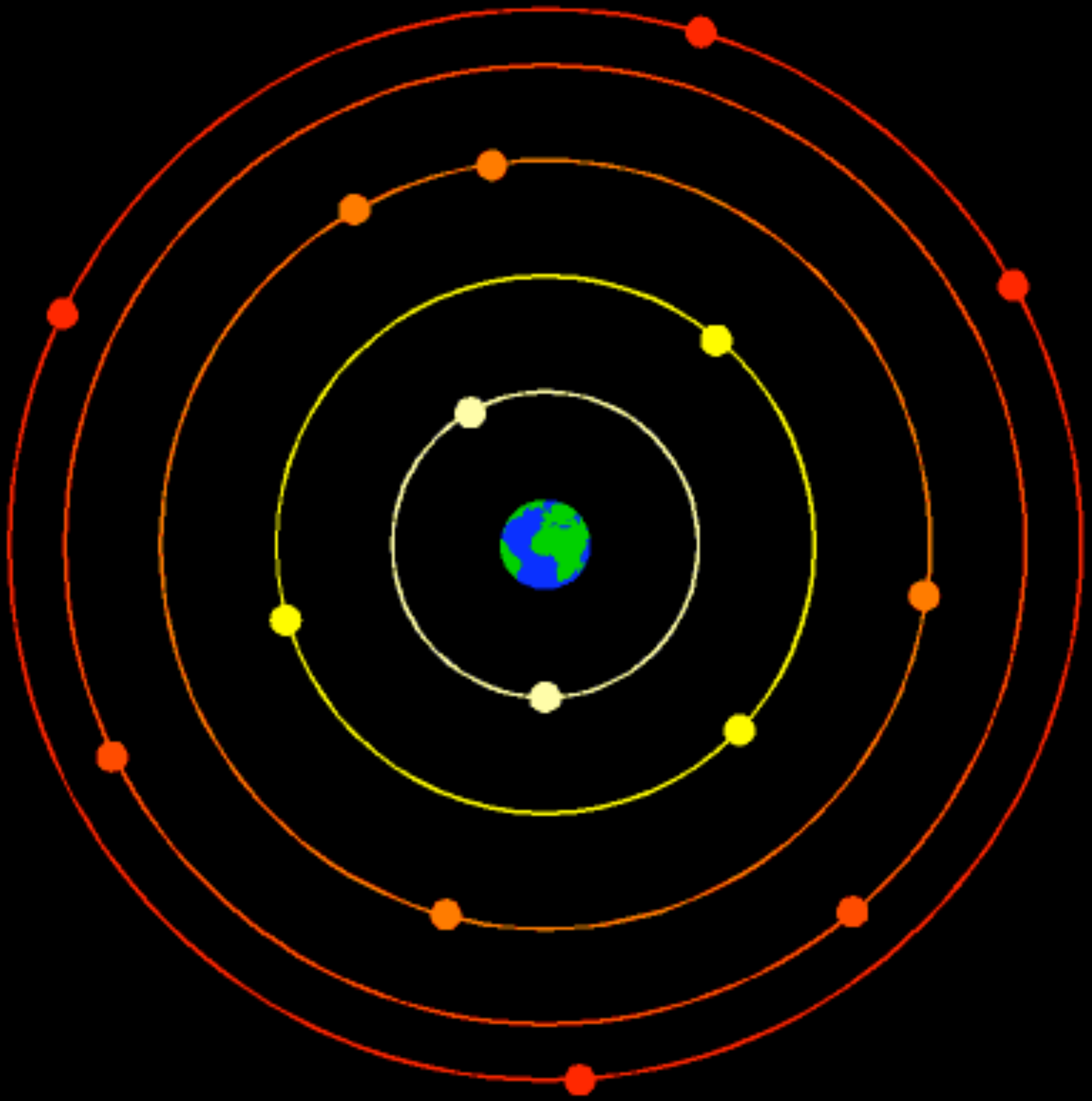
From a Geocentric to a Heliocentric Universe

A Changing View of our Universe

THE GEOCENTRIC (Earth Centered) **MODEL**

- A model of the universe with the **stationary Earth at the center** and the Sun, Moon, and stars arranged around in a perfect sphere with all of these bodies moving around the Earth in perfectly circular orbits and at constant speeds. Originally created by Aristotle (Greek Philosopher, 384 to 322 B.C.)

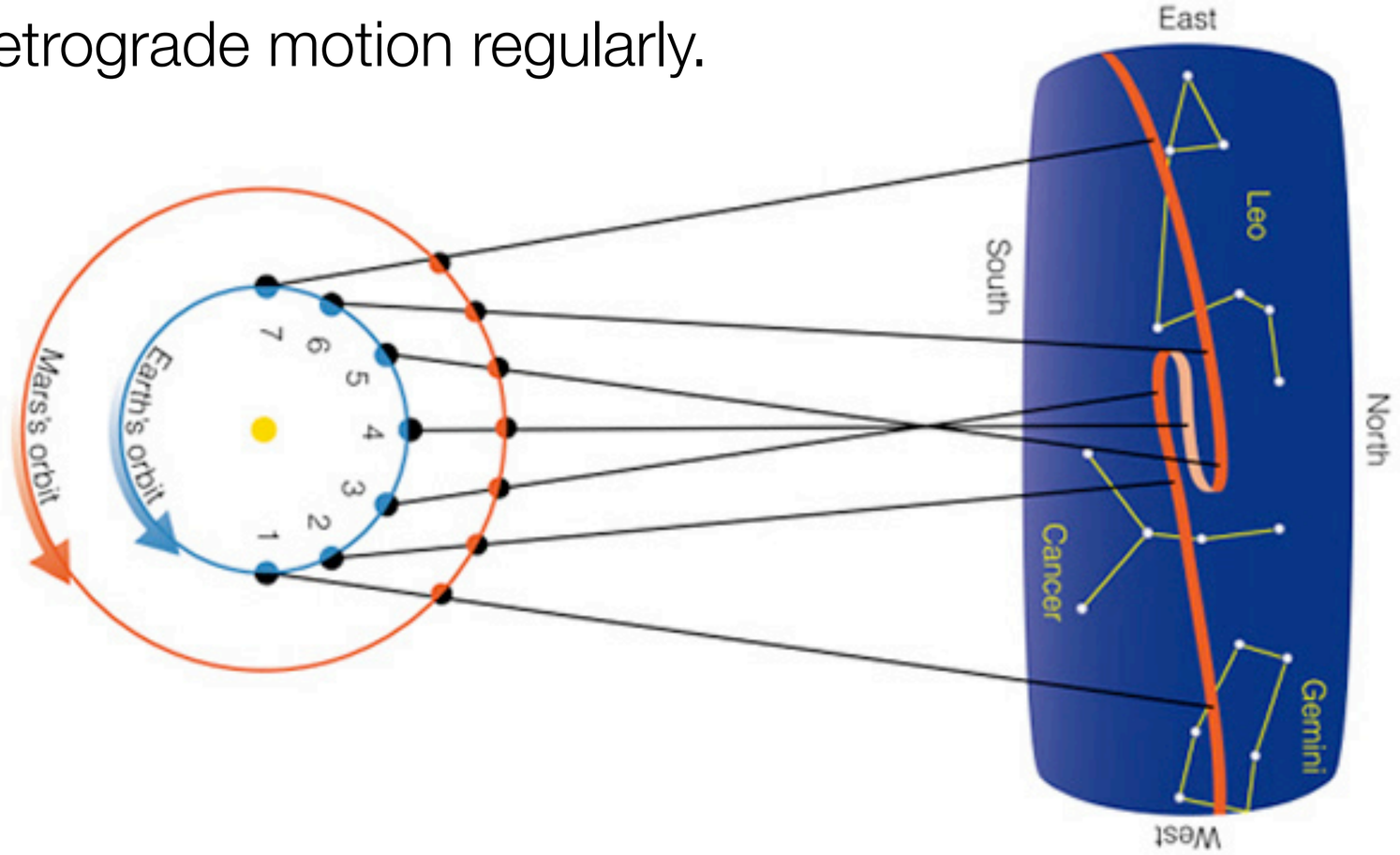





HISTORY.COM

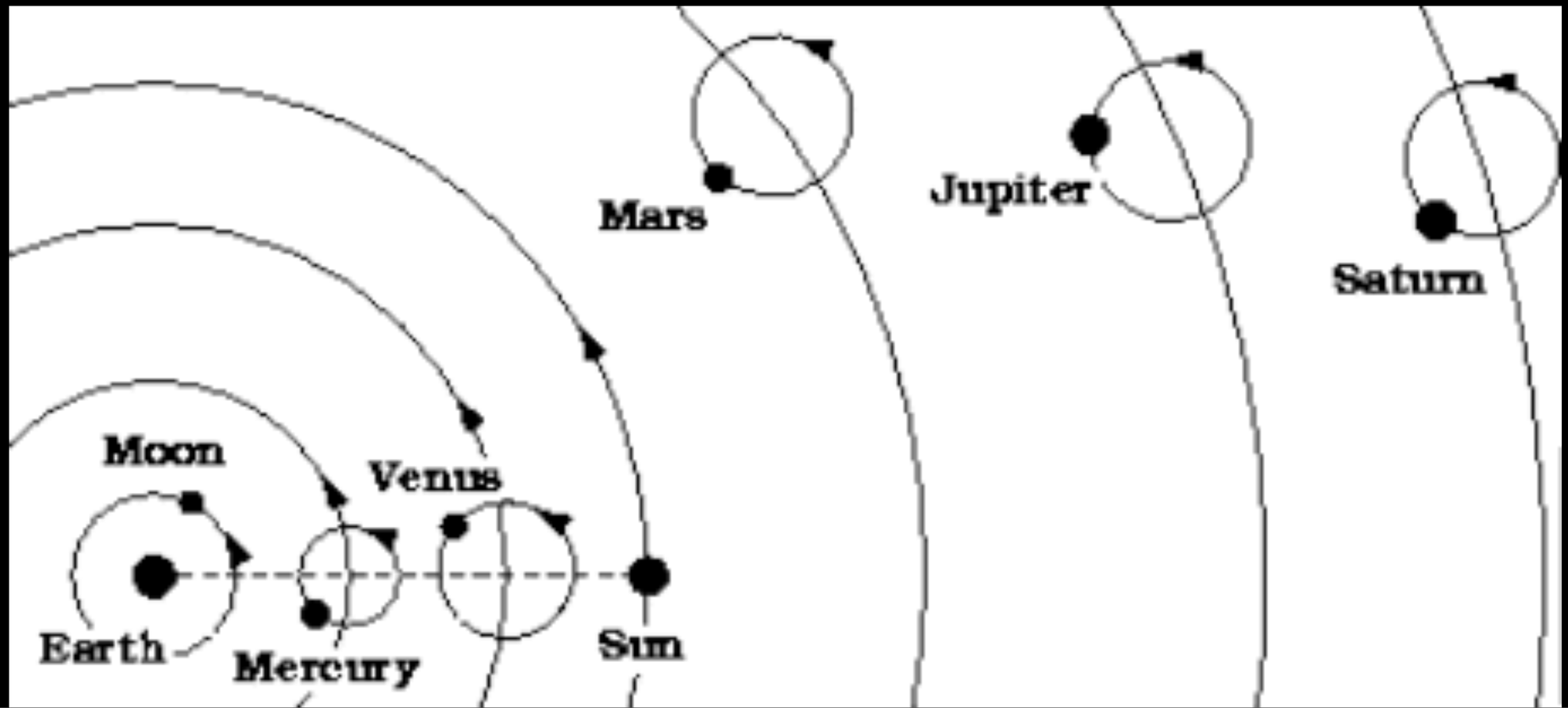
Retrograde Motion

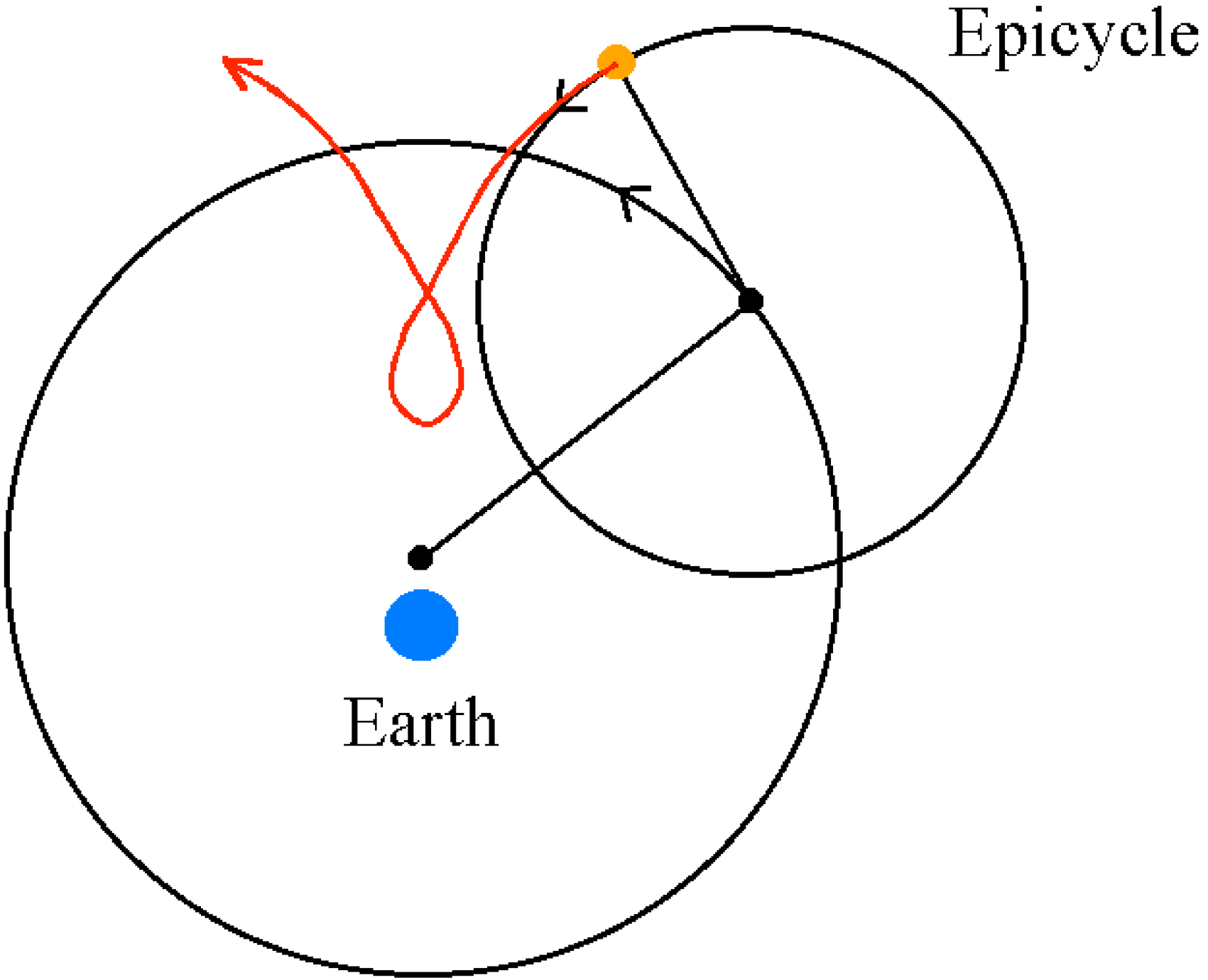
- Retrograde motion is when a celestial object appears to stop its motion and move backwards for a time and then restore its normal motion. Mars can be observed in retrograde motion regularly.



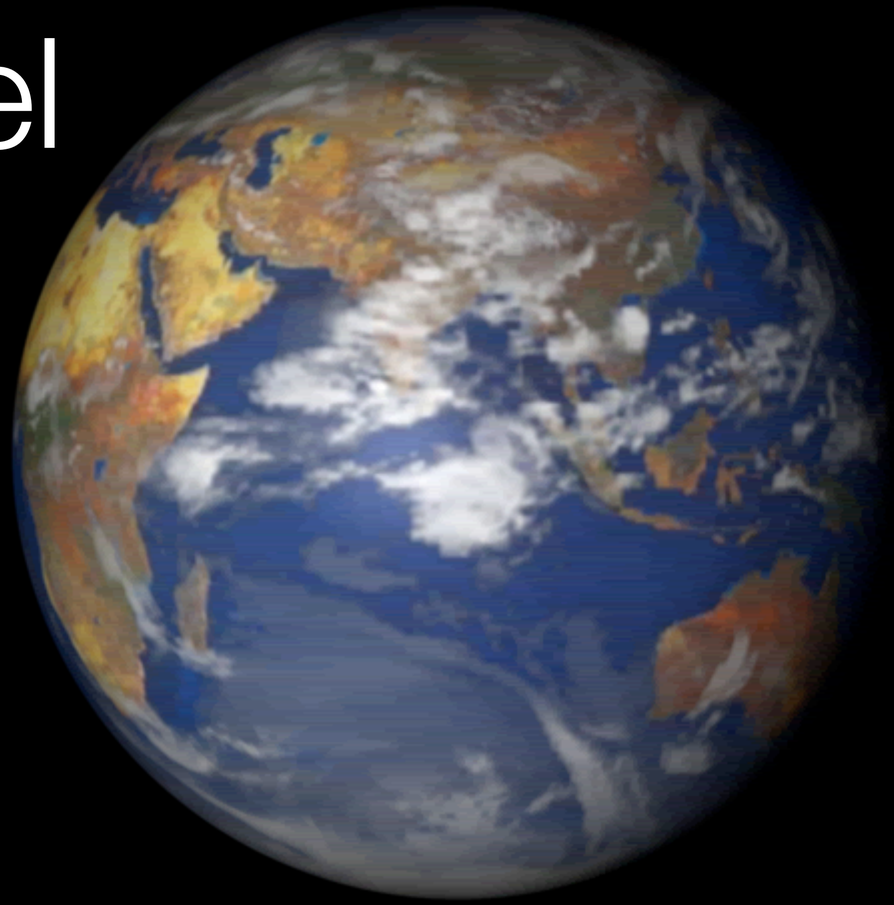
Explanation for Retrograde Motion

- Ptolemy said that planets were fixed to smaller spheres (epicycles) that were, in turn, fixed to larger spheres. The smaller sphere moved at the same time as the larger sphere.




Epicycle
Earth

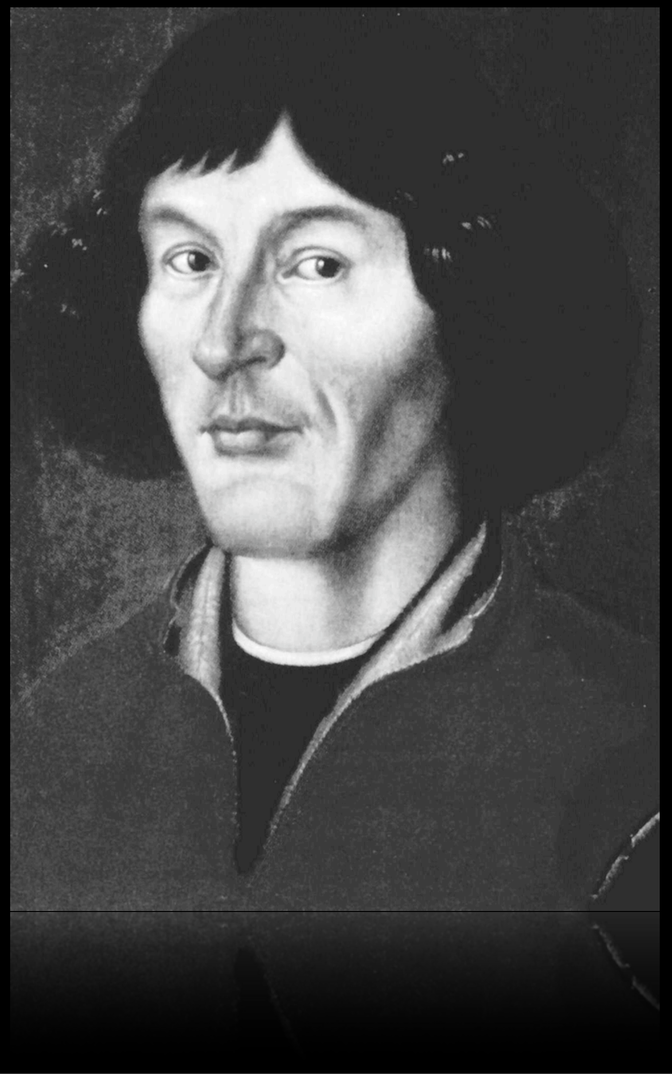
The
Geocentric model
doesn’t work
if the
Earth rotates!



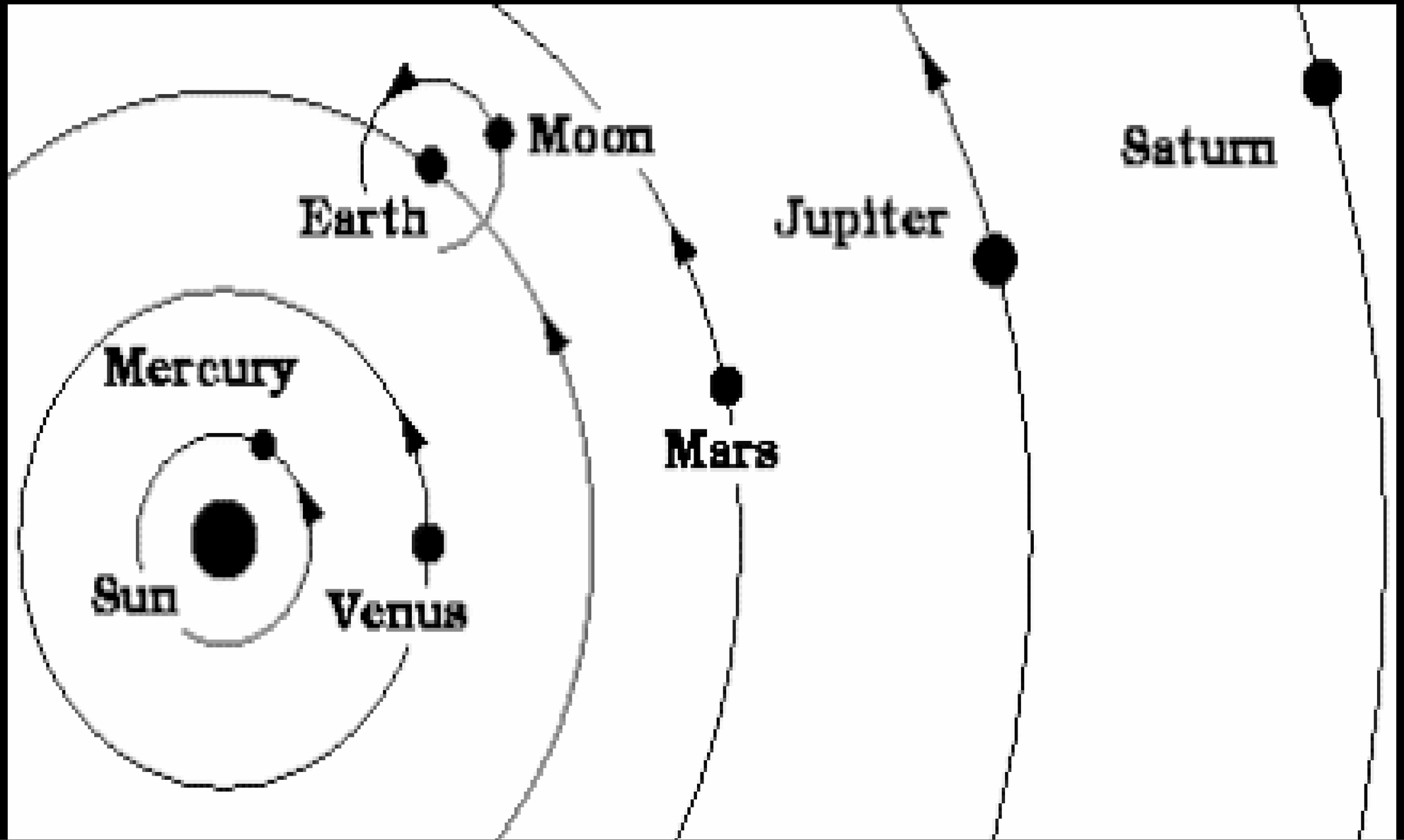
The Heliocentric Model

- After studying the problems with the Ptolemaic model, astronomer Nicolaus Copernicus developed a much more elegant "**sun-centered**" or heliocentric model.

- This model provided a better explanation based on new observations.

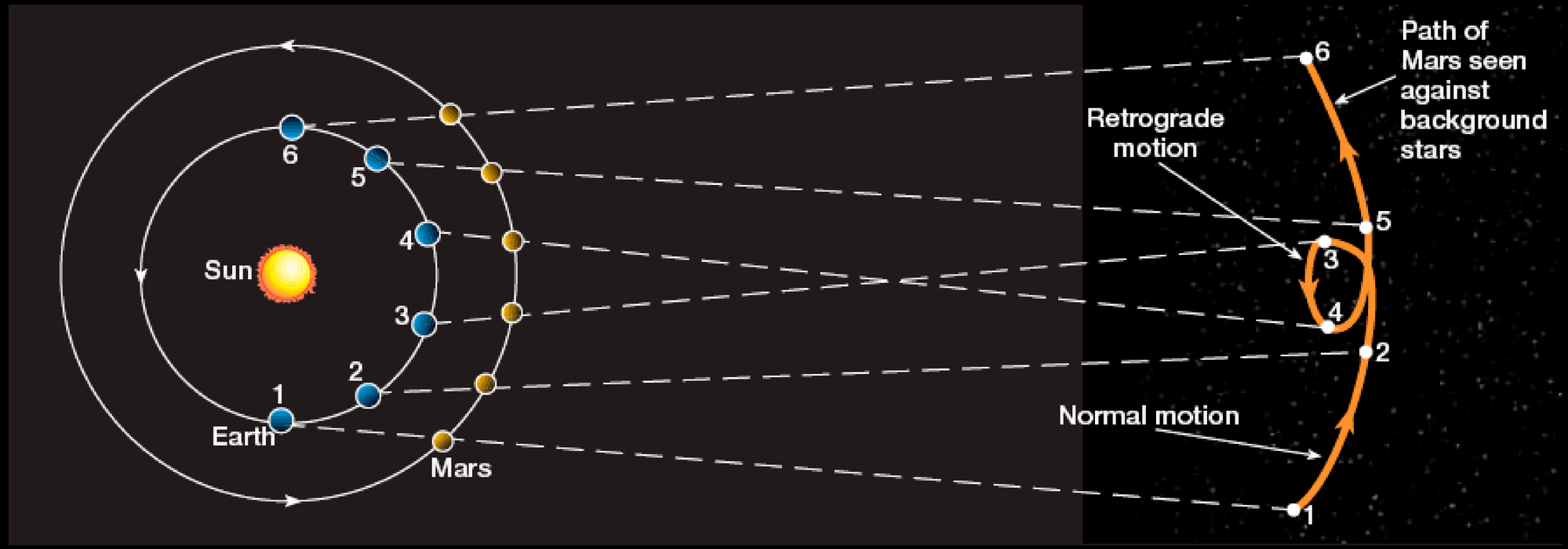


Copernicus' Heliocentric Model



The Heliocentric Model

- Copernicus' model was eventually accepted mainly because of how well it explained retrograde motion.



Apparent Motion

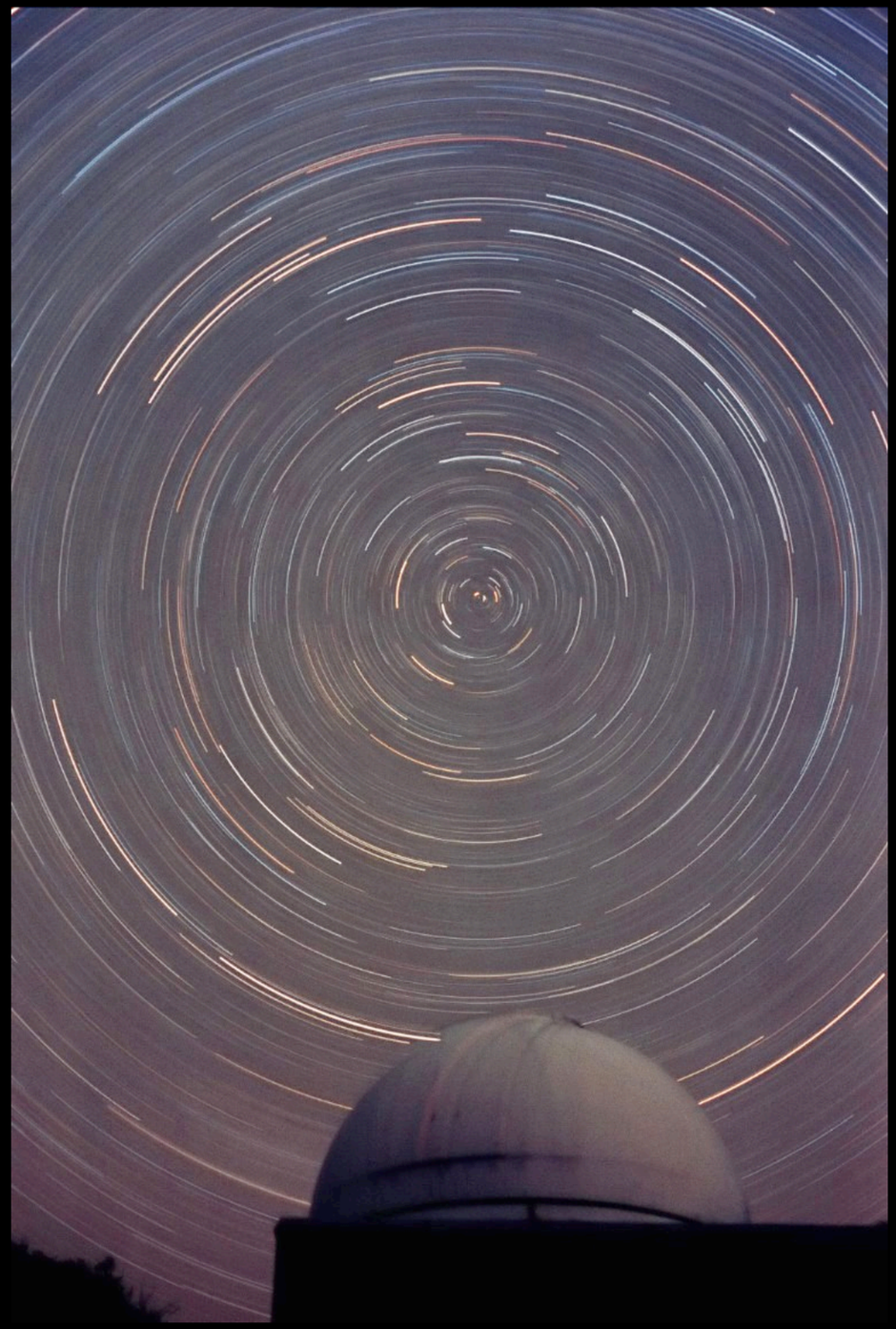
- All objects in the sky appear to move across the sky, together, from east to west. This is called “apparent motion”.



Star Trails

Circumpolar Motion

(looking North)



Star Trails

- Always look from left to right.

East



South



West



Evidence for the Heliocentric Model (Proof that the Earth rotates)

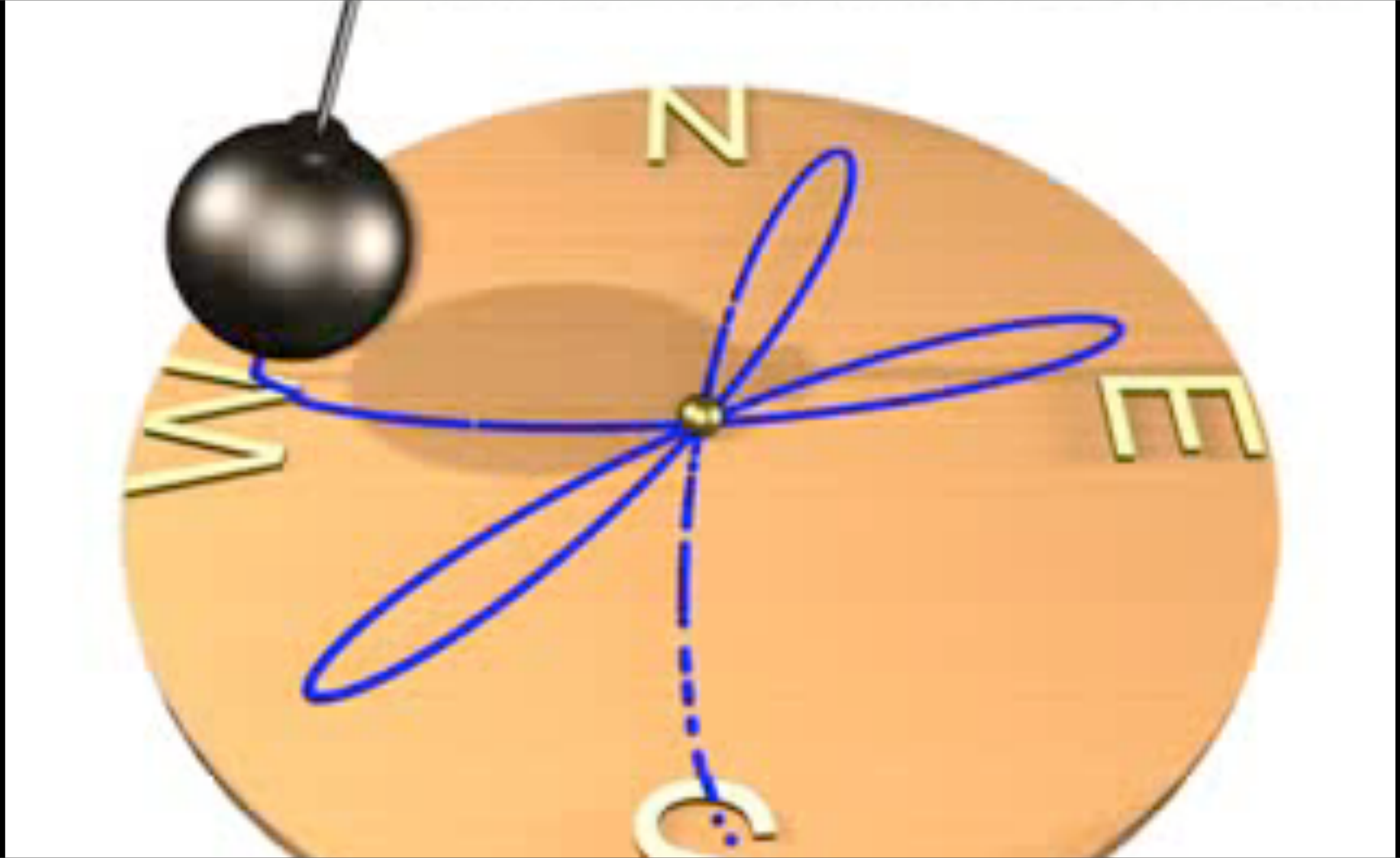
1. Foucault's Pendulum

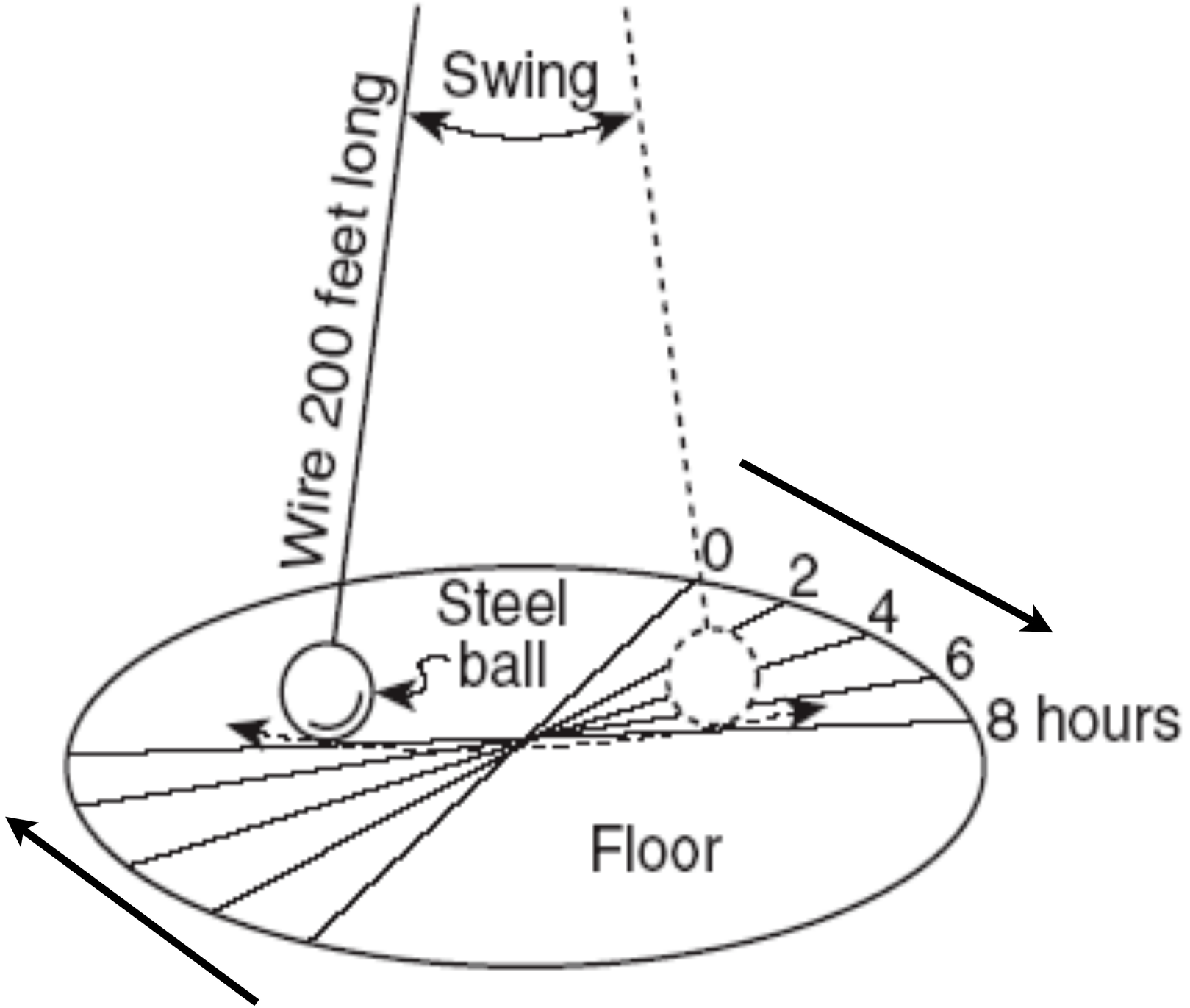
In 1850, for the Paris Exhibition, physicist Leon Foucault constructed a 67-metre tall Foucault Pendulum using a 28 pound cannon ball. He set the pendulum swinging. At first, it went back and forth. After a while, it began to change its path and over 24 hours it had completed a full circle. **The pendulum didn't actually move, it was the earth rotating underneath the pendulum** (drawing the rosette pattern) showing that the earth rotates.







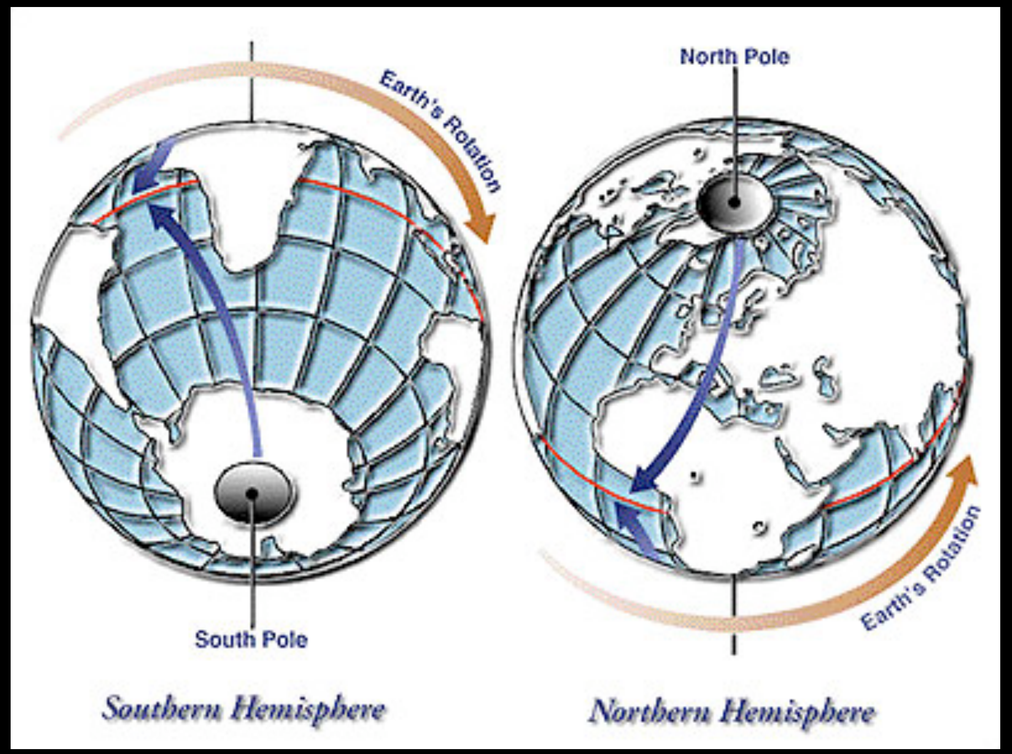

N
W
E


Swing
Wire 200 feet long
0
2
4
6
8 hours
Steel
ball
Floor

2. The Coriolis Effect

It's a force acting on winds or ocean currents because the Earth is spinning.

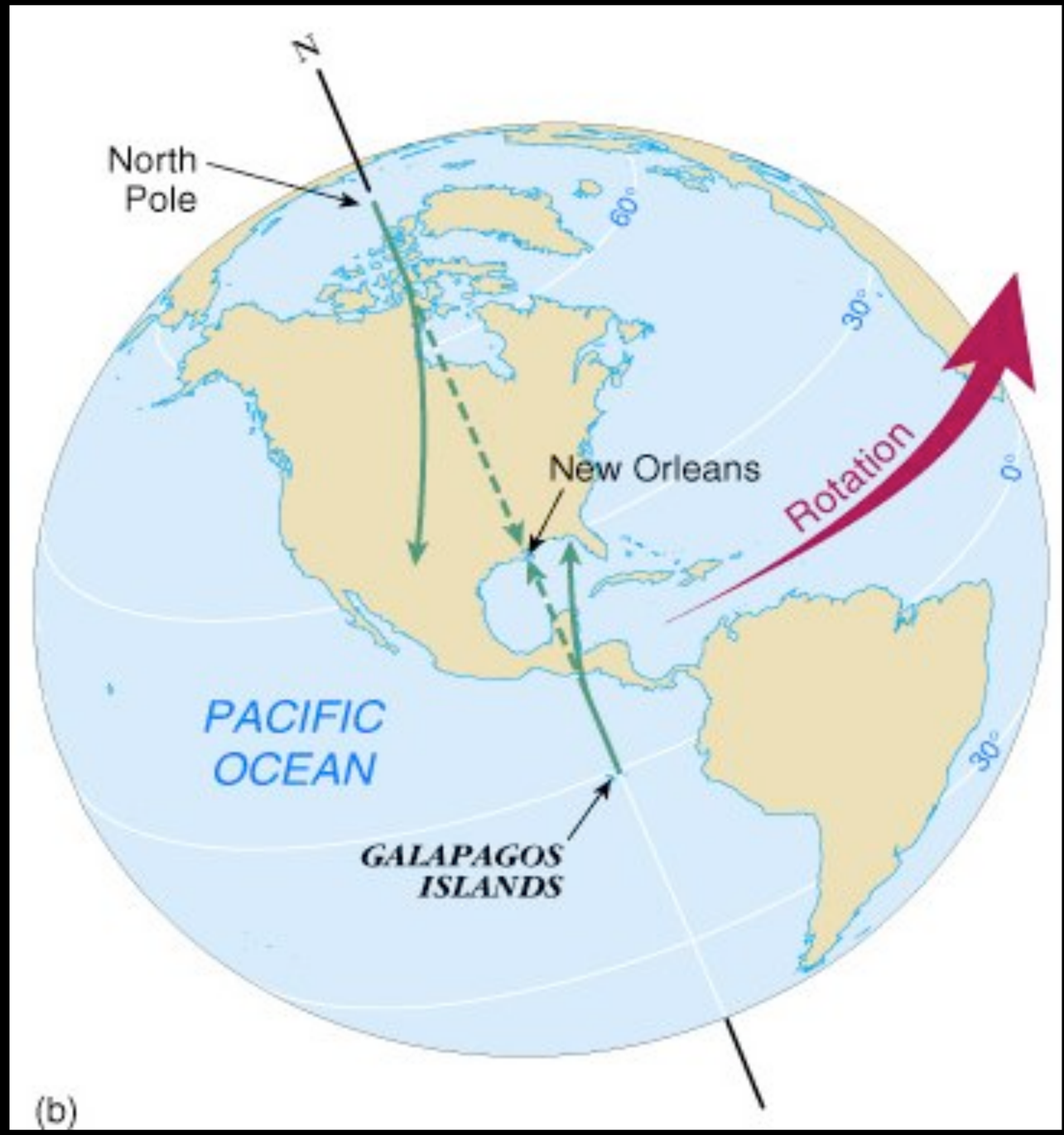
Objects normally move in a straight line when you're on a non-spinning world.



However, in a spinning world, if you move in a straight line, you really wind up curving and never get to the place you want to go.

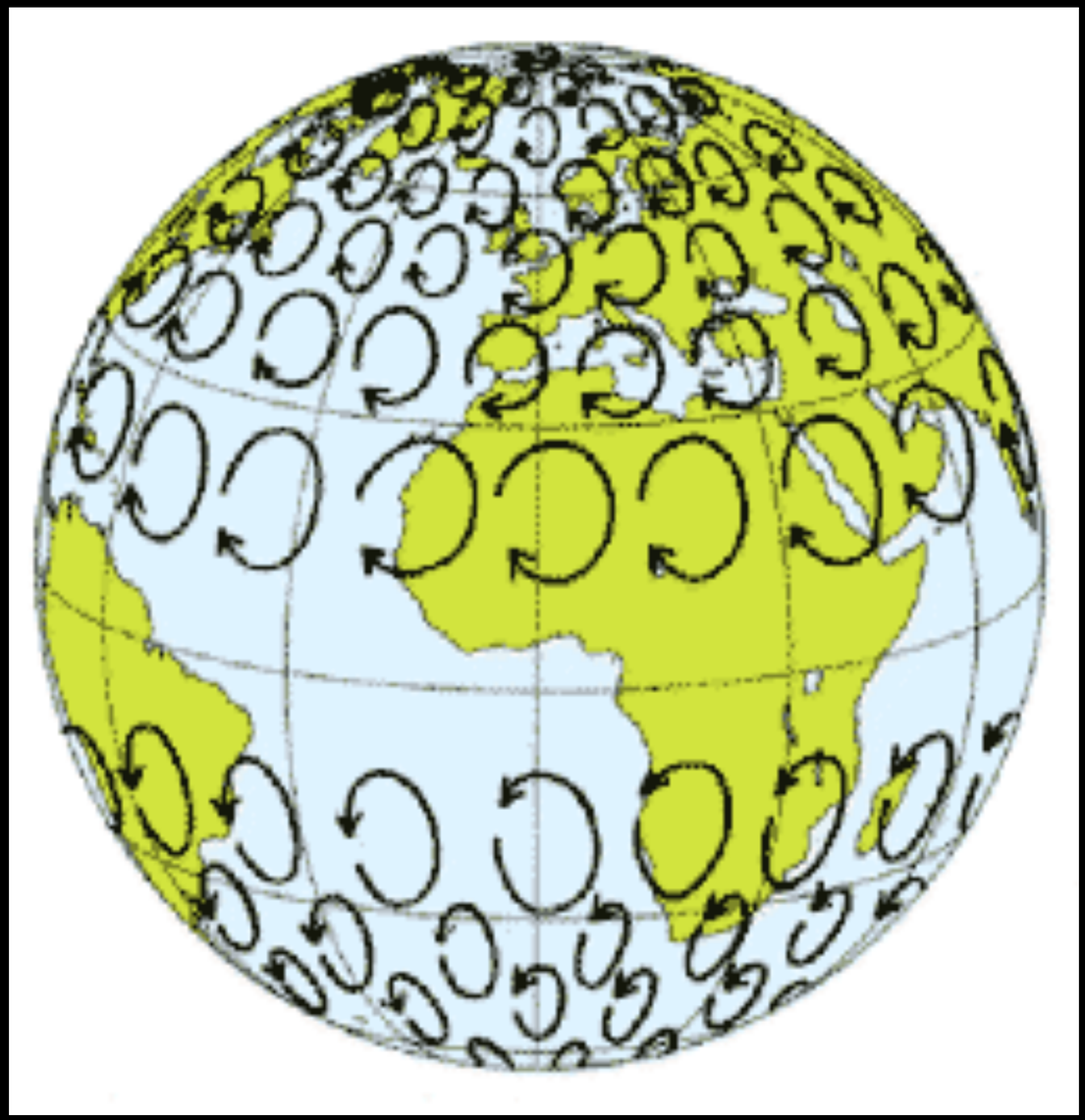
As Earth rotates, different latitudes travel at different speeds.

The change in speed with latitude causes the Coriolis effect.



Winds, ocean currents, and other moving objects curve to the **Right** in the **northern hemisphere**,

Winds, ocean currents, and other moving objects curve to the **Left** in the **southern hemisphere**.

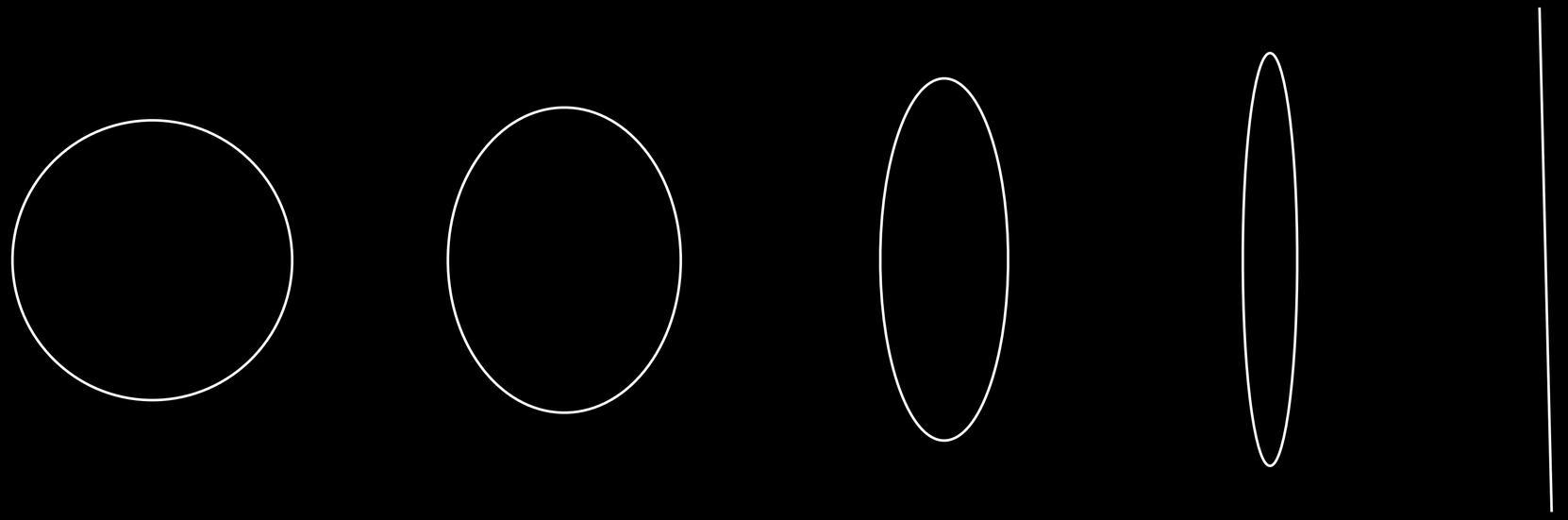


Ellipses

The Shape of Orbits

What is an Ellipse?

- A rounded shape that can be anywhere from perfectly circular to flat.



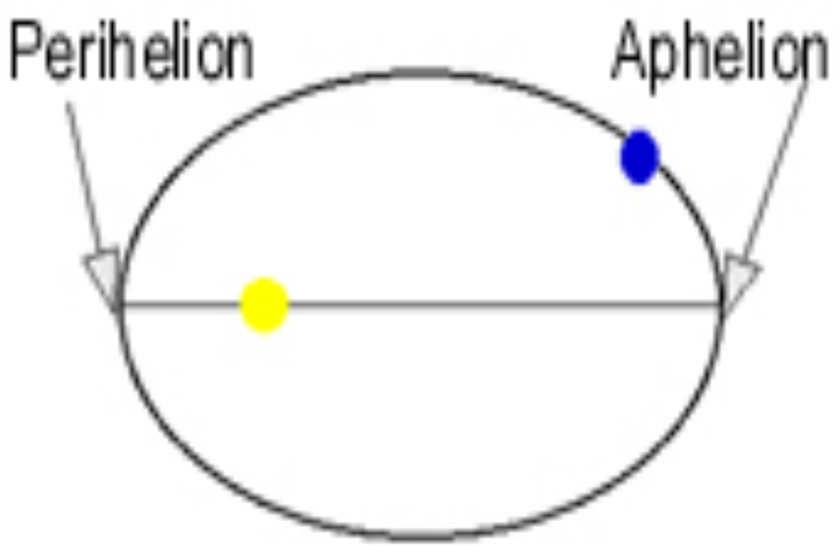


Why do we care?

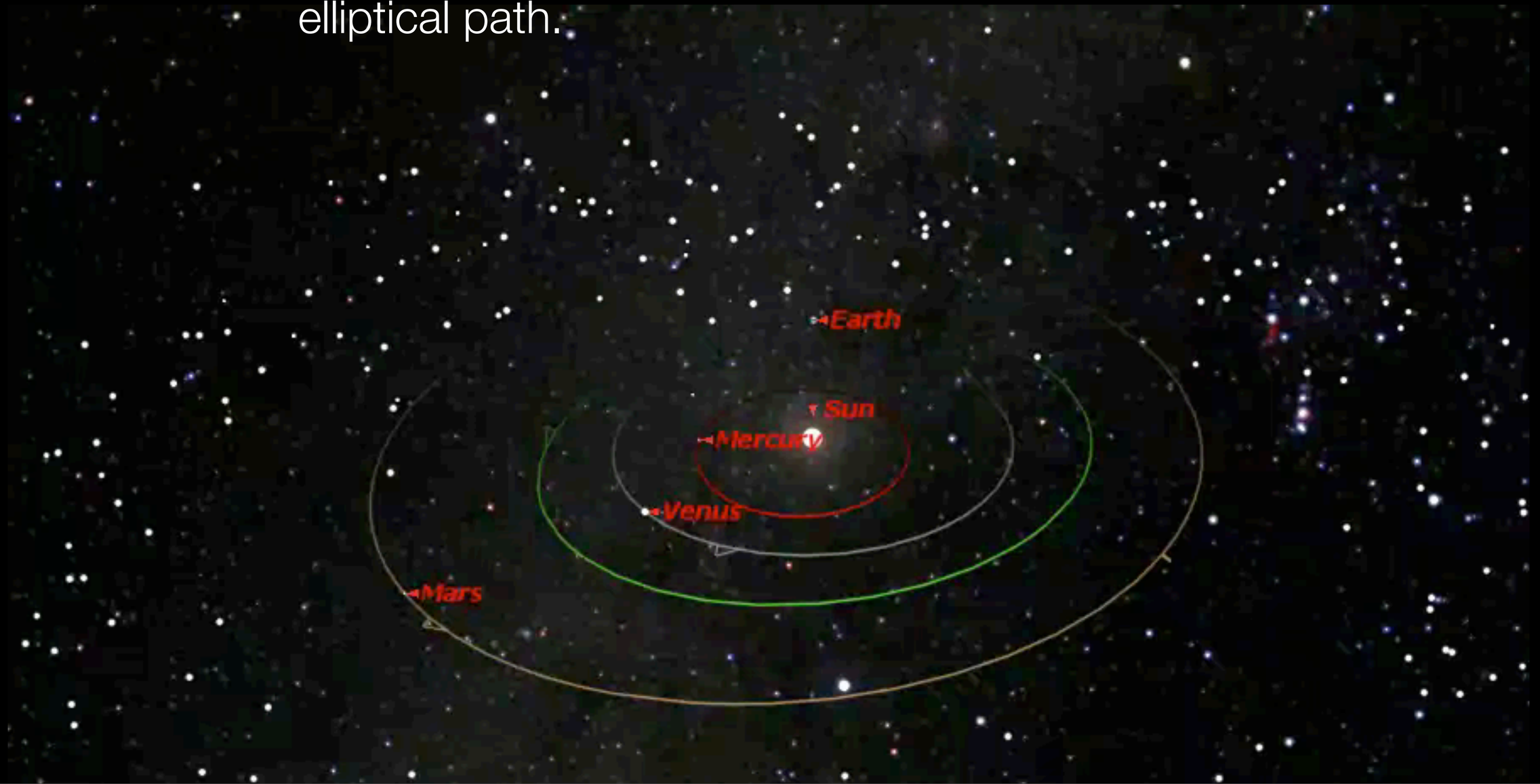
Kepler's Laws of Planetary Motion

(1st law)

The orbits of the planets are ellipses, with the Sun at one focus of the ellipse.



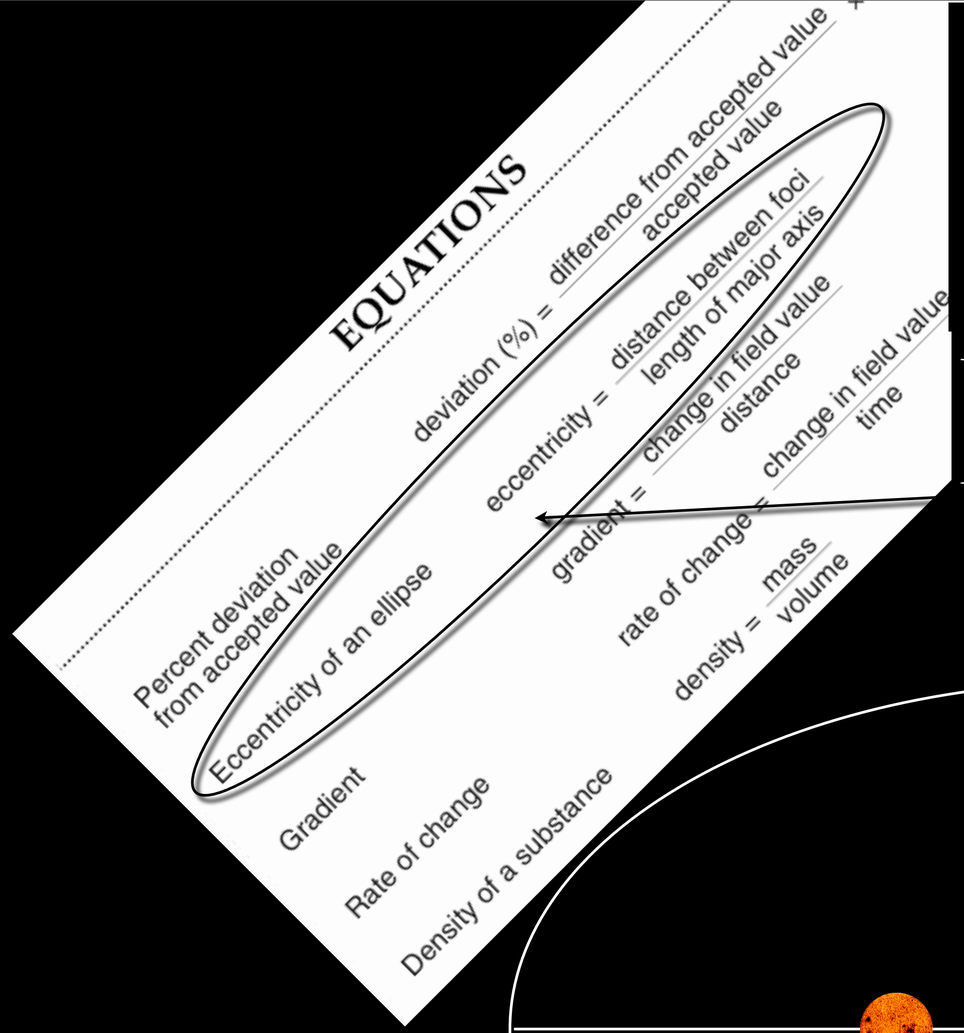
- All solar system objects orbit the Sun along an elliptical path.



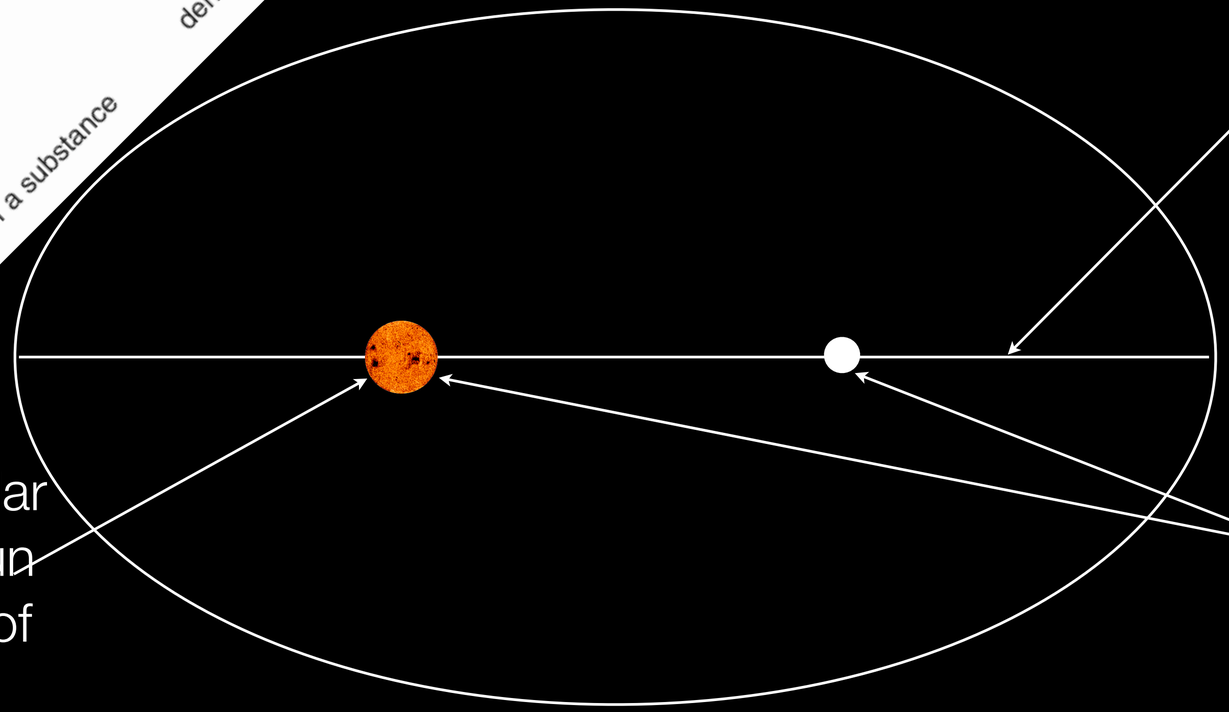
Solar System Data

Object	Mean Distance from Sun (millions of km)	Period of Revolution	Period of Rotation	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)	Number of Moons
SUN	—	—	27 days	—	1,392,000	333,000.00	1.4	—
MERCURY	57.9	88 days	59 days	0.206	4,880	0.553	5.4	0
VENUS	108.2	224.7 days	243 days	0.007	12,104	0.815	5.2	0
EARTH	149.6	365.26 days	23 hr 56 min 4 sec	0.017	12,756	1.00	5.5	1
MARS	227.9	687 days	24 hr 37 min 23 sec	0.093	6,787	0.1074	3.9	2
JUPITER	778.3	11.86 years	9 hr 50 min 30 sec	0.048	142,800	317.896	1.3	16
SATURN	1,427	29.46 years	10 hr 14 min	0.056	120,000	95.185	0.7	18
URANUS	2,869	84.0 years	17 hr 14 min	0.047	51,800	14.537	1.2	21
NEPTUNE	4,496	164.8 years	16 hr	0.009	49,500	17.151	1.7	8
PLUTO	5,900	247.7 years	6 days 9 hr	0.250	2,300	0.0025	2.0	1
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 days	27 days 8 hr	0.055	3,476	0.0123	3.3	—

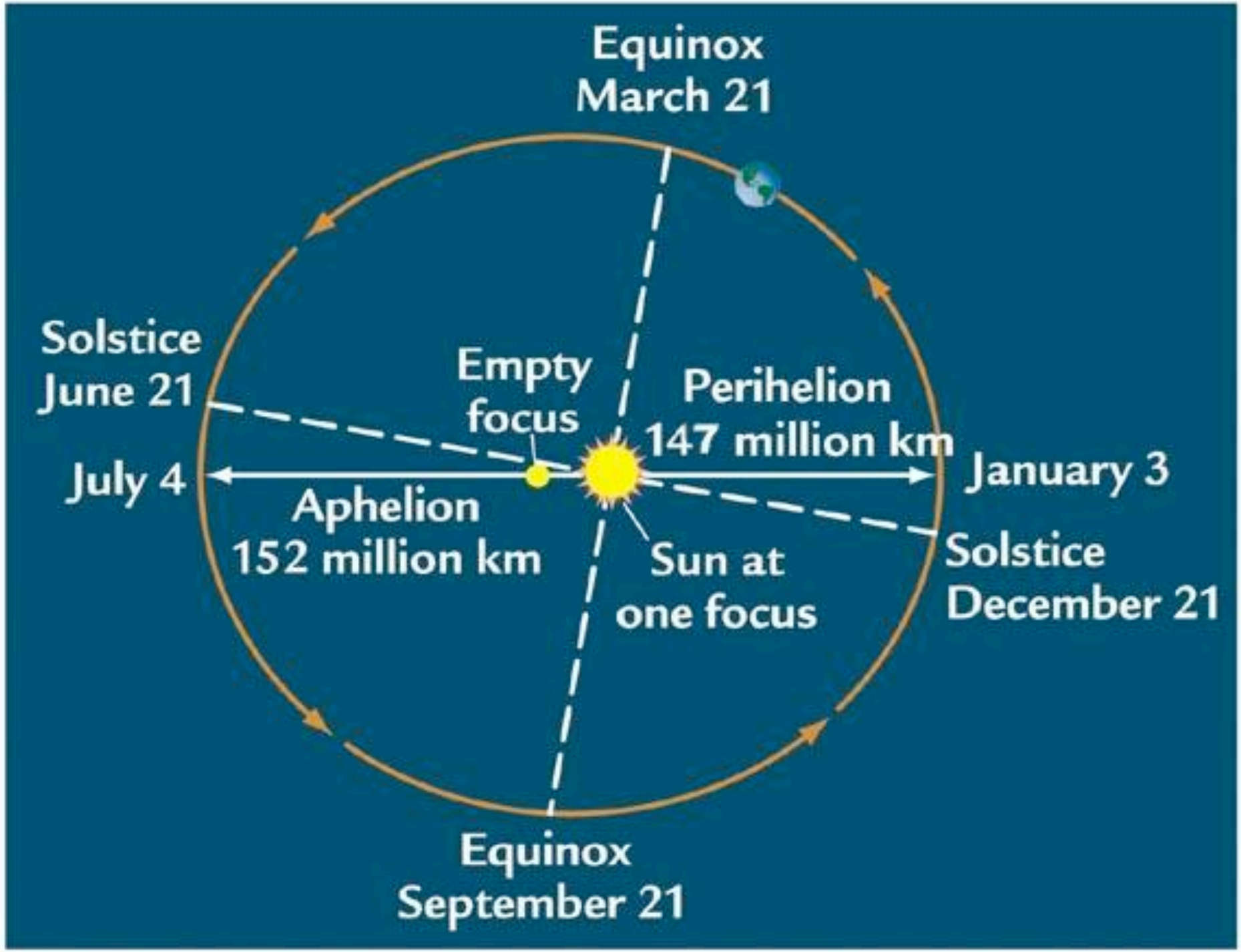
Eccentricity



- How flat or circular an orbit is
- Eccentricity= $\frac{\text{Distance Between Foci}}{\text{Length of Major Axis}}$



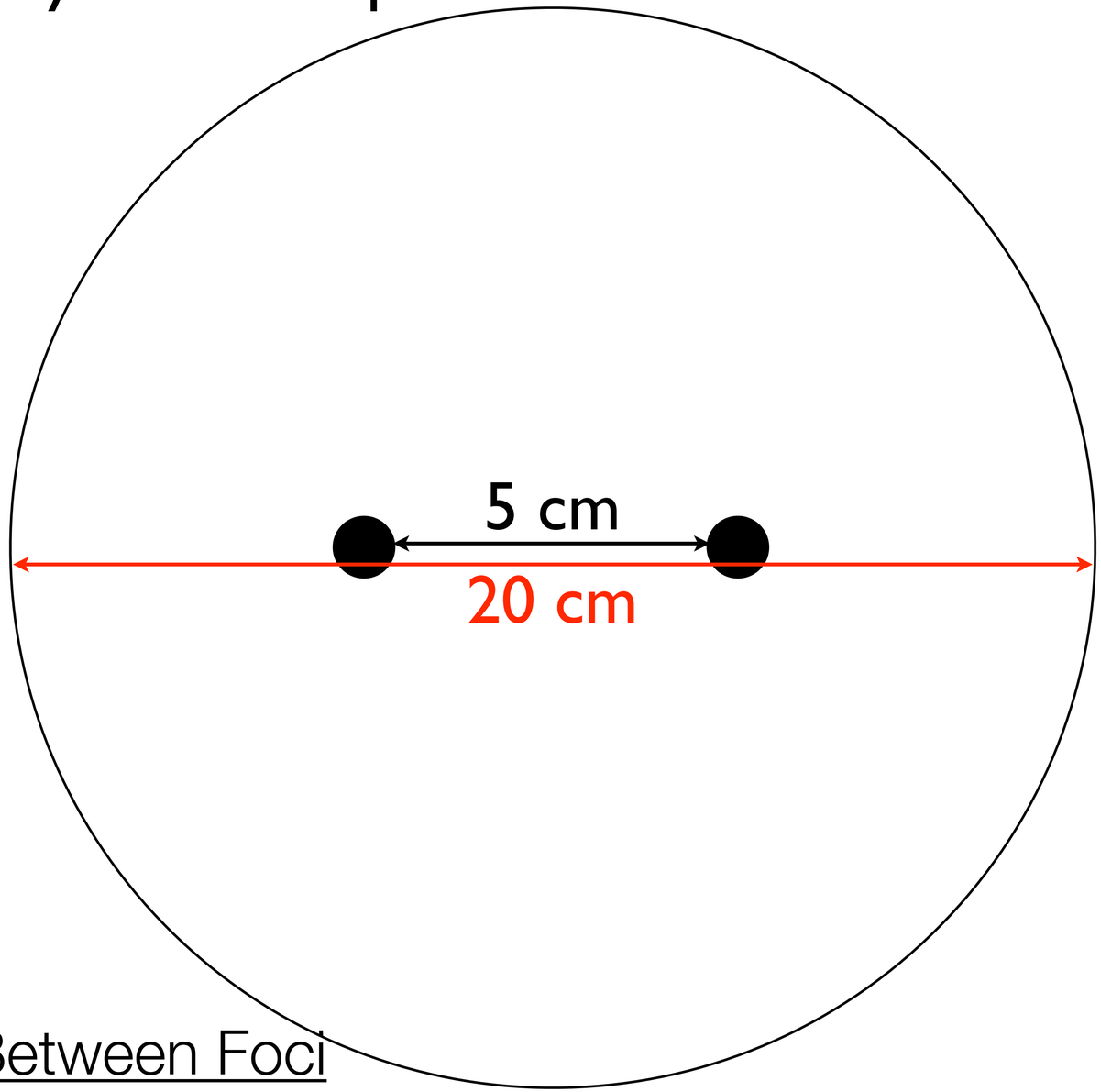
Note: In our solar system, the Sun is always one of the two foci


Equinox
March 21
Solstice
June 21
Empty
focus
Perihelion
147 million km
July 4
January 3
Aphelion
152 million km
Sun at
one focus
Solstice
December 21
Equinox
September 21

Eccentricity

- Eccentricity is always between 0 and 1 (if it is not, you did something wrong)!
- The closer to zero, the less eccentric the orbit, which means it will be more circular.
- The closer to one, the more eccentric the orbit, which means it will be flatter.
  - E = 0, Perfect circle
  - E = 1, Flat line

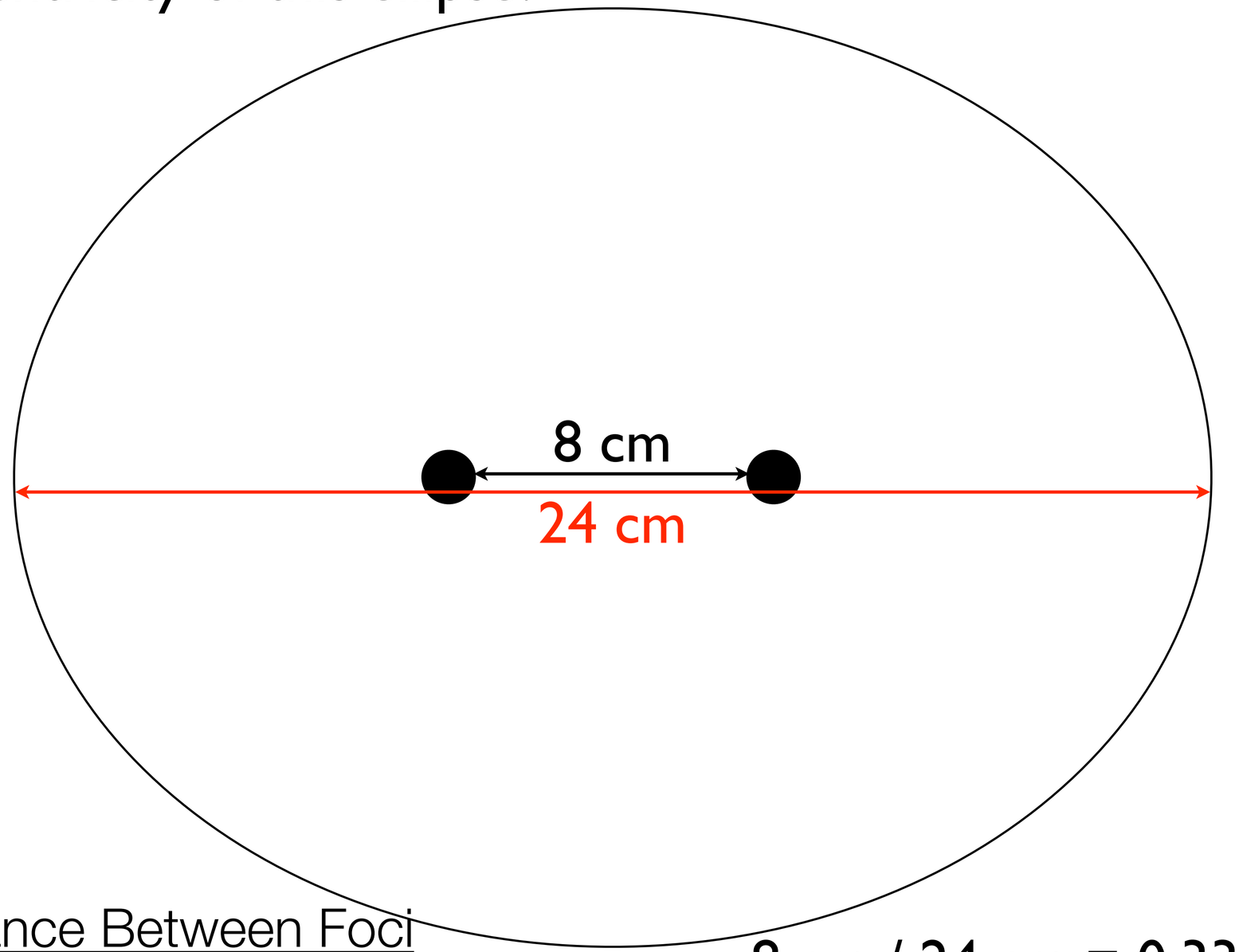
Eccentricity of this ellipse?



$$\frac{\text{Distance Between Foci}}{\text{Length of Major Axis}}$$

5 cm / 20 cm = 0.25

Eccentricity of this ellipse?

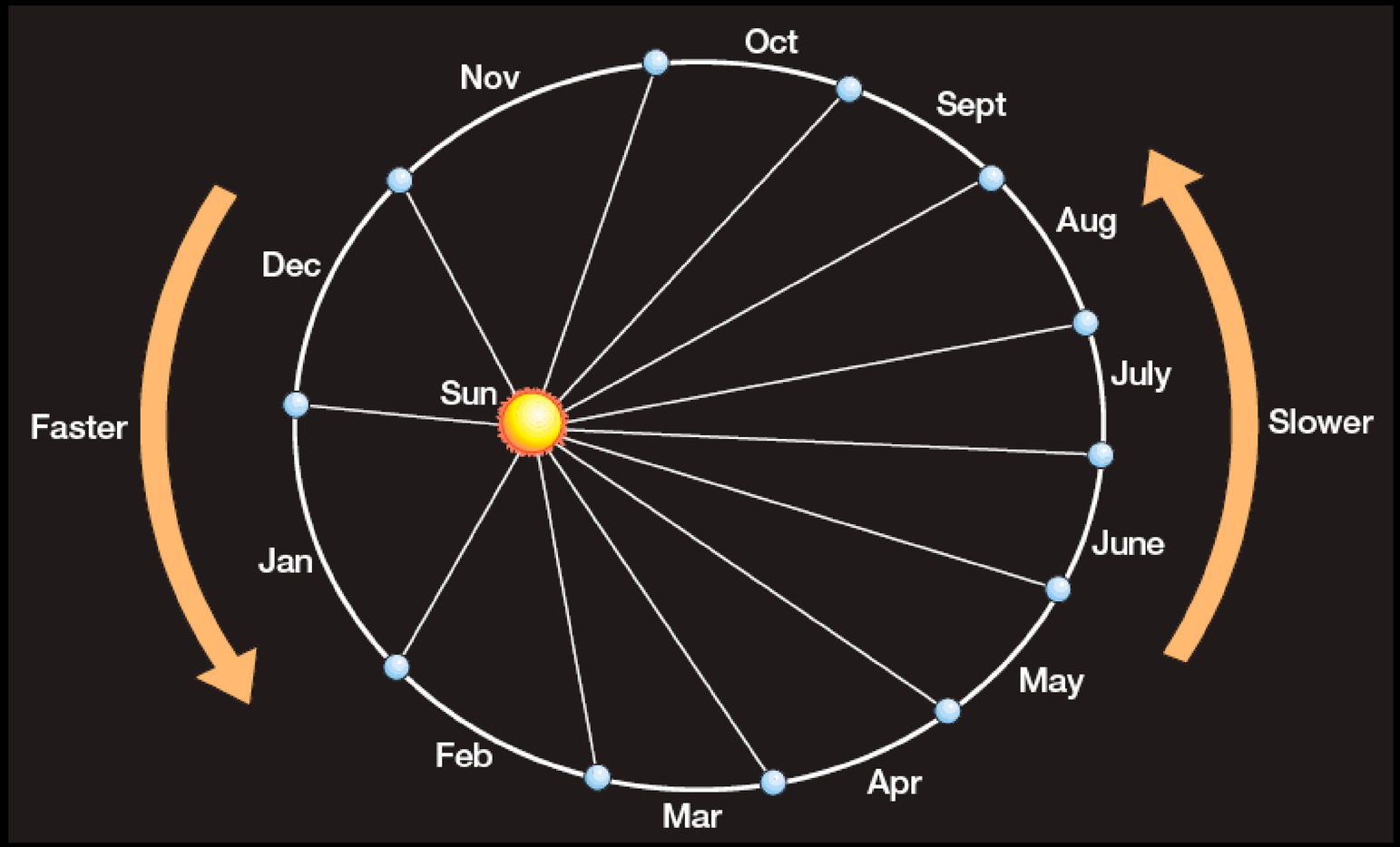


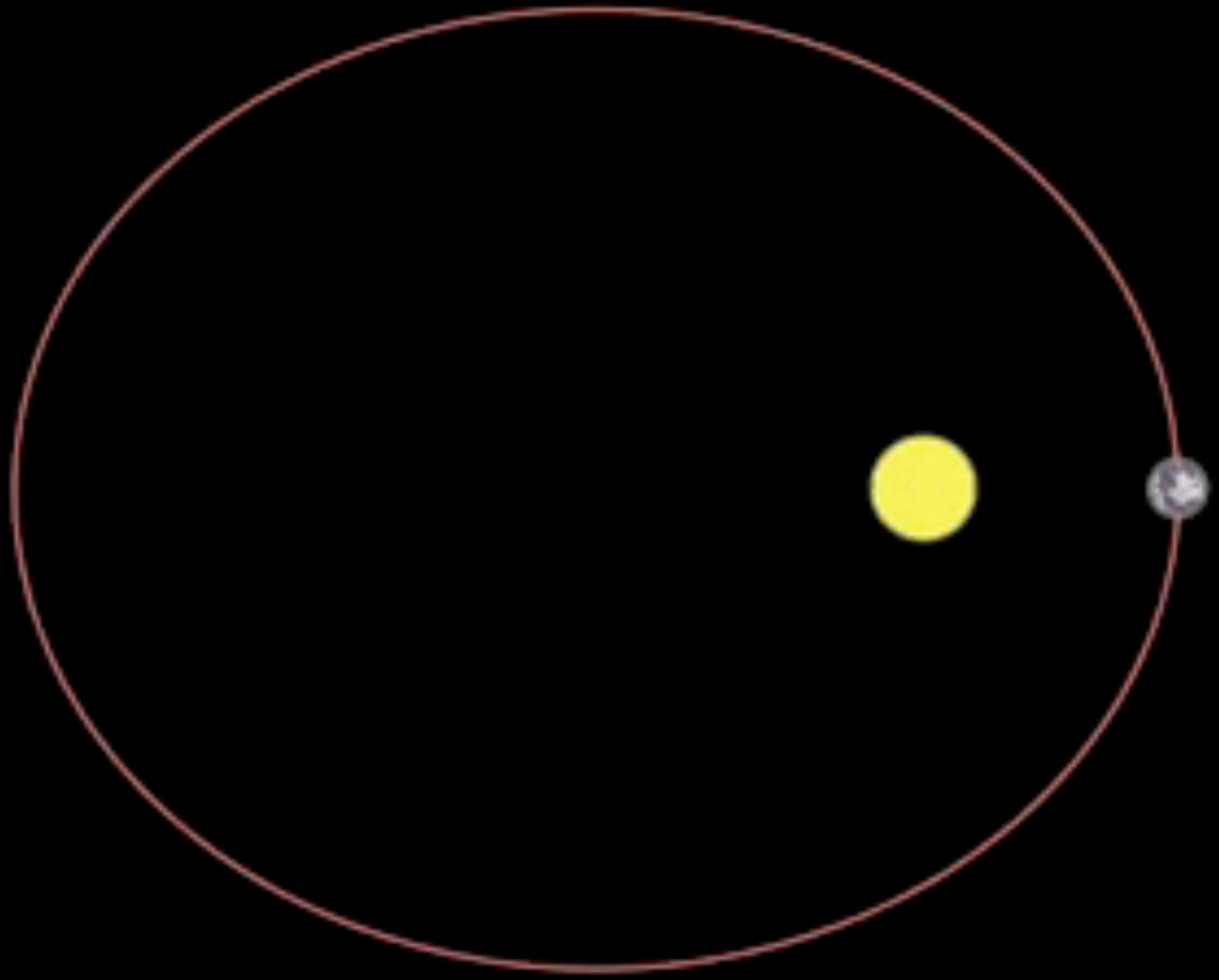
$$\frac{\text{Distance Between Foci}}{\text{Length of Major Axis}}$$

8 cm / 24 cm = 0.33

Kepler's Laws of Planetary Motion (2nd law)

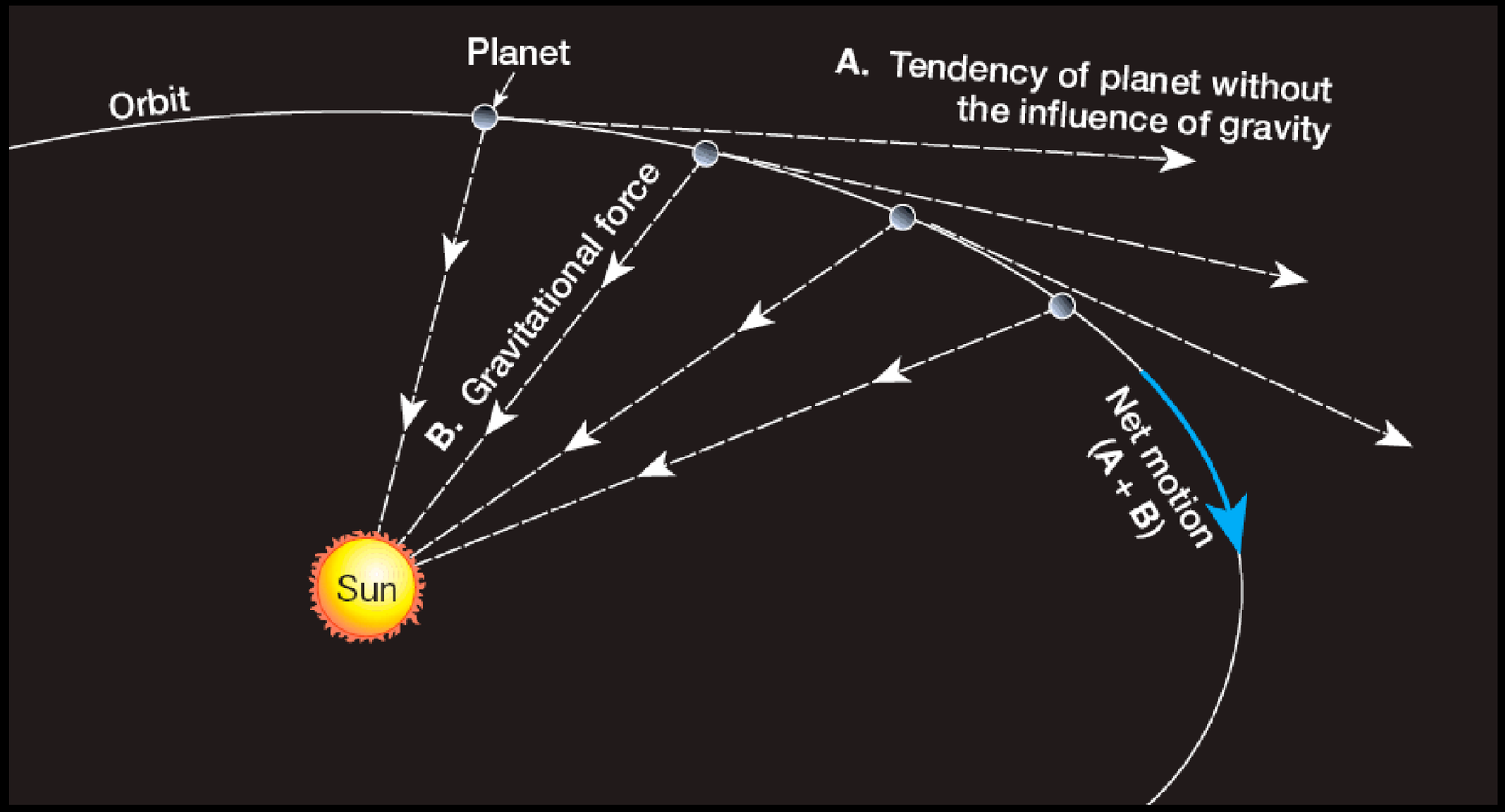
The line joining the planet to the Sun sweeps out equal areas in equal times as the planet travels around the ellipse.

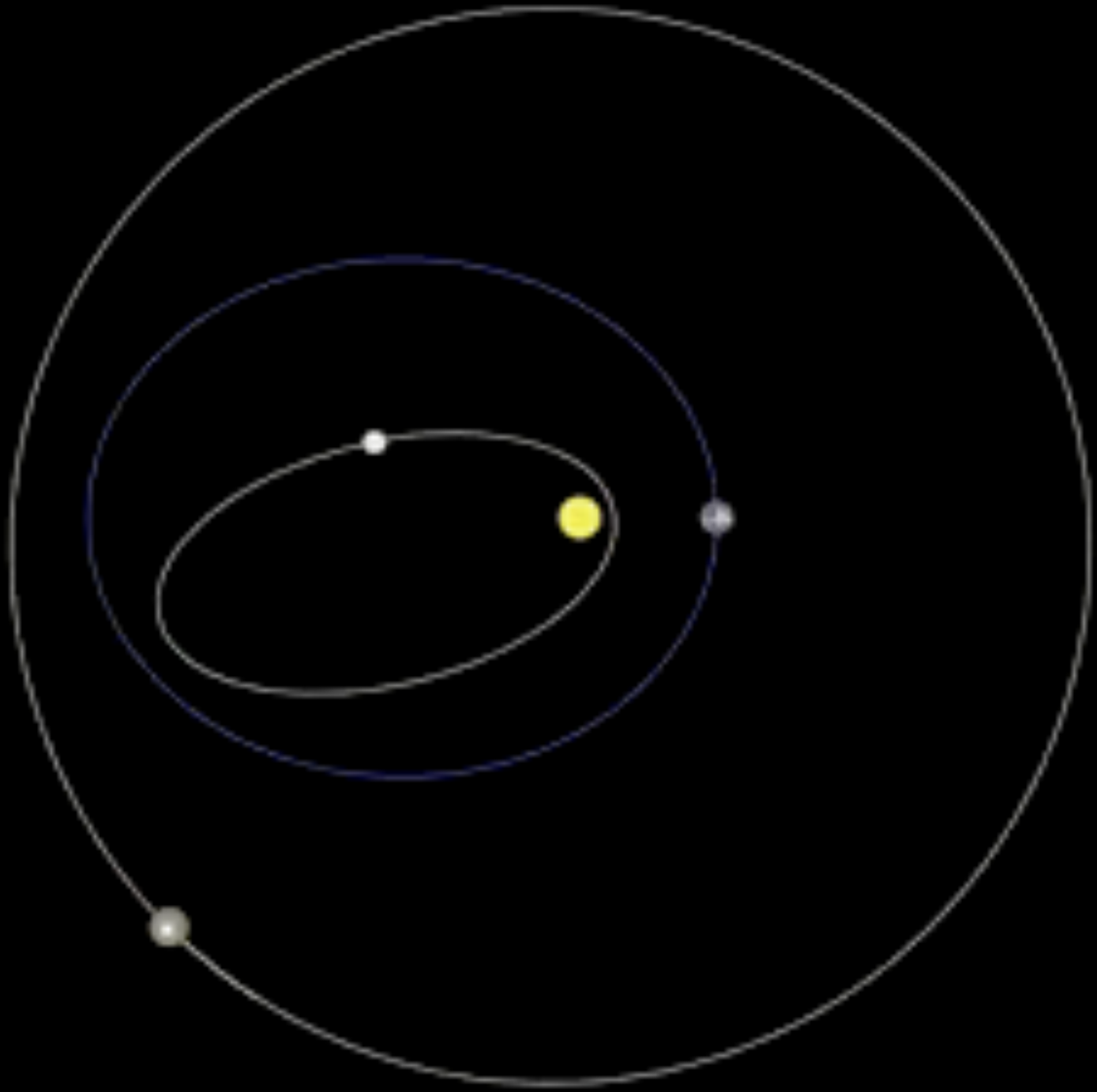


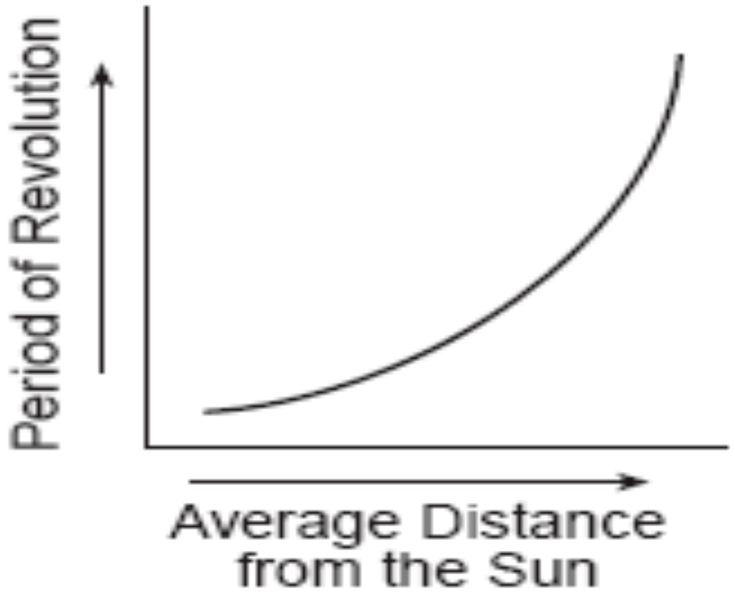


Kepler's Laws of Planetary Motion (3rd law)

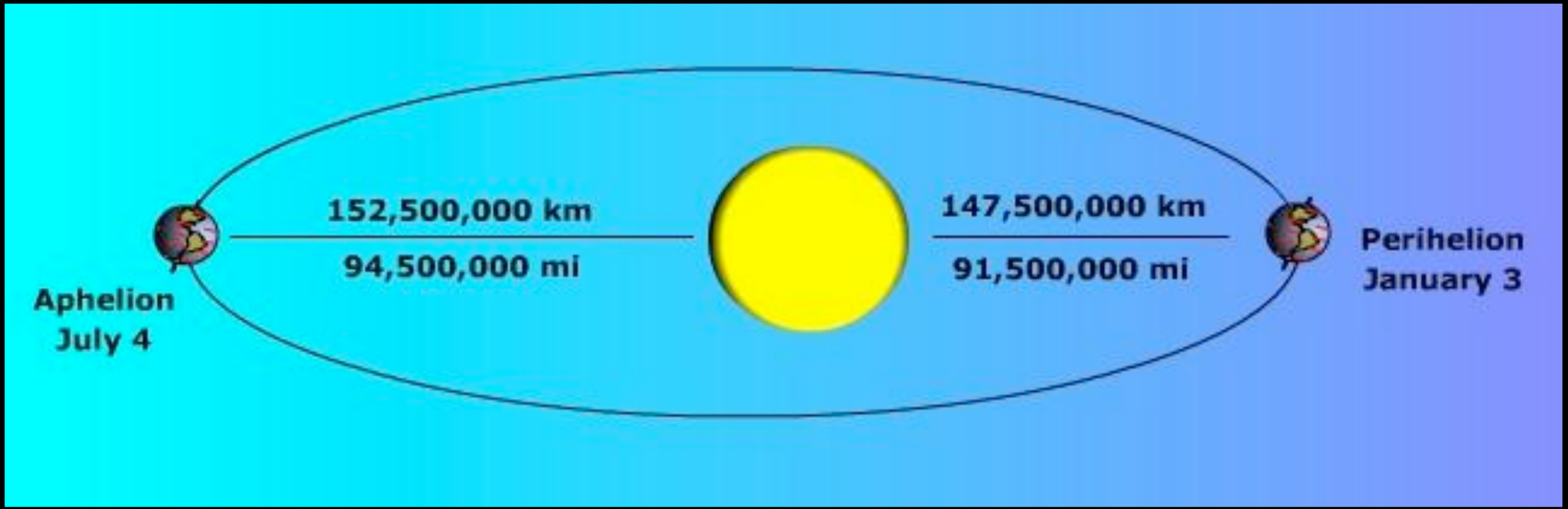
The period for a planet to orbit the Sun increases rapidly with the radius of its orbit (closer = faster, farther = slower).







The closer a planet is to a star, the faster it moves.


152,500,000 km
94,500,000 mi
147,500,000 km
91,500,000 mi
Aphelion
July 4
Perihelion
January 3

KEPLER'S LAWS

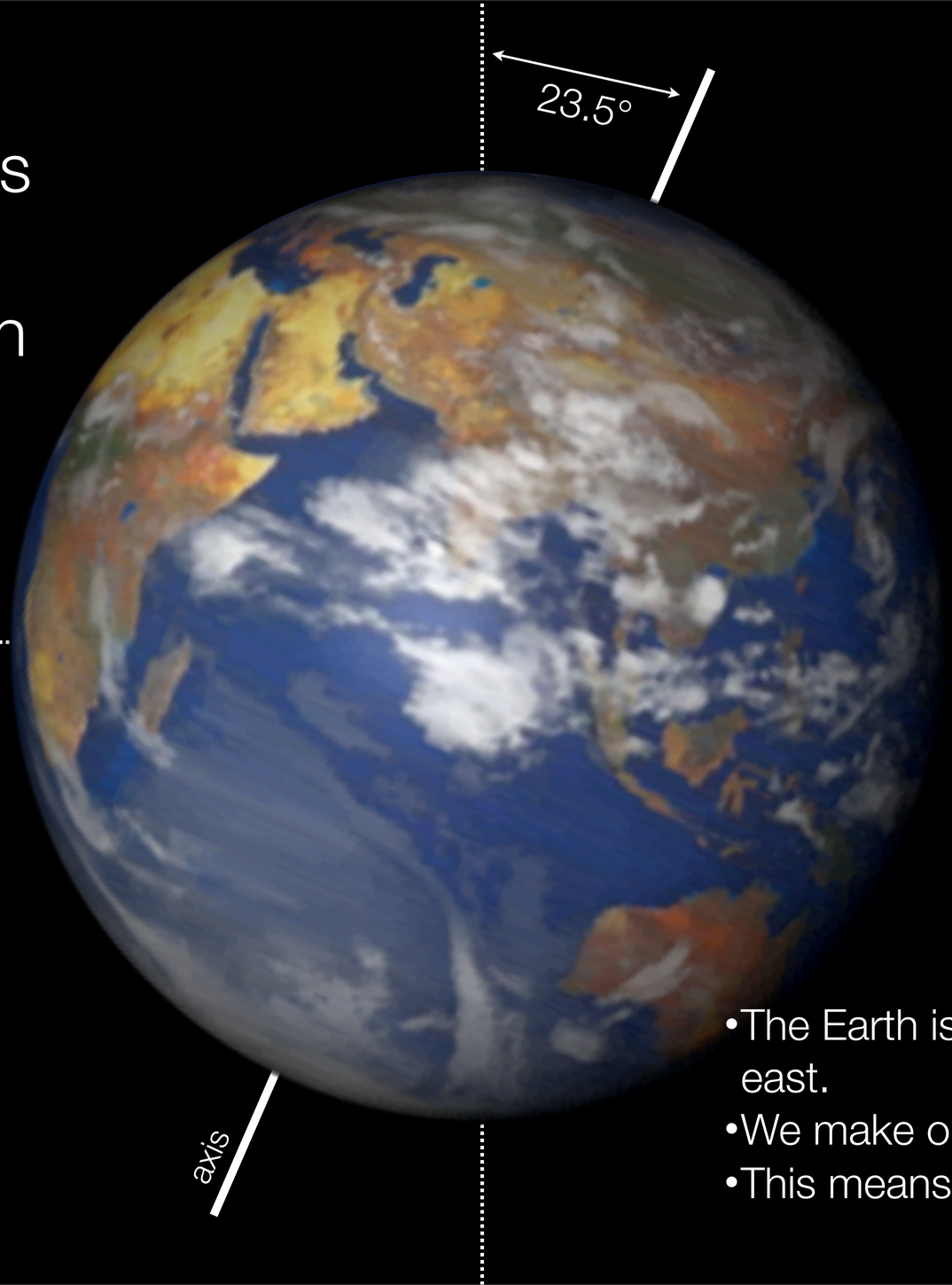
I. The orbits of the planets are ellipses, with the Sun at one focus of the ellipse.

II. The line joining the planet to the Sun sweeps out equal areas in equal times as the planet travels around the ellipse.

III. The period for a planet to orbit the Sun increases rapidly with the radius of its orbit.

Earth’s Motions

The Earth’s axis is tilited 23.5° relative to its path around the Sun



orbit around the Sun

- The Earth is ***rotating*** on its axis from west to east.
- We make one complete ***rotation*** each day.
- This means we spin 15° each hour (360°/24)

The Tilt of the Earth Causes our Seasons.

- **The seasons are the result of the tilt of the Earth's axis** relative to the ecliptic (the plane of orbit around the Sun).

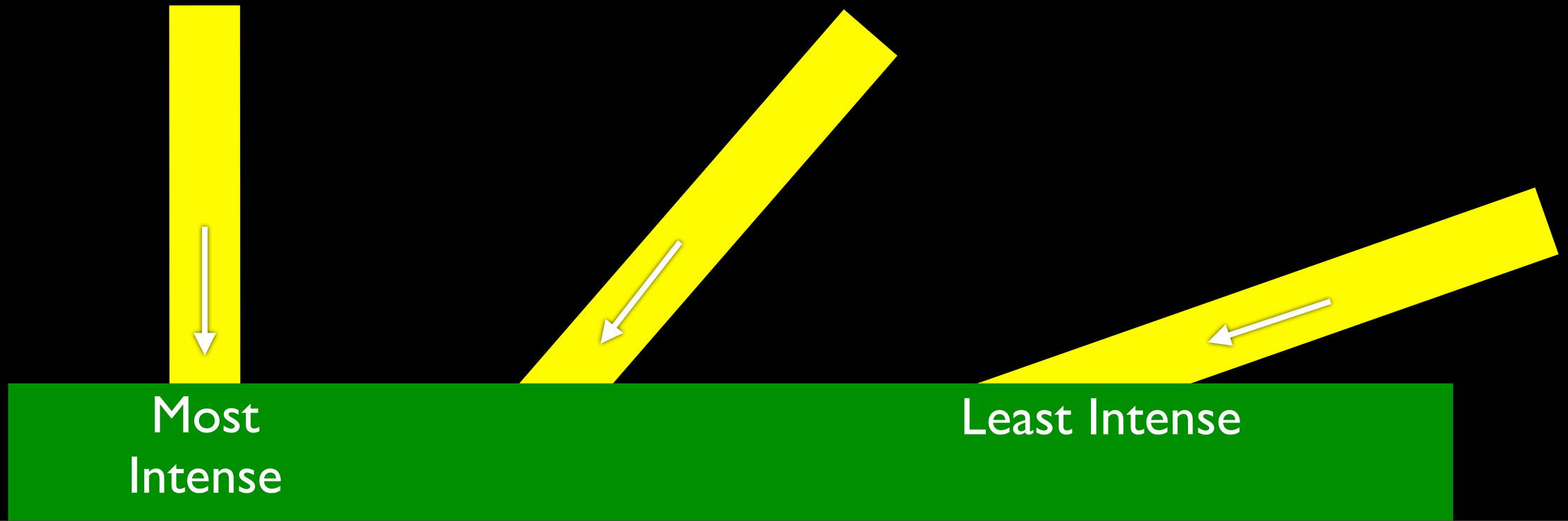
- The most direct insolation provides the most heat.

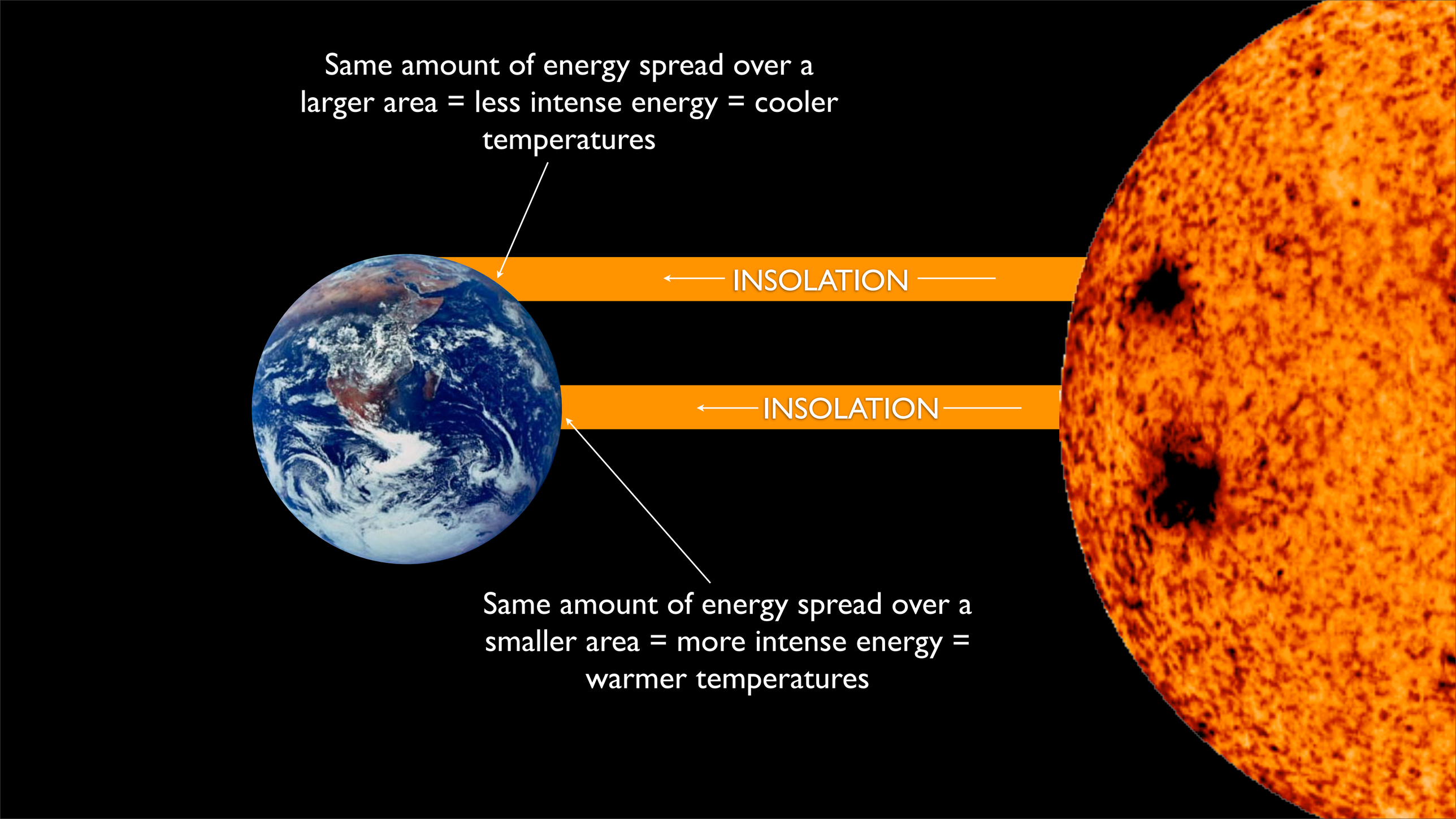
- It has nothing to do with the Earth's distance to the Sun!

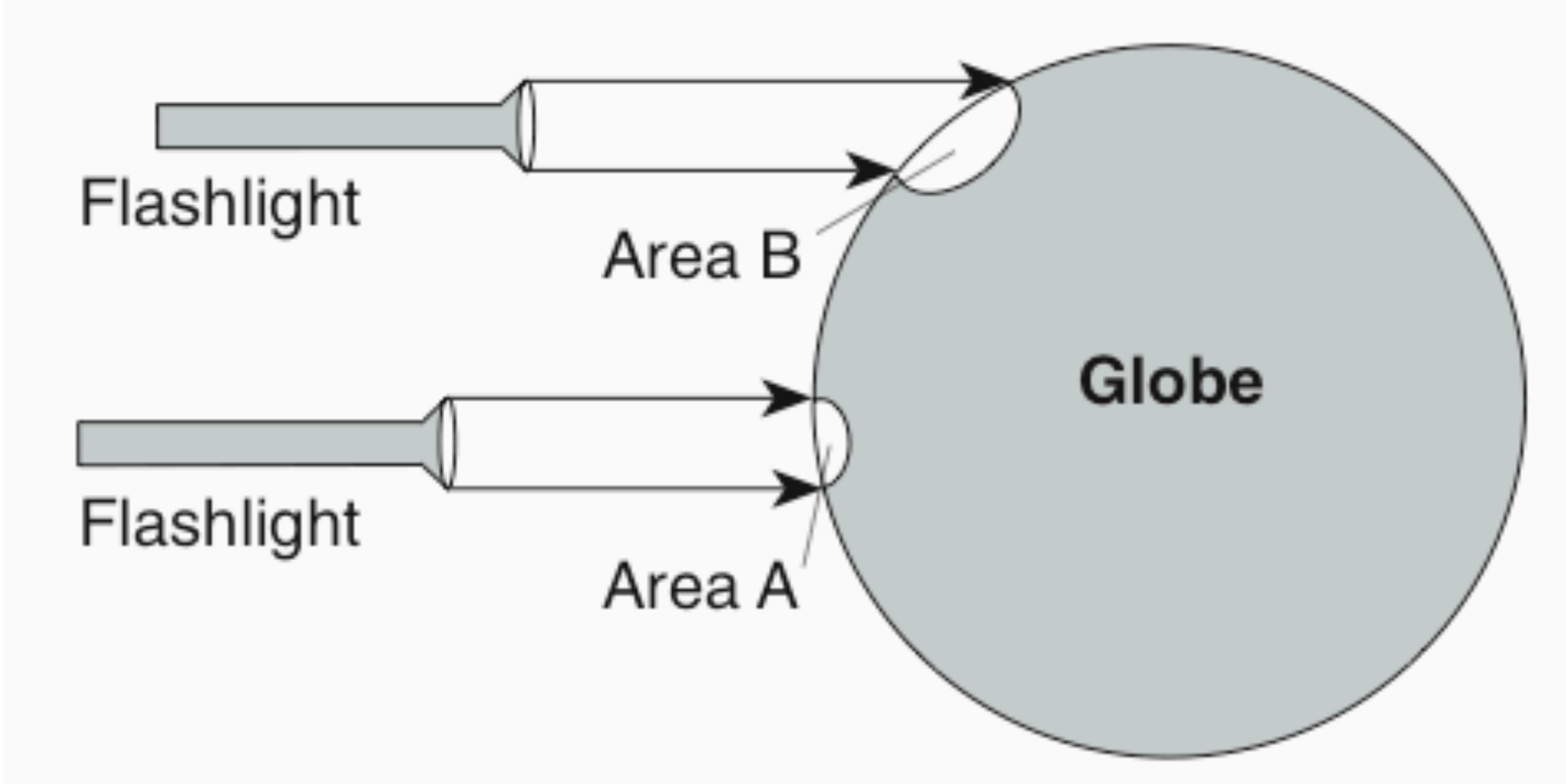
Angle of Insolation

(In sol ation = Incoming Solar Radiation)

- How directly the energy from the Sun hits a part of the Earth.
- The higher the angle, the more intense the energy.



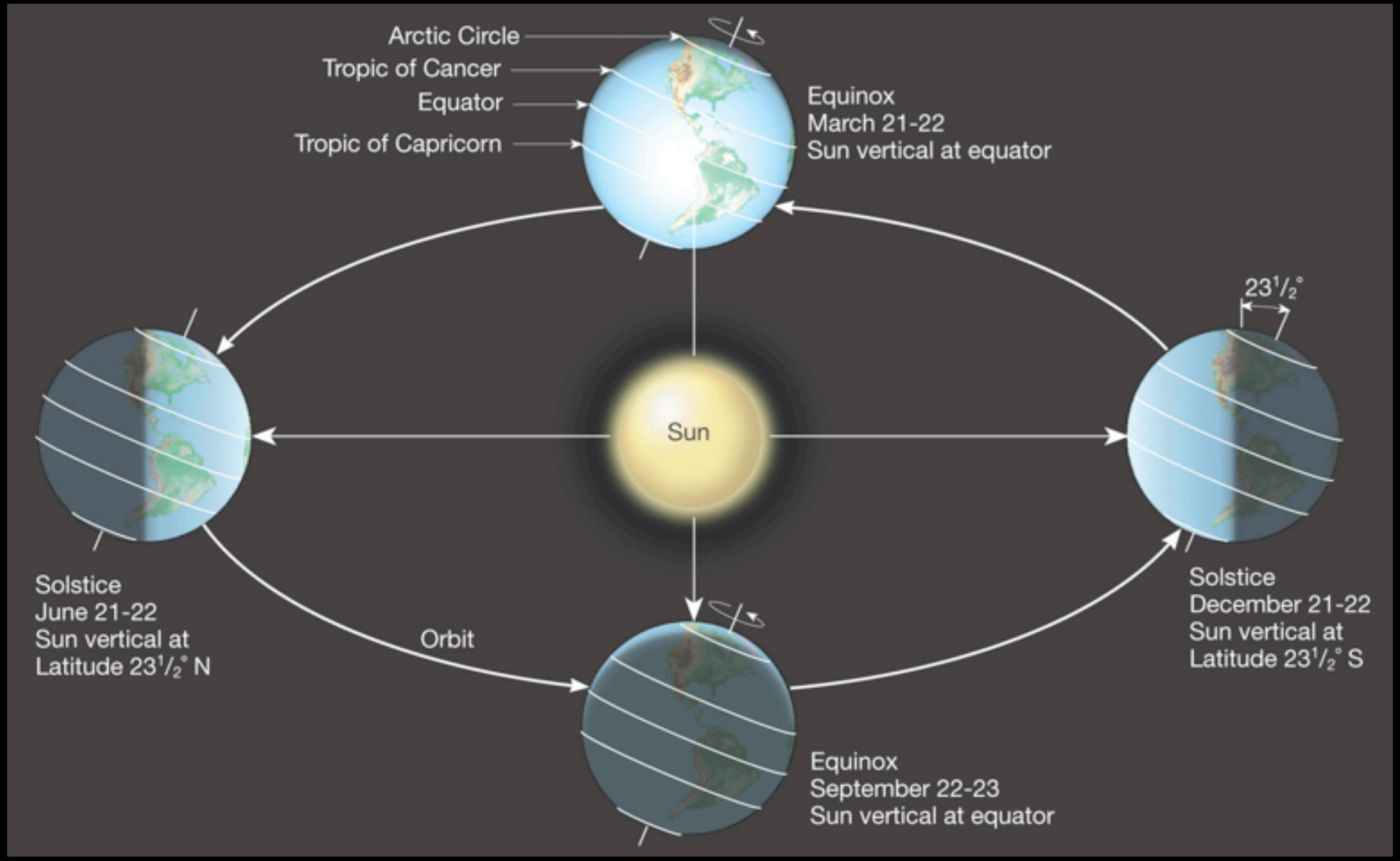

Same amount of energy spread over a larger area = less intense energy = cooler temperatures
INSOLATION
INSOLATION
Same amount of energy spread over a smaller area = more intense energy = warmer temperatures


Flashlight
Area B
Globe
Flashlight
Area A

The Seasons

- When the northern hemisphere is tilted toward the Sun, it is summer.
- When the northern hemisphere is tilted away from the Sun, it is winter.

- The opposite is true for the southern hemisphere.

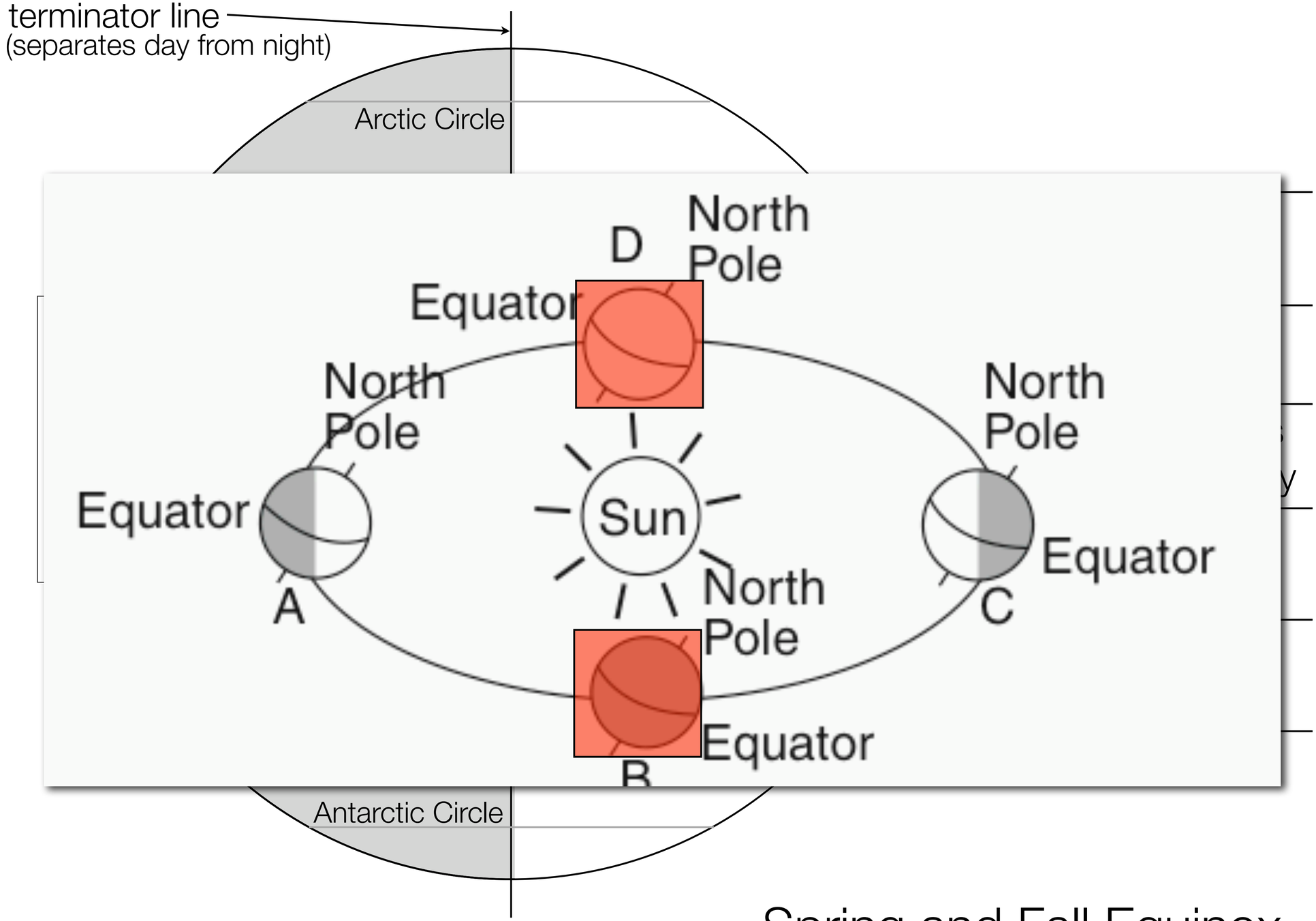

Arctic Circle
Tropic of Cancer
Equator
Tropic of Capricorn
Equinox
March 21-22
Sun vertical at equator
23 1/2°
Sun
Solstice
June 21-22
Sun vertical at
Latitude 23 1/2° N
Orbit
Solstice
December 21-22
Sun vertical at
Latitude 23 1/2° S
Equinox
September 22-23
Sun vertical at equator

Important Points

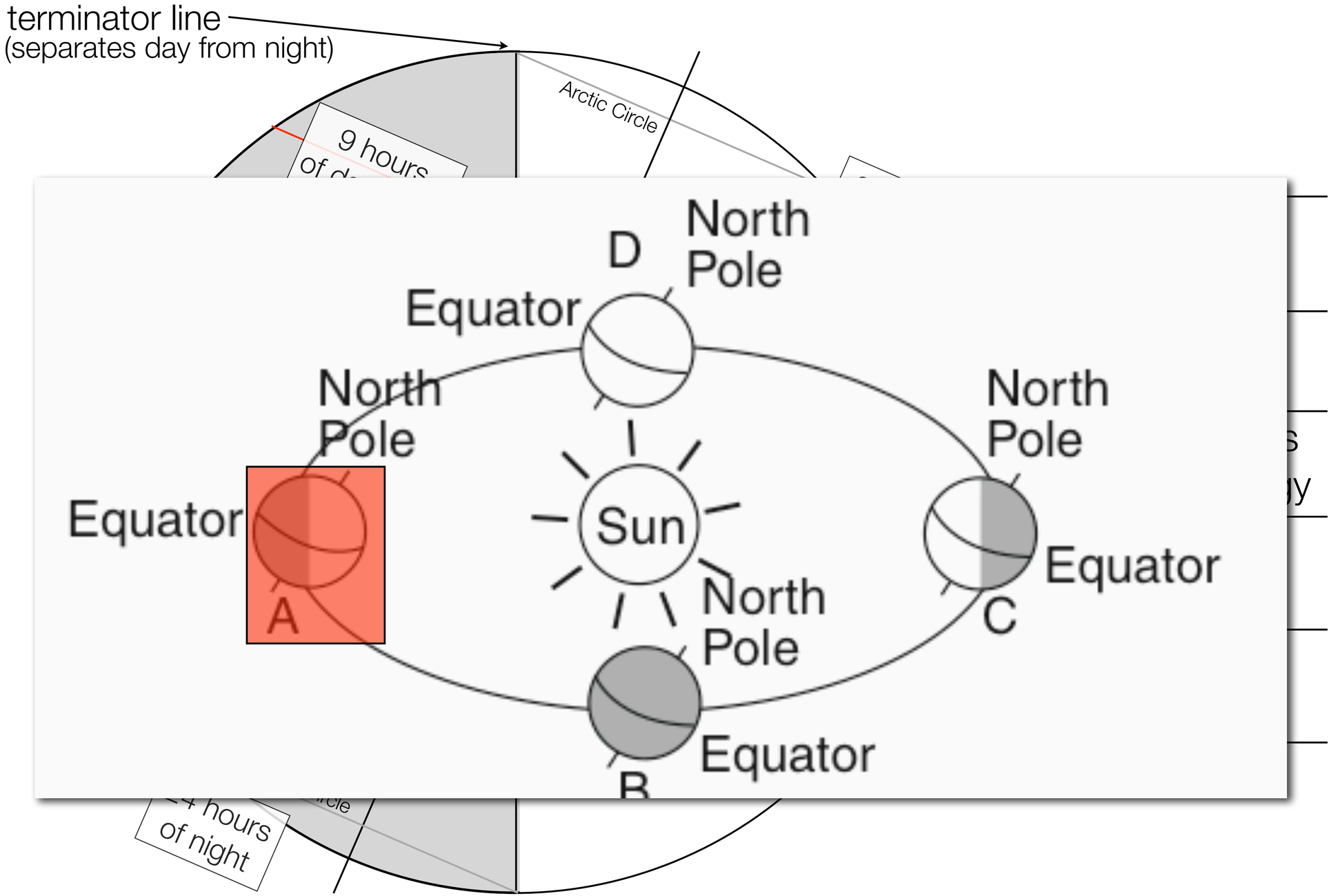
- The Earth completes a full rotation on its axis once a day.
- The axis of rotation is tilted 23.5° relative to its plane of revolution.
- The Earth orbits the Sun once in a year.
- The tilt of the axis remains the same throughout the orbit.
- The result is that different places on Earth receive different amounts of energy from the Sun during different times of year.

A Summary of the Seasons

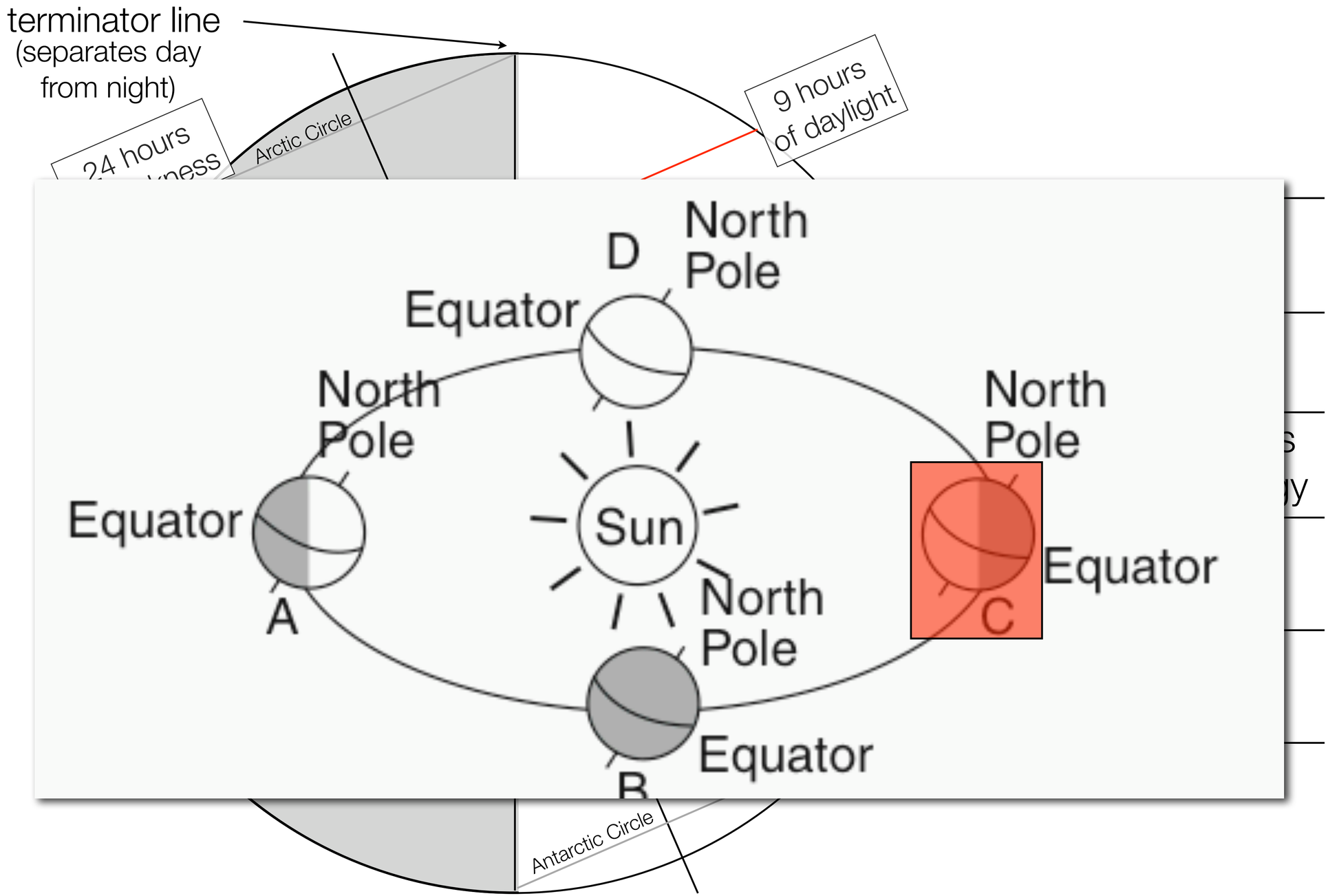
March 21	June 21	September 23	December 21
Spring Equinox- First day of Spring	**Summer Solstice**- First day of Summer	**Fall Equinox**- First day of Fall	**Winter Solstice**- First day of Winter
Sun is directly overhead at the equator	Sun is directly overhead farthest north (23.5° north, the Tropic of Cancer)	Sun is directly overhead at the equator	Sun is directly overhead farthest north (23.5° south, the Tropic of Capricorn)
Day and night are equal (12 hours each)	Day is longest, night is shortest	Day and night are equal (12 hours each)	Day is shortest, night is longest



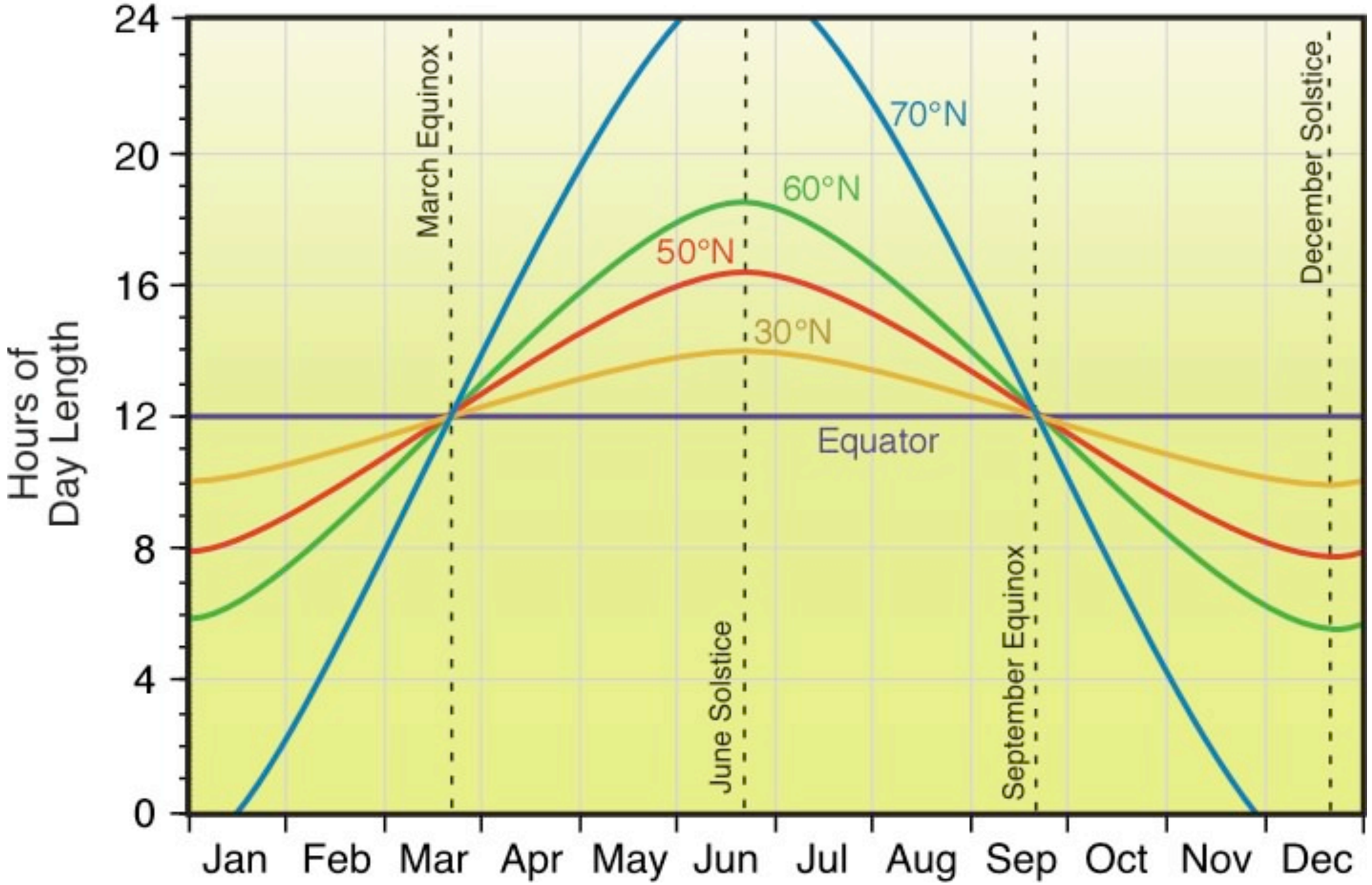
Spring and Fall Equinox



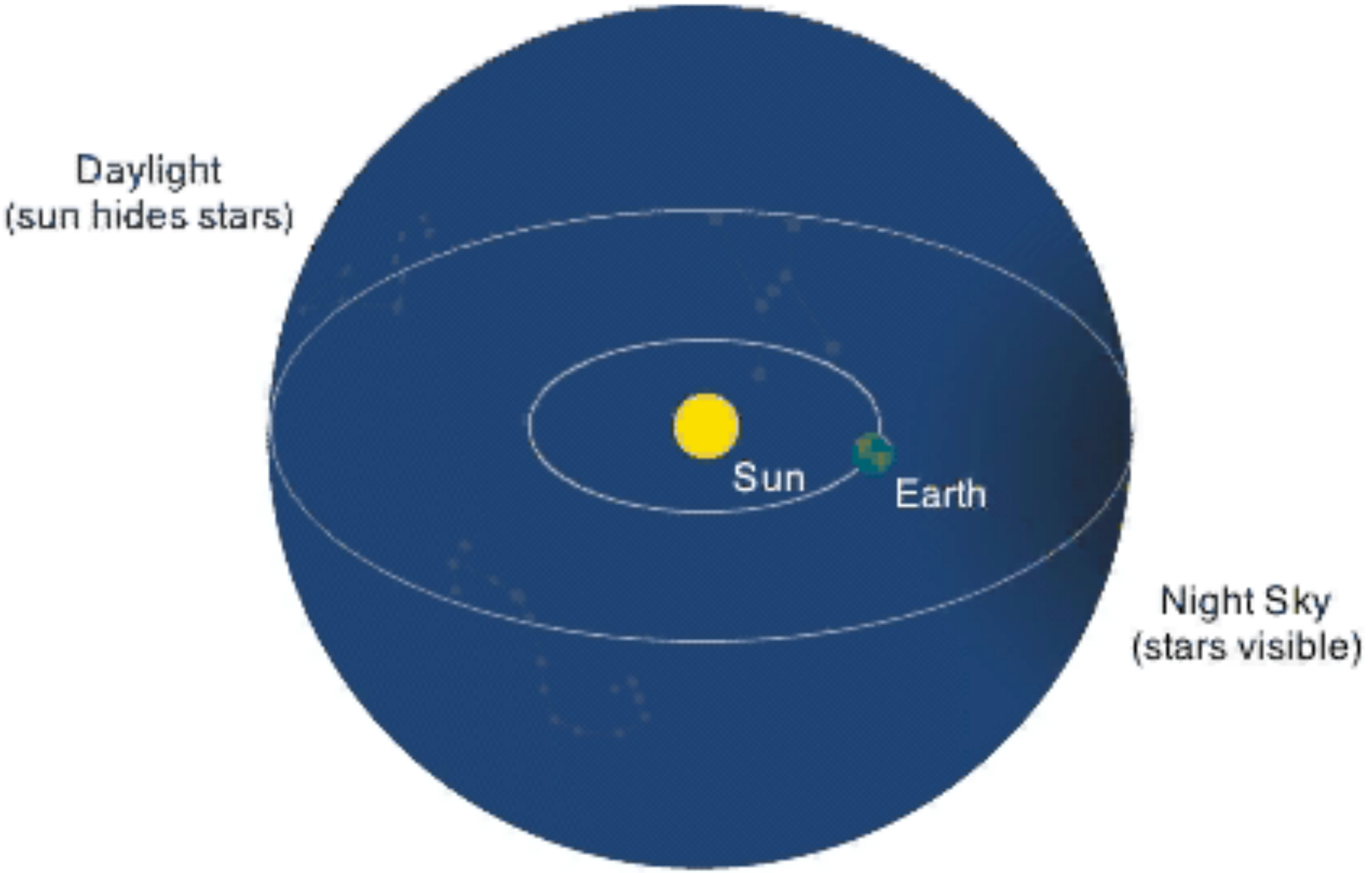
Summer Solstice



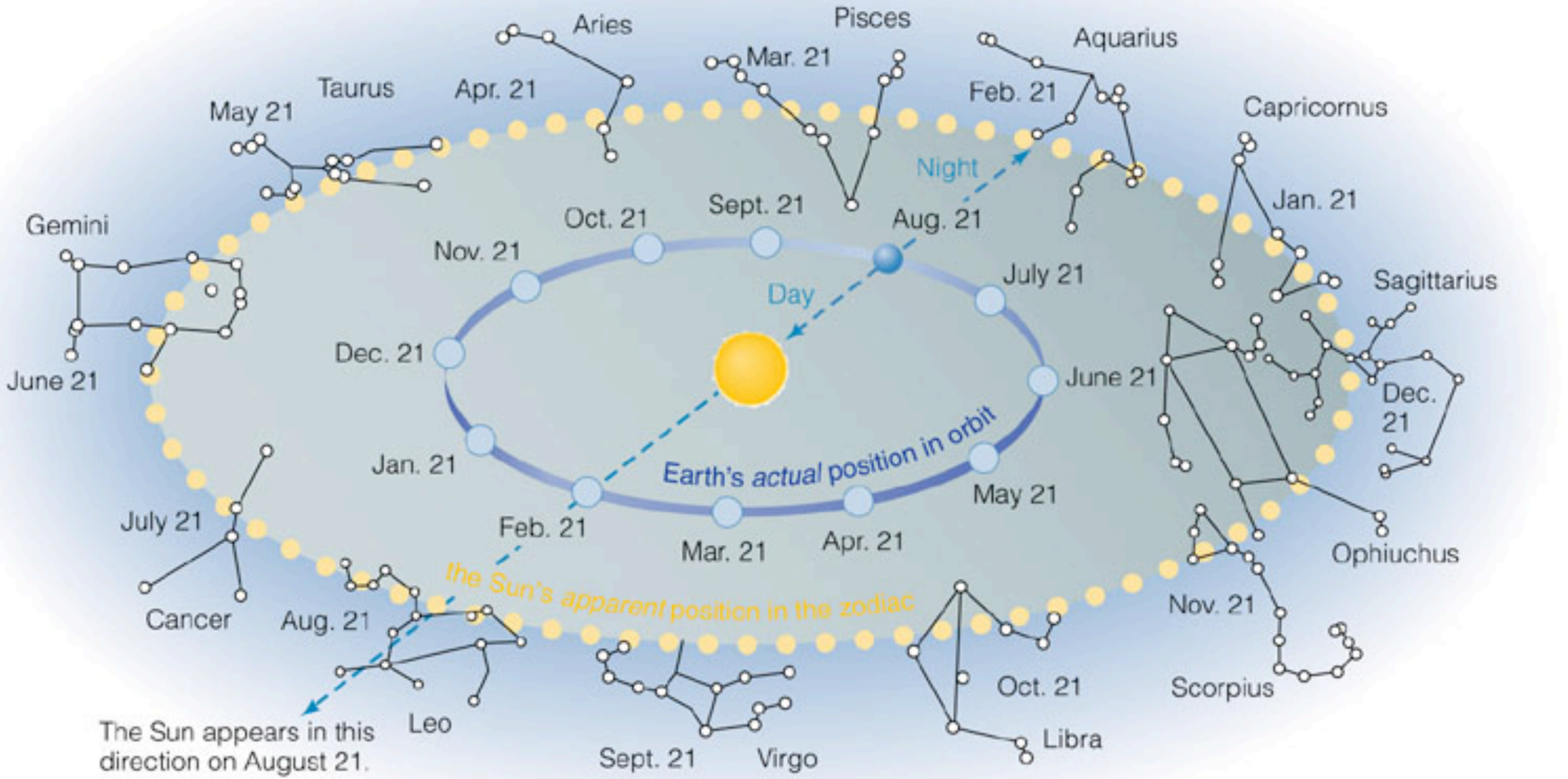
Winter Solstice


Hours of Day Length
24
20
16
12
8
4
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
March Equinox
June Solstice
September Equinox
December Solstice
70°N
60°N
50°N
30°N
Equator

We see different constellations at different times of year.



We see different constellations at different times of year.



The Path of the Sun



Apparent Motion of the Sun

- The Sun rises in the eastern sky and sets in the western sky.
- Throughout the year, the Sun's height in the sky at noon changes.
- The Sun's path across the sky during the day is an arc.
- In New York the Sun is never directly overhead (the "Zenith") or North of the Zenith.

Which Way is the Earth Rotating?

- The Earth rotates from West to East.
- This is why objects in the sky appear to move from East to West.
- The Sun rises in the East and sets in the West.
- The Earth rotates 15 degrees per hour (360/24).



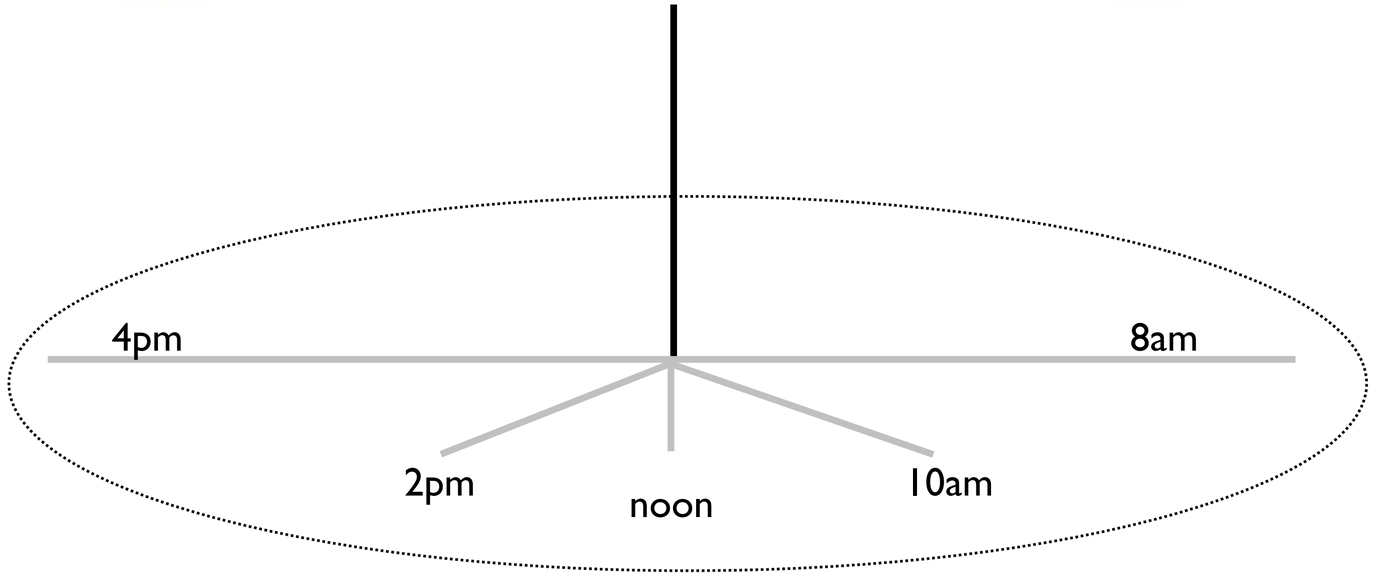
noon

10am

2pm

8am

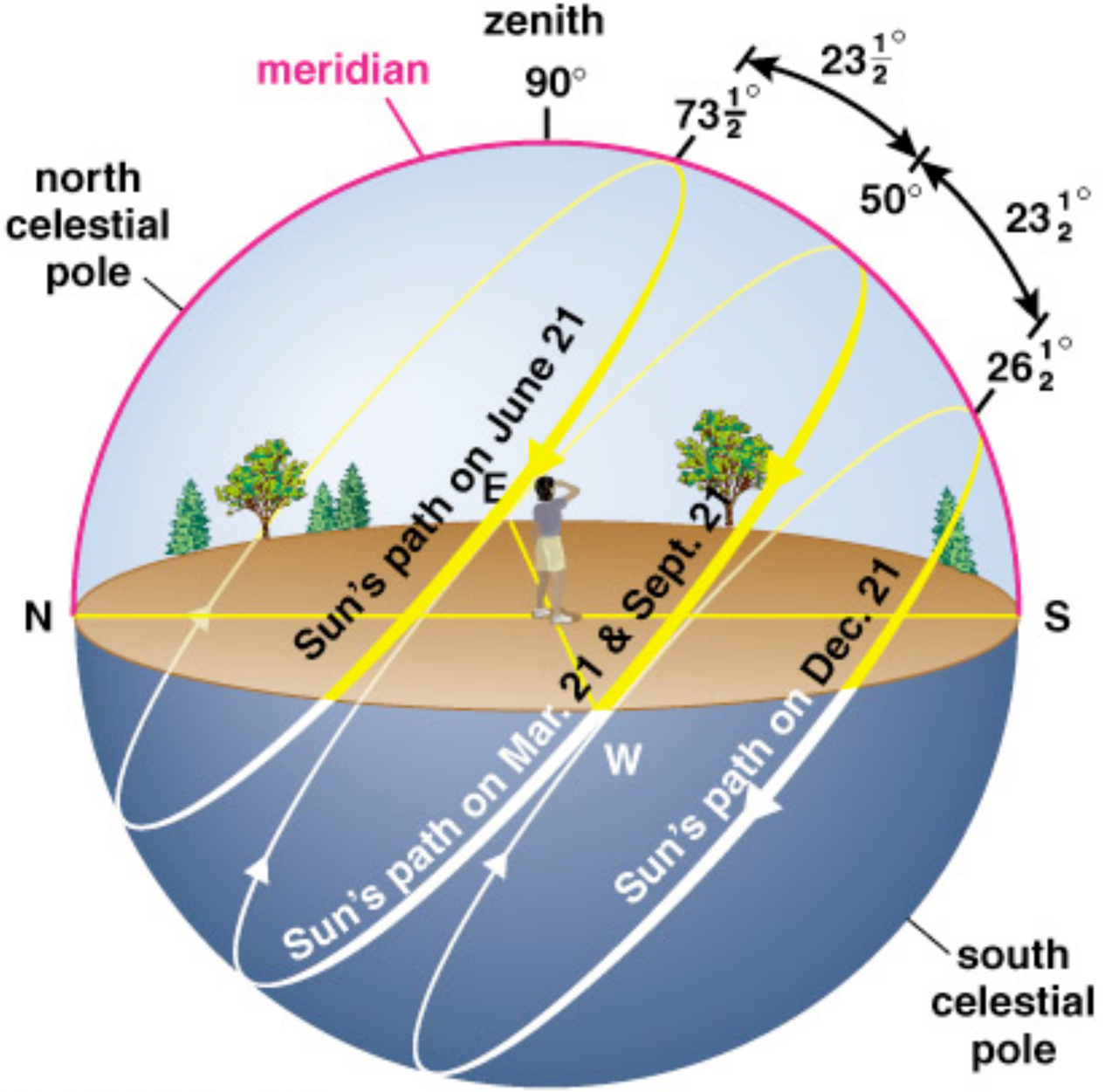
4pm



Using a Sun-Dial to Track the Earth's Rotation

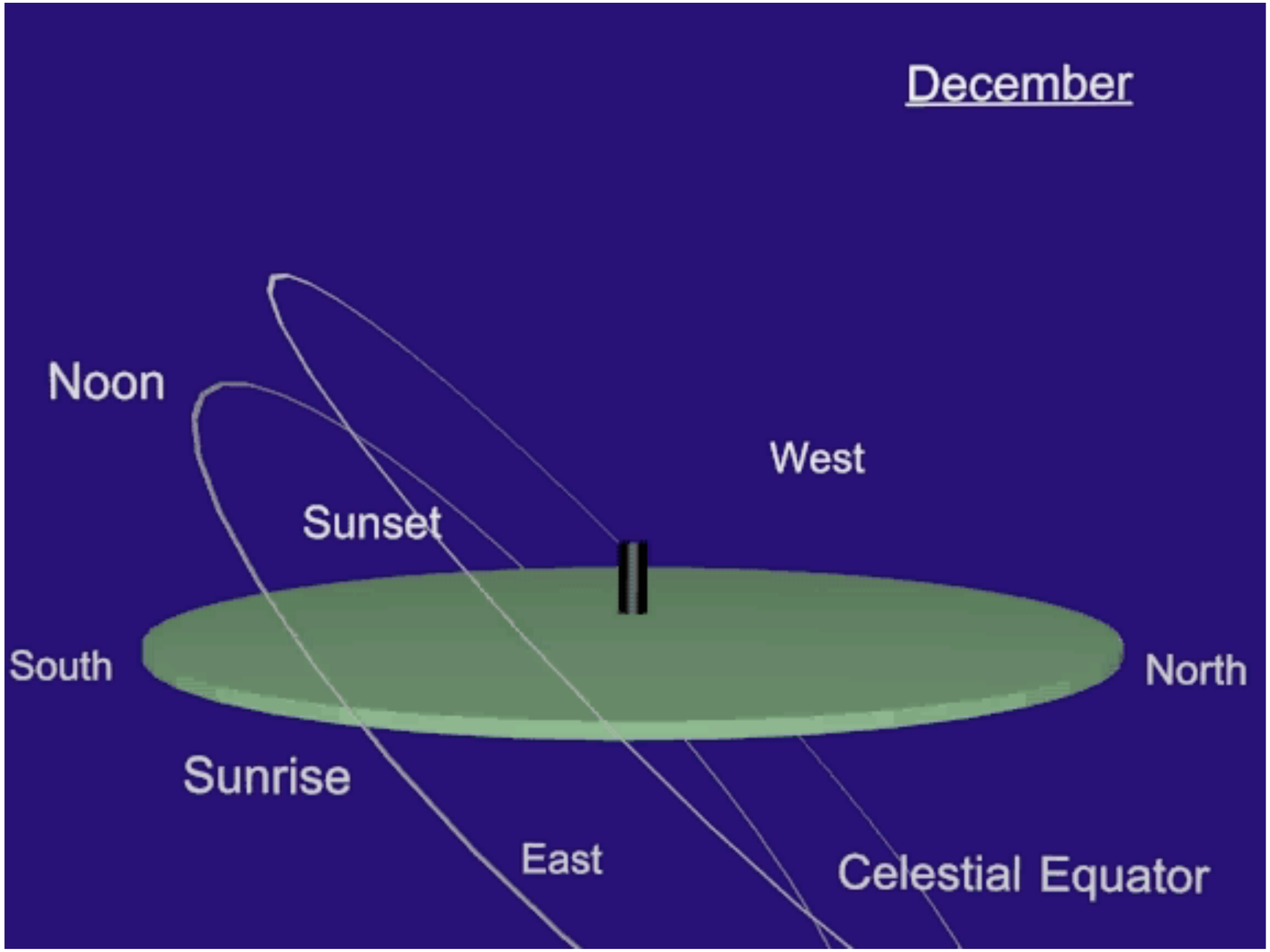
- A sun-dial allows you to observe the shadows cast by the sun throughout the day.
- A simple sun-dial can be constructed by placing a stick in the ground and watching the shadow over the course of a day.



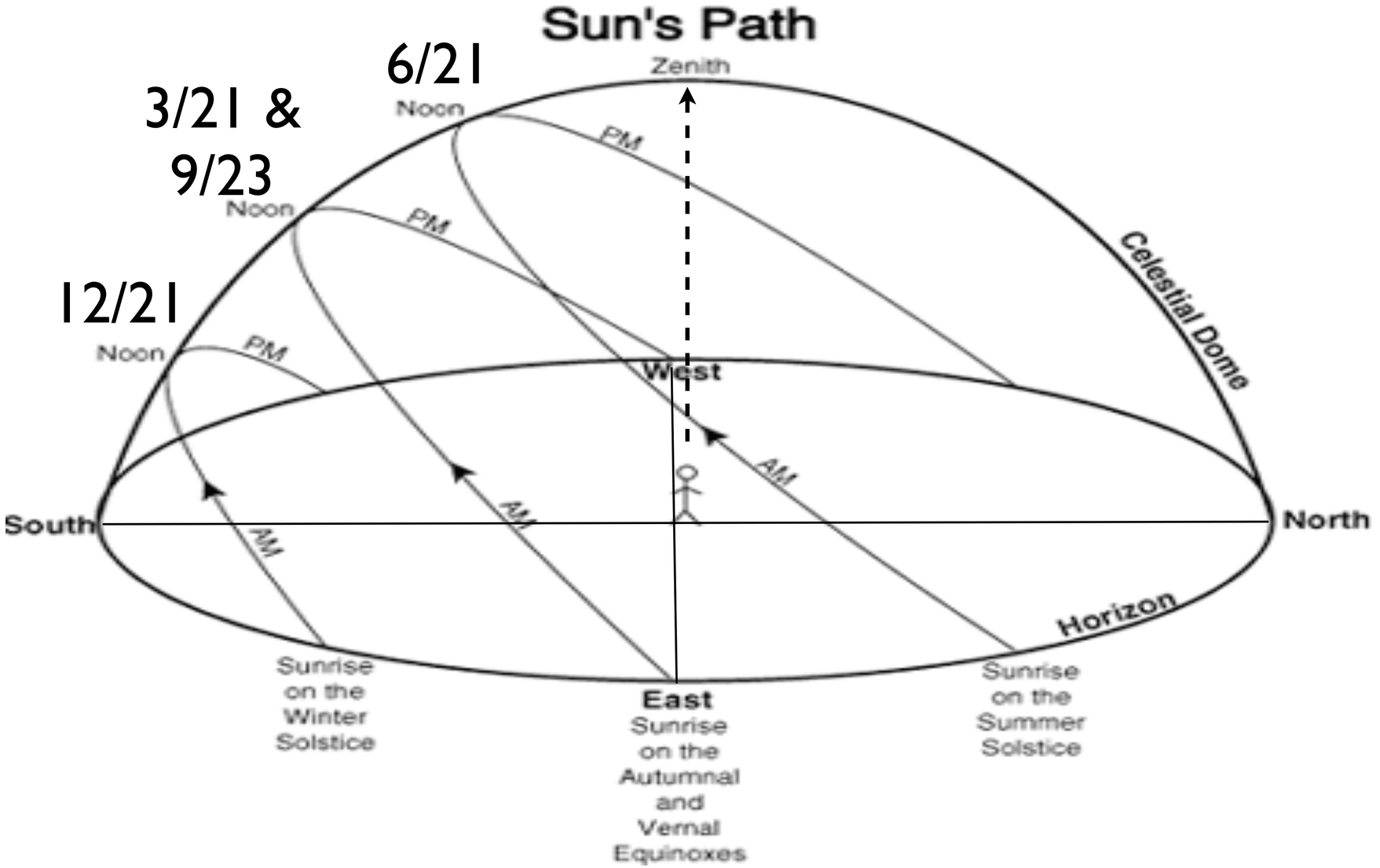


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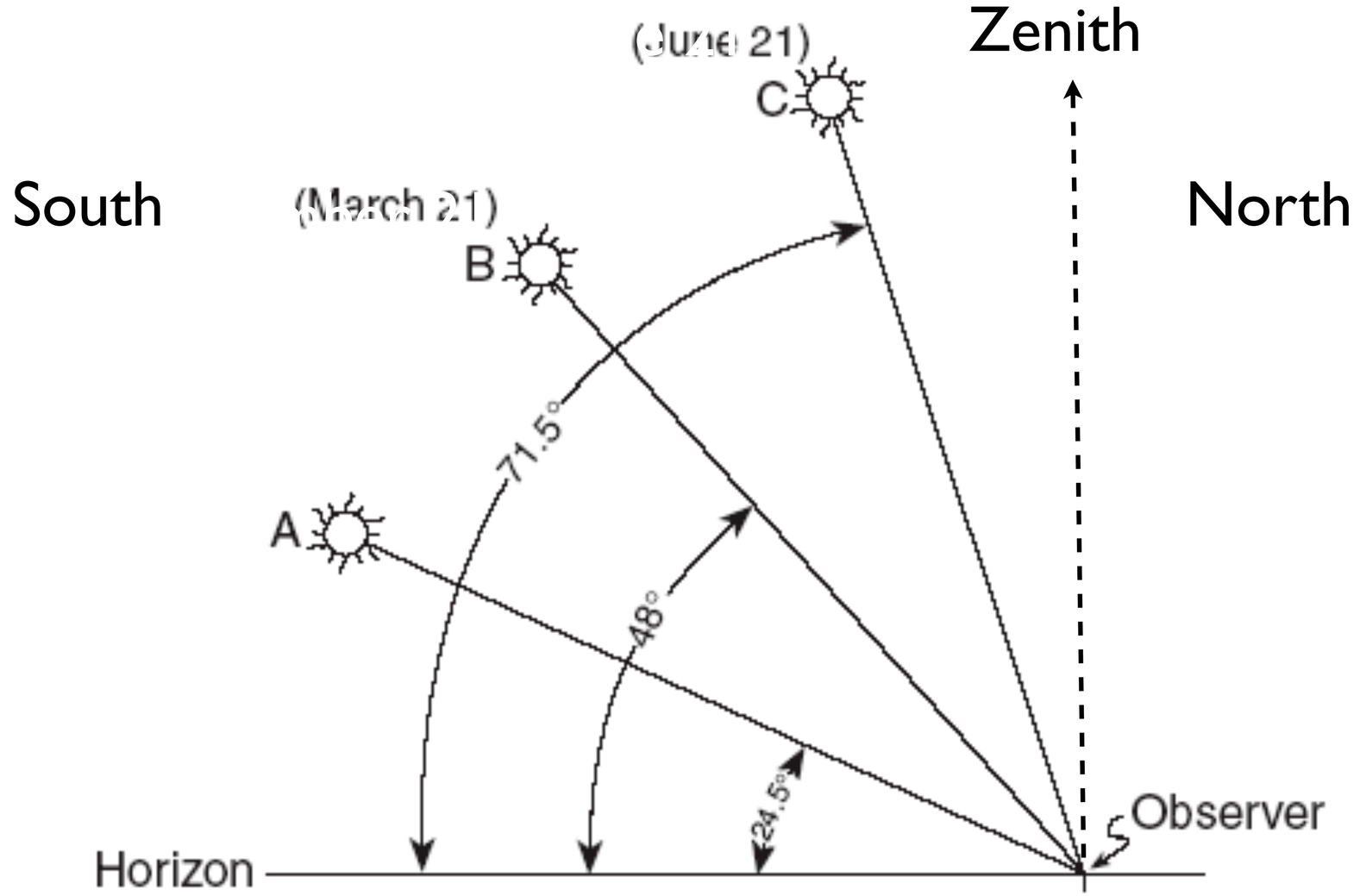
Throughout the year, the path of the Sun changes



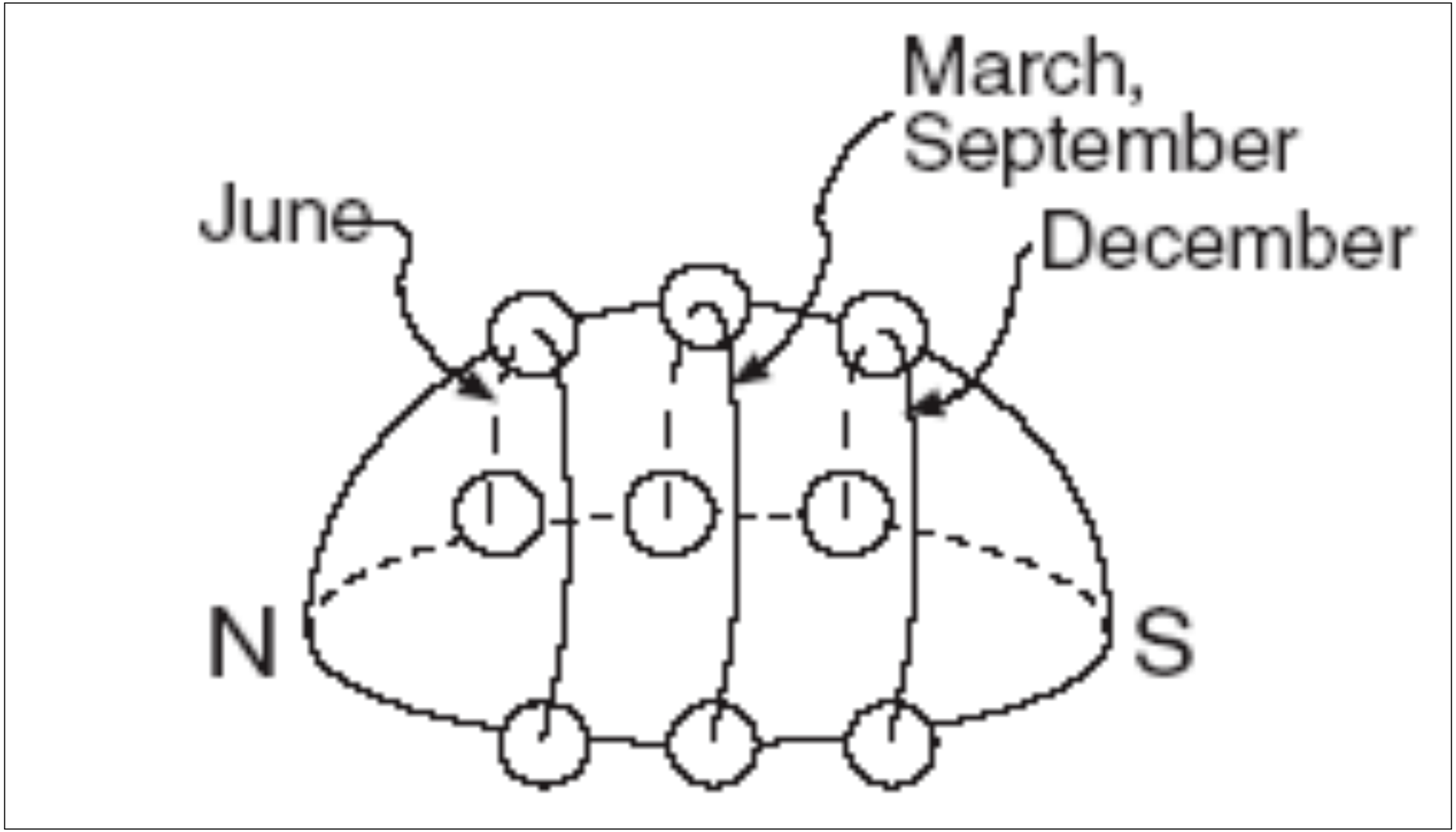
Sun's Path in New York



Approximate Sun's Elevation in New York



Sun's Path at the Equator



Sun's Path at the Pole

(in Summer)

