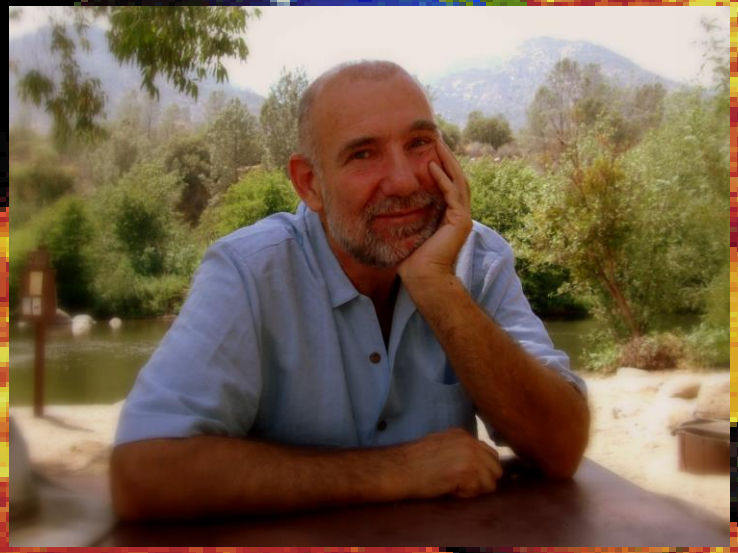
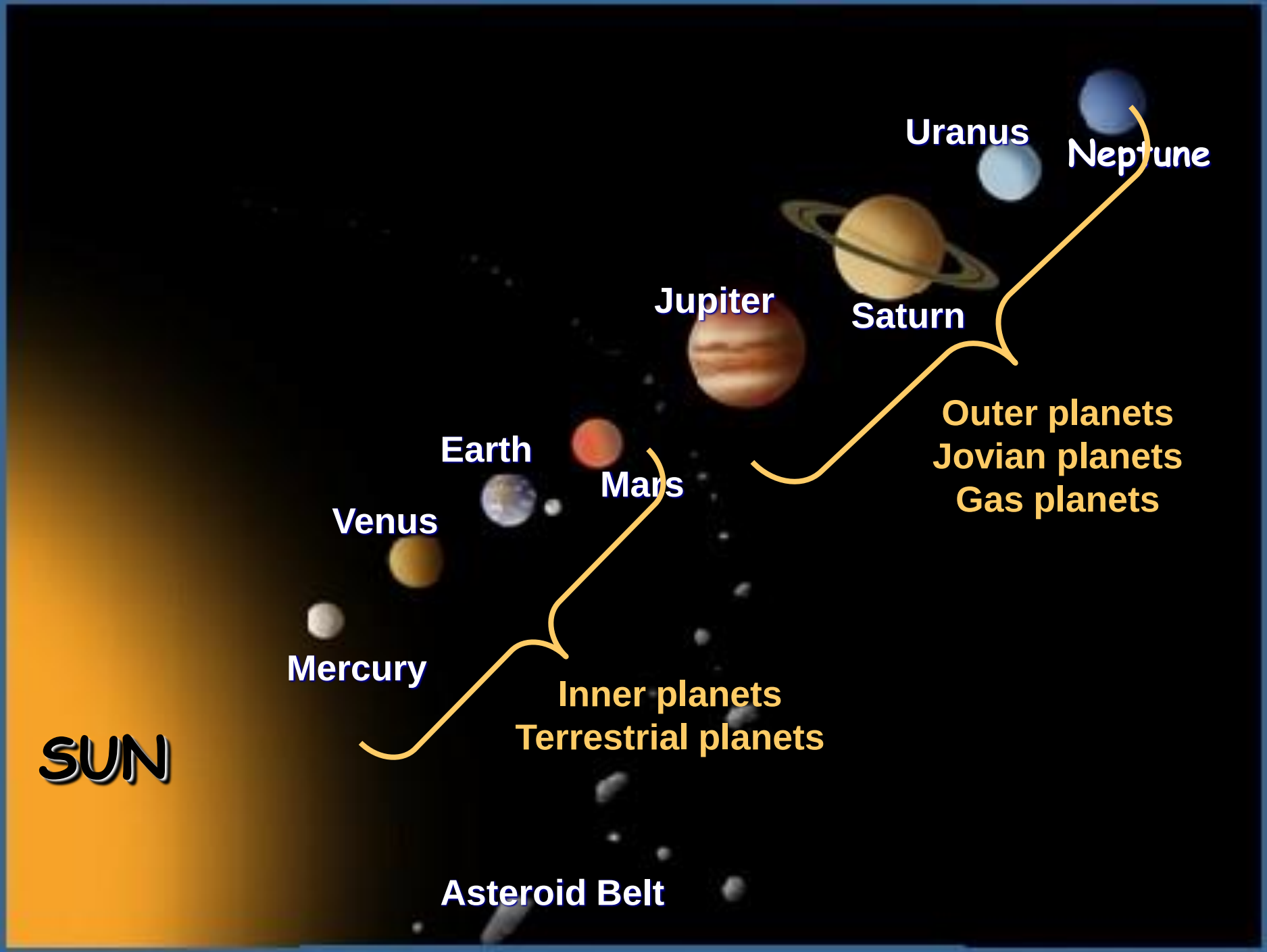
The Nature of Our Solar System

INTRODUCTION TO EARTH SCIENCE

The Nature of Our Solar System

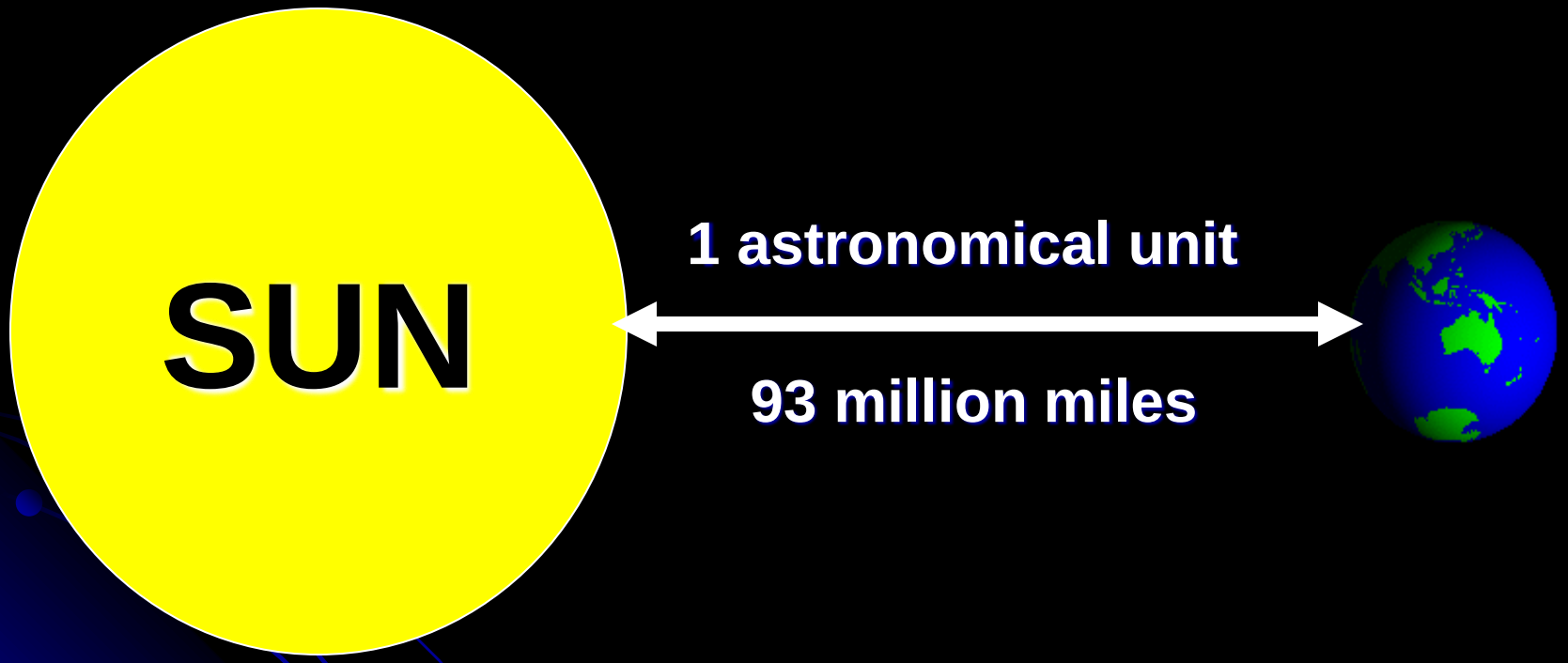


Dr. Gregg Wilkerson and Jack Pierce


Uranus
Neptune
Jupiter
Saturn
Outer planets
Jovian planets
Gas planets
Earth
Mars
Venus
Mercury
Inner planets
Terrestrial planets
SUN
Asteroid Belt

Astronomical Unit (AU)

- distance from the sun to earth



So, how many miles is 3 AU?

3 X 93 million = 279,000,000 miles

I ♥ the planets.

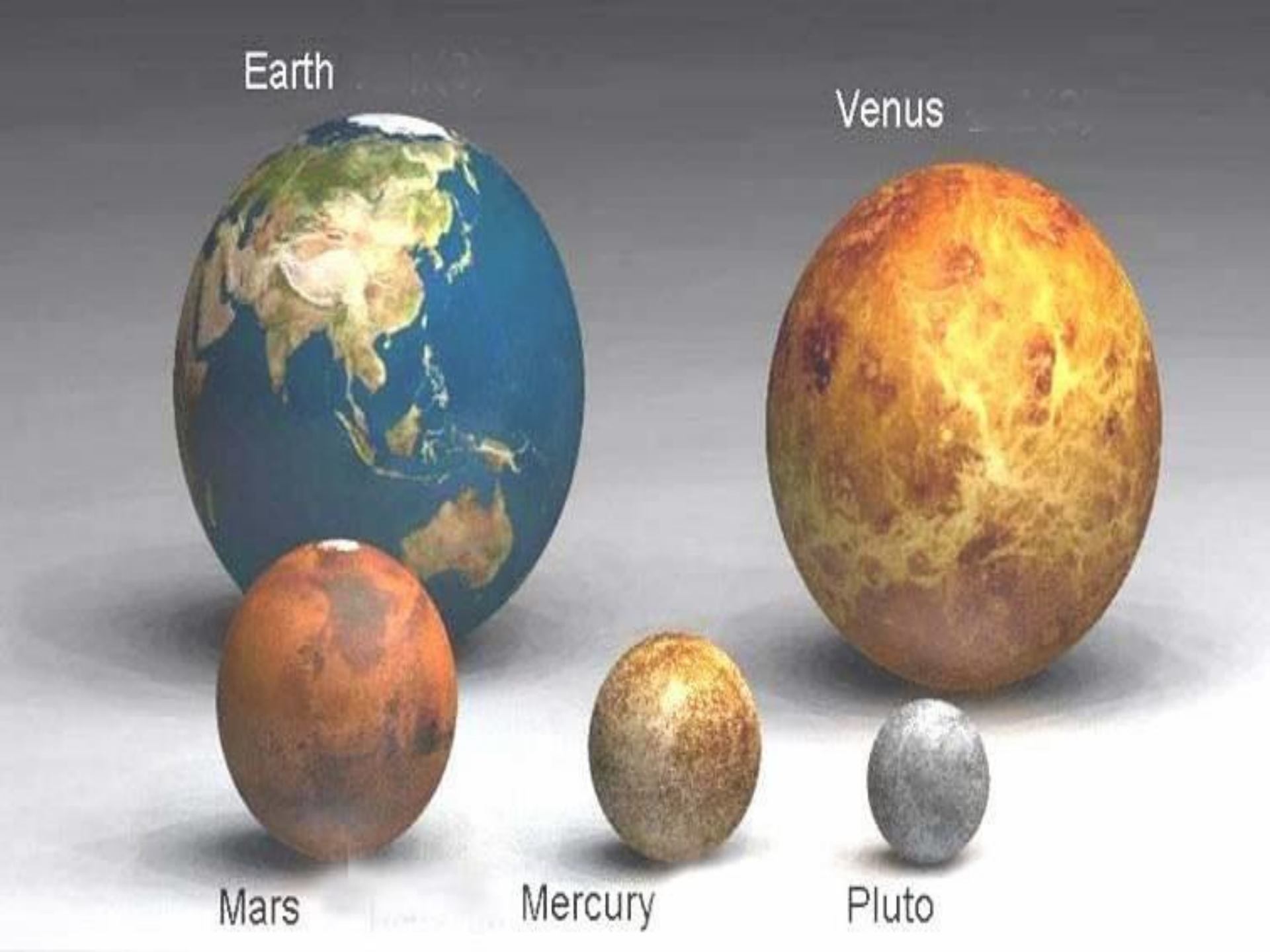
Discuss with a friend:

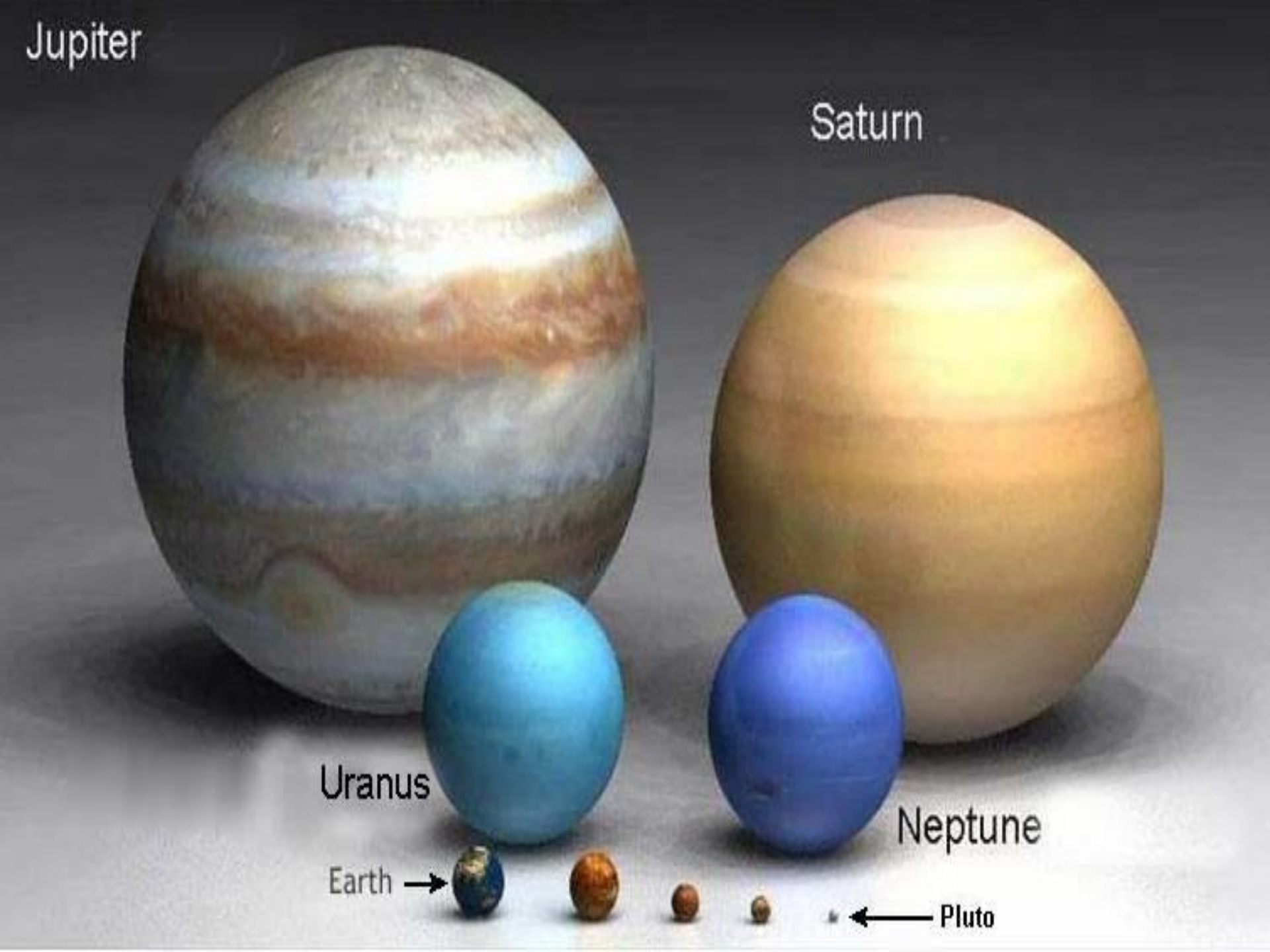
1. Write down the order of planets.
   Know them backwards and forwards.

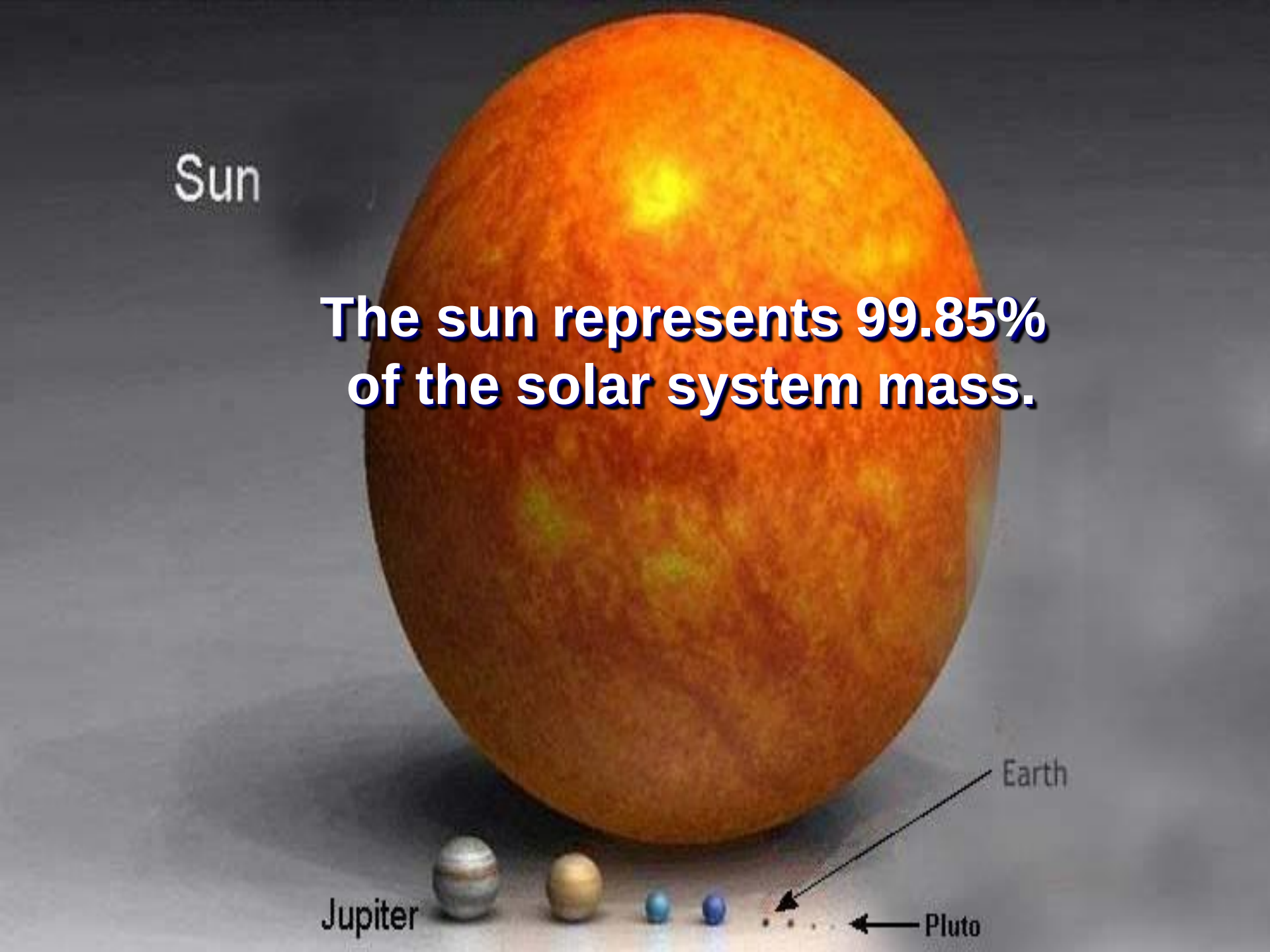
2. Define an <u>astronomical unit.</u>

I will get an A on my exams and quizzes.

How big do you think the Earth is compared with other celestial bodies?

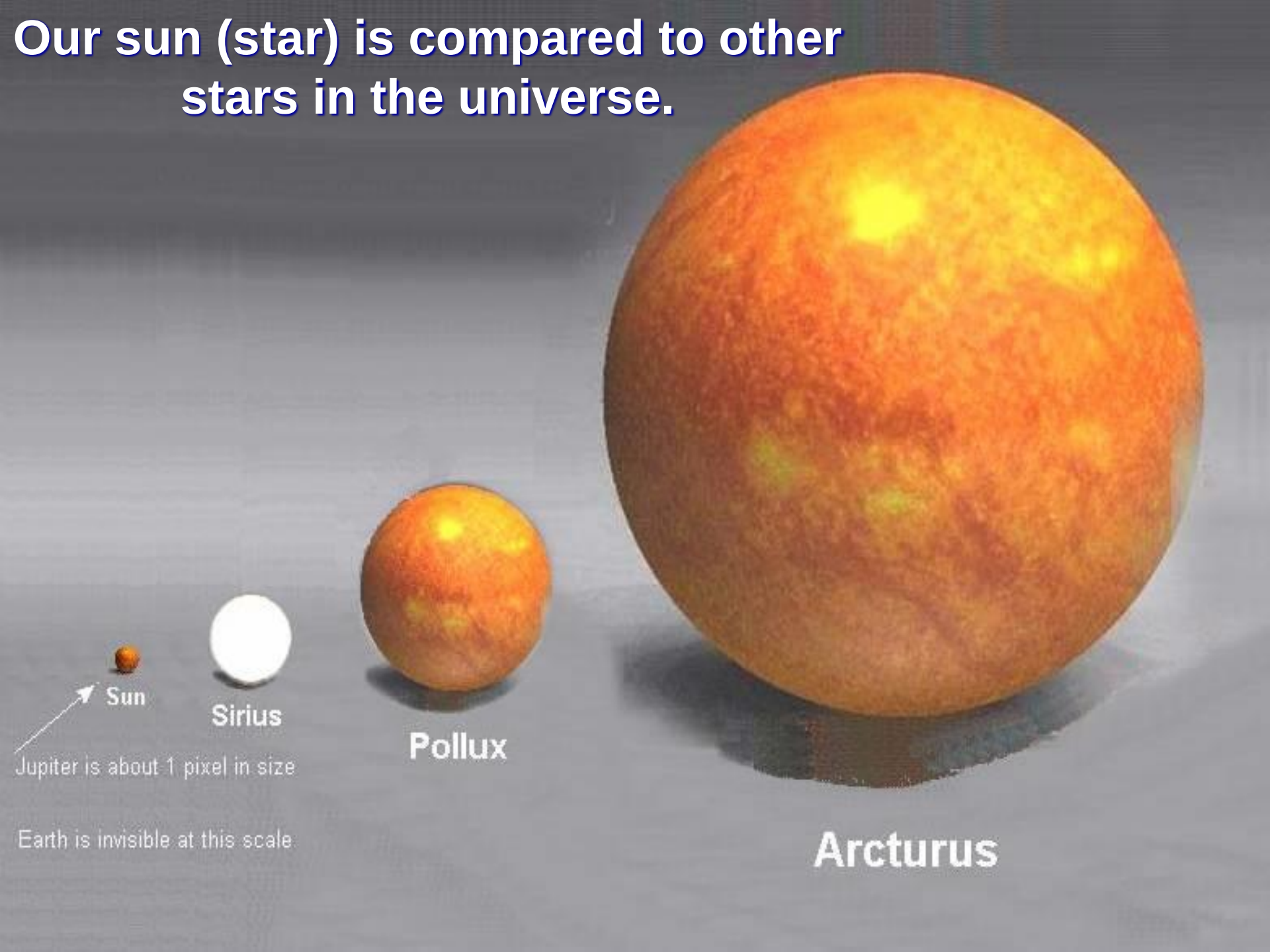

Earth
Venus
Mars
Mercury
Pluto


Jupiter
Saturn
Uranus
Neptune
Earth
Pluto



The sun represents 99.85% of the solar system mass.

Our sun (star) is compared to other stars in the universe.



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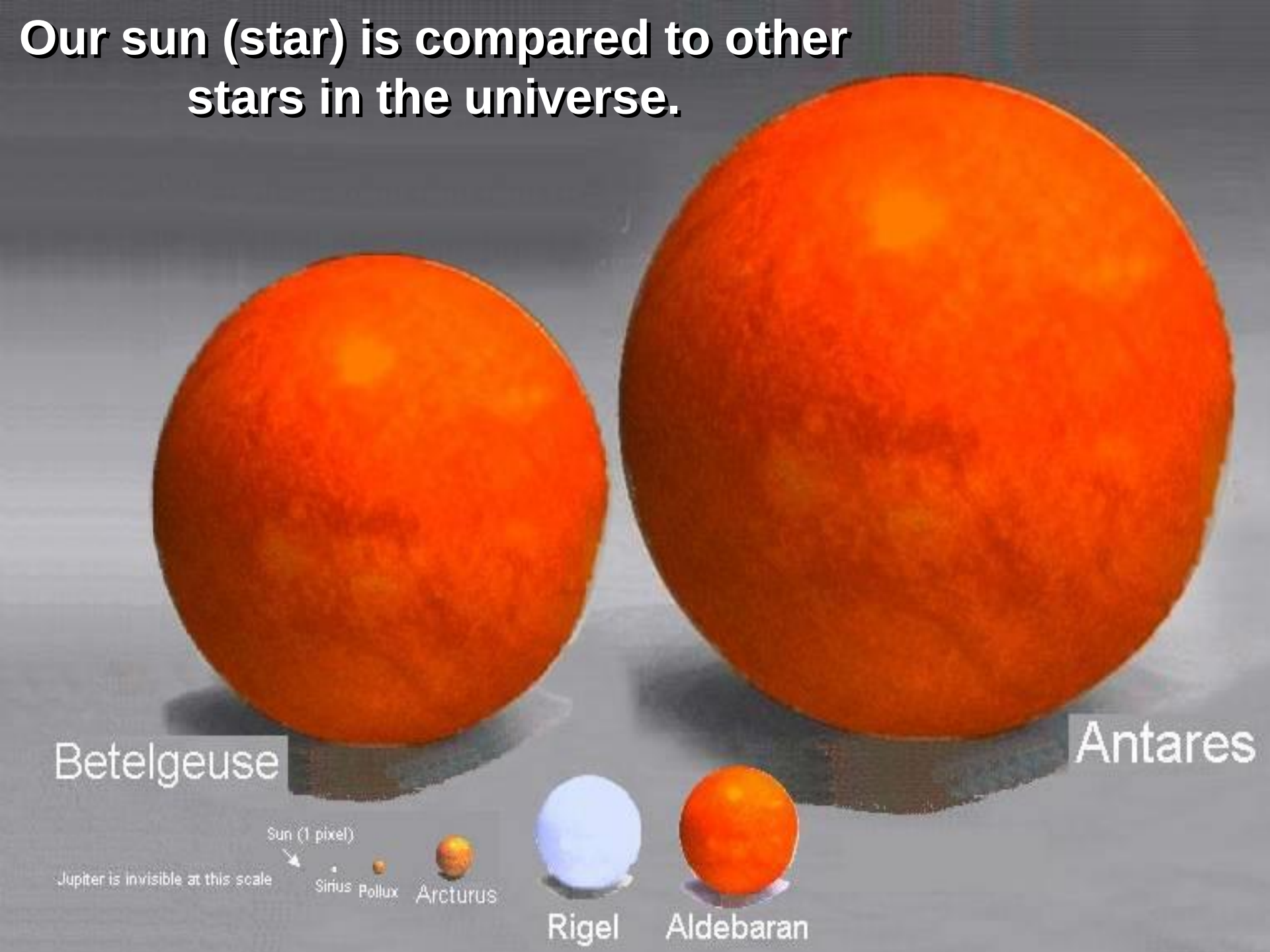


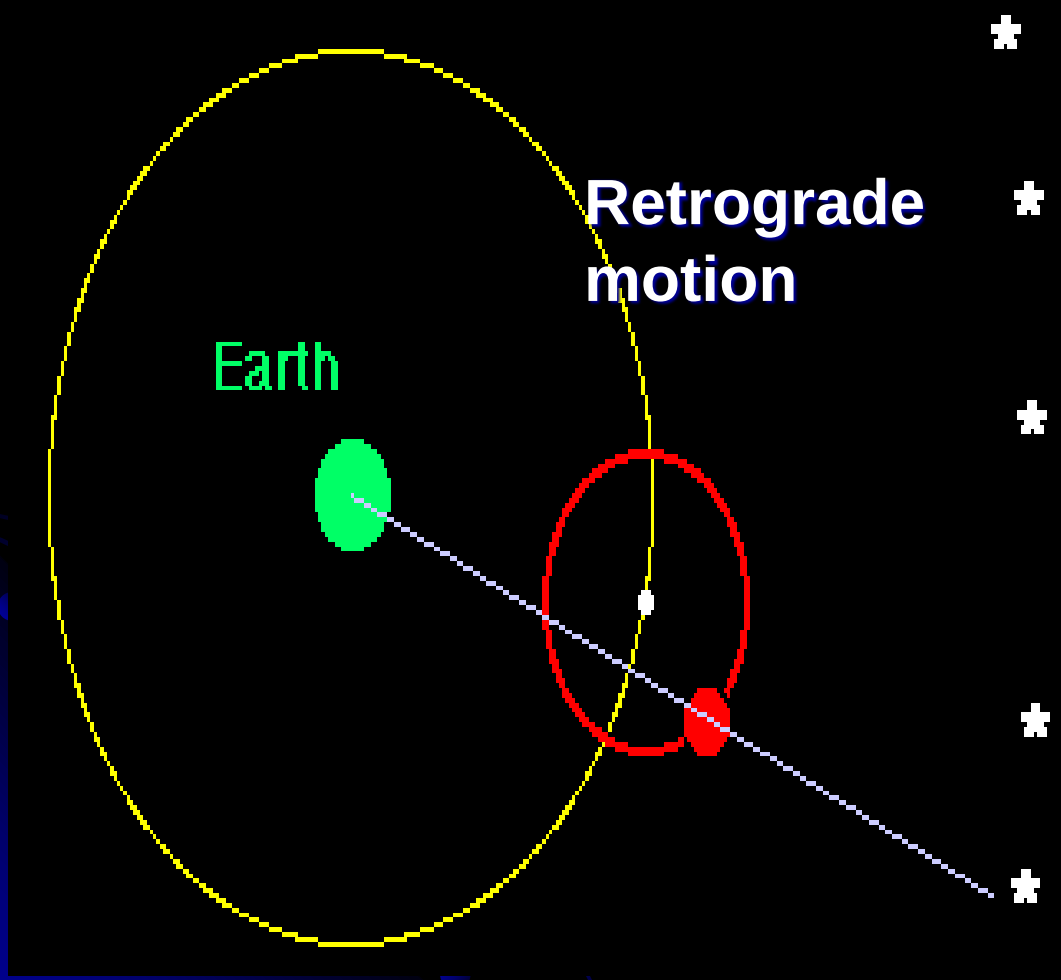
What beliefs existed about our solar system? Ancient astronomy:

The Early Greeks:

- 600 BC – 150 AD
- used geometry / trigonometry principles
    - presented the "geocentric" model
        - all heavenly bodies move around the earth – the earth is motionless
        - presented by Claudius Ptolemy – The Almagest, 141 AD

The solar system was viewed as a geocentric model.

- based on planetary motion observations



Earth-centered

Geocentric

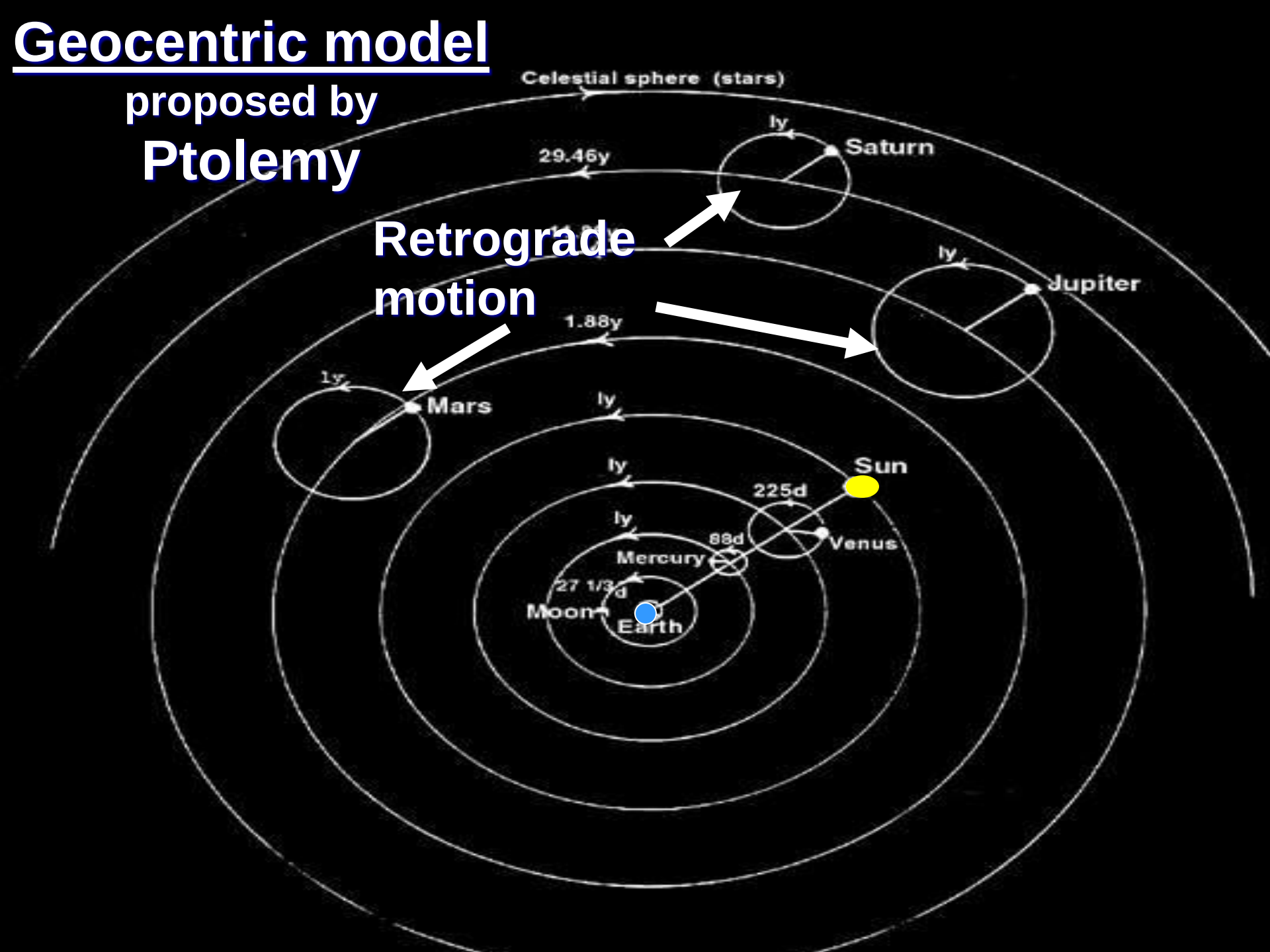
Earth **center**

Proposed by Ptolemy

Geocentric model

proposed by

Ptolemy



I ♥ astronomy.

Discuss with a friend:

3. Describe the geocentric model.

4. What is retrograde motion?

5. Describe what an observer would see during a planet's retrograde motion.

I will get an A on my exams and quizzes.

The Birth of Modern Astronomy:

The breakthrough from philosophical and religious views:

Nicholas Copernicus (1473 – 1543)

- Concluded the earth is another planet
- Daily motions of earth can be explained by a rotating earth
- Developed the heliocentric model – the sun-centered earth
- Used circles as orbital paths for each planet

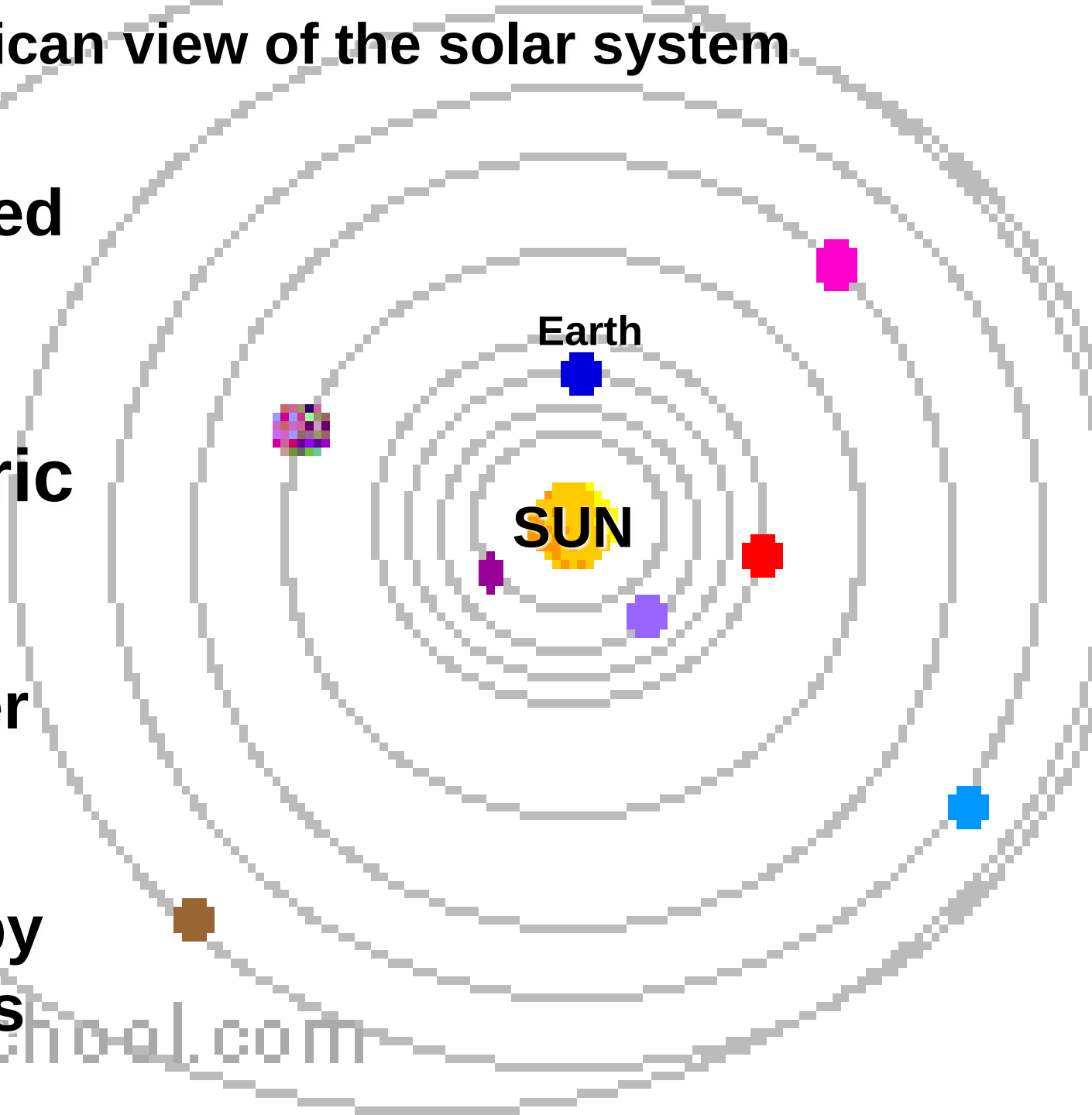
The Copernican view of the solar system

Sun-centered

heliocentric

Sun center

Proposed by Copernicus



Retrograde Motion in the Copernican System

I ♥ solar system history.

6. How does geocentric retrograde motion compare to heliocentric retrograde motion?

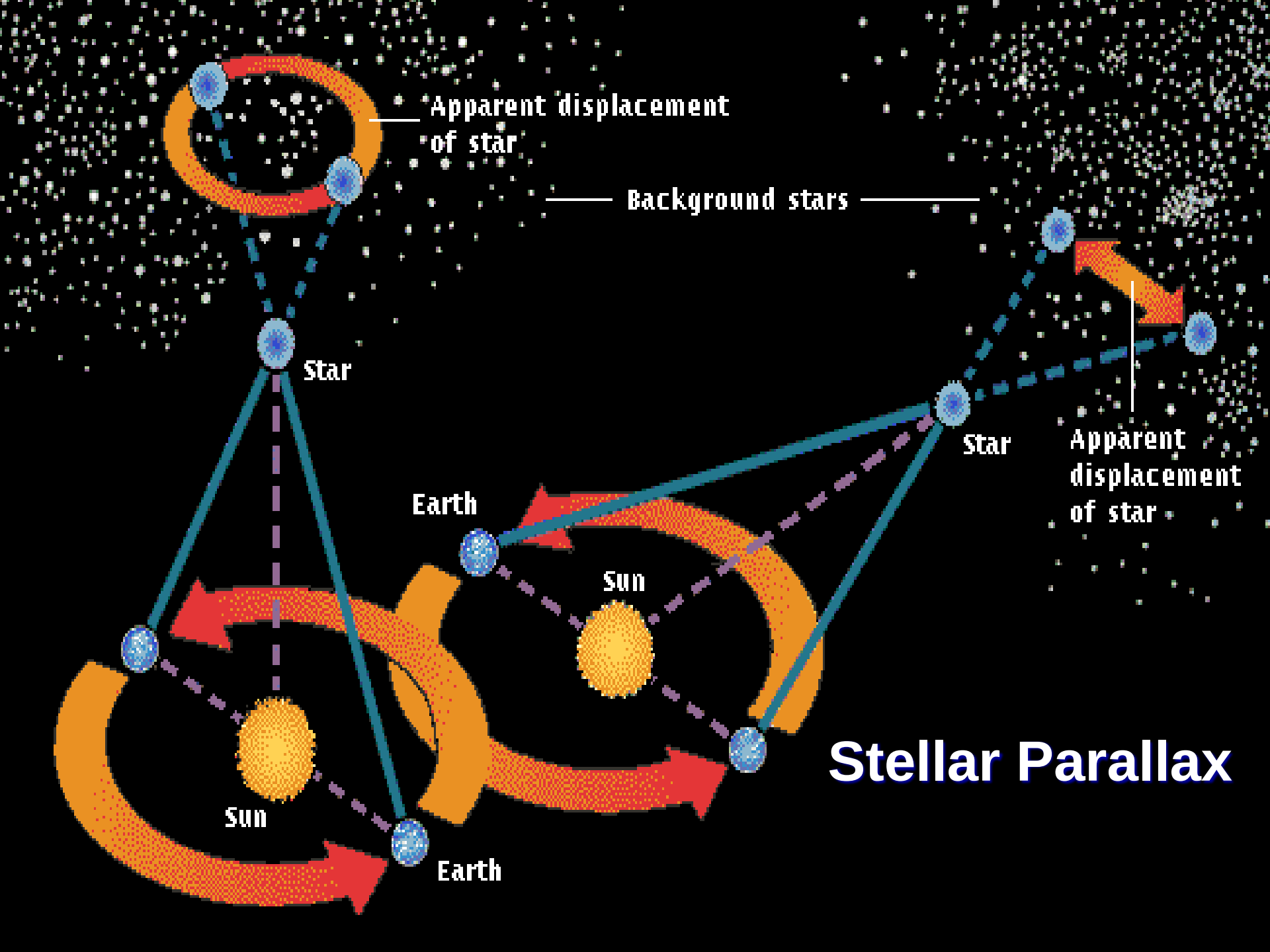
7. Describe the differences between the geocentric and heliocentric solar system models.

I will get an A on my exams and quizzes.

The Birth of Modern Astronomy

Tycho Brahe (1546 – 1601)

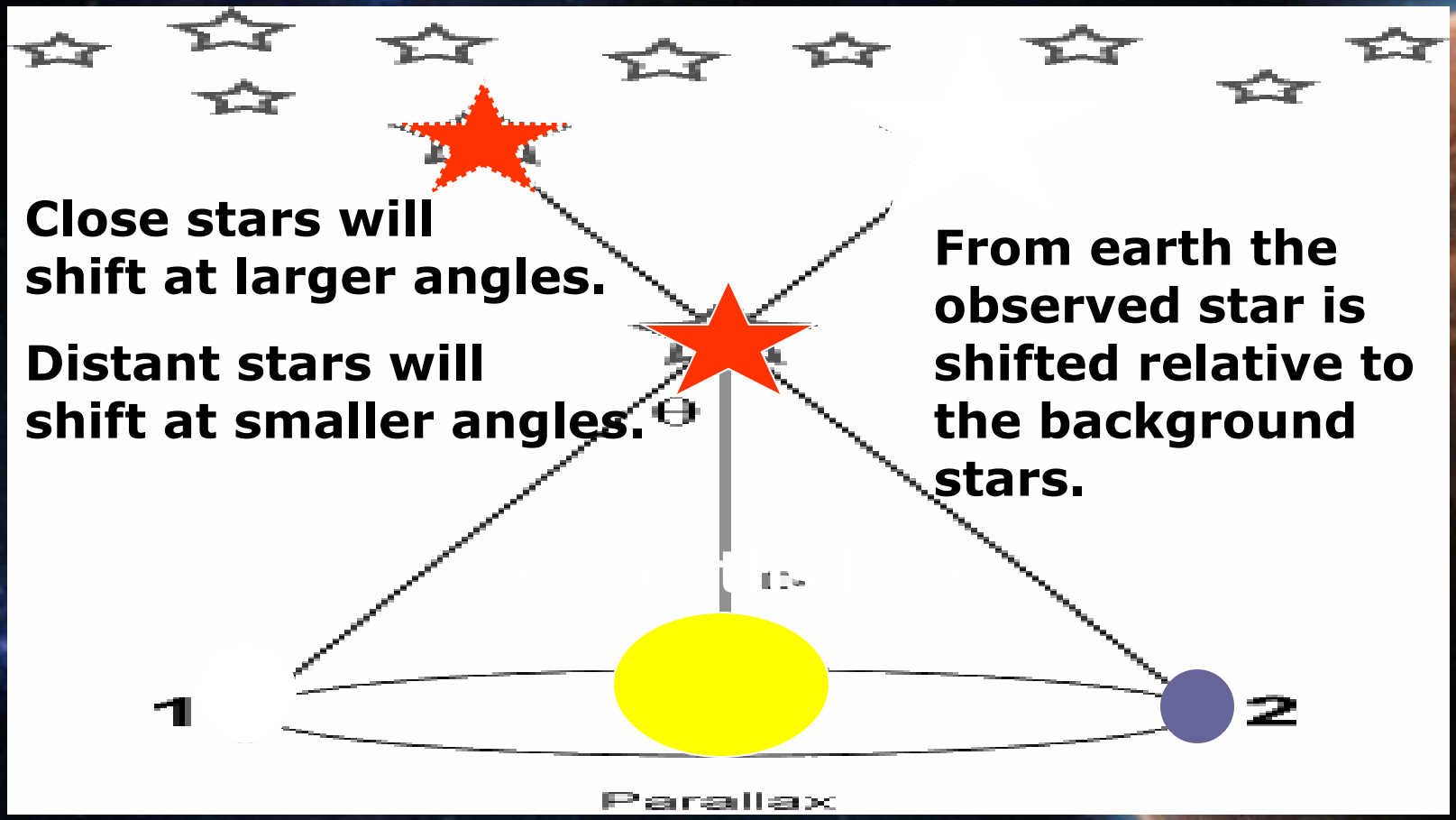
- Danish nobility – Copenhagen
- Designed and built "pointers" that accurately predicted the positions of planets in the sky
- DID NOT believe in the heliocentric model
  - Stars in the background should be shifting every six months?
  - The stellar parallax concept "thumb demonstration"


Apparent displacement of star
Background stars
Star
Star
Apparent displacement of star
Earth
Sun
Sun
Earth
Stellar Parallax

How far is far? - Astronomical distances?

Using parallax

- the “slight” shifting of a star due to the orbit of the earth around our sun



I ♥ Tycho Brahe.

8. What is Tycho Brahe's contribution to our understanding of the solar system?

9. Explain the concept of stellar parallax.

10. How does the "thumb" test show stellar parallax?

I will get an A on my exams and quizzes.

The Birth of Modern Astronomy:

Johannes Kepler (1571 – 1630)

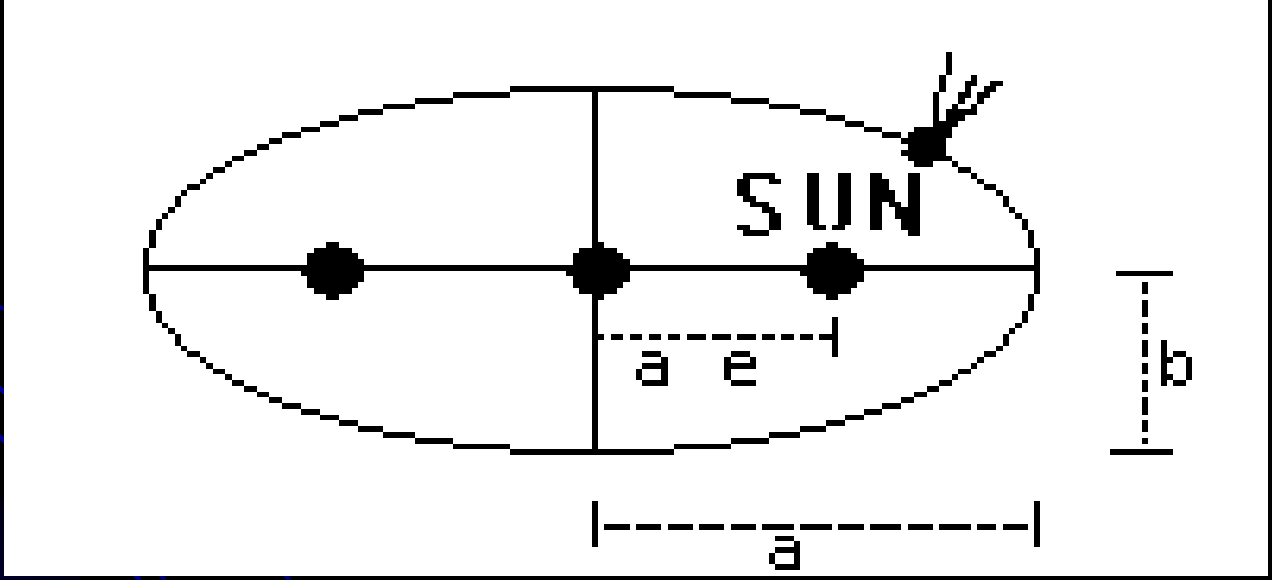
- Used Brahe's data to enhance the three laws of planetary motion

- A mathematical mind
- An emphasis on interstellar accuracy!
- Proposed 3 laws of planetary motion
  - based on 10 years of mathematical computing
  - “Mars” did not fit the Brahe model

Kepler's 1st law of planet motion

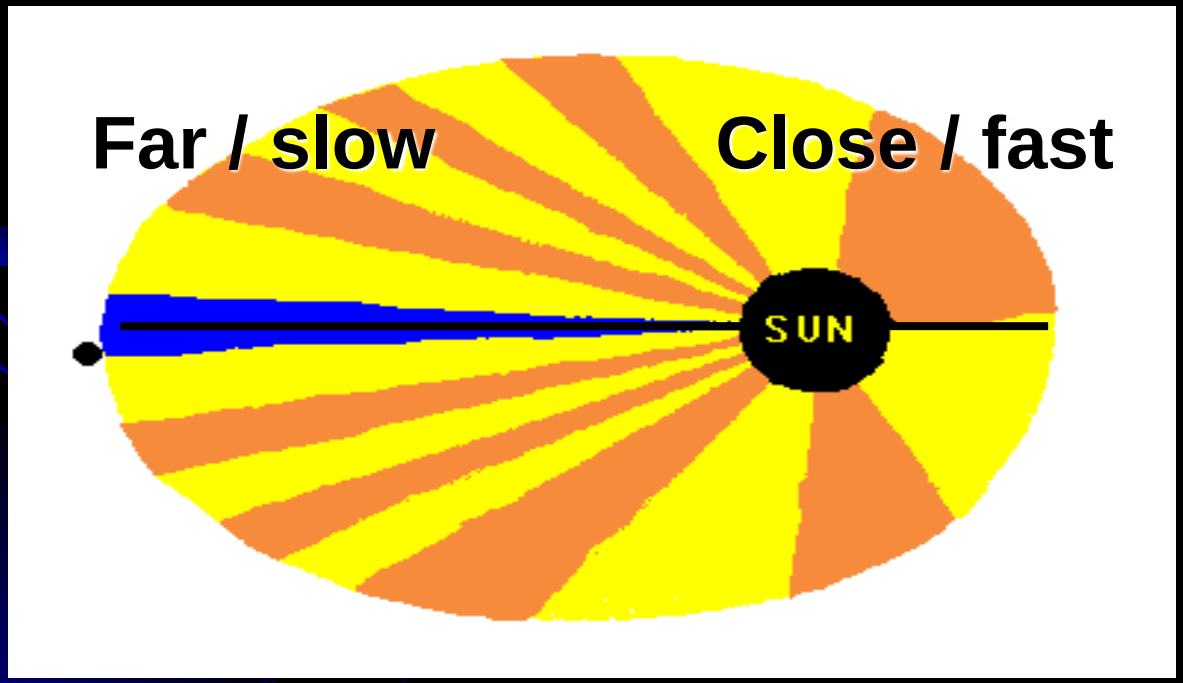
The Law of Ellipses

- All planets follow elliptical orbit paths (not circular paths!)



Kepler's 2nd law of planet motion

- The closer the planet is to the sun, the faster it "sweeps" around the sun ---



Kepler's 3rd law of planetary motion

$$T_a^2 / T_b^2 = R_a^3 / R_b^3$$

- Square of any planet's orbital period (sidereal) is proportional to cube of its mean distance (semi-major axis) from Sun
- Mathematical statement: $T = kR^{3/2}$, where T = sidereal period, and R = semi-major axis
- Example - If a is measured in astronomical units (AU = semi-major axis of Earth's orbit) and sidereal period in years (Earth's sidereal period), then the constant k in mathematical expression for Kepler's third law is equal to 1, and the mathematical relation becomes $T^2 = R^3$

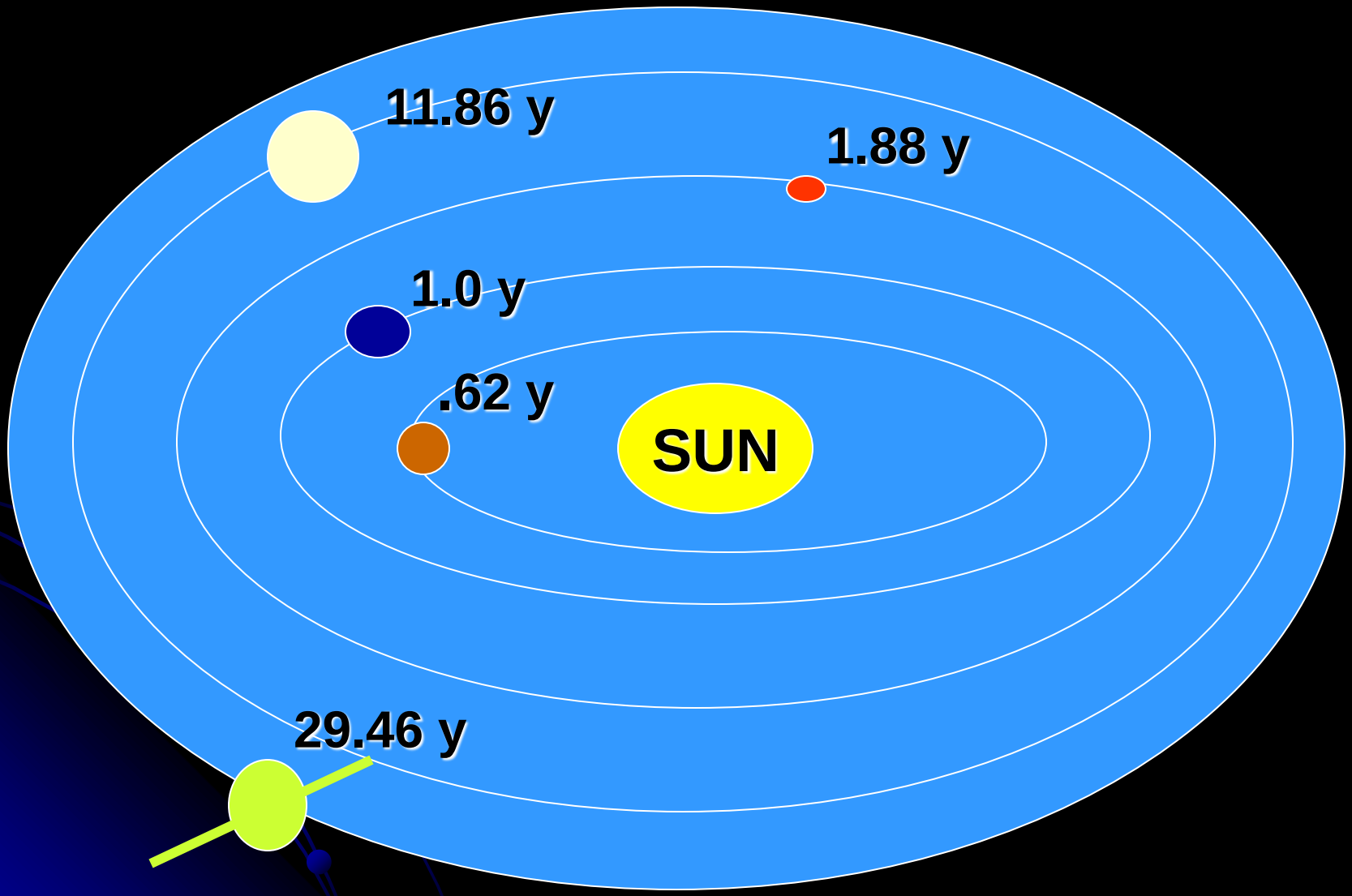
Examples of Kepler's Third Law

The third law says:
One can calculate the distance of a planet from the sun – That's all folks!

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

Orbital periods - Elliptical patterns

The more distance – the longer the orbital period



I ♥ Johannes Kepler.

Discuss with a friend:

11. Describe EACH law of planetary motion presented by Johannes Kepler.

12. How do these laws influence our knowledge and travel in our solar system?

I will get an A on my exams and quizzes.

The Birth of Modern Astronomy

Galileo Galilei (1564 – 1642)

- Strongly supported the heliocentric model
- Greatest contribution to astronomy – the descriptions of moving objects

All astronomical discoveries were made without a telescope

- 1609 – constructed the first telescope
  - 3 times the actual size
  - 30 times the actual size

With the telescope – Galileo made several discoveries that supported the Copernican model.

Galileo's discoveries in a "nutshell"

1. Discovery of Jupiter's moons (4) – predicted the periods and showed the earth is not in the center
2. The planets are "spheres," not points of light
3. Discovery of phases of Venus – and it is the second planet from the sun
4. Discovered the topography of the moon – NOT smooth and made of cheese
5. Discovered that the sun had sun-spots – leading to the calculation of the sun's rotation

The Birth of Modern Astronomy

Sir Isaac Newton (1642 – 1727)

- "Greatest genius ever to exist in mathematics and physics"
- Realized what the gravitational force is
  - Keeps the planets from leaving --- and not following a straight line (the tetherball concept)

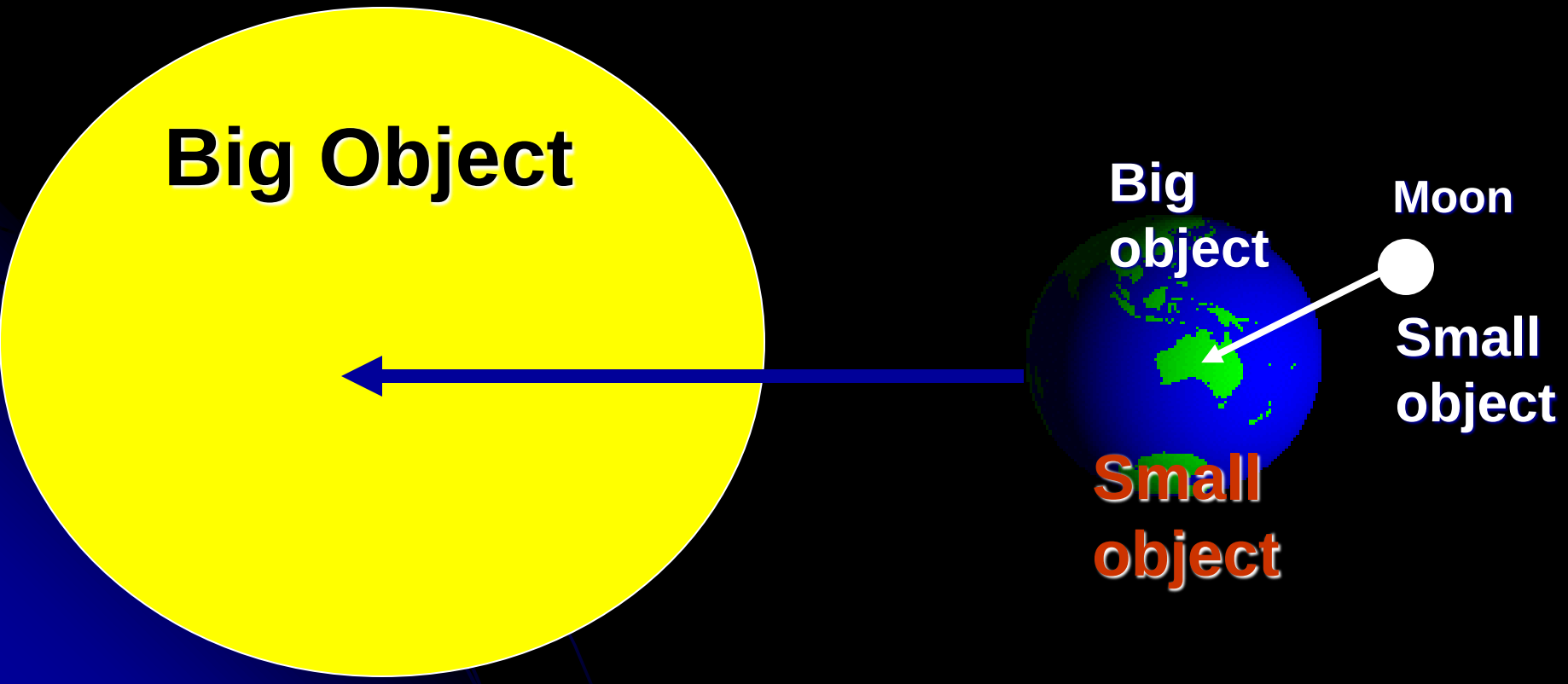
Universal Gravitational Theory

Every body in the universe attracts every other body with a force that is directly proportional to their masses and inversely proportional to the distance between them –

BIGGER OBJECTS ATTRACT SMALLER OBJECTS.

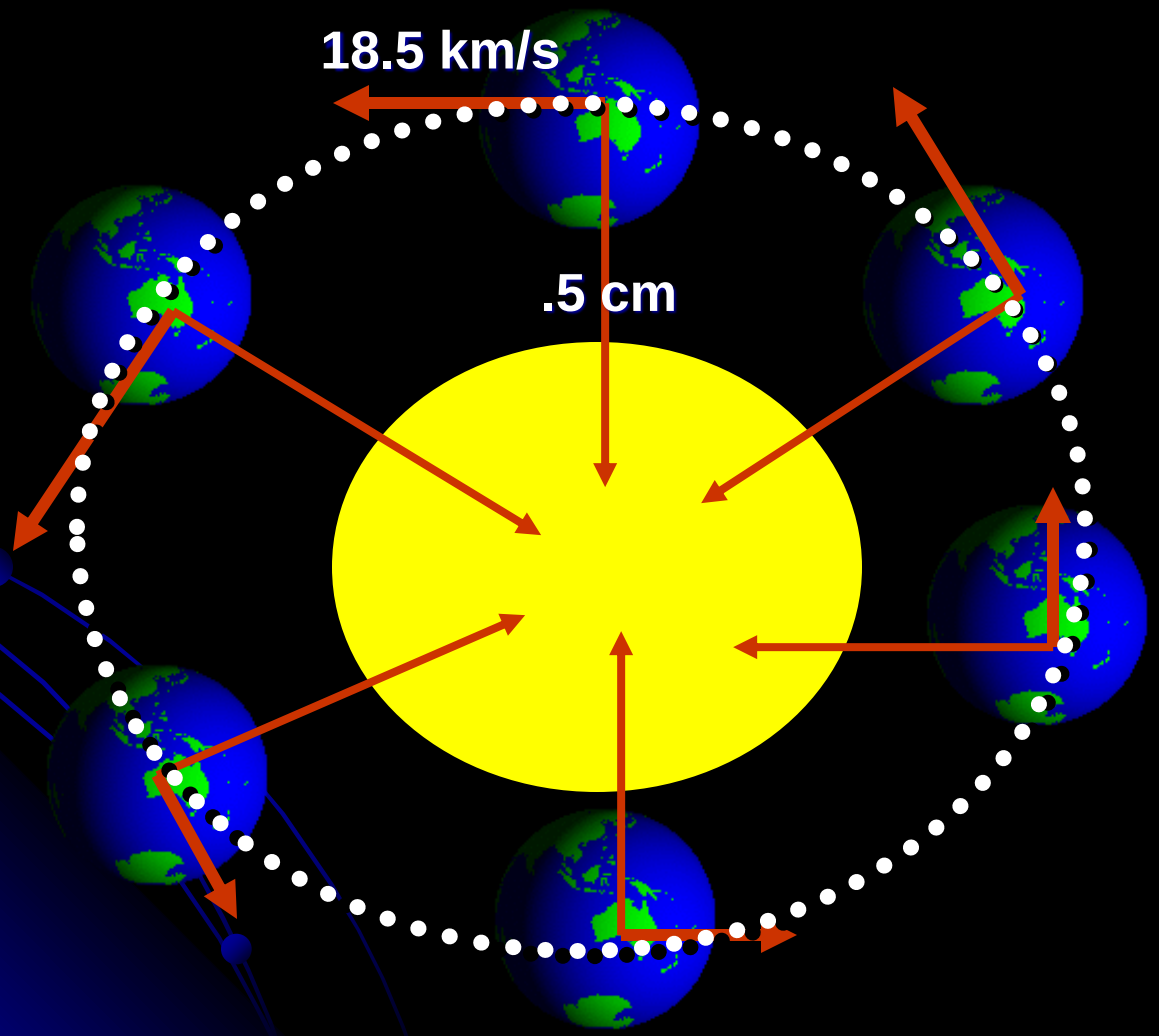
Universal Gravitation:

- Gravity gets weaker as distance increases.
- Smaller objects are attracted to bigger objects.



Isaac Newton

- Proved the force of gravity
- Earth moves forward about 30 km/s (18.5 mi/s)
- The sun pulls the earth about .5 cm



I ♥ Galileo and Newton.

Discuss with a friend:

13. How did Galileo contribute to our understanding of the solar system?

14. What is Newton's contribution to our solar system --- the way we look at the solar system today?

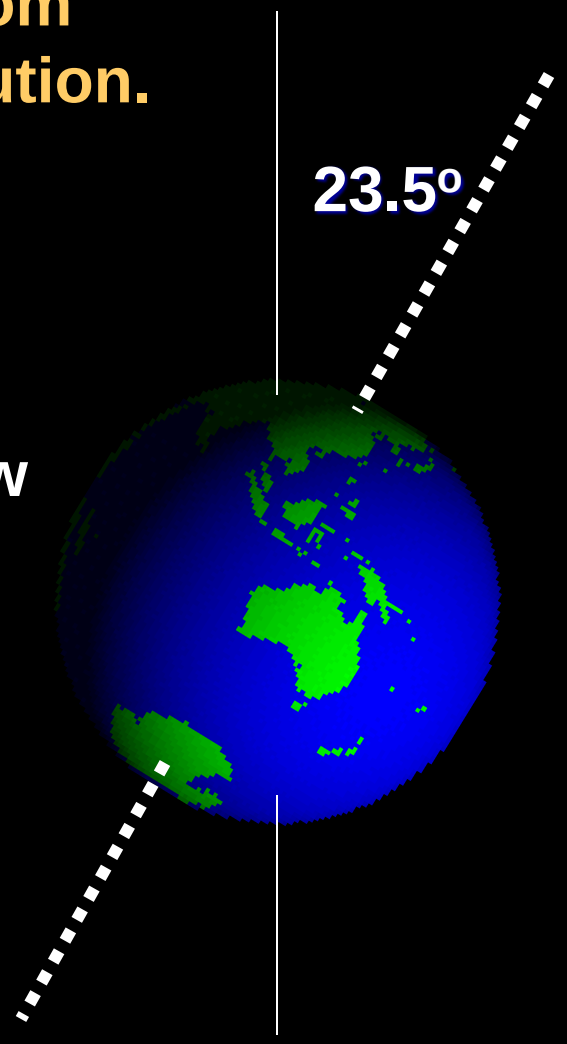
I will get an A on my exams and quizzes.

Reasons for the Earth's Seasons

Why does the earth have seasons?

The most common wrong answer:

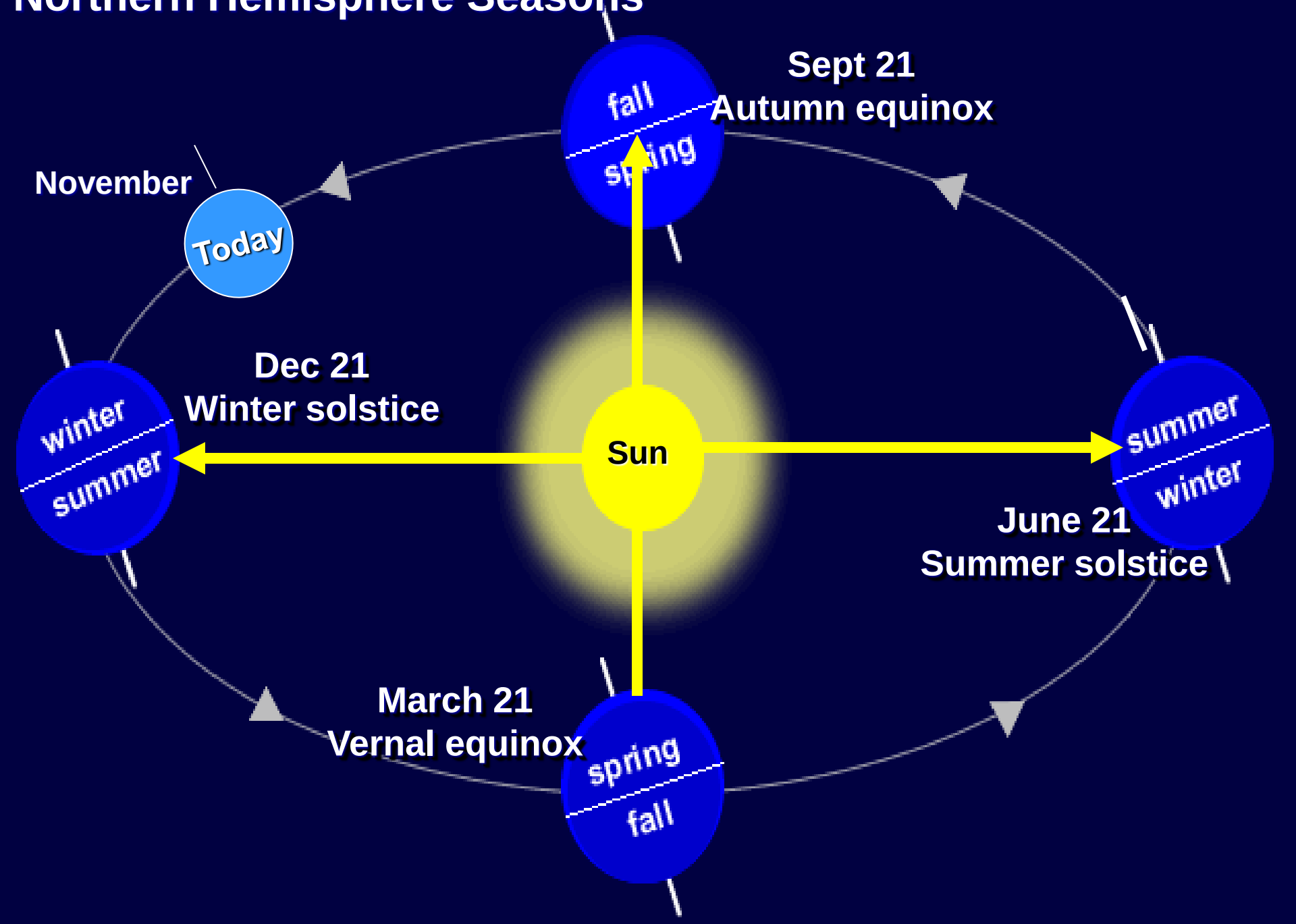
The earth gets close and far from the sun during its one-year revolution.



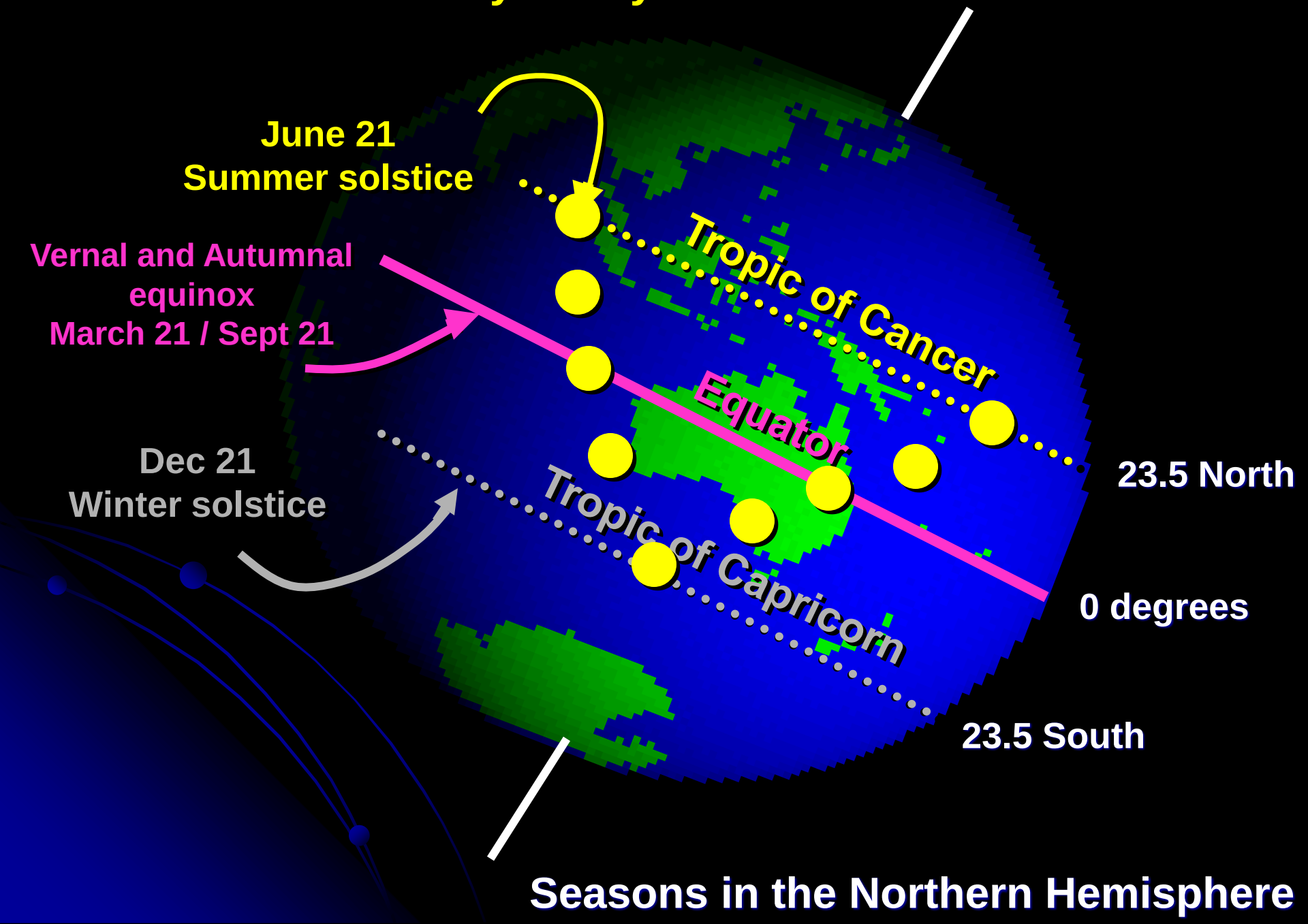
As the earth orbits around the sun, insolation is directed above and below the equator during the year.

Earth's axis is tilted at 23.5°

Northern Hemisphere Seasons



When is the sun directly over your head?



Seasons in the Northern Hemisphere

The view of earth from the sun's perspective

simulated path of the sun over 1 year

Bakersfield, California

June 21(longest day)

May	July
April	August
March	September
February	October
January	November

Dec 21(shortest day)

Bakersfield College

I ♥ The seasons.

Discuss with a friend:

1. Describe why the earth experiences the four seasons. Use terms such as:

   tilt of earth, equinoxes, solstice, tropics of Capricorn and Cancer

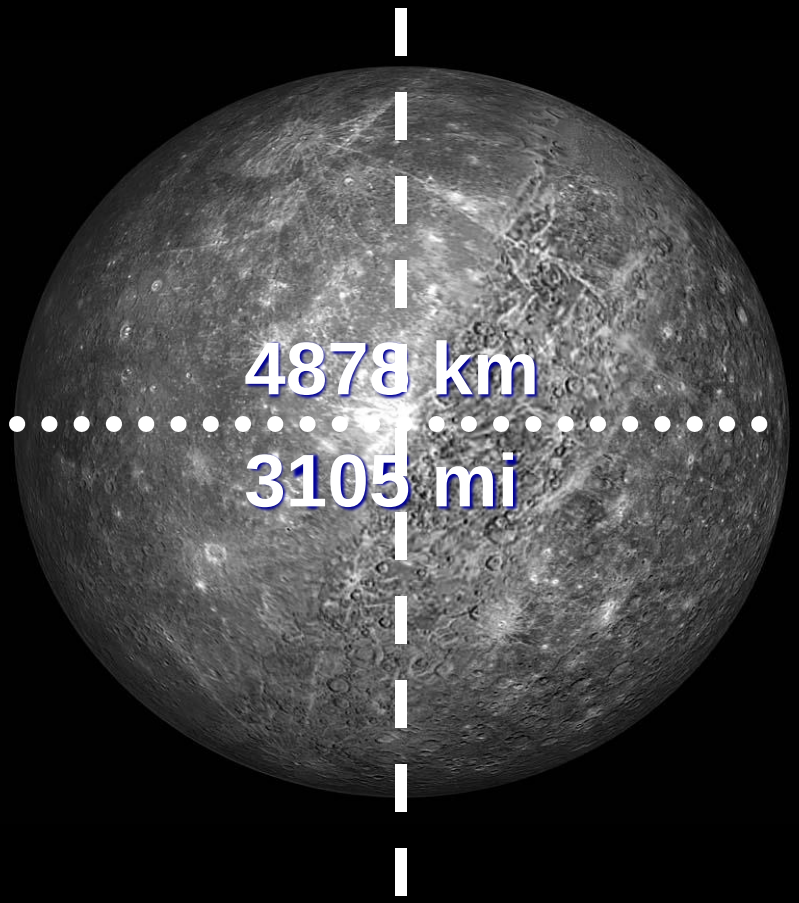
I will get an A on my exams and quizzes.

An Overview of the Planets

1500 years of astronomical contributions

Know the "common differences" between inner and outer planets

Mercury

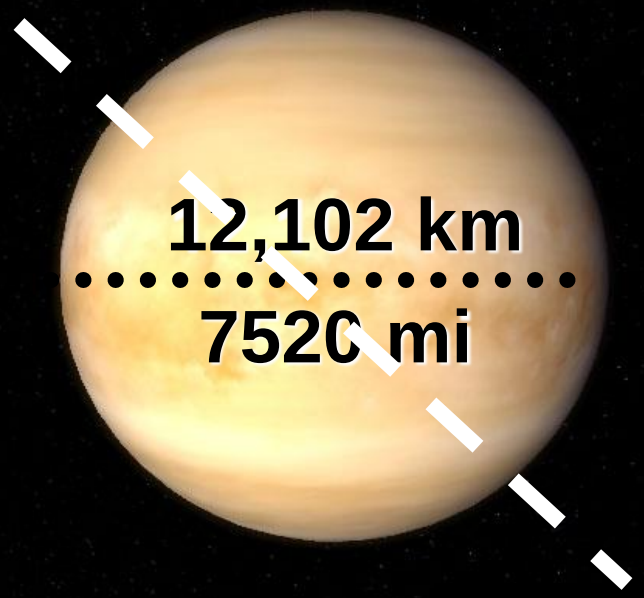


Axial tilt:	0^0
1 M-day	167 E-days
Orbital period	88 days
Moons	0
Surface T	332 ^{0}C
Atmosphere	none

Named after the ancient god of messengers

Mercury is 36 million miles from the SUN.

Venus



Axial tilt:	177^0
1 V-day	116 E-days
Orbital Period	225 days
Moons	0
Atmosphere	Thick CO_2
Surface Temp	867 ^{0}F

Named after the Roman goddess of love

- All features are named after women
- Maxwell Montes (Mt. range) "only man on Venus"

Venus is 67 million miles from the SUN.

Earth

Axial tilt:	23.5^0
1 E-day	1 E-day
Orbital Period	365 days
Moons	1
Surface Temp	60 ^{0}F
Atmosphere	O, N

Named after Gaea (Greek)

- Named for all living things

Earth is 93 million miles from the SUN.

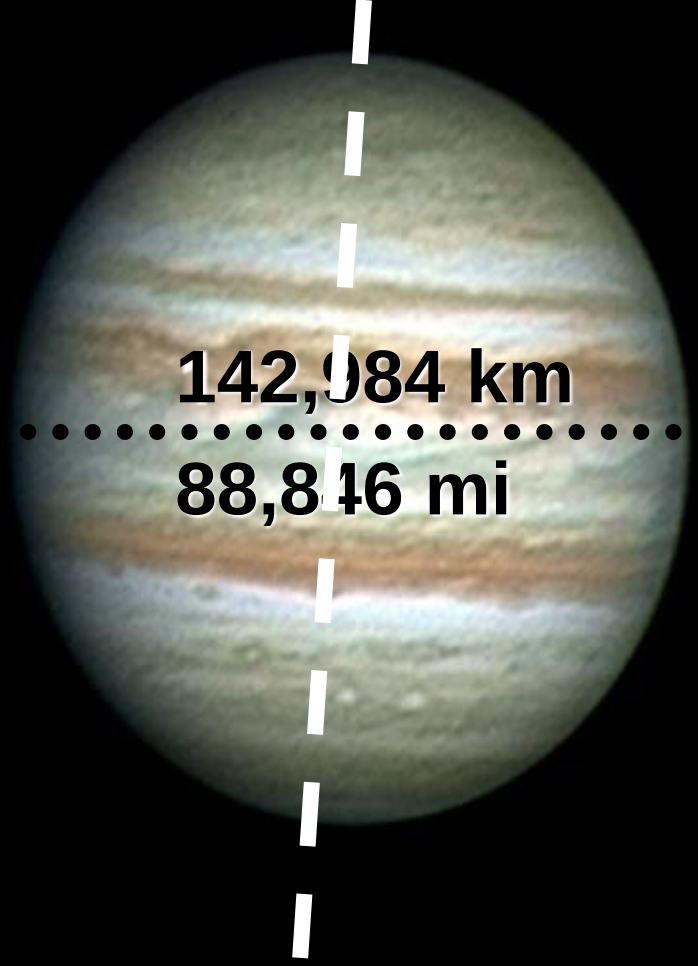
Mars

Axial tilt:	25.2^0
1 M-day	24.6 E-hr
Orbital Period	687 days
Moons	2
Surface Temp	-85 ^{0}F
Atmosphere	CO_2

Named after Roman gods of war (the red planet)

Mars is 141 million miles from the SUN.

Jupiter

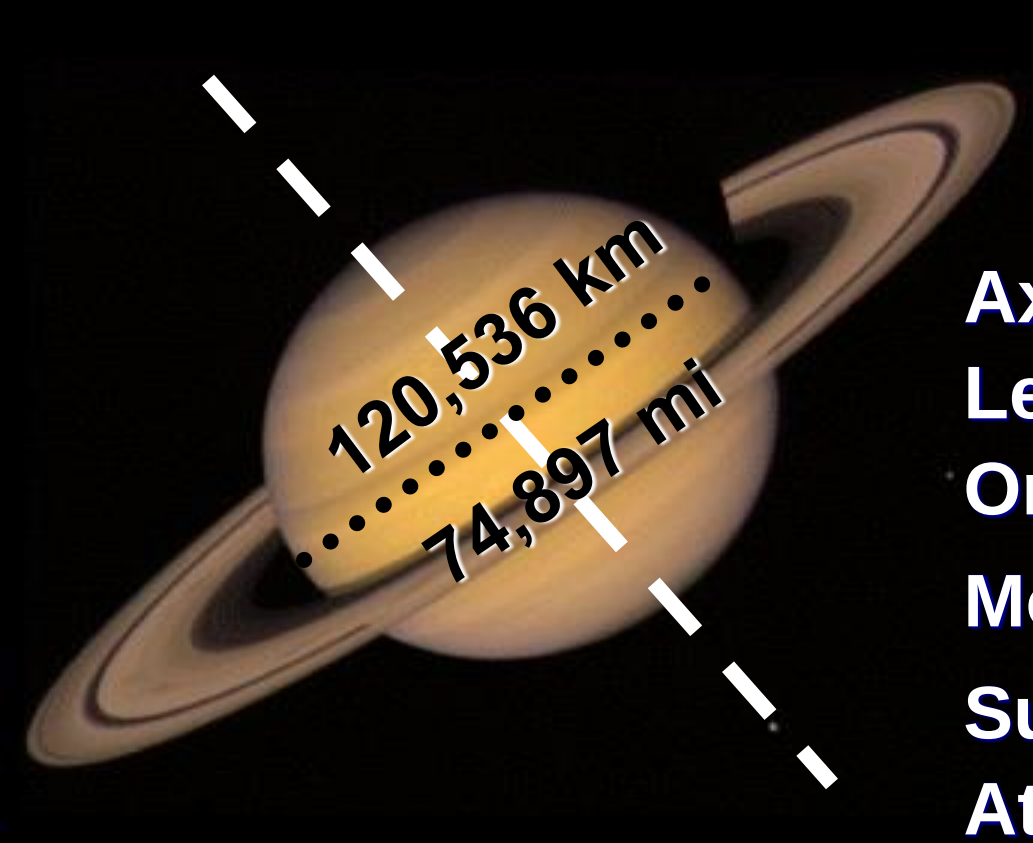


Axial tilt:	3.13^0
Length of day	10 E-hr
Orbital Period	11.9 yr
Moons	63
Surface Temp	-166 ^{0}F
Atmosphere	H_2, He

Named after the Roman god of lightning

Jupiter is 483 million miles from the SUN.

Saturn

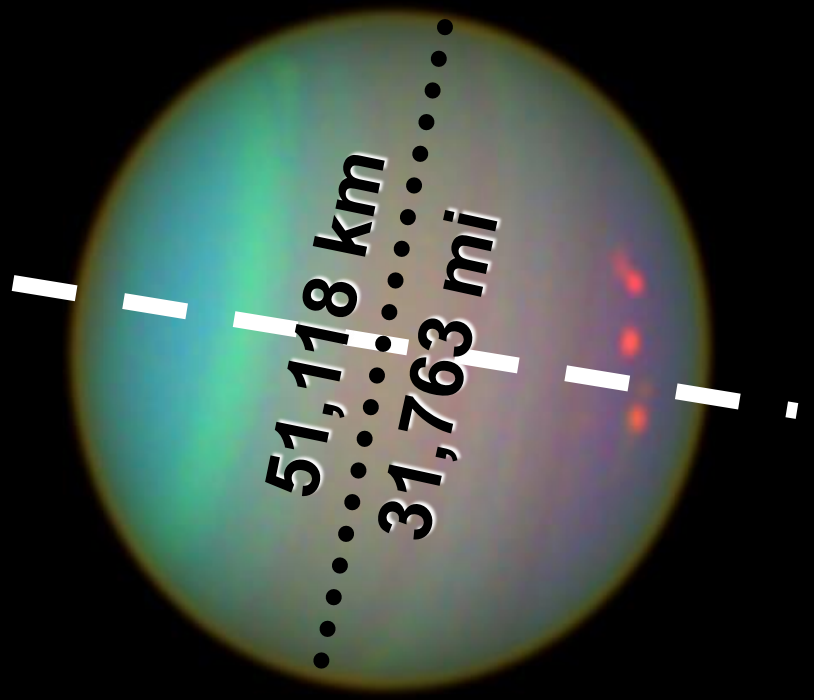


Axial tilt:	26.7^0
Length of day	10.6 E-hr
Orbital Period	29.5 yrs
Moons	47
Surface Temp	-140 ^{0}F
Atmosphere	H_2, He

Named after Roman lord of the rings

Saturn is 887 million miles from the SUN.

Uranus

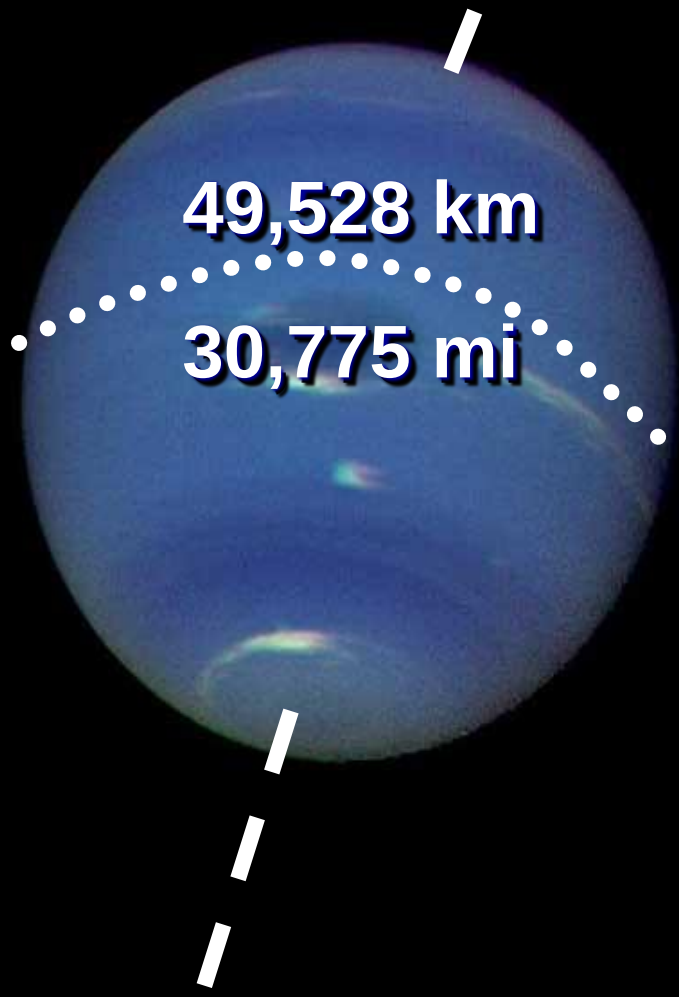


Axial tilt:	97.7^0
1 day	17.2 E-hr
Orbital Period	83.8 yrs
Moons	27
Surface Temp	-319 ^{0}F
Atmosphere	H_2, CH_4

Named after god (Greek) of heavens

Uranus is 1784 million miles from the SUN.

Neptune



Axial tilt:	28.3^0
Length of day	16 E-hrs
Orbital Period	163.7 yrs
Moons	13
Surface Temp	-200 ^{0}F
Atmosphere	CH_4, H_2

Named after Roman god of the sea

Neptune is 2795 million miles from the SUN.

I ♥ those planets.

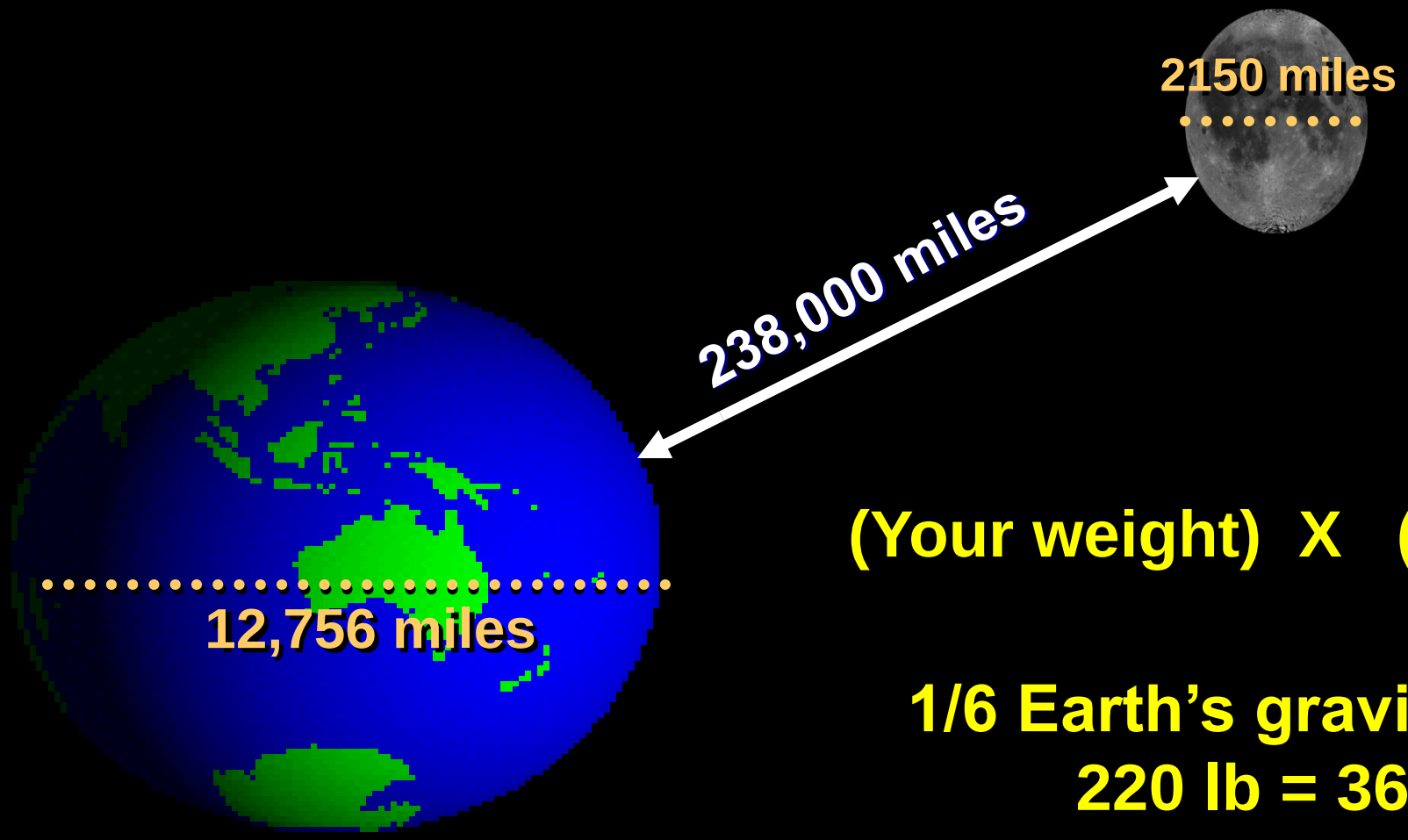
Discuss with a friend:

15. Give at least 3 characteristics of each planet:

Mercury	Jupiter
Venus	Saturn
Earth	Uranus
Mars	Neptune

I will get an A on my exams and quizzes.

Moon Phases and Eclipses

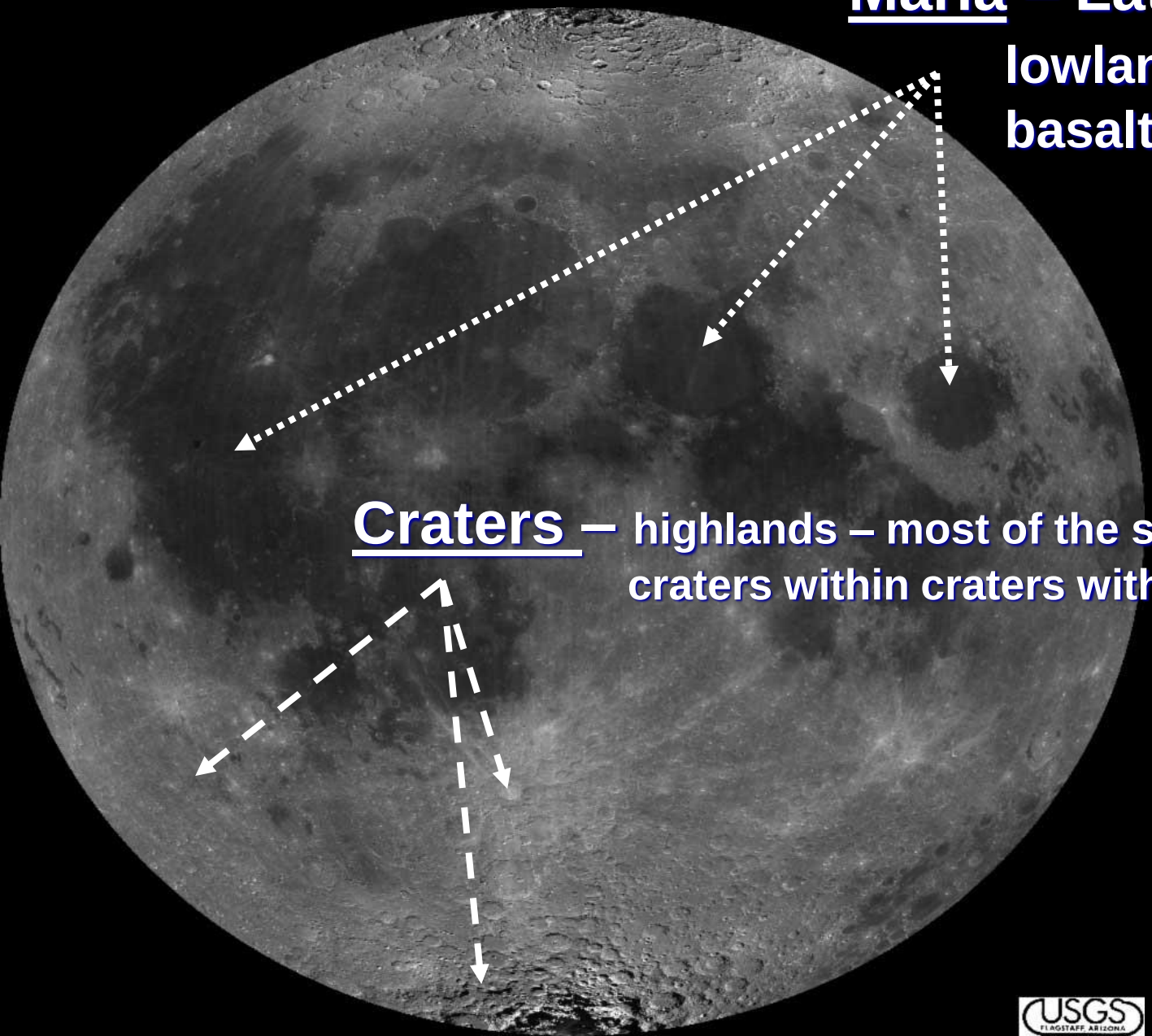


(Your weight) X (.16)

1/6 Earth's gravity
220 lb = 36 lb

3.3 g/cm^3 = density

The moon's surface



Maria – Latin for sea

lowlands

basalt flows

Craters – highlands – most of the surface

craters within craters within craters

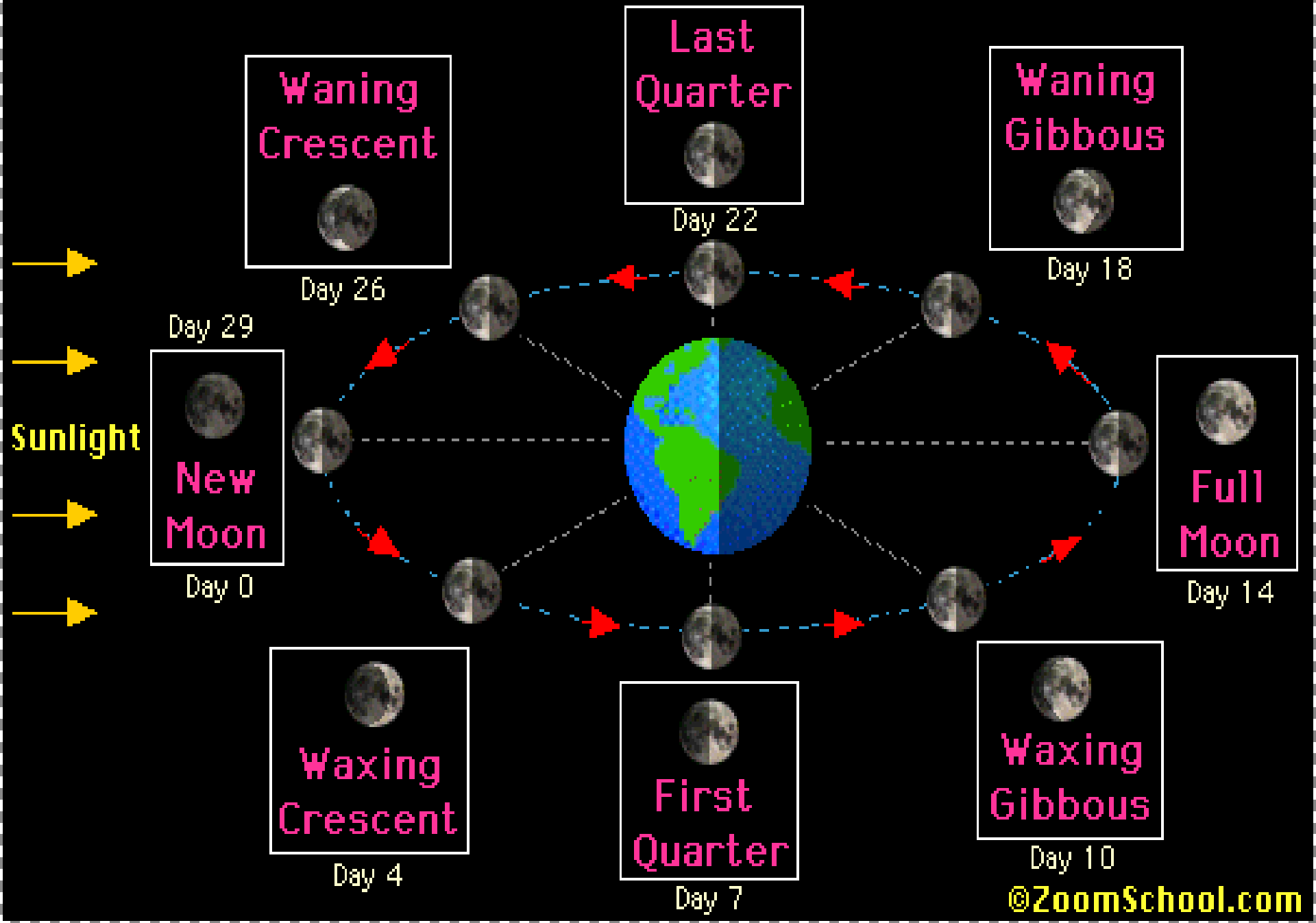
USGS FLAGSTAFF, ARIZONA

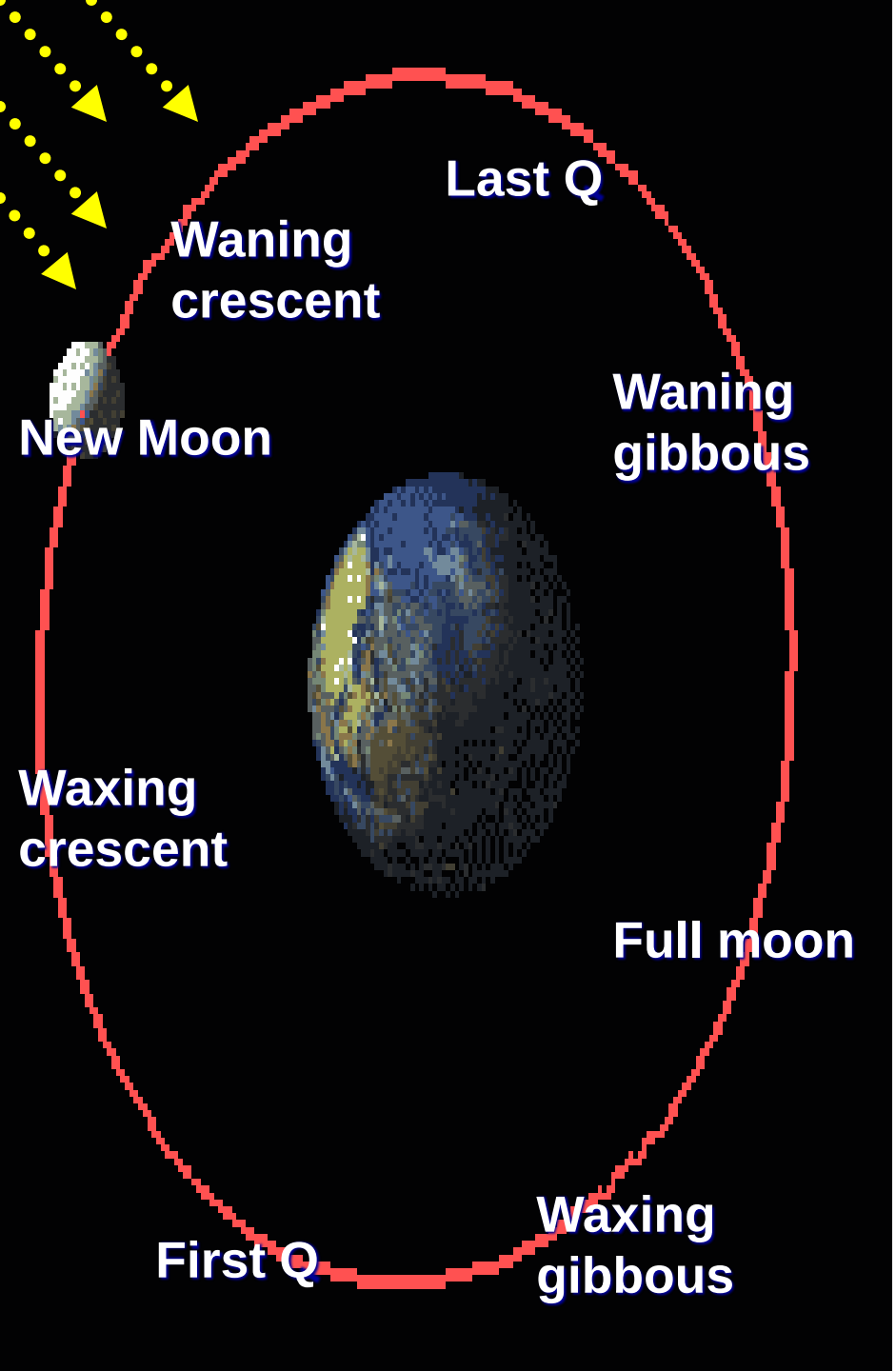
Phases of the moon

- 7 major phases in a period of 1 month
- 1 orbital moon period = 29 days

<u>Fast speed</u> - What the moon would look like over a month-long period

The Phases of the Moon





View from earth

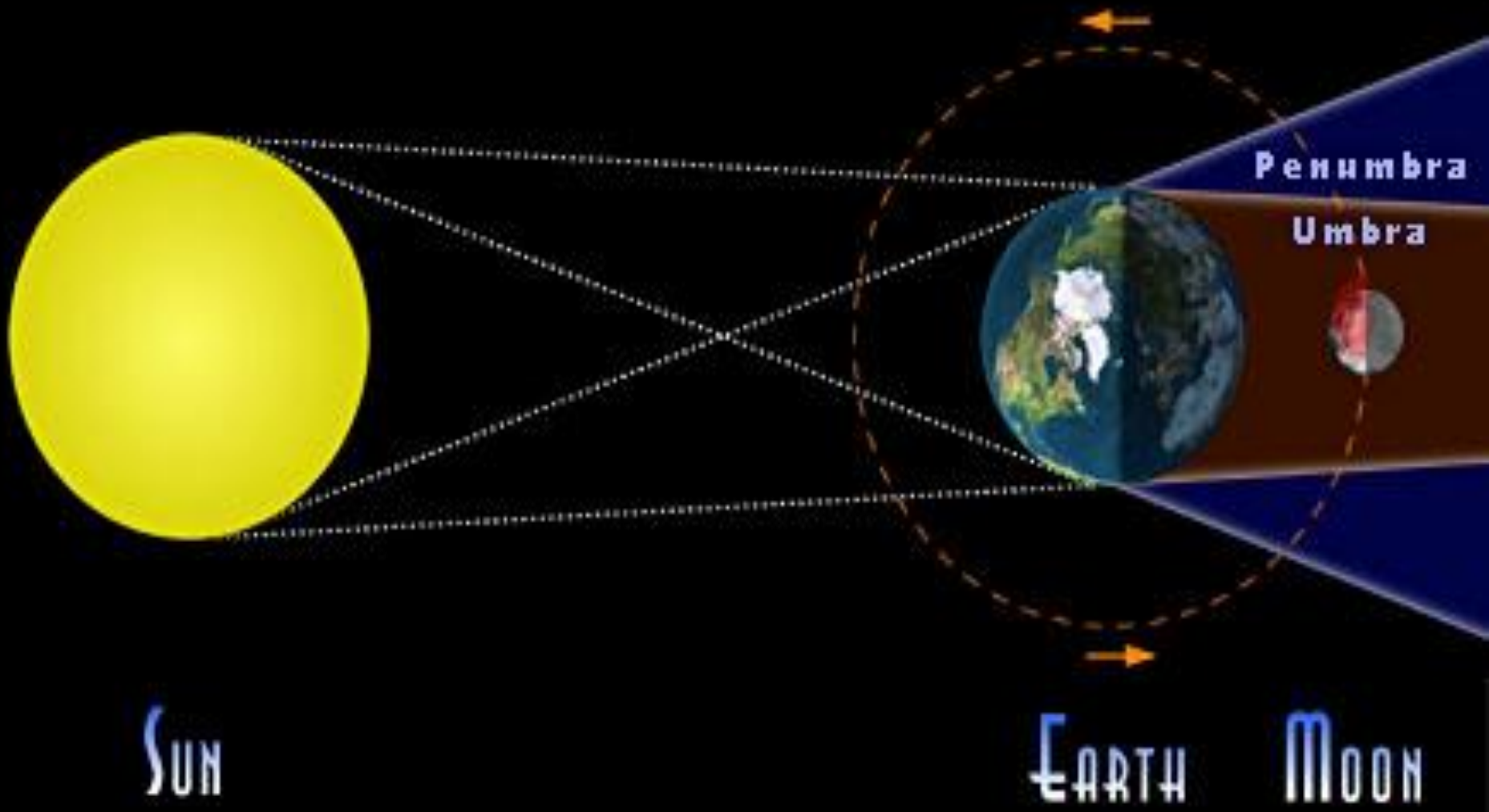
<u>Waxing</u> = increasing brightness

<u>Waning</u> = decreasing brightness

Eclipses of the Moon

- Lunar Eclipse
- Solar Eclipse

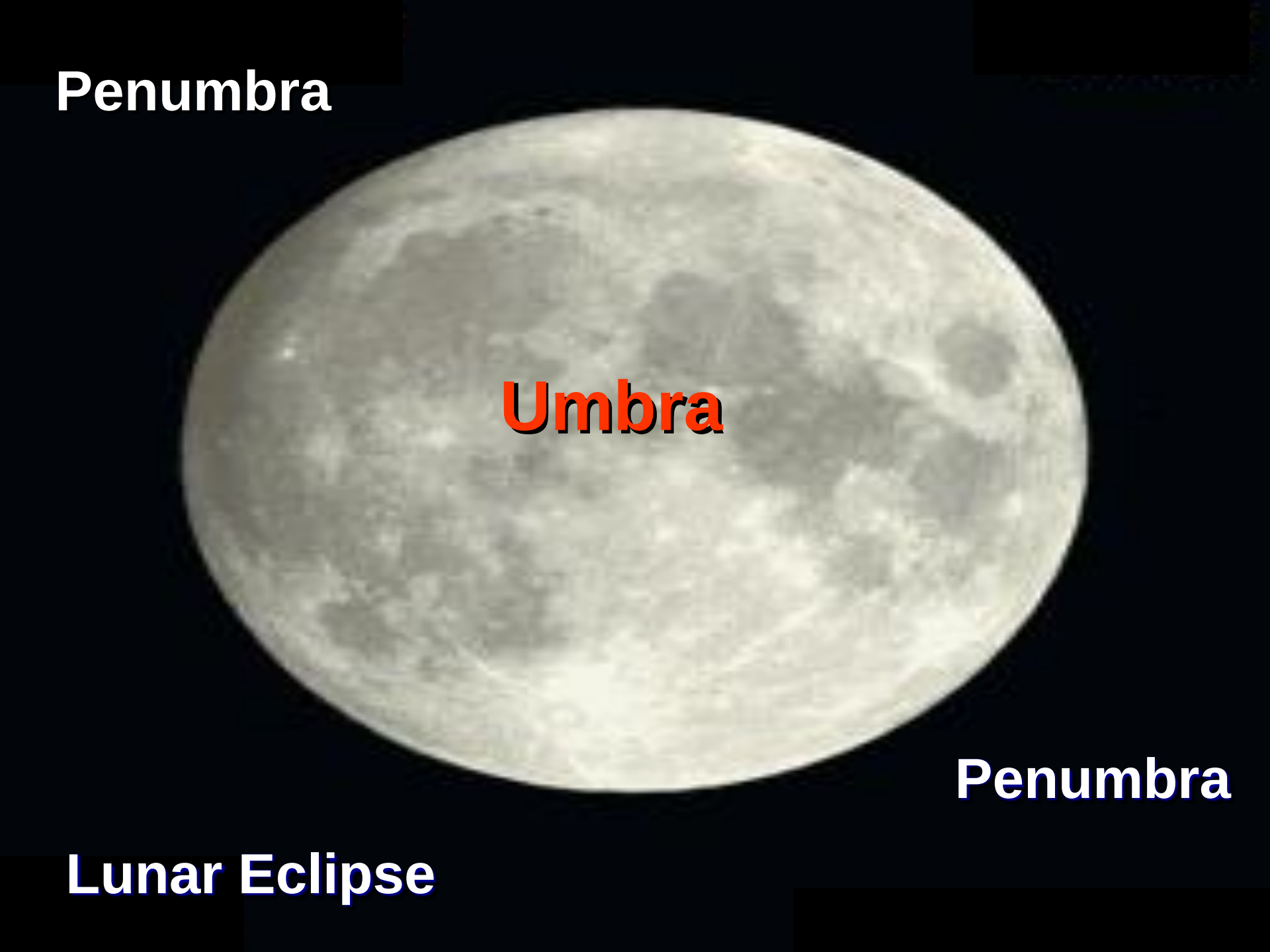
Lunar Eclipse Geometry



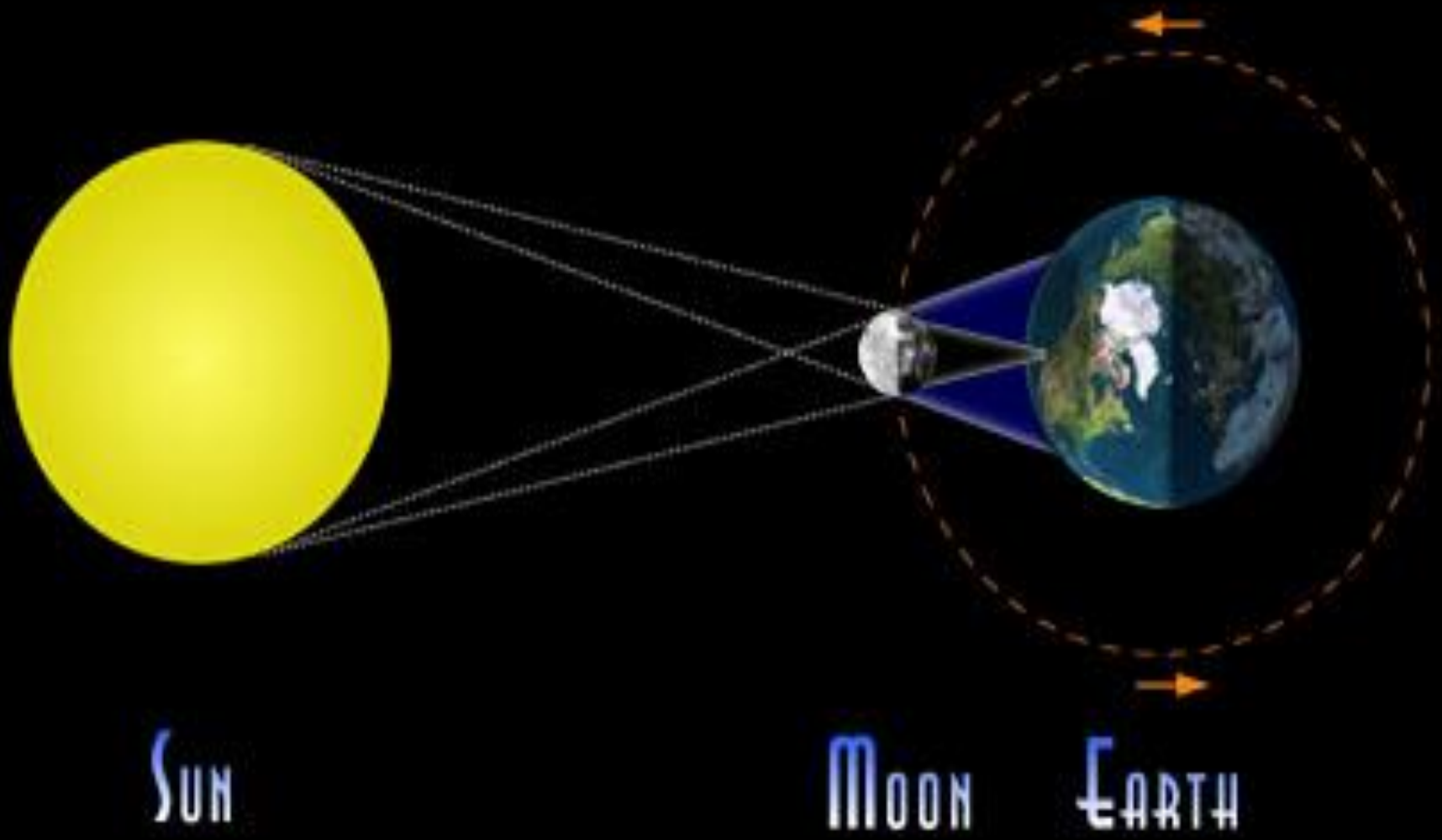
www.MrEclipse.com

Animation of a Total Lunar Eclipse

(Distances not to scale)


Penumbra
Umbra
Penumbra
Lunar Eclipse

Solar Eclipse Geometry



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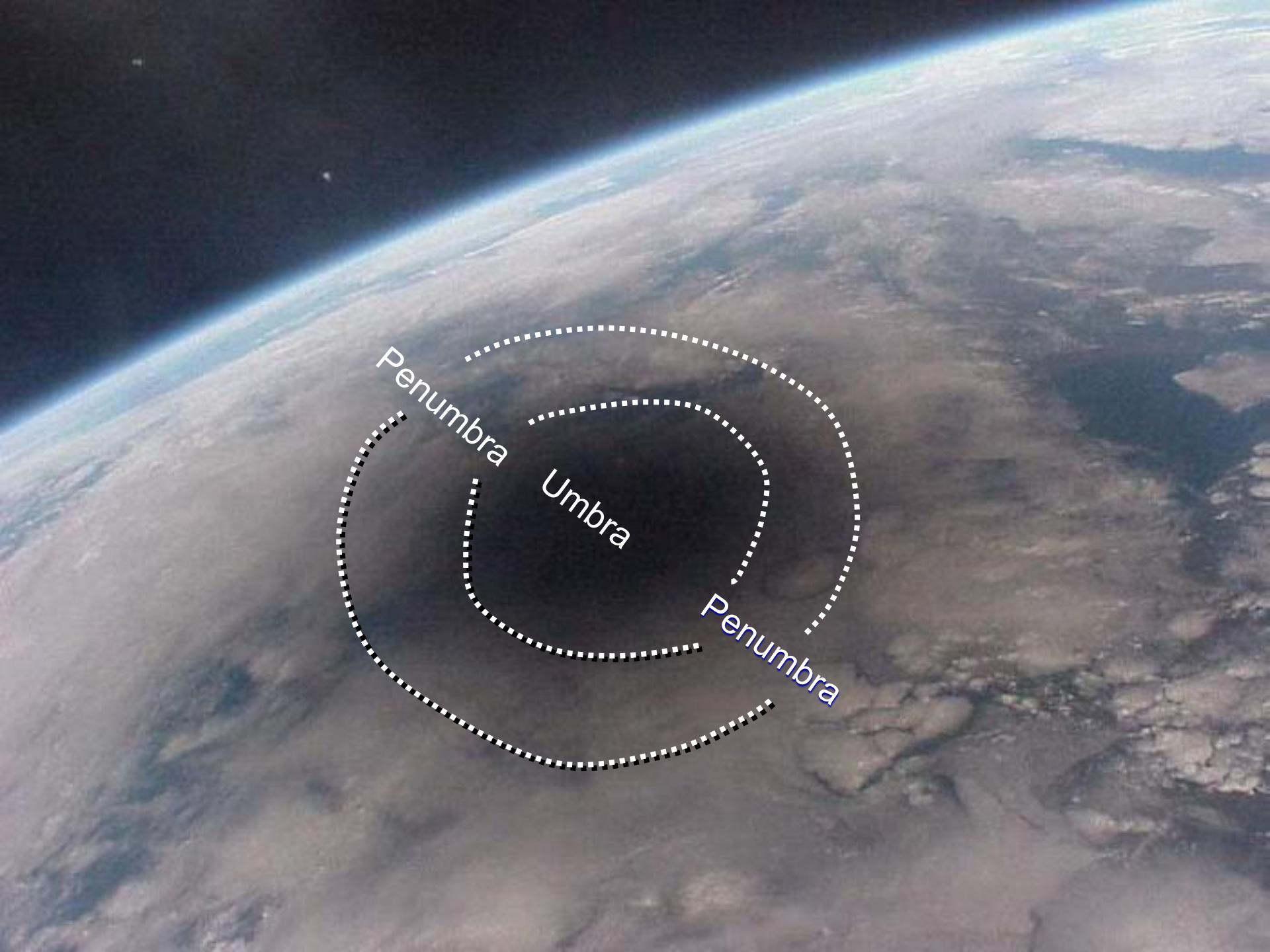
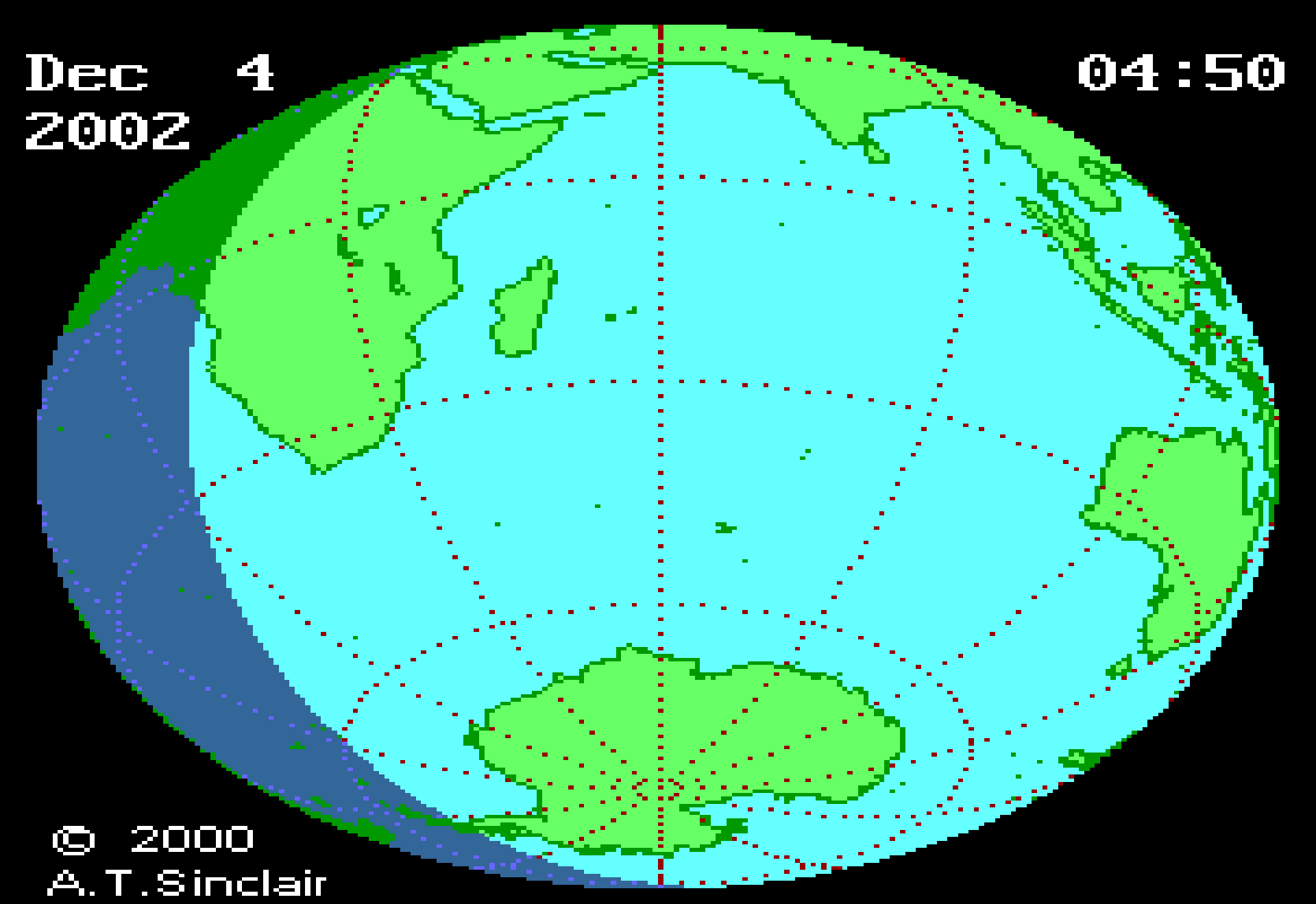
Animation of a Total Solar Eclipse

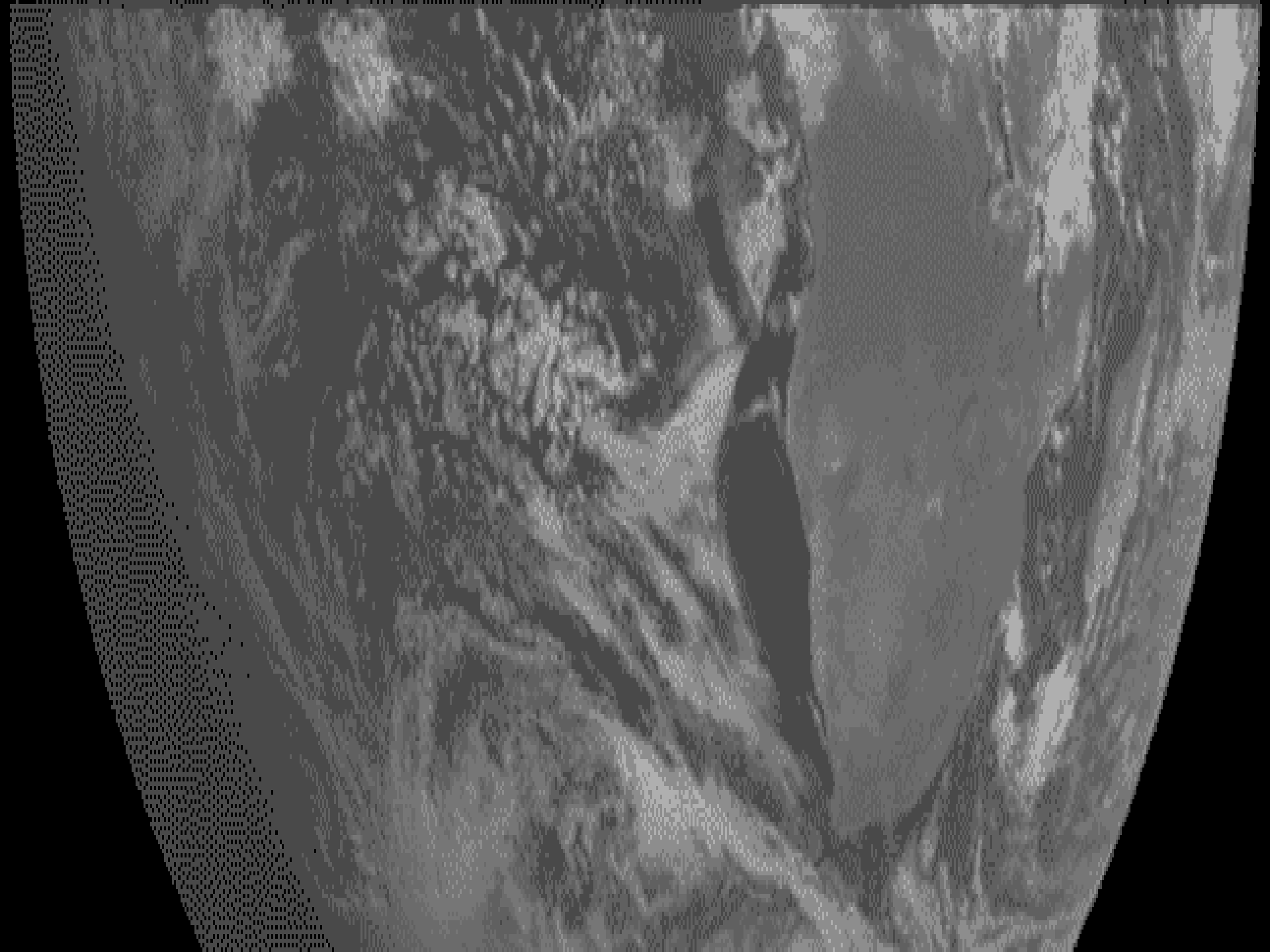
(Distances not to scale)

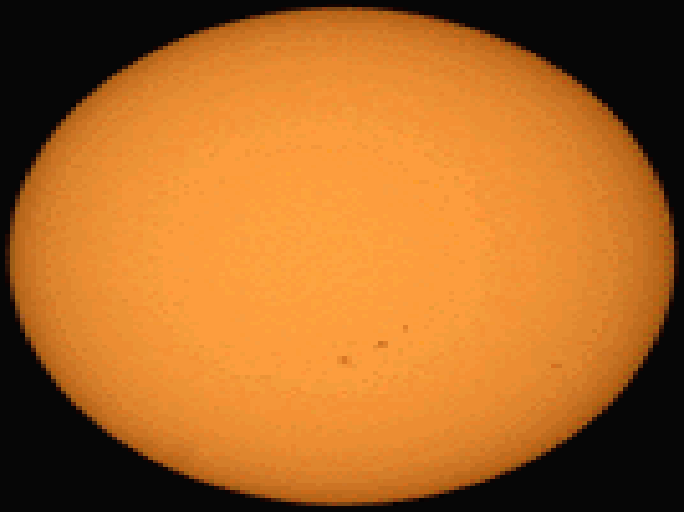

Penumbra
Umbra
Penumbra


Penumbra
Umbra
Penumbra



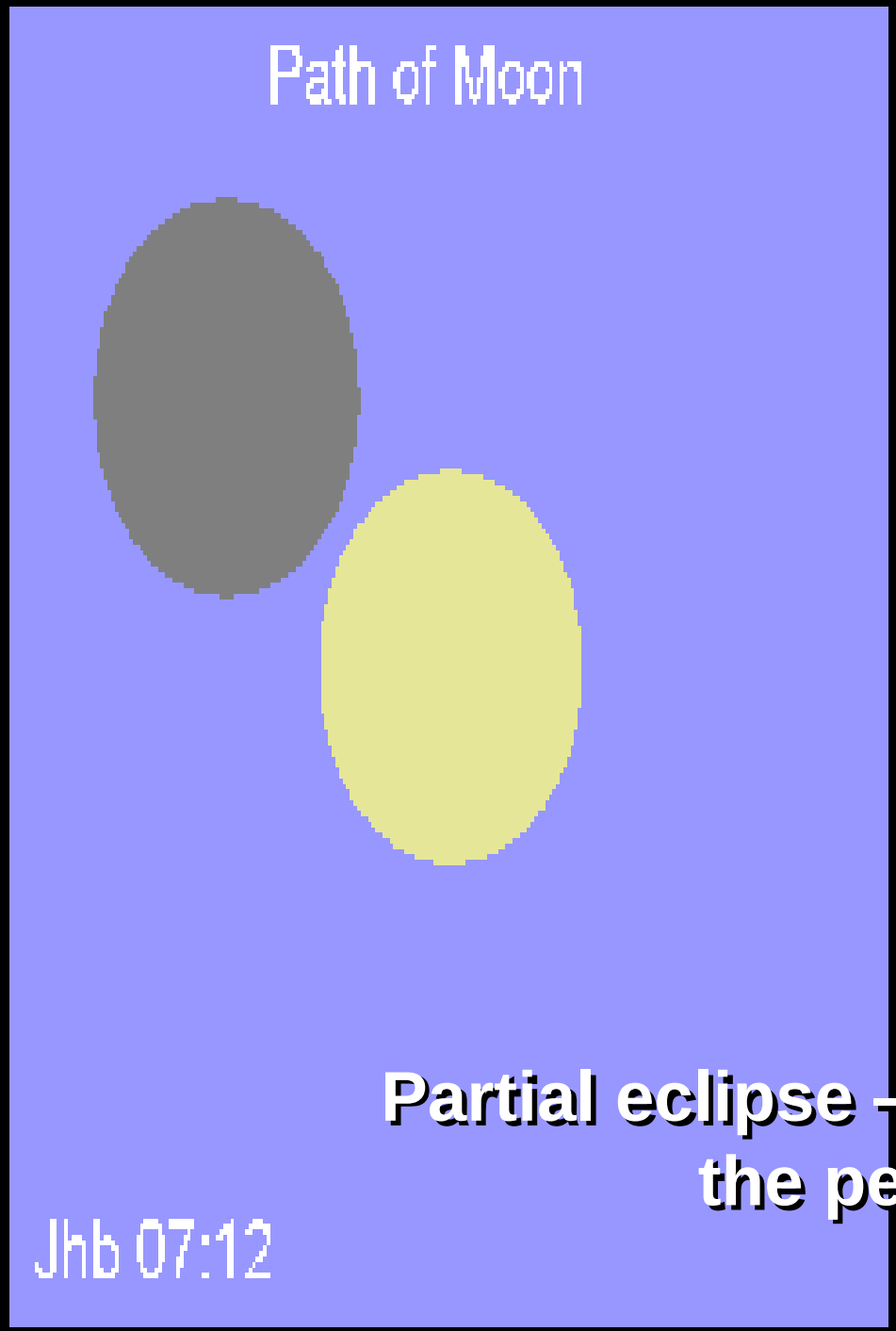
Espenak's Eclipse Home Page

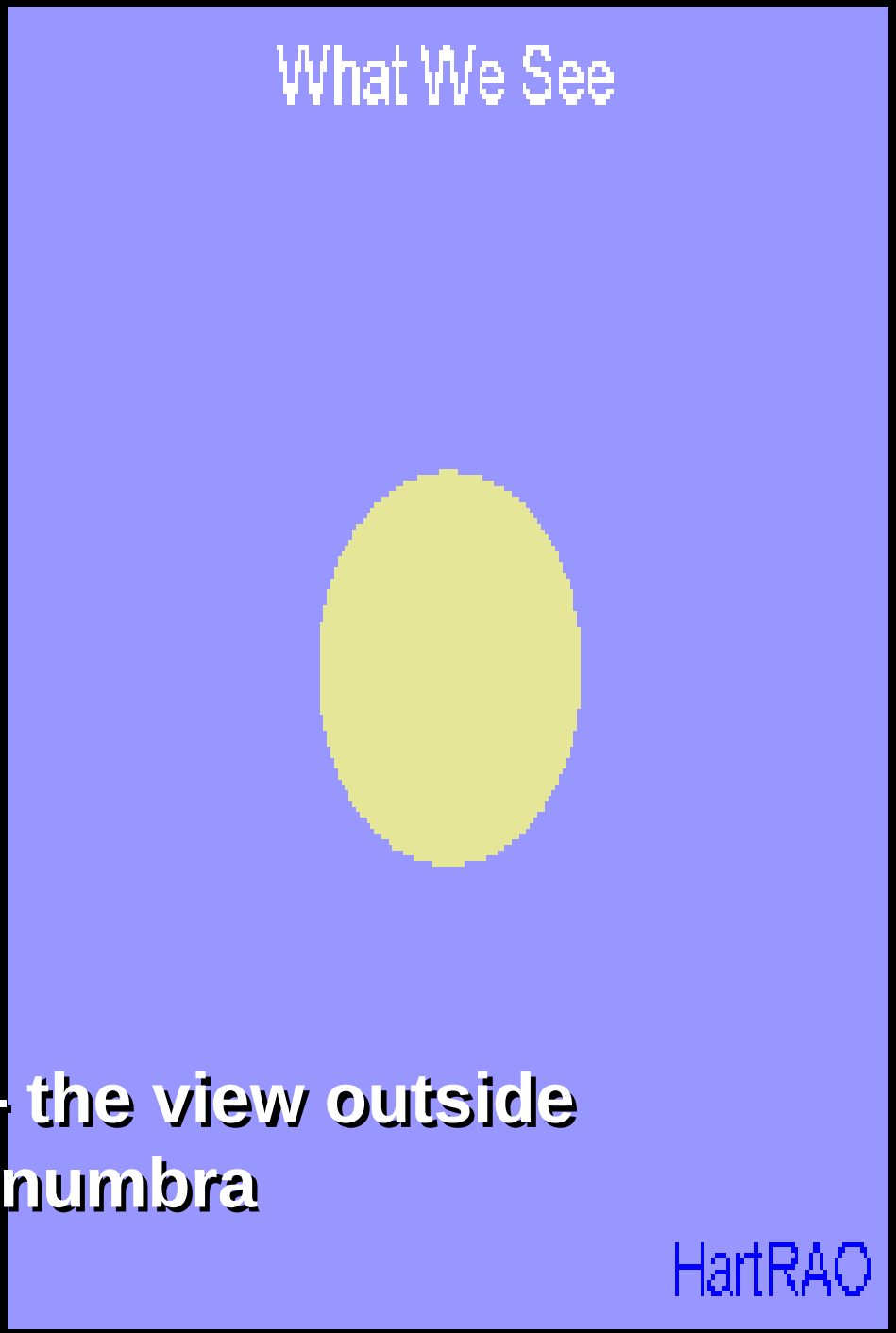




Total Eclipse of the Sun

Solar eclipse May 21st, 2012 over the west coast of USA

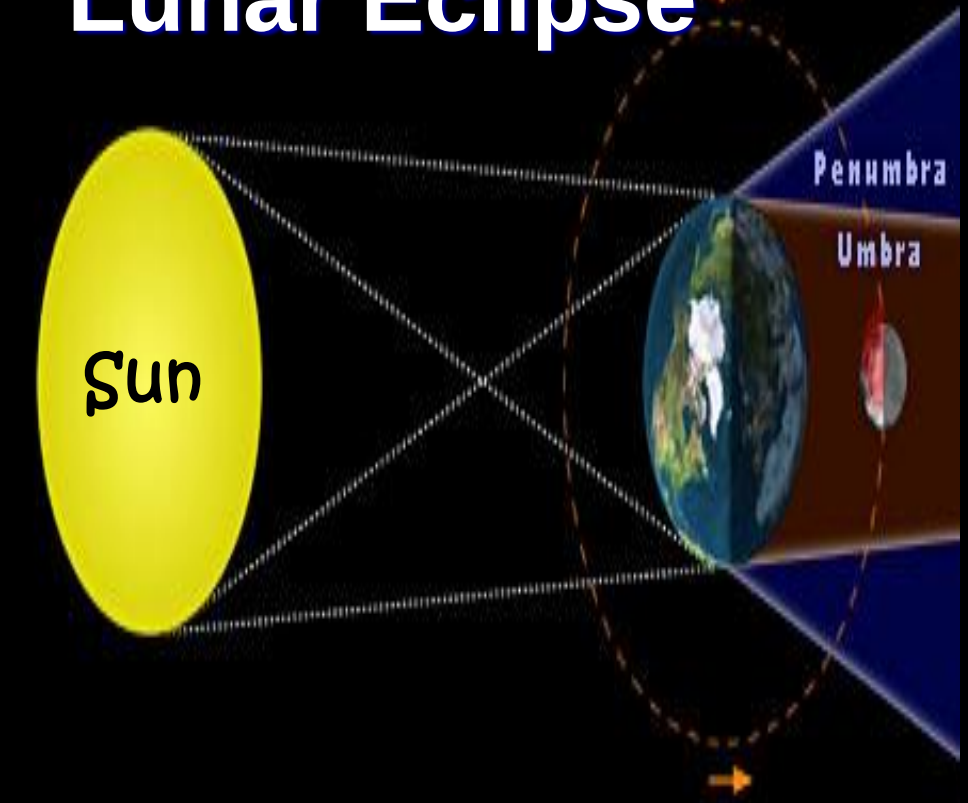




Partial eclipse – the view outside the penumbra

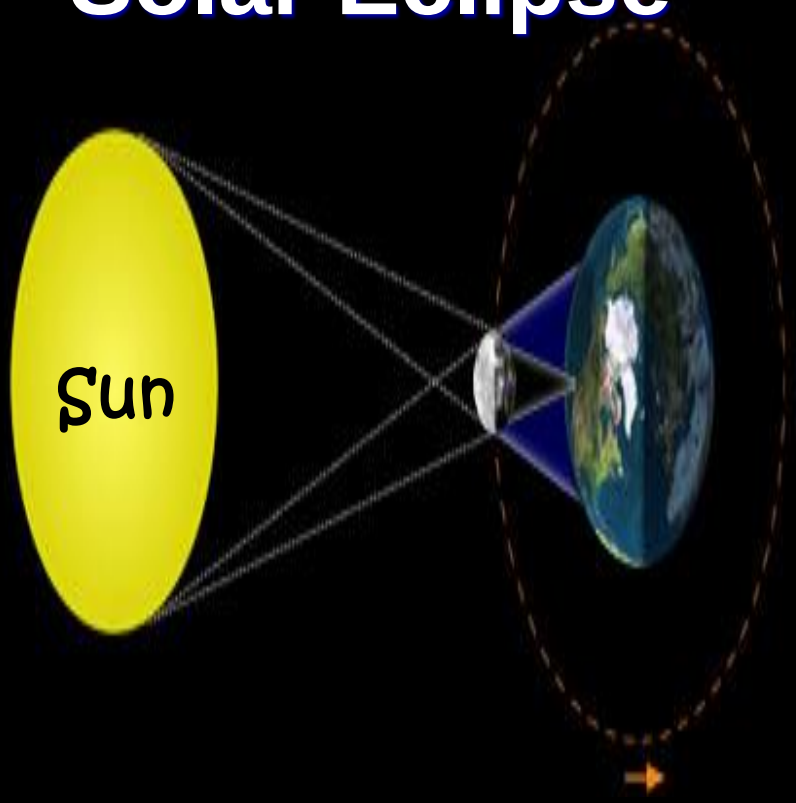
Spectators pay BIG money to be in the umbra.

Lunar Eclipse



SUN – EARTH---MOON

Solar Eclipse

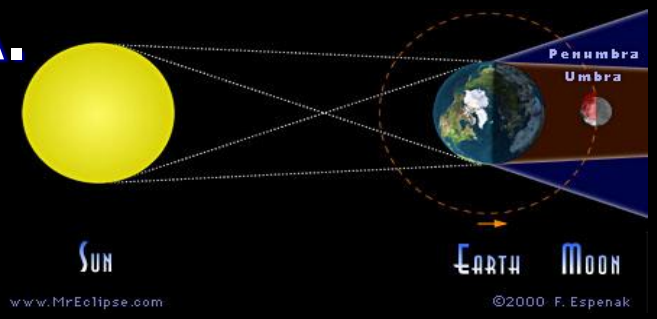


SUN – MOON – EARTH

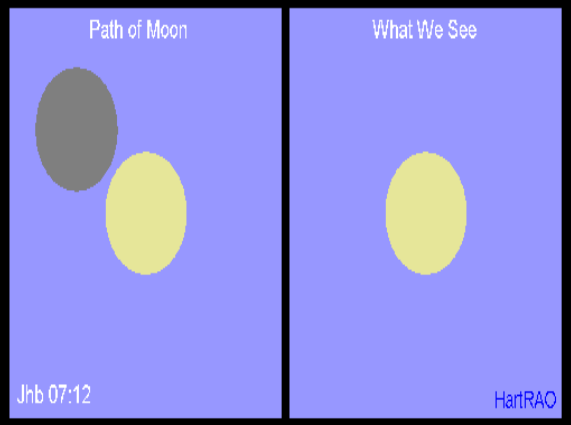
I>clicker

Which diagram below depicts a solar eclipse?

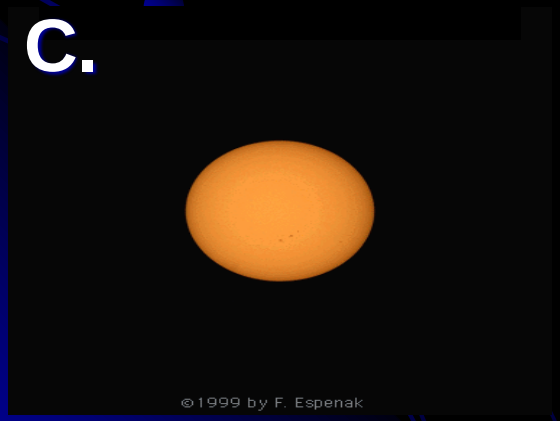
A.



B.



C.



D.

I ♥ the nebular hypothesis.

Discuss with a friend:

1. Draw a diagram that shows the various phases of the moon – use the vocabulary (waxing / waning).
2. Draw a diagram depicting the differences between a <u>lunar</u> and a <u>solar</u> eclipse.

I will get an A on my exams and quizzes.

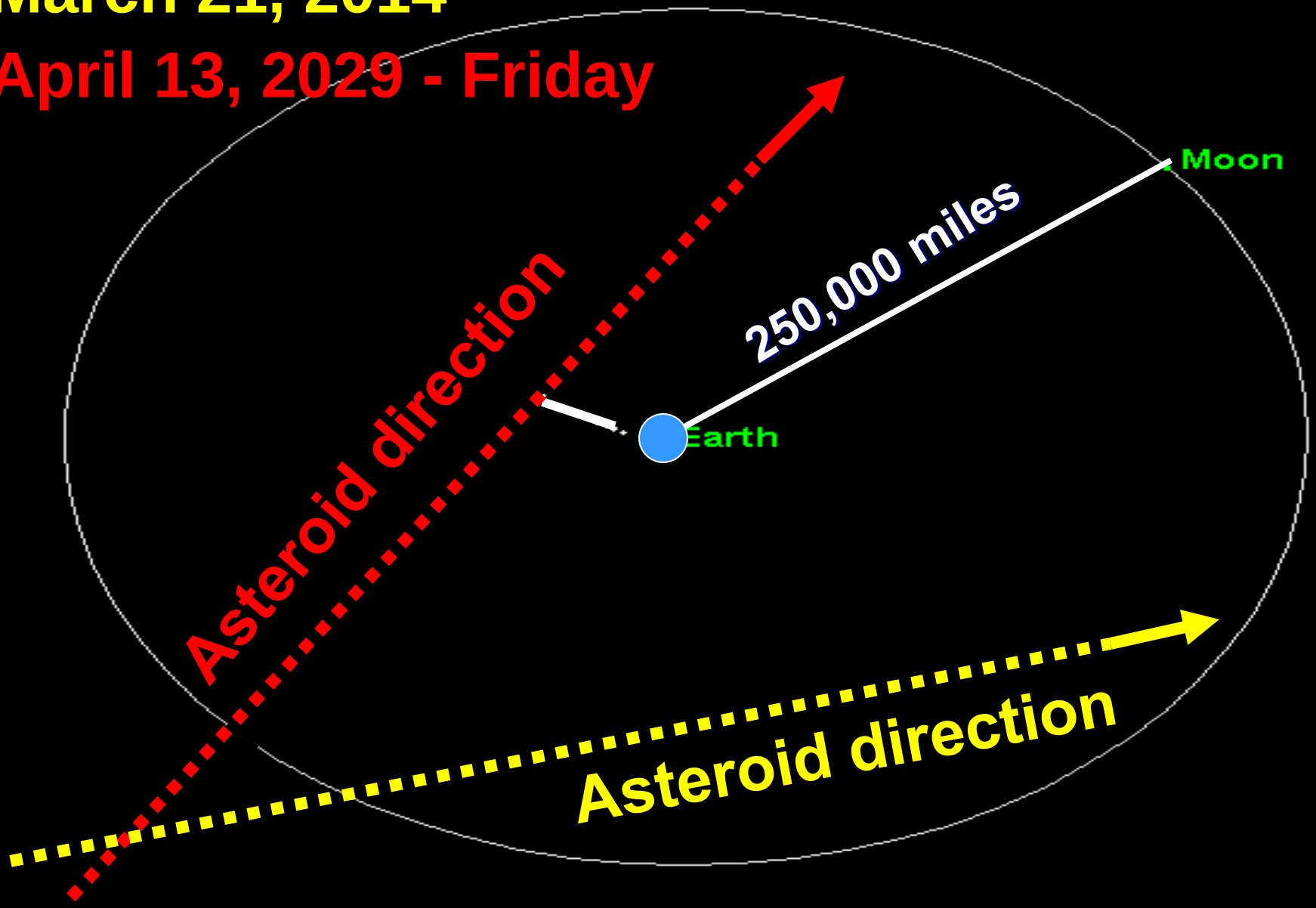
Minor members of the solar system

Asteroid - small rocky bodies that are irregular in shape – 10,000 or more lie between Jupiter and Mars (the asteroid belt)

Proposed asteroid impact on Earth

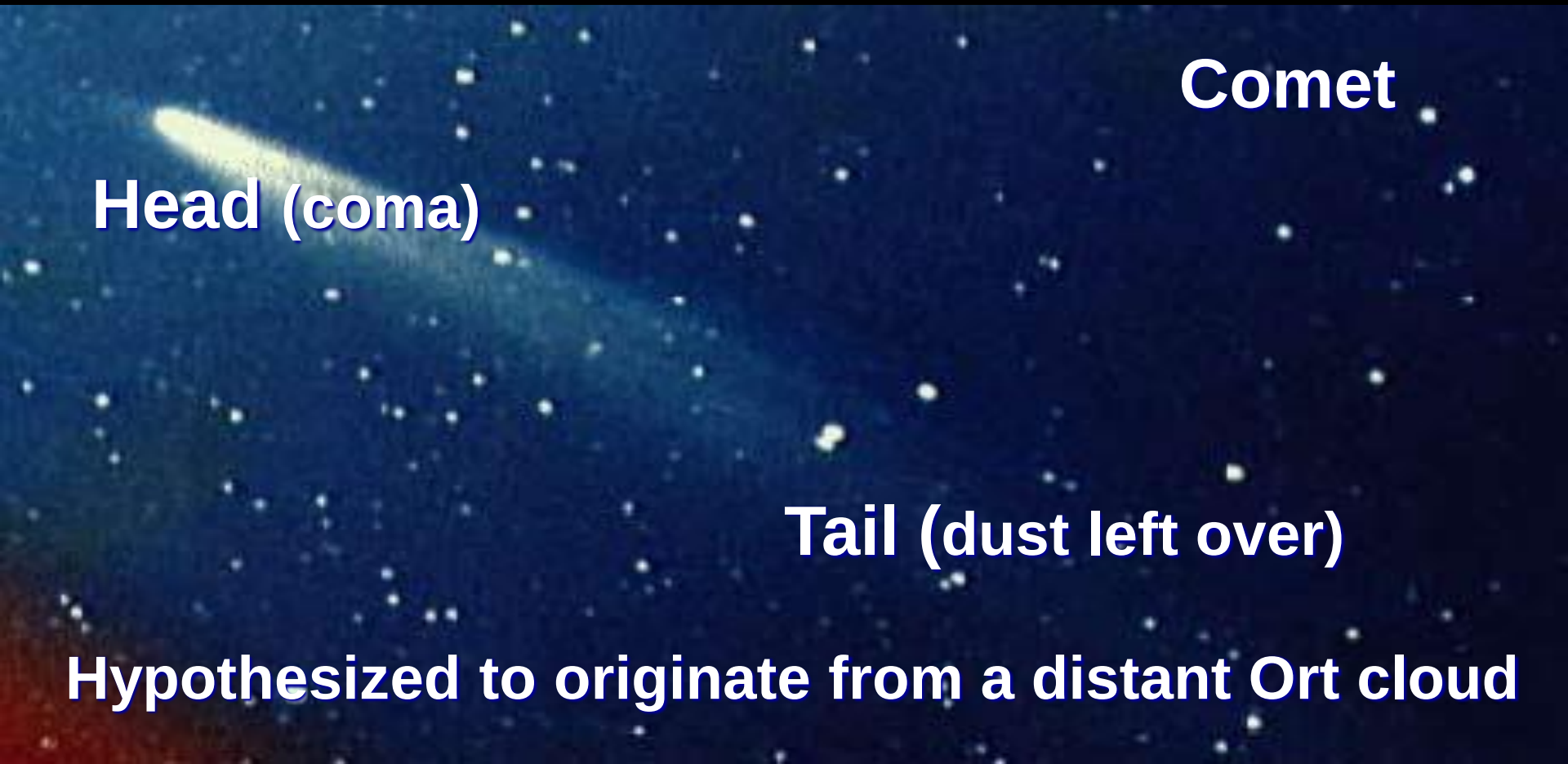
March 21, 2014

April 13, 2029 - Friday



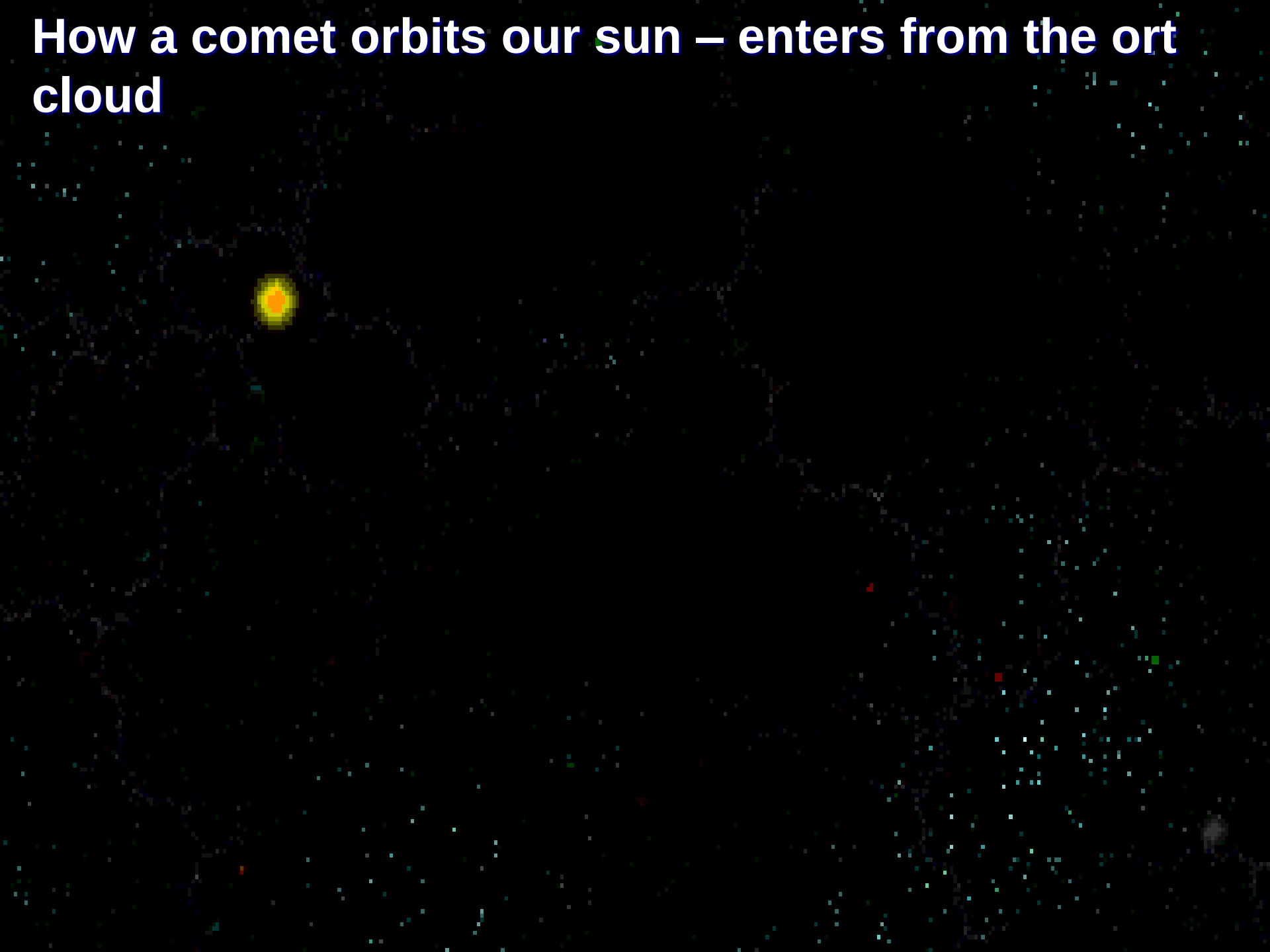
Minor members of the solar system

<u>Comet</u>: - A large "ice-ball" composed of dust and space debris which enters the solar system from an outside source



Hypothesized to originate from a distant Ort cloud

How a comet orbits our sun – enters from the ort cloud



Halley's Comet

- 1986 was its last appearance
- appears every 76 years
- next appearance -- 2062

What year should a person have been born to see Halley's comet twice in their lifetime?

Halley’s Comet

Astronomy Vocabulary

Meteor – small to boulder-size rock particle that enters the earth's atmosphere – air friction causes the rock to "burn" creating a "falling-star"

I ♥ comets, asteroids, and meteorites.

Discuss with a friend:

1. Describe the differences between an asteroid, meteorite, and comet.

I will get an A on my exams and quizzes.