Big Idea:

Beyond the Earth

Objective:

Explain the Big Bang Theory and discuss the evidence that supports it.

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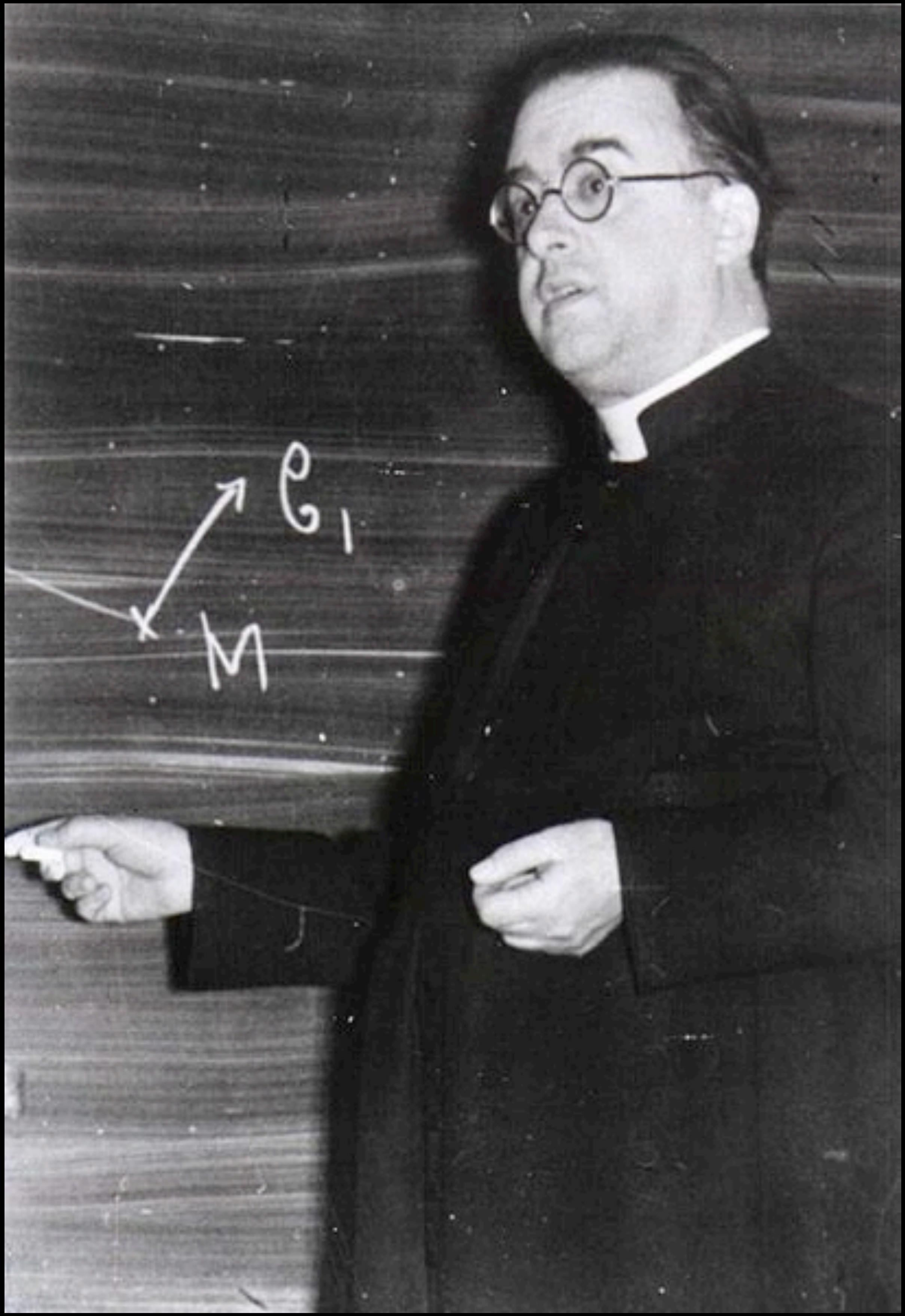
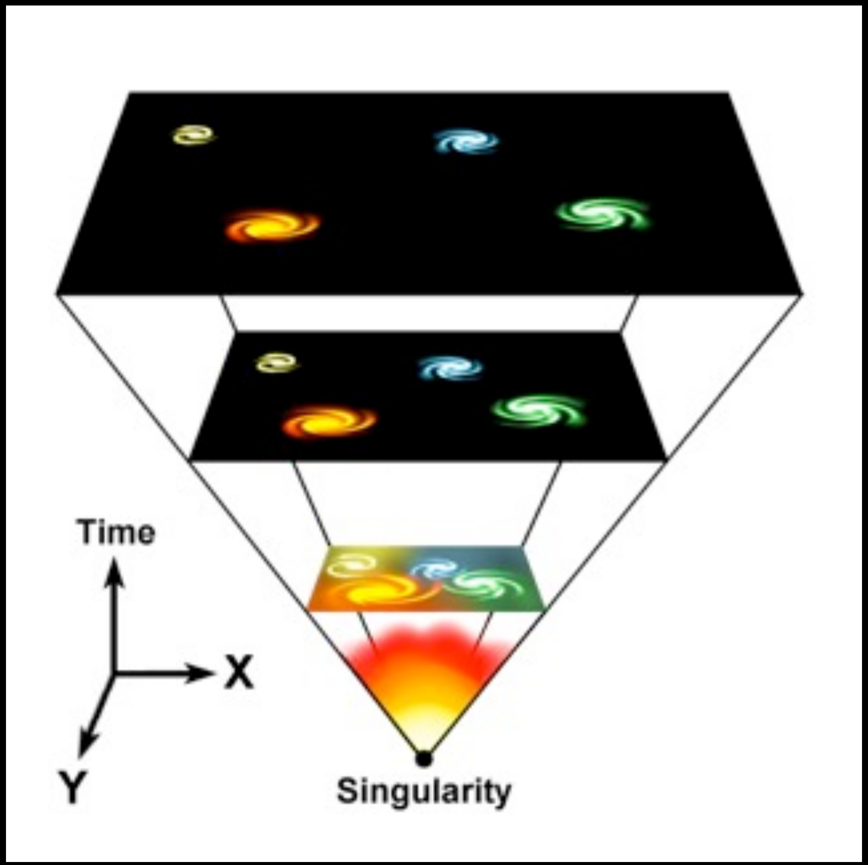
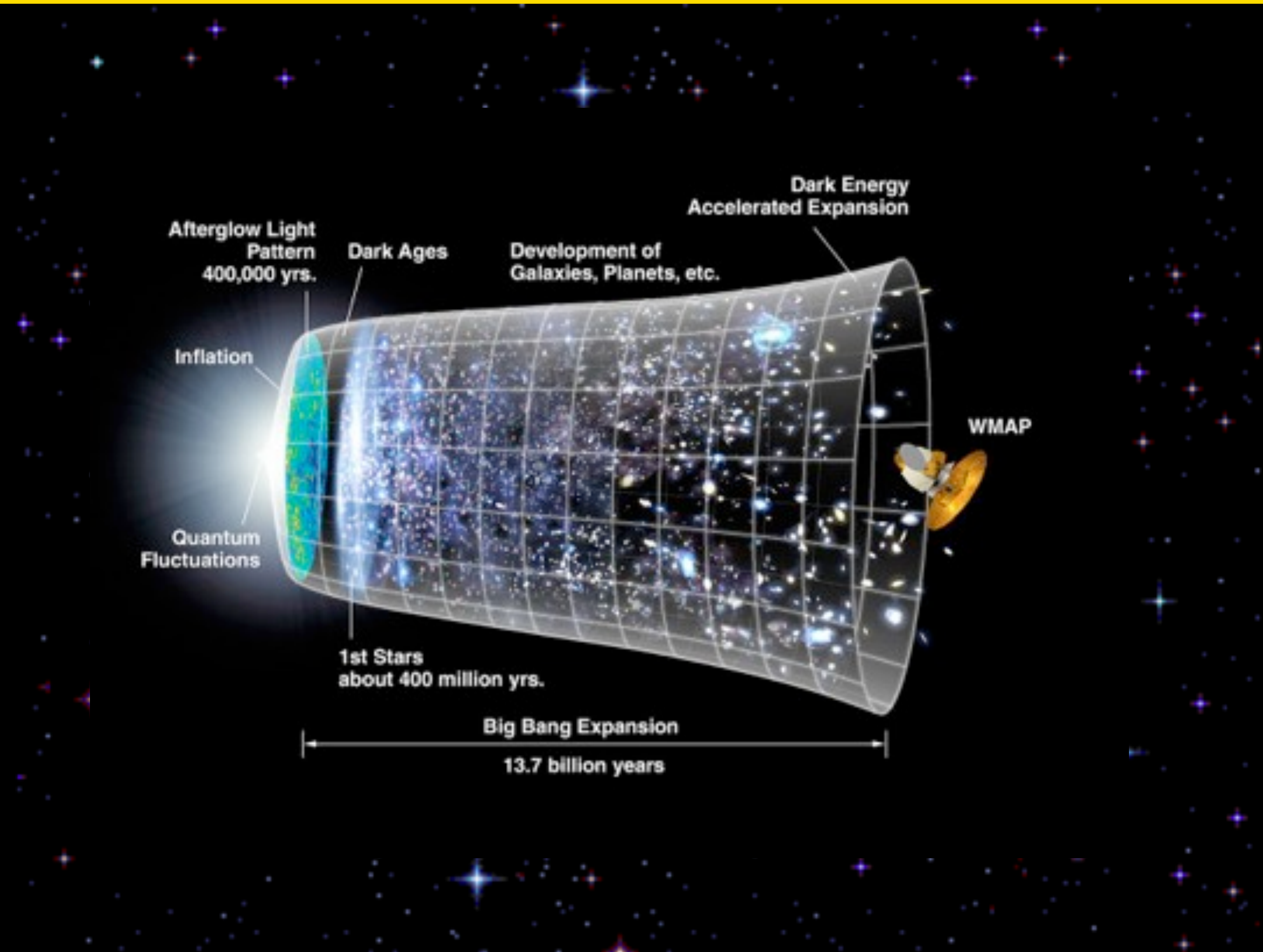


Monsignor Georges Henri Joseph Édouard Lemaître (lemaitre.ogg (help·info) 17 July 1894 – 20 June 1966) was a Belgian priest, astronomer and professor of physics at the Catholic University of Louvain.

Lemaître proposed what

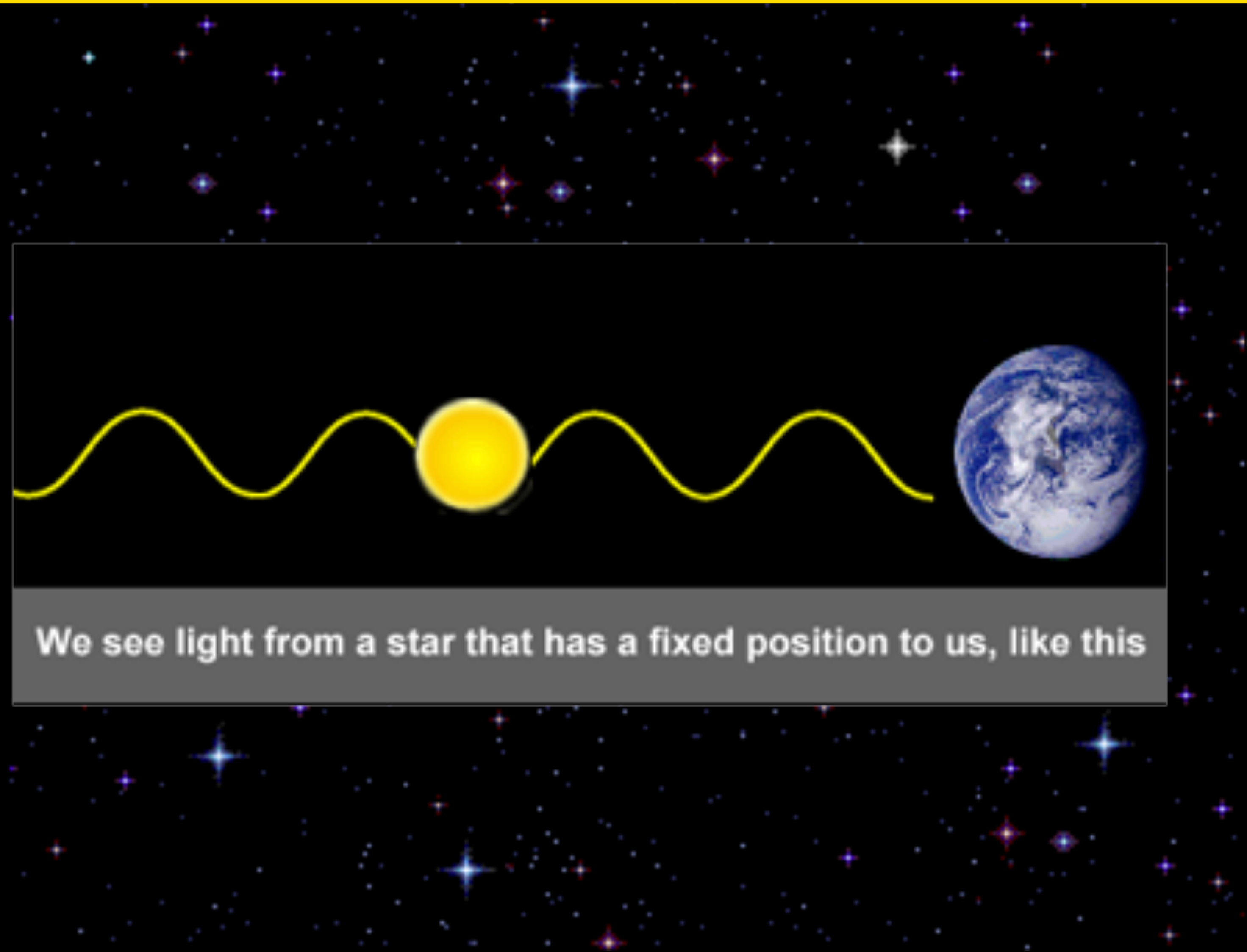


What was the Big



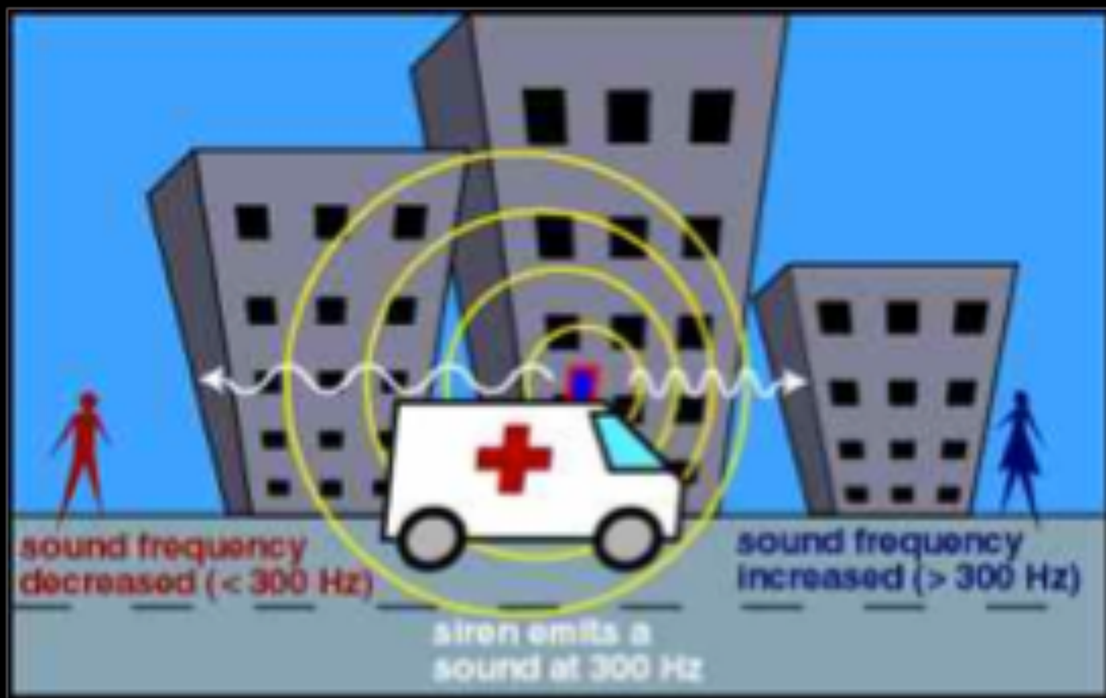
- The universe started as a single, dense point, 13.7 billion years ago.
- It became unstable and exploded outward.
- Today the universe continues to expand.

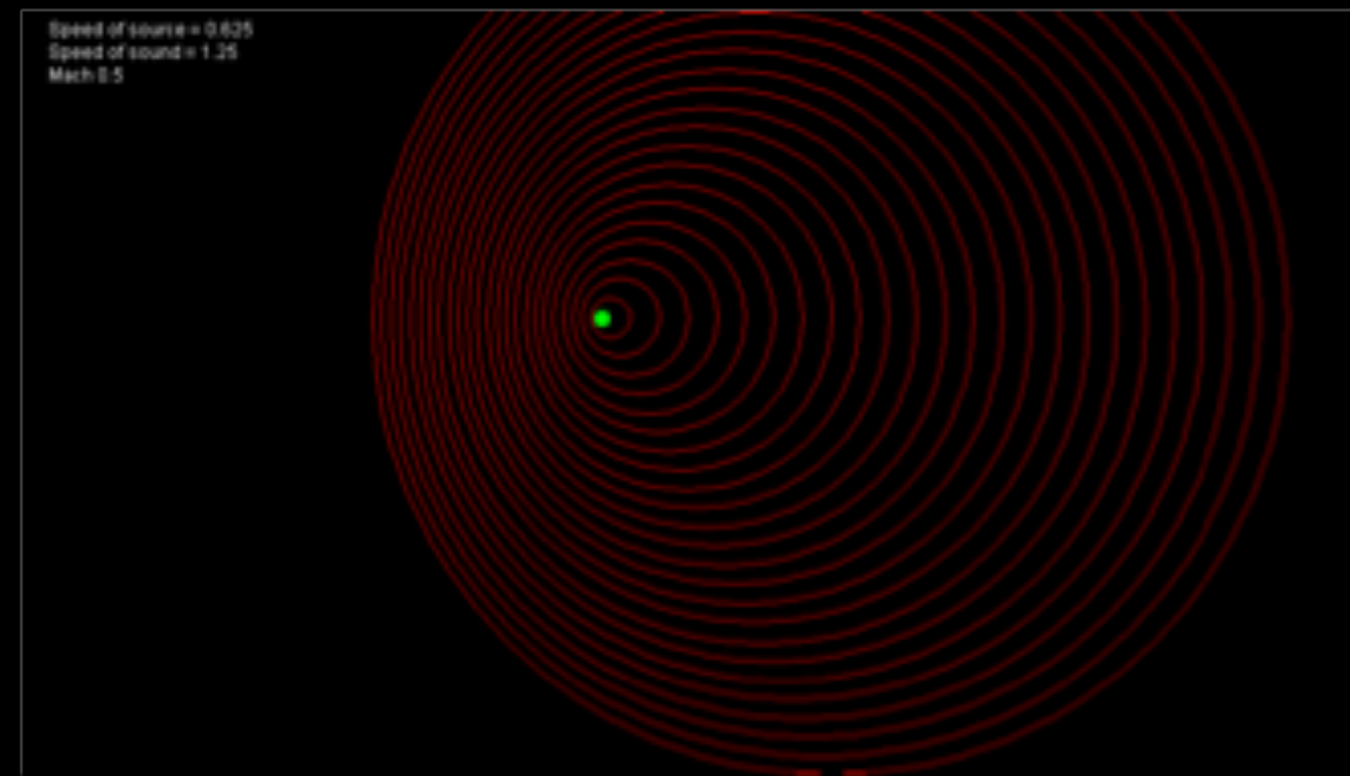
Evidence for the



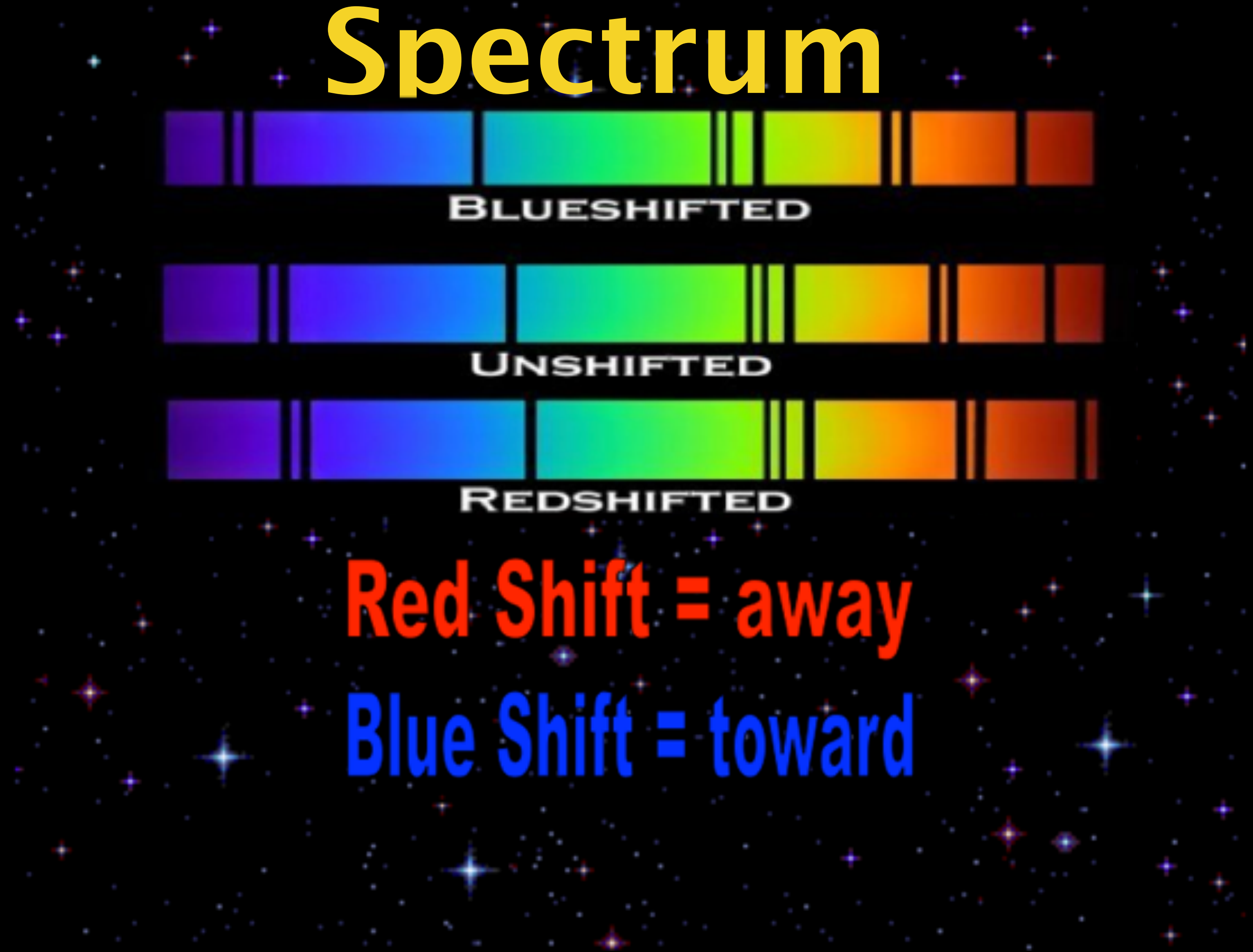
light from distance
galaxies all shift toward red

The Doppler Effect

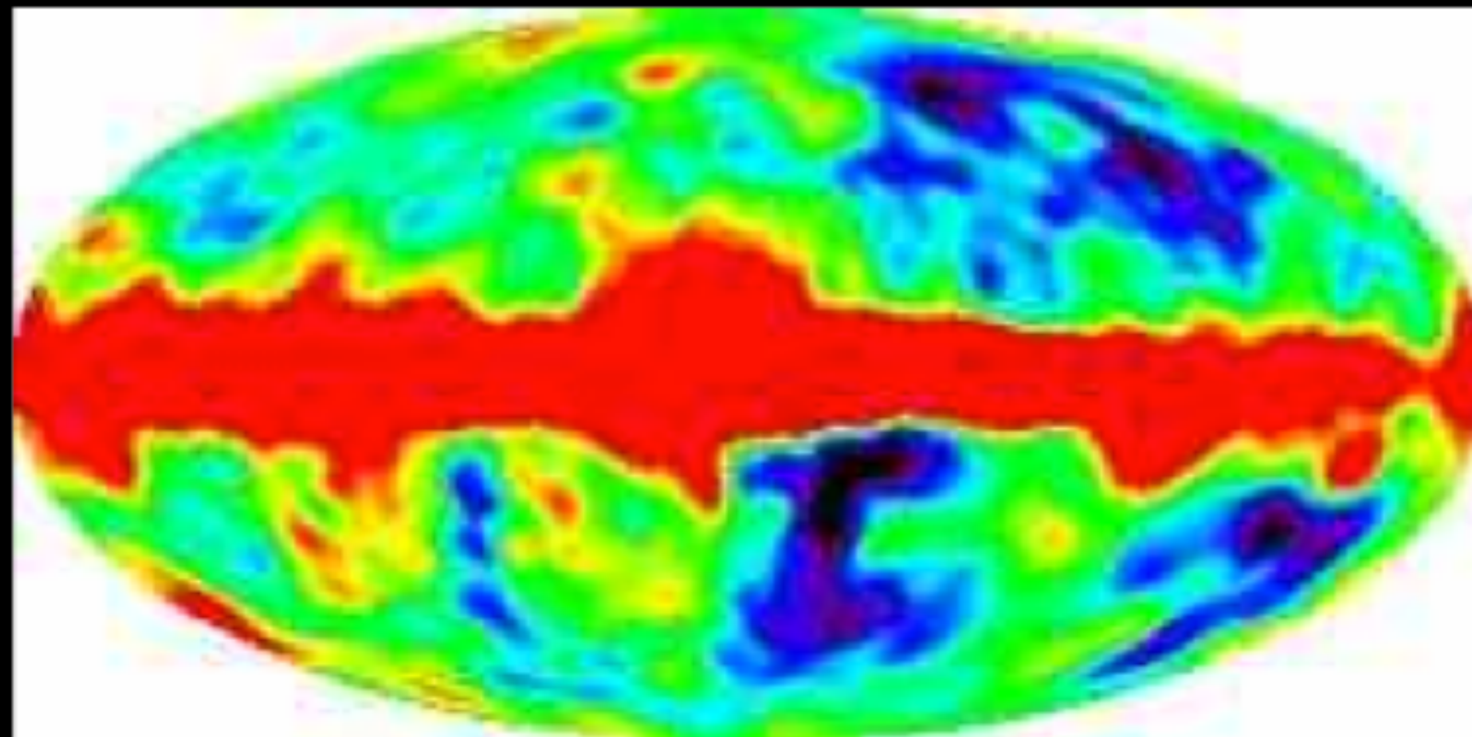




Shift in the Electromagnetic Spectrum

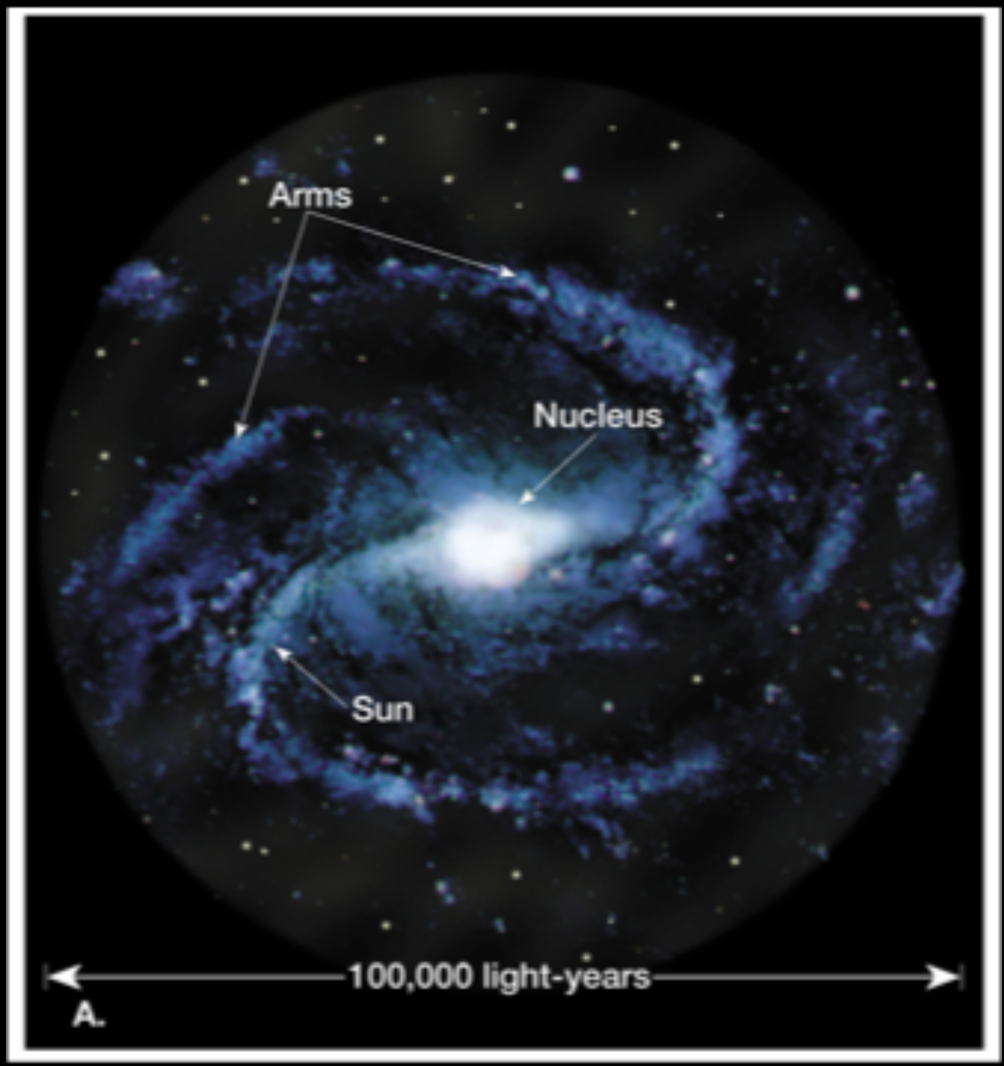


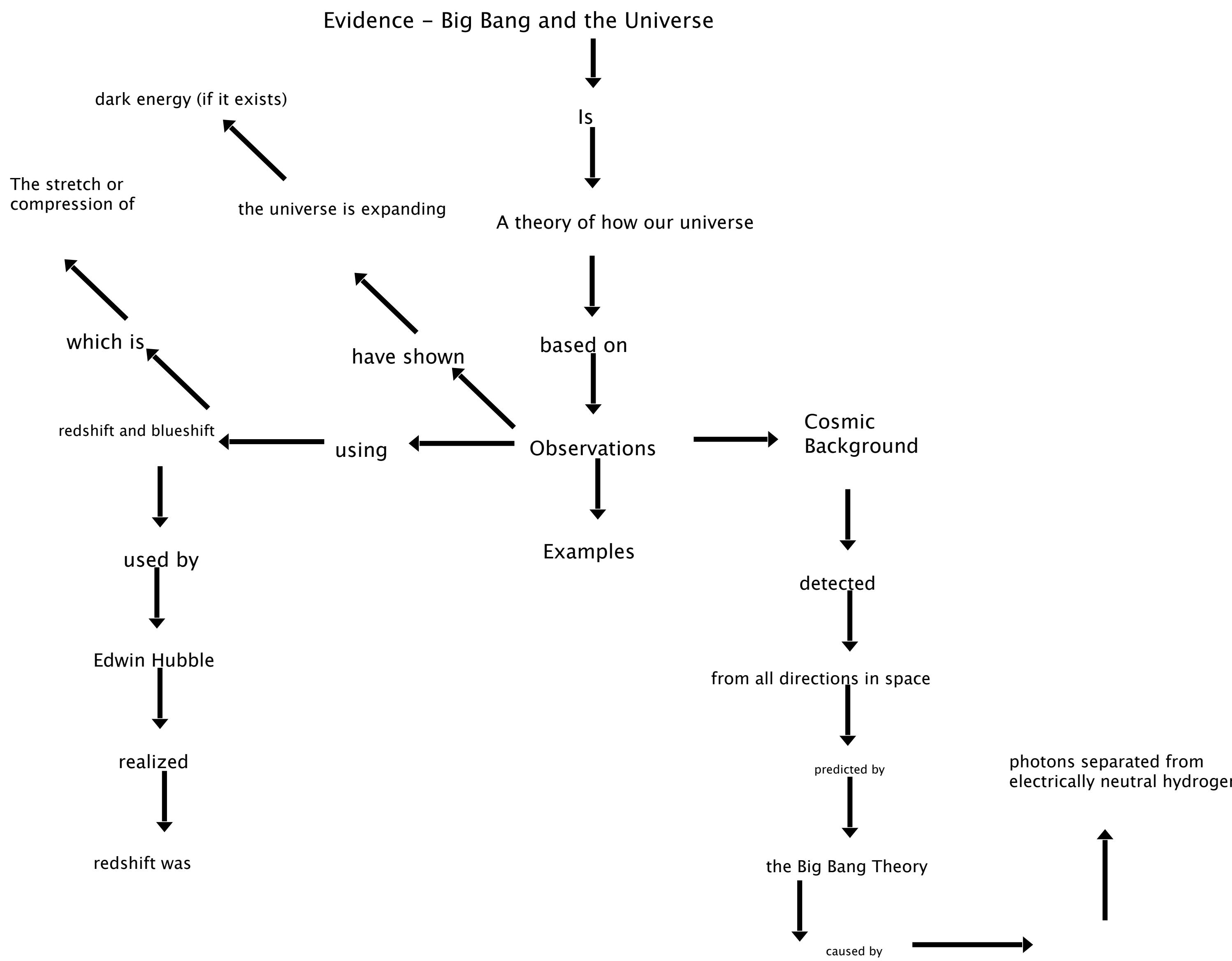
Additional Evidence



Cosmic Background Radiation

Our solar system is part of the spiral Milky Way Galaxy



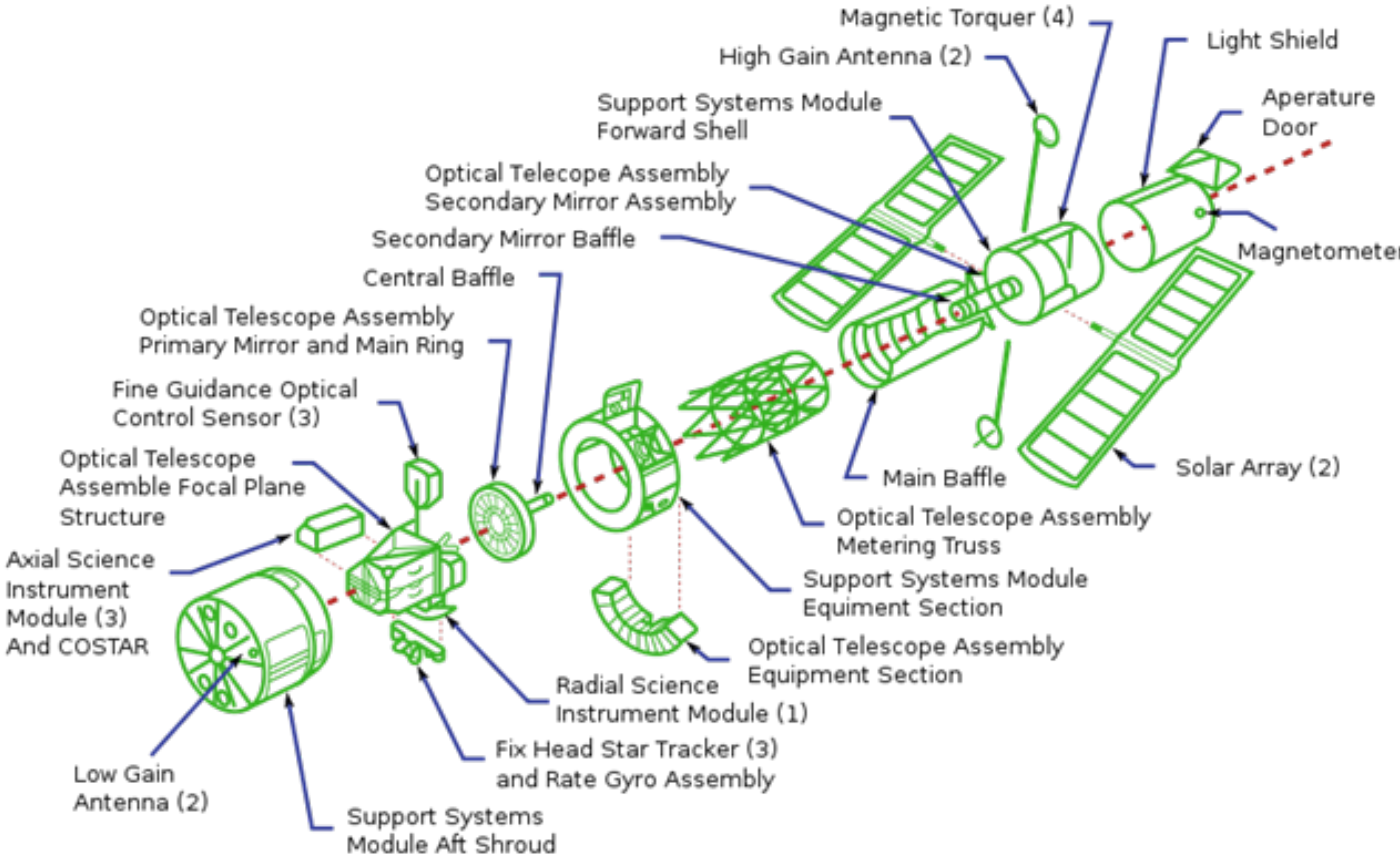

Evidence - Big Bang and the Universe
Is
A theory of how our universe
based on
Observations
Examples
using
redshift and blueshift
which is
The stretch or
compression of
used by
Edwin Hubble
realized
redshift was
have shown
the universe is expanding
dark energy (if it exists)
Cosmic
Background
detected
from all directions in space
predicted by
the Big Bang Theory
caused by
photons separated from
electrically neutral hydrogen

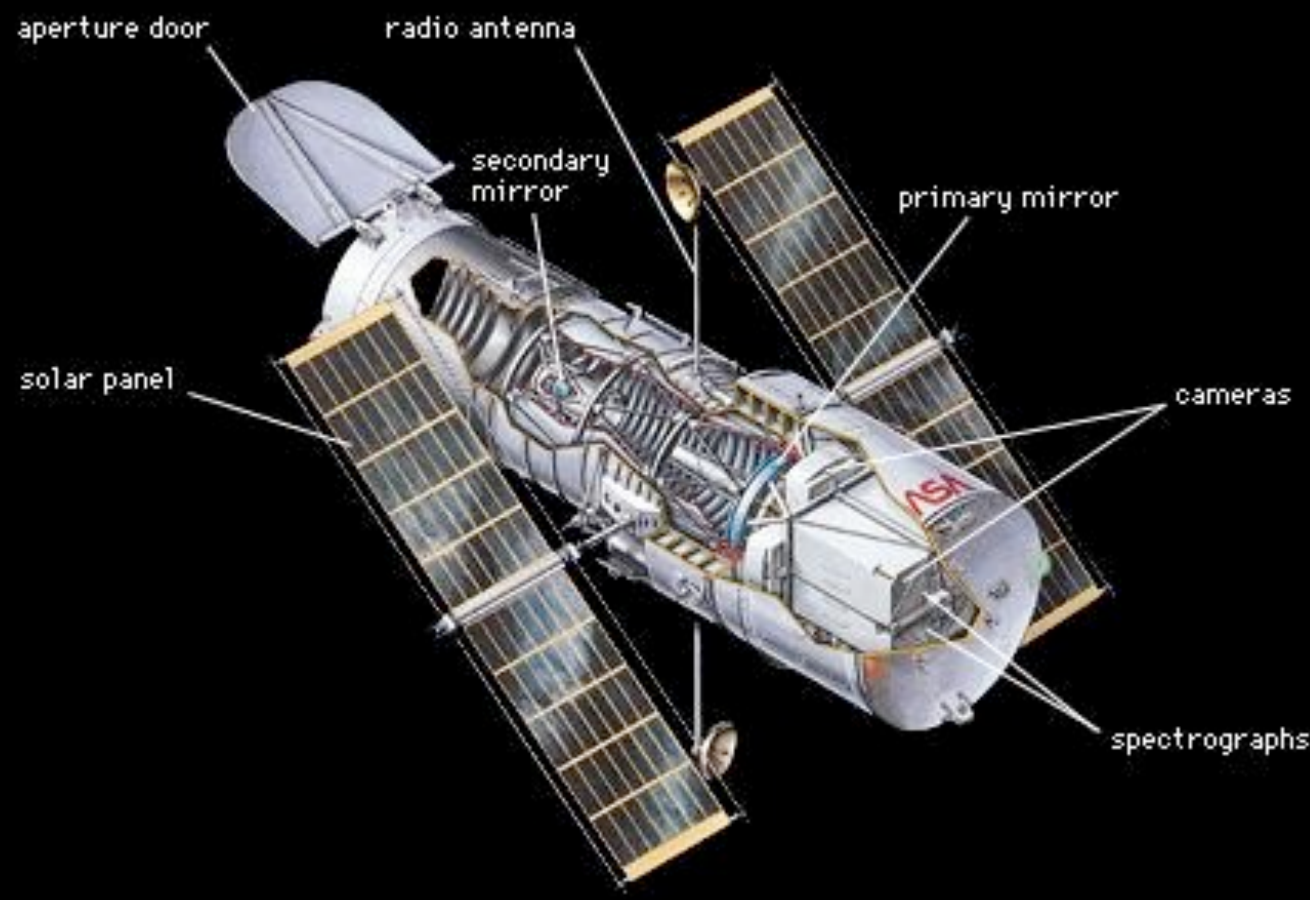
The Great Hubble

OBJECTIVES:

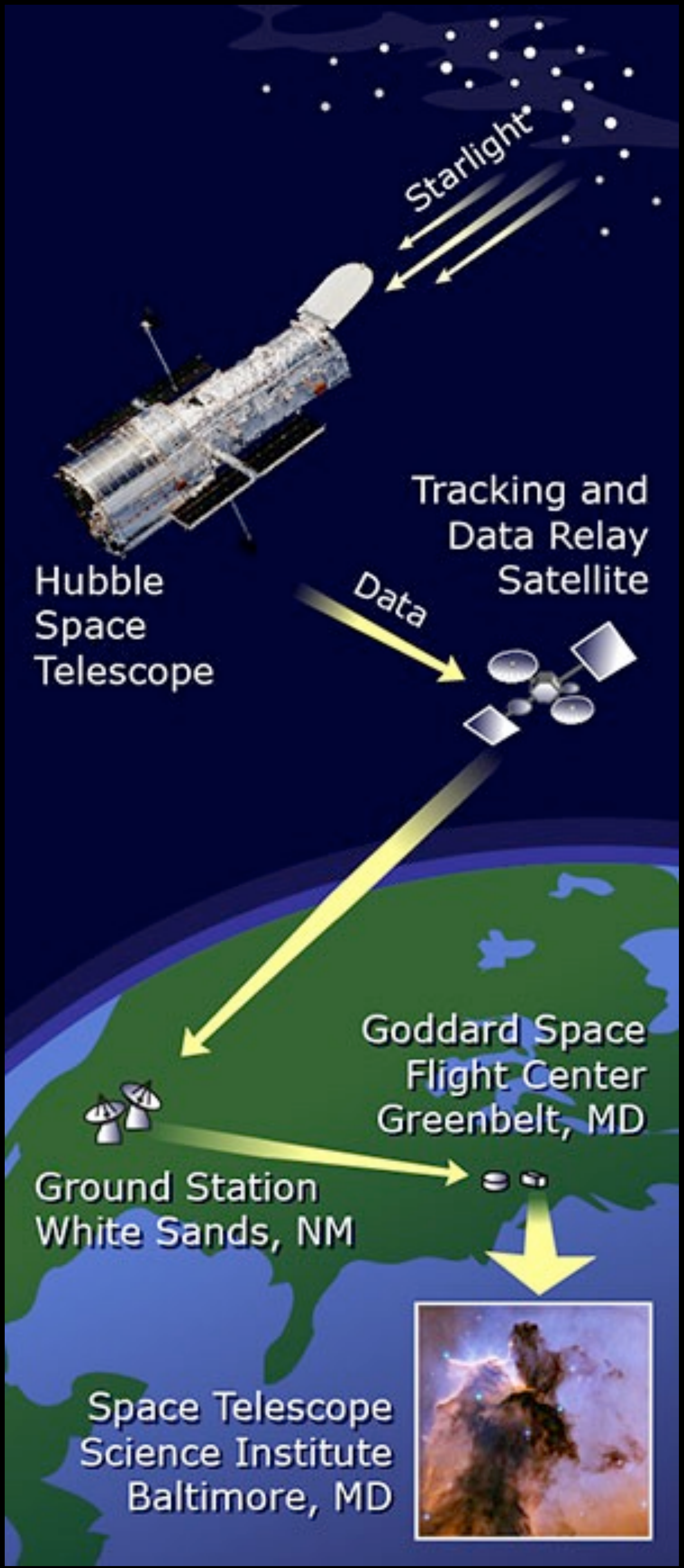
1. The Hubble Space Telescope lets us see farther into space than ever before.
2. The Hubble gives us images that are thousands of years old because light travels at a finite speed across vast distances of space.
3. The Hubble could be used to search the universe for other Earthlike planets, but such exploration is expensive.


The telescope that revolutionized astronomy
The Hubble telescope is a time machine that has radically altered our vision and comprehension of the universe
Communications antennae send images back to Earth
Solar panels power the telescope
Aim of NASA's service mission
To make Hubble more powerful, more robust and extend the star-gazer's life until at least 2014
Aperture door protects Hubble's optics
The 7 NASA astronauts will carry out 5 space walks to replace the telescope's gyroscopes and batteries, and upgrade its optical instruments
Source: NASA
AFP
Placed in orbit at an altitude of 600 kms on April 25, 1990
Operational since 1993
Length: 13.3 m
Weight: 11 tonnes
Hubble has transmitted more than 750,000 spectacular images and streams of data from the far reaches of the universe


Magnetic Torquer (4)
Light Shield
High Gain Antenna (2)
Aperature Door
Support Systems Module Forward Shell
Optical Telecope Assembly Secondary Mirror Assembly
Secondary Mirror Baffle
Magnetometer
Central Baffle
Optical Telescope Assembly Primary Mirror and Main Ring
Fine Guidance Optical Control Sensor (3)
Optical Telescope Assemble Focal Plane Structure
Main Baffle
Solar Array (2)
Optical Telescope Assembly Metering Truss
Axial Science Instrument Module (3) And COSTAR
Support Systems Module Equiment Section
Optical Telescope Assembly Equipment Section
Radial Science Instrument Module (1)
Fix Head Star Tracker (3) and Rate Gyro Assembly
Low Gain Antenna (2)
Support Systems Module Aft Shroud


aperture door
radio antenna
secondary mirror
primary mirror
solar panel
cameras
spectrographs


Communications antenna
Control and pointing systems
Light
Solar array
Instrument and system bays


Starlight
Hubble Space Telescope
Tracking and Data Relay Satellite
Data
Goddard Space Flight Center Greenbelt, MD
Ground Station White Sands, NM
Space Telescope Science Institute Baltimore, MD

CHAPTER 28—SKILL SHEET 1: THE ELECTROMAGNETIC SPECTRUM

Light is one form of electromagnetic energy. All electromagnetic energy travels through space at a speed of 3×10^8 meters per second. That is fast enough to travel around Earth seven times in just one second! Sunlight takes only eight minutes to travel from the sun to Earth.

Figure 28-1 shows that electromagnetic energy includes a wide range of wavelengths. Visible light makes up a small part of the electromagnetic spectrum. However, most of the energy given off by the sun is in the form of visible light. Invisible forms of radiation in sunlight are less intense than visible light.

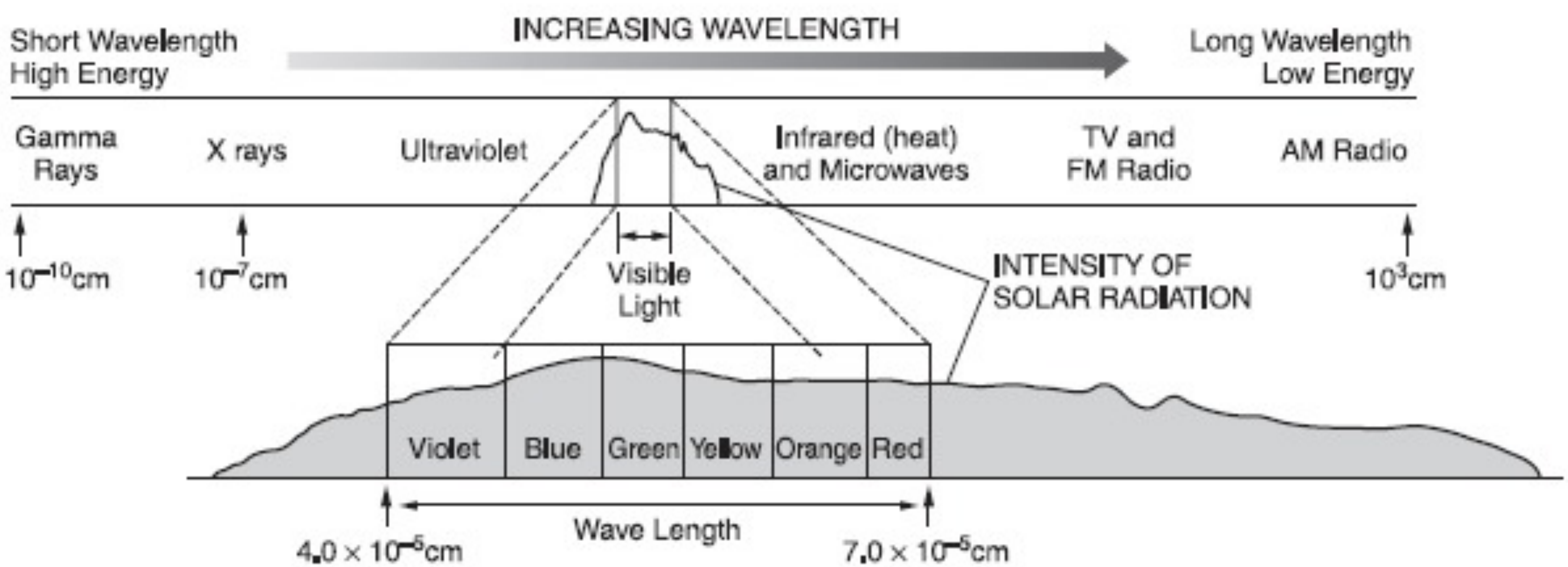


FIGURE 28-1. The sun gives off electromagnetic radiation that is visible and invisible.

White light is a mixture of all the colors of the rainbow. Sir Isaac Newton demonstrated the compound nature of white light when he passed a ray of sunlight through a glass prism as shown in Figure 28-2. Light slows and bends when it travels at an angle through glass. The colors separate because when sunlight enters glass, short wavelengths, such as blue light, are slowed more than long wavelengths, such as red. Therefore the blue end of the spectrum is bent more than the red end, and the colors separate.

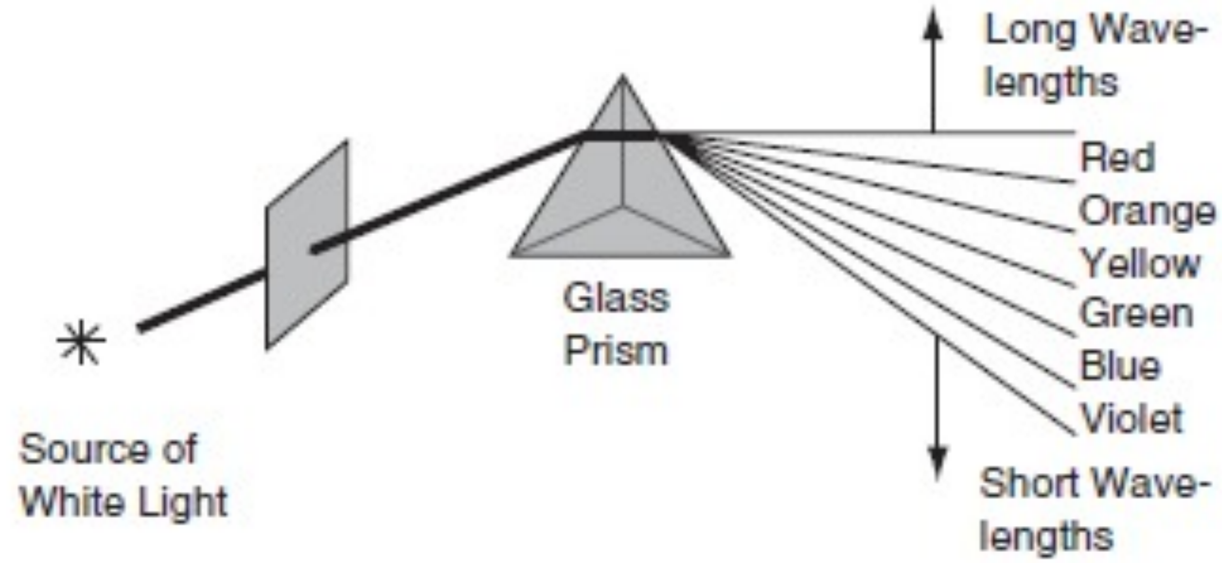


FIGURE 28-2. A glass prism can split light into its component colors.

1. Name the six colors of the visible spectrum.

Red, orange, yellow, green, blue, and violet.

2. What part of the electromagnetic spectrum can our eyes detect?

Visible light

3. Name three forms of electromagnetic energy that our eyes cannot see.

gamma rays, X-rays, ultraviolet, infrared, and radio

4. Which invisible electromagnetic energy has the shortest wavelength?

Gamma rays

5. How can you demonstrate that white light is a mixture of colors?

White light can be separated into its component colors.

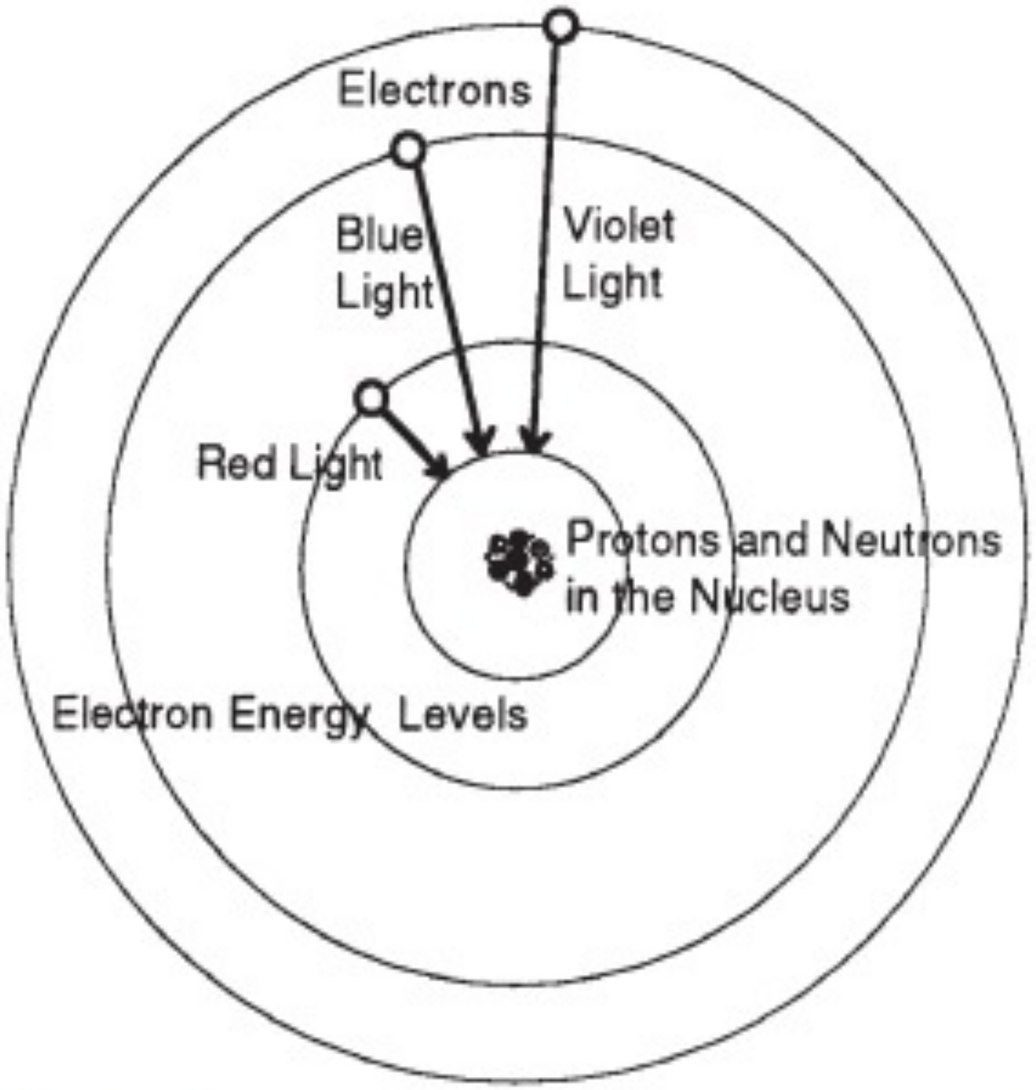


FIGURE 28-3. Various colors of light are given off when electrons fall to different energy levels within an atom.

Electromagnetic energy results from the movement of charged particles. Electrons within the atom can be bumped to a higher energy level by absorbing heat or light energy. When an electron falls back to a lower level, it gives off a photon (particle) of light. A small jump produces red light, and a larger jump creates light near the blue end of the visible spectrum. The color of light absorbed when an electron is boosted to a higher level, is the same color that is given off when it falls back to the lower energy level. Thus, the color of light is a clue to how it was created.

Each element has its own characteristic energy levels. These energy levels determine the wavelength of light given off when the element is heated to glowing. Thus, the colors of light given off by an element are like its fingerprints. Each element can be identified by the colors in its own spectrum.

Astronomers can use glass prisms, diffraction gratings, or other devices to split the light from distant stars into a spectrum of colors. This technique allows them to determine the mass, surface temperature, recession or approach velocity, and the chemical composition of stars. They can do this in spite of the fact that most stars are so far away they appear as tiny points of light even in the world's most powerful telescopes.

6. What happens to electrons that absorb light energy?

They move to a higher energy level.

7. What change within an atom causes it to give off light?

Electrons that have moved to a higher energy level drop to lower energy levels.

8. What determines the color of the light given off?

Its wavelength

9. What color of visible light is produced by the longest wavelength of visible light?

Red

10. What color of visible light is produced by the shortest wavelength of visible light?

Violet

11. What is the average wavelength of X-rays?

10^{-7} cm

12. What is the range of wavelengths of visible light?

4.0×10^{-5} to 7.0×10^{-5} cm

13. Which has a longer wavelength, ultraviolet rays or infrared rays?

Infrared rays

Objectives:

Compare and Contrast the Heliocentric model of the solar

Astronomy

Ancient Philosophies

Aristotle (384-322) B.C.

Greek philosopher
Believed the Earth was the center of the universe (Geocentric)
Earth was surrounded by water, air, and

Geocentric model - The moon, sun, five planets, and the

Aristarchus (3rd Century B.C

·1st to measure the distance to the sun & moon

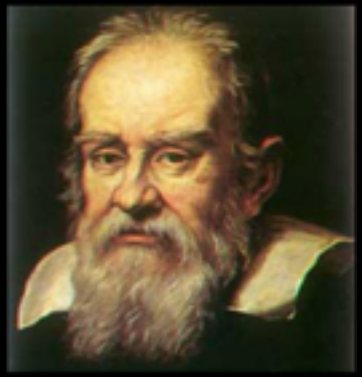
·Heliocentric model - Sun is the center of the universe
·REVOLUTION - cycle in which a planet orbits the sun (one year)
·ROTATION - cycle of a planet spinning on its axis; day to night (one

Ptolemy (2nd century A.D)

·Agreed with ARISTOTLE'S

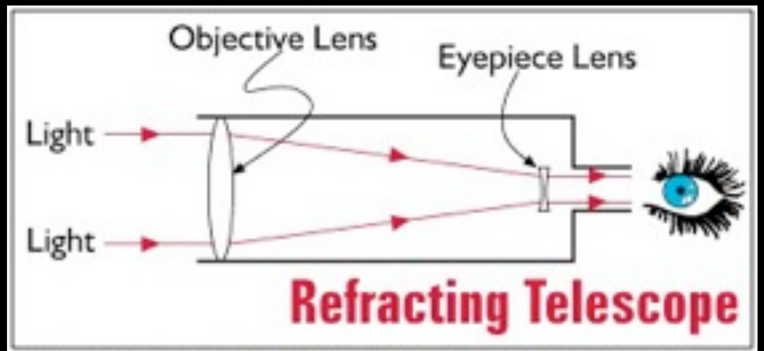
Copernicus (1473-1543)

Heliocentric model
Expanded the ideas of Aristarchus
Identified the positions of the planets (wi



Galileo (1564-1642)

·Spent most of his life trying to prove the theories of Copernicus



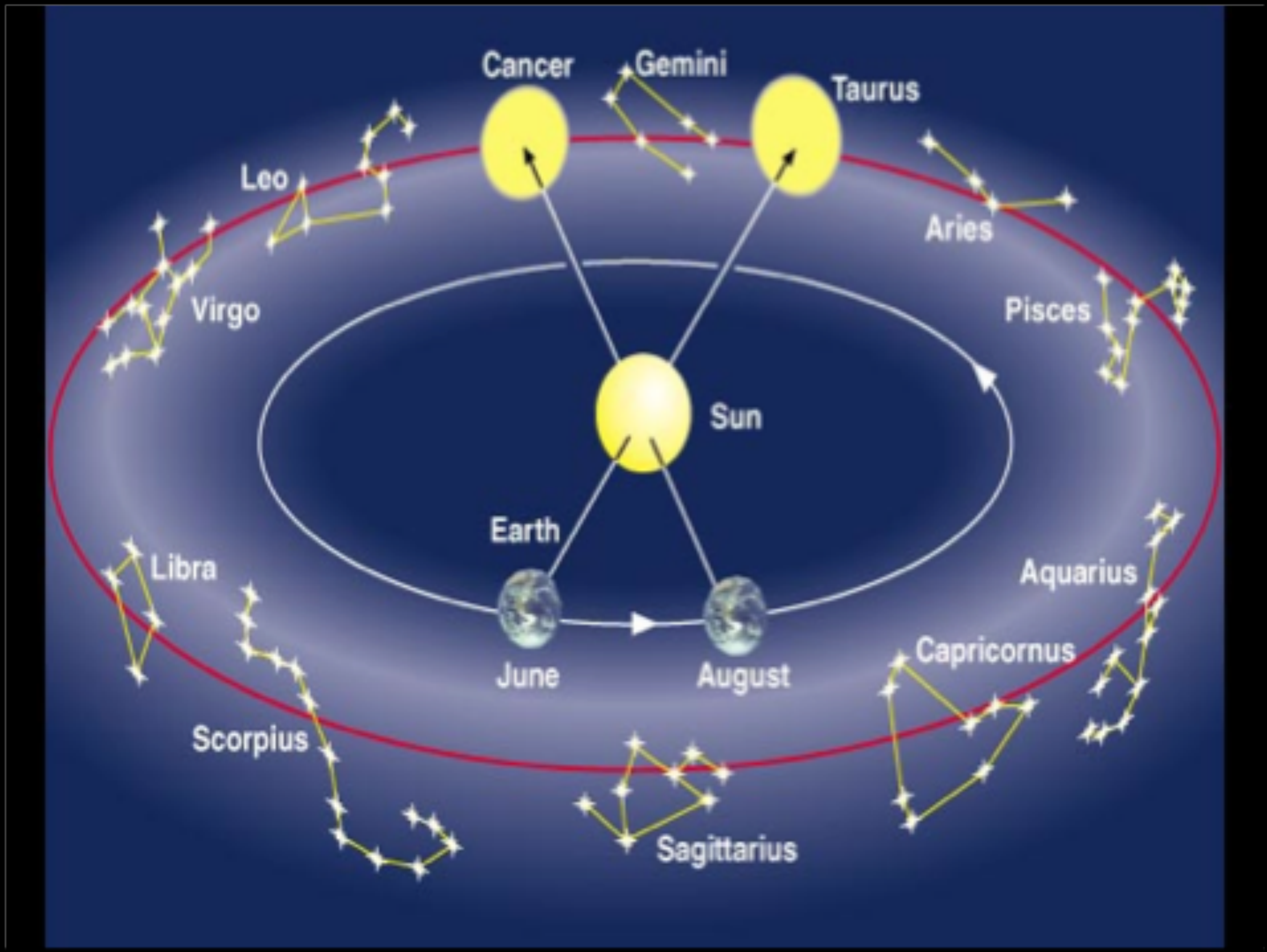
Light enters through the front objective lens and then passes through the eyepiece lens before reaching your eye.

Heliocentric model

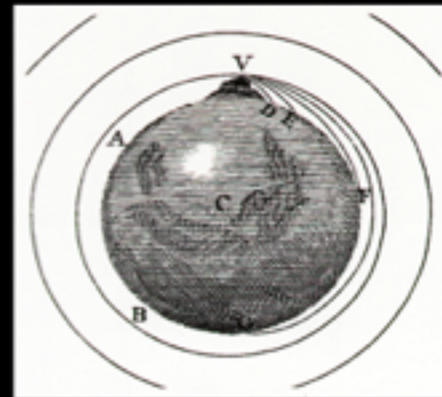
Johannes Kepler (1571 – 1630)

- Believed the Universe was driven by mathematical principals.
- There must be a force, propelling planets to move.
- The force was something like magnetism between the Sun and the planets.
- Devised Three Laws of Planetary Motion

Earth's Revolution



Different constellations at different times of the year



c Newton(1642 - 17

Came up with his three laws, Calculus, and law of Universal Gravitation.

Believed in Copernican, and then Keplerian, model of solar system.

Newton’s Law of Universal Gravitation verifies Kepler’s Third Law!

Days of the week:

Tuesday - Martedì (*Italian*) Mars' day
Wednesday - Mercoledì (*Italian*) Mercury's day
Thursday - Giovedì (*Italian*) Jupiter's day
Friday - Venerdì (*Italian*) Venus' day
Saturday - Saturn's day

Sunday - Sun's day (not a planet but still important)
Monday - Lunedì (*Italian*) Moon's day (also not planet, but also important because it moves differently than the other things in the sky.

You do not need to copy this!

Review - Put these in order of size:

galaxy

solar system

universe

Smallest Largest

Do Now:

1. How is the sun like a human?

Objectives:

1. Describe the Life Cycle of a Star
2. Identify the properties used to classify stars.

Star Life Cycle: Stars are like humans.

Nebula – cloud

Protostar – new, just

Steller Nebula

Where stars are born

Stellar Nursery

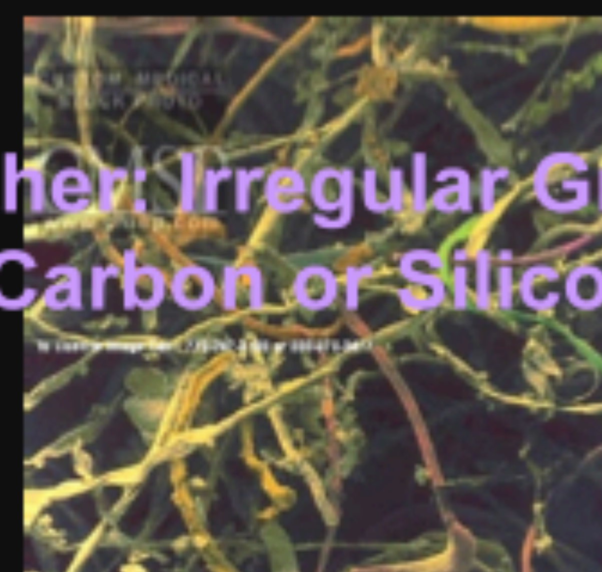
Space is filled with the stuff to make stars – mostly hydrogen gas.

Image of the pillars of creation inside the crab nebula

Stars start from clouds

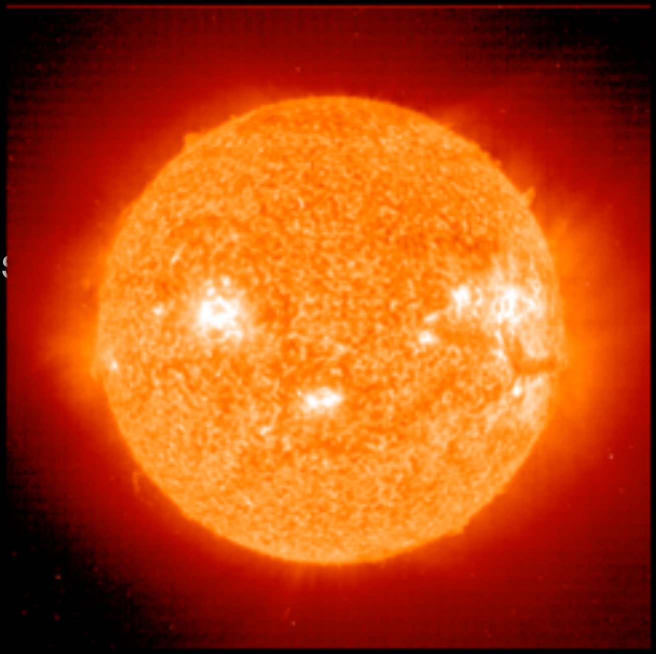
Clouds provide the gas and dust from which stars form.

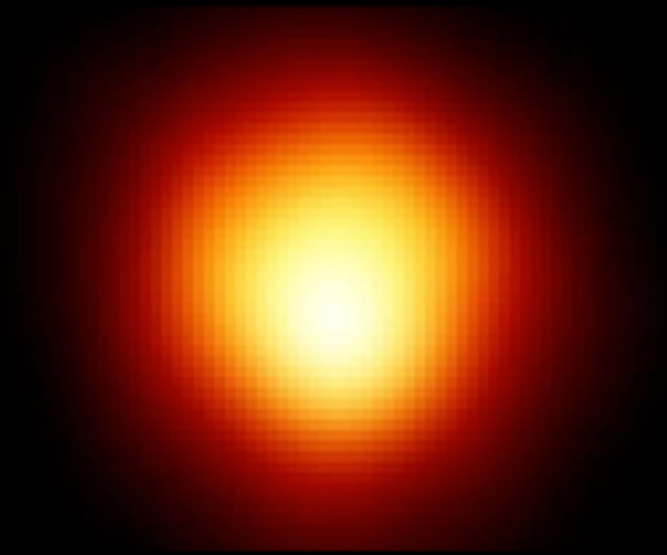
But not this kind of dust



Rather: Irregular Grains
Of Carbon or Silicon

Main Sequence (like the s



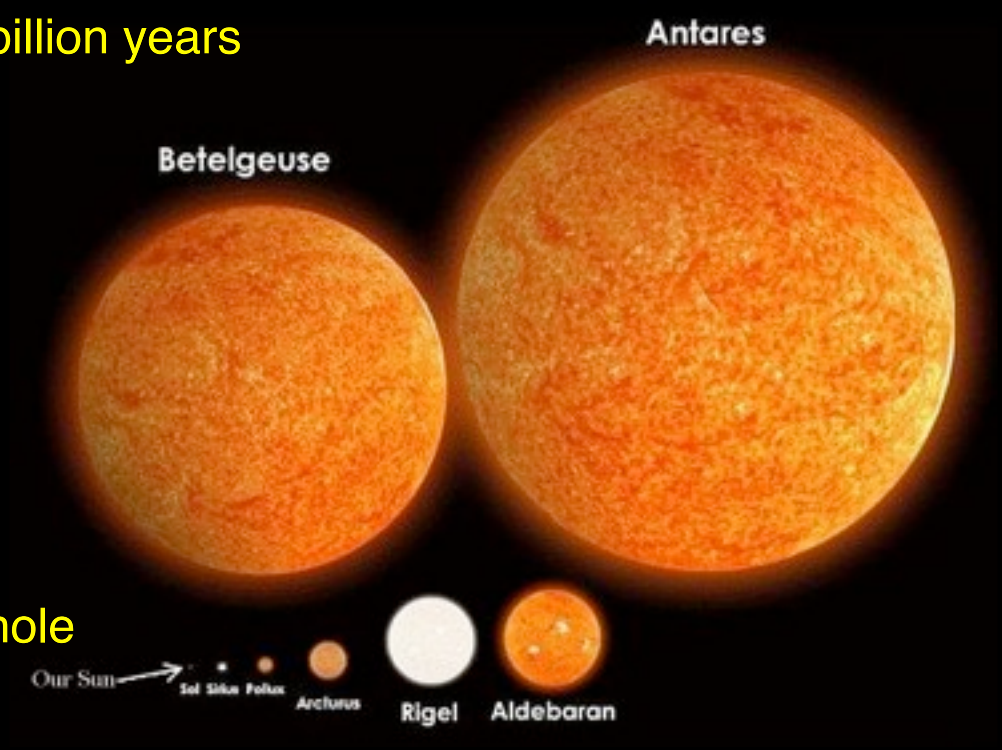


Red Giant (Betleguise) – once the star runs out of hydrogen and the balance of

Life Cycle of Stars

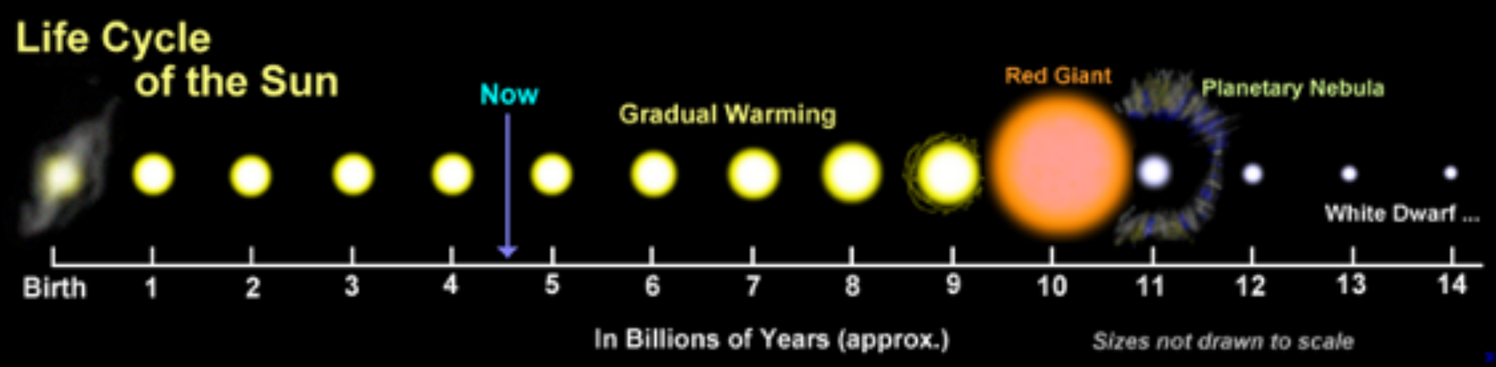
Spend most of their life as main sequence star ….

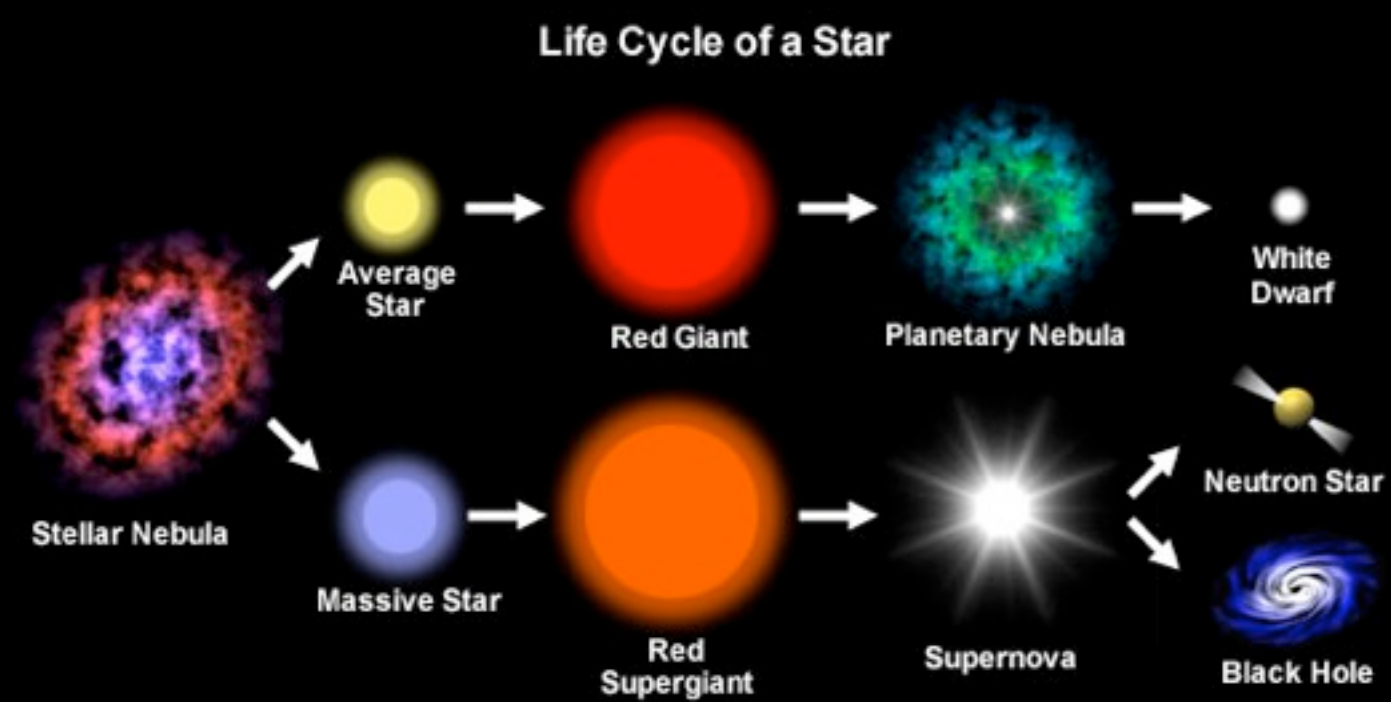
Sun **size**
> expand to red giant in 5 billion years
> white dwarf
> black dwarf

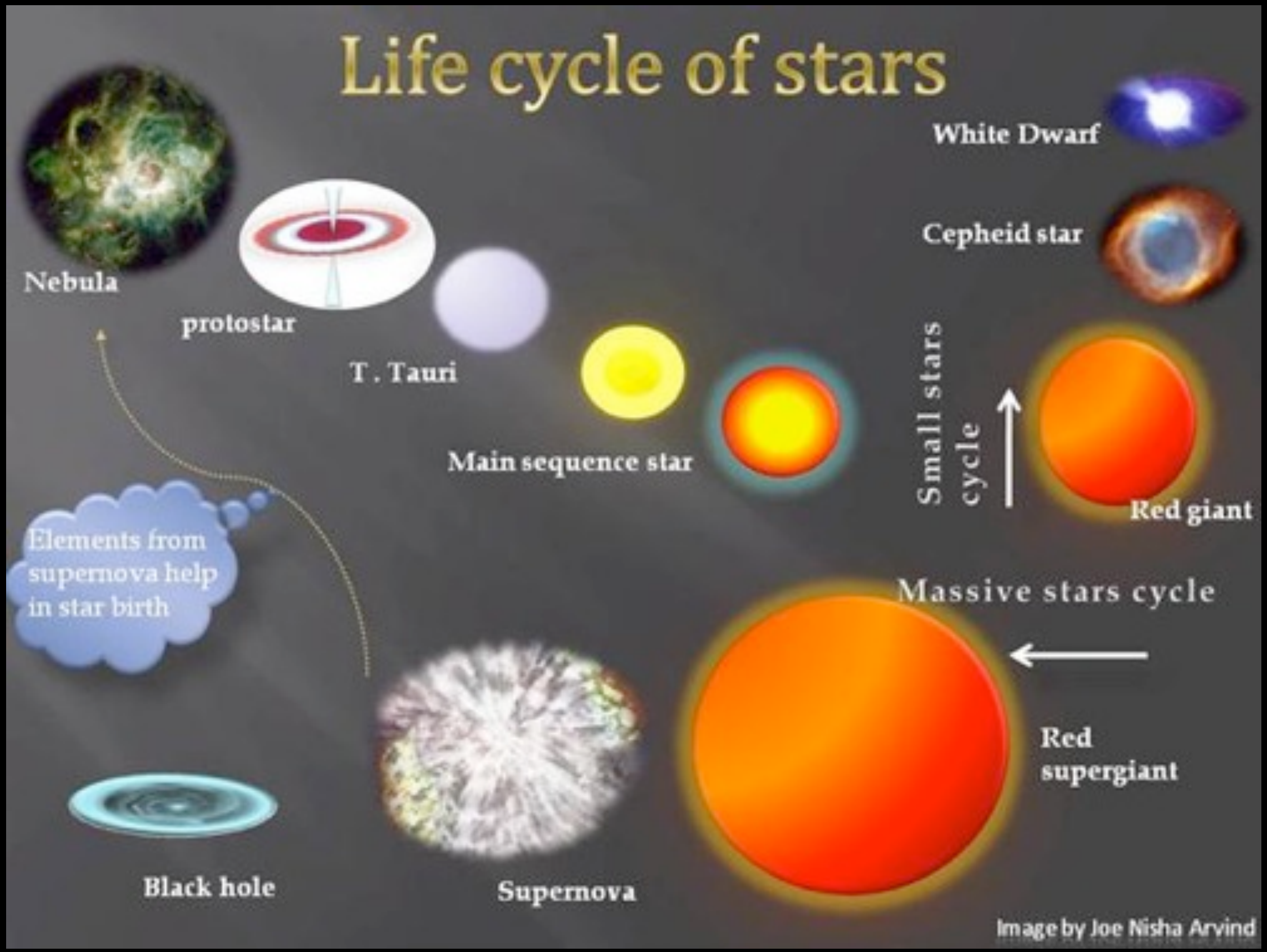


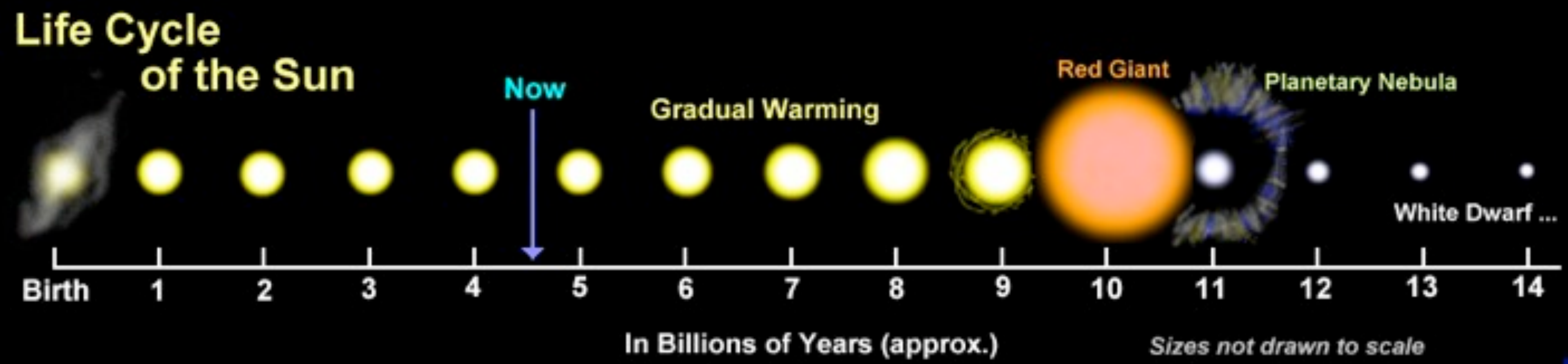
Super **giant**
> supernova
> very high mass – black hole
> high mass – neutron star

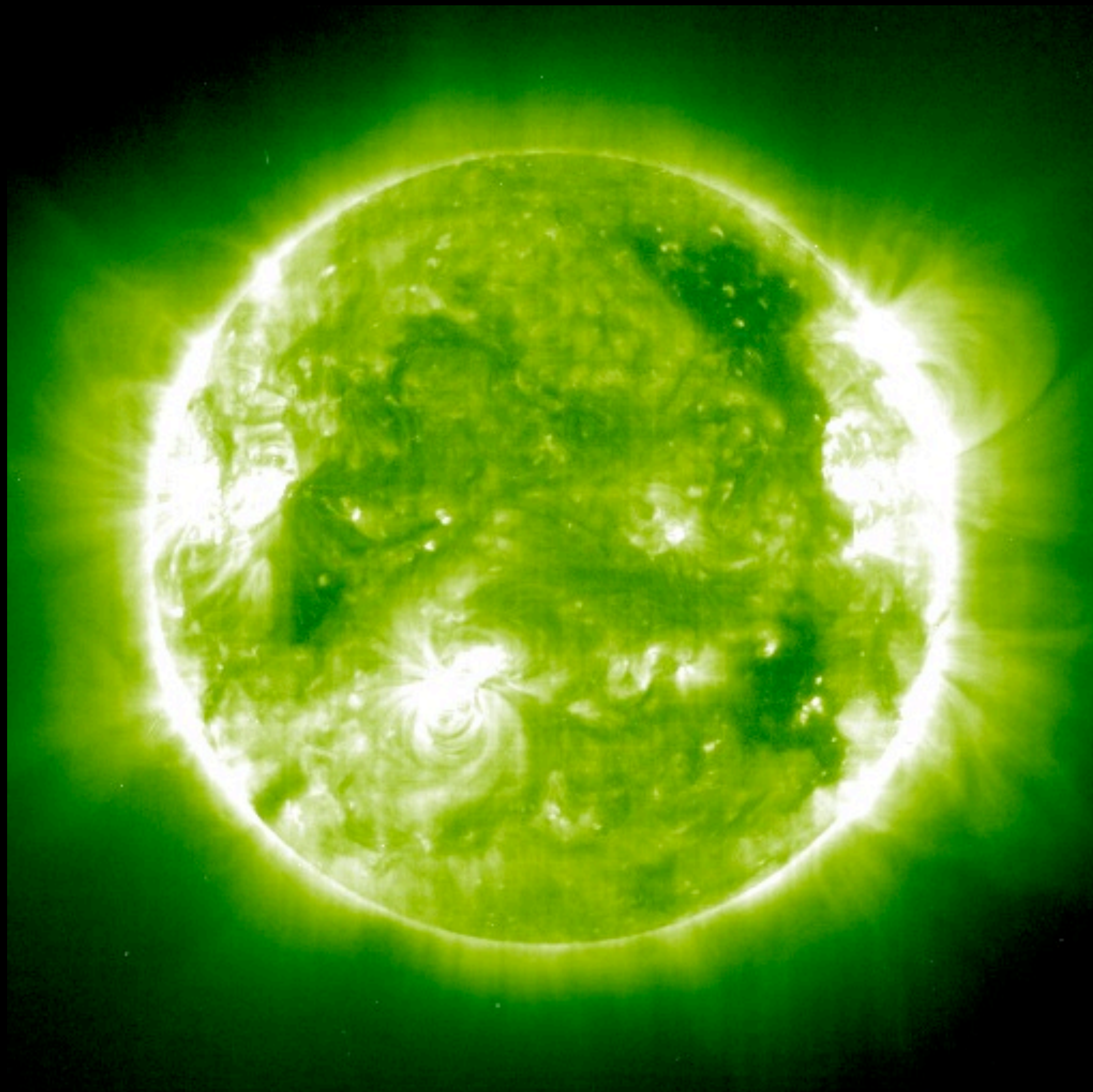
Life Cycle of a Sun

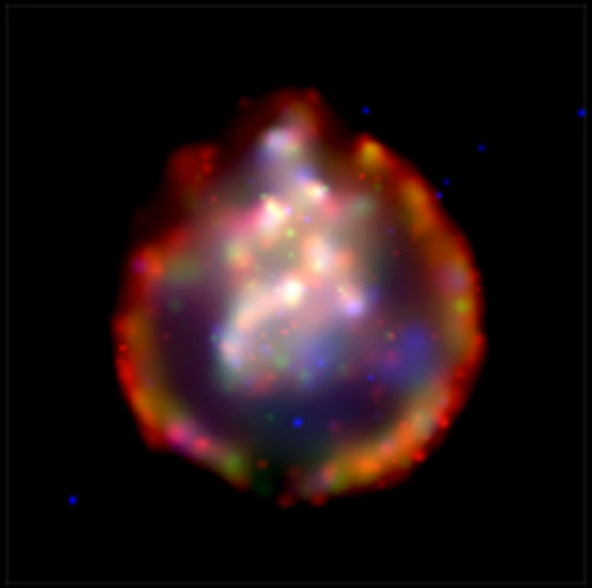





Life cycle of stars
White Dwarf
Cepheid star
Nebula
protostar
T . Tauri
Main sequence star
Small stars cycle
Red giant
Elements from supernova help in star birth
Massive stars cycle
Red supergiant
Black hole
Supernova
Image by Joe Nisha Arvind

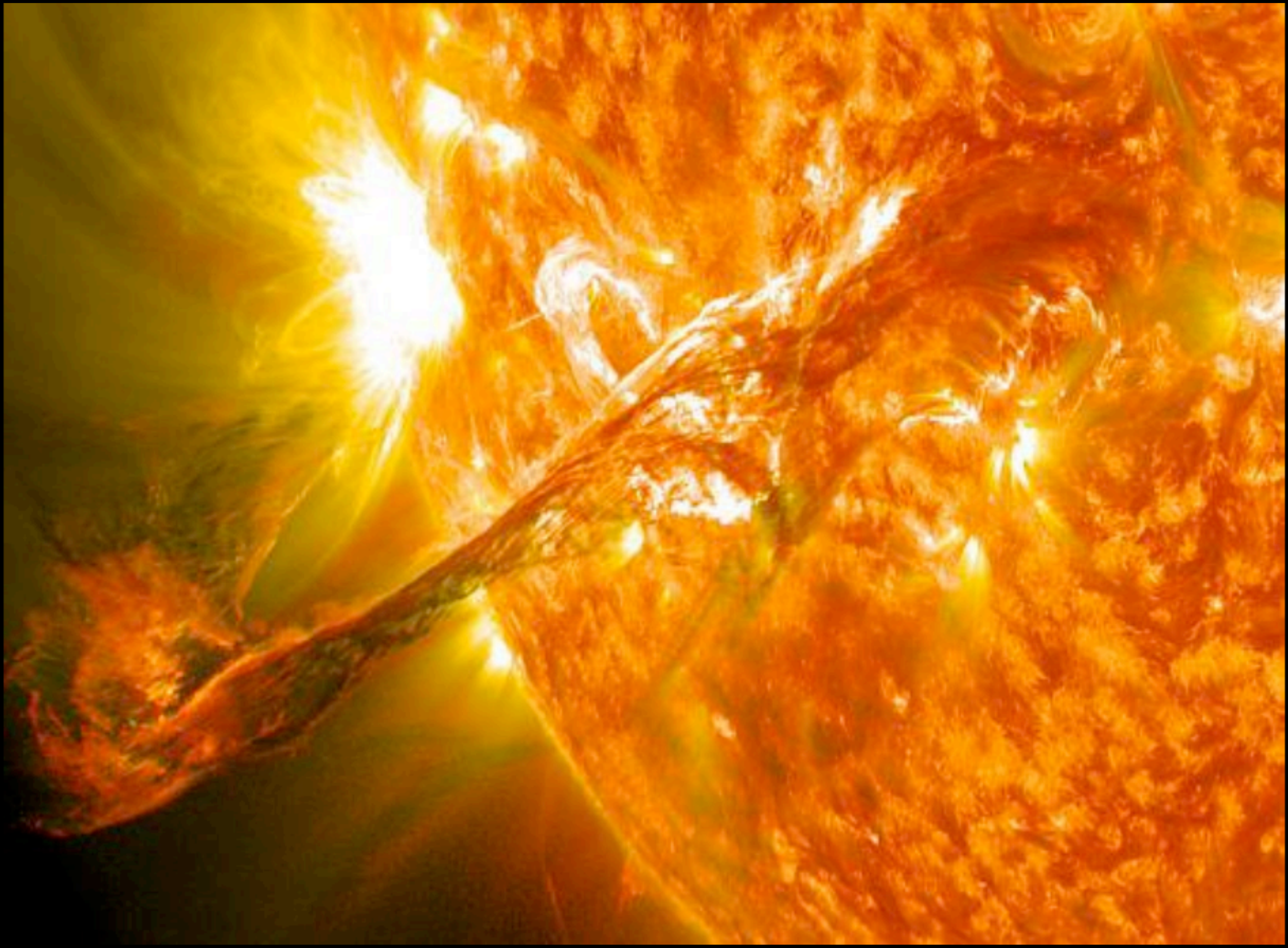

Life Cycle
of the Sun
Now
Gradual Warming
Red Giant
Planetary Nebula
White Dwarf ...
Birth
1
2
3
4
5
6
7
8
9
10
11
12
13
14
In Billions of Years (approx.)
Sizes not drawn to scale

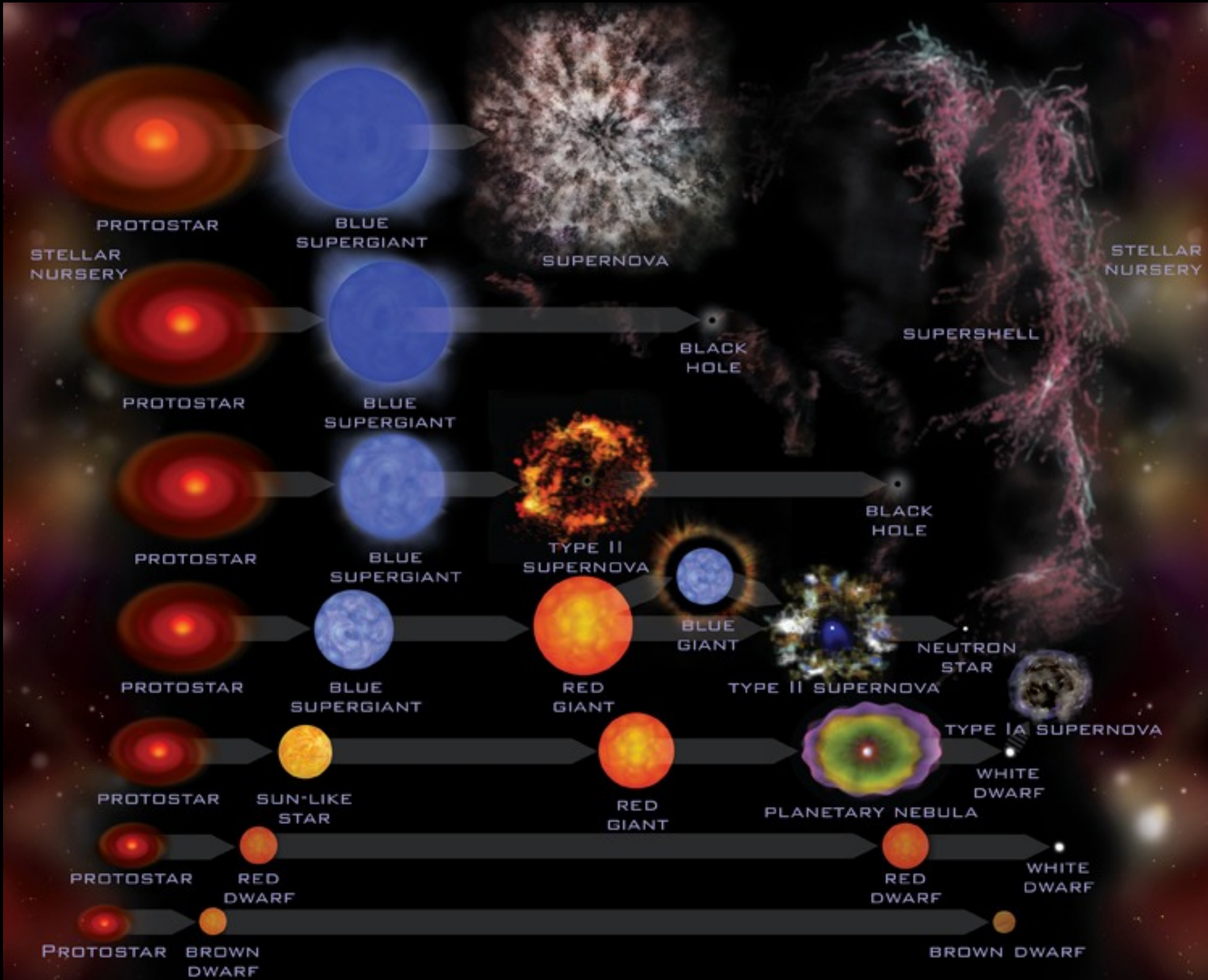




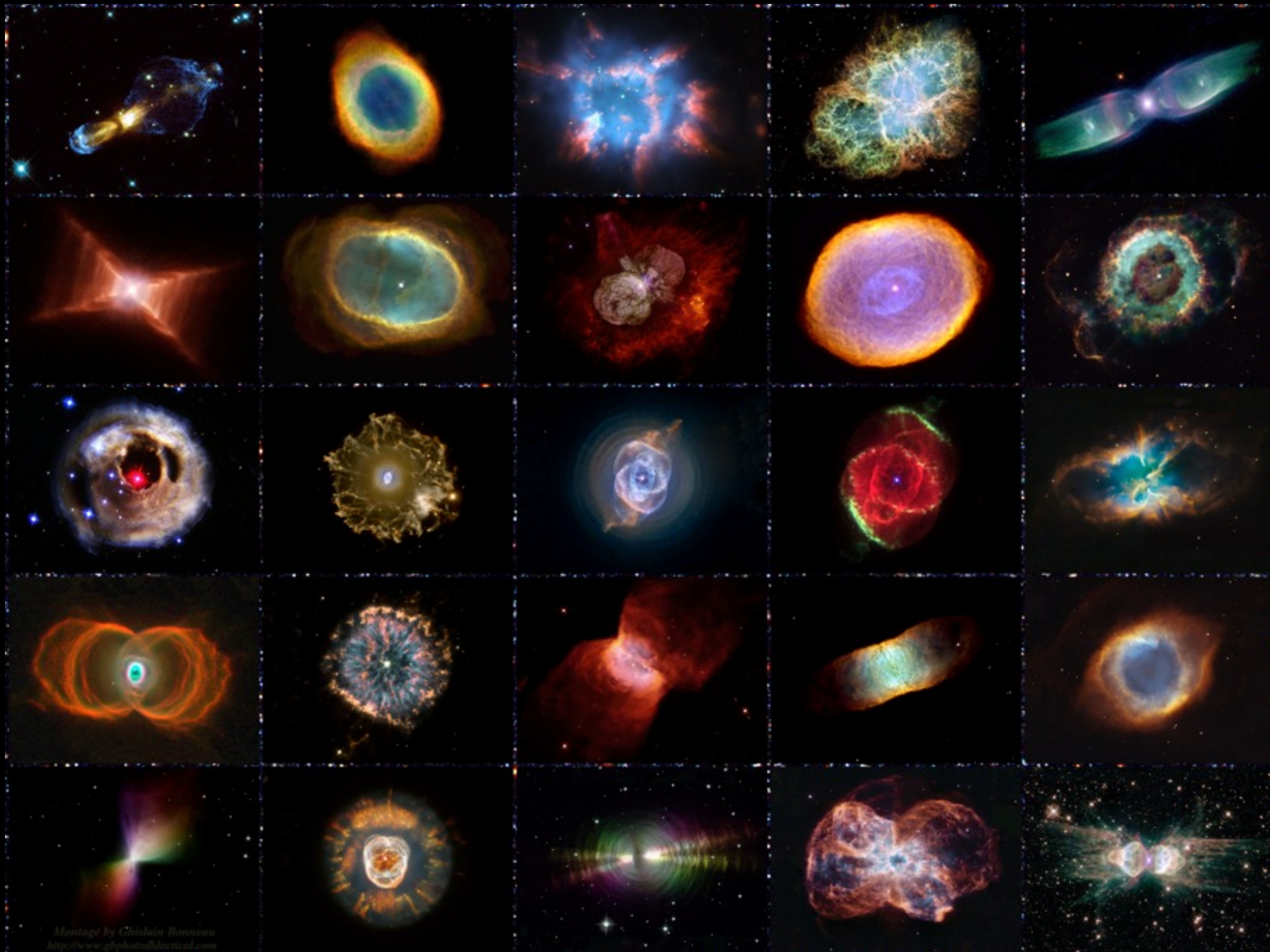
White Dwarf: Smaller stars shrink and cool and eventually become cold

Supernova: Star that has died an explosive death.

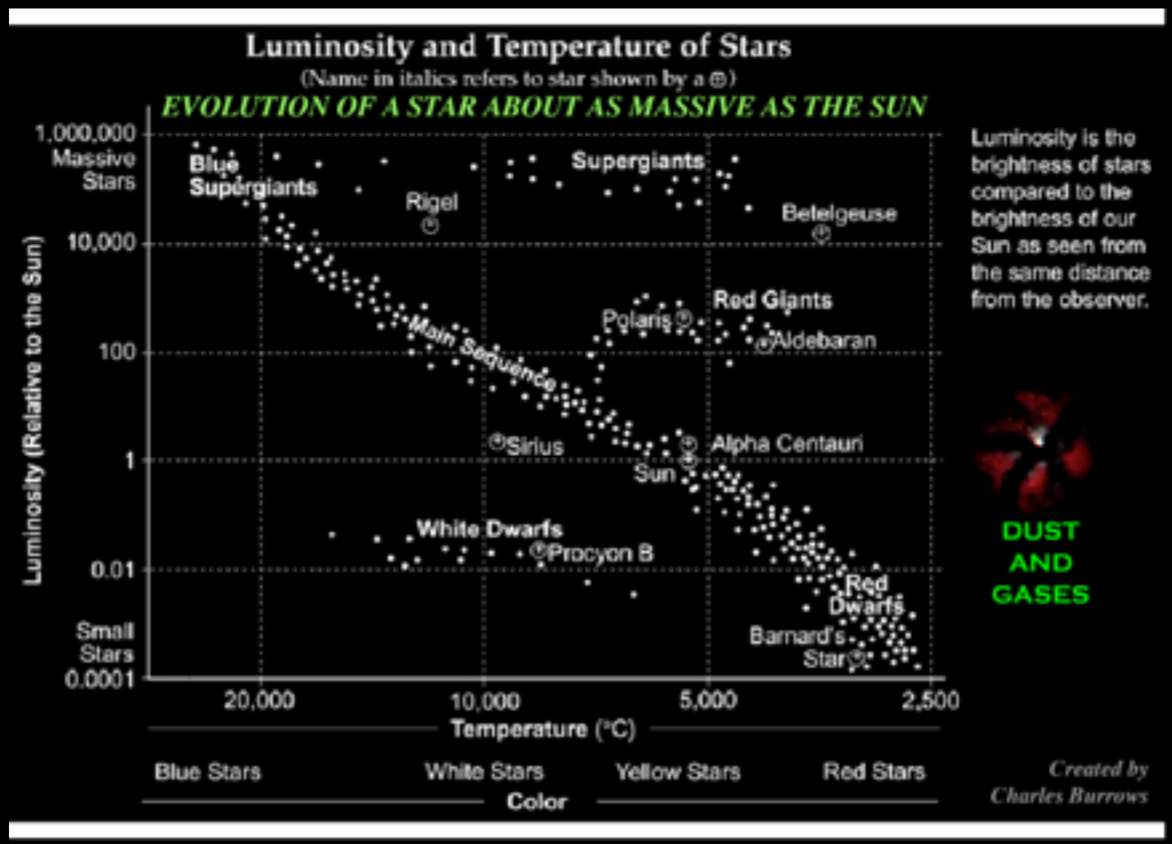




PROTOSTAR
BLUE SUPERGIANT
SUPERNOVA
STELLAR NURSERY
STELLAR NURSERY
PROTOSTAR
BLUE SUPERGIANT
BLACK HOLE
SUPERSHELL
PROTOSTAR
BLUE SUPERGIANT
TYPE II SUPERNOVA
BLACK HOLE
PROTOSTAR
BLUE SUPERGIANT
RED GIANT
BLUE GIANT
TYPE II SUPERNOVA
NEUTRON STAR
TYPE IA SUPERNOVA
PROTOSTAR
SUN-LIKE STAR
RED GIANT
PLANETARY NEBULA
WHITE DWARF
PROTOSTAR
RED DWARF
RED DWARF
WHITE DWARF
PROTOSTAR
BROWN DWARF
BROWN DWARF


Montage by Ghislain Bonneau
http://www.gbphotodidactical.com

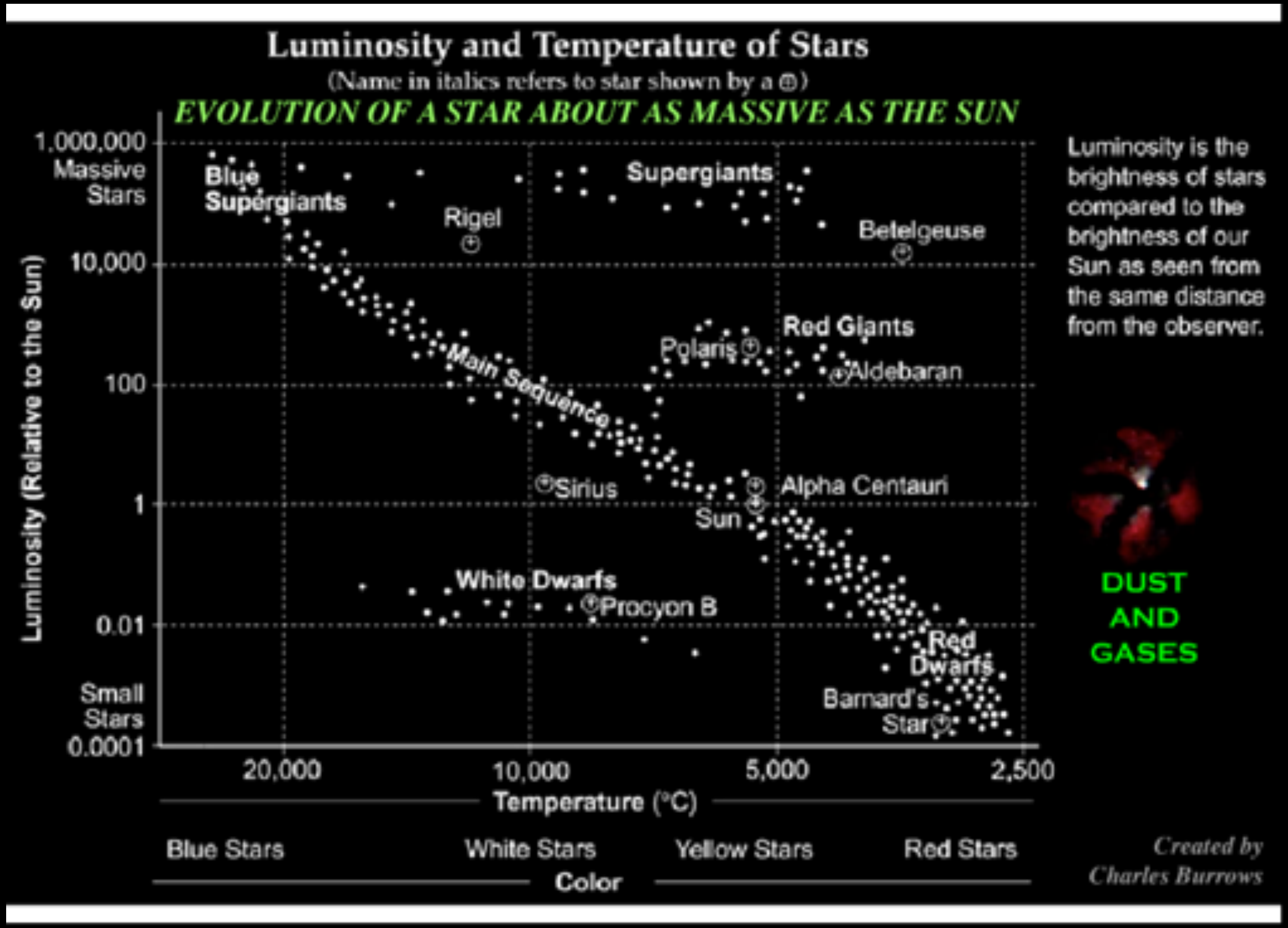
How are stars classified?



Can you name the different types of stars?

Hertzsprung-Russell diagram (H-R diagram)

Graph that relates stellar characteristics— class, mass, temperature,



Classification of Stars

Main Sequence Stars

Spectral Type:	O	B	A	F	G	K	M
Temperature:	40 000K	20 000K	8500K	6500K	5700K	4500K	3200K
Radius (Sun=1):	10	5	1.7	1.3	1.0	0.8	0.3
Mass (Sun=1):	50	10	2.0	1.5	1.0	0.7	0.2
Luminosity (Sun=1):	100 000	1000	20	4	1.0	0.2	0.01
Lifetime (million yrs):	10	100	1000	3000	10 000	50 000	200 000
Abundance:	0.00001%	0.1%	0.7%	2%	3.5%	8%	80%

Giant Stars

Low mass stars near the end of their lives.

Spectral Type:	Mainly G, K or M
Temperature:	3000 to 10 000K
Radius (Sun=1):	10 to 50
Mass (Sun=1):	1 to 5
Luminosity (Sun=1):	50 to 1000
Lifetime (million yrs):	1000
Abundance:	0.4%

White Dwarfs

Dying remnant of an imploded star.

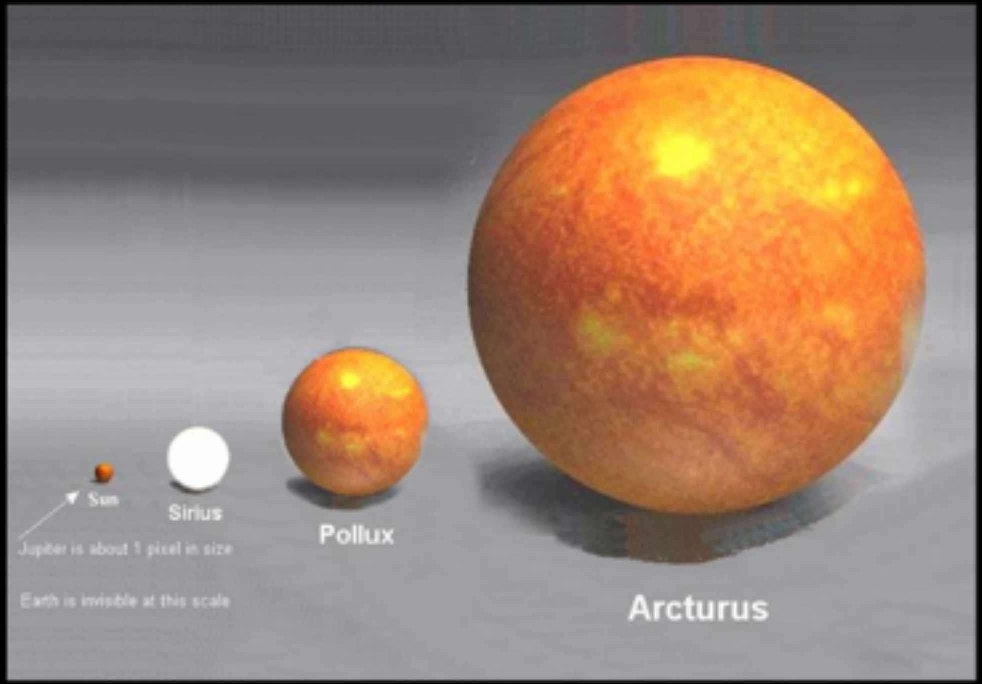
Spectral Type:	D
Temperature:	Under 80 000K
Radius (Sun=1):	Under 0.01
Mass (Sun=1):	Under 1.4
Luminosity (Sun=1):	Under 0.01
Lifetime (million yrs):	–
Abundance:	5%

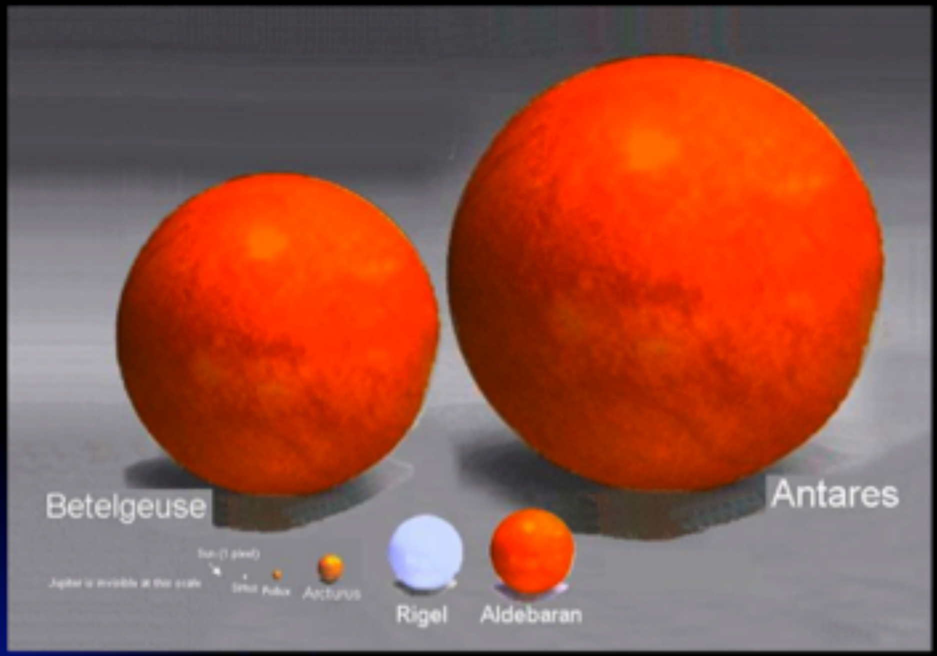
Supergiant Stars

High mass stars near the end of their lives.

Spectral Type:	O, B, A, F, G, K or M
Temperature:	4000 to 40 000K
Radius (Sun=1):	30 to 500
Mass (Sun=1):	10 to 70
Luminosity (Sun=1):	30 000 to 1000 000
Lifetime (million yrs):	10
Abundance:	0.0001%

r powell

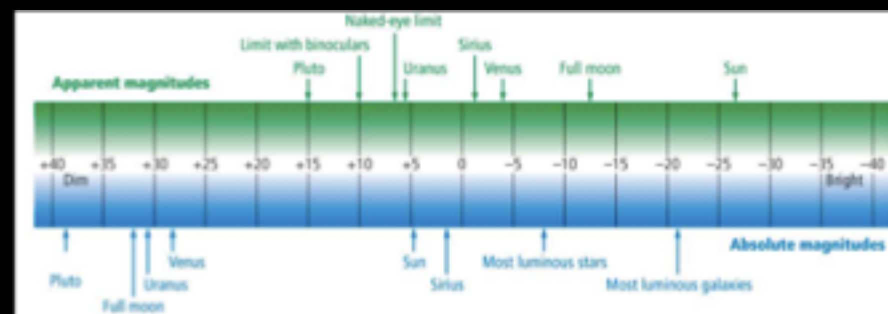

Sun
Sirius
Pollux
Jupiter is about 1 pixel in size
Earth is invisible at this scale
Arcturus


Betelgeuse
Antares
Sun (1 pixel)
Jupiter is invisible at this scale
Sirius
Pollux
Arcturus
Rigel
Aldebaran

Basic Properties of Stars

Absolute magnitude -
How bright a star would appear if it were placed at a distance of 10 pc. (1 Parsec =

Apparent magnitude -

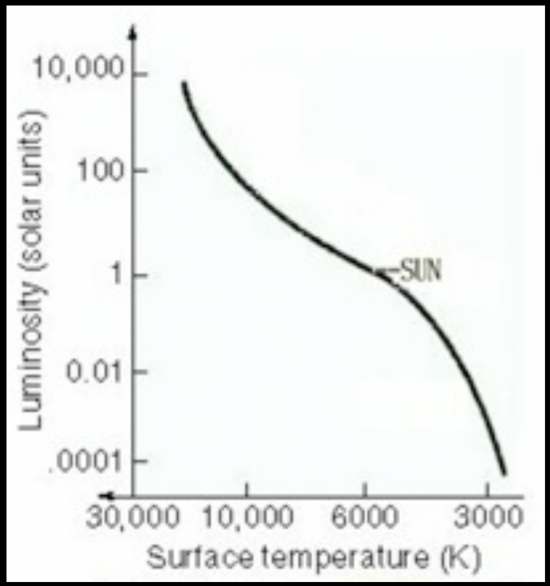


The absolute magnitude compared to the apparent magnitude is used to

Luminosity - total energy output of a star

To measure**:**

1. Star’s apparent magnitude



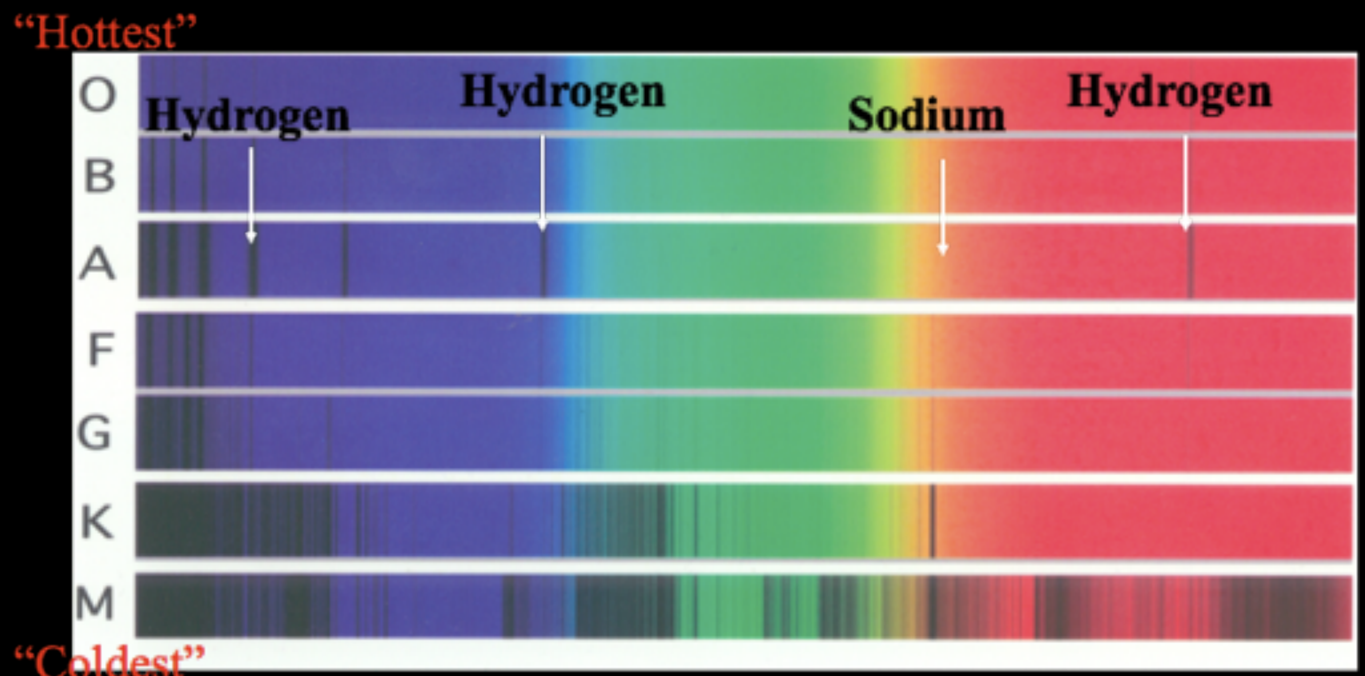
Surface Temperature -

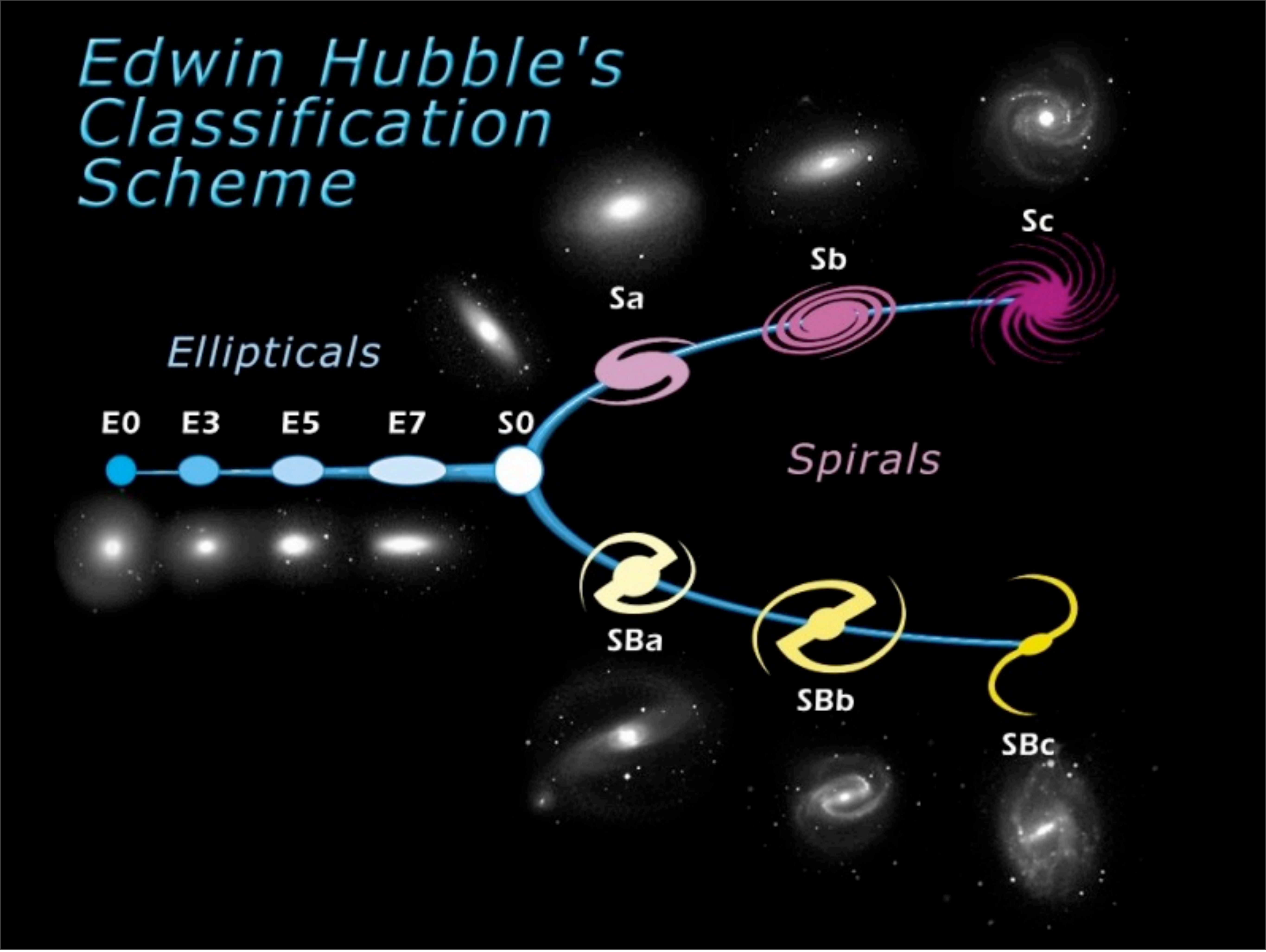
Hotter stars put out more light than stars with lower temperatures.

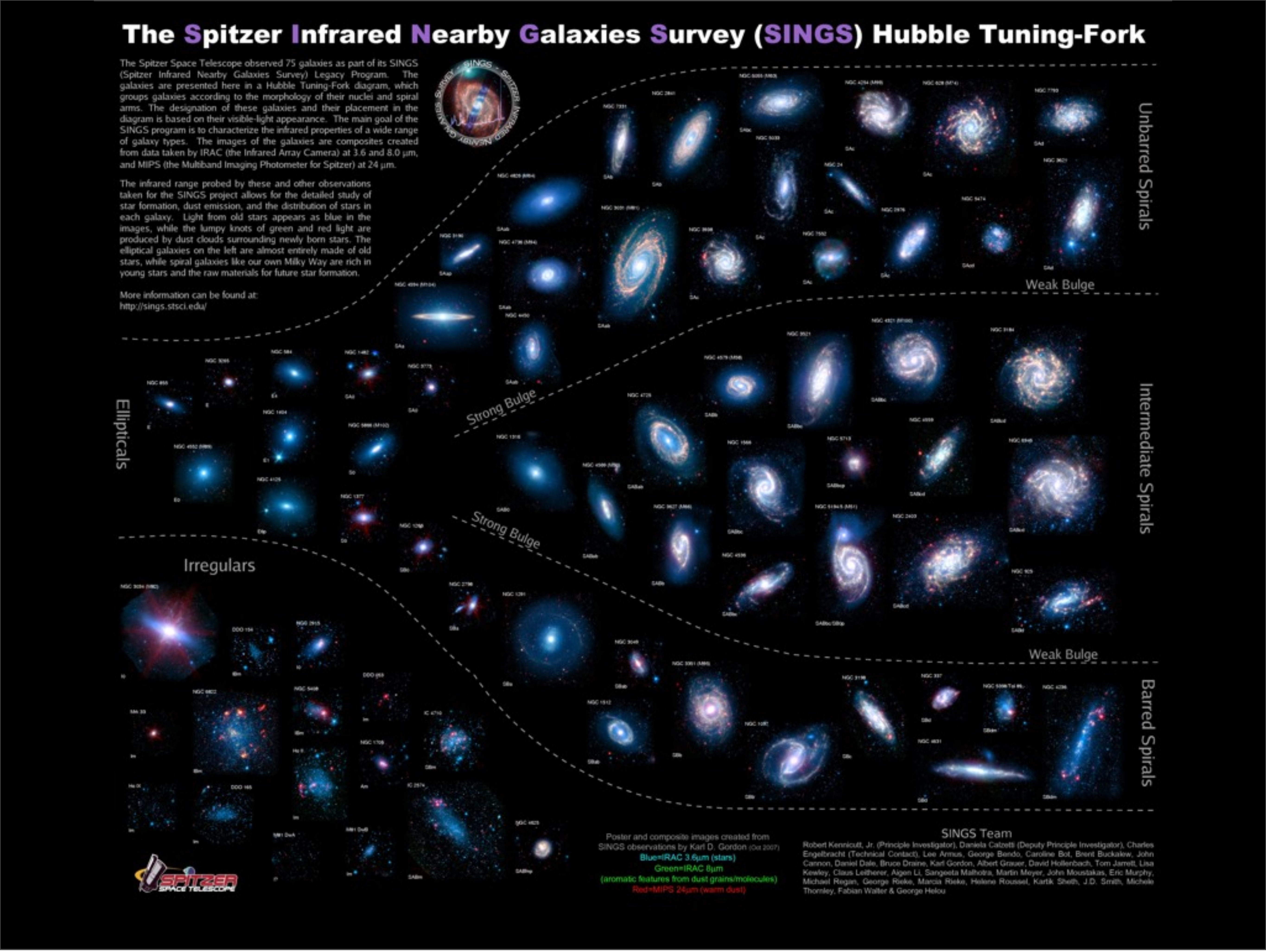
Composition - All stars, including the Sun, have nearly identical

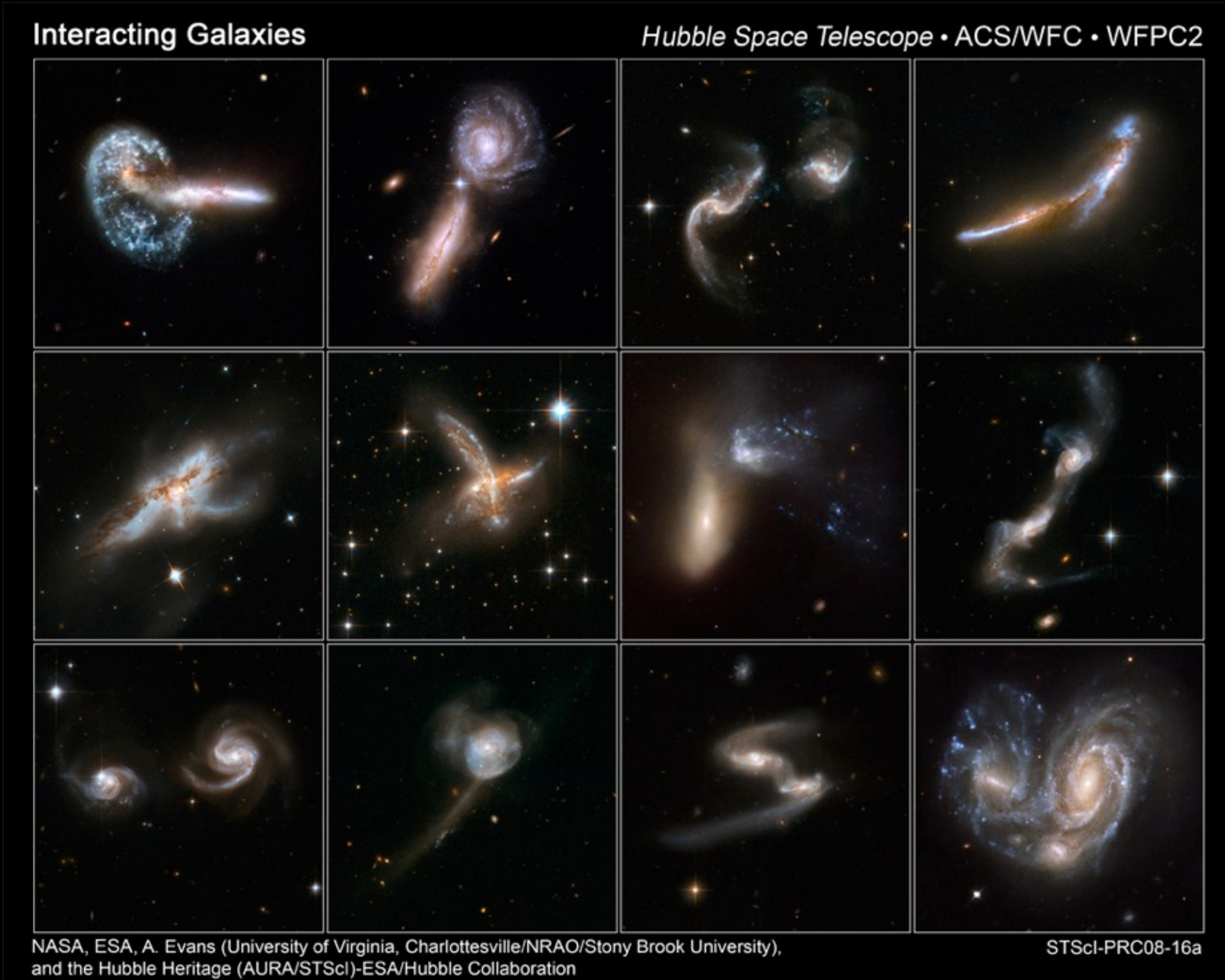
73% hydrogen,
25% helium

Each class of star has a unique pattern of lines ("bar code") to identify it.




Edwin Hubble's Classification Scheme
Ellipticals
E0
E3
E5
E7
S0
Sa
Sb
Sc
Spirals
SBa
SBb
SBc


The Spitzer Infrared Nearby Galaxies Survey (SINGS) Hubble Tuning-Fork
The Spitzer Space Telescope observed 75 galaxies as part of its SINGS (Spitzer Infrared Nearby Galaxies Survey) Legacy Program. The galaxies are presented here in a Hubble Tuning-Fork diagram, which groups galaxies according to the morphology of their nuclei and spiral arms. The designation of these galaxies and their placement in the diagram is based on their visible-light appearance. The main goal of the SINGS program is to characterize the infrared properties of a wide range of galaxy types. The images of the galaxies are composites created from data taken by IRAC (the Infrared Array Camera) at 3.6 and 8.0 µm, and MIPS (the Multiband Imaging Photometer for Spitzer) at 24 µm.
The infrared range probed by these and other observations taken for the SINGS project allows for the detailed study of star formation, dust emission, and the distribution of stars in each galaxy. Light from old stars appears as blue in the images, while the lumpy knots of green and red light are produced by dust clouds surrounding newly born stars. The elliptical galaxies on the left are almost entirely made of old stars, while spiral galaxies like our own Milky Way are rich in young stars and the raw materials for future star formation.
More information can be found at:
http://sings.stsci.edu/
Unbarred Spirals
Weak Bulge
Strong Bulge
Intermediate Spirals
Strong Bulge
Weak Bulge
Barred Spirals
Ellipticals
Irregulars
Poster and composite images created from SINGS observations by Karl D. Gordon (Oct 2007)
Blue=IRAC 3.6µm (stars)
Green=IRAC 8µm
(aromatic features from dust grains/molecules)
Red=MIPS 24µm (warm dust)
SINGS Team
Robert Kennicutt, Jr. (Principle Investigator), Daniela Calzetti (Deputy Principle Investigator), Charles Engelbracht (Technical Contact), Lee Armus, George Bendo, Caroline Bot, Brent Buckalew, John Cannon, Daniel Dale, Bruce Draine, Karl Gordon, Albert Grauer, David Hollenbach, Tom Jarrett, Lisa Kewley, Claus Leitherer, Aigen Li, Sangeeta Malhotra, Martin Meyer, John Moustakas, Eric Murphy, Michael Regan, George Rieke, Marcia Rieke, Helene Roussel, Kartik Sheth, J.D. Smith, Michele Thornley, Fabian Walter & George Helou
SPITZER SPACE TELESCOPE


Interacting Galaxies
Hubble Space Telescope • ACS/WFC • WFPC2
NASA, ESA, A. Evans (University of Virginia, Charlottesville/NRAO/Stony Brook University), and the Hubble Heritage (AURA/STScI)-ESA/Hubble Collaboration
STScI-PRC08-16a

Do Now:

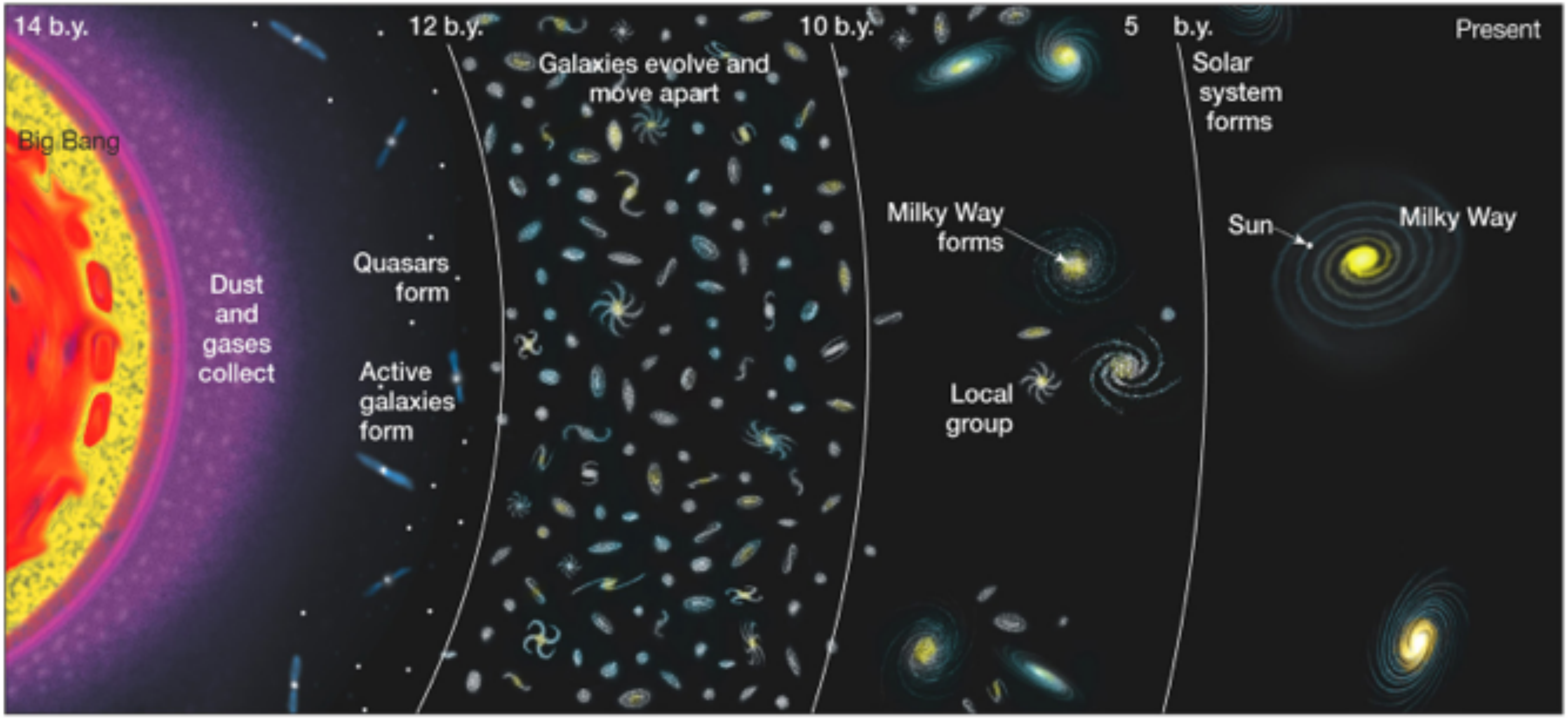
If we were going to take a "Journey to the Stars," how would we measure distance in space?

Important Astronomical Measurements

An **astronomical unit (AU)** is the average distance between Earth and the sun; (150 million kilometers).

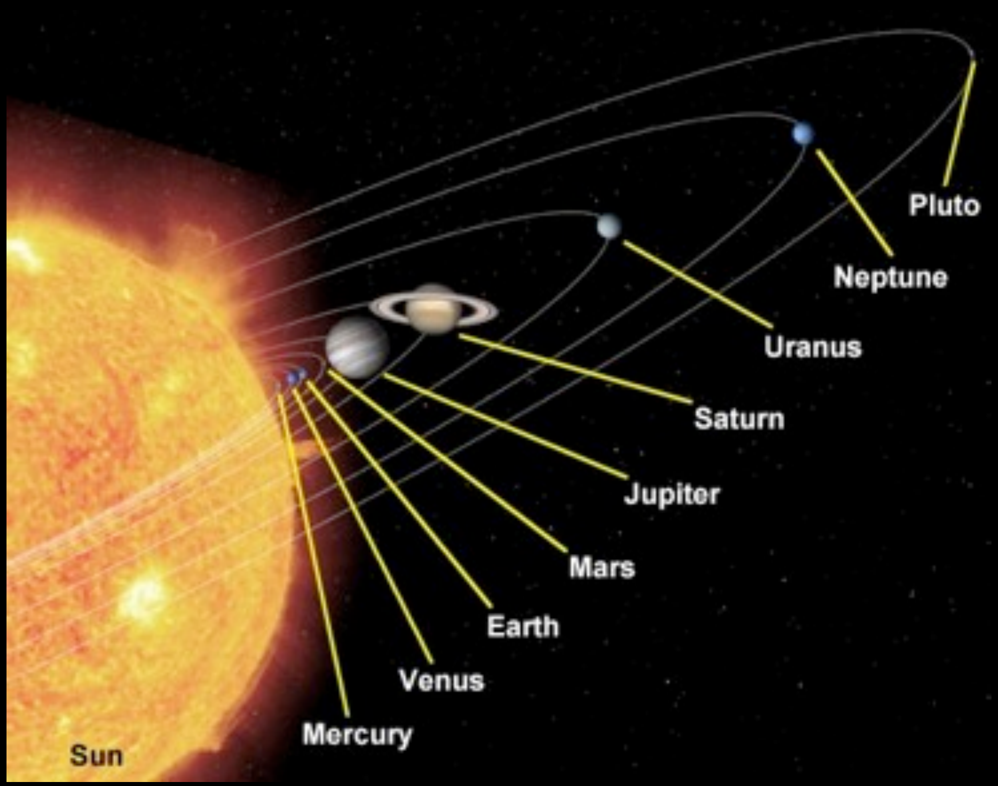
Light-year The distance that light travels in one year, about 9.5 trillion kilometers.

Parsec: A unit of measurement used to describe distances between celestial objects, equal to 3.258 light-years.


14 b.y.
12 b.y.
10 b.y.
5 b.y.
Present
Big Bang
Dust and gases collect
Quasars form
Active galaxies form
Galaxies evolve and move apart
Milky Way forms
Local group
Solar system forms
Sun
Milky Way

Objectives

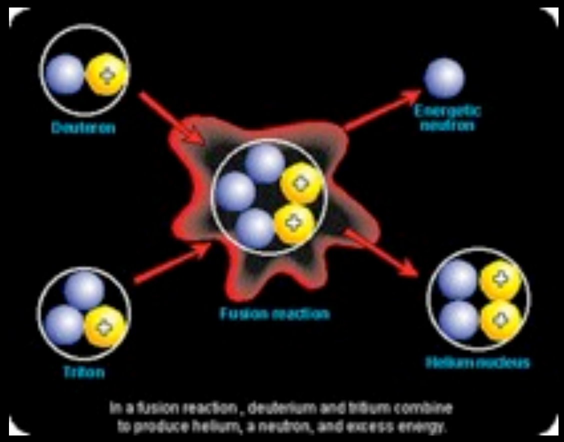
1. **Explain** the process of energy production in the Sun.
2. Identify the major components

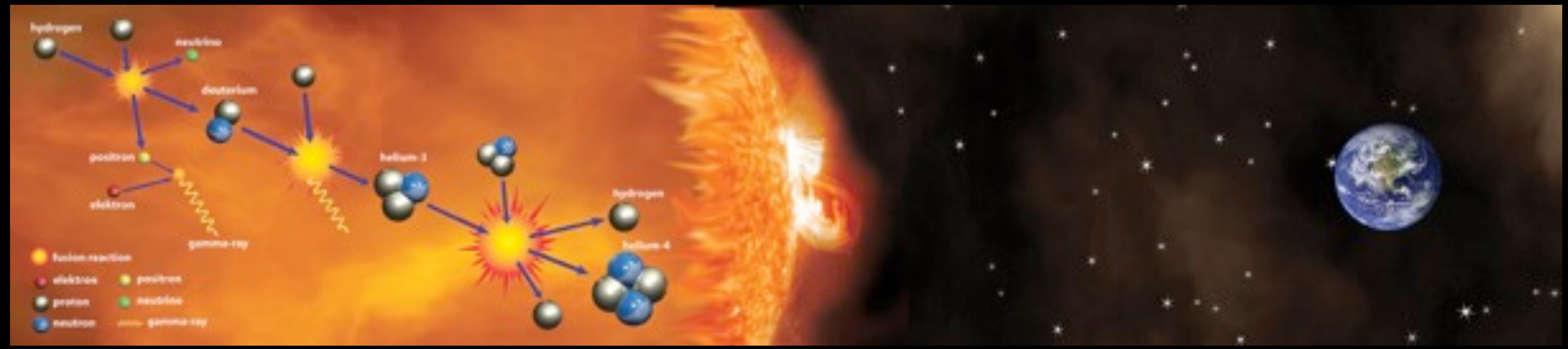


Sun's Energy Production

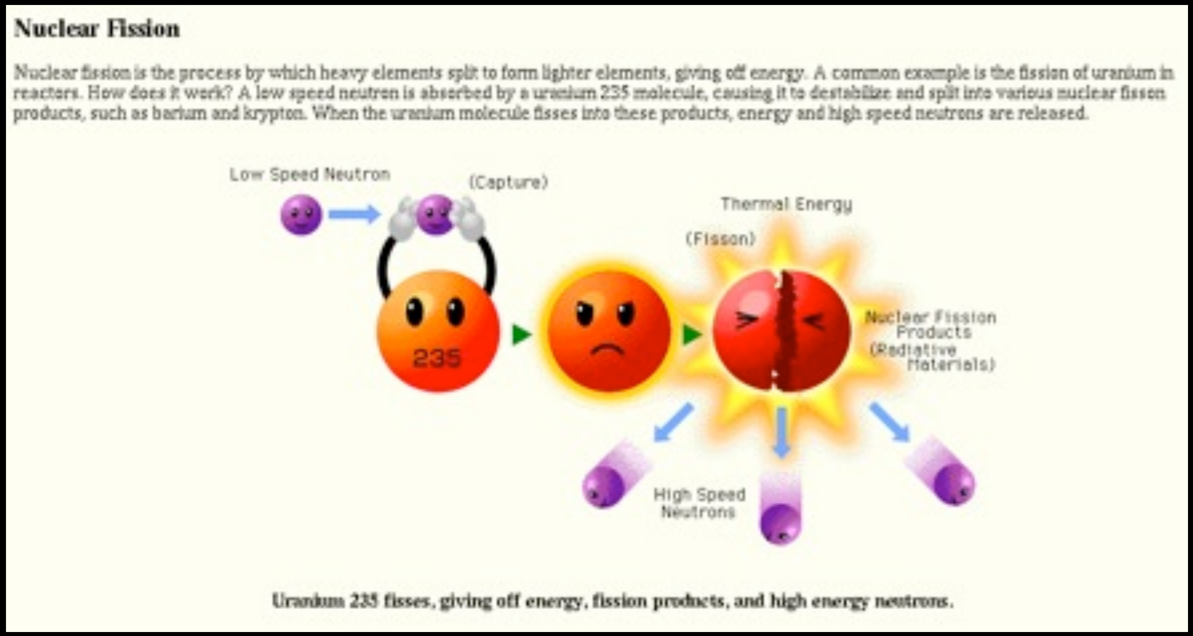
Nuclear Fusion – the combining of smaller elements to form the nuclei of larger elements

The Sun converts hydrogen nuclei into helium nuclei





Fusion - the combination of lightweight atomic nuclei into heavier nuclei, such



The Sun & Stars

Corona

the outermost

Solar

Sunspot

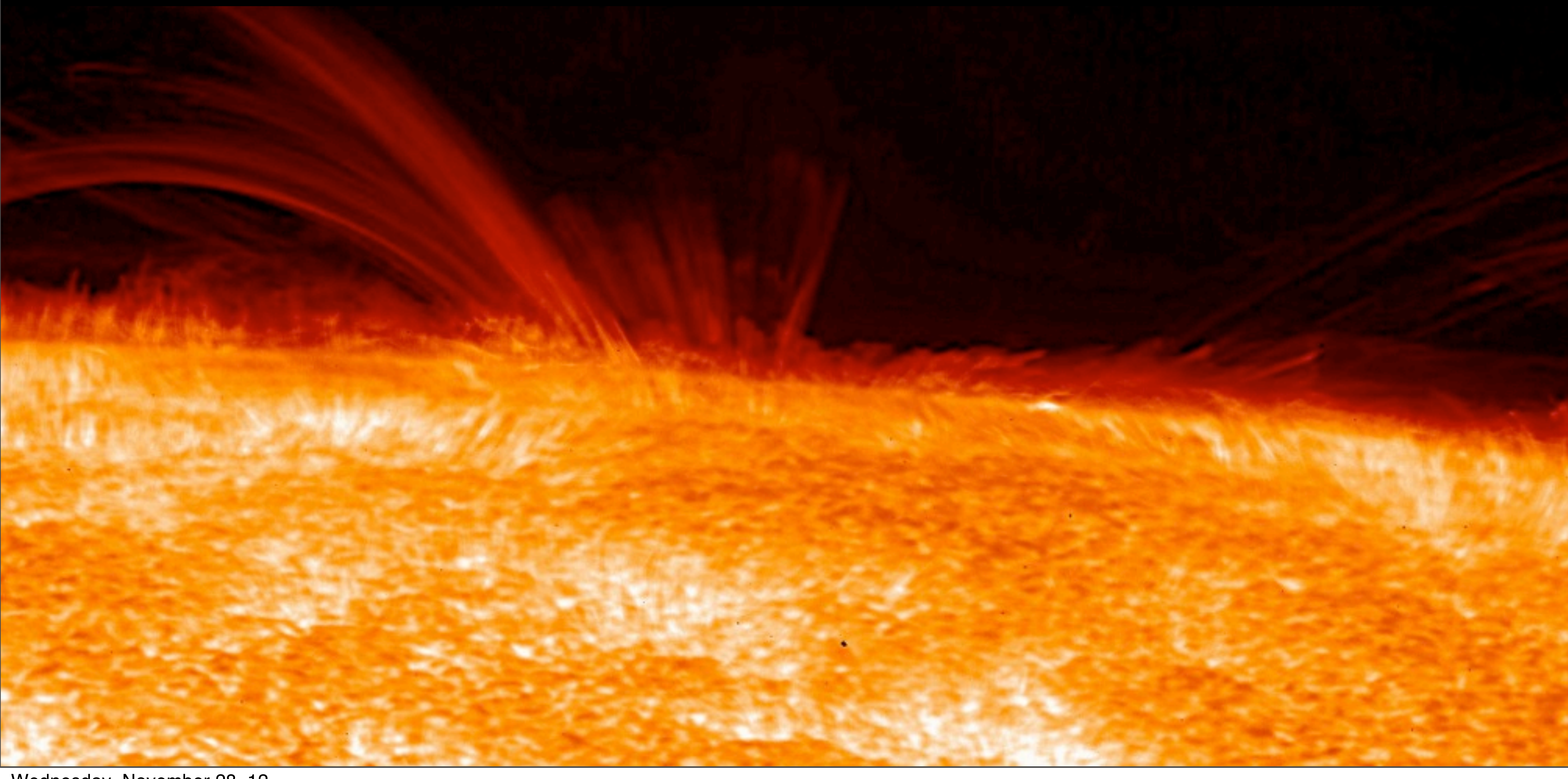
What we know about the sun:

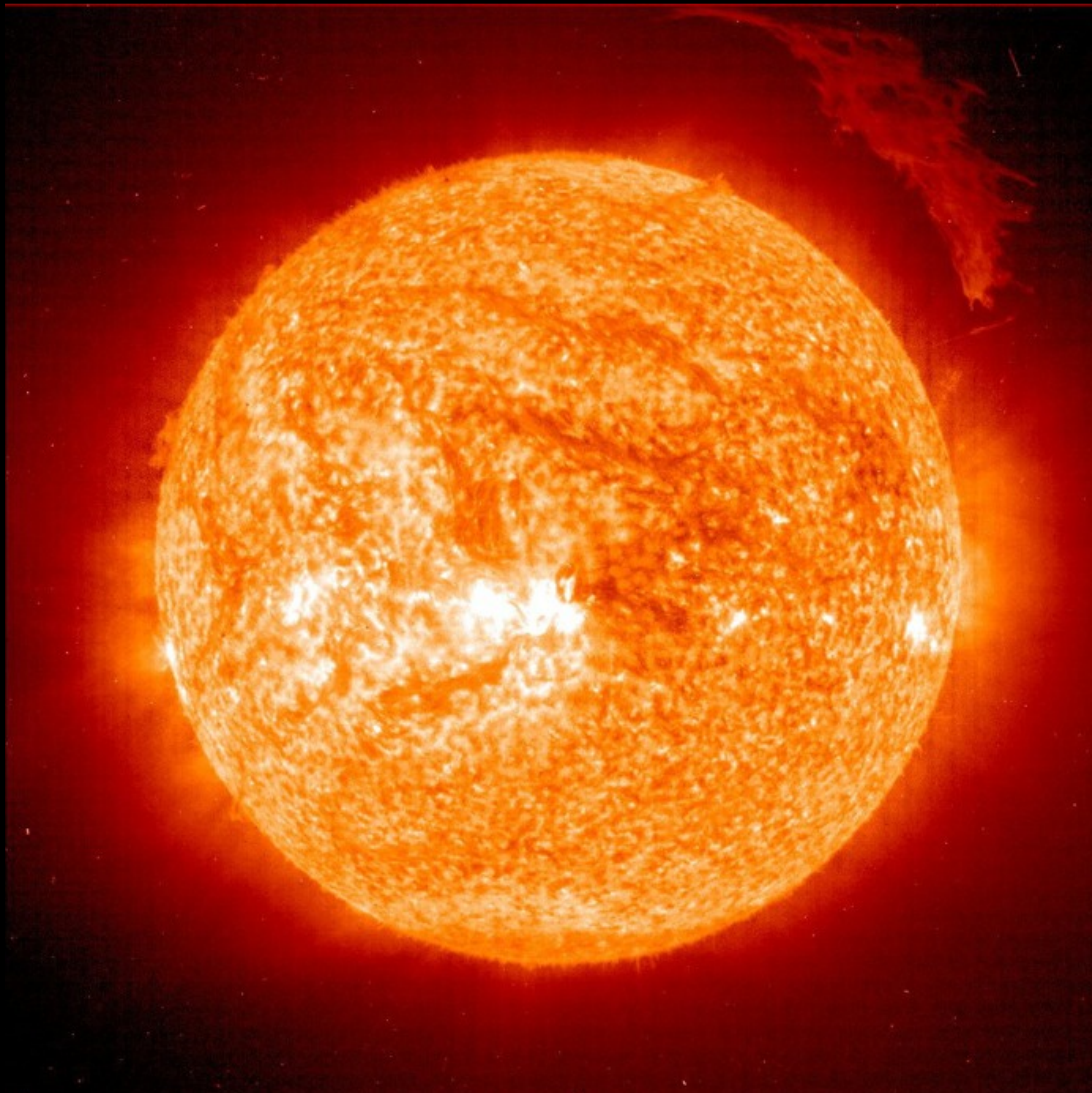
contains most of the mass of the solar system

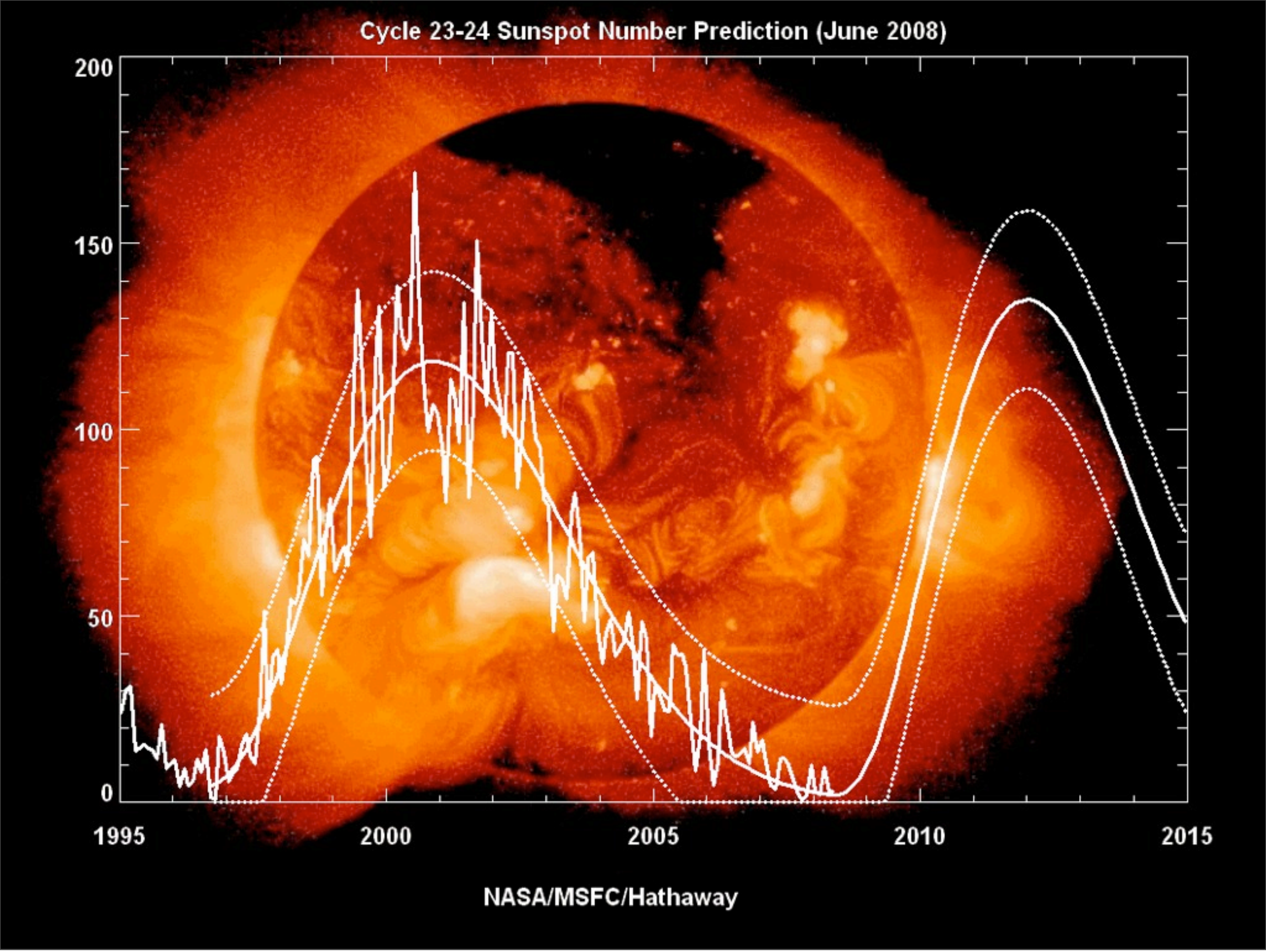
has many features typical of other stars

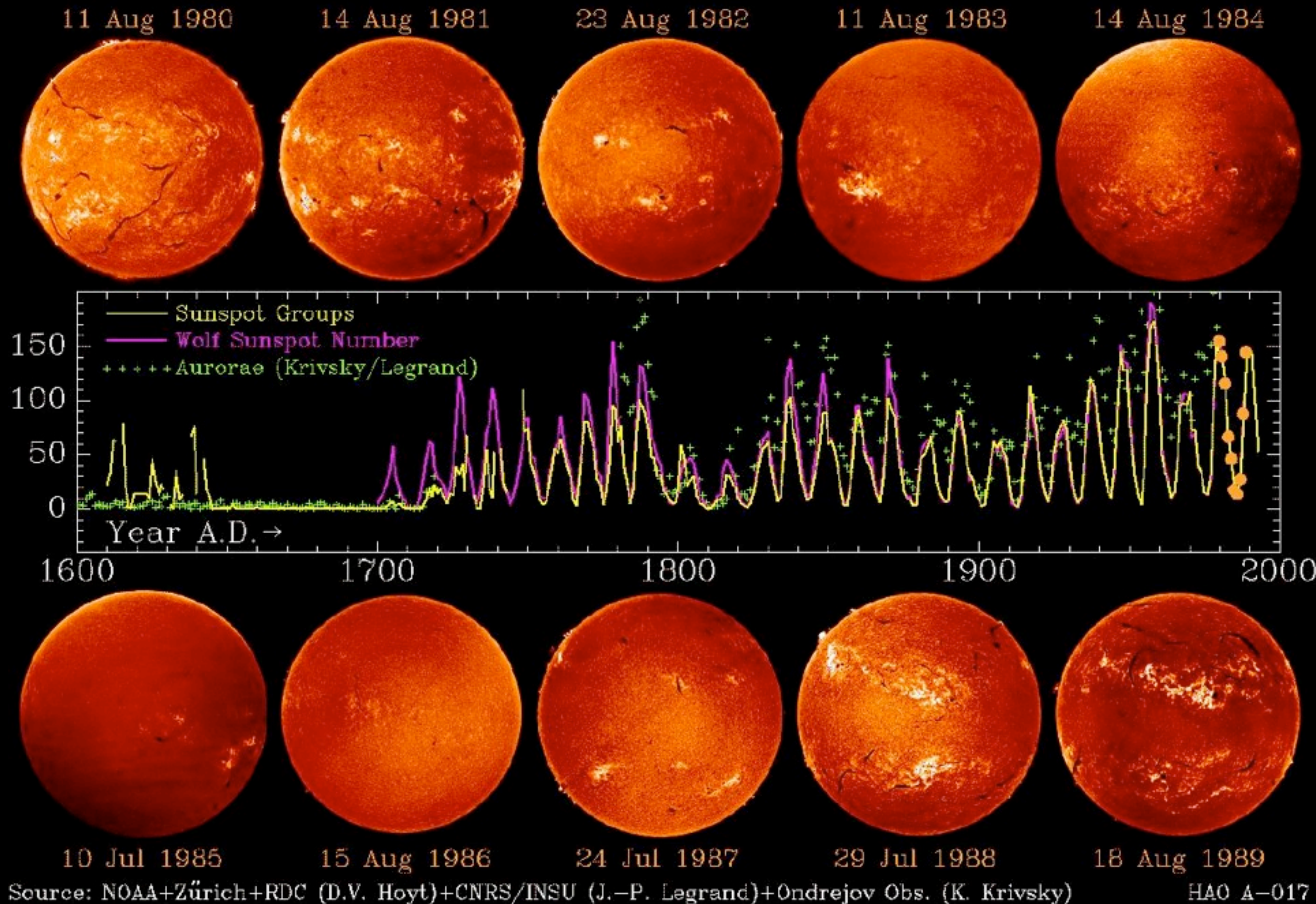
Solar Flares

Violent eruptions of particles and radiation from the

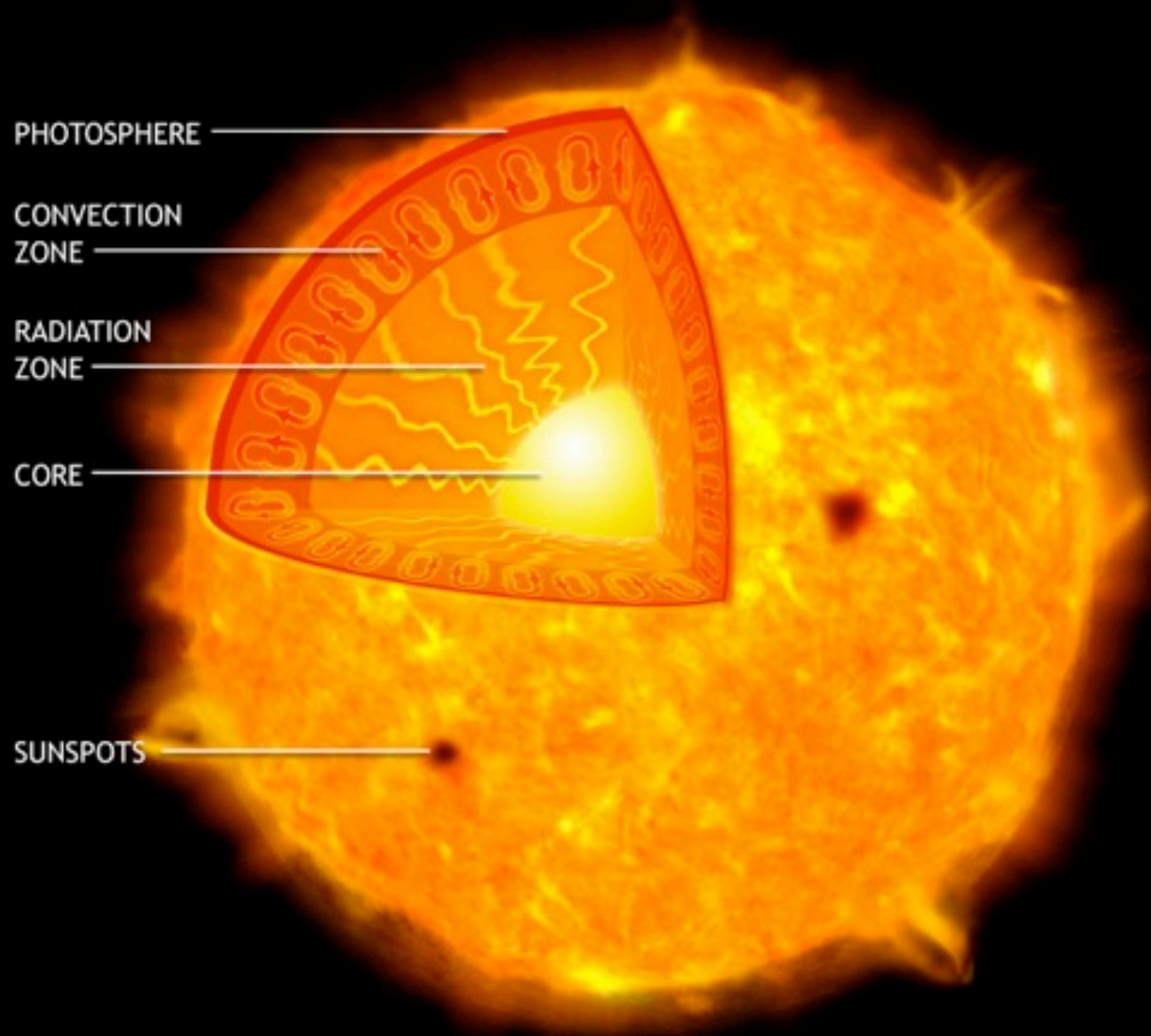




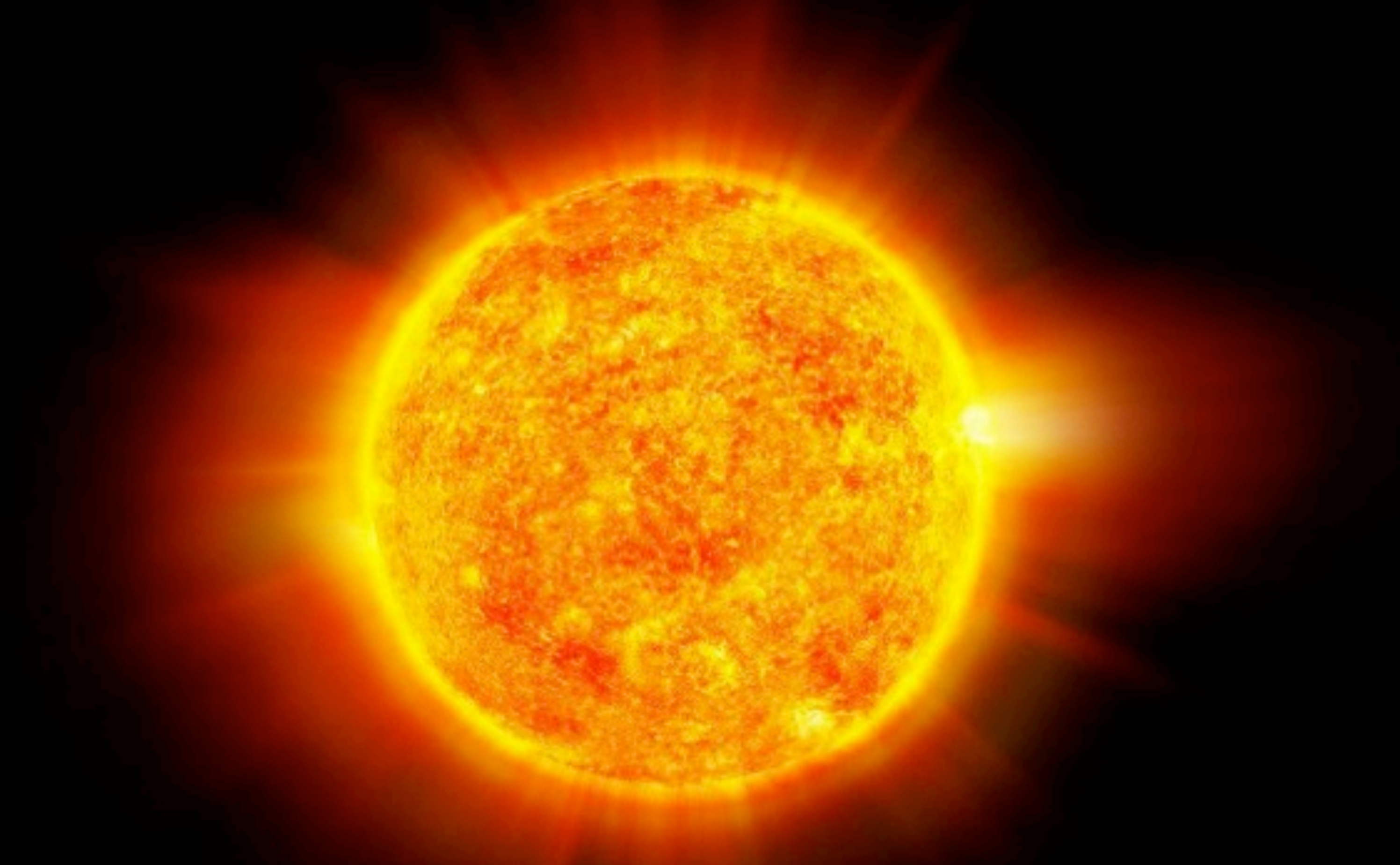

Cycle 23-24 Sunspot Number Prediction (June 2008)
200
150
100
50
0
1995
2000
2005
2010
2015
NASA/MSFC/Hathaway


11 Aug 1980
14 Aug 1981
23 Aug 1982
11 Aug 1983
14 Aug 1984
Sunspot Groups
Wolf Sunspot Number
Aurorae (Krivsky/Legrand)
150
100
50
0
Year A.D.→
1600
1700
1800
1900
2000
10 Jul 1985
15 Aug 1986
24 Jul 1987
29 Jul 1988
18 Aug 1989
Source: NOAA+Zürich+RDC (D.V. Hoyt)+CNRS/INSU (J.-P. Legrand)+Ondrejov Obs. (K. Krivsky)
HAO A-017

Anatomy of the Sun

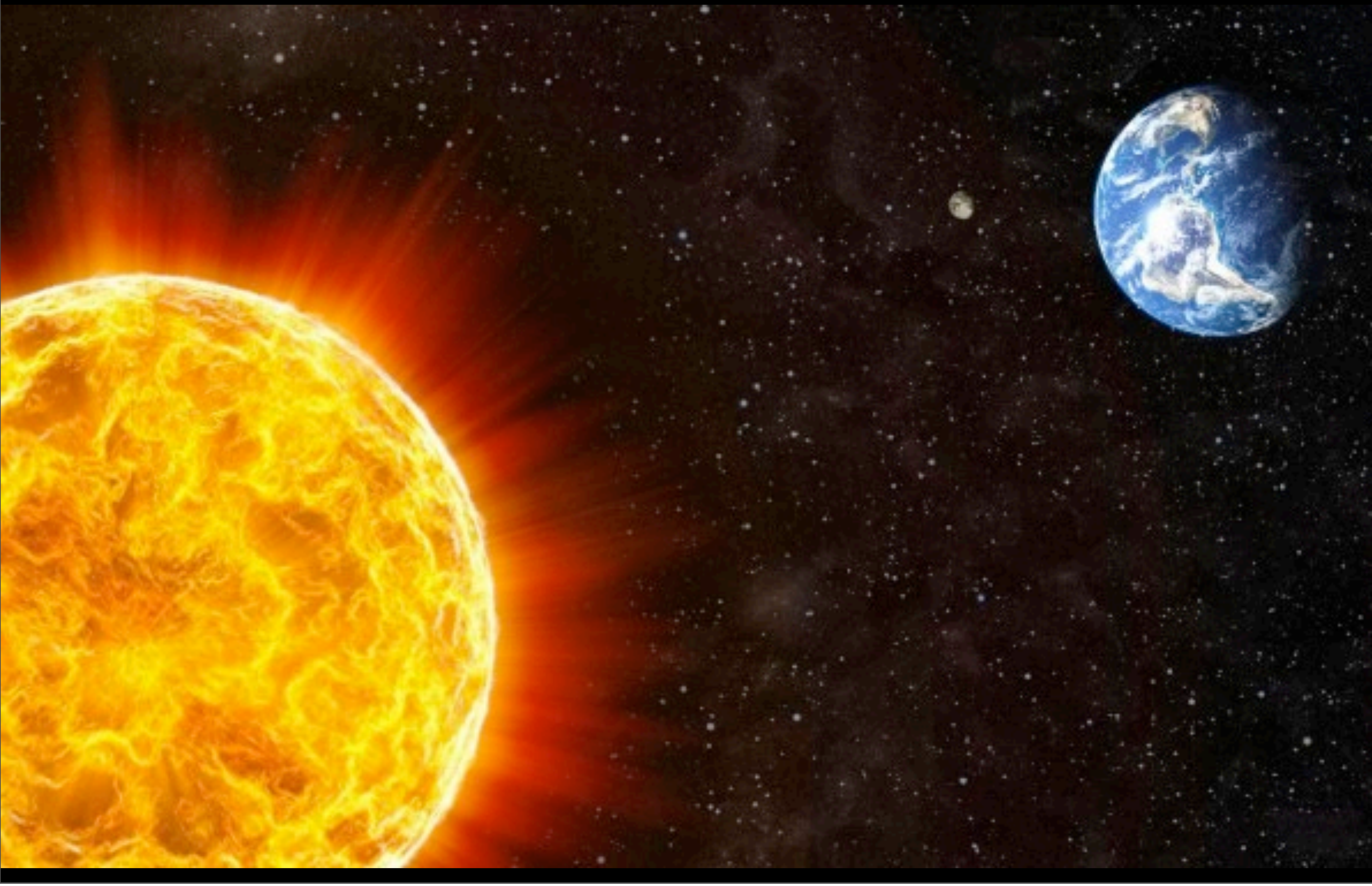


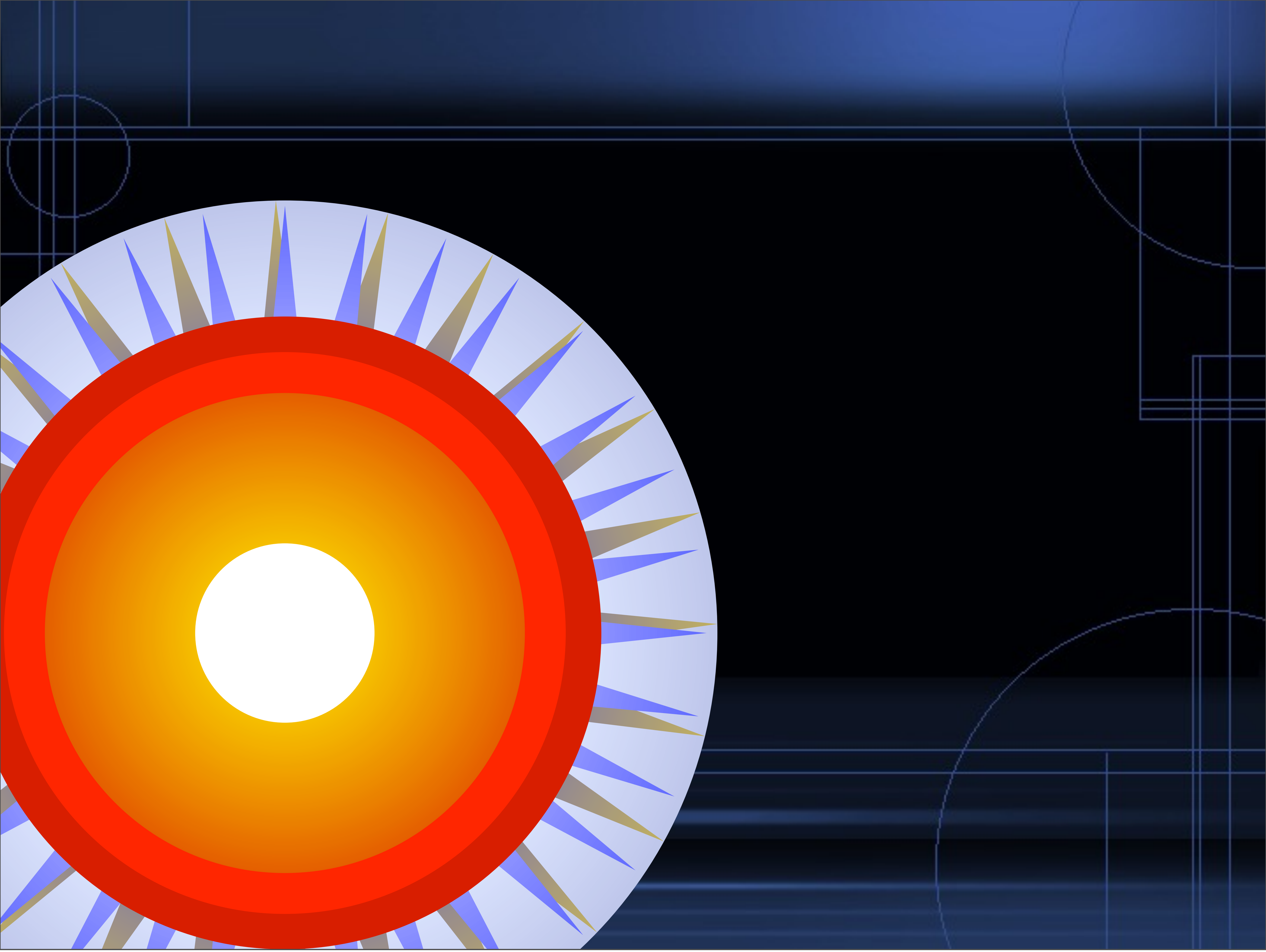
Energy Transfer from Sun

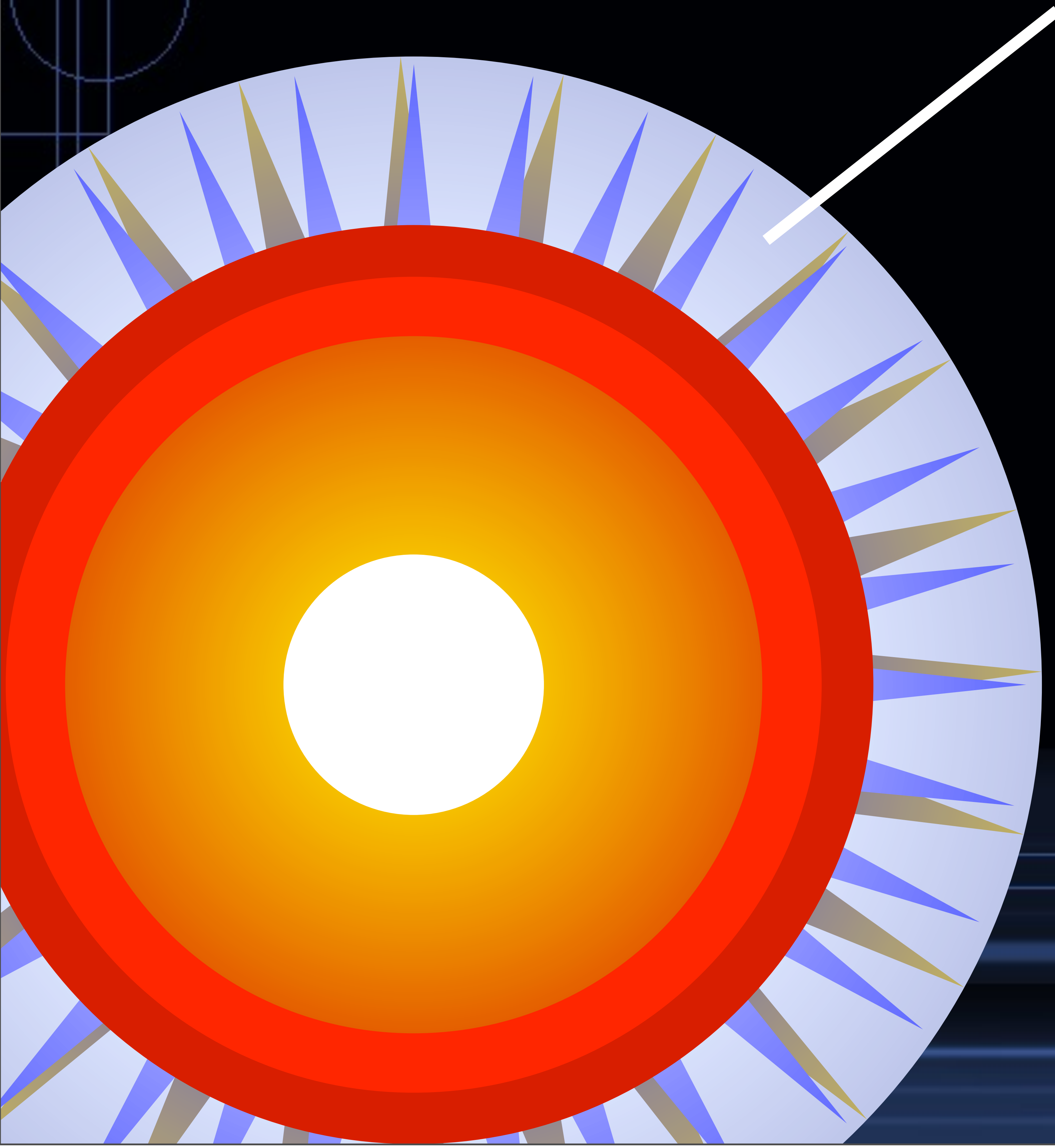


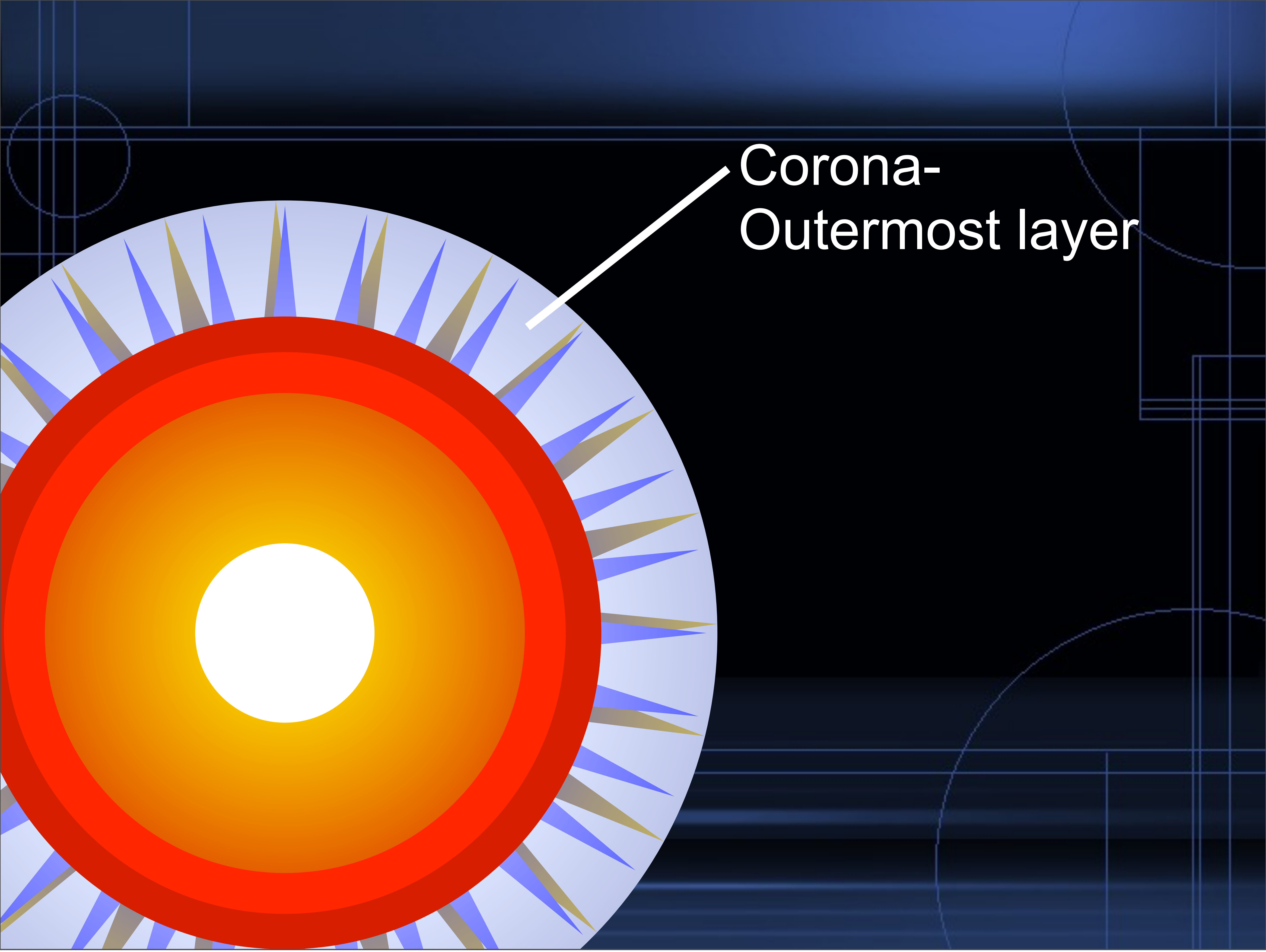
Electromagnetic energy is radiated by the sun

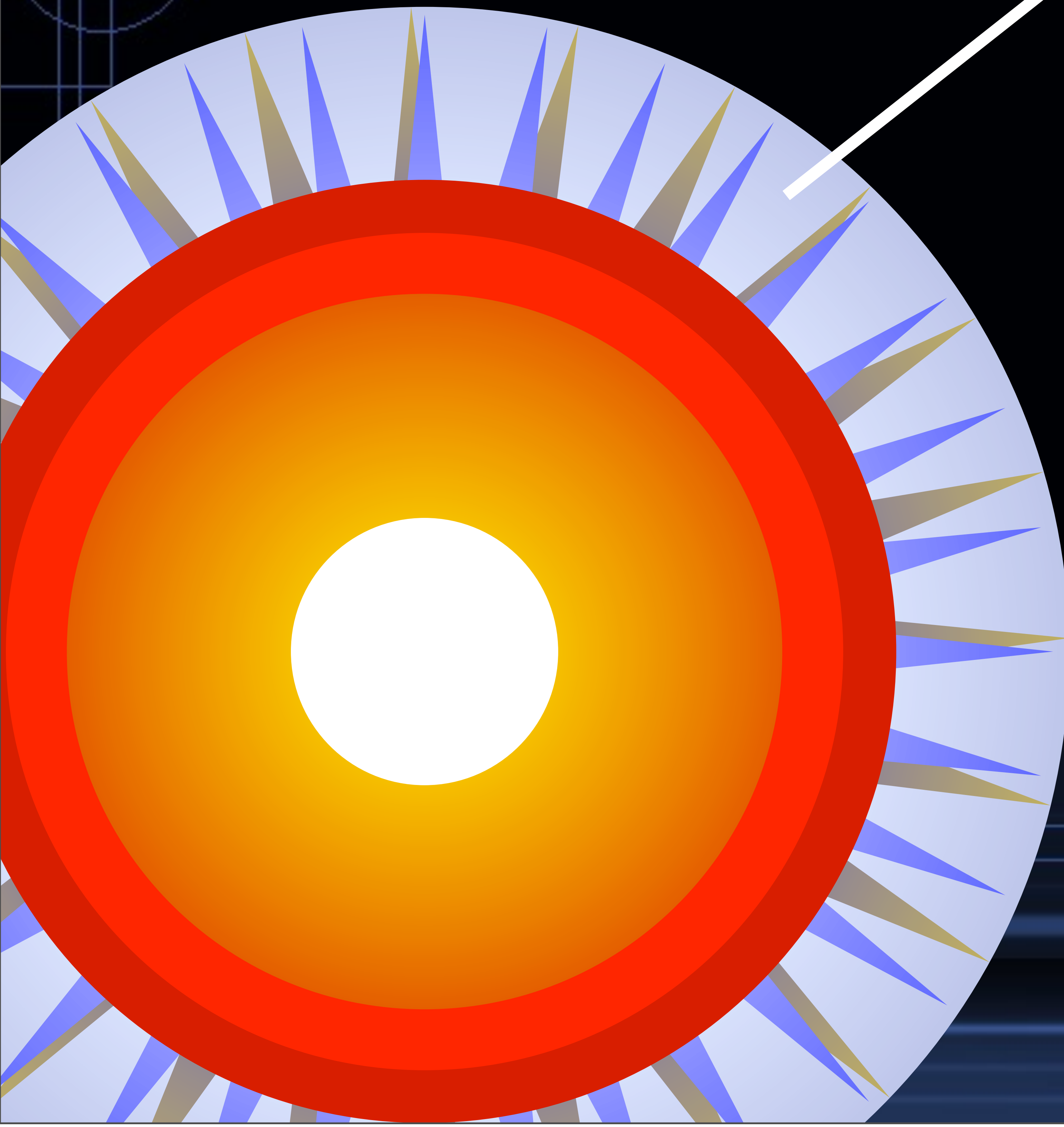
Energy is transmitted through a medium less space



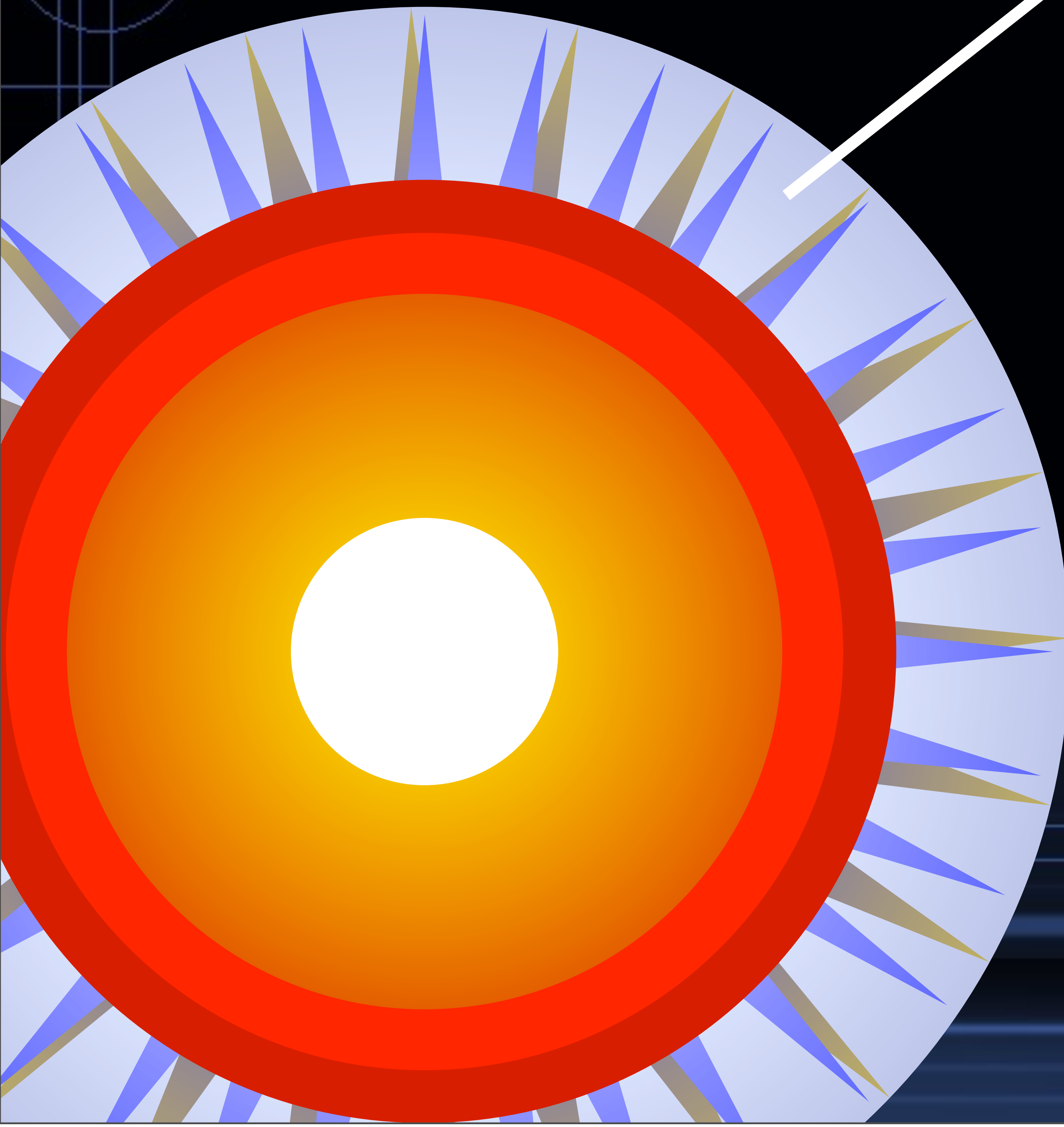




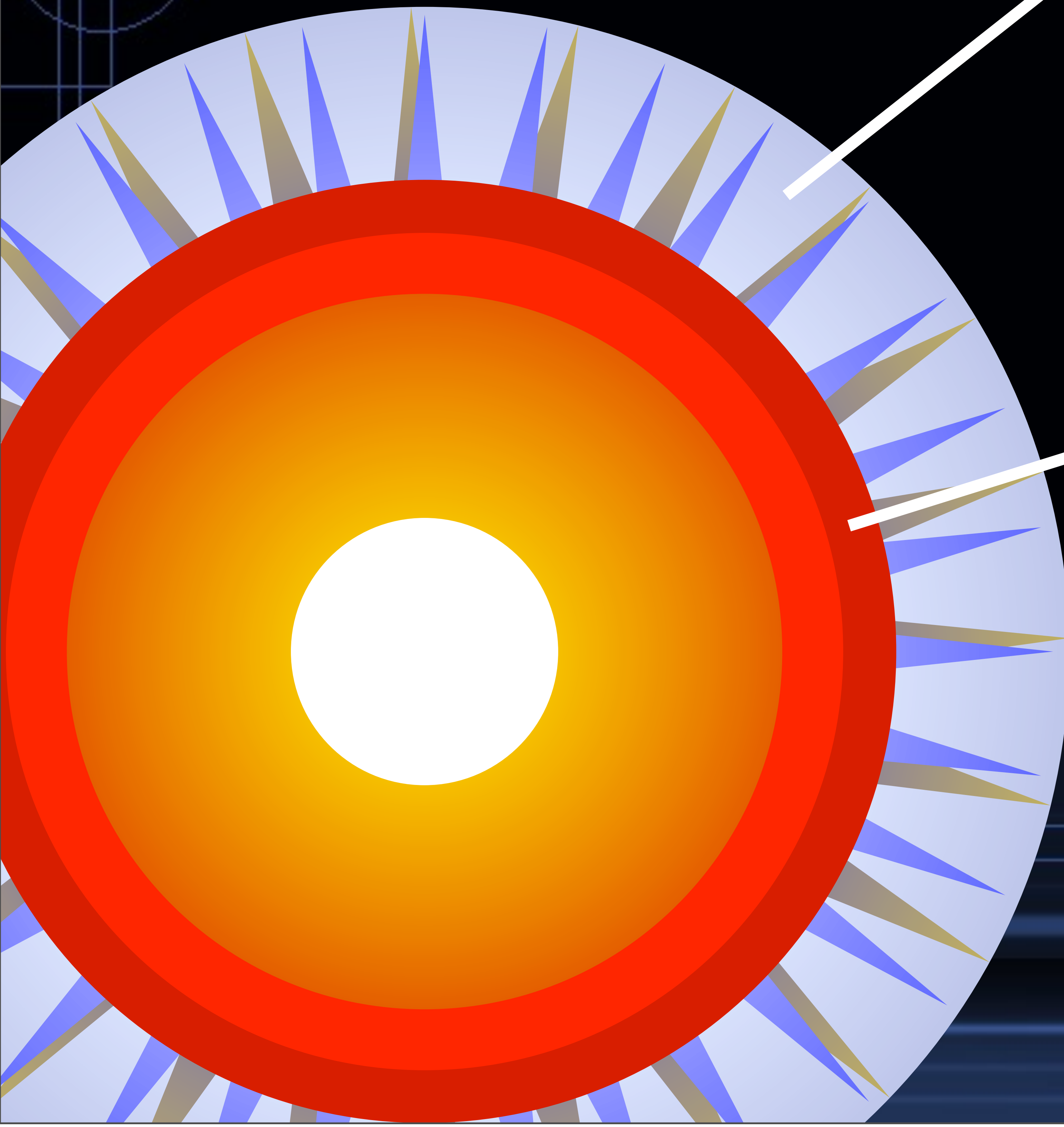

Corona-
Outermost layer



Corona-
Outermost layer
•Temp-1,700,000º C

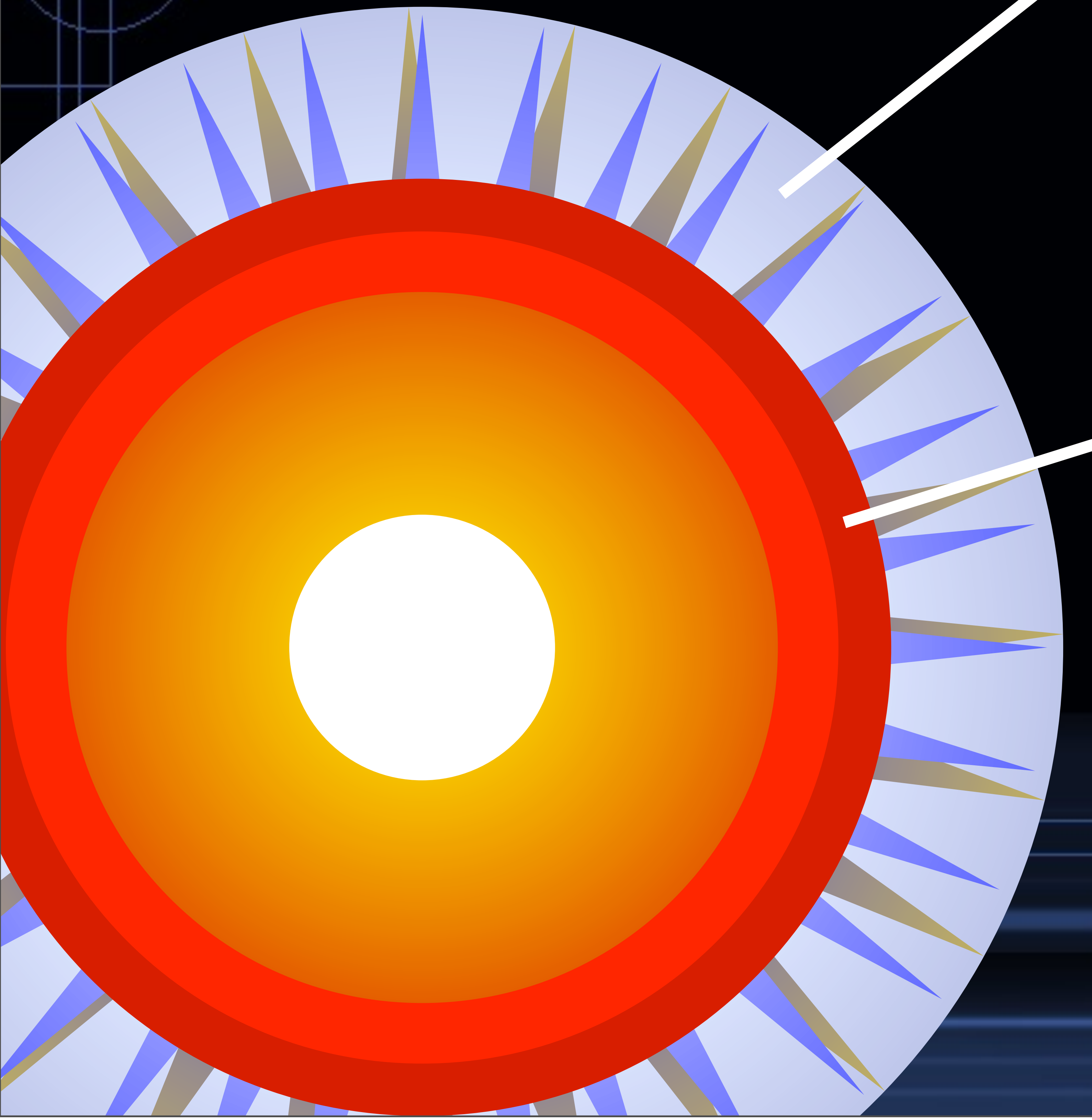


Corona-
Outermost layer
•Temp-1,700,000º C
•Few particles



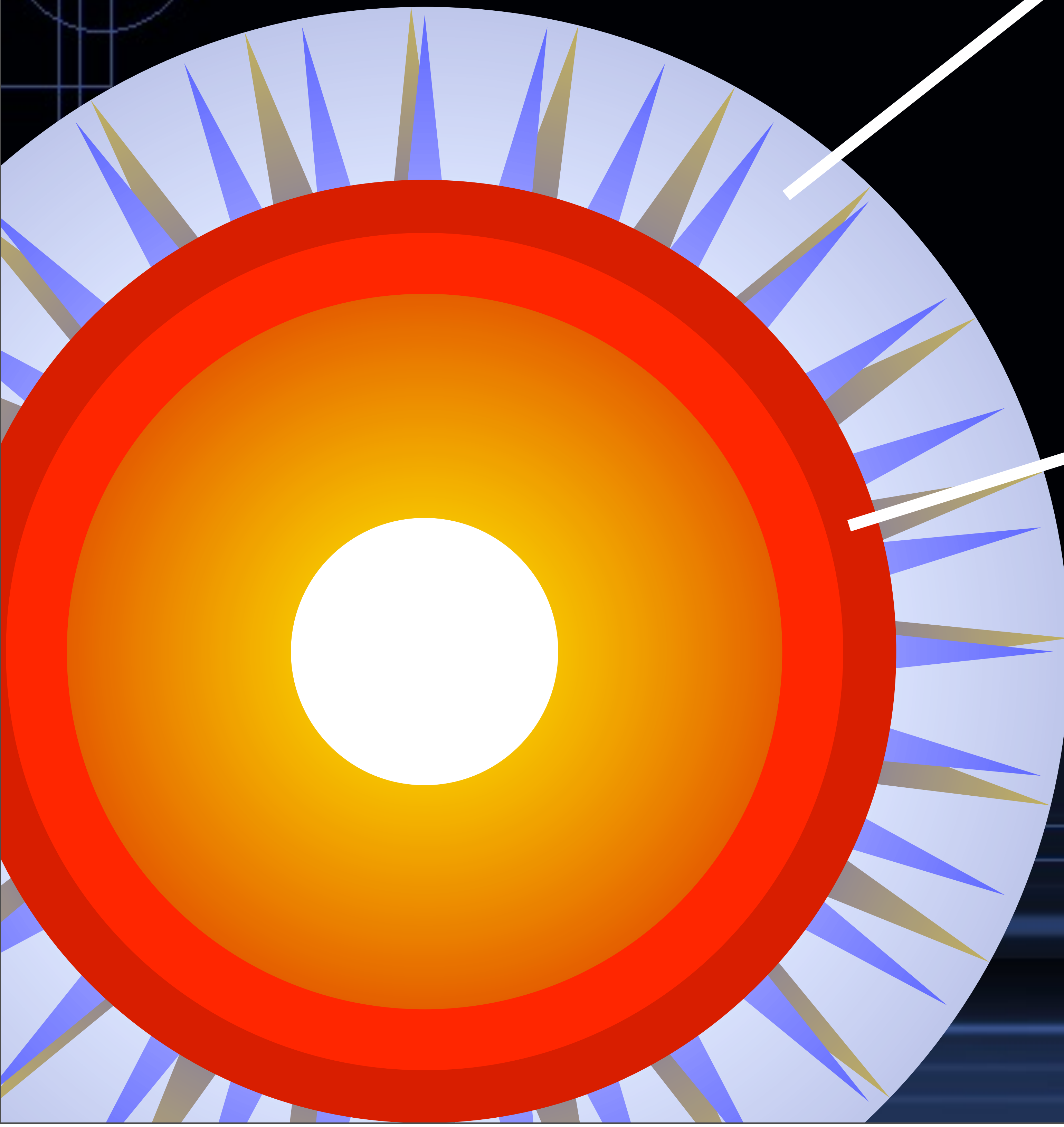
Corona- Outermost layer

- Temp-1,700,000° C
- Few particles



Corona-
Outermost layer
•Temp-1,700,000º C
•Few particles

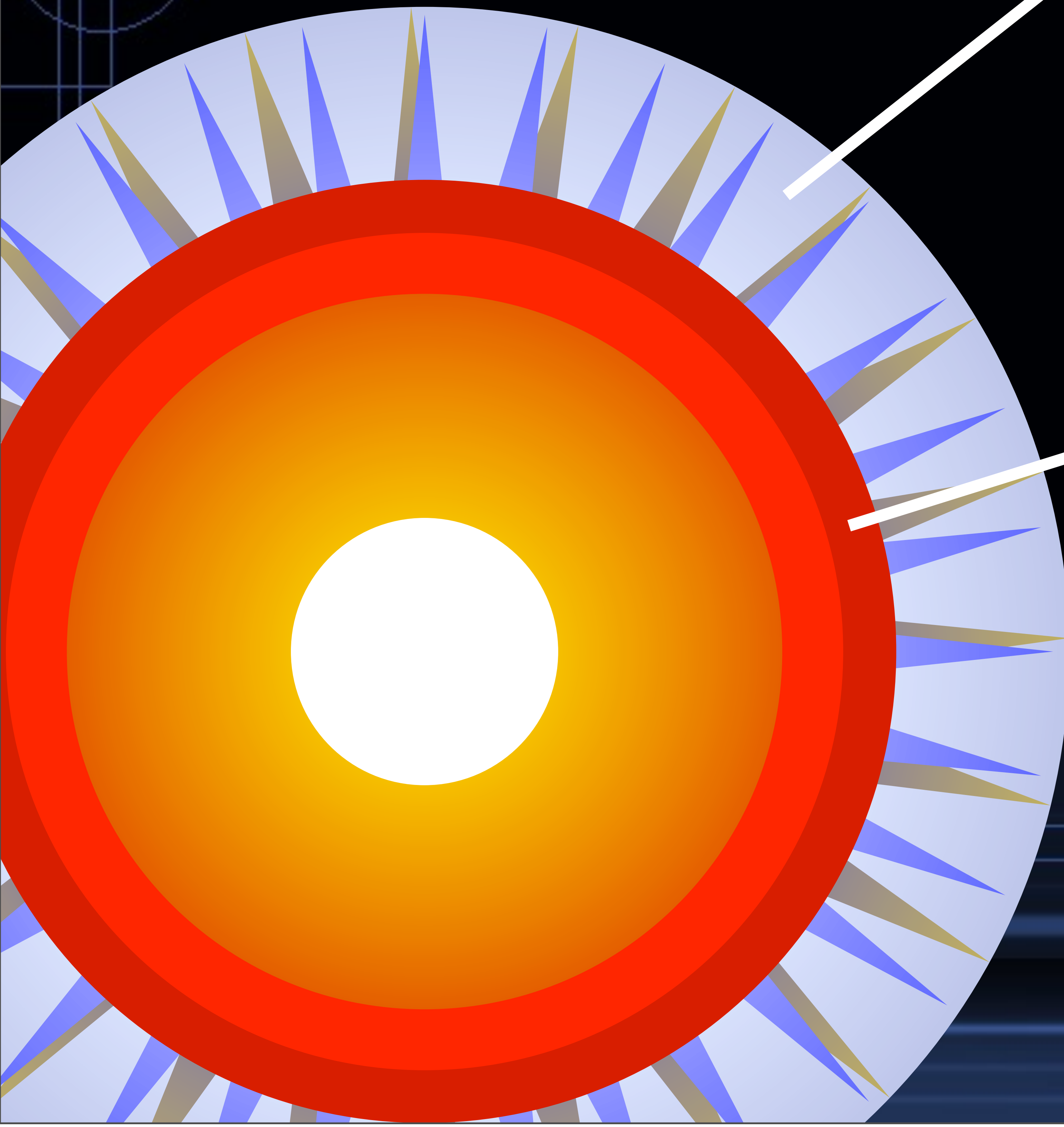
Chromosphere-



Corona-
Outermost layer

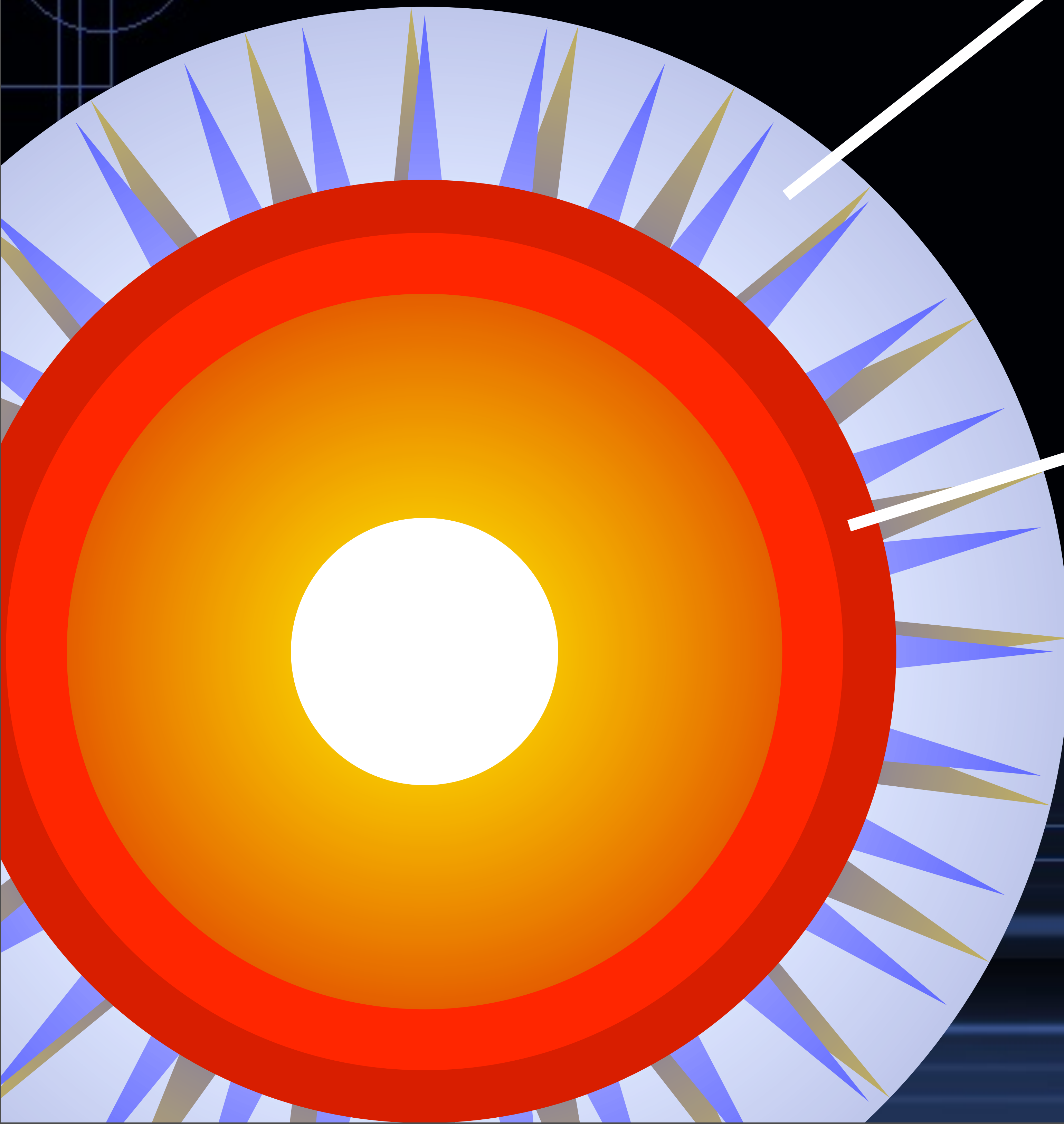
- Temp-1,700,000º C
- Few particles

Chromosphere-
middle of
atmosphere



Corona-
Outermost layer
•Temp-1,700,000º C
•Few particles

Chromosphere-
middle of atmosphere
•Temp-27,800ºC

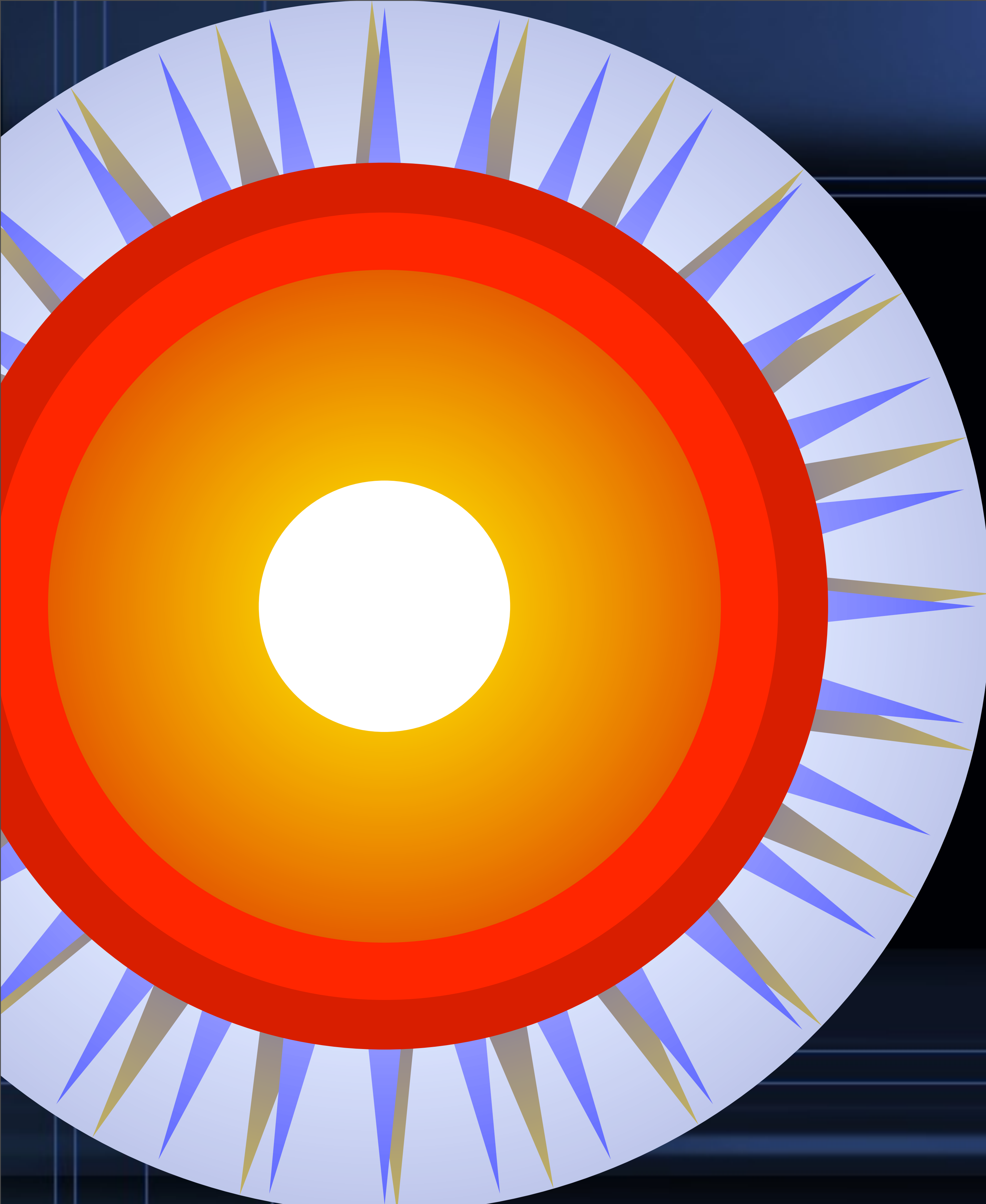


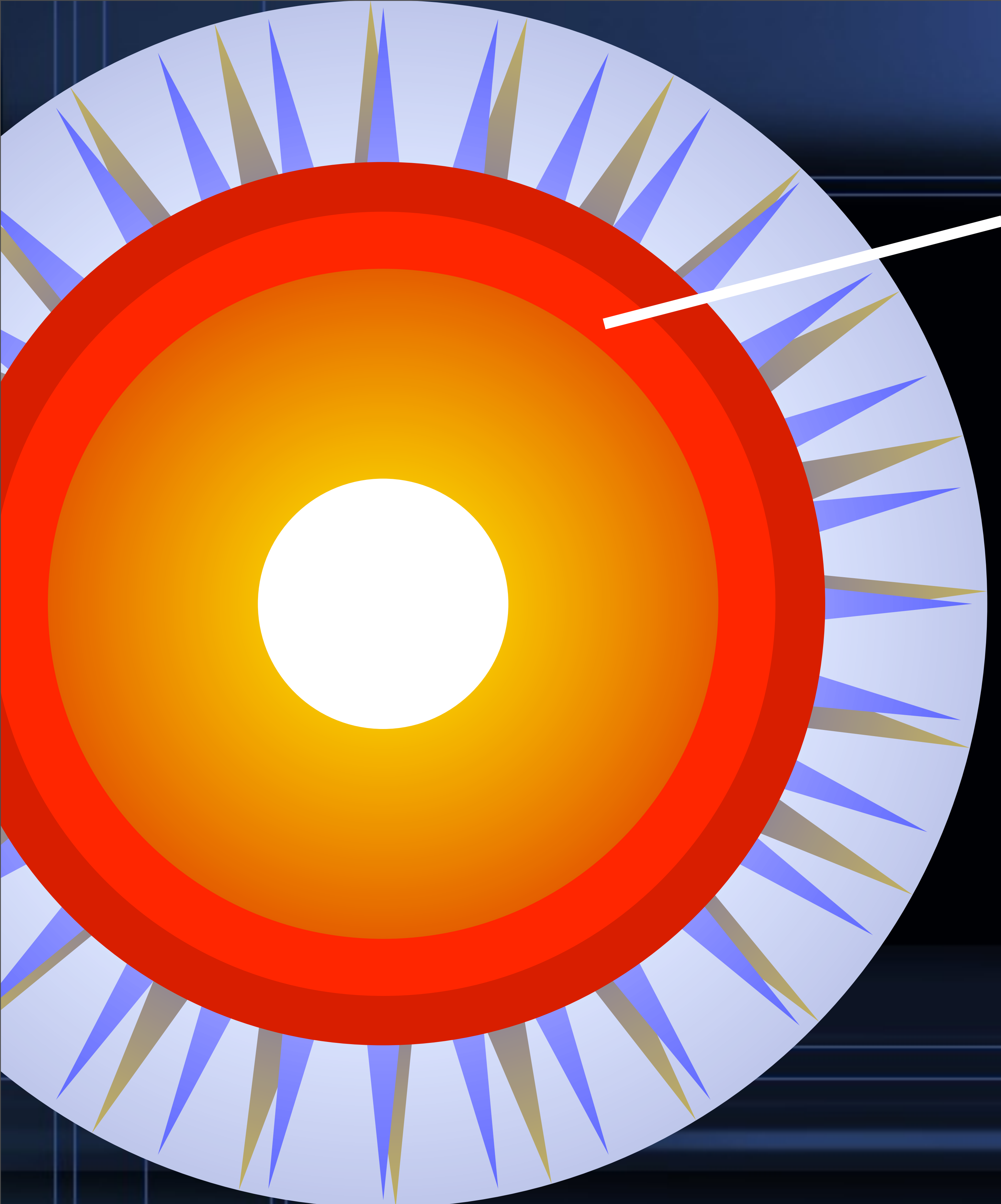
Corona-
Outermost layer

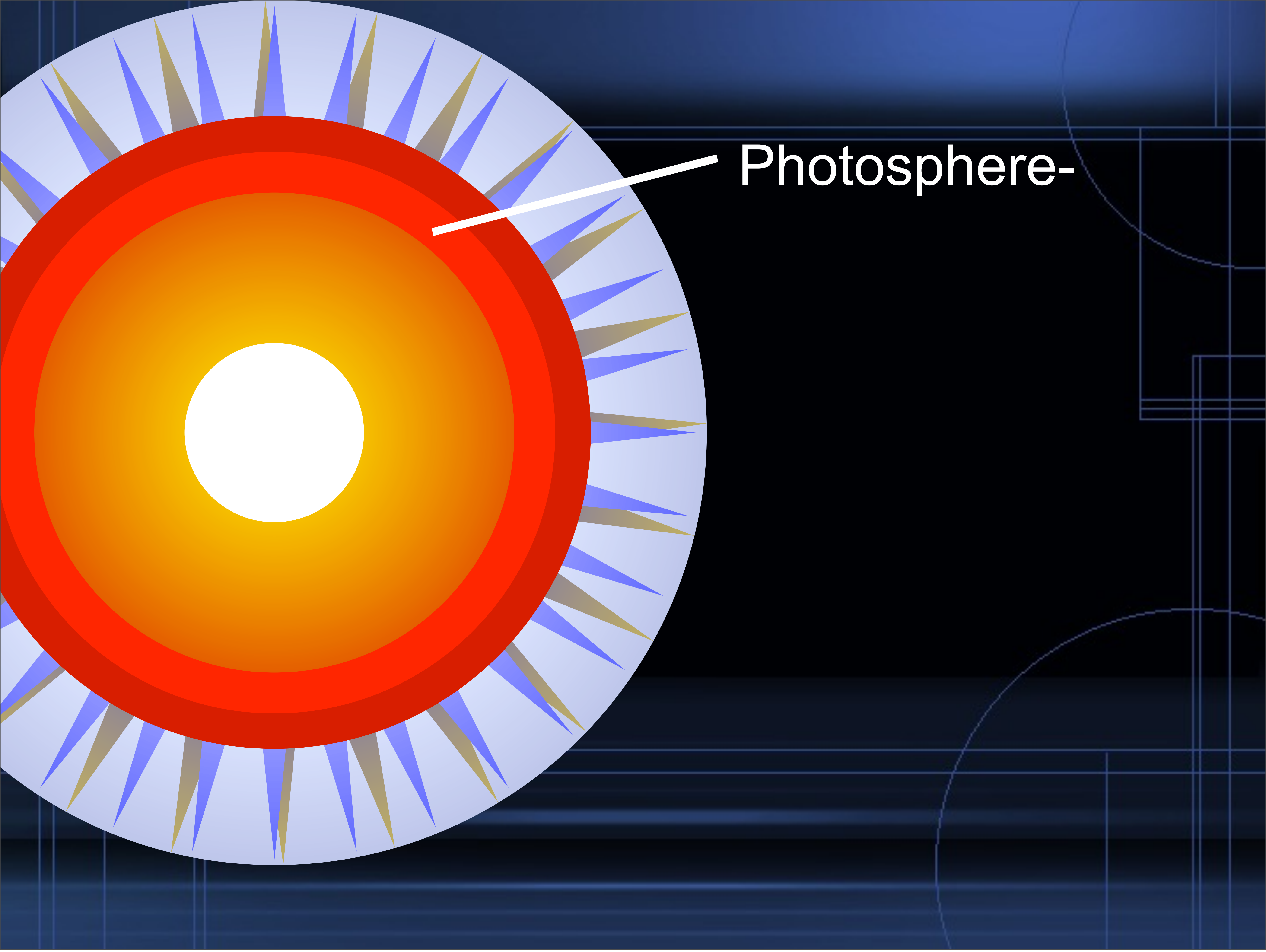
- Temp-1,700,000º C
- Few particles

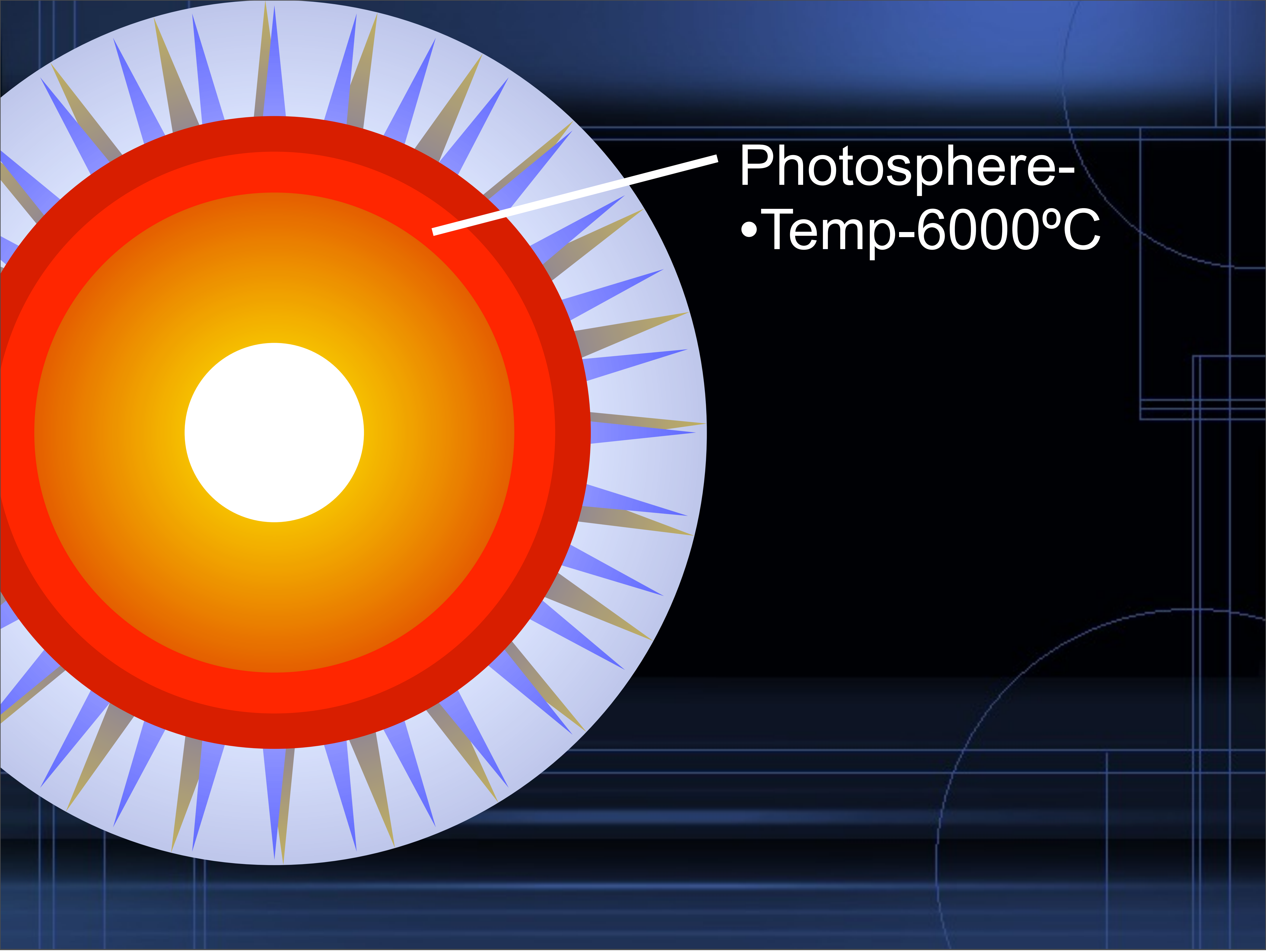
Chromosphere-
middle of atmosphere

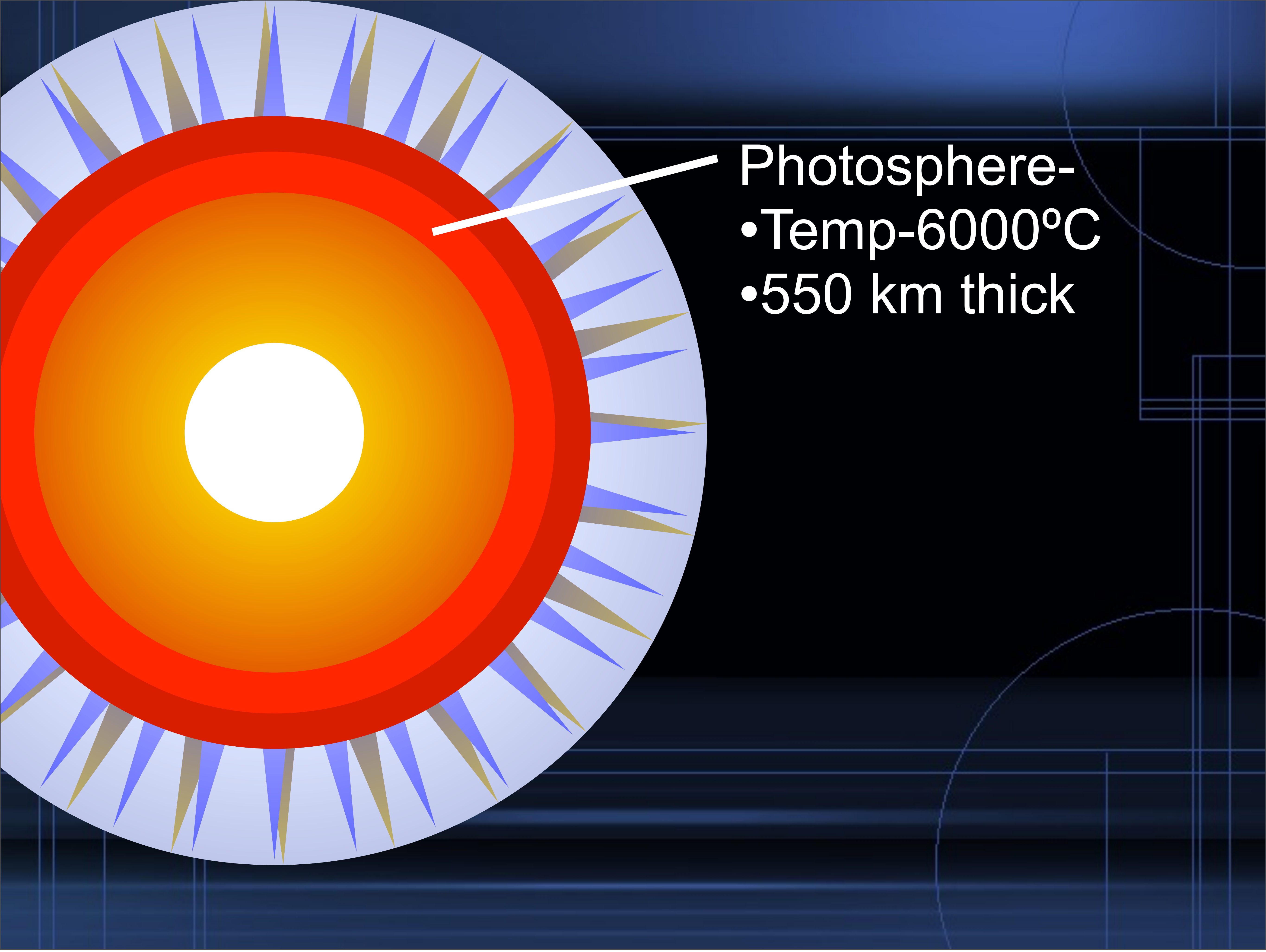
- Temp-27,800ºC
- 1000's of km thick

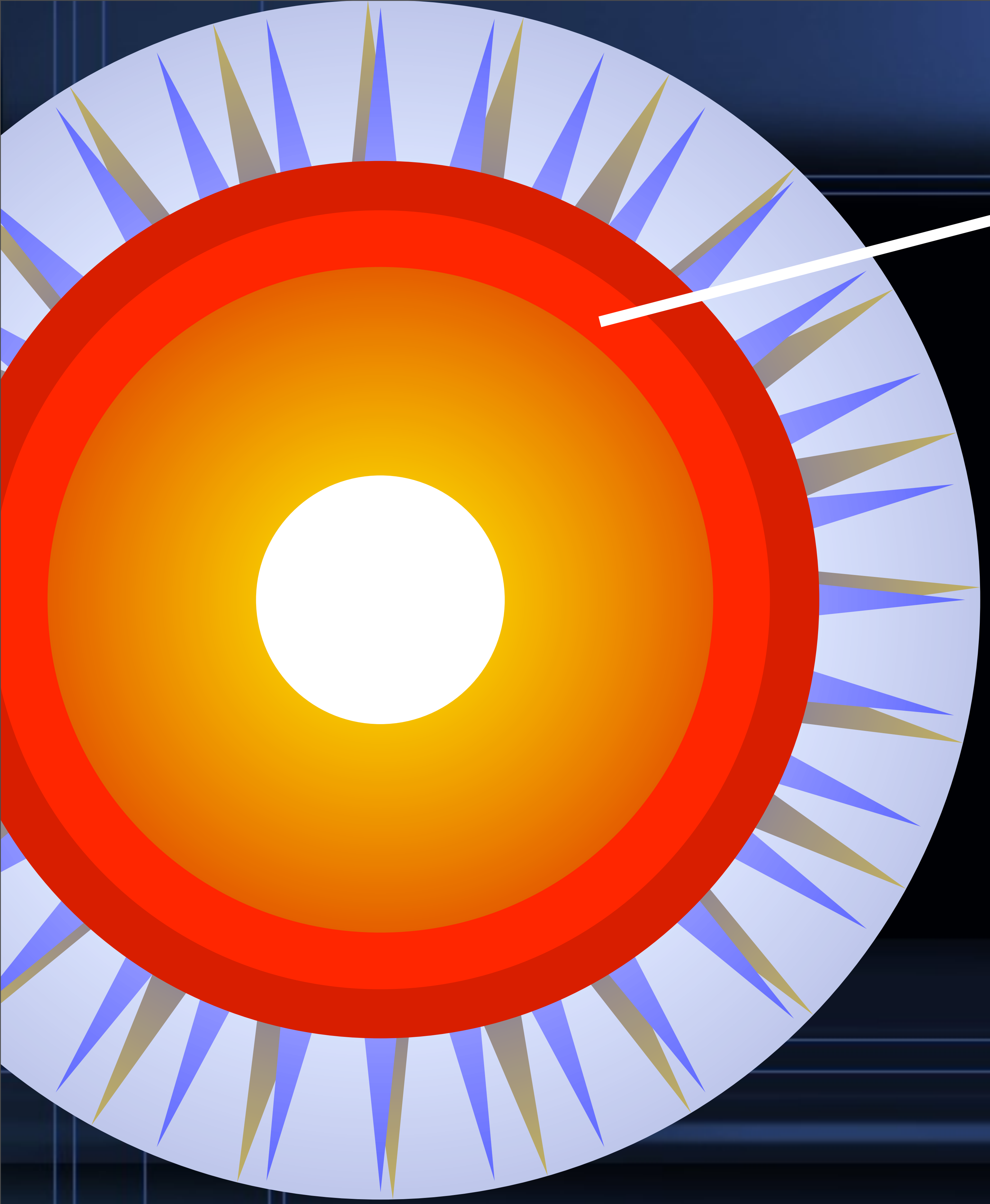




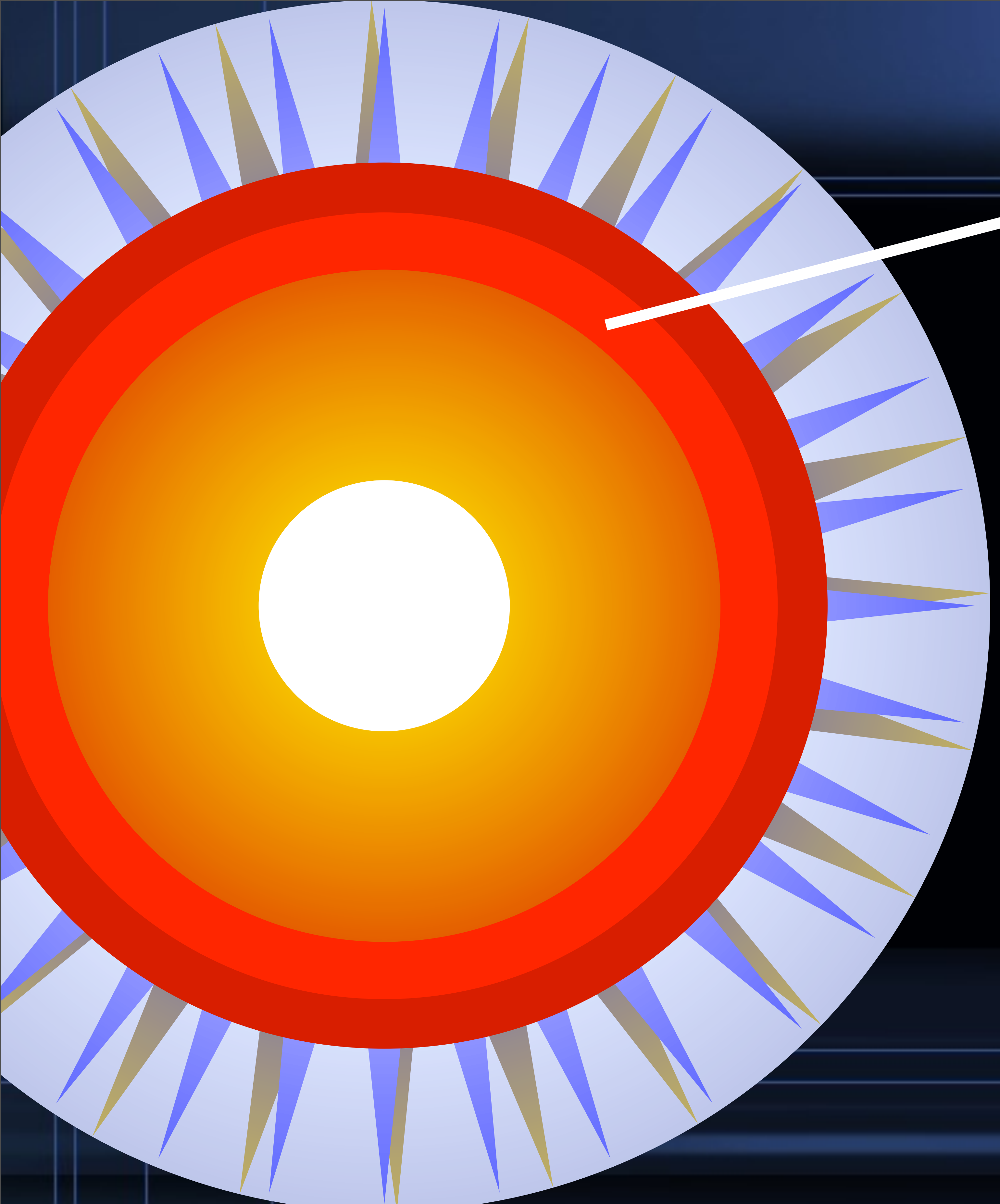

Photosphere-


Photosphere-
•Temp-6000ºC


Photosphere-
•Temp-6000ºC
•550 km thick



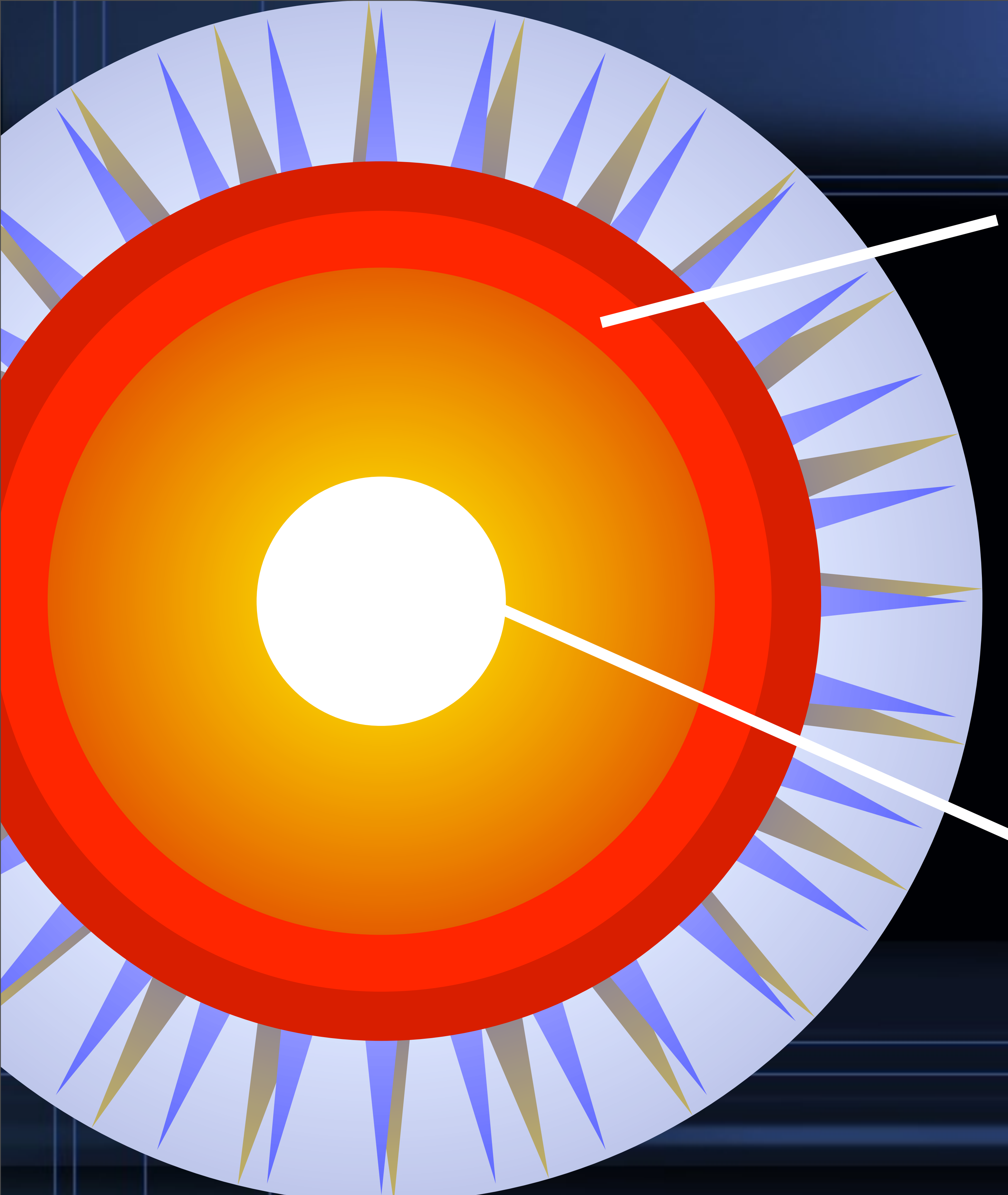
Photosphere-
•Temp-6000ºC
•550 km thick
•Surface of the sun



Photosphere-

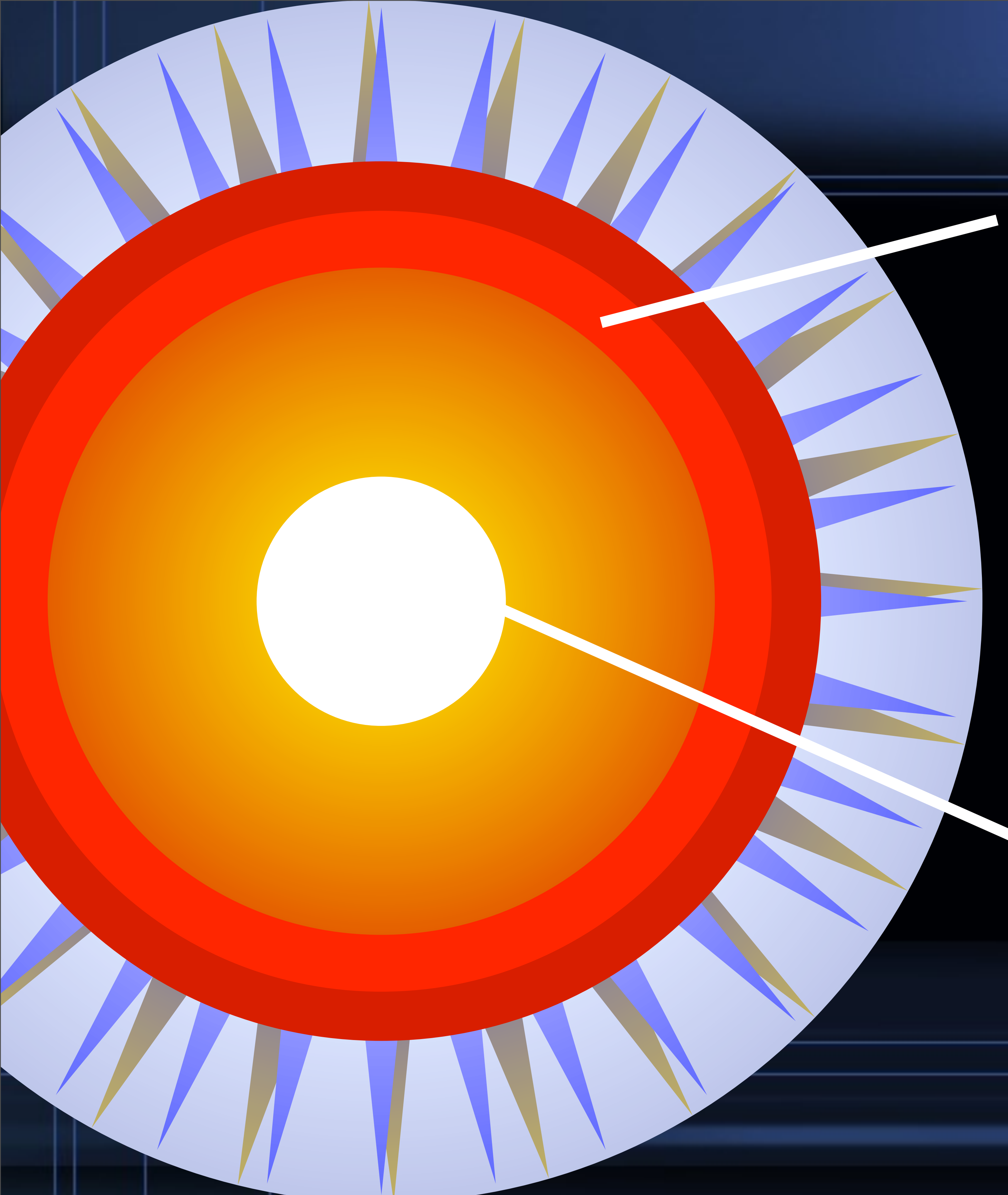
- Temp-6000ºC
- 550 km thick
- Surface of the sun

Core-



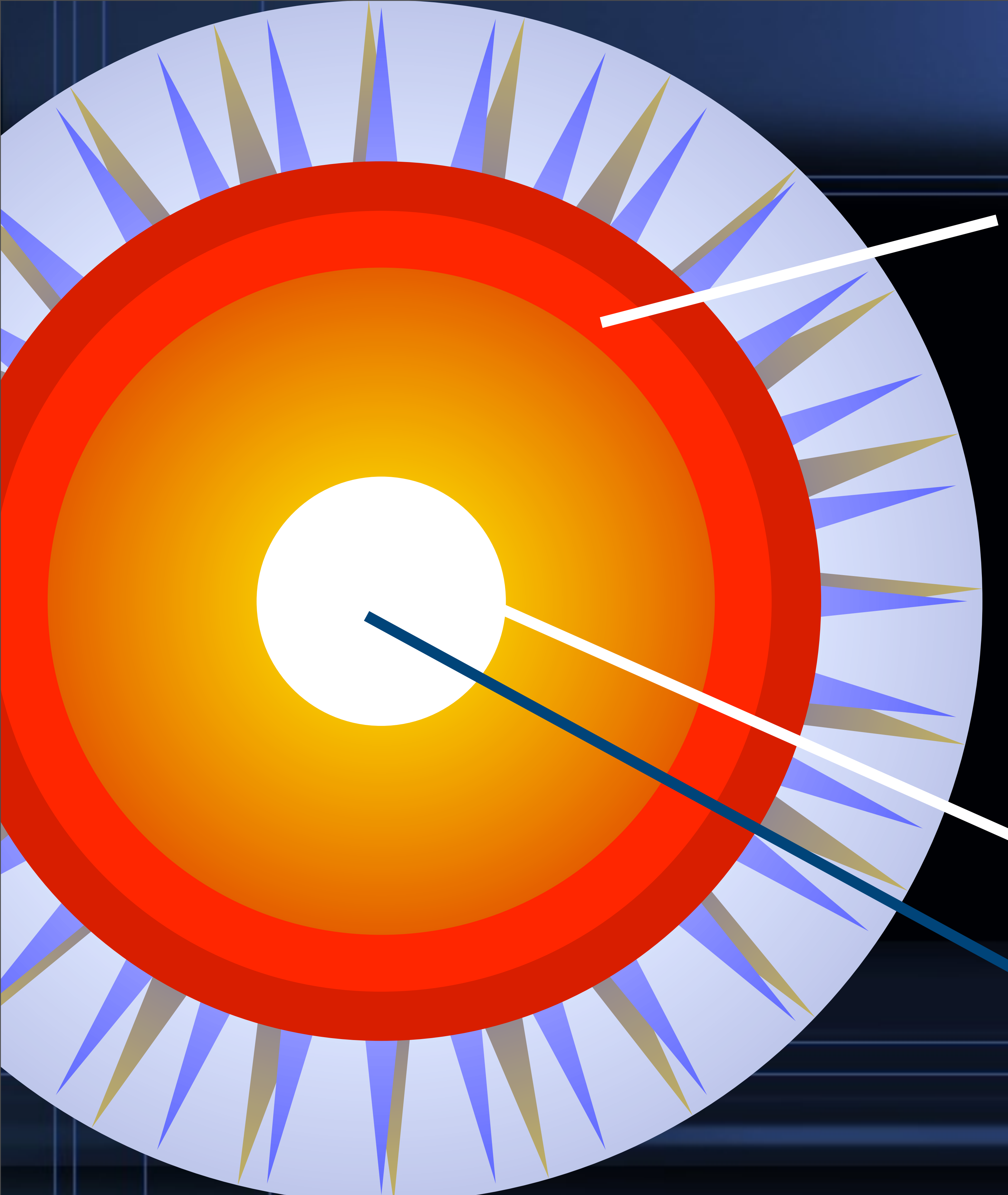
Photosphere-
- Temp-6000ºC
- 550 km thick
- Surface of the sun

Core-



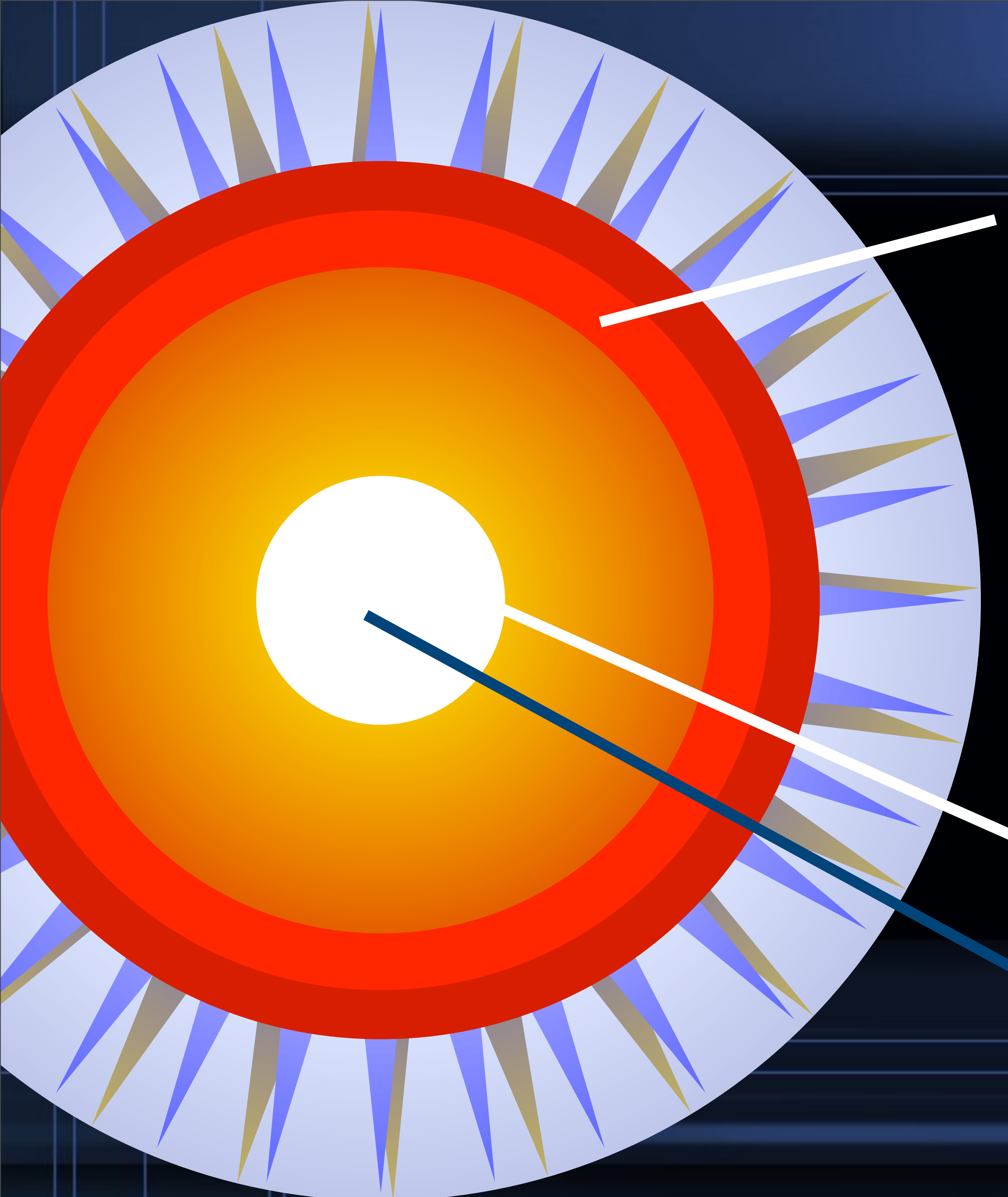
Photosphere-
- Temp-6000ºC
- 550 km thick
- Surface of the sun

Core-
1,000,000ºC



Photosphere-
- Temp-6000ºC
- 550 km thick
- Surface of the sun

Core-
1,000,000ºC



Photosphere-

•Temp-6000ºC

•550 km thick

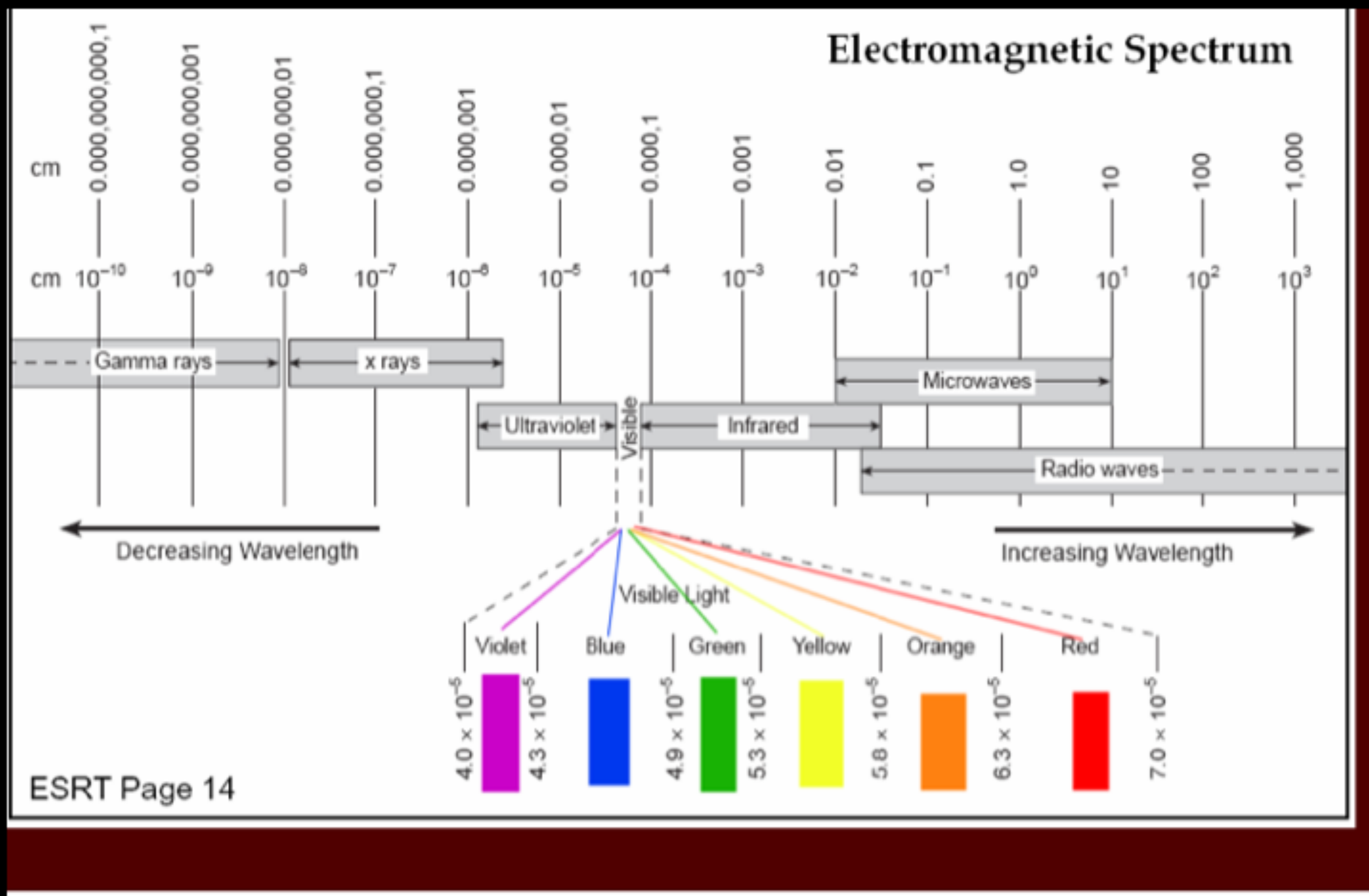
•Surface of the sun

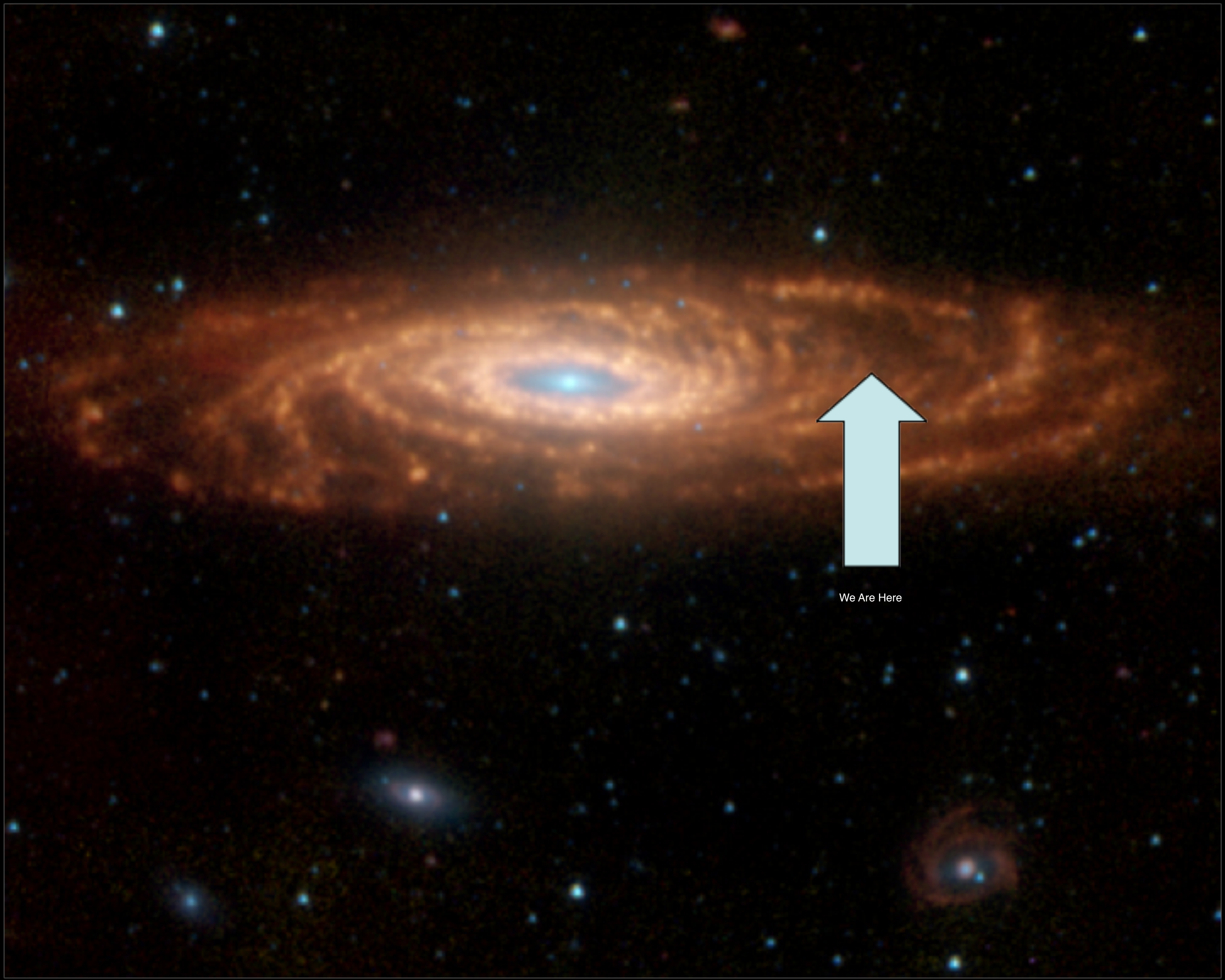
Core-

1,000,000ºC

15,000,000ºC

Electromagnetic Spectrum




We Are Here

Lab # 6

The H-R Diagram- Stellar Luminosity and Temperature

Introduction: Astronomers use two basic properties of stars to classify them. These two properties are luminosity, or brightness, and surface temperature. Astronomers will often use a star's color to measure it's temperature. Stars with low temperature produce a reddish light, while stars with high temperature shine with a brilliant blue-white light. Surface temperatures of stars range from 2,000 Kelvin to 50,000 Kelvin. When these surface temperatures are plotted on a graph against luminosity, the stars fall into groups.

Problem: To create a Hertzsprung-Russell diagram.

Procedures:

1. Plot the stars listed below on the graph paper provided.
2. Draw a circle around each grouping of stars on the graph.
3. Label the following on your graph: ***Main Sequence, Red Giants, White Dwarfs, Supergiants.***
4. Circle the dot representing the Sun.

Due at the end of class,
no exceptions!

November 9, 2012

Agenda:

(1) Read & annotate Characteristics of Stars (homework from before Sandy)

(2) With a partner, make a list of six facts from the reading.

(3) Review your homework with

Light is one form of electromagnetic energy. All electromagnetic energy travels through space at a speed of 3×10^8 meters per second. That is fast enough to travel around Earth seven times in just one second! Sunlight takes only eight minutes to travel from the sun to Earth.

Figure 28-1 shows that electromagnetic energy includes a wide range of wavelengths. Visible light makes up a small part of the electromagnetic spectrum. However, most of the energy given off by the sun is in the form of visible light. Invisible forms of radiation in sunlight are less intense than visible light.

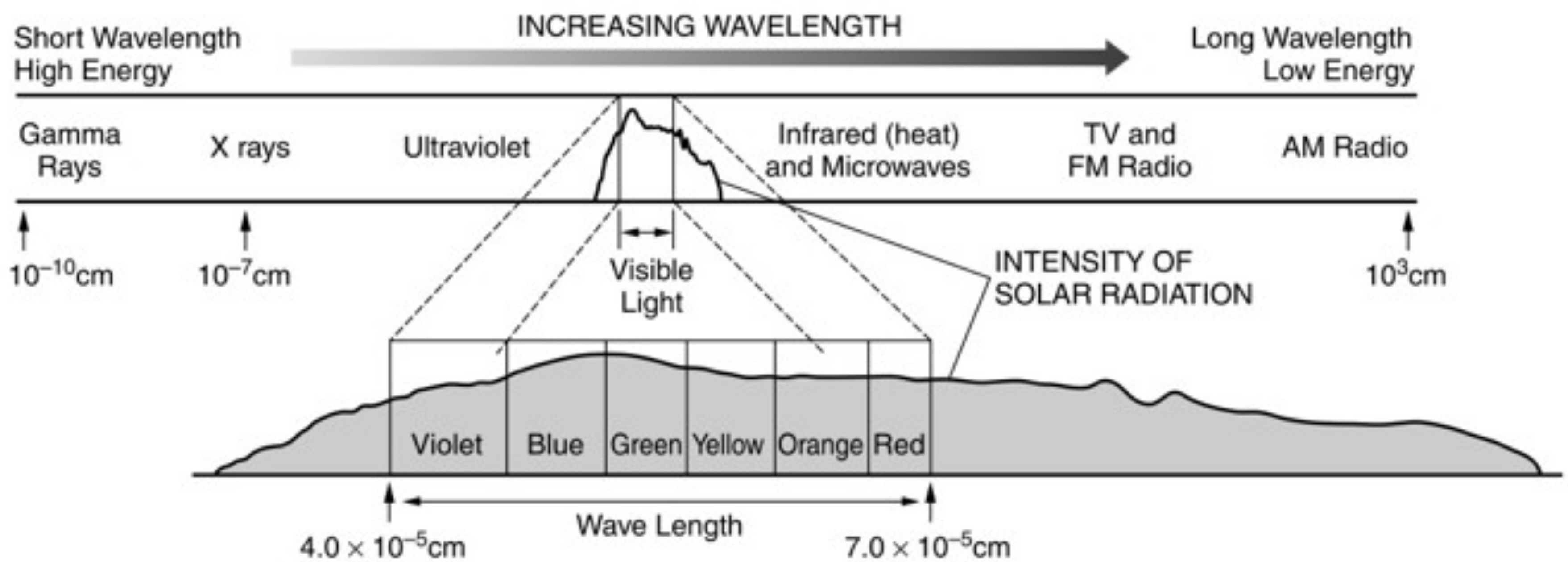


FIGURE 28-1. The sun gives off electromagnetic radiation that is visible and invisible.

White light is a mixture of all the colors of the rainbow. Sir Isaac Newton demonstrated the compound nature of white light when he passed a ray of sunlight through a glass prism as shown in Figure 28-2. Light slows and bends when it travels at an angle through glass. The colors separate because when sunlight enters glass, short wavelengths, such as blue light, are slowed more

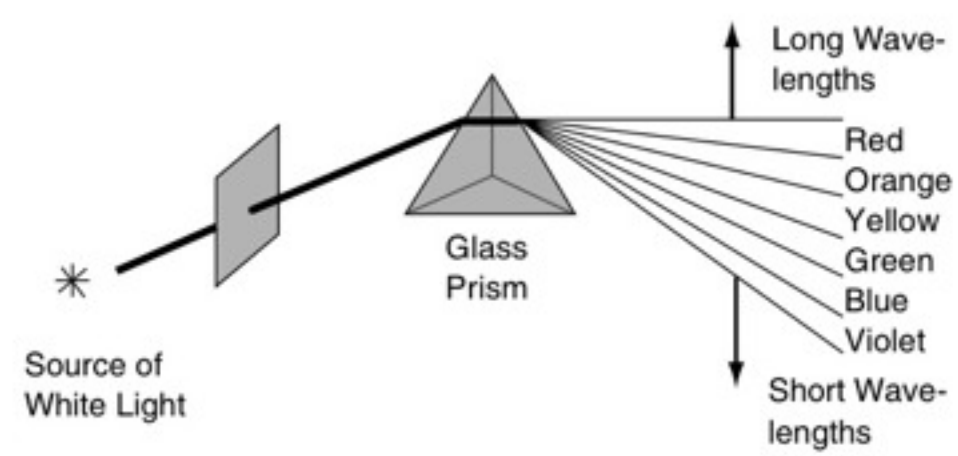


FIGURE 28-2. A glass prism can split light into its

than long wavelengths, such as red. Therefore the blue end of the spectrum is bent more than the red end, and the colors separate.

1. Name the six colors of the visible spectrum.

2. What part of the electromagnetic spectrum can our eyes detect?

3. Name three forms of electromagnetic energy that our eyes cannot see.

4. Which invisible electromagnetic energy has the shortest wavelength?

5. How can you demonstrate that white light is a mixture of colors?

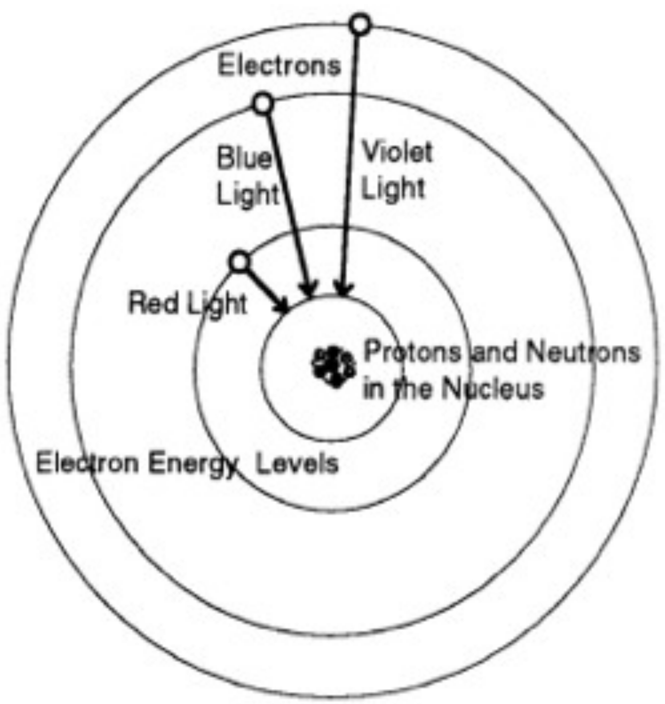


FIGURE 28-3. Various colors of light are given off when electrons fall to different energy levels within an atom.

Electromagnetic energy results from the movement of charged particles. Electrons within the atom can be bumped to a higher energy level by absorbing heat or light energy. When an electron falls back to a lower level, it gives off a photon (particle) of light. A small jump produces red light, and a larger jump creates light near the blue end of the visible spectrum. The color of light absorbed when an electron is boosted to a higher level, is the same color that is given off when it falls back to the lower energy level. Thus, the color of light is a clue to how it was created.

Each element has its own characteristic energy levels. These energy levels determine the wavelength of light given off when the element is heated to glowing. Thus, the colors of light given off by an element are like its fingerprints. Each element can be identified by the colors in its own spectrum.

Astronomers can use glass prisms, diffraction gratings, or other devices to split the light from distant stars into a spectrum of colors. This technique allows them to determine the mass, surface temperature, recession or approach velocity, and the chemical composition of stars. They can do this in spite of the fact that most stars are so far away they appear as tiny points of light even in the world's most powerful telescopes.

than long wavelengths, such as red. Therefore the blue end of the spectrum is bent more than the red end, and the colors separate.

1. Name the six colors of the visible spectrum.

   Red, orange, yellow, green, blue, and violet.

2. What part of the electromagnetic spectrum can our eyes detect?

   Visible light

3. Name three forms of electromagnetic energy that our eyes cannot see.

   Answers include gamma rays, X-rays, ultraviolet, infrared, and radio

4. Which invisible electromagnetic energy has the shortest wavelength?

   Gamma rays

5. How can you demonstrate that white light is a mixture of colors?

   White light can be separated into its component colors.

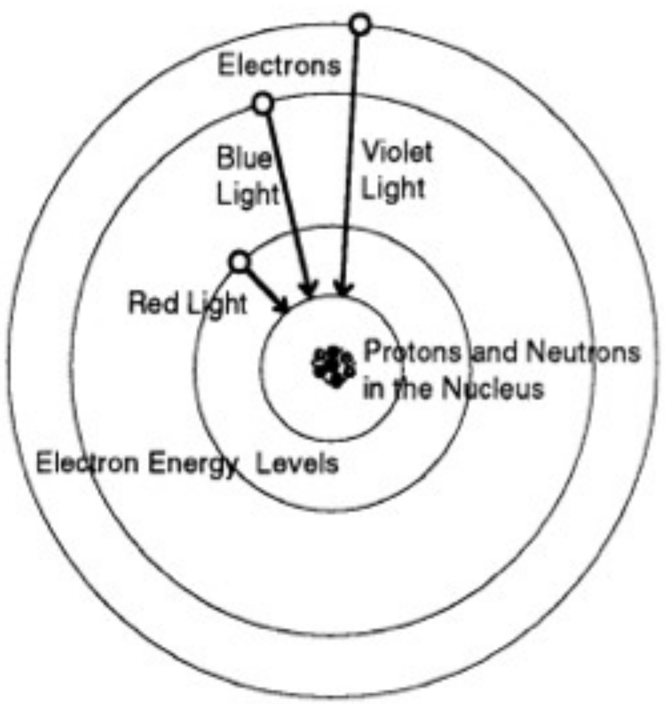


FIGURE 28-3. Various colors of light are given off when electrons fall to different energy levels within an atom.

Electromagnetic energy results from the movement of charged particles. Electrons within the atom can be bumped to a higher energy level by absorbing heat or light energy. When an electron falls back to a lower level, it gives off a photon (particle) of light. A small jump produces red light, and a larger jump creates light near the blue end of the visible spectrum. The color of light absorbed when an electron is boosted to a higher level, is the same color that is given off when it falls back to the lower energy level. Thus, the color of light is a clue to how it was created.

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6. What happens to electrons that absorb light energy?

7. What change within an atom causes it to give off light?

8. What determines the color of the light given off?

9. What color of visible light is produced by the longest wavelength of visible light?

10. What color of visible light is produced by the shortest wavelength of visible light?

For the next three questions, use the Electromagnetic Spectrum table (page 14) from the *Earth Science Reference Tables.*

11. What is the average wavelength of X-rays?

12. What is the range of wavelengths of visible light?

13. Which has a longer wavelength, ultraviolet rays or infrared rays?

6. What happens to electrons that absorb light energy?

They move to a higher energy level.

7. What change within an atom causes it to give off light?

Electrons that have moved to a higher energy level drop to lower energy levels.

8. What determines the color of the light given off?

Its wavelength

9. What color of visible light is produced by the longest wavelength of visible light?

Red

10. What color of visible light is produced by the shortest wavelength of visible light?

Violet

For the next three questions, use the Electromagnetic Spectrum table (page 14) from the *Earth Science Reference Tables*.

11. What is the average wavelength of X-rays? 10^{-7} cm

12. What is the range of wavelengths of visible light?

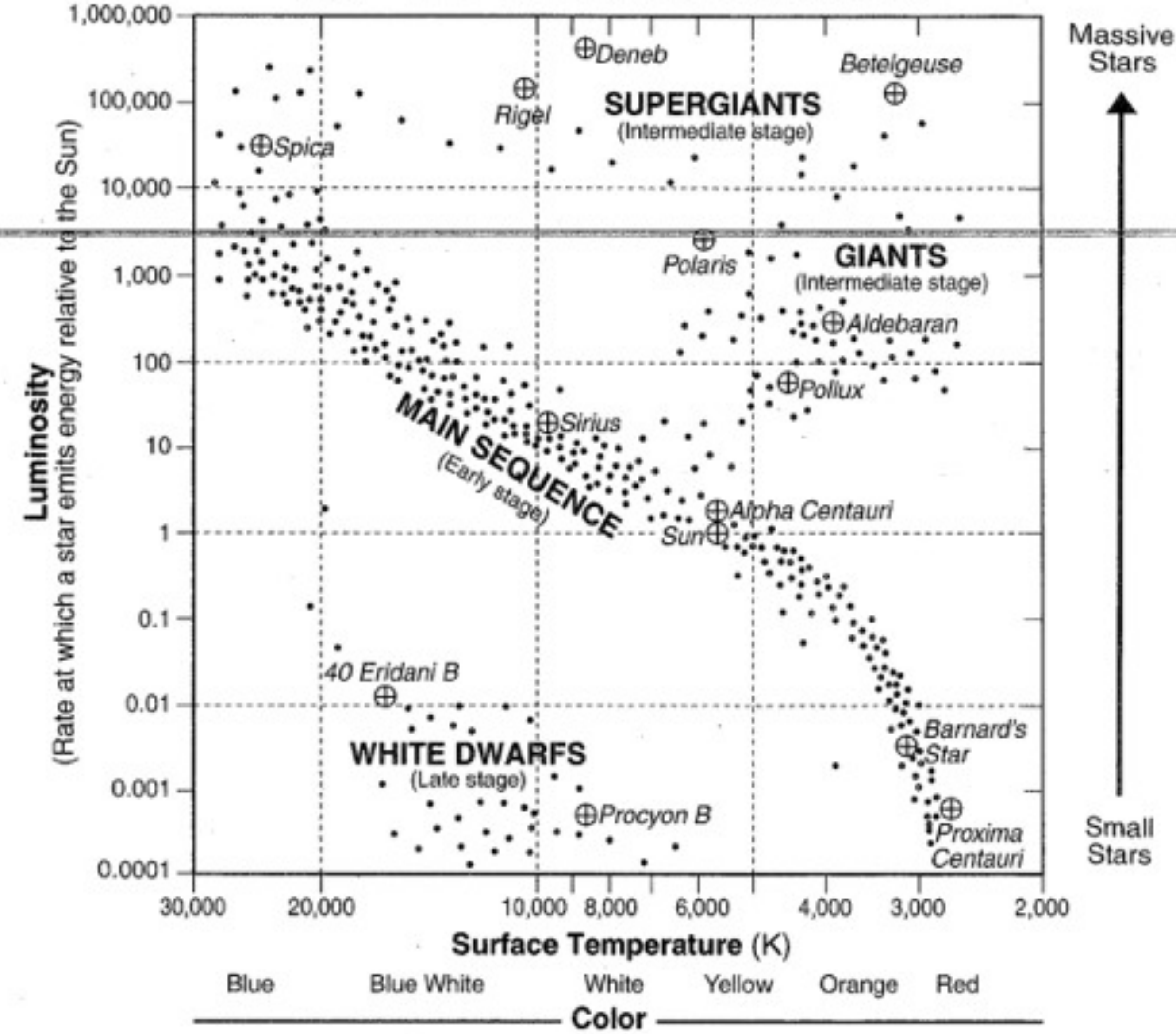
4.0×10^{-5} to 7.0×10^{-5} cm

13. Which has a longer wavelength, ultraviolet rays or infrared rays?

Infrared rays

Characteristics of Stars

(Name in italics refers to star represented by a ⊕.)
(Stages indicate the general sequence of star development.)



Overview:

When stars were plotted according to their temperature and luminosity (brightness) a strange pattern occurred. Most of the stars fell within a specific region that ran diagonally across the chart, later to be named the main sequence. Stars off the main sequence fall mainly into groups of supergiants, giants and white dwarfs. Years later, it was discovered that this chart revealed stellar evolution according to their position on this chart. Stars spend most of their active lives on the main sequence (Early stage), being young and average age stars. Eventually in the later stages of stellar evolution a star moves off this main sequence area.

Stars, through nuclear fusion, convert hydrogen fuel into heavier elements, mostly helium. This nuclear reaction will continue for millions or billions of years, generating the star's energy. Eventually, when the hydrogen fuel starts to become exhausted, stars, in reaction to the force of gravity, expand greatly, becoming giants or supergiant stars (intermediate stages). This expansion causes the star's surface temperature to cool. When these events occur, the star moves off the main sequence, indicating that the star has entered into its dying stages. In time these dying, giant stars, depending on their mass, can collapse to become white dwarf stars (late stage), or explode violently as a supernova. Our Sun is an average yellow star and is presently positioned on the main sequence. One day when its fuel runs out, our Sun will greatly expand to become a red giant, vaporizing some of the inner planets, while toasting the Earth. It will eventually collapse and become a white dwarf. But not to worry, this will not happen this year, so concentrate on passing the regents. The two scientists that independently made this chart, Hertzsprung and Russell, are credited for making a tremendous contribution to astronomy. Thus, this chart is usually referred to as the H-R diagram.

The Graph:

The *x*-axis is the Temperature Scale. The surface temperature of a star produces its color. Red stars are the coolest, having a temperature around 3,000 K, while blue stars are the hottest and may have temperatures over 20,000 K. Our yellow Sun is shown to have a surface temperature just over 5,000 K. On the left side of the *y*-axis is the Luminosity Scale and on the right side the relative size of the stars are given. This scale shows the relative brightness of stars compared to our Sun, if they were placed side by side at a given distance from the Earth. Our Sun is assigned the luminosity value of 1. As expected, small stars would have a low luminosity value while massive, larger stars would be very bright, having a high luminosity value. The white dwarf stars are quite hot, but being so small, are relatively dull, as shown by their low luminosity value. Betelgeuse is a red giant star that has a low temperature, around 3,500K, but due to its large size, has a luminosity just over 100,000 times that of our Sun.

Additional Information:

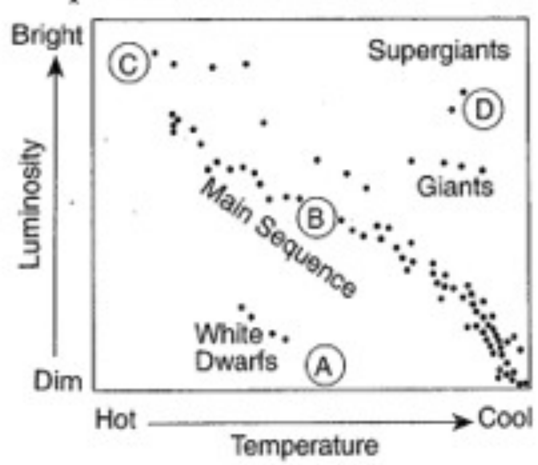
- There are two types of magnitude (brightness): absolute magnitude and relative magnitude. Relative magnitude is how bright a star appears to us in the night sky. Absolute magnitude (which this chart is based on) is a measurement of a star's luminosity (brightness) from a set distance from the Earth.
- Astronomers believe that a black hole is formed from the collapse of the core of a massive star. This black hole creates so much gravity that light can't escape.
- In nuclear fusion a small amount of matter is converted into a tremendous amount of energy in accordance with Einstein equation, $E = mc^2$, where E = energy, m = mass and c is the speed of light squared.
- Our Sun is approximately 4.6 billion years old and is expected to last another 4 to 5 billion years.

Set 1 — Characteristics of Stars

1. Which star color indicates the hottest star surface temperature?

   (1) blue (3) yellow
   (2) white (4) red 1 _______

2. The graph below represents the brightness and temperature of stars visible from Earth.



   Which location on the graph best represents a star with average brightness and temperature?

   (1) *A* (3) *C*
   (2) *B* (4) *D* 2 _______

3. Compared with our Sun, the star Betelgeuse is

   (1) smaller, hotter, and less luminous
   (2) smaller, cooler, and more luminous
   (3) larger, hotter, and less luminous
   (4) larger, cooler, and more luminous 3 _______

4. Which star is cooler and many times brighter than Earth's Sun?

   (1) Barnard's Star (3) Rigel
   (2) Betelgeuse (4) Sirius 4 _______

5. Which two stars have the most similar luminosity and temperature?

   (1) Betelgeuse and Barnard's Star
   (2) Rigel and Betelgeuse
   (3) Alpha Centauri and the Sun
   (4) Sirius and Procyon B 5 _______

6. Compared to the temperature and luminosity of the star Polaris, the star Sirius is

   (1) hotter and more luminous
   (2) hotter and less luminous
   (3) cooler and more luminous
   (4) cooler and less luminous 6 _______

7. In nuclear fusion what occurs?

   (1) Lighter elements are converted to heavier elements.
   (2) Lighter elements are converted to even lighter elements.
   (3) Heavier elements are converted to lighter elements.
   (4) Heavier elements chemically combine with lighter elements. 7 _______

8. Betelgeuse and Aldebaran are both red-giant stars. Give a statement comparing their luminosity and temperature values.

____

9. A star located off the main sequence indicates what?

Set 2 — Characteristics of Stars

10. Compared to the surface temperature and luminosity of massive stars in the Main Sequence, the smaller stars in the Main Sequence are

(1) hotter and less luminous
(2) hotter and more luminous
(3) cooler and less luminous
(4) cooler and more luminous 10 ______

11. Which star's surface temperature is closest to the temperature at the boundary between Earth's mantle and core?

(1) Sirius (3) the Sun
(2) Rigel (4) Betelgeuse 11 ______

Base your answers to 12 and 13 on the passage below.

The Future of the Sun

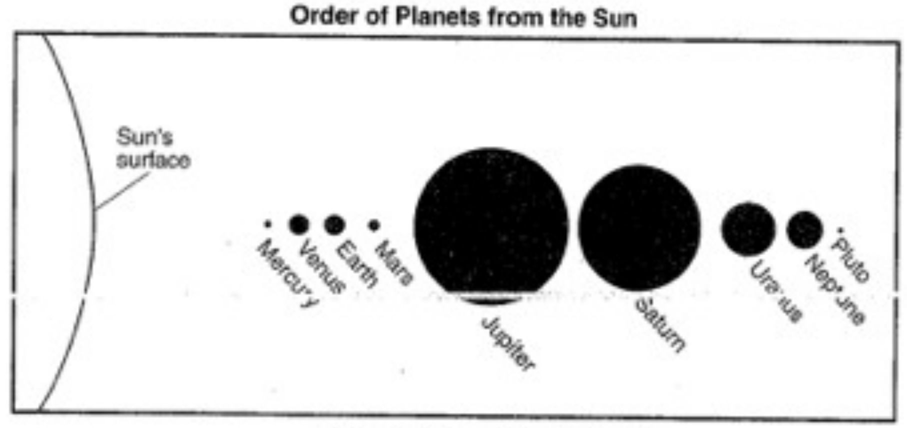
Hydrogen gas is the main source of fuel that powers the nuclear reactions that occur in the Sun. But just like many sources of fuel, the hydrogen is in limited supply. As the hydrogen gas is used up, scientists predict that the helium created as an end product of earlier nuclear reactions will begin to fuel new nuclear reactions. When this happens, the Sun is expected to become a red giant star with a radius that would extend out past the orbit of Venus and possibly out as far as Earth's orbit. Earth will probably not survive this change in the Sun's size. But no need to worry at this time. The Sun is not expected to expand to this size for a few billion years.

12. Identify the nuclear reaction referred to in this passage that combines hydrogen gas to form helium and produces most of the Sun's energy.

____

13. On the diagram of the planets and the Sun's surface, draw a vertical line to represent the inferred location of the Sun's surface when it becomes a red giant star.

Order of Planets from the Sun

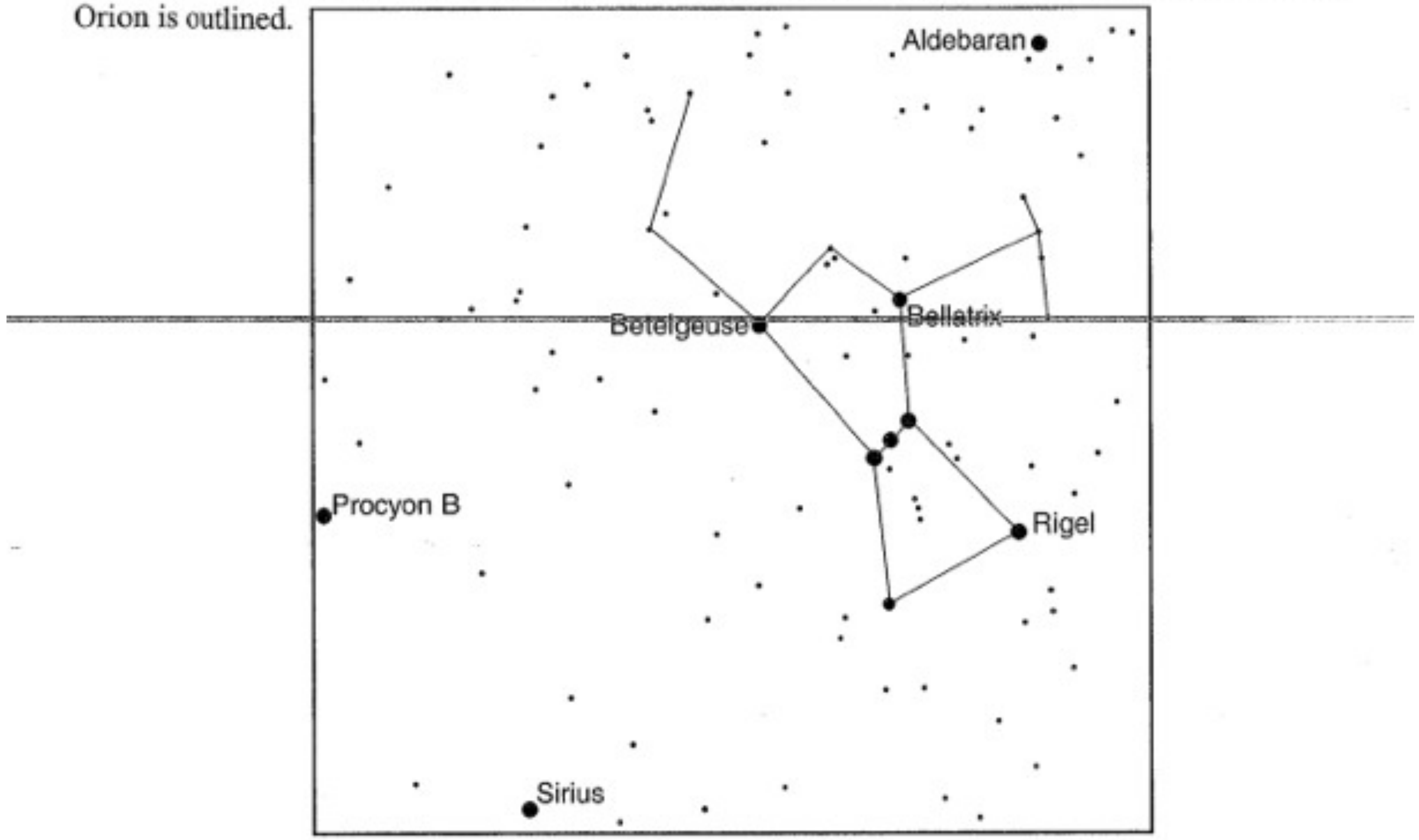


(Distances are not drawn to scale)

14. Explain why a giant star that is cooler than our Sun, similar to Aldebaran, has a greater luminosity than the Sun. ______________________________

____

Base your answers to questions 15*a* and *b* on the accompanying star chart, which shows part of the winter sky visible from New York State. Some of the brighter stars are labeled and the constellation Orion is outlined.



15. *a*) Identify the color of the star Bellatrix, which has a surface temperature of approximately 21,000 K. ____________________

b) In the accompanying space, list the stars, other than Bellatrix, found on the chart in order of decreasing luminosity. Rigel, the most luminous star, has been listed.

Most luminous	(1)	Rigel
	(2)	______
	(3)	______
	(4)	______
Least luminous	(5)	______

16. Give a statement on the relationship between Temperature and Luminosity of the main sequence stars.

____

____

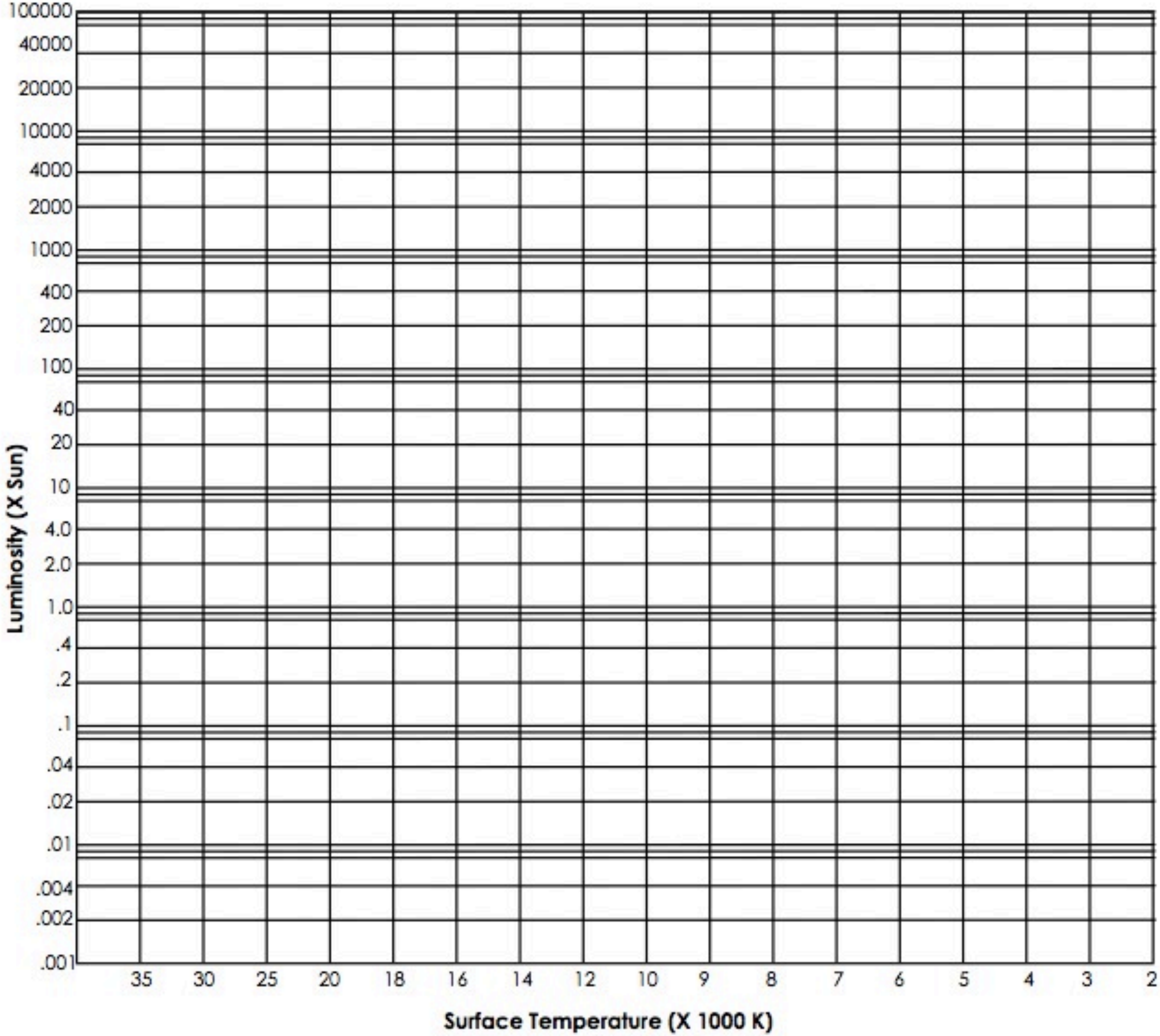
November 13, 2012

Agenda: *Review for test*

(1) Cornell Notes (use your notes or textbook pages 682 - 707)

(2) Notes are due at end of class (5 pts towards your

Star	Luminosity (X Sun)	Surface Temperature (X 1000 K)
Orion	10,000	20
Polaris	6	5.9
Antares	1,000	3
Spica	800	25
Vega	40	12
Procyon A	50	6.9
Regulus	1,000	18
Lacaille	0.02	4.5
Sirius B	0.01	8
Betelgeuse	20,000	3
Achemar	2,000	24
Aldebaran	100	4
Ceti	0.1	4.5
Sirius A	20	11
Sun	1	5.7
Procyon B	0.004	6.6
Altair	0.01	9
Alpha Centauri	1.6	5.7


100000
40000
20000
10000
4000
2000
1000
400
200
100
40
20
10
4.0
2.0
1.0
.4
.2
.1
.04
.02
.01
.004
.002
.001
Luminosity (X Sun)
35
30
25
20
18
16
14
12
10
9
8
7
6
5
4
3
2
Surface Temperature (X 1000 K)

Conclusion Questions:

1. How many types of stars are shown on the H-R Diagram? ______________________________

2. How does the temperature and luminosity of the Sun compare to that of the other stars on the Main Sequence? ____

3. What is the relationship between luminosity and temperature for stars on the Main Sequence? ____

4. Which is the hottest star plotted? ________________ the brightest? _________________________

Regents Questions:

1. According to the *Luminosity and Temperature of Stars* Earth Science reference table, the Sun is classified as a

A) blue supergiant star with a temperature of approximately 20,000K and a luminosity of 700,000

B) main sequence star with a temperature of approximately 5,500K and a luminosity of 1

C) main sequence star with a temperature of approximately 4,000K and a luminosity of 100

D) white dwarf star with a temperature of approximately 10,000K and a luminosity of 0.01

2. Which star is cooler and many times brighter than Earth's Sun?

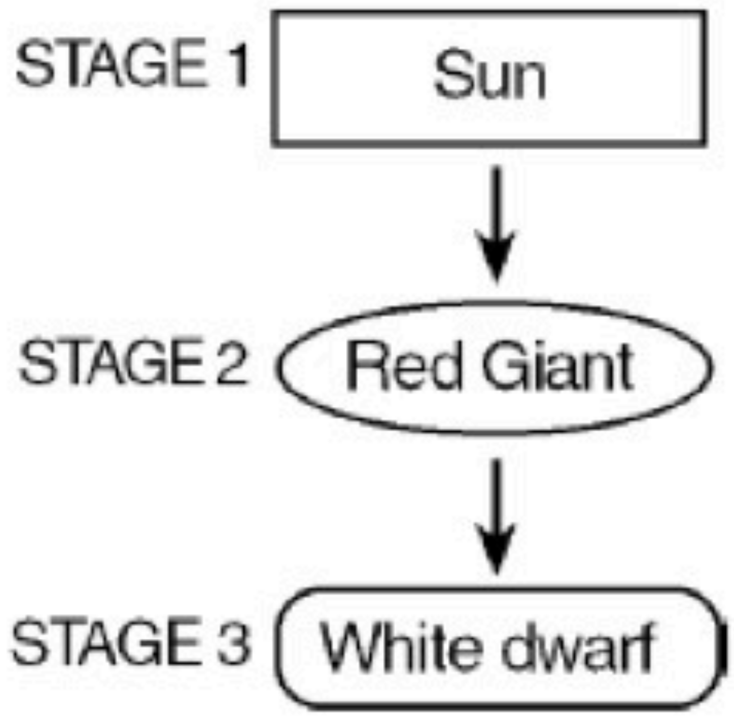
A) Rigel

B) Betelgeuse

C) Barnard's Star

D) Sirius

3. Stars are believed to undergo evolutionary changes over millions of years. The flowchart below shows stages of predicted changes in the Sun.



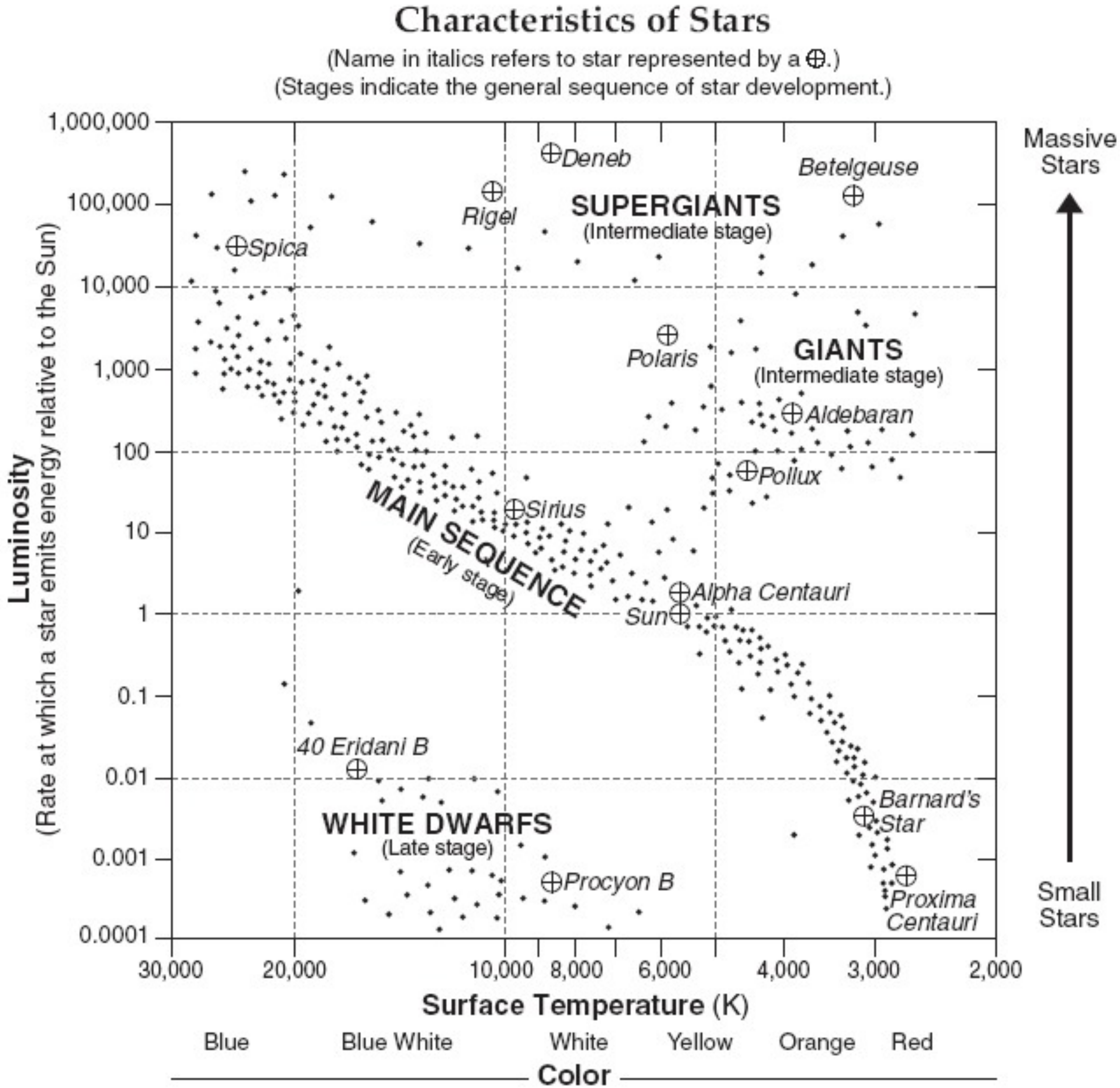
According to the *Luminosity and Temperature of Stars* Earth Science reference table and the flowchart above, the Sun will become

A) hotter and brighter in stage 2, then cooler and dimmer in stage 3
B) cooler and dimmer in stage 2, then hotter and brighter in stage 3
C) cooler and brighter in stage 2, then hotter and dimmer in stage 3
D) hotter and dimmer in stage 2, then cooler and brighter in stage 3

Introduction

When you think of certainty in your life you may think of the march of the sun across the sky each day. When the sun sinks below the horizon, causing night, you are confident that it will rise again at a precisely predictable time and place a few hours later. If the sun were to change significantly, the effect on planet Earth could be catastrophic. In fact, the sun will change as it completes its life cycle.

Find photographs or Internet images that illustrate the various stages in stellar evolution and paste them on Figure 28-5, from the *Earth Science Reference Tables*. Label each image with the name of a star that is currently in that stage of stellar evolution. On your diagram, draw a line or lines to show the evolution of stars from their formation to the time they no longer give off significant amounts of visible electromagnetic energy.



Characteristics of Stars
(Name in italics refers to star represented by a ⊕.)
(Stages indicate the general sequence of star development.)
Luminosity
(Rate at which a star emits energy relative to the Sun)
1,000,000
100,000
10,000
1,000
100
10
1
0.1
0.01
0.001
0.0001
Deneb
Betelgeuse
Rigel
SUPERGIANTS
(Intermediate stage)
Spica
Polaris
GIANTS
(Intermediate stage)
Aldebaran
Pollux
Sirius
MAIN SEQUENCE
(Early stage)
Alpha Centauri
Sun
40 Eridani B
WHITE DWARFS
(Late stage)
Procyon B
Barnard's Star
Proxima Centauri
Massive Stars
Small Stars
30,000
20,000
10,000
8,000
6,000
4,000
3,000
2,000
Surface Temperature (K)
Blue
Blue White
White
Yellow
Orange
Red
Color

Wrap-Up

1. How long will it take for the sun to complete its evolution?

   The evolution of the sun is expected to take about 10 billion years.

2. How do stars make electromagnetic energy?

How do stars make electromagnetic energy? Nuclear fusion in a star's core produces energy that moves mostly by convection to the stellar surface where it radiates as various forms of electromagnetic energy.

3. Why do stars change?

   Stars change because as they age, the elements used for fusion change, which changes the energy the star produces.

4. Do you think that future changes in the sun will play an important part in the future of humans? Please explain your answer.

   Answers will vary. One possibility is that by the time the sun changes significantly, it is unlikely that humans will exist due to biological evolution or some kind of human-caused or natural disaster. Accept all reasonable answers.

CHAPTER 28—LAB 2: IS THE SUN AN AVERAGE STAR?

Introduction

Clearly, the easiest star to study is our sun. However, can we reasonably assume that most stars are like the sun? On the other hand, is the sun unusual in more than how close it is to Earth? To answer this question, we will use a graph developed by two astronomers. The graph is called the Hertzsprung-Russell (H-R) diagram.

Objective

You will plot the characteristics of the sun and other stars on the Hertzsprung-Russell diagram, to determine whether the sun is a typical star. The Hertzsprung-Russell diagram will show whether the sun is much brighter, dimmer, hotter, or cooler than most other stars. If that is what you find, you should be careful in thinking of our sun as a typical star. If, on the other hand, the sun is near the center of the group of stars, it would appear to be typical.

However, in this lab you will find that there is another important issue in using this method. You must also consider the group of stars that you use to compare with the sun. If you select an atypical group, the comparison will not be valid. How can you select the most representative group of stars?

5. How do scientists know that the sun will evolve in a particular way?

By looking out into deep space, astronomers see stars in various stages of evolution, which they can relate to the sun by inference.

6. Some stars do not follow the same path as the sun and similar stars. Why?

Stellar mass determines both how a star will develop and how long it will take. (Larger stars evolve more explosively and more rapidly.)

Procedure

Part I

Table 28-2 lists the twenty brightest stars we see from Earth. If you have observed the night sky, these star and constellation names may already be familiar to you. Plot the sun as a letter *S* on the H-R diagram (Figure 28-4), and then plot each of the other stars as a small *x*.

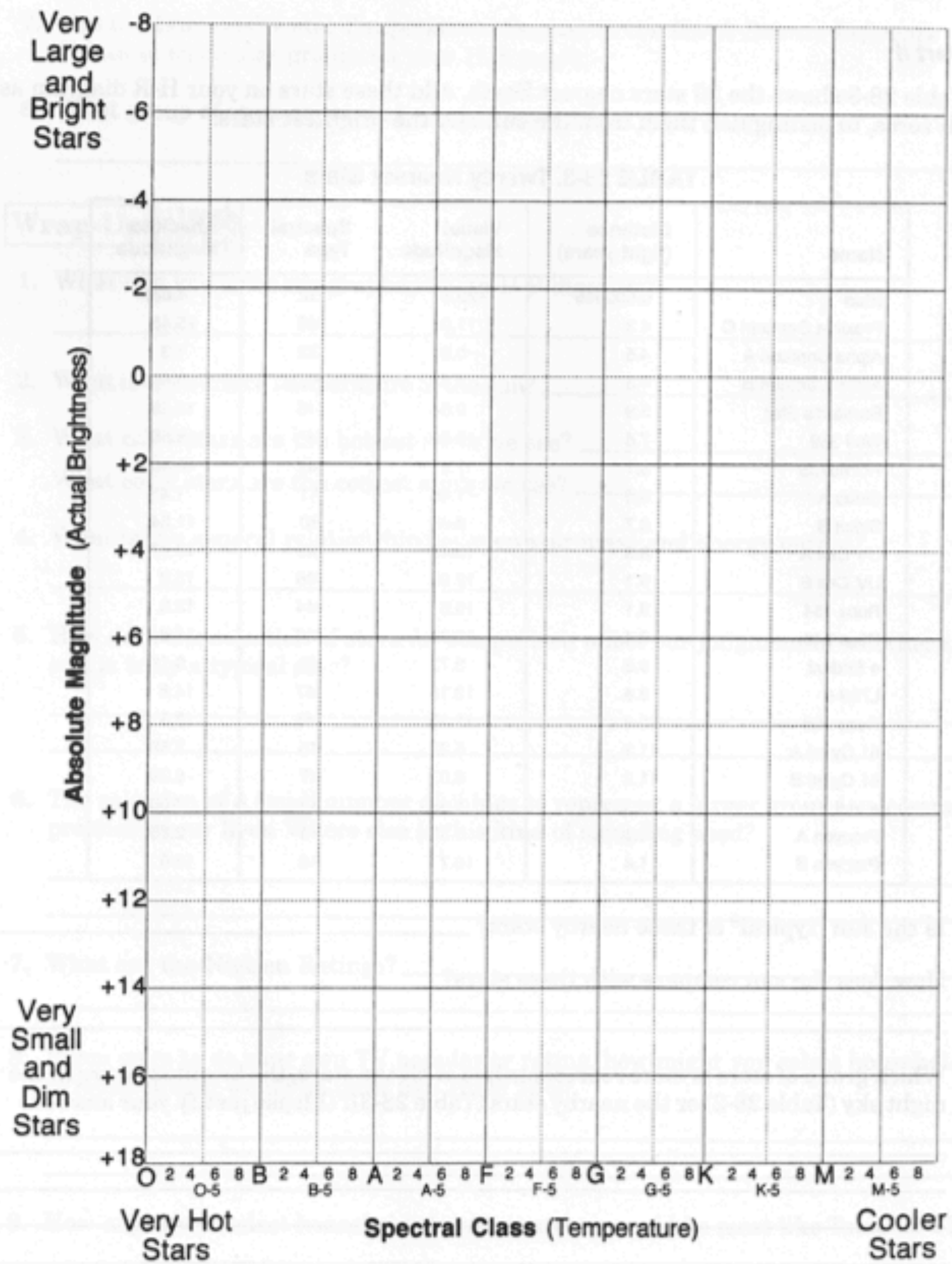
TABLE 28-2. The 20 Brightest Stars

Name	Constellation	Visual Magnitude	Spectral Type	Absolute Magnitude
Sun	None	−26.72	G2	+4.8
Sirius	Canis Major	−1.46	A1	+1.4
Canopus	Carina	−0.72	F0	−3.1
Rigil	Centaurus	−0.01	G2	+4.4
Arcturus	Boötes	−0.06	K2	−0.3
Vega	Lyra	0.04	A0	+0.5
Capella	Auriga	0.05	G8	−0.67
Rigel	Orion	0.14	B8	−7.1
Procyon	Canis Minor	0.37	F5	+2.6
Betelgeuse	Orion	0.41	M2	−5.6
Achernar	Eridanus	0.51	B3	−2.3
Hadar	Centaurus	0.63	B1	−5.2
Altair	Aquilla	0.76	A7	+2.2
Aldebaran	Taurus	0.86	K5	−0.7
Acrux	Southern Cross	0.90	B2	−3.5
Spica	Virgo	0.91	B1	−3.3
Antares	Scorpius	0.92	M1	+5.1
Fomalhaut	Pices Austrinis	1.15	A3	2.0
Pollux	Gemini	1.16	K0	+1.0
Deneb	Cygnus	1.26	A2	−7.1

1. How does the sun compare with the other bright stars we see in the sky?

____

2. Would you call the sun a "typical" member of this group of bright stars? ____________



Very Large and Bright Stars
-8
-6
-4
-2
0
+2
+4
+6
+8
+10
+12
+14
+16
+18
Very Small and Dim Stars
Absolute Magnitude (Actual Brightness)
O 2 4 6 8 B 2 4 6 8 A 2 4 6 8 F 2 4 6 8 G 2 4 6 8 K 2 4 6 8 M 2 4 6 8
O-5 B-5 A-5 F-5 G-5 K-5 M-5
Very Hot Stars
Spectral Class (Temperature)
Cooler Stars

Part II

Table 28-3 shows the 20 stars nearest Earth. Add these stars on your H-R diagram as small zeros, to distinguish them from the sun and the brightest stars.

TABLE 28-3. Twenty Nearest Stars

Name	Distance (light years)	Visual Magnitude	Spectral Type	Absolute Magnitude
(Sun	0.000015	−26.8	G2	4.83)
Proxima Centauri C	4.3	11.05	M5	15.45
Alpha Centauri A	4.5	−0.01	G2	4.3
Alpha Centauri B	4.5	1.33	K5	5.69
Barnard's Star	5.9	9.54	M5	13.25
Wolf 359	7.6	13.53	M8	16.68
HD 95735	8.1	7.5	M2	10.49
Sirius A	8.6	−1.45	A1	1.41
Sirius B	8.7	8.68	B0	11.54
UV Ceti A	8.9	12.45	M5	15.27
UV Ceti B	9.1	12.95	M6	15.8
Ross 154	9.1	10.6	M4	13.3
Ross 248	9.4	12.29	M6	14.8
e Eridani	9.5	3.73	K2	6.13
L789-6	9.6	12.18	M7	14.6
Ross 128	10.8	11.10	M5	13.5
61 Cygni A	11.2	5.22	K5	7.58
61 Cygni B	11.2	6.03	K7	8.39
e Indi	11.3	4.68	K5	7.00
Procyon A	11.4	0.35	F5	2.65
Procyon B	11.4	10.7	A8	13.0

3. Is the sun "typical" of these nearby stars? ______

4. How does the sun compare with these stars?

______

5. Which group of stars is more representative of all the stars, the brightest stars in the night sky (Table 28-2) or the nearby stars (Table 28-3)? (Please justify your answer.)

______

______

______

______

6. Many of the stars in Table 28-2 have names that are unfamiliar to you. Can you suggest why the stars in Table 28-2 have such unusual names?

______

7. Use the Luminosity and Temperature diagram in the *Earth Science Reference Tables* to write star groups on your H-R graph.

8. What group of stars seems to be most common?

______

Wrap-Up

1. What two variables are graphed on an H-R diagram?

____

2. What is the surface temperature of the sun? ______________________

3. What color stars are the hottest stars we see? ______________________

What color stars are the coolest stars we see? ______________________

4. What is the general relationship between star mass and energy output?

____

5. How does the selection of stars for comparison affect our judgment of whether the sun is truly a typical star?

____

____

6. The selection of a small number of things to represent a larger group is a common practice in our lives. Where else is this kind of sampling used?

____

____

7. What are the Nielsen Ratings? ______________________________

____

8. If you were to do your own TV popularity rating, how might you select households to monitor that would be most like Table 28-2?

____

____

9. How might you select households to monitor that would be most like Table 28-3?

____

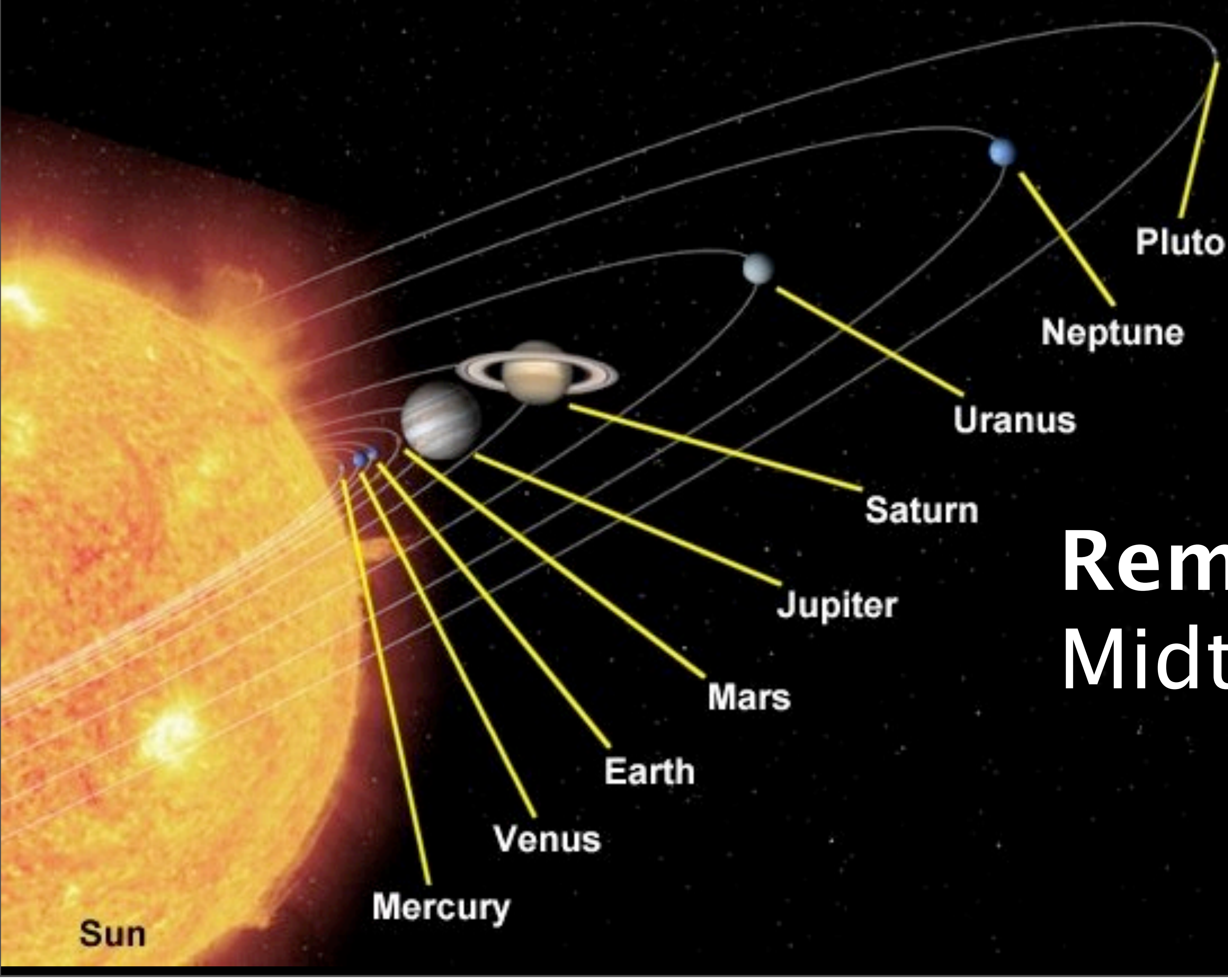
10. If we consider the sun an average star, how can we justify that evaluation? Base your answer to this question on the results of this investigation. (Please explain your answer in one or more complete sentences.)

____

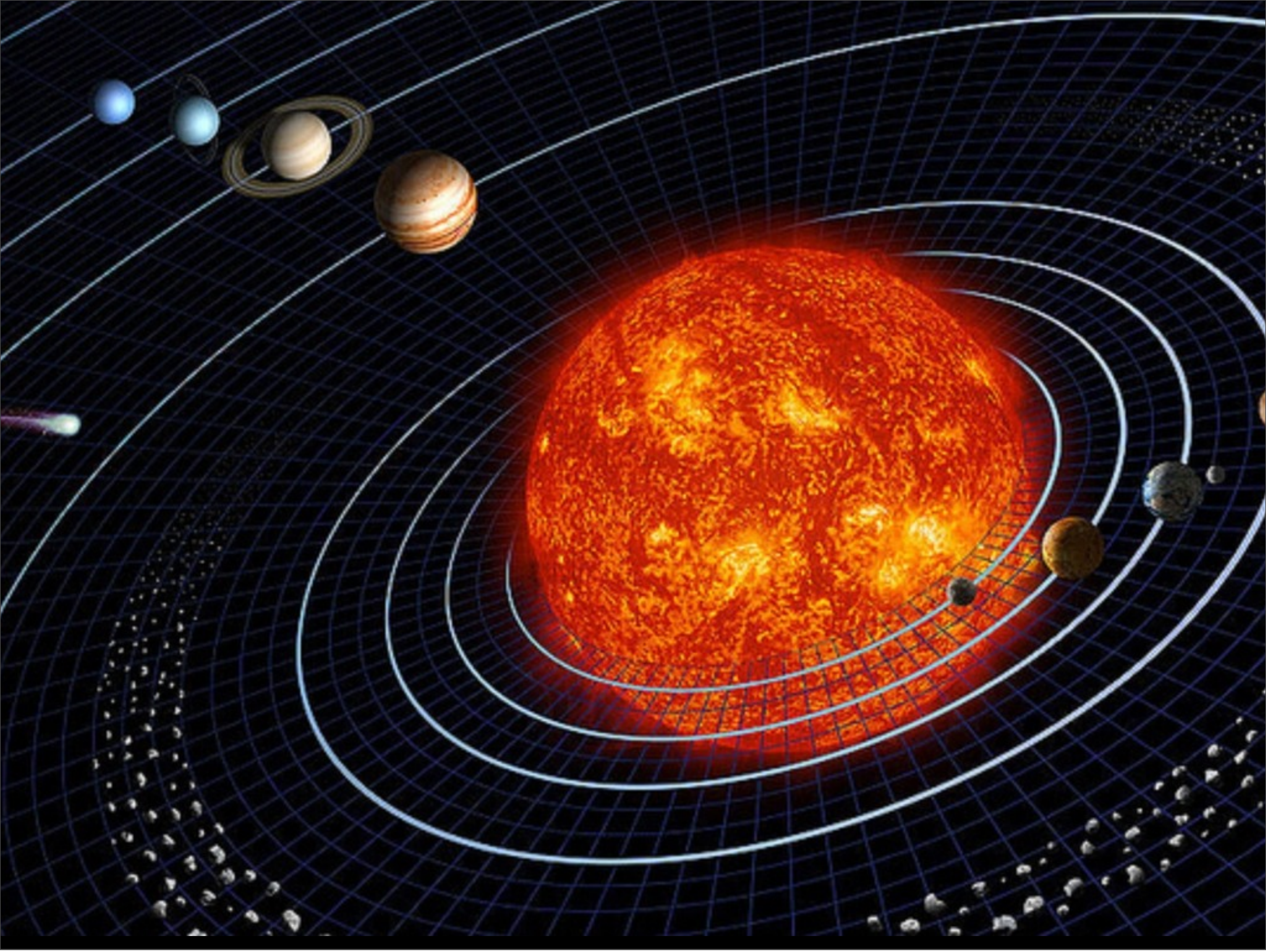
____

Objectives November 26

Define Kepler's 3 Laws of Planetary Motion
Explain the movements of the Planets

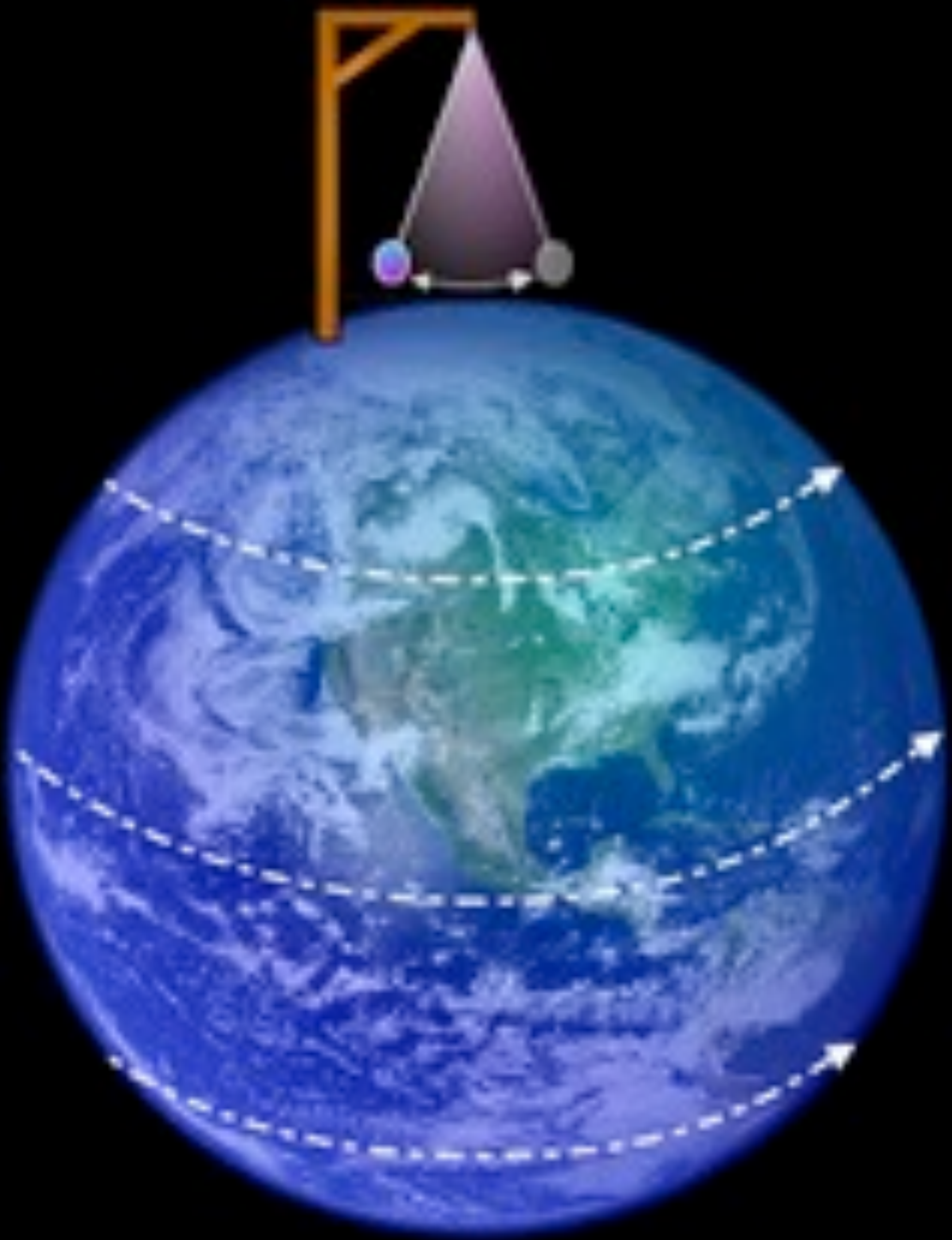


Reminders:
Midterm is on Thursday



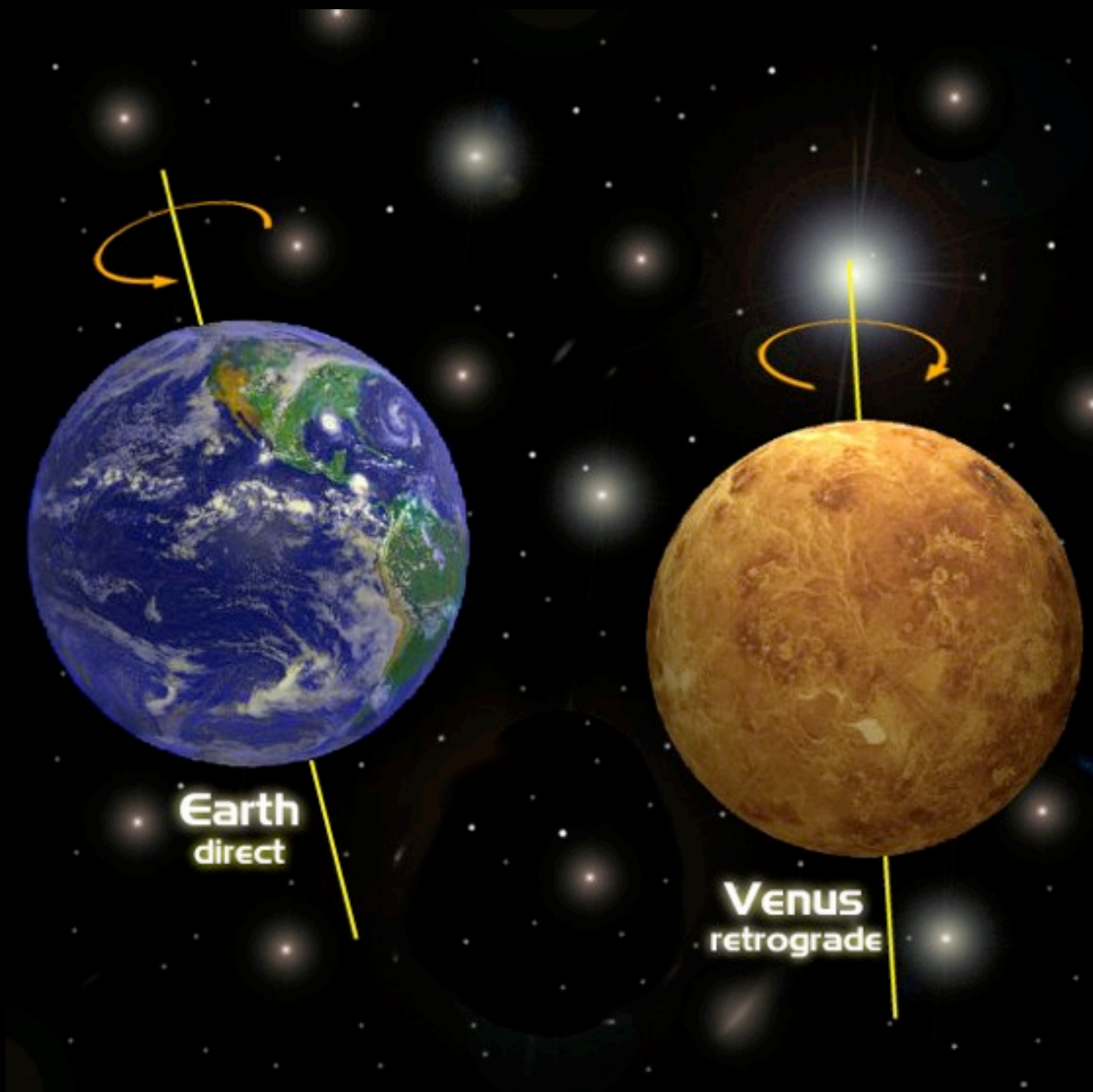
How do we know the Earth rotates?

Foucault Pendulum



Retrograde

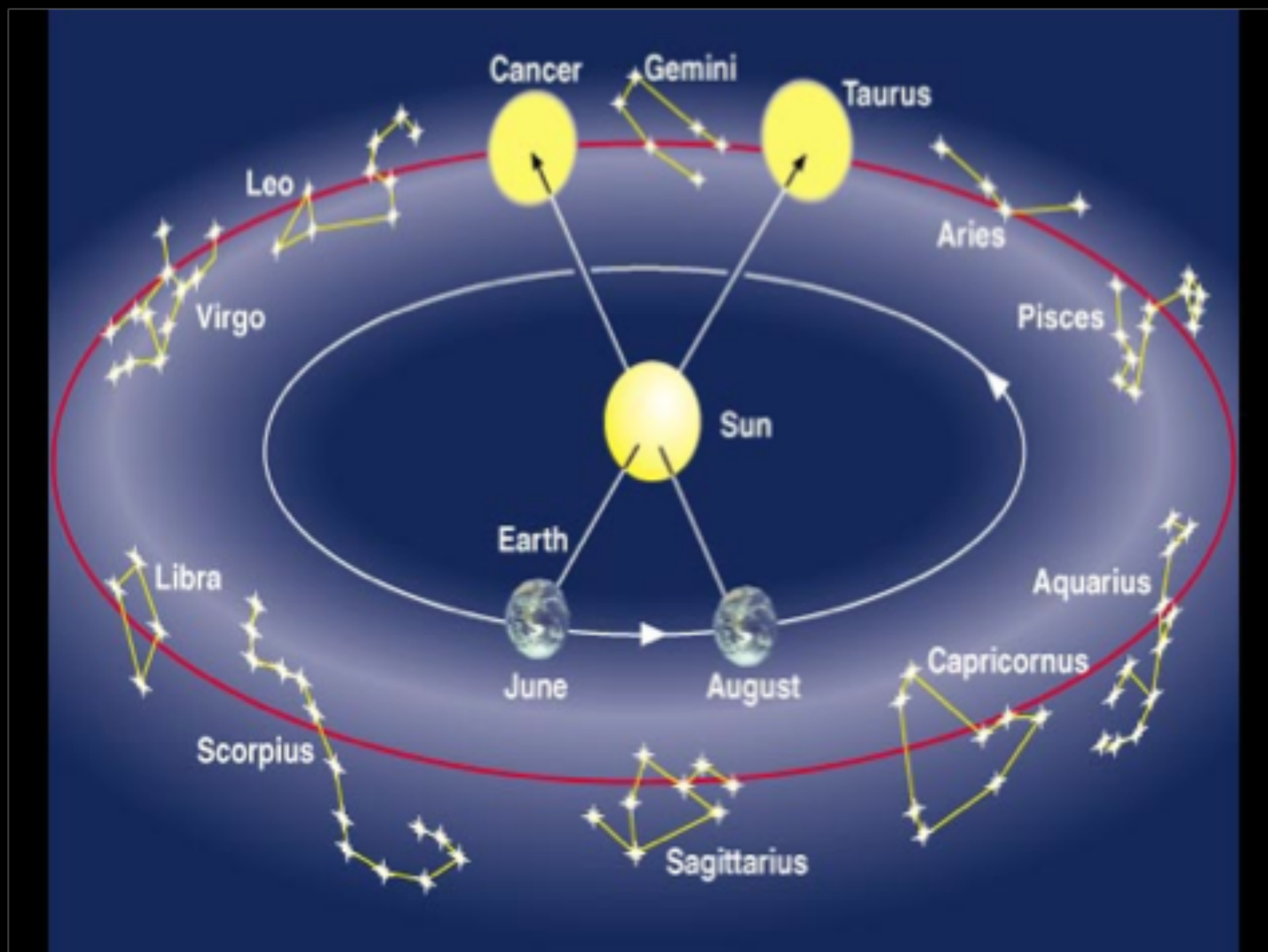
Motion in the direction opposite to the movement of something else

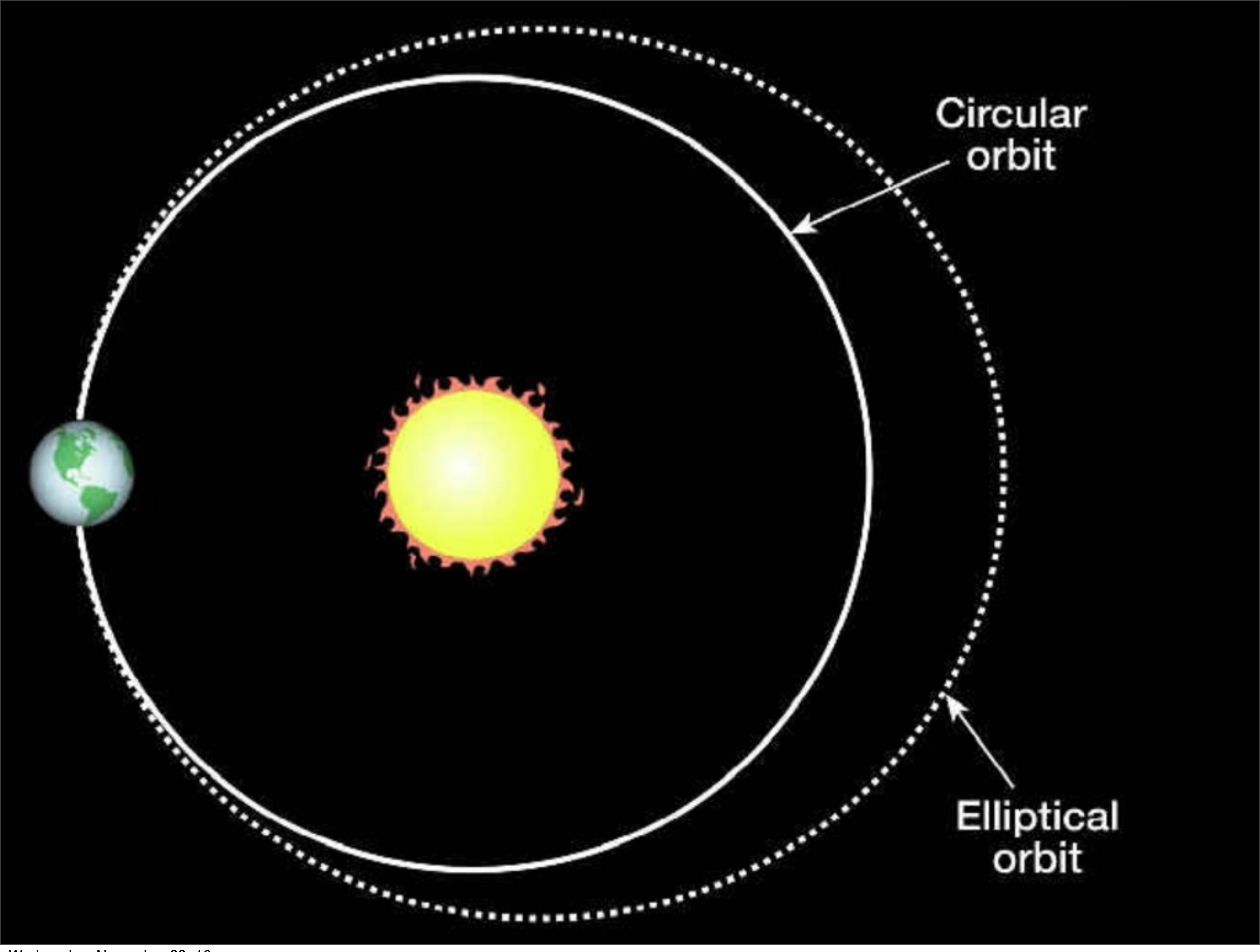


The planets with retrograde rotations are Venus, Uranus, and Pluto. Venus' orbit is clearly retrograde.

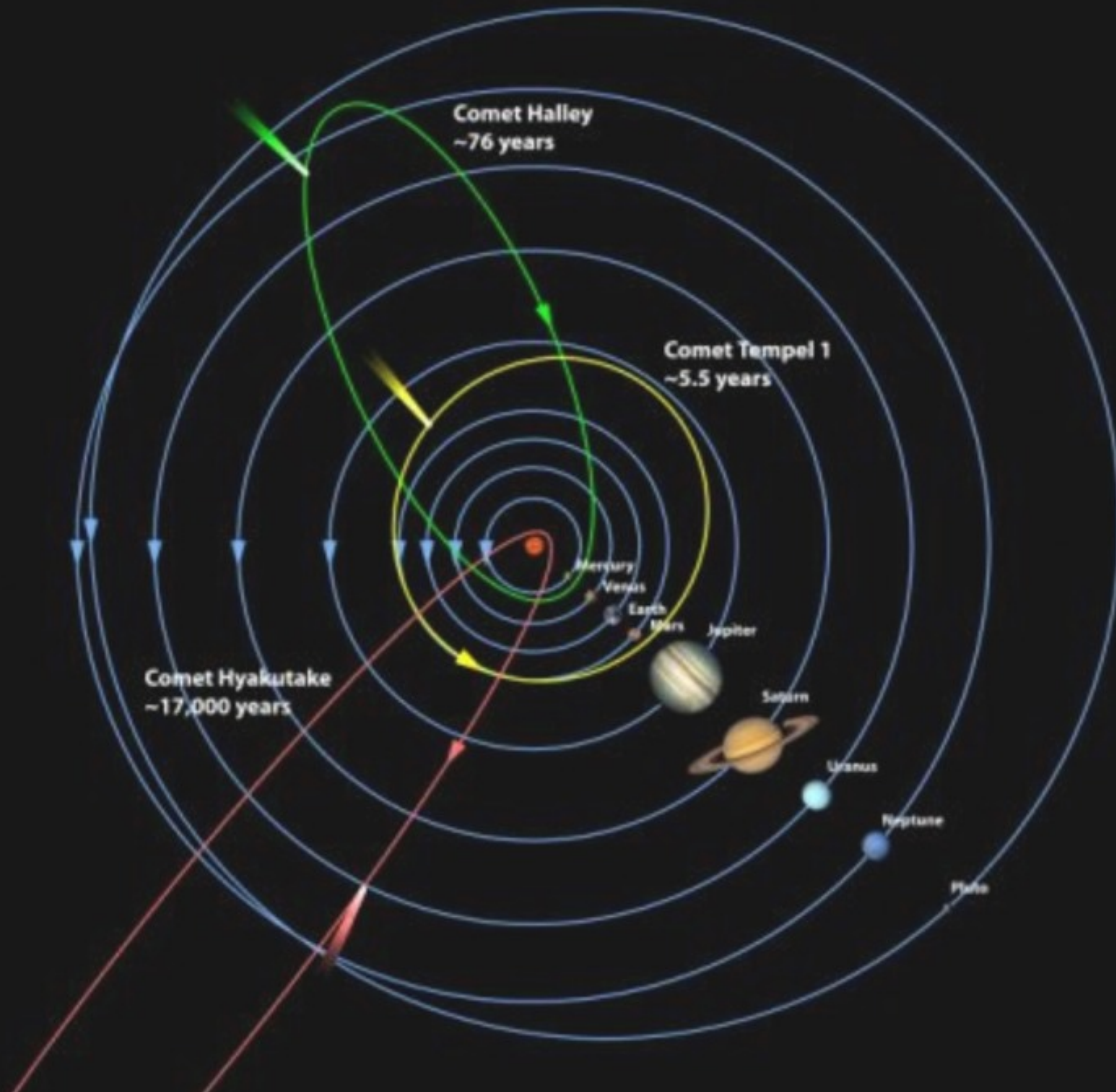
How do we know the Earth Revolves

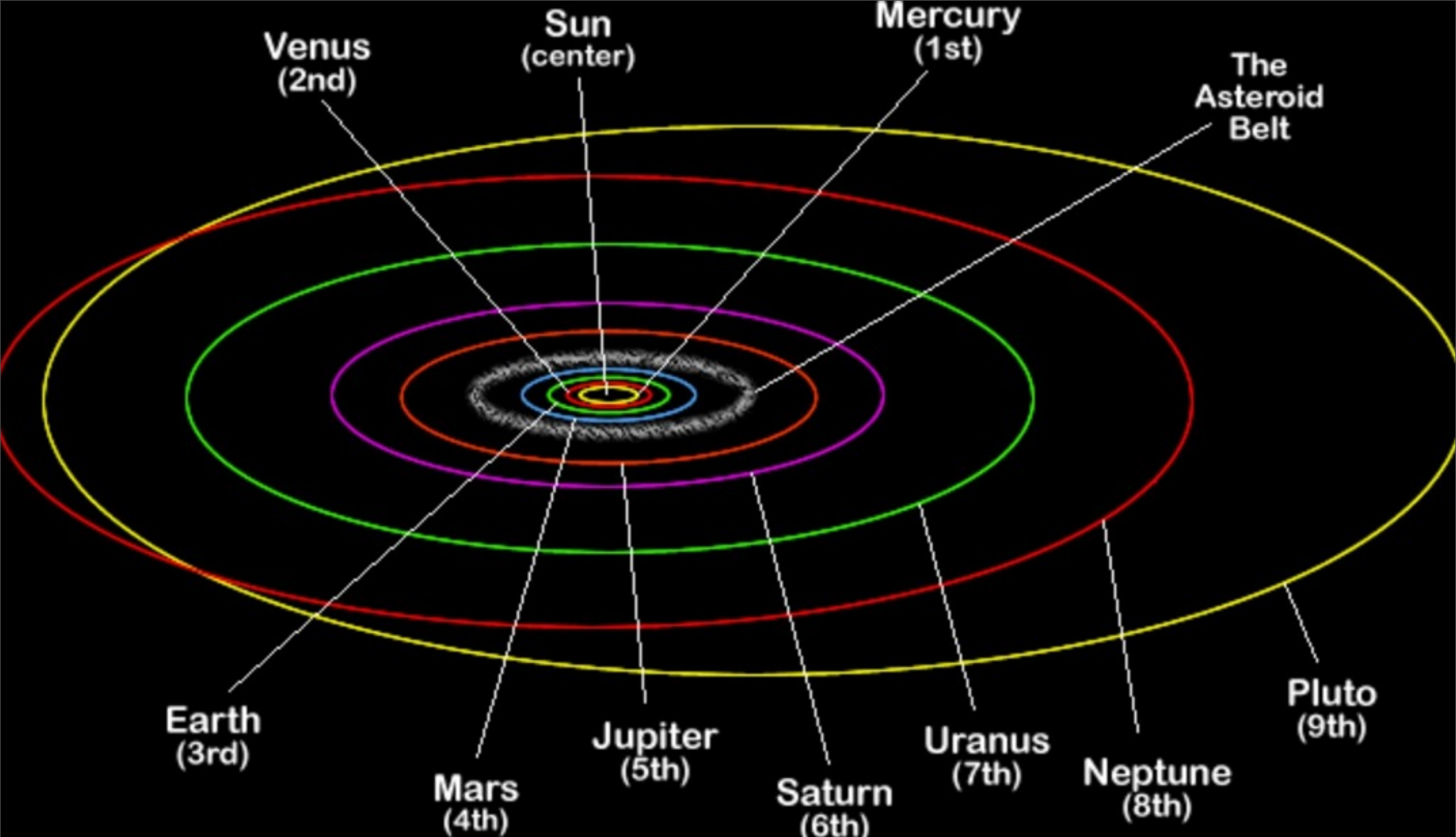
Different constellations at different times of the year

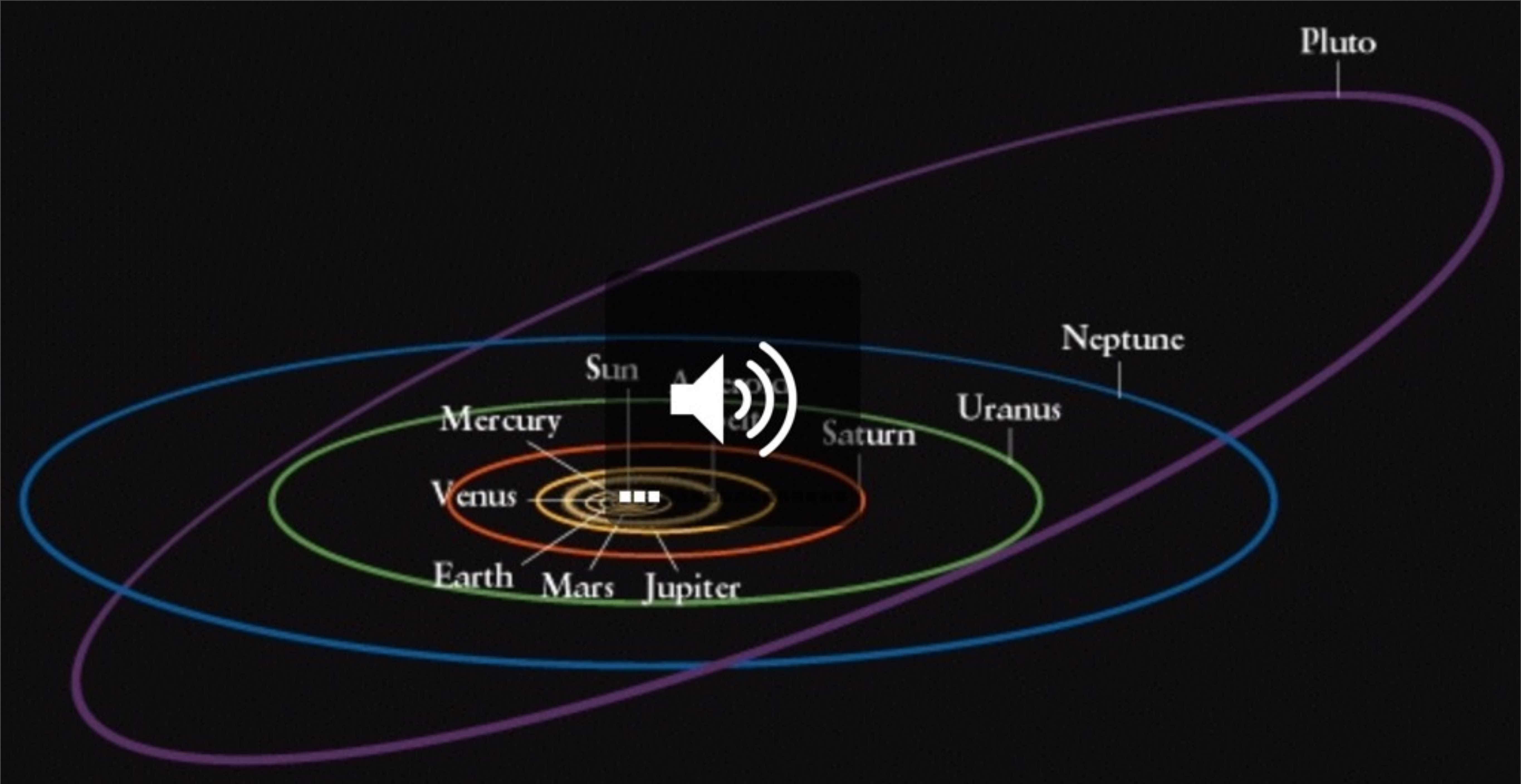



Circular
orbit
Elliptical
orbit

Comets Follow Different Orbits

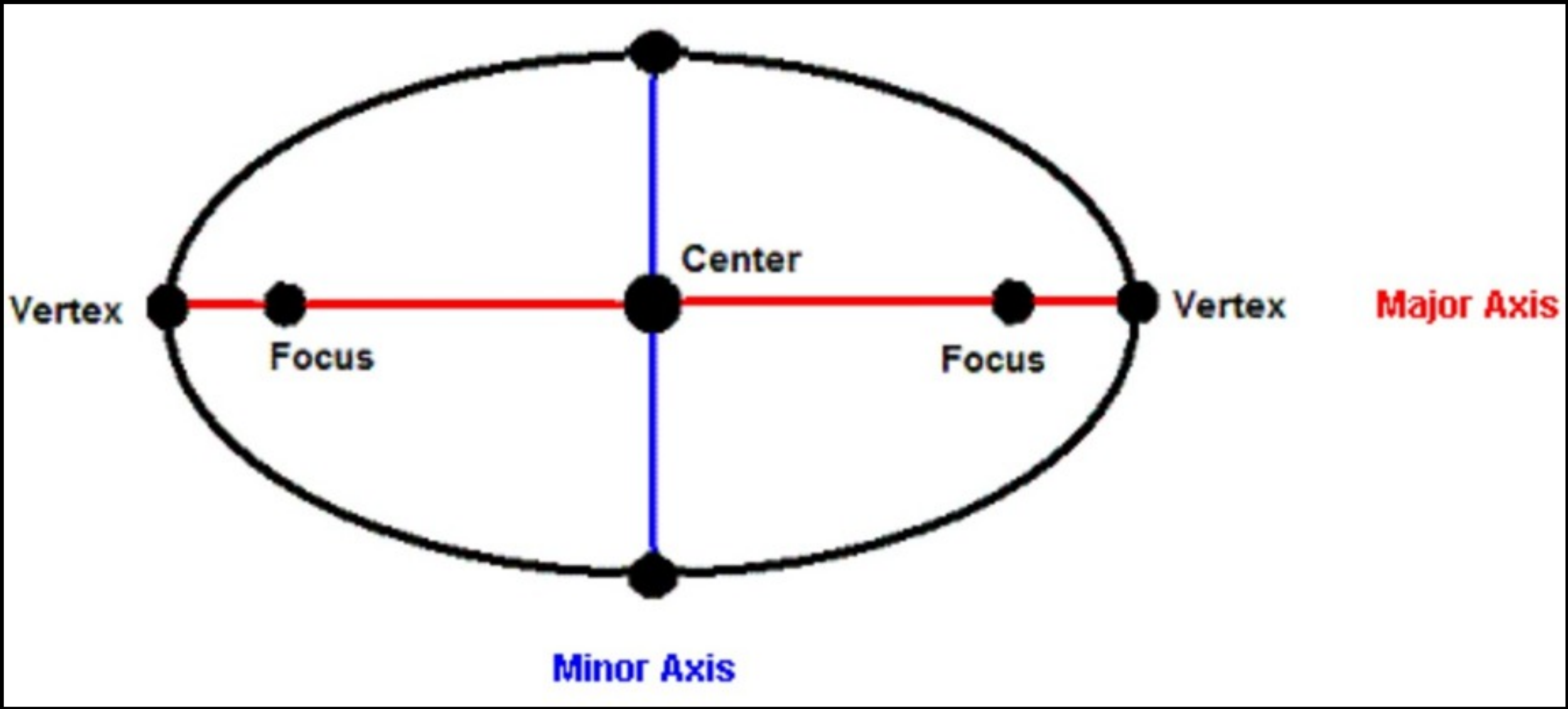



Venus
(2nd)
Sun
(center)
Mercury
(1st)
The
Asteroid
Belt
Earth
(3rd)
Mars
(4th)
Jupiter
(5th)
Saturn
(6th)
Uranus
(7th)
Neptune
(8th)
Pluto
(9th)


Pluto
Neptune
Uranus
Saturn
Sun
Mercury
Venus
Earth
Mars
Jupiter

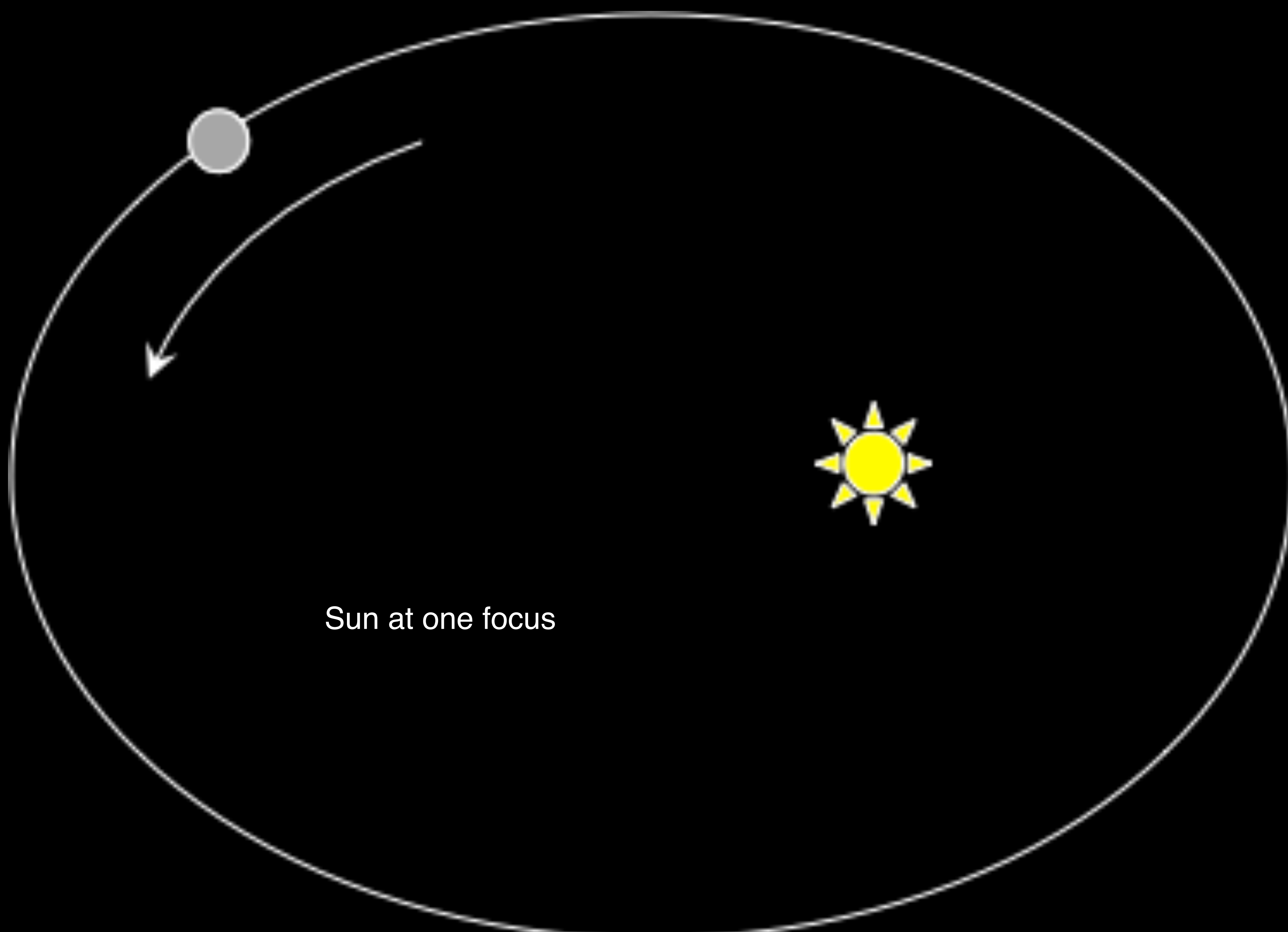
Ellipse

an oval shape that is centered on two points (foci).

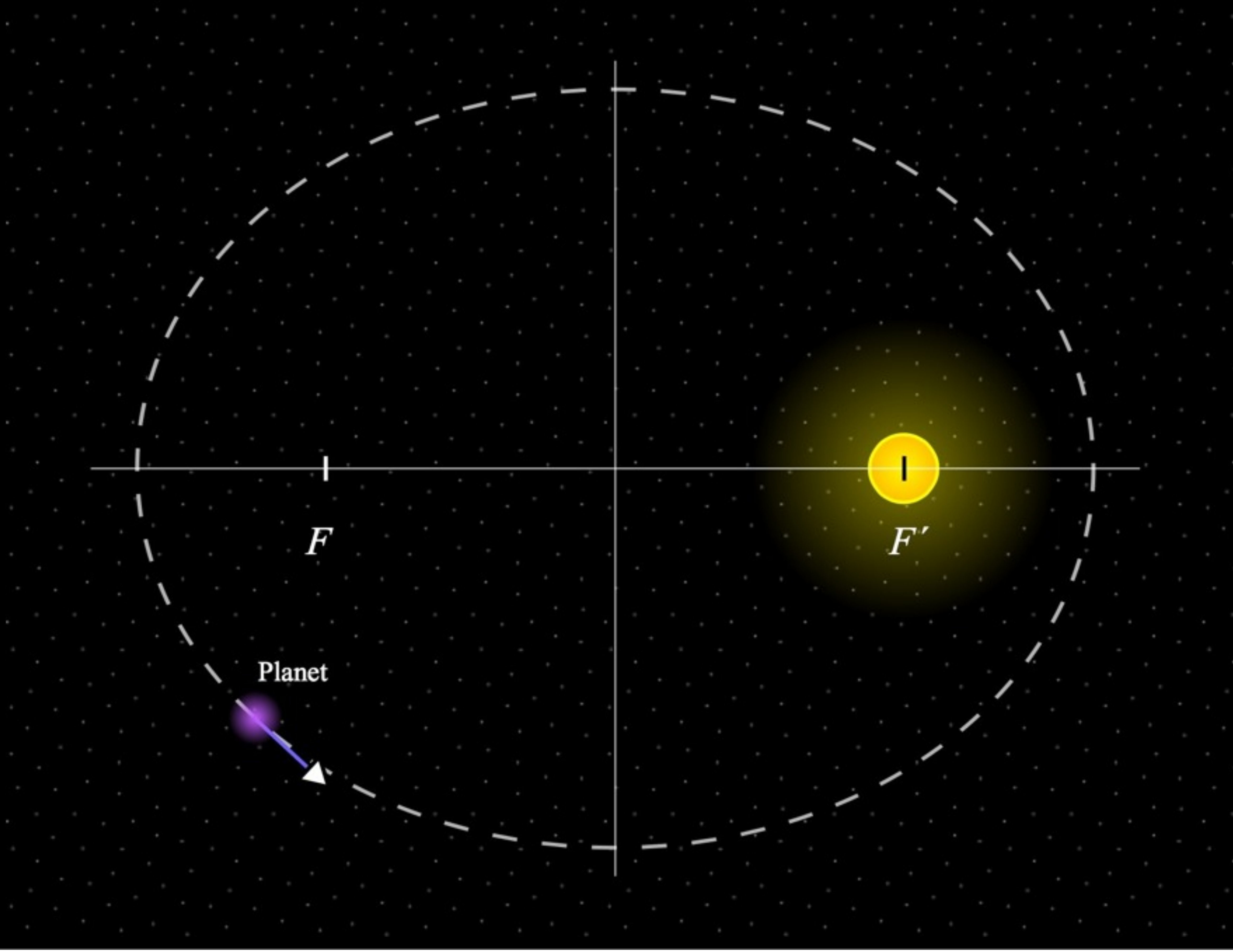


Keplers's First Law

Planets orbit the Sun in an ellipses with the Sun at one of the focus

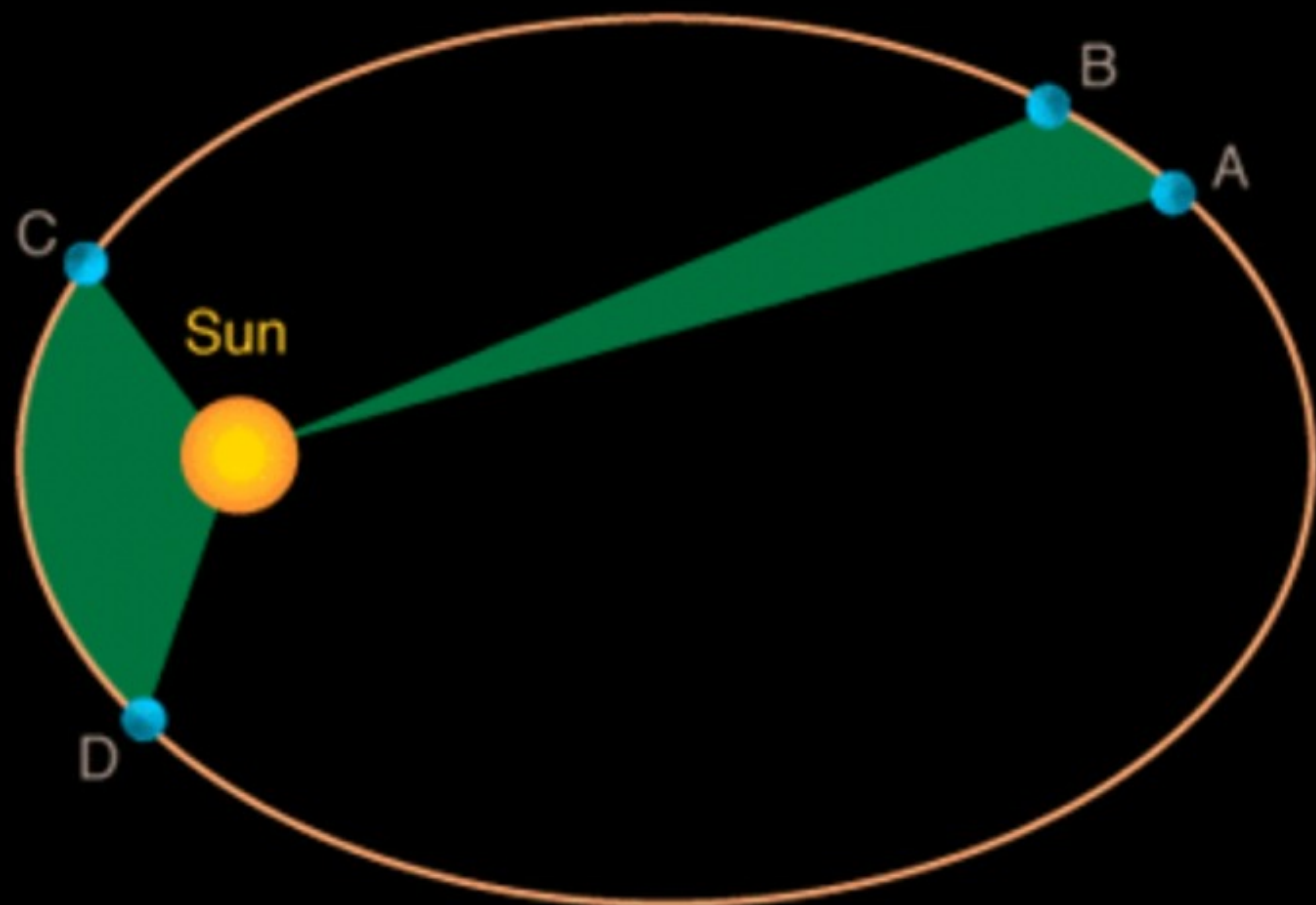


Keplers's First Law



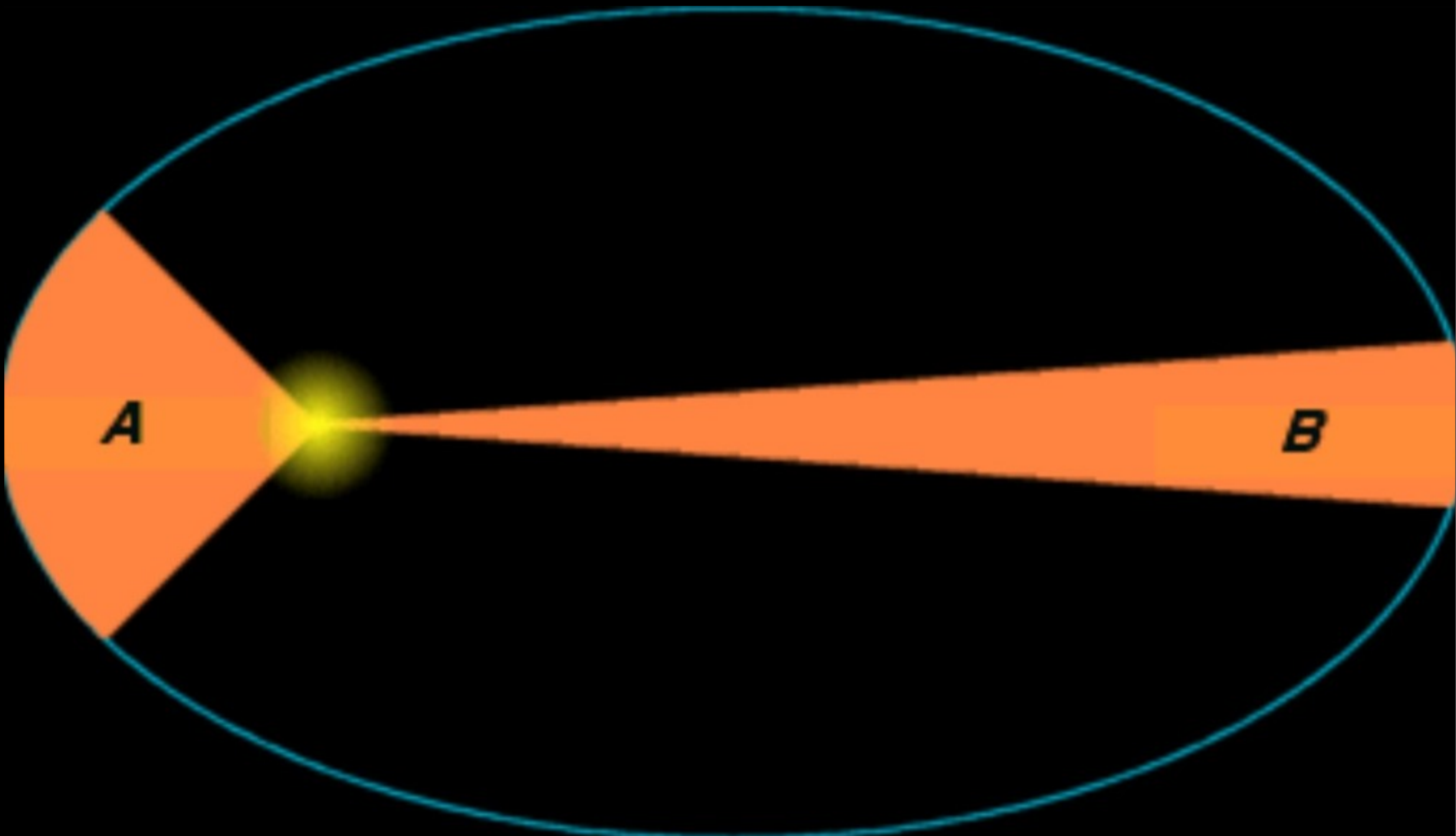
Keplers's Second Law

Planets move faster when close to the Sun
& slower when farther away from the Sun.

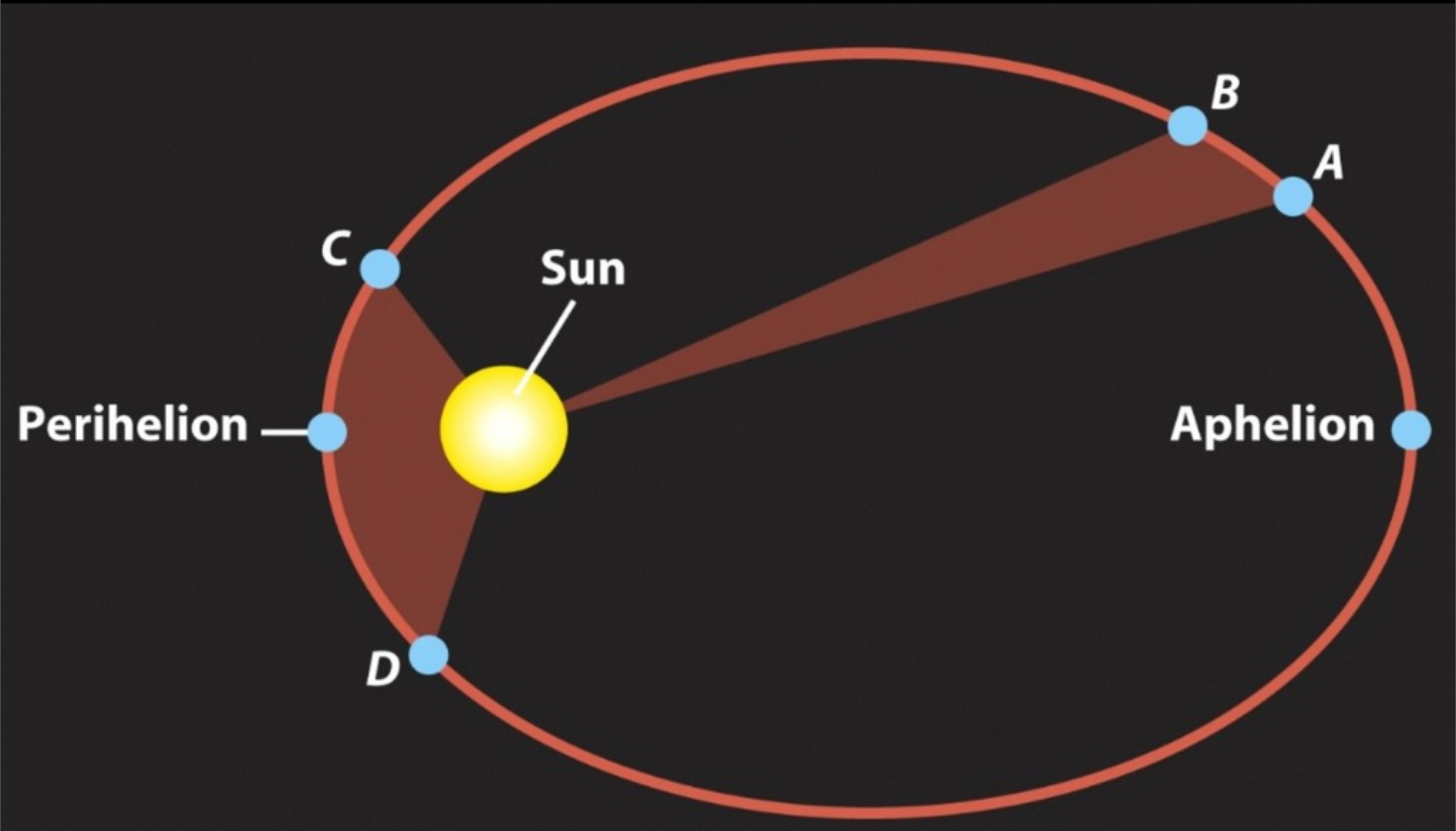


Keplers's Second Law

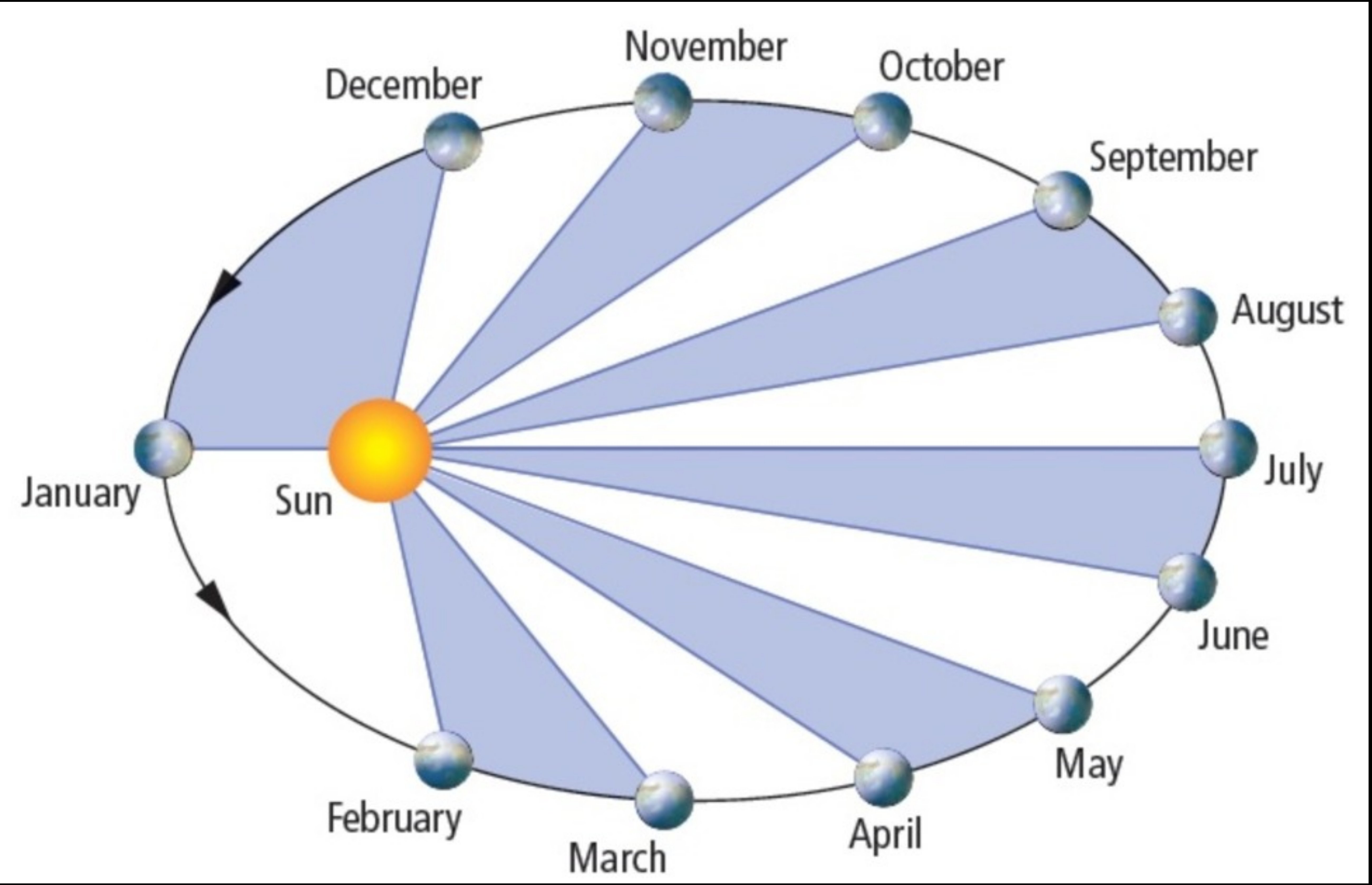
planet sweeps out equal areas in equal time..



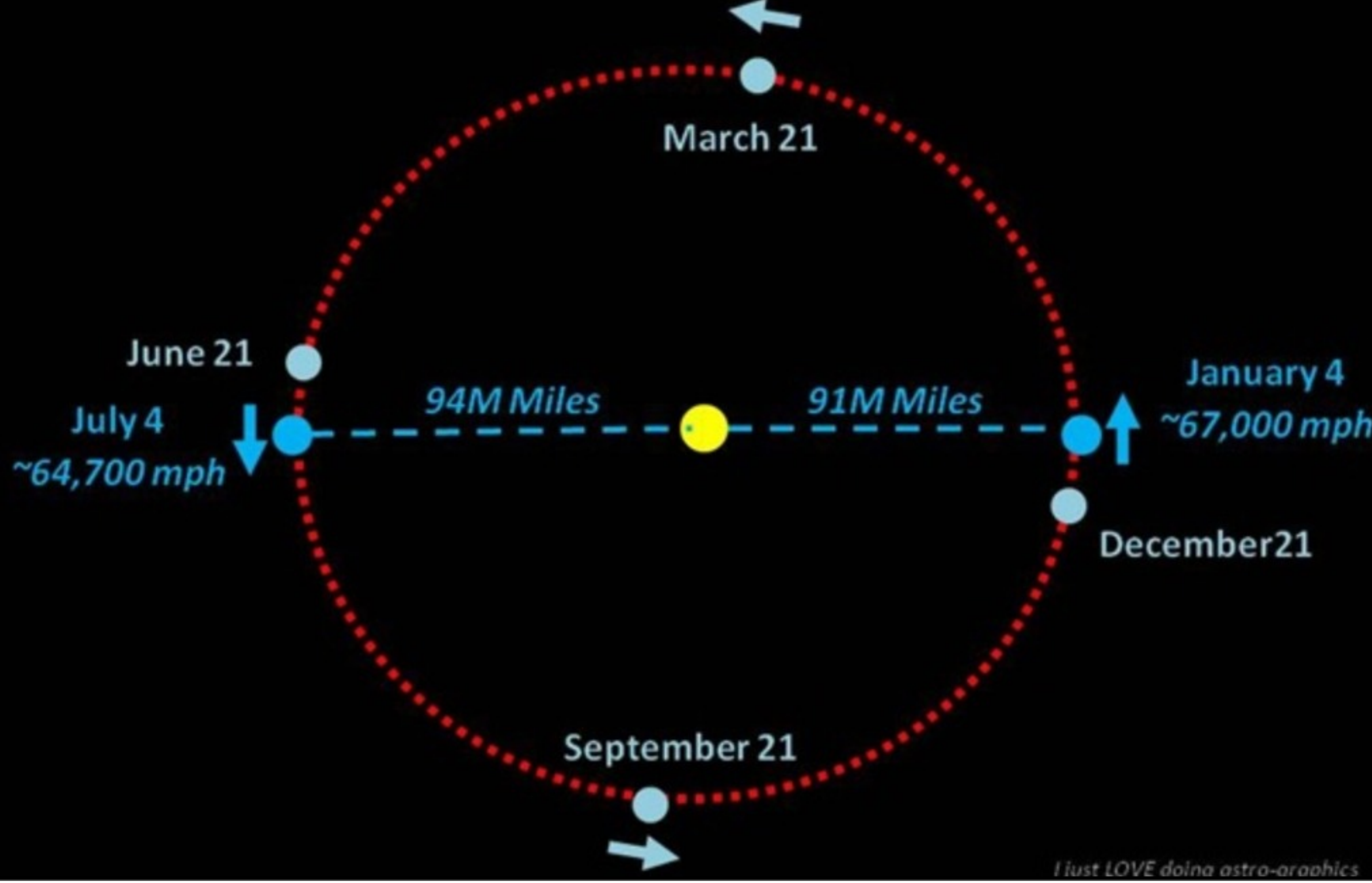
Keplers's Second Law



Keplers's Second Law

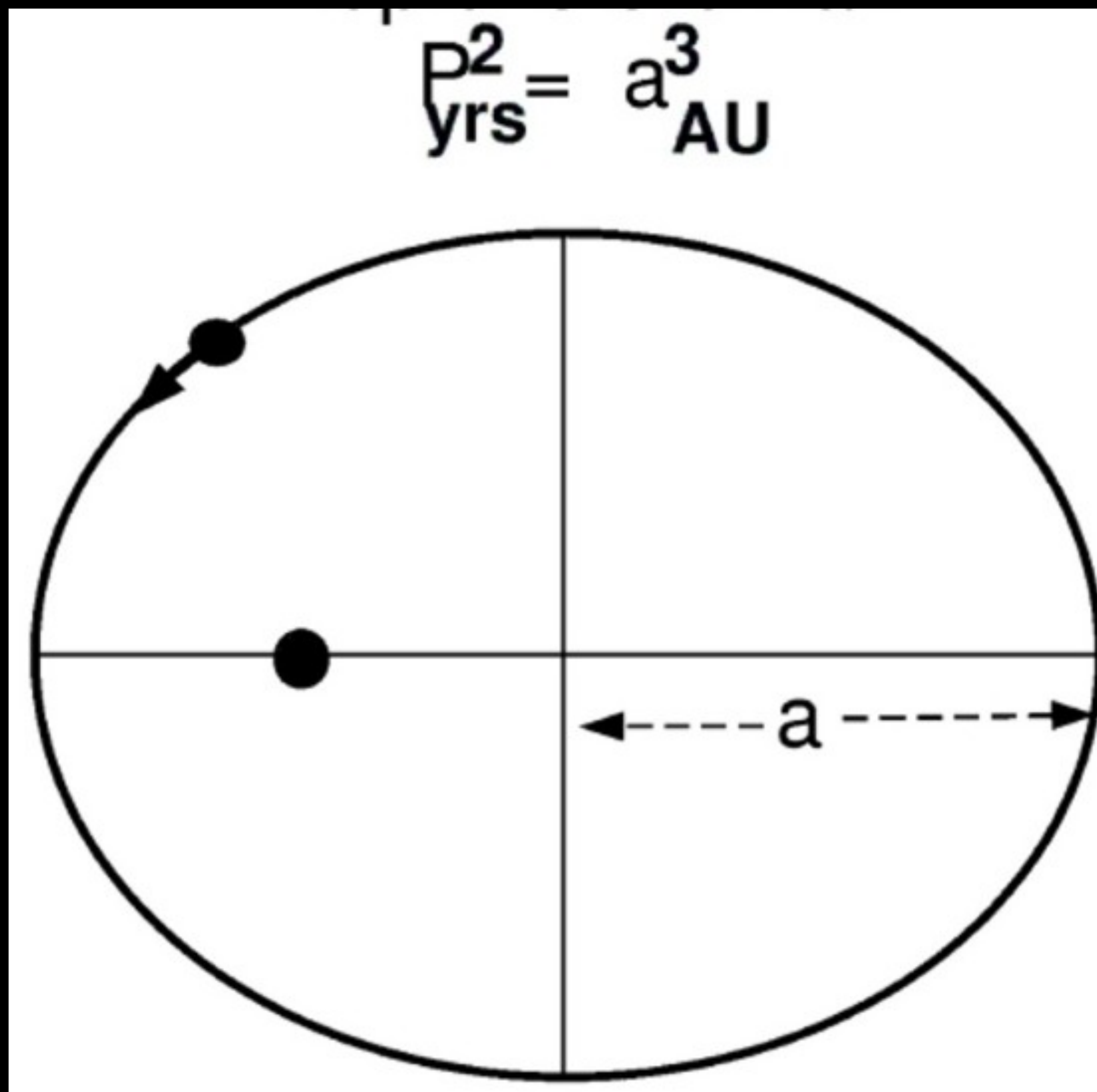


Earth's Position, Speed Relative to Sun

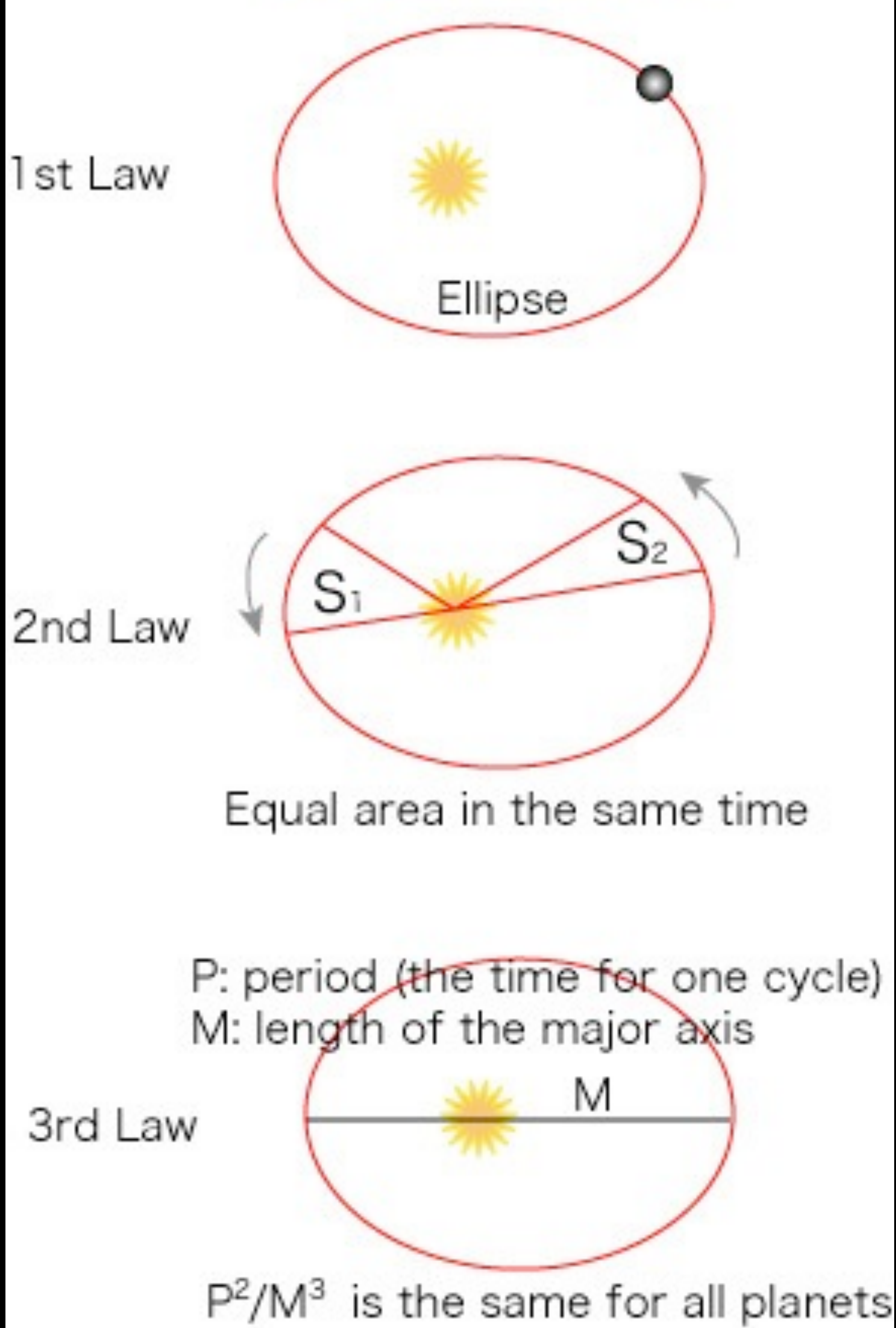


Keplers's Third Law

Planets with large orbits take longer to orbit the sun than planets with small orbits



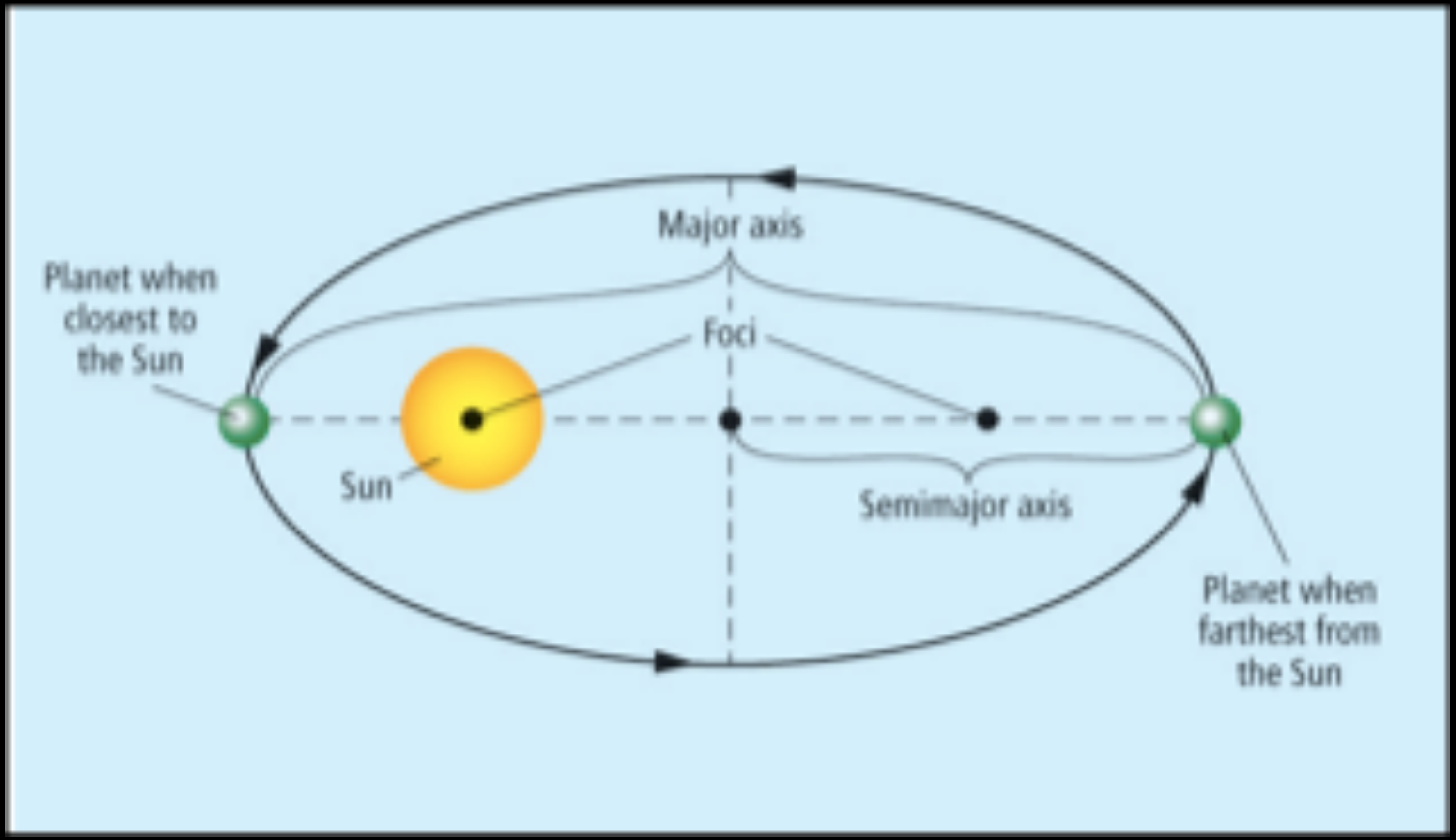
KEPLER'S LAWS



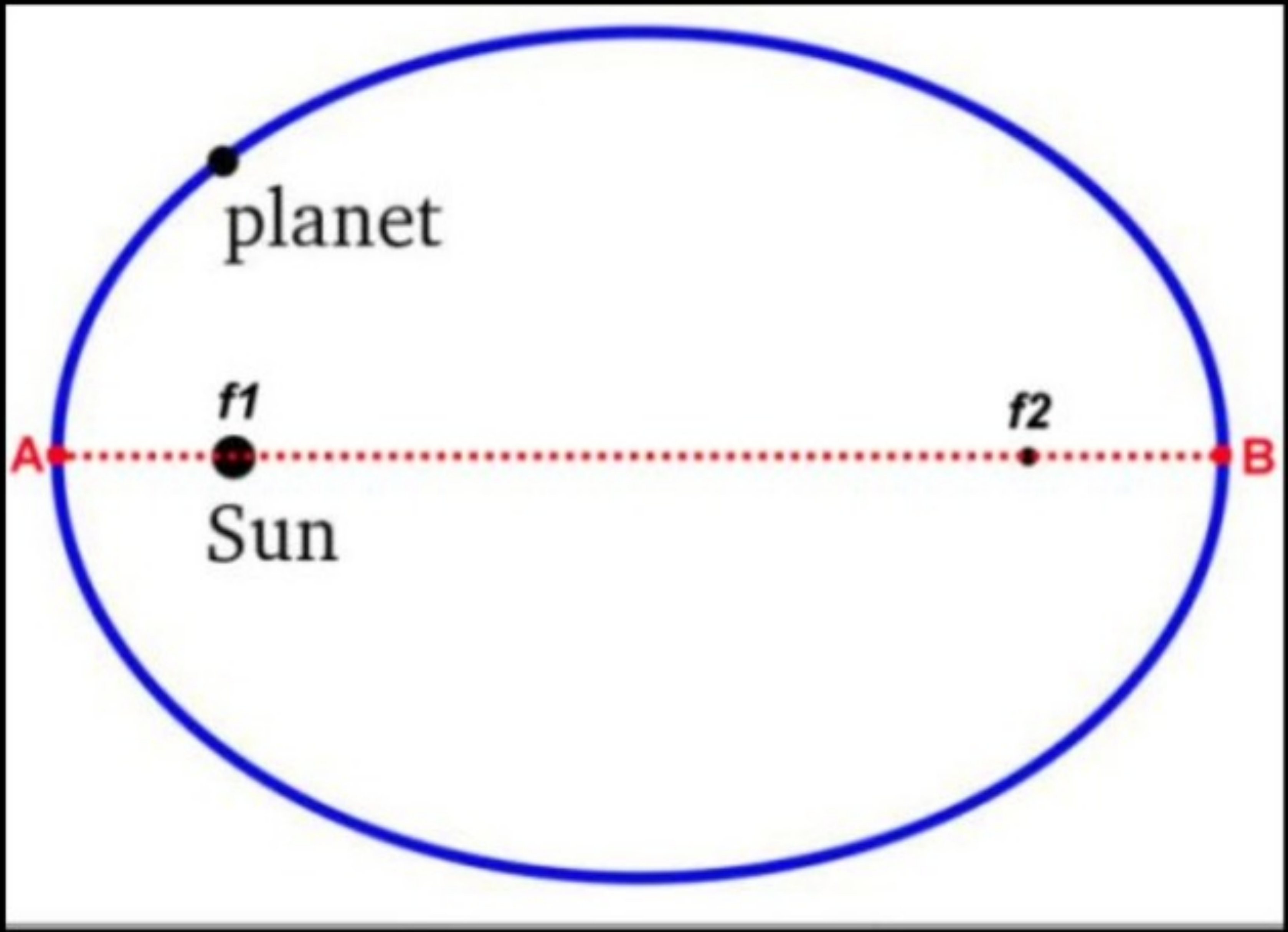
Eccentricity

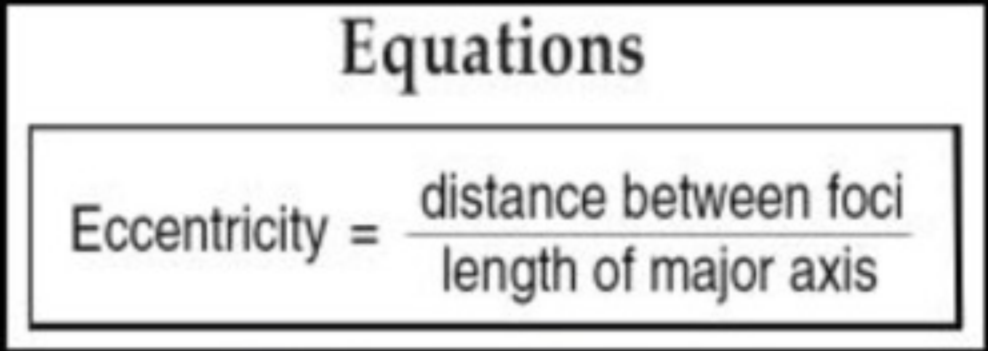
Ratio of the distance between the foci to the length of the major axis.

$$= \frac{\textit{Distance between the foci}}{\text{Length of major axis}}$$



To find use the formula on ESRT page



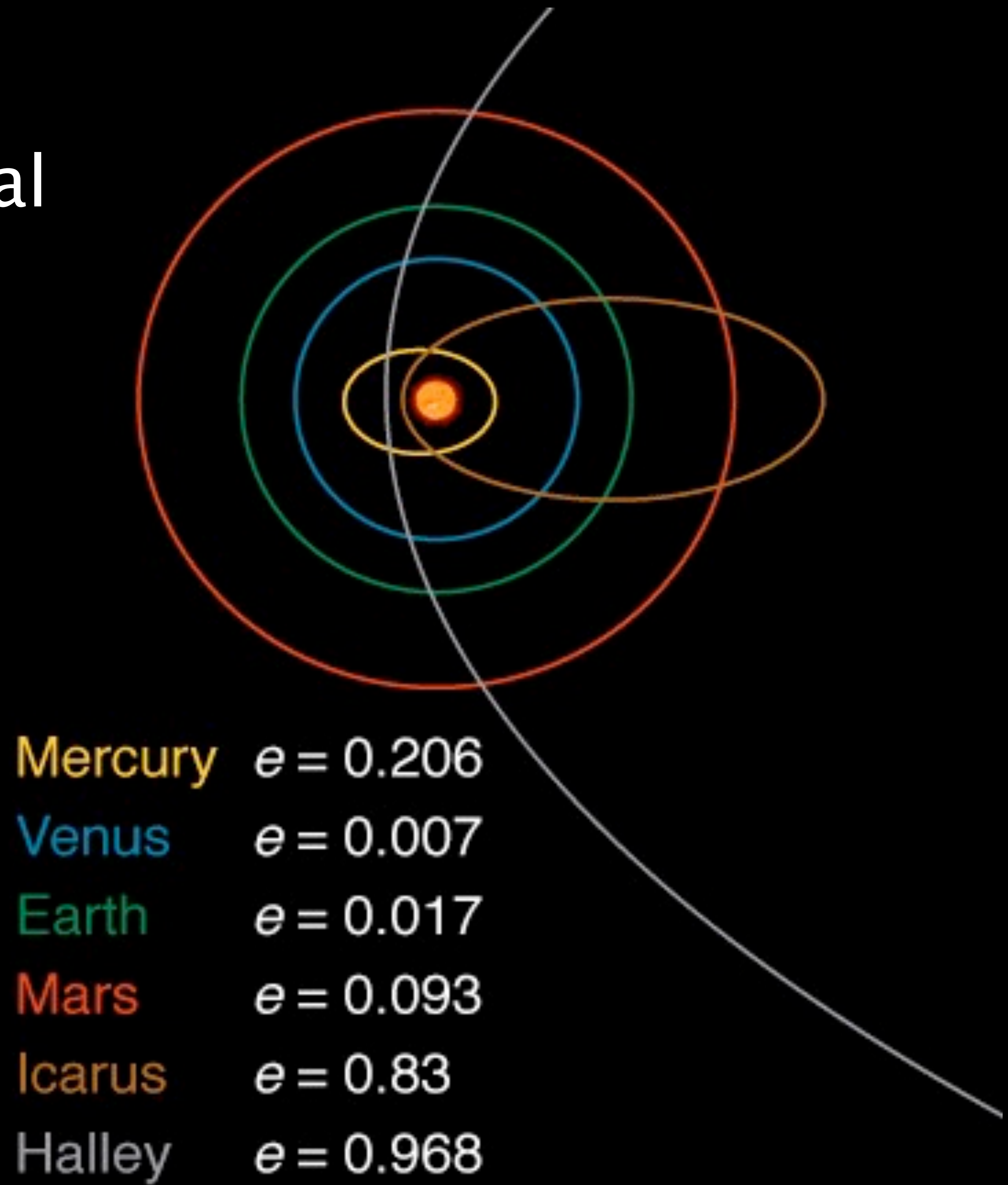


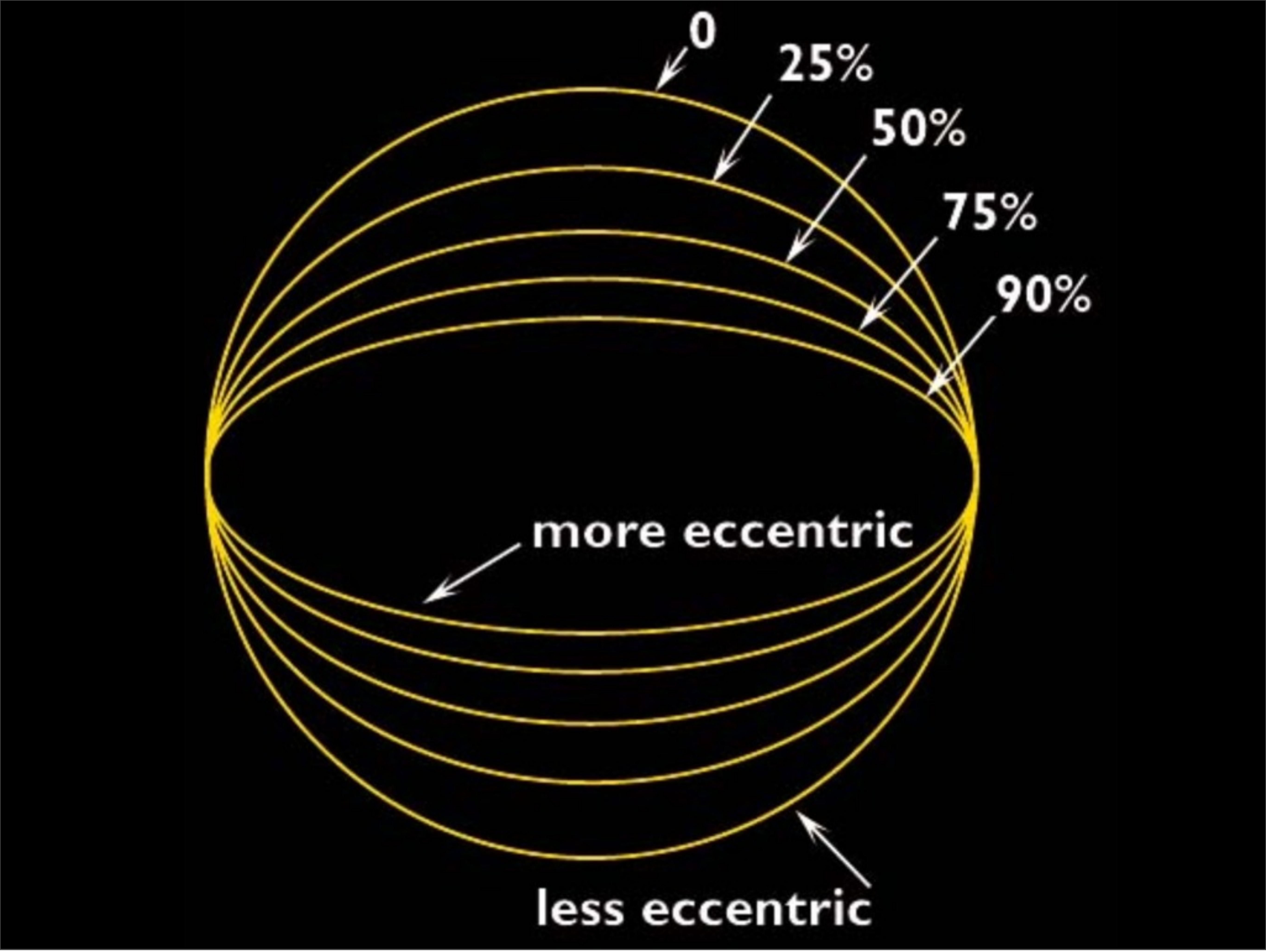
ESRT page 1

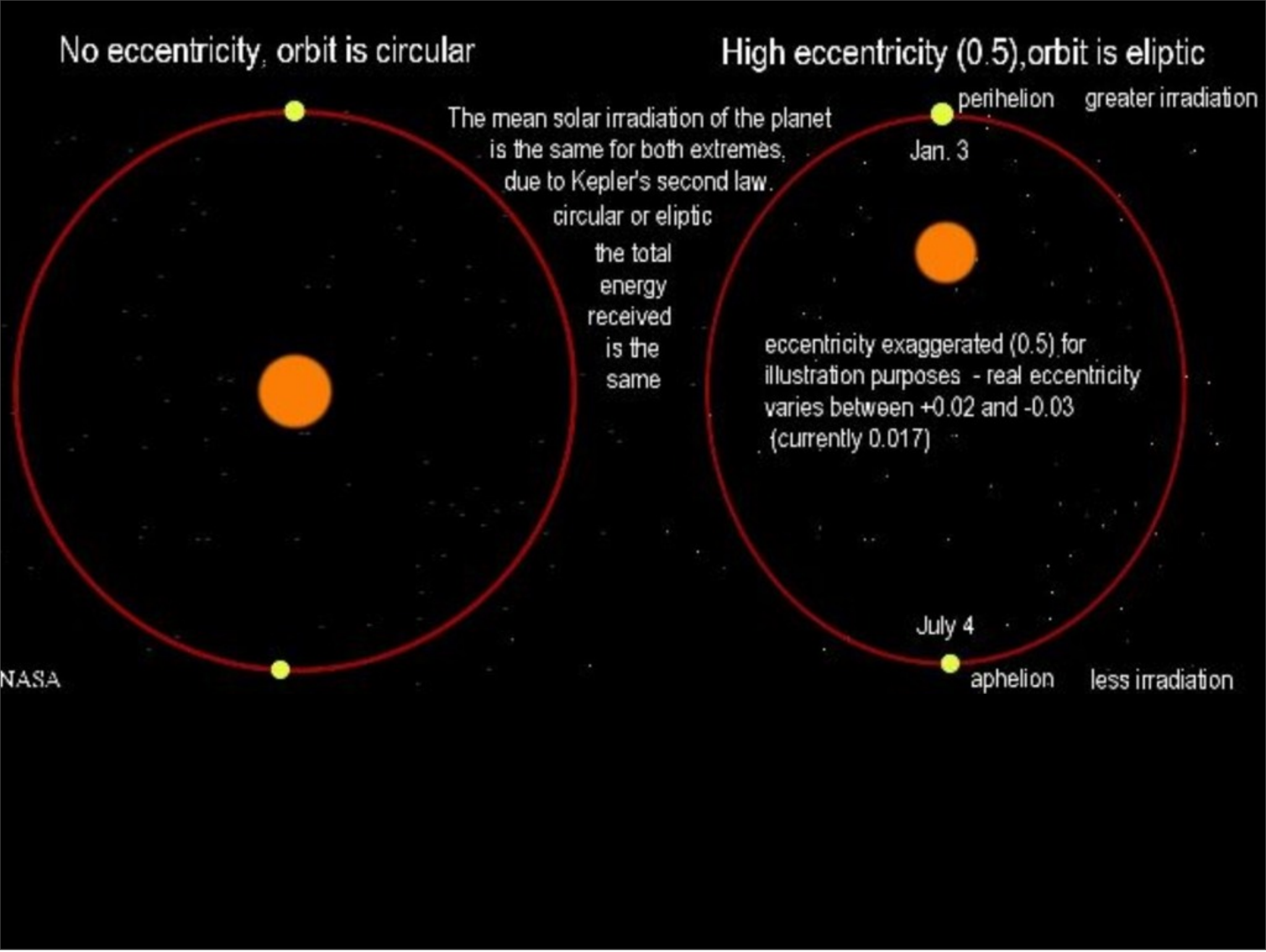
$$e = \frac{d}{L}$$

e is a number without units.
The maximum possible value of e is 1
The minimum possible value of e is 0

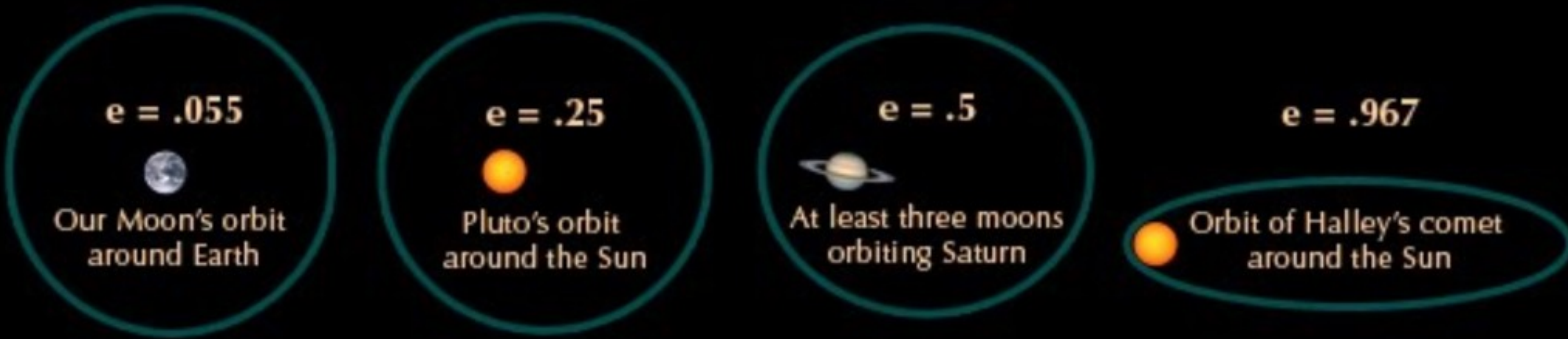
Elliptical orbits of the inner, terrestrial planets, Icarus (an asteroid), and Halley's comet.

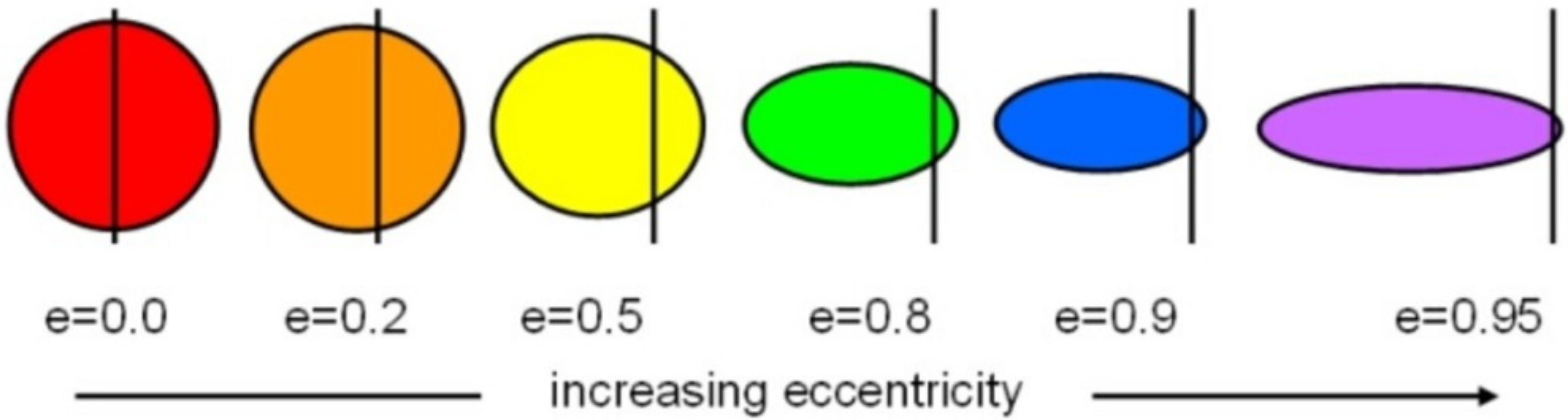



0
25%
50%
75%
90%
more eccentric
less eccentric

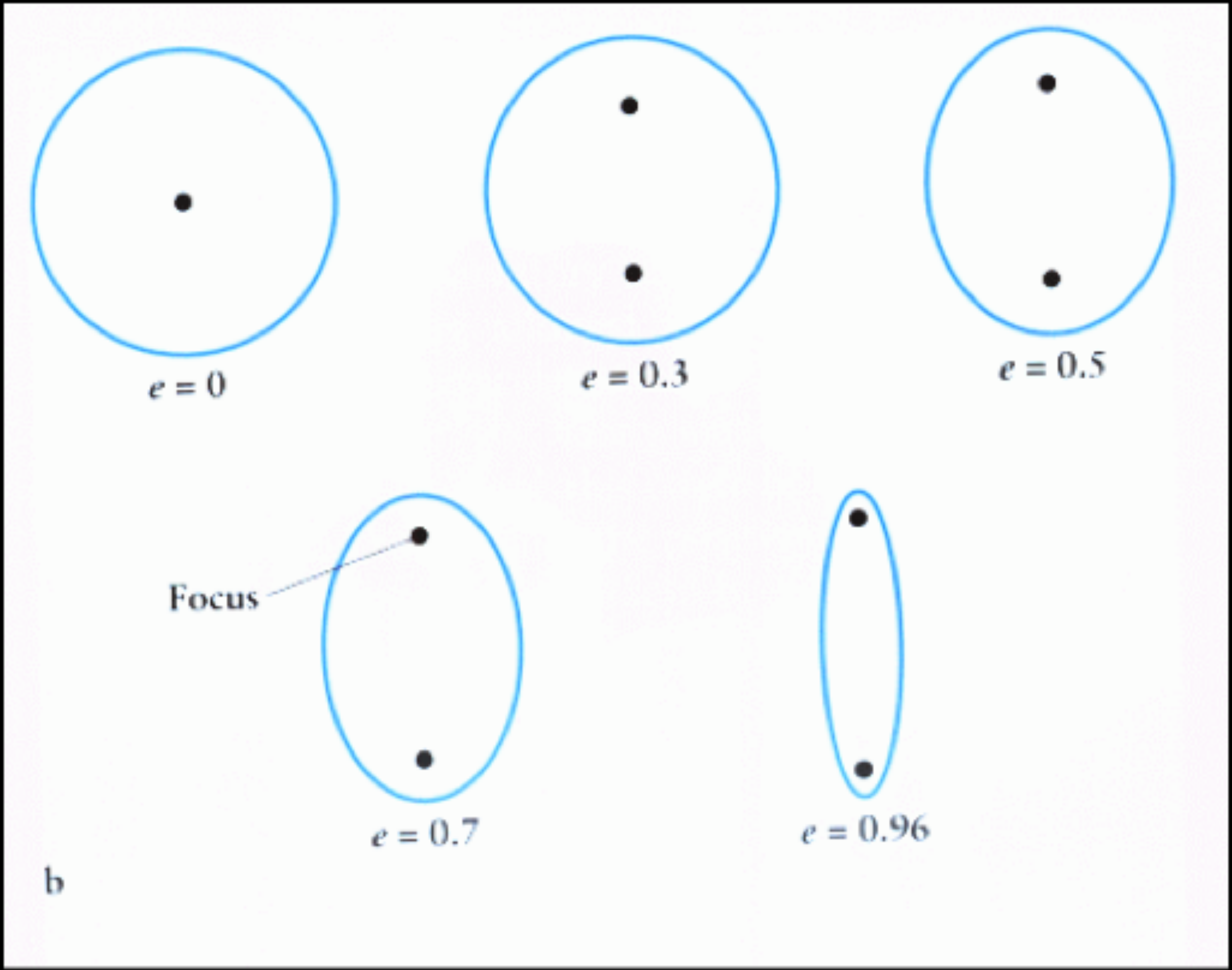


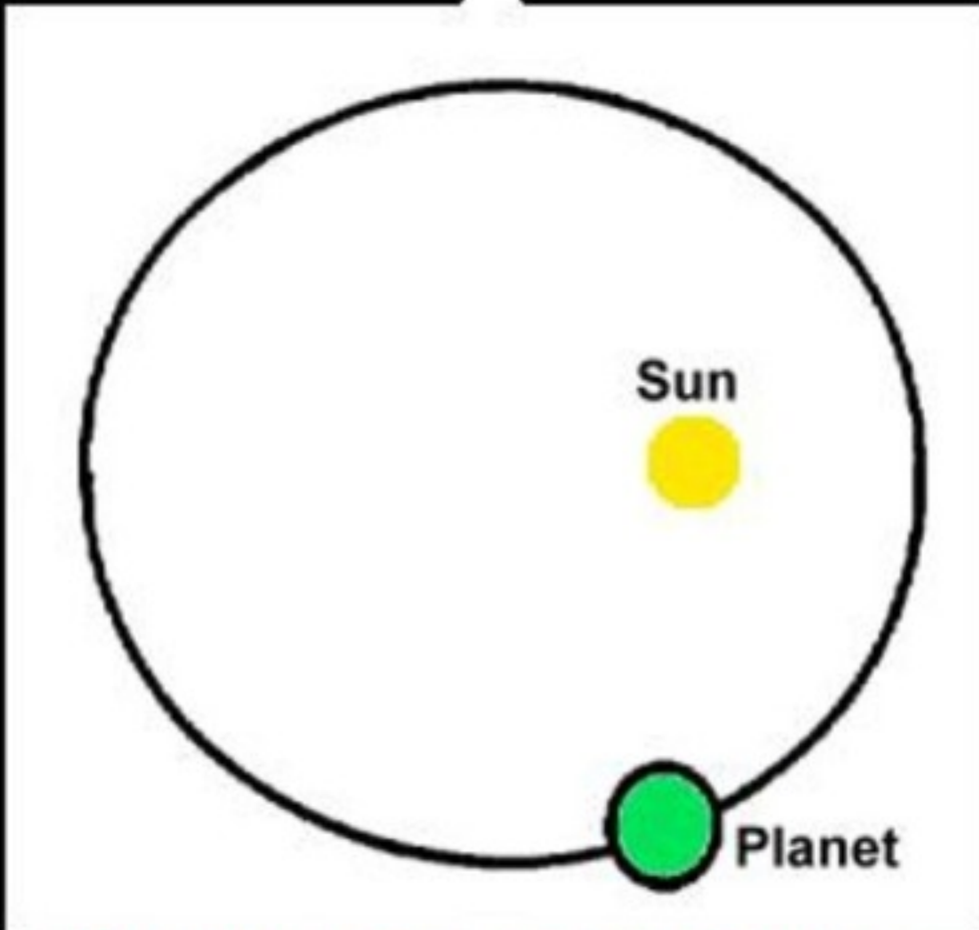
No eccentricity, orbit is circular
High eccentricity (0.5),orbit is eliptic
perihelion
greater irradiation
The mean solar irradiation of the planet
is the same for both extremes,
due to Kepler's second law.
circular or eliptic
the total
energy
received
is the
same
Jan. 3
eccentricity exaggerated (0.5) for
illustration purposes - real eccentricity
varies between +0.02 and -0.03
(currently 0.017)
July 4
aphelion
less irradiation
NASA


e = .055
Our Moon's orbit around Earth
e = .25
Pluto's orbit around the Sun
e = .5
At least three moons orbiting Saturn
e = .967
Orbit of Halley's comet around the Sun

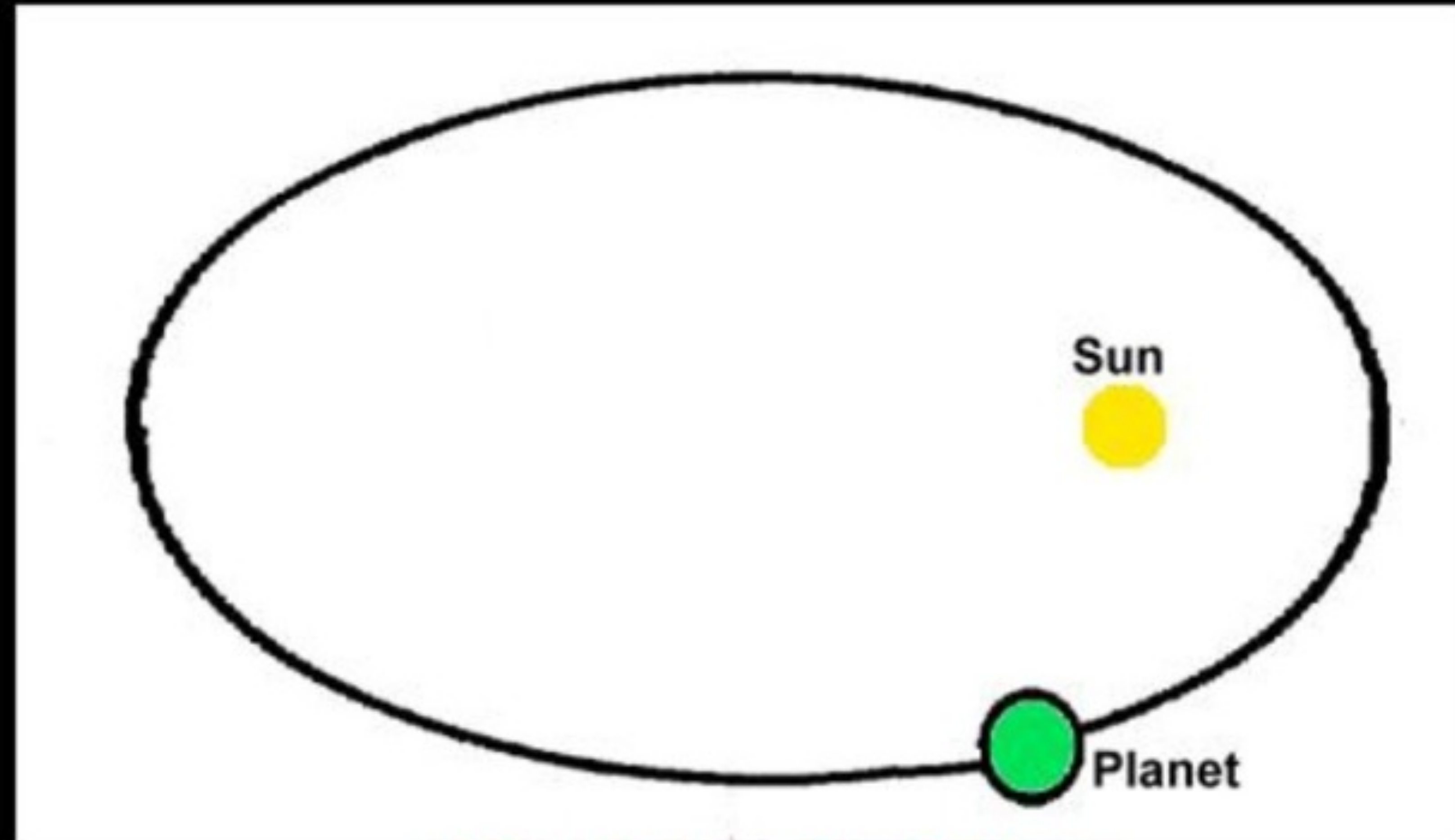

e=0.0
e=0.2
e=0.5
e=0.8
e=0.9
e=0.95
increasing eccentricity

Eccentricity





Slightly Eccentric Ellipse



Very Eccentric Ellipse

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	—

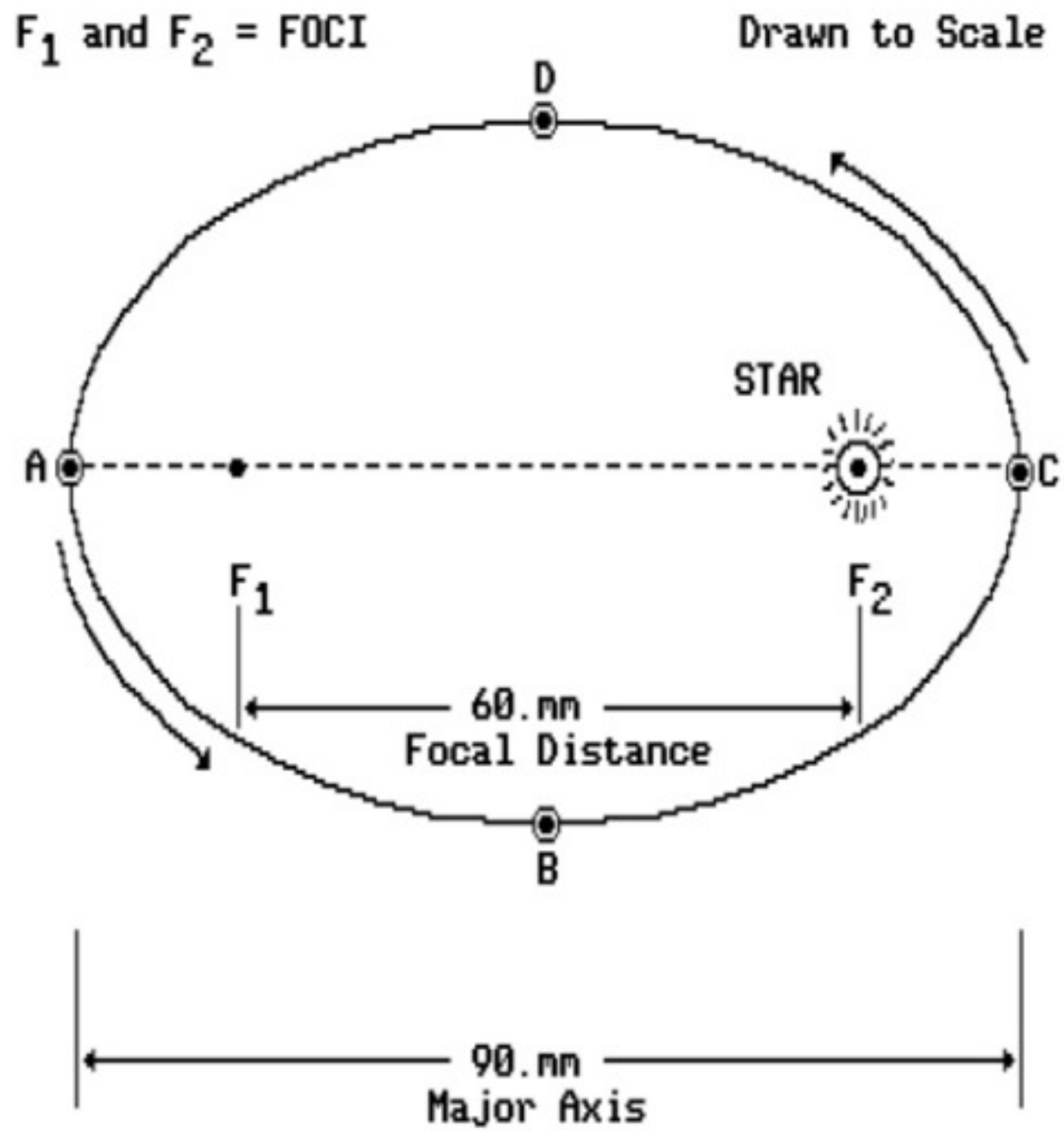
ESRT page 15

Practice

1. The actual shape of the Earth's orbit around the Sun is best described as
    a. a slightly eccentric ellipse
    b. an oblate spheroid
    c. a perfect circle
    d. a very eccentric ellipse

2. What is the eccentricity of an orbit having a major axis length of 100 million miles and a focal distance of 10 million miles?
    a. 1.0
    b. 0.01
    c. 10.0
    d. 0.1

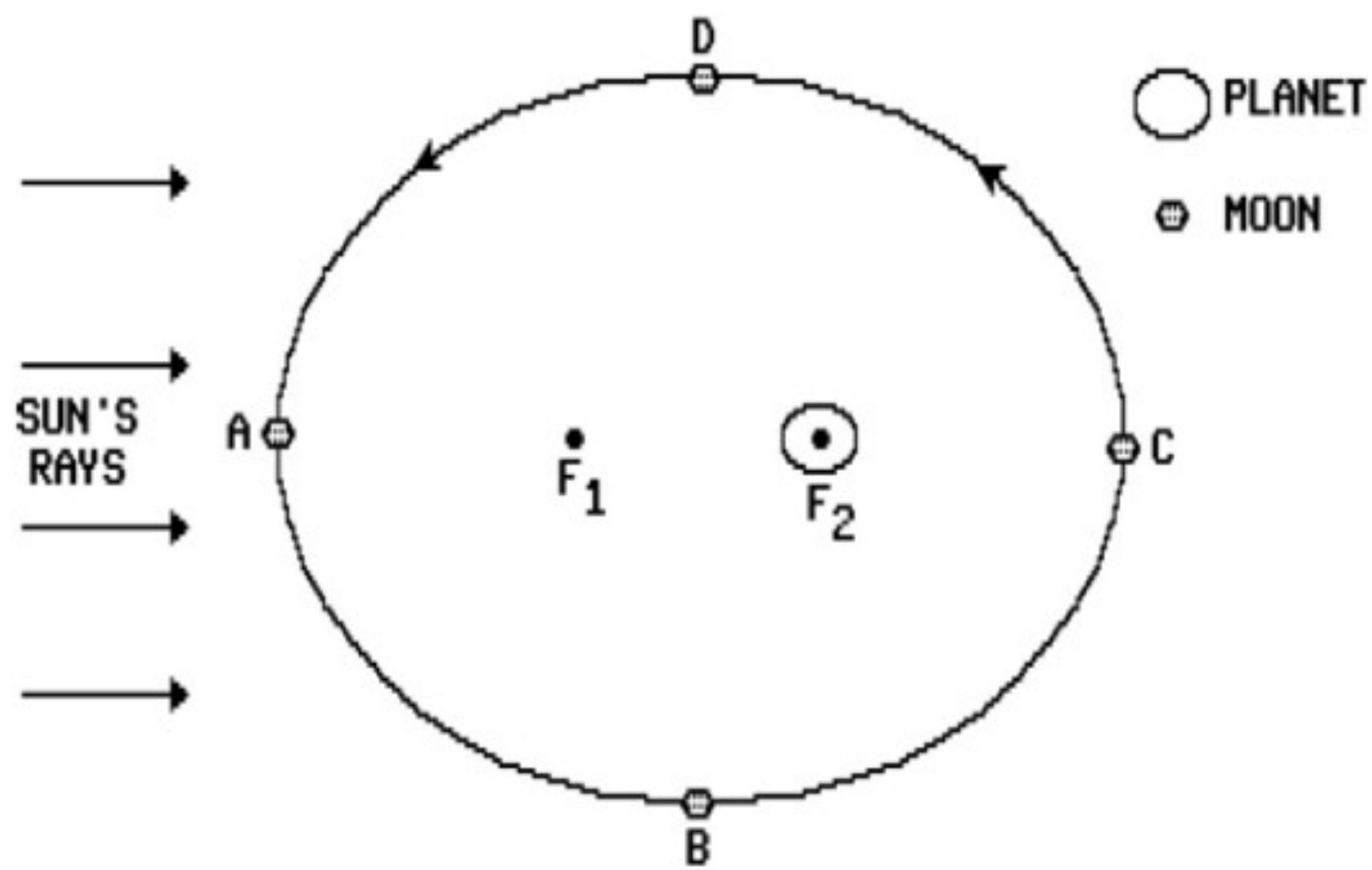
The diagram below is a model of the orbit of an imaginary planet Q around a star. Points A, B, C, and D indicate four orbital positions of the planet Q.



3. What is the approximate eccentricity of planet Q's orbit?
   a. 0.67
   b. 1.50
   c. 0.15
   d. 0.06

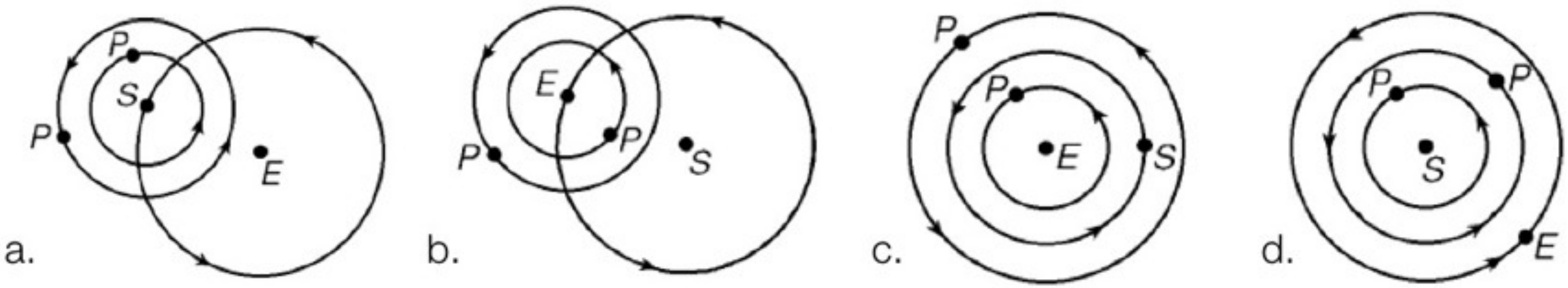
4. According to the Earth Science Reference Tables, which planet has the most eccentric orbit?
   a. Pluto
   b. Mars
   c. Venus
   d. Saturn

The diagram below represents a model of the orbit of a moon around a planet. Points A, B, C, and D indicate four positions of the moon in its orbit. Points F1 and F2 are focal points of the orbit.

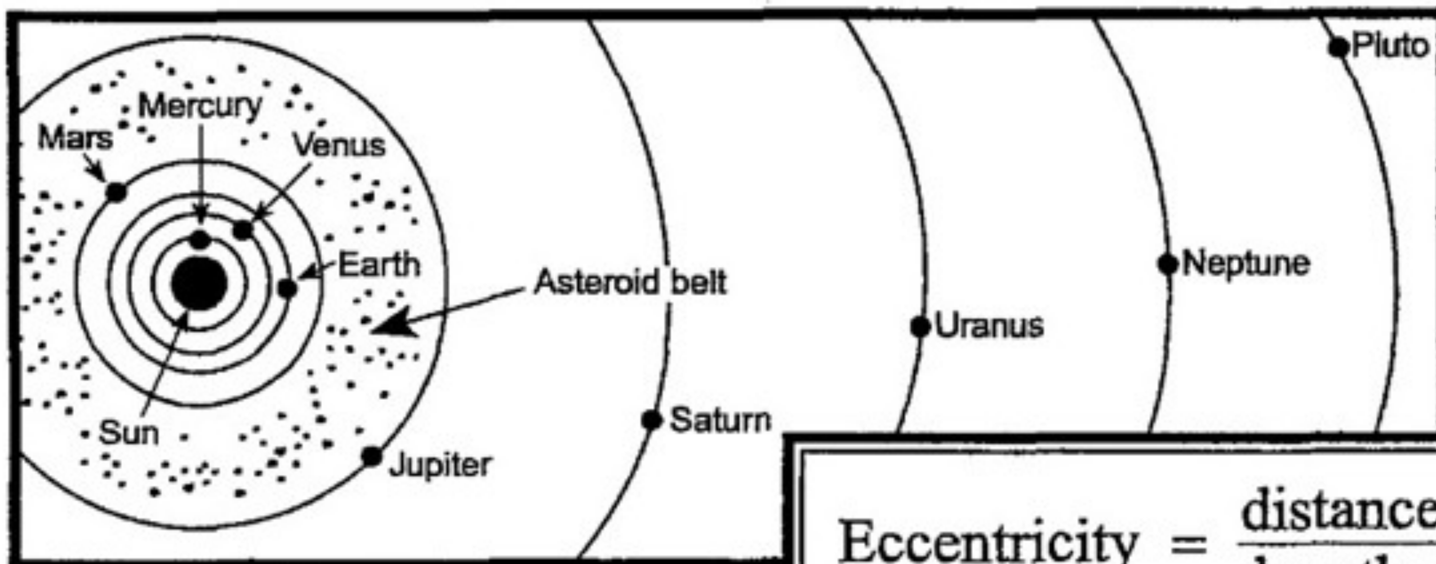


5. If the distance from F1 to F2 is 42,000 kilometers and the distance from A to C is 768,000 kilometers, what is the eccentricity of the moon's orbit?
   a. 0.055
   b. 0.81
   c. 0.94
   d. 0.18

6. Which diagram best represents a heliocentric model of a portion of the solar system? [Diagrams are not drawn to scale.] KEY: E = Earth; P = Planet; S = Sun



Eccentricity



$$\text{Eccentricity} = \frac{\text{distance between foci}}{\text{length of major axis}}$$

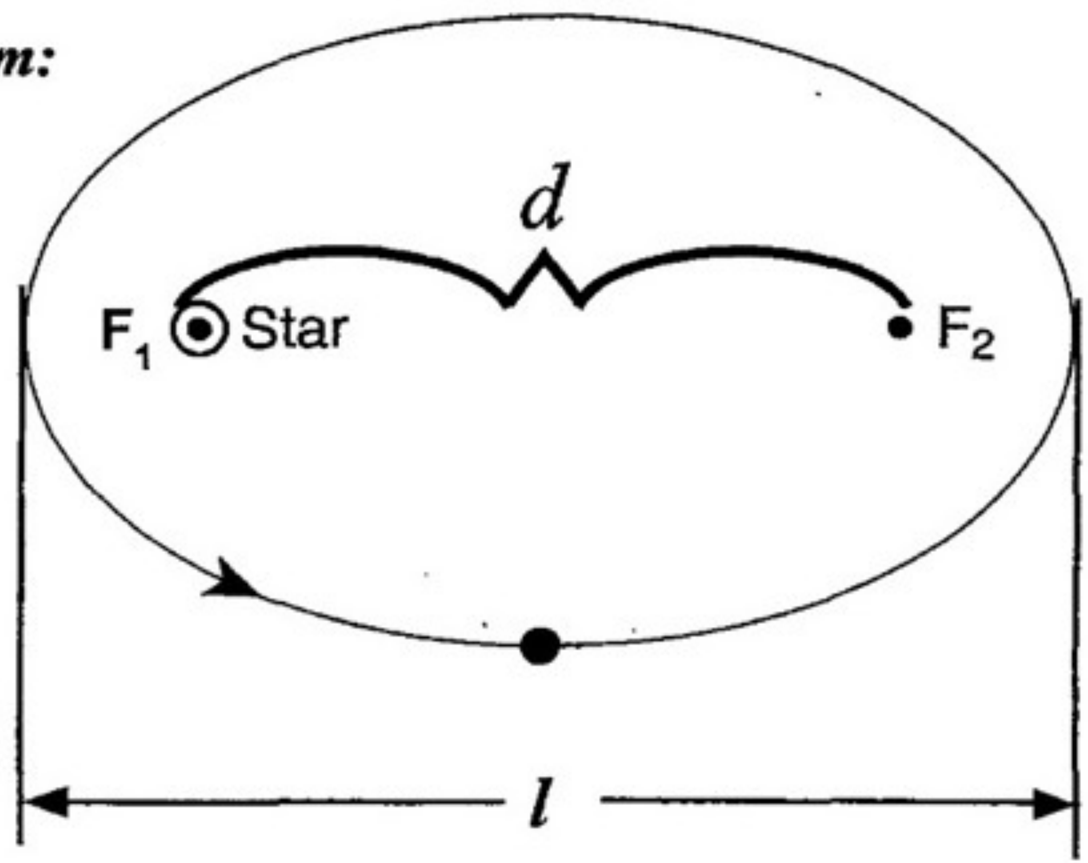
Overview:

Years ago it was assumed that the planets, comets and other astronomical objects revolved around the Sun in circular orbits. In time, it was proven that they do not revolve in circular orbits, but in elliptical orbits. These orbits are not round, but slightly flatten, giving it an oval shape. It's easy to describe a circular orbit, but how does one describe an elliptical orbit? This was solved by mathematicians using a term called eccentricity. Think of this term as a measurement of how much the shape of an ellipse deviates from a circle. Eccentricity (e) is a value that is used to indicate how elliptical an orbit is.

The Equation:

To arrive at the eccentricity, the distance (d) between the two foci (F_1 and F_2) is measured. Located at one ıese foci may be a star (like our Sun), while the other focus is at an imaginary position in space. The length of the major axis (l) is determined by measuring the longest axis of the elliptical orbit. Dividing, $\frac{d}{l}$ gives us the eccentricity or e value. This e value has no units. The larger the eccentricity, the more elliptical the orbit will be. Turn to the Solar System Data chart in the reference table and locate the Eccentricity of Orbit column. Mercury, having the largest eccentricity or e value, must have the most elliptical orbit of all planets. Venus, having the smallest eccentricity has an almost circular orbit. The Earth's orbit, having a very low eccentricity of 0.017, would appear to be almost circular, but because e is more than 0, it's orbit is slightly elliptical.

Eccentricity Diagram:



$$e = \frac{d}{l}$$

d = distance between foci

l = length of major axis

Additional Information:

- Due to the elliptical shape of orbits, when the orbiting body (planets, comets, etc.) revolves around the Sun, its distance from the Sun changes, at times being closer and other times being farther away.
- When an orbiting object is closer to the Sun (star), it speeds up. This is because the gravitational attraction with the Sun increases, causing the increase in orbital speed.
- When an orbiting object is farther from the Sun in its orbit, the gravitational attraction with the Sun decreases, causing a decrease of orbital speed.
- Earth is closer to the Sun in winter, thus having its greatest orbital speed during this time.
- Earth is farther from the Sun in summer, thus having its slowest orbital speed during this time.

Set 1 — Eccentricity

1. Which object is located at one foci of the elliptical orbit of Mars?

   (1) the Sun
   (2) *Betelgeuse*
   (3) Earth
   (4) Jupiter

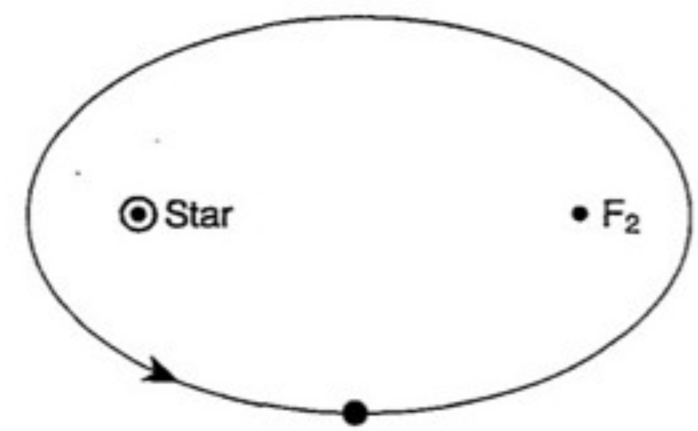
   1 ______

2. Which planet has the most eccentric orbit?

   (1) Mercury
   (2) Venus
   (3) Neptune
   (4) Saturn

   2 ______

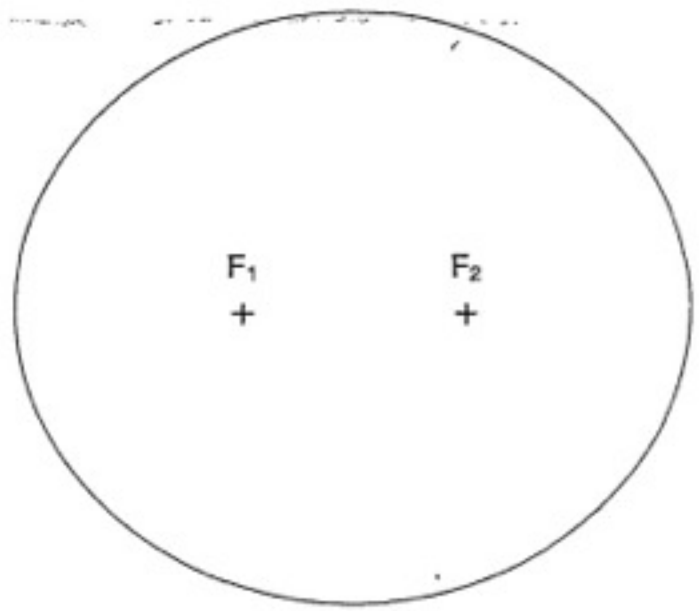
3. The diagram below shows the elliptical orbit of a planet revolving around a star. The star and F_2 are the foci of this ellipse. What is the approximate eccentricity of this ellipse?



   (1) 0.22
   (2) 0.47
   (3) 0.68
   (4) 1.47

   3 ______

Base your answers to questions 4 and 5 on the diagram below of the ellipse.



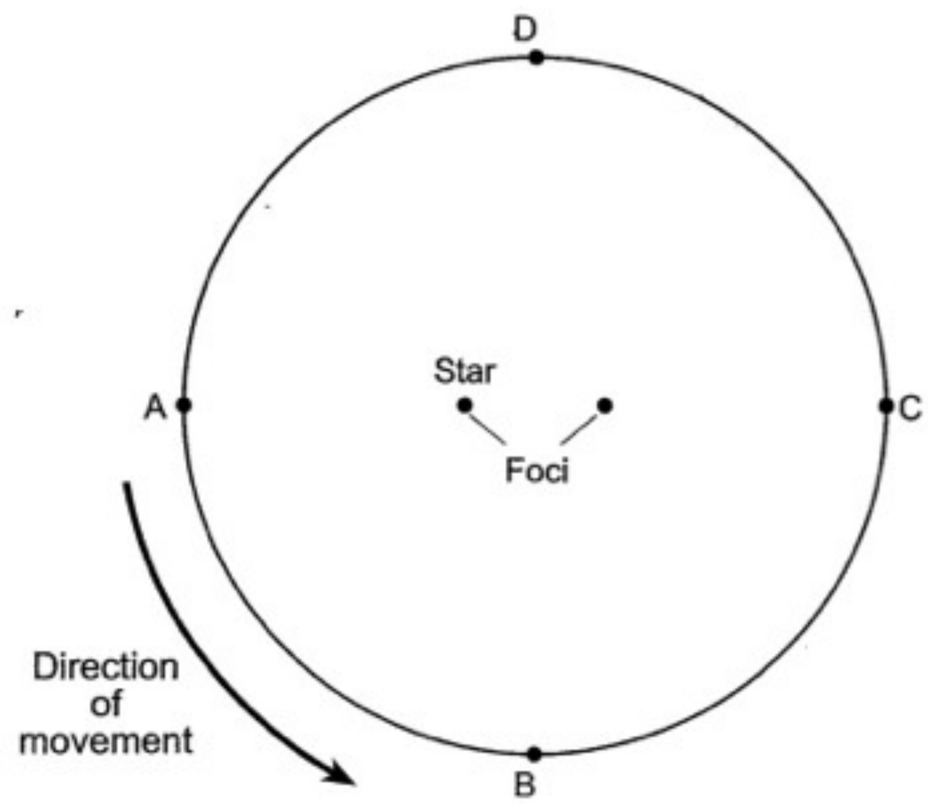
4. *a*) Write out the eccentricity equation.

b) From the given ellipse, subsitute the correct values into the equation.

c) Calculate the eccentricity of the ellipse.

5. State how the eccentricity of the given ellipse compares to the eccentricity of the orbit of Mars.

Base your answers to questions 6 through 8 on the diagram below, which represents the elliptical orbit of a planet traveling around a star. Points *A*, *B*, *C*, and *D* are four positions of this planet in its orbit.



(Drawn to scale)

6. The calculated eccentricity of this orbit is approximately

(1) 0.1 (2) 0.2 (3) 0.3 (4) 0.4 6 ________

7. The gravitational attraction between the star and the planet will be greatest at position

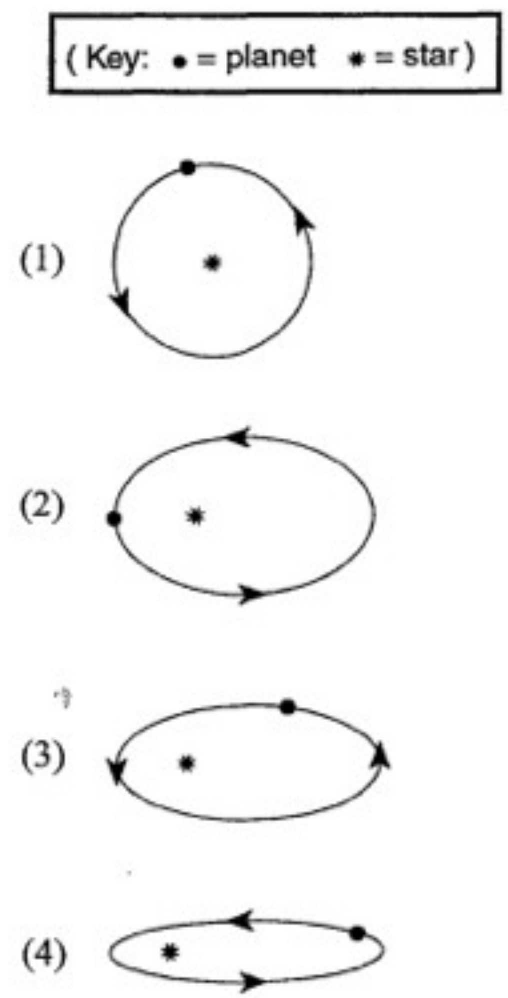
(1) *A* (2) *B* (3) *C* (4) *D* 7 ________

8. What planet could this orbit represent? ______________________________

9. Which planet has the least elliptical orbit?

(1) Jupiter
(2) Mars
(3) Venus
(4) Saturn 9 _____

10. Which diagram shows a planet with the *least* eccentric orbit?



10 _____

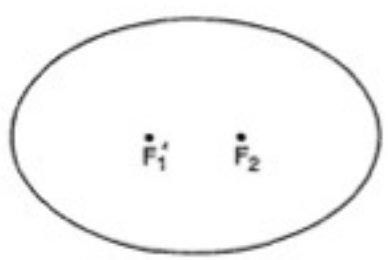
11. The actual orbits of the planets are

(1) elliptical, with Earth at one of the foci
(2) elliptical, with the Sun at one of the foci
(3) circular, with Earth at the center
(4) circular, with the Sun at the center 11 _____

12. Earth is farthest from the Sun during the Northern Hemisphere's summer, and Earth is closest to the Sun during the Northern Hemisphere's winter. During which season in the Northern Hemisphere is Earth's orbital velocity greatest?

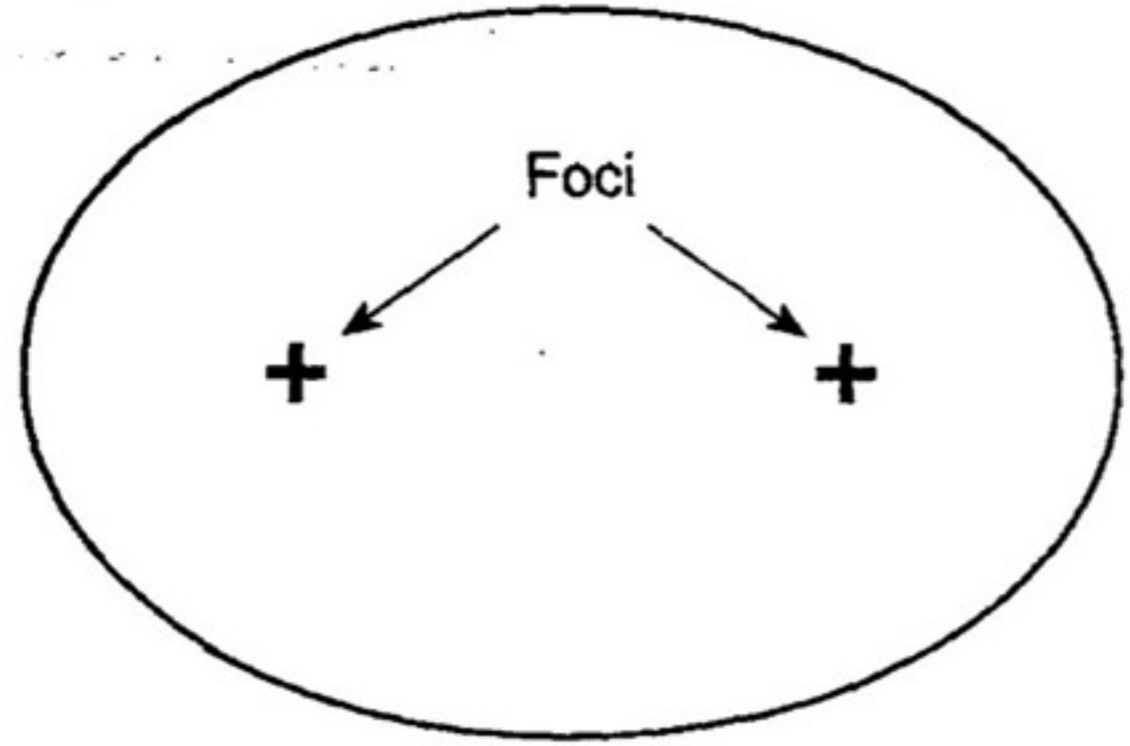
(1) winter (3) summer
(2) spring (4) fall 12 _____

13. The diagram below is a constructed ellipse. F_1 and F_2 are the foci of the ellipse. The eccentricity of this constructed ellipse is closest to the eccentricity of the orbit of which planet?



(1) Mercury (3) Saturn
(2) Earth (4) Venus 13 _____

14. The accompanying diagram represents the elliptical orbit of a spacecraft around the Sun. Calculate the eccentricity of the spacecraft's orbit following the directions below:



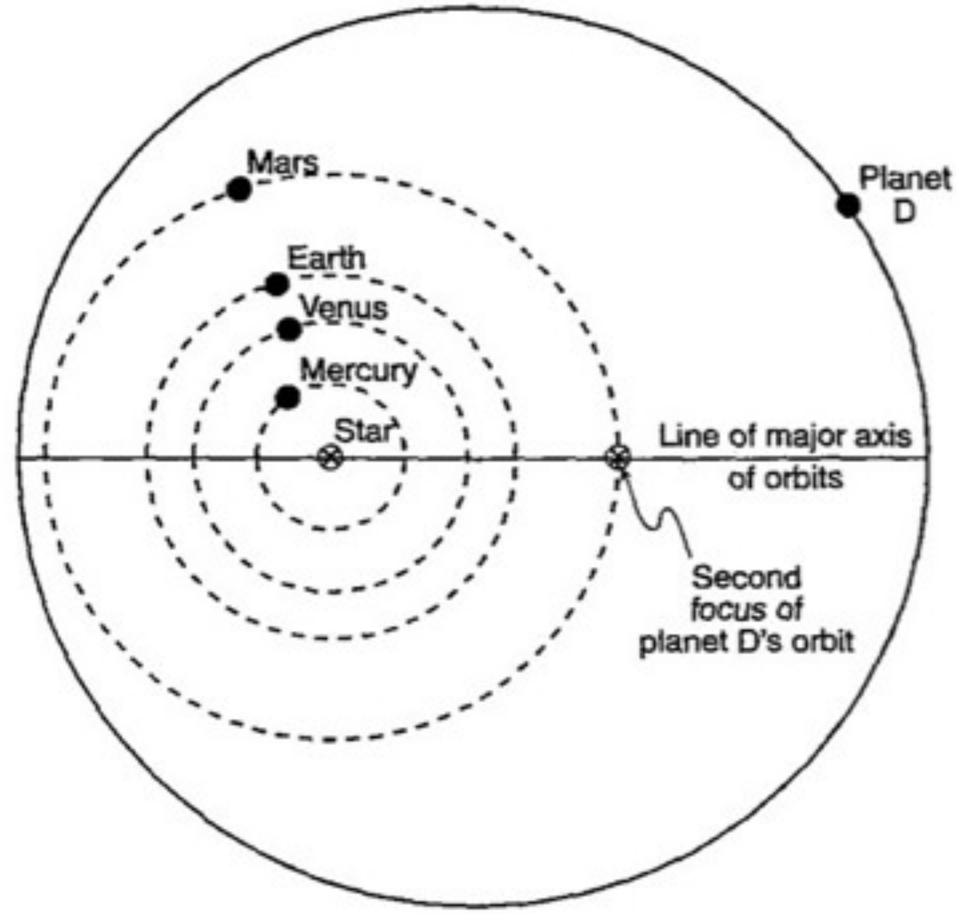
(Drawn to scale)

a) Write the equation for eccentricity.

b) Substitute measurements of the diagram into the equation.

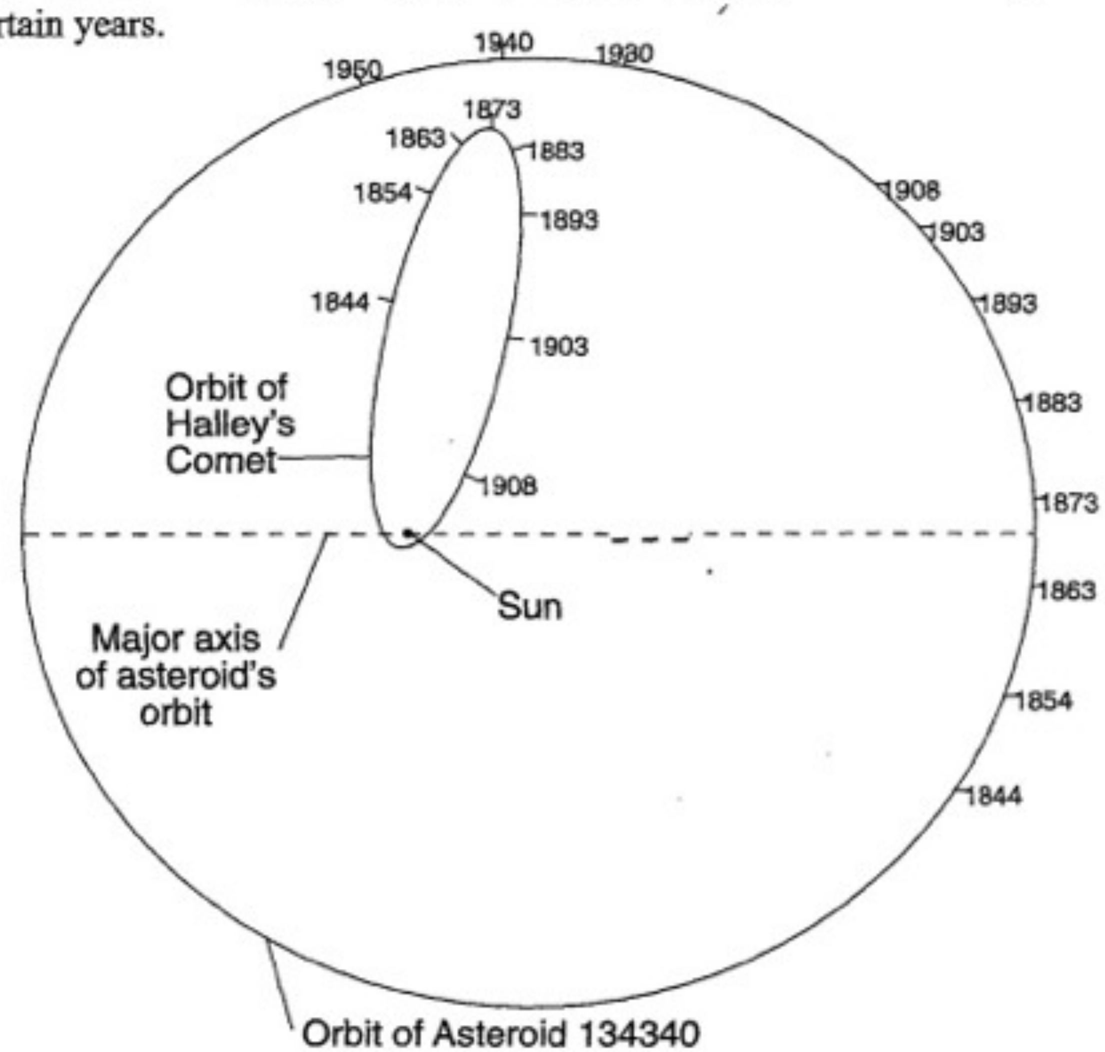
c) Calculate the eccentricity and record your answer in decimal form.

15. Describe the eccentricity of planet *D*'s orbit relative to the eccentricities of the orbits of the planets shown in our solar system.



[redacted]

Base your answers to questions 16*a*, *b*, *c* and *d* on the diagram below. The diagram shows the positions of Halley's Comet and Asteroid 134340 at various times in their orbits. Specific orbital positions are shown for certain years.



16. *a*) The eccentricity of the asteroid's orbit is 0.250. On the orbital diagram above, mark the position of the second focus of the asteroid's orbit by placing an **X** on the major axis at the proper location.

b) Determine which was traveling faster, Halley's Comet or the asteroid, between the years 1903 and 1908. State one reason for your choice.

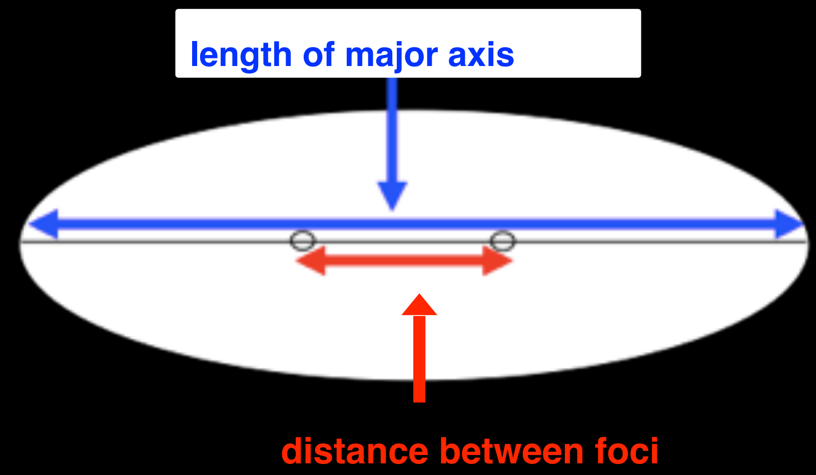
c) Explain why Halley's Comet is considered to be part of our solar system.

d) Of the two orbiting objects, which would have a higher eccentricity value? Explain why.

Review:

eccentricity - ratio of the distance between the foci to the length of the ma

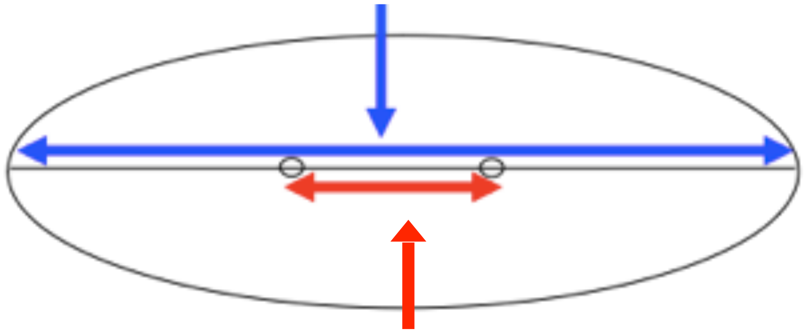
eccentricity distance between foci



Review:

eccentricity - ratio of the distance between the foci to the length of the major

eccentricity = **distance between foci**



Do Now:

Make a list of objects that orbit the sun

November 15

Objectives:

1. Identify the objects within our **Solar System**
2. Understand the difference between **Rotation** and **Revolution**

How was it formed

- The Nebular Theory
- Started as nebula about 5 billion years ago
  - Composed of hydrogen and helium
- Nearby supernova sent shock waves through galaxy
  - caused gases to be pulled inward
  - supplied new elements
- Shrank to a spinning disk –10 billion kilometers across
- Gravity heated center to protostar - the sun

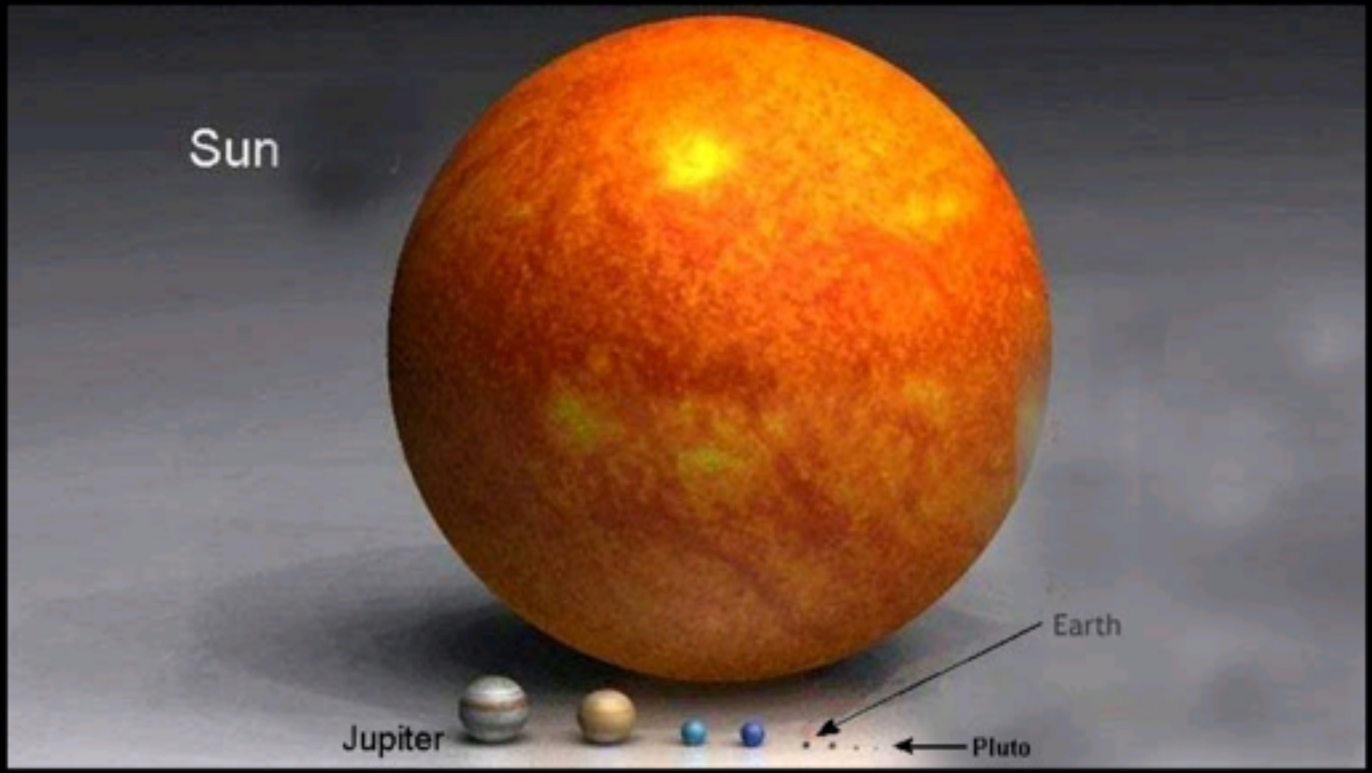
How was it formed

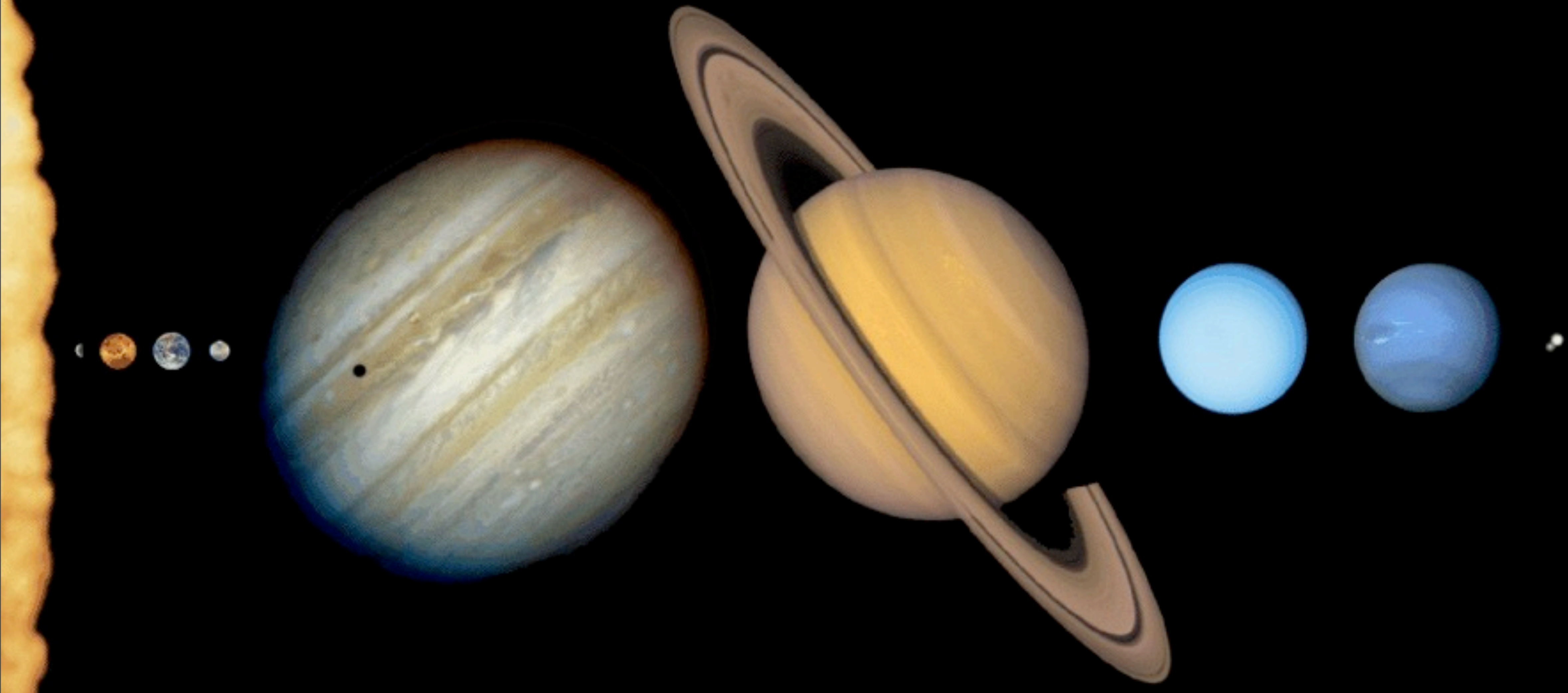
- Other matter spun around the new sun
- gathered into clumps- protoplanets
- Near the sun the light weight gases boiled away
  - Mercury, Venus, Earth, Mars
- In those far away the gases did not boil away
  - Jupiter, Saturn, Uranus, Neptune
  - the gas giants

How was it formed

- Around the protoplanets smaller clumps formed moons or satellites.
- Pluto is thought to be a moon of Neptune that broke away.
- Asteroid belt- clumps of rocks between Mars and Jupiter
- Jupiter’s gravity stopped a planet from forming
- Oort Cloud- Near the edge clumps of

All planets compared to Our Sun

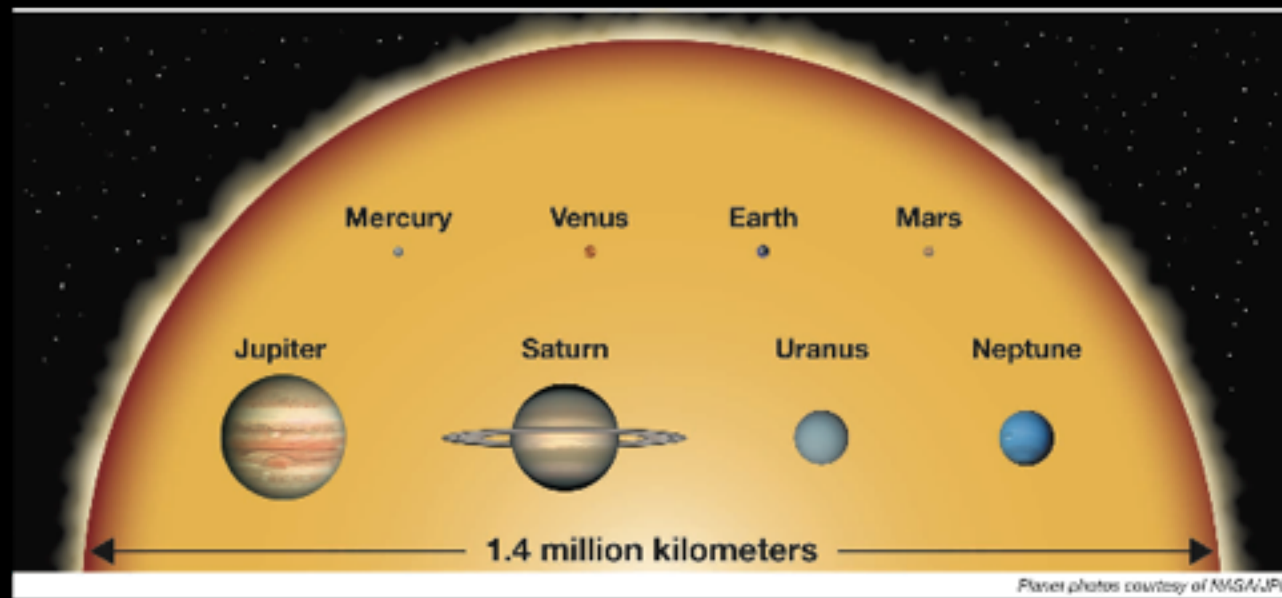




Rotation: The spin of the Earth on it’s axis (24 hours or 1 day)

Revolution: Period of time that it takes the Earth to orbit around the sun (365.25 days or 1 year)

Scaled Sizes of the Planets



Planet: A non-luminous celestial body larger than an asteroid or comet, illuminated by light from a star, such as the sun, around which it revolves.

Planet Classification

Gas giant Planets (Outer or Jovian planets)

Large masses, low densities, and many moons and rings.

Jupiter, Saturn, Uranus, and Neptune

Terrestrial Planets (Inner Planets)

Similar in density (high) to Earth and have solid, rocky surfaces.

Mercury, Venus, Earth & Mars

Dwarf Planet

Objects close to Pluto's size.

Satellite

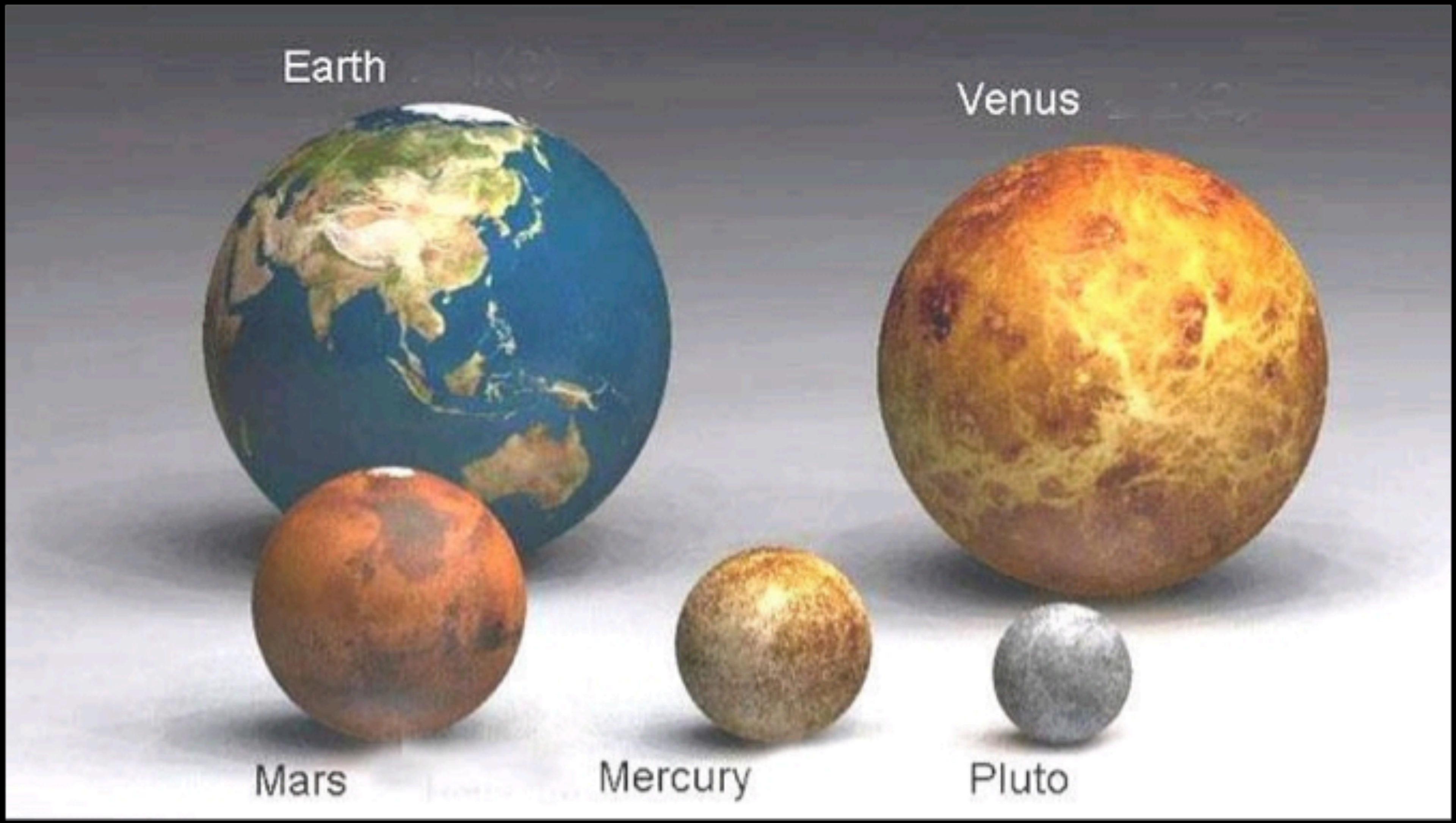
A celestial body that orbits a planet; **a moon.**

ESRT - Page

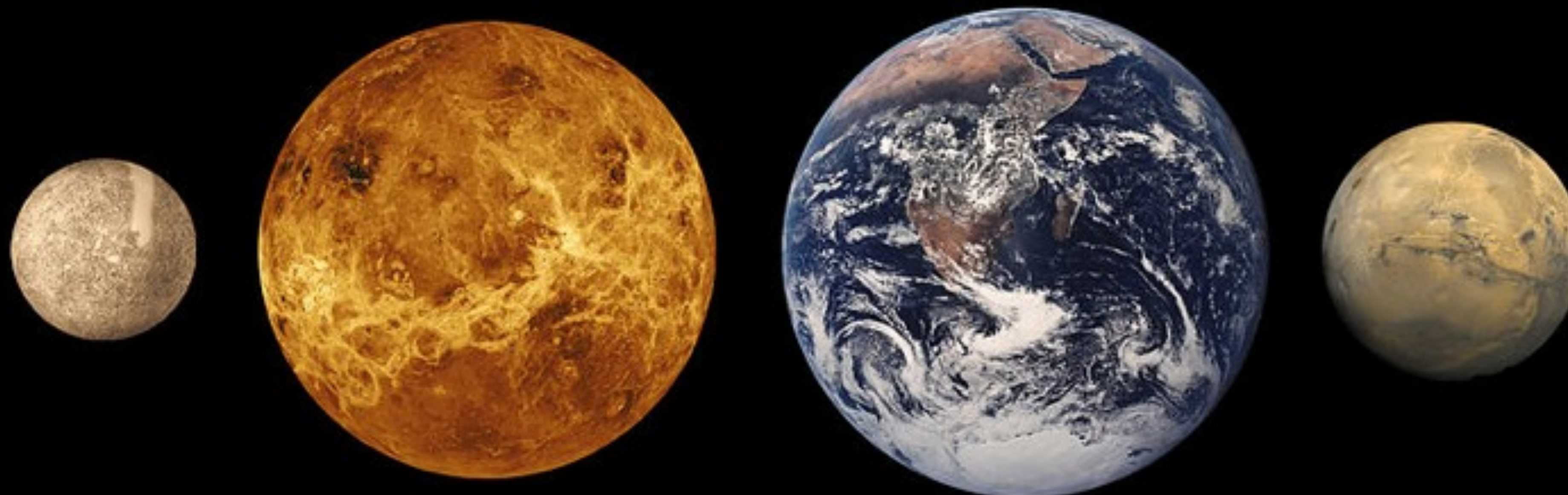
Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)
SUN	—	—	27 d	—	1,392,000	333,000.00	1.4
MERCURY	57.9	88 d	59 d	0.206	4,879	0.06	5.4
VENUS	108.2	224.7 d	243 d	0.007	12,104	0.82	5.2
EARTH	149.6	365.26 d	23 h 56 min 4 s	0.017	12,756	1.00	5.5
MARS	227.9	687 d	24 h 37 min 23 s	0.093	6,794	0.11	3.9
JUPITER	778.4	11.9 y	9 h 50 min 30 s	0.048	142,984	317.83	1.3
SATURN	1,426.7	29.5 y	10 h 14 min	0.054	120,536	95.16	0.7
URANUS	2,871.0	84.0 y	17 h 14 min	0.047	51,118	14.54	1.3
NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

Terrestrial Planets



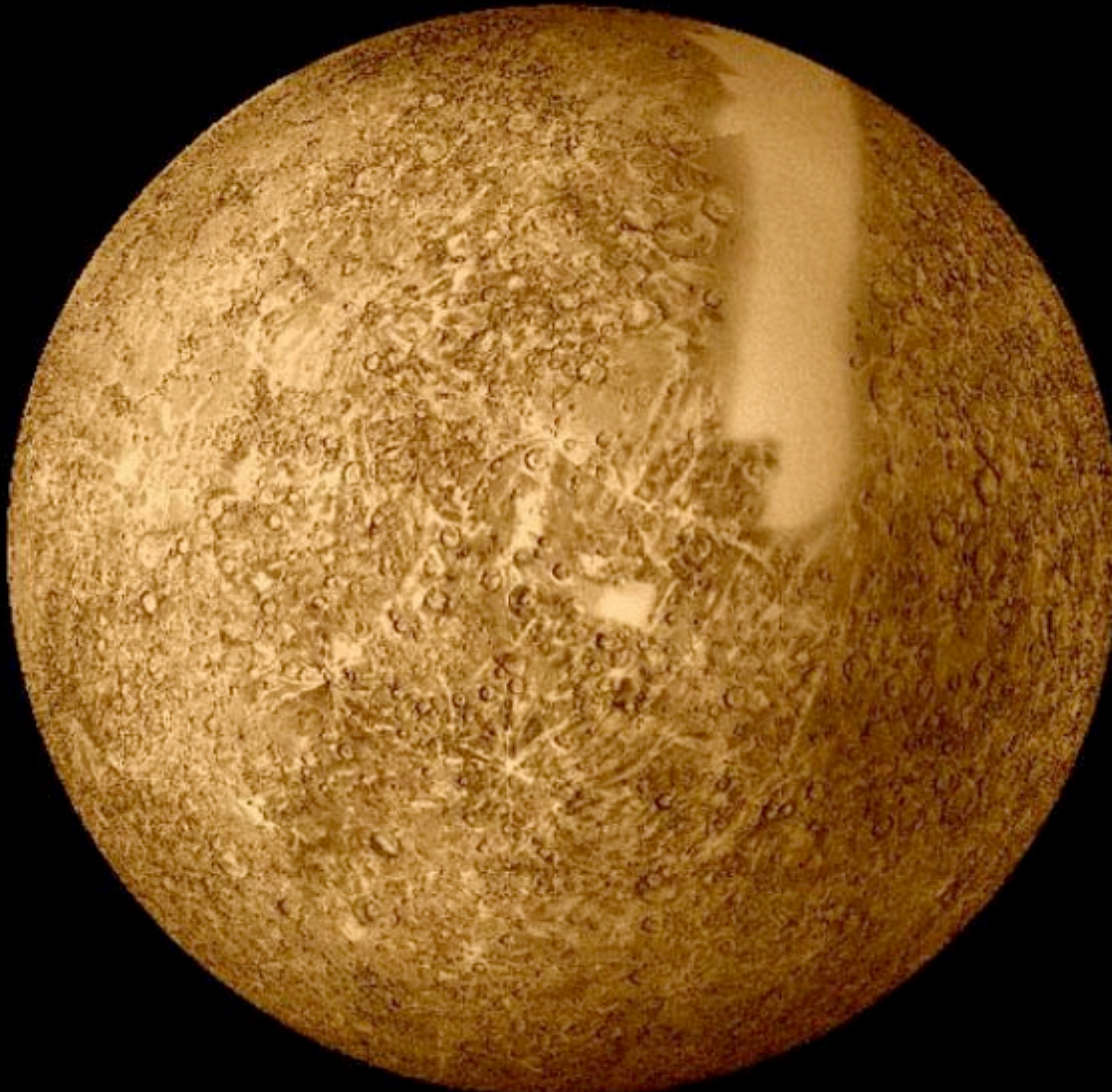
Terrestrial Planets



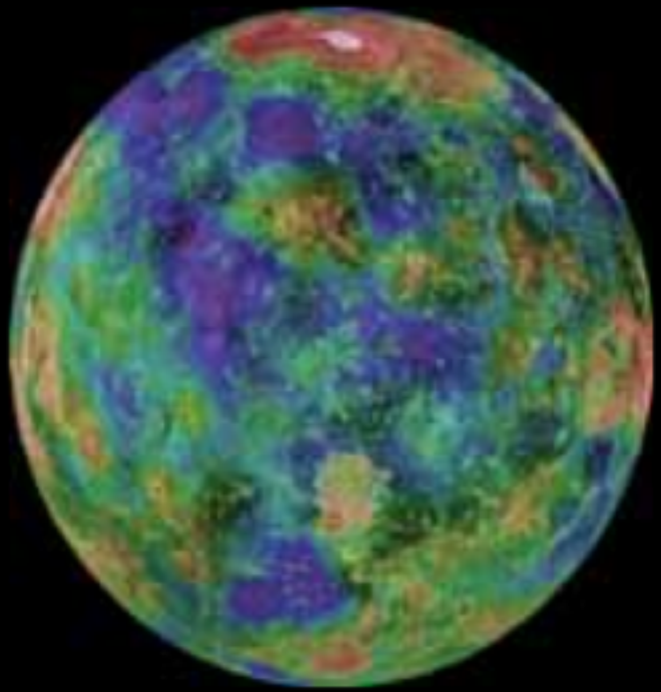
Mercury

solid and is covered with craters.
has almost no atmosphere.
the eighth largest planet.

Mercury

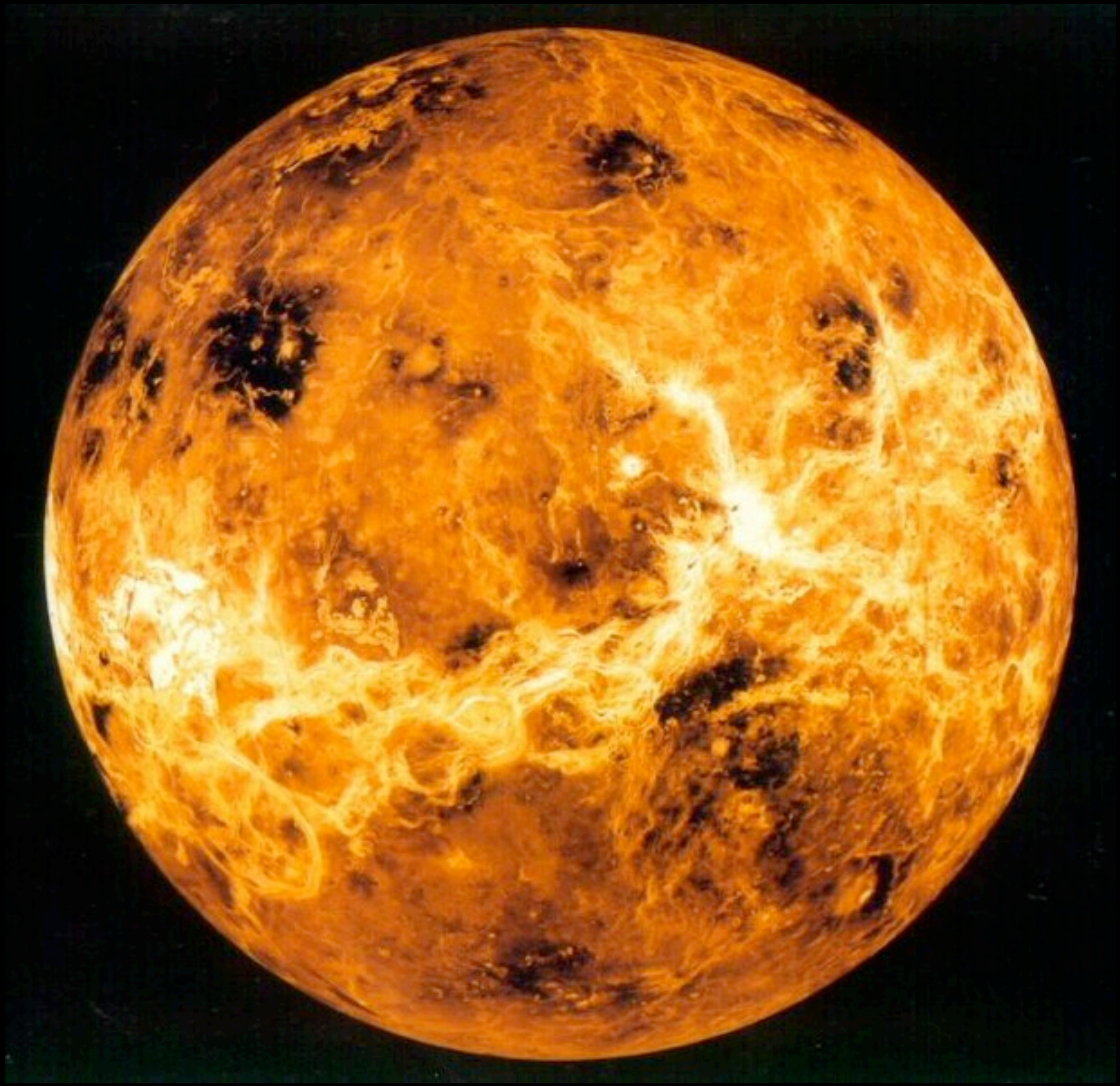


Venus



the sixth largest planet.
It’s about 75% of the size of earth.
Surface is rocky and very hot.
The atmosphere completely hides the surface and traps the heat (Greenhouse Effect)

Venus

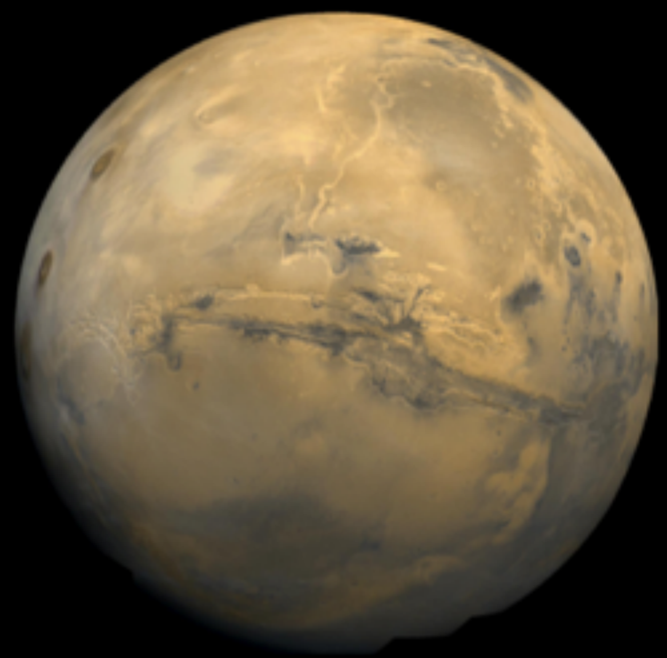


Earth

the fifth largest planet and the third from the sun.
Liquid covers 71 percent of the Earth’s surface.
The Earth has one moon.

Earth

Mars



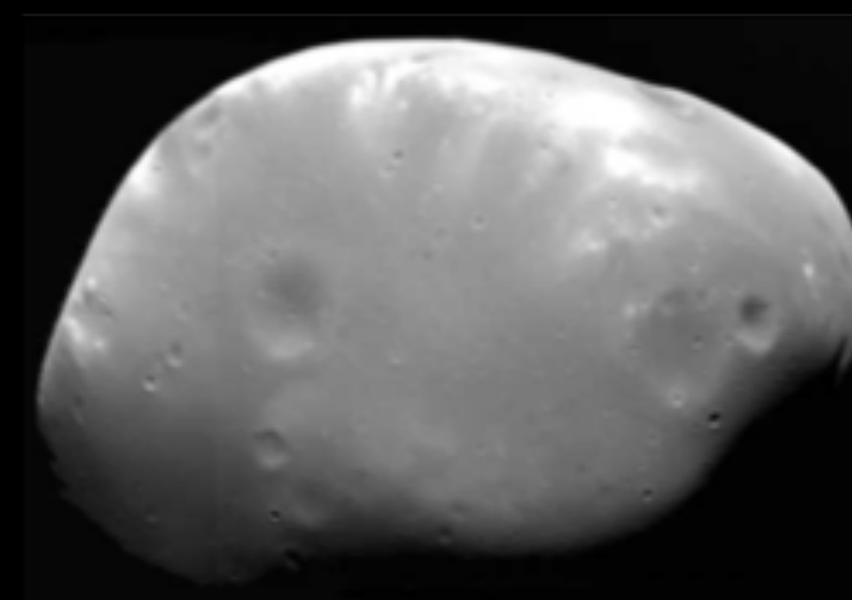
the fourth planet from the sun.
has a thin atmosphere that contains mostly carbon dioxide.
has two small moons.

Mars

Moons of Mars

Phobos

Deimos



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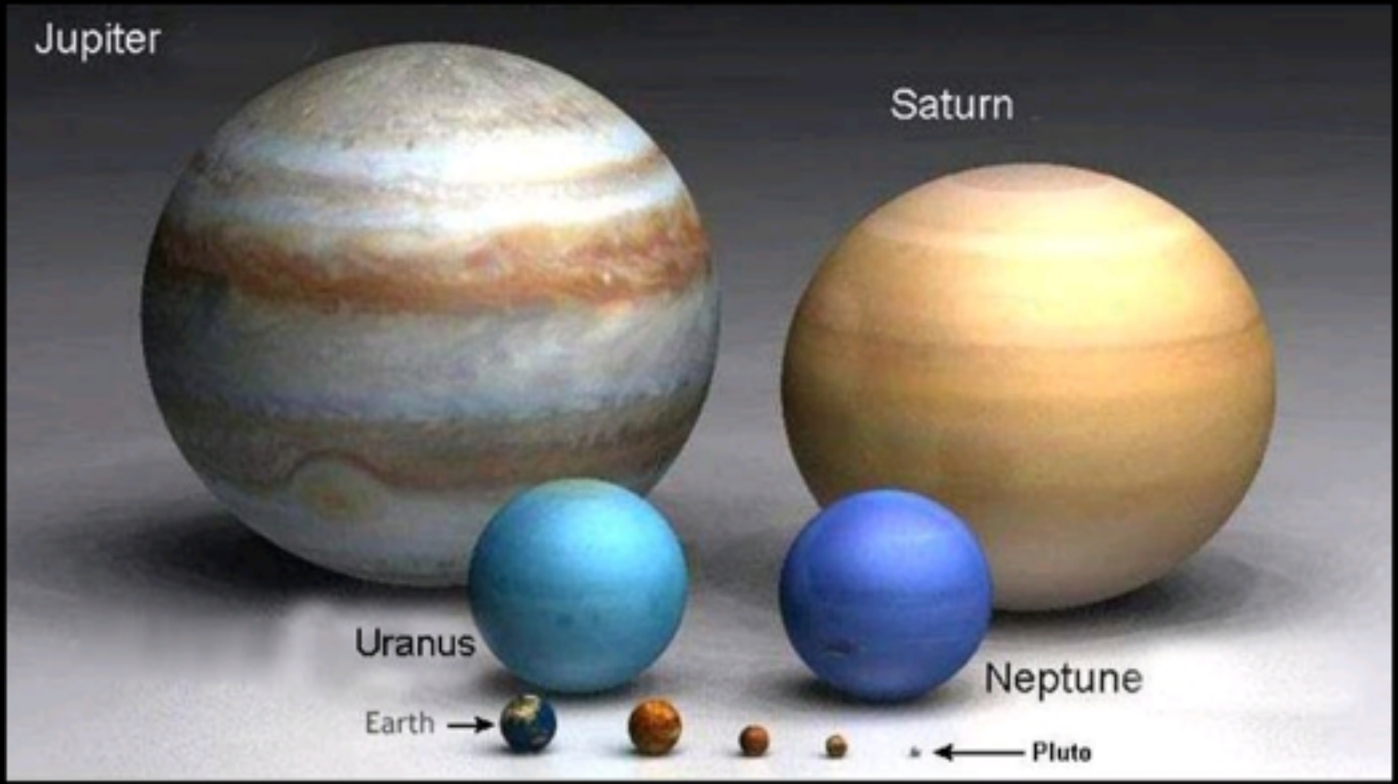
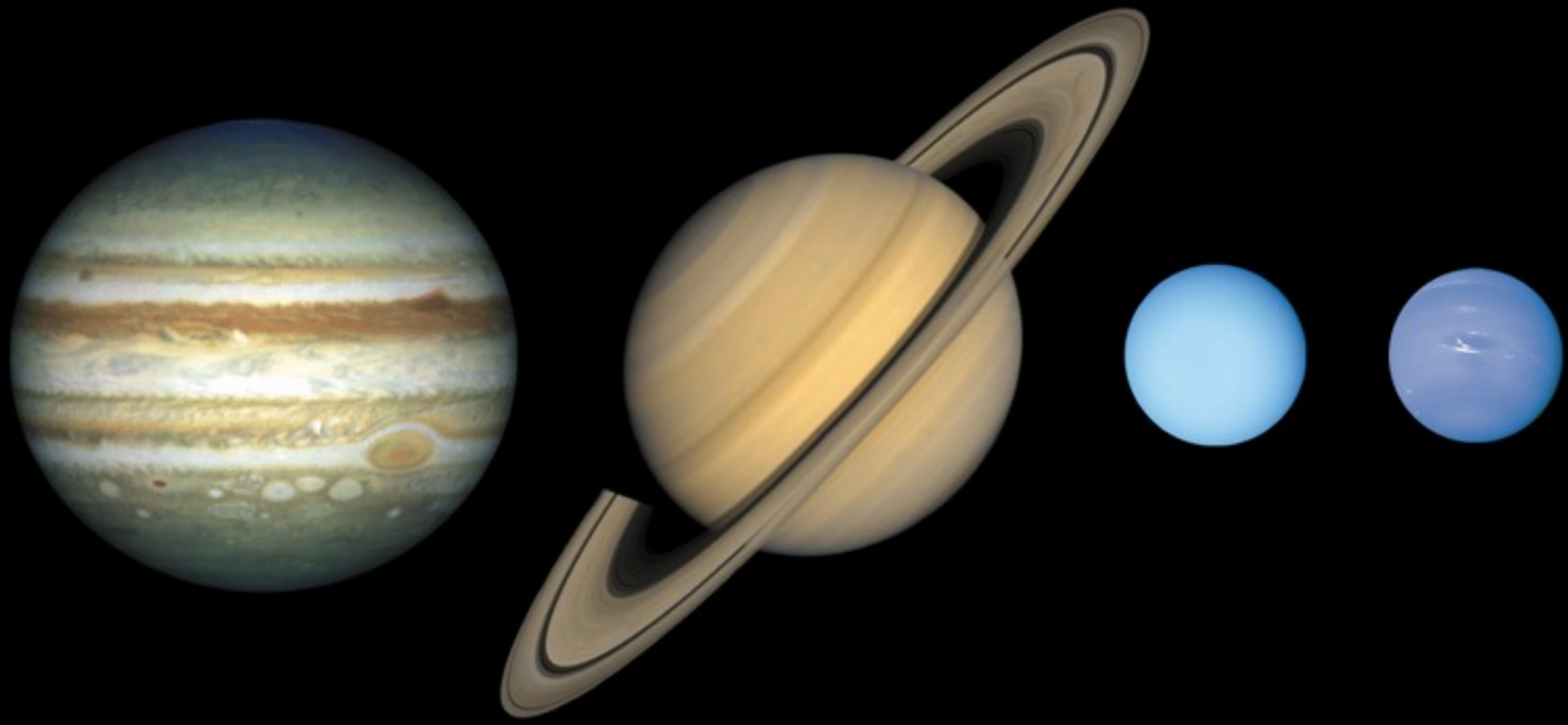
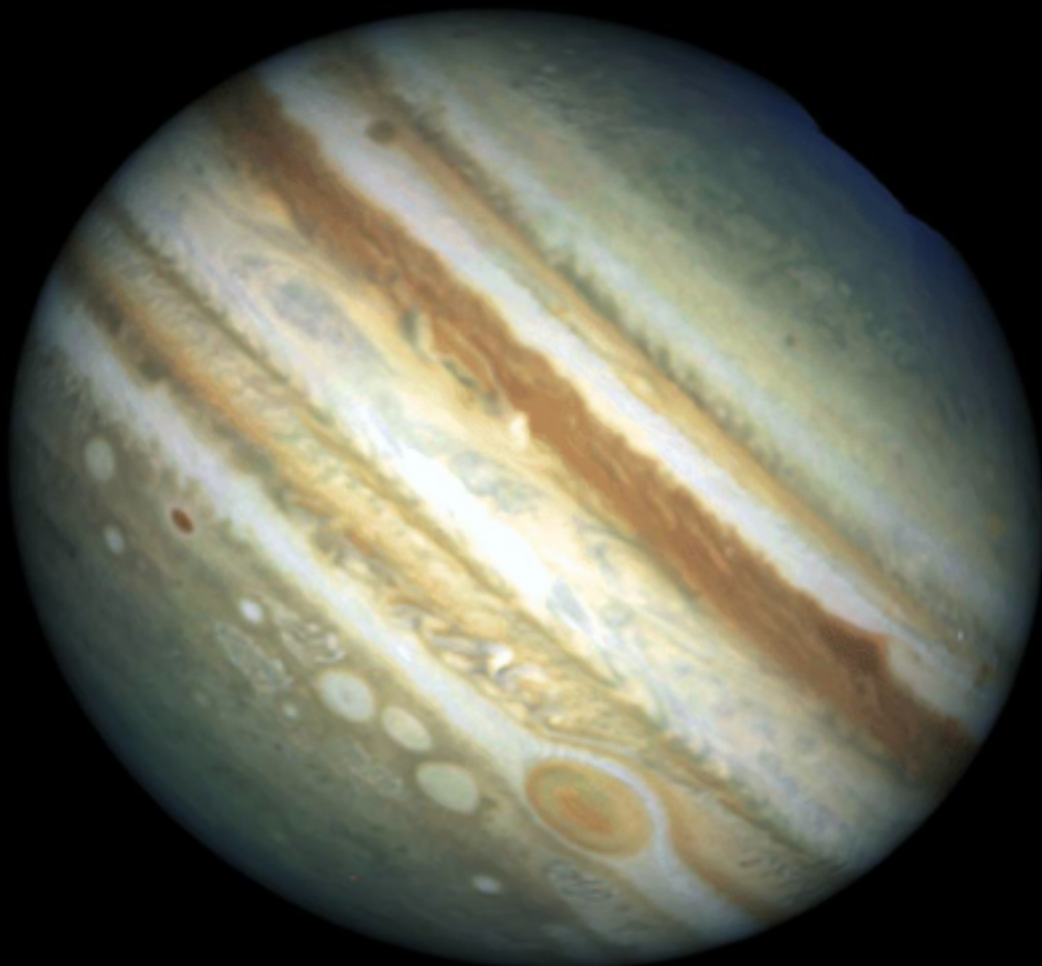
Jovian, Gas Giants or Outer Planets



Jovian, Gas Giants or Outer Planets



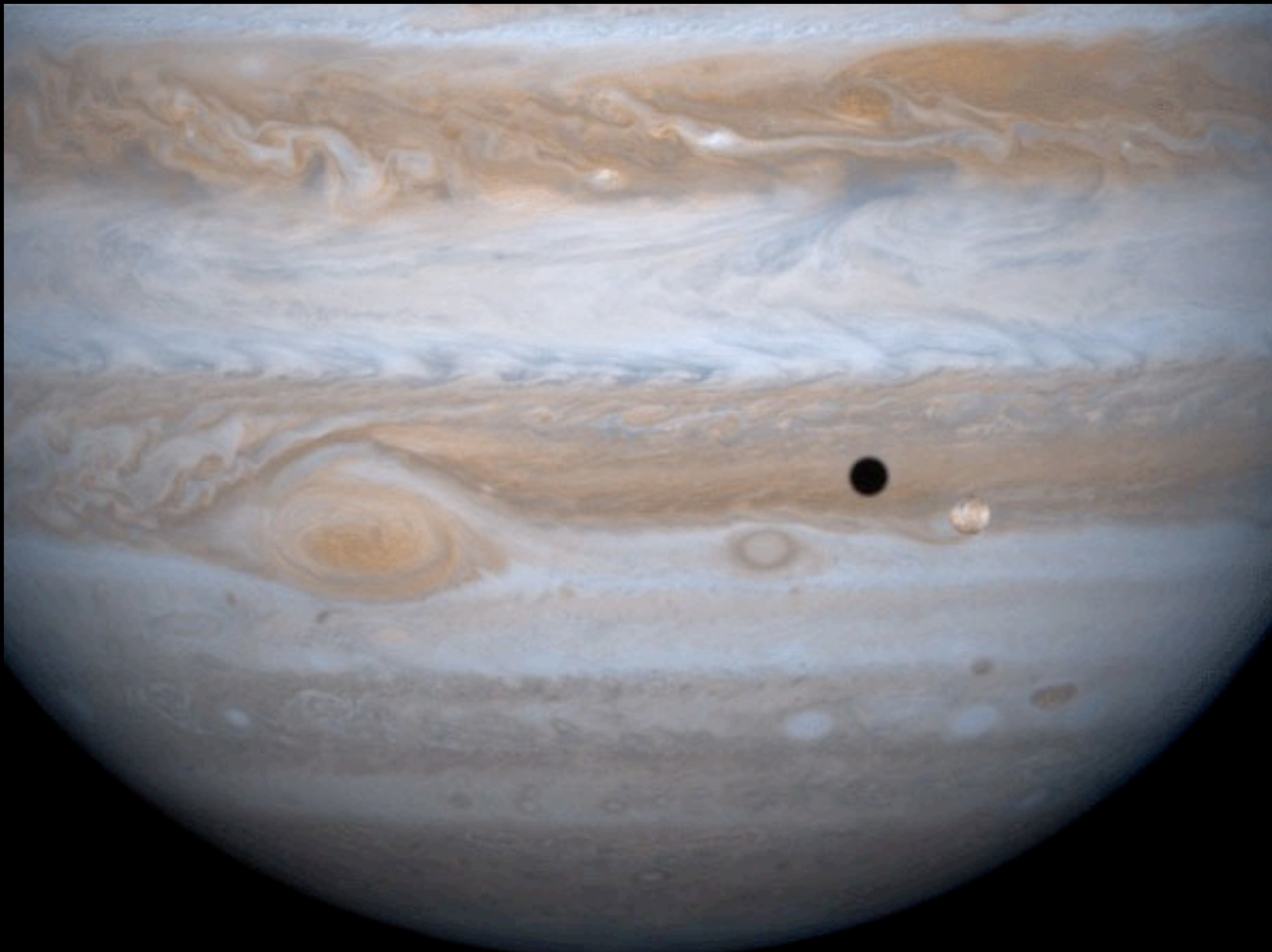
Jupiter



The planet is a ball of liquid surrounded by gas.

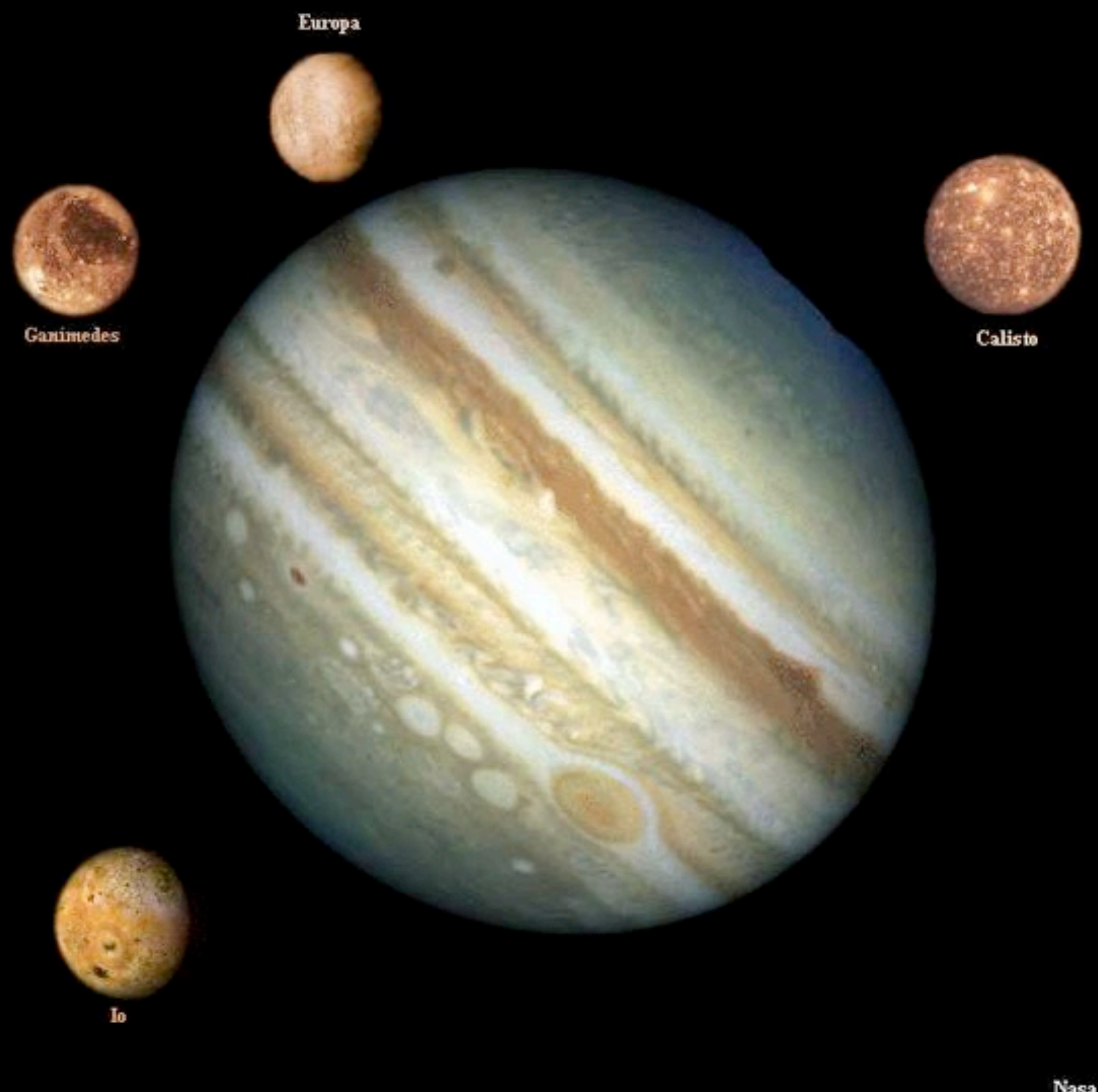
The Great Red Spot, a huge storm of swirling gas that has lasted for hundreds of years.

Jupiter



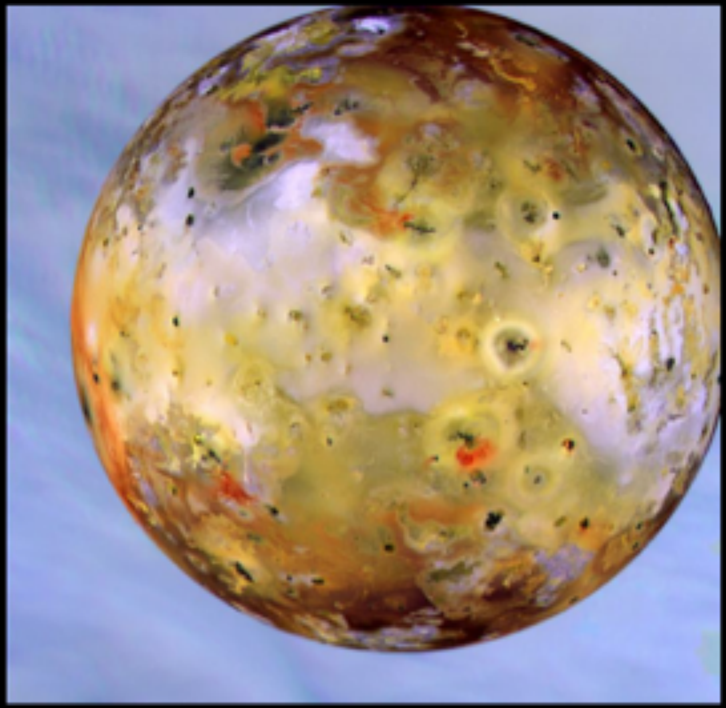
Moons of Jupiter

Jupiter has 4 large Galilean moons,
12 smaller named moons
23 more recently discovered but not named moons.



Moons of Jupiter with telescope & iphone

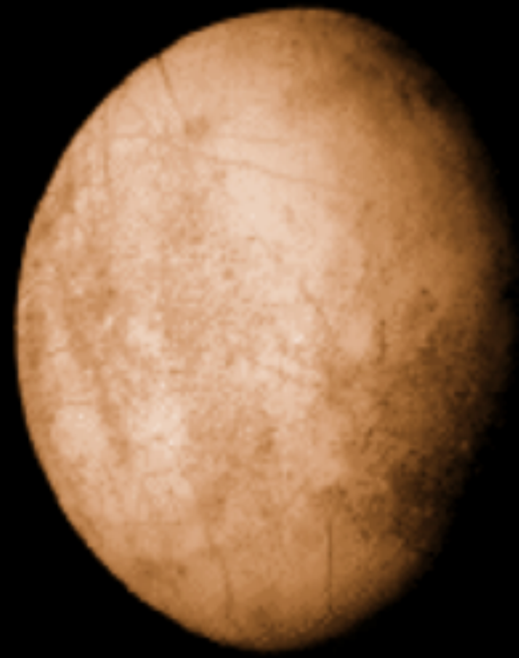
Io



Io is the fifth moon of Jupiter. It's the third largest of Jupiter's moons.
Io has hundreds of volcanic calderas. Some of the

****Do not copy****

Europa



Europa is the sixth of Jupiter's moons and is the fourth largest.
It is slightly smaller than the Earth's moon.
The surface strongly resembles images of sea ice on Earth.
There may be a liquid water sea under the crust.
Europa is one of the five known moons in the solar system to

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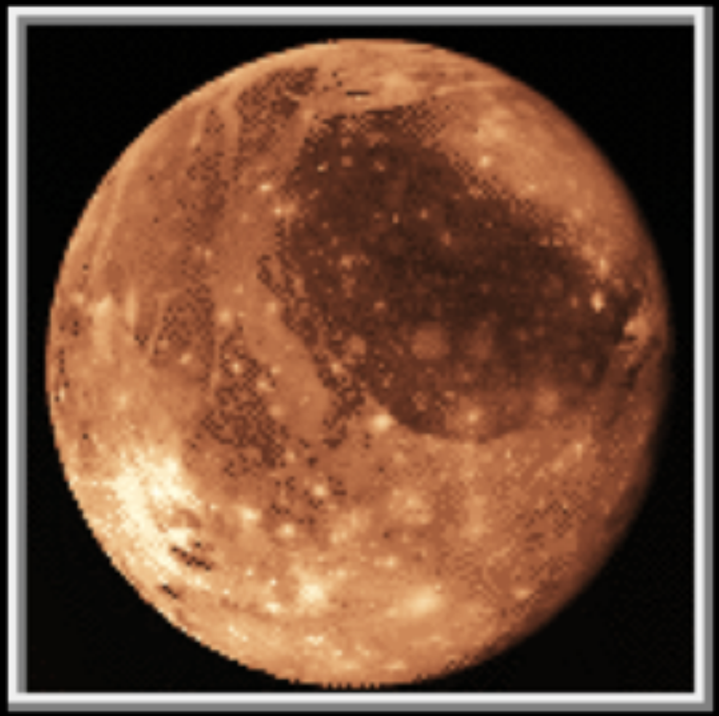
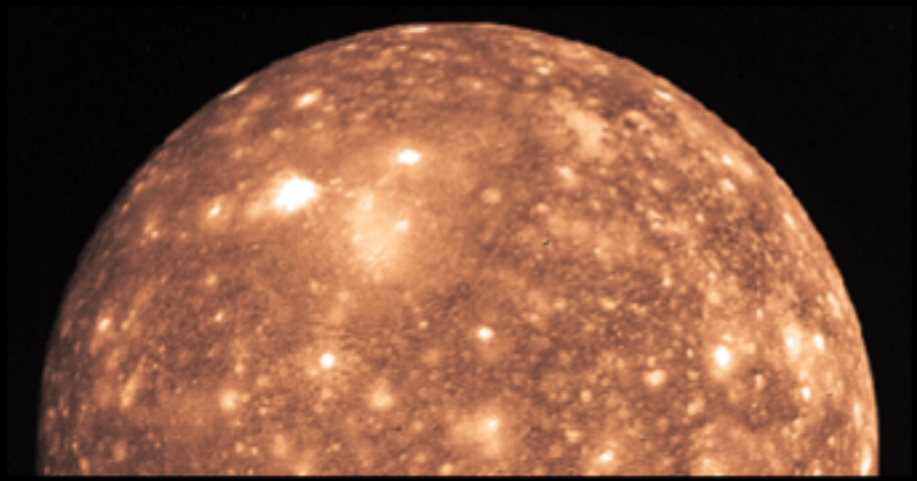
Ganymede



Ganymede is the seventh and largest of Jupiter's known satellites.
Ganymede has extensive cratering and an icy crust.

Callisto

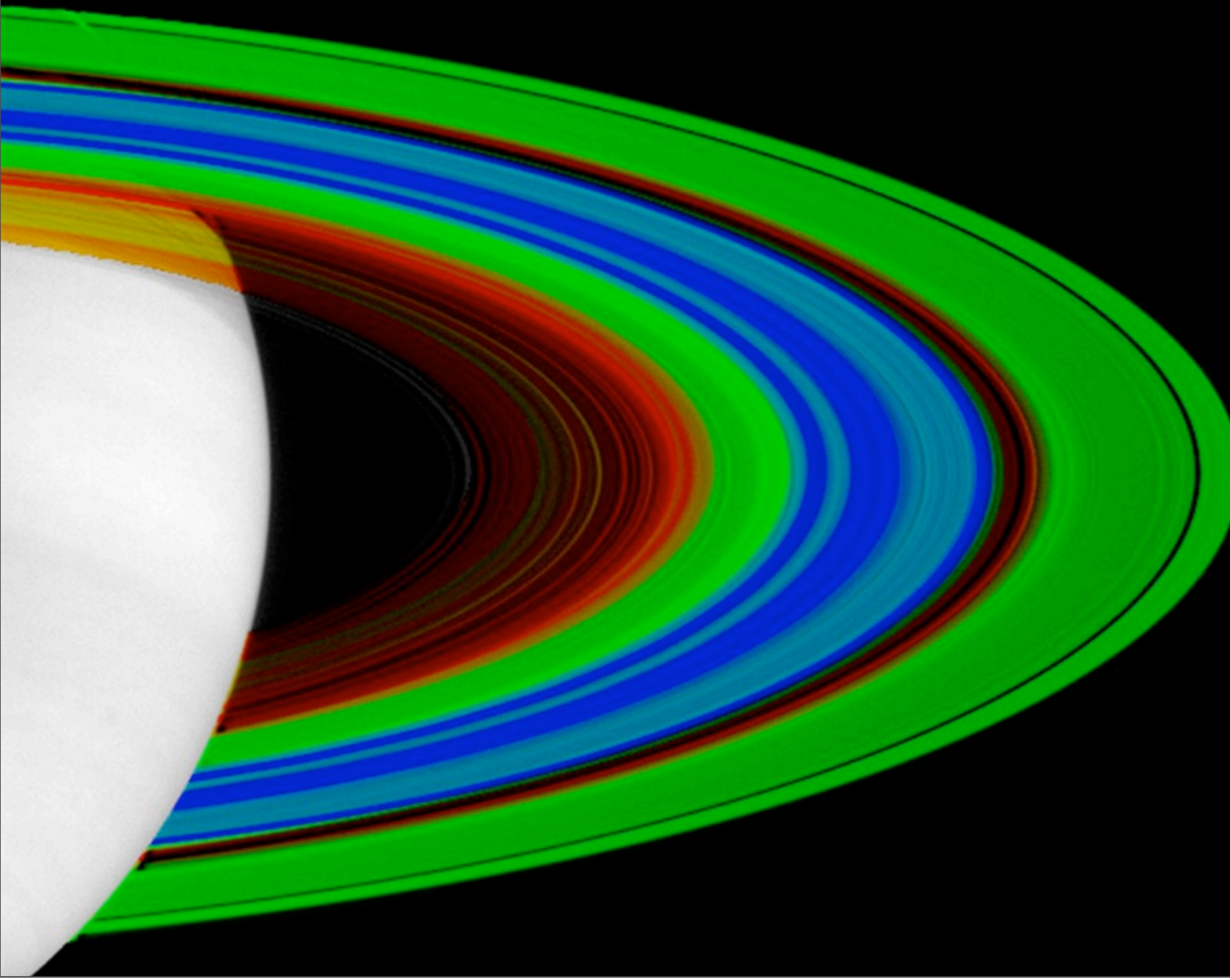


Callisto is the eighth of Jupiter's known satellites and the second largest.
Callisto has the oldest, most cratered surface of any body yet observed in the solar system.

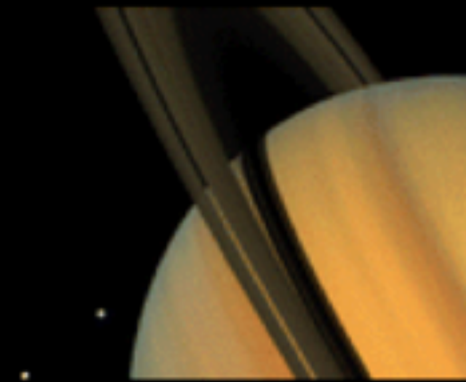
Saturn

is the second largest planet and the sixth from the sun.
made of materials that are lighter than water.
If you could fit Saturn in a lake, it would float!

Saturn



Rings of Saturn



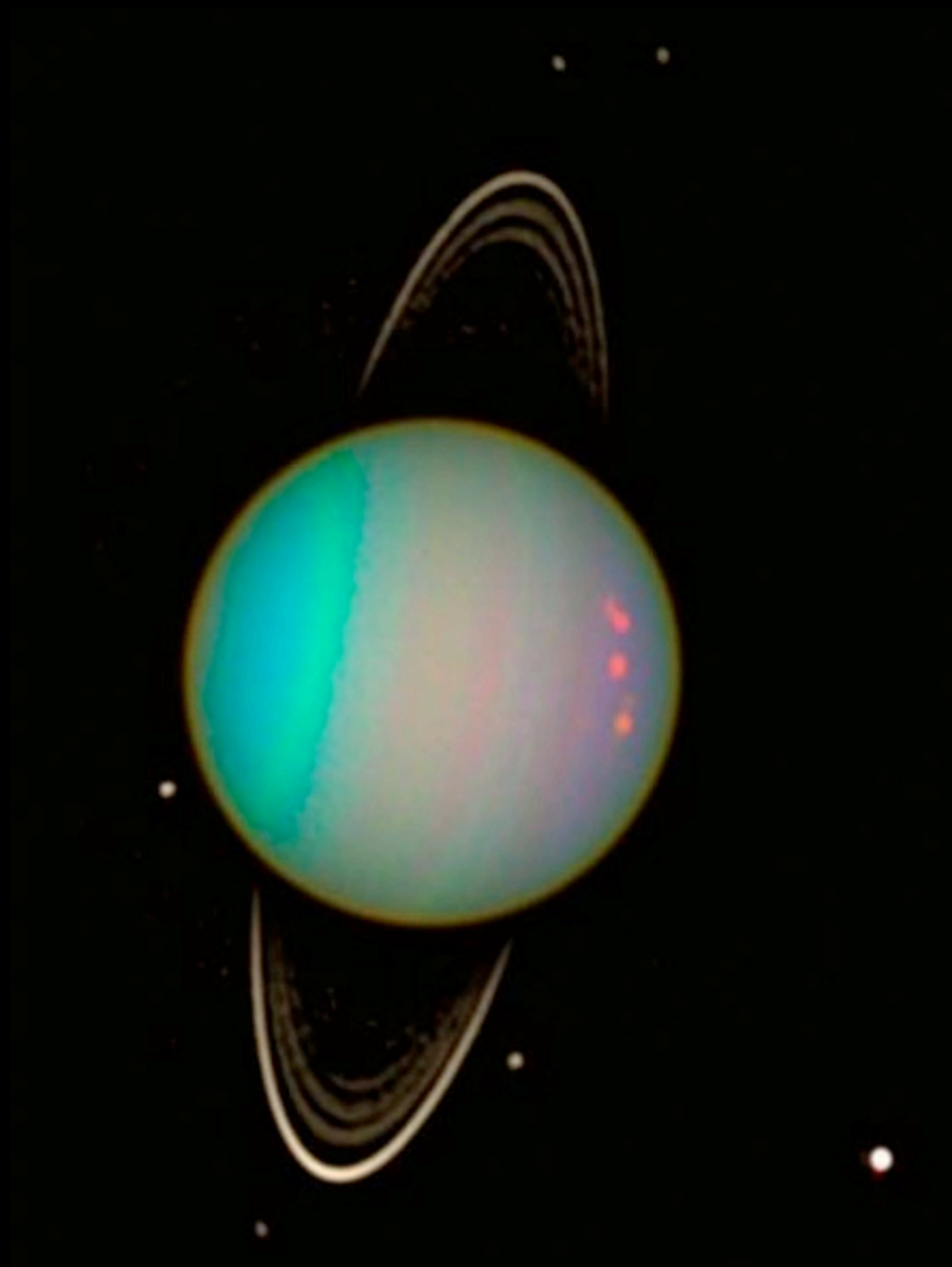
Saturn’s rings are not solid; they are composed of small countless particles.

The rings are very thin. Though they’re 250,000km or more in diameter, they’re less than one kilometer thick.

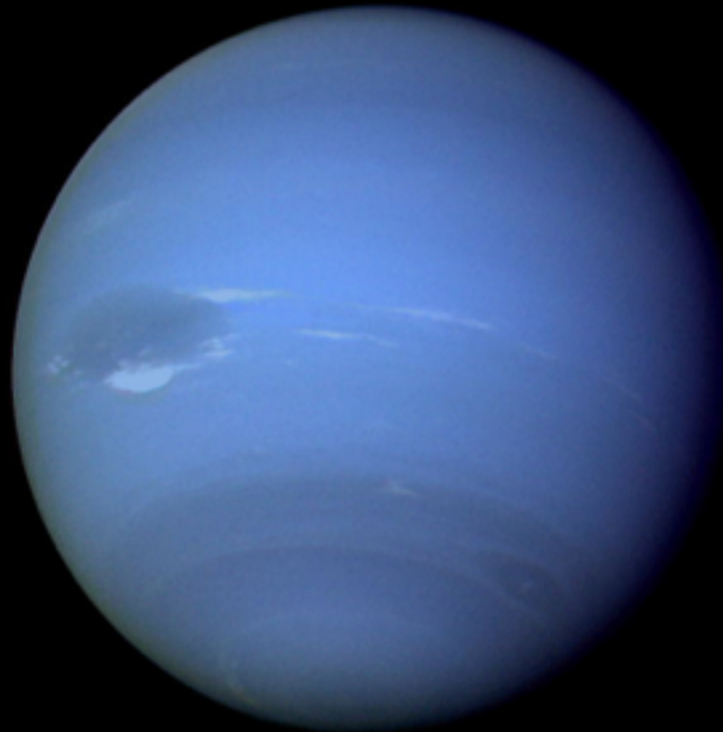
Uranus

is the third largest planet and the seventh from the sun.
is one of the giant gas planets.
is blue-green because of the methane in its atmosphere.

Uranus



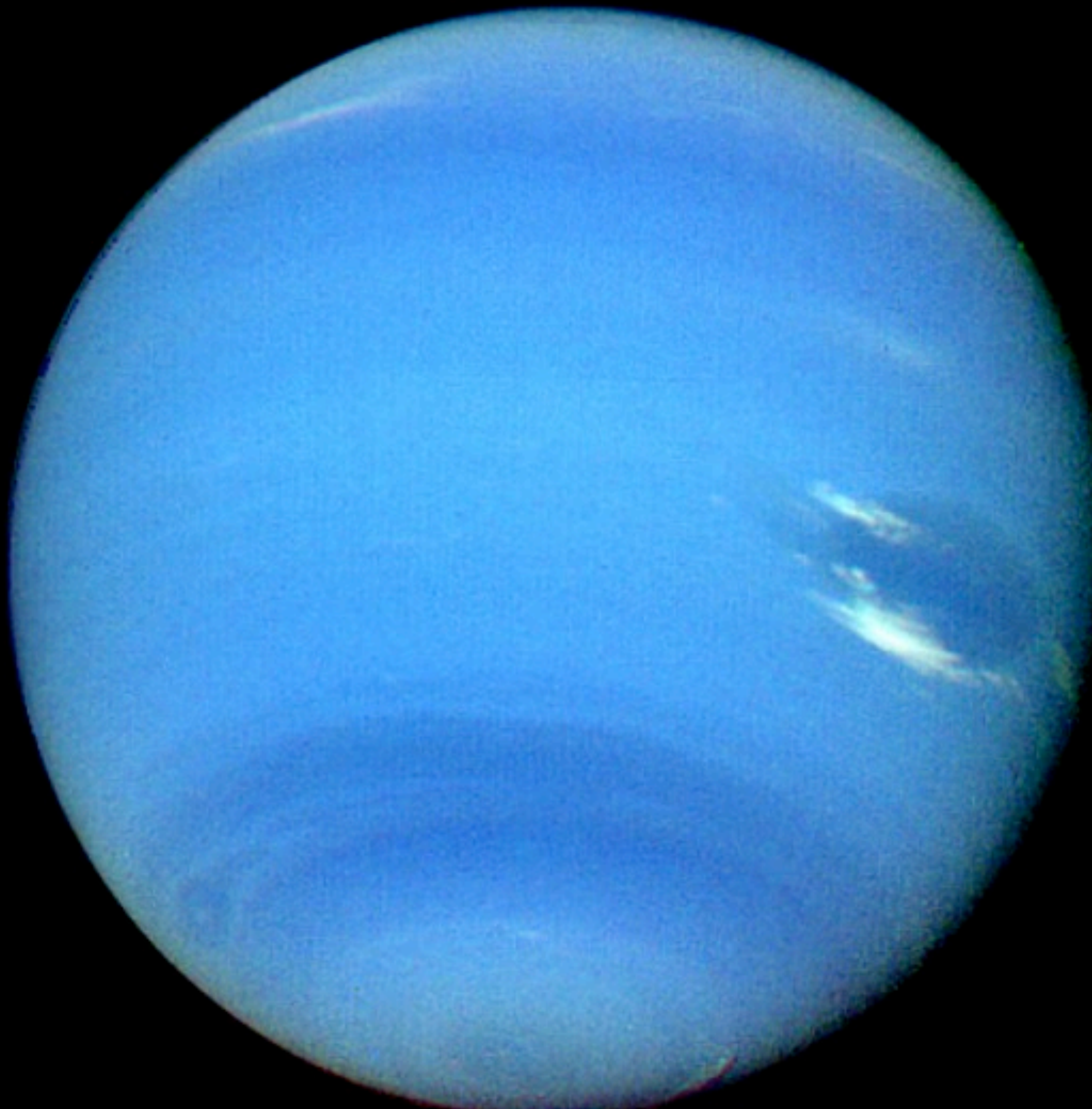
Neptune



is the fourth largest planet and the eight from the sun.

Like Uranus, the methane gives Neptune its color.

Neptune

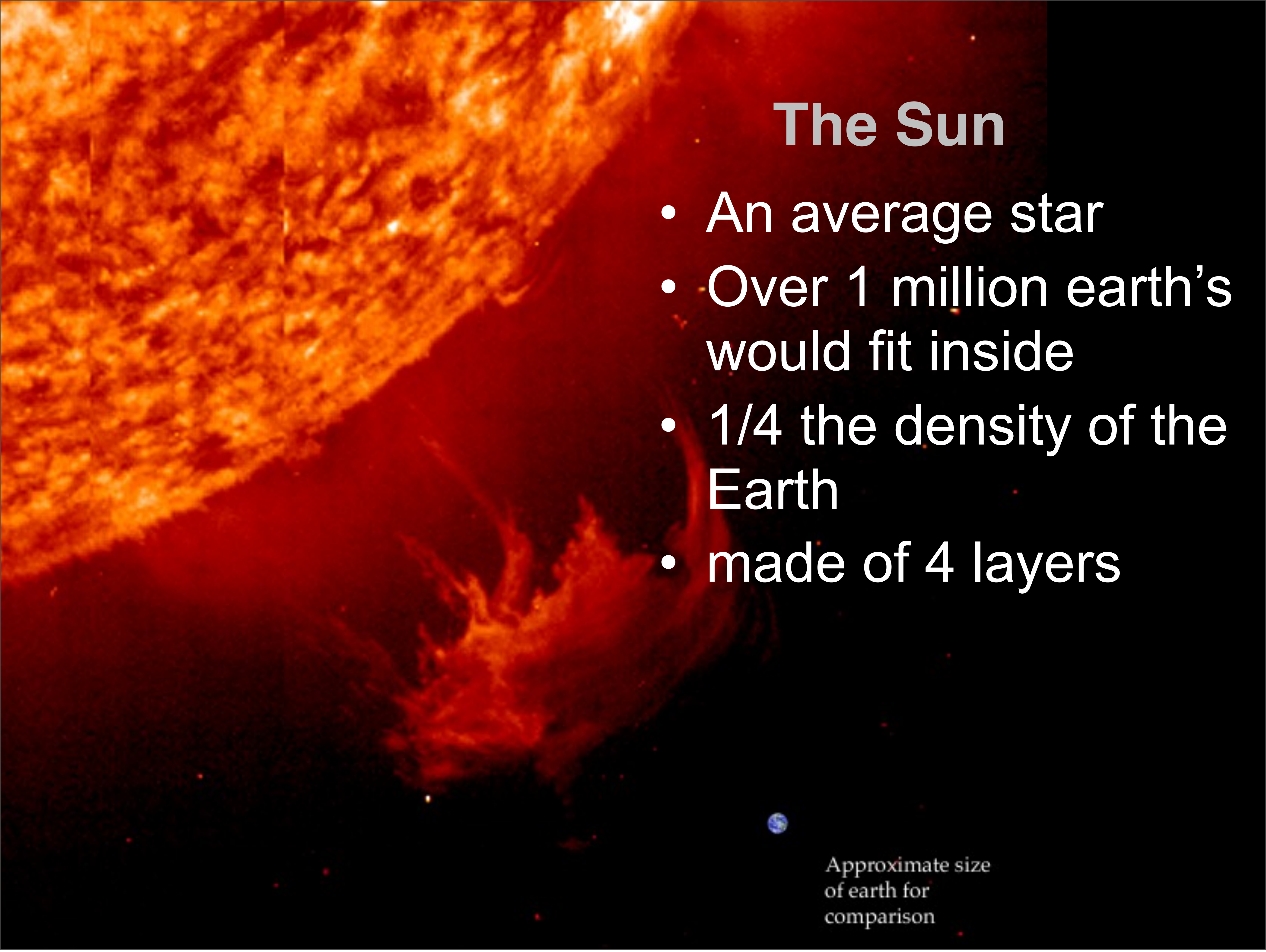


Pluto

- Moon sized
- Made of methane
- Pink atmosphere on the sunny side
- Moon Charon 1/2 the size of Pluto
- Scientists think it is a moon broken away from Neptune
  - Orbit crosses Neptune
  - Orbit not in plane with other planets

The Sun

- An average star
- Over 1 million earth's would fit inside
- 1/4 the density of the Earth
- made of 4 layers



Small Solar System Bodies

asteroid – small body that orbits the Sun (between Mars and Jupiter)

Meteoroid - boulder size debris, pass through the atmosphere, heated by friction and burns, producing a streak of light (**meteor).**

---

meteorite - meteoroid that does not burn up completely and part of it strikes the ground (shooting star)

Comets are small, icy bodies that have highly **<u>elliptic</u>** orbits around the Sun.

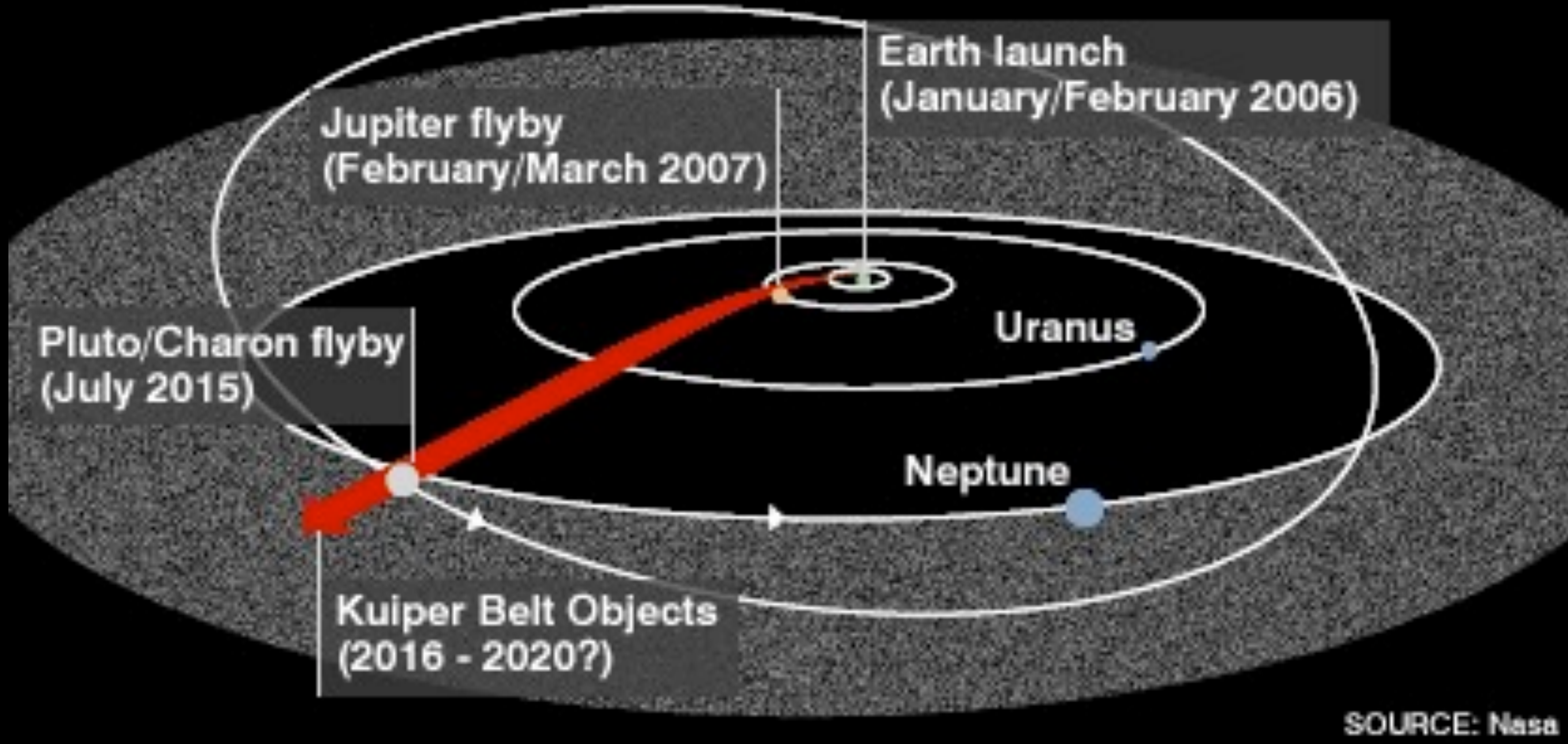
Comets

- Chunks of dust and gas from the Oort Cloud that orbit the sun
- When it gets close to the sun it gets hotter
- Some of the gas and dust form a cloud around the head called the coma
- Solar wind pushes the gases away from the sun and make the tail
- Tail is pushed by the solar wind
- Tail always points way from the sun

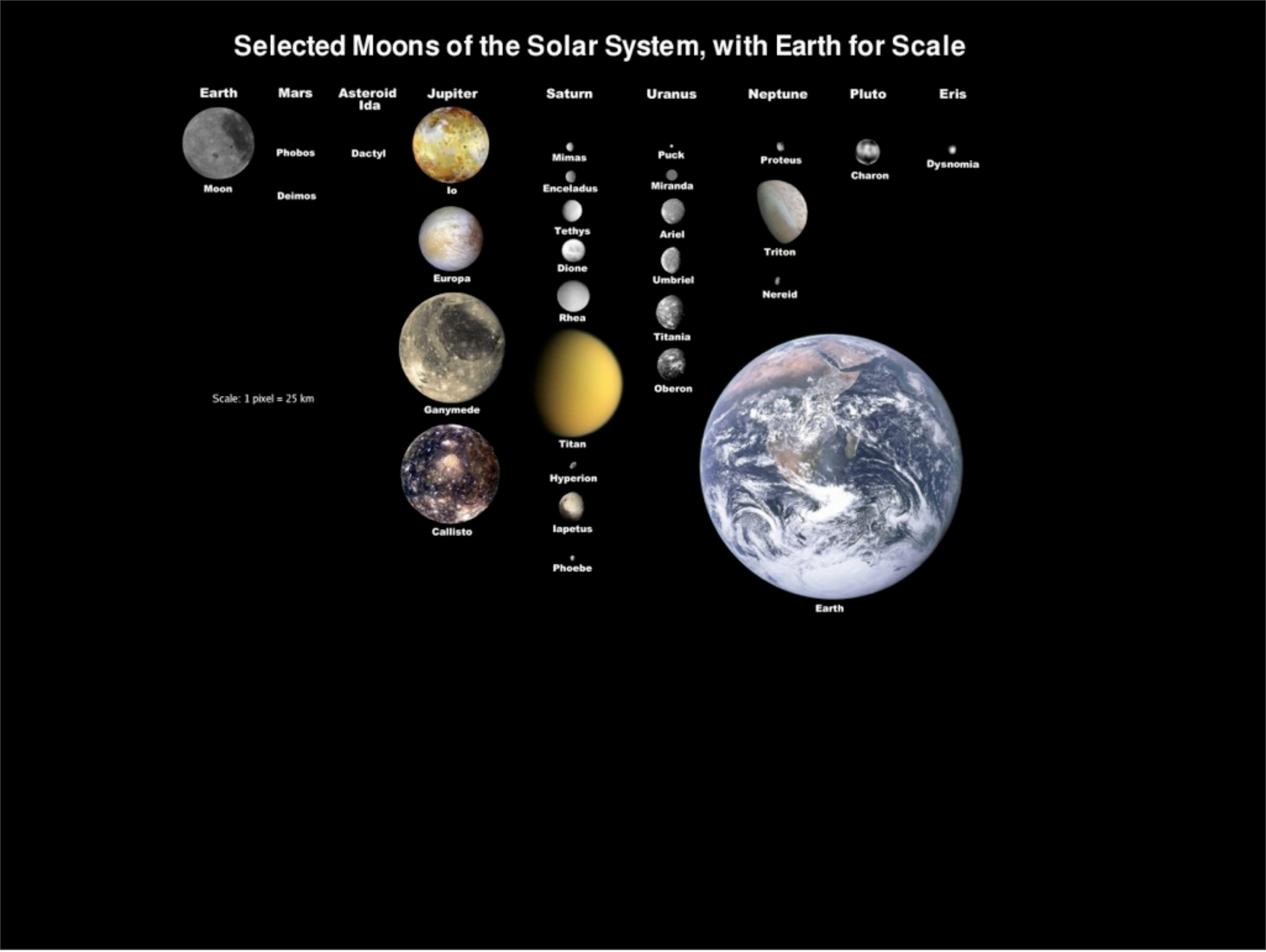
Meteorites

- Leave a crater where they hit the ground
- Meteorite Crater in Arizona
- Evidence of meteorites from the moon and from Mars

Kuiper Belt Objects




Charon
2003 UB313
Pluto
2005 FY9
2003 EL61
Sedna
Quaoar


Selected Moons of the Solar System, with Earth for Scale
Earth
Mars
Asteroid Ida
Jupiter
Saturn
Uranus
Neptune
Pluto
Eris
Moon
Phobos
Deimos
Dactyl
Io
Europa
Ganymede
Callisto
Mimas
Enceladus
Tethys
Dione
Rhea
Titan
Hyperion
Iapetus
Phoebe
Puck
Miranda
Ariel
Umbriel
Titania
Oberon
Proteus
Triton
Nereid
Charon
Dysnomia
Earth
Scale: 1 pixel = 25 km

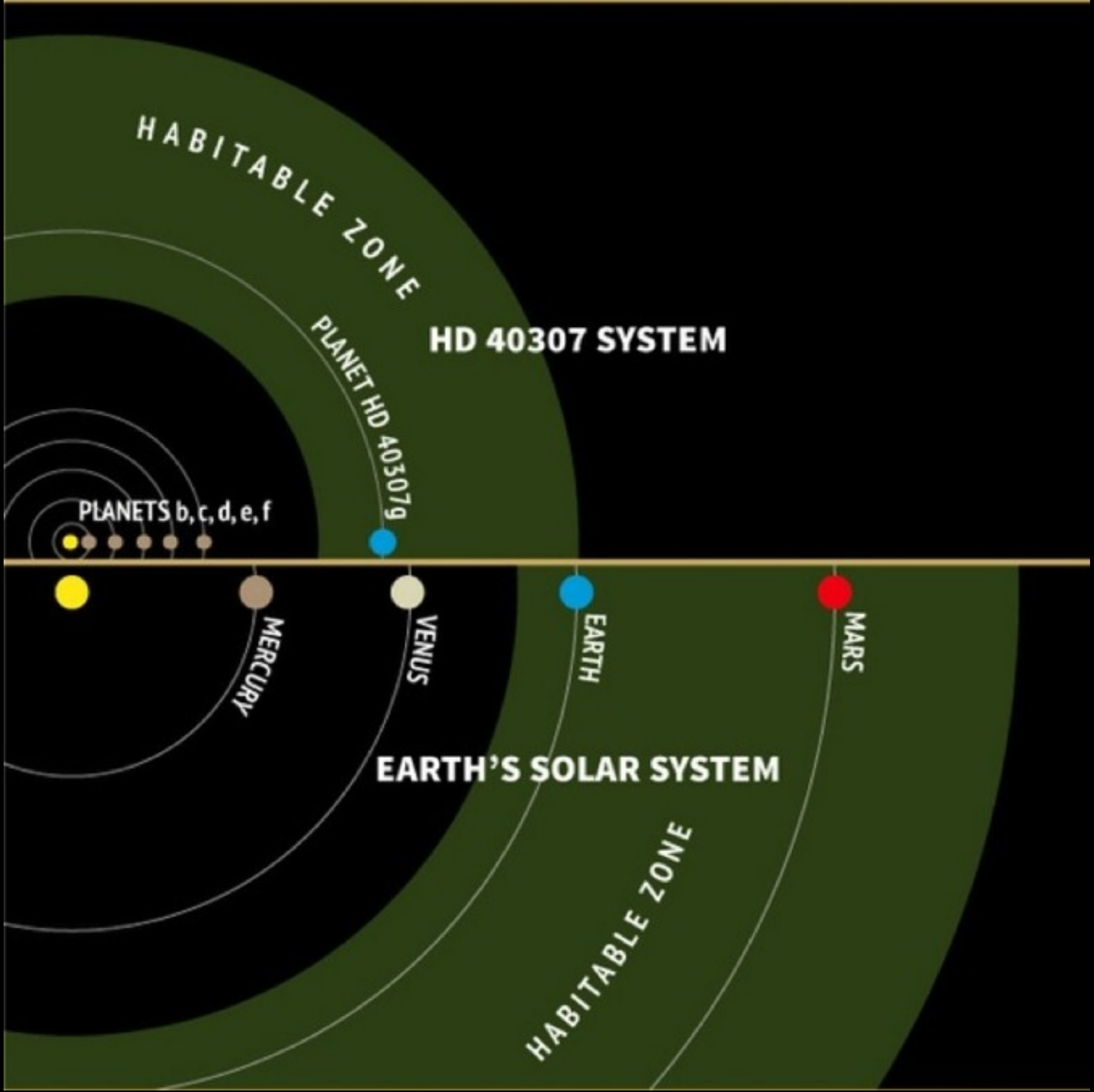

QUAOAR
2002 LM60
VARUNA
2000 WR106
ORCUS
2004 DW
1996 TO66
2002 TX300
2002 UX25
IXION
2001 KX76
PLUTO
'SANTA'
2003 EL61
'EASTERBUNNY'
2005 FY9
2002 TC302
ERIS
2003 UB313
SEDNA
2003 VB12
1,000 km
CHARON
NIX
S/2005 P2
HYDRA
S/2005 P1
S/2005 (2003EL61) 2
'RUDOLPH'
S/2005 (2003EL61) 1
DYSNOMIA
S/2005 (2003 UB313) 1
©2006 Timothy King

A Habitable Super-Earth?

The dwarf star HD 40307, located 44 light-years from Earth, hosts a system of planets, including one at an orbital distance just right to support life as we know it. The planet could theoretically be photographed by next-generation space satellites now on the drawing board.

	Planet HD 40307g	Earth
MASS (EARTH = 1):	more than 7	1
DISTANCE FROM PARENT STAR:	55.8 million miles (90 million kilometers)	93 million miles (150 million km)
LENGTH OF YEAR (EARTH DAYS):	197.8	365.3

Planetary Orbits Shown To Scale



November 16, 2012

Agenda:

(1) Read & annotate Solar System (10 minutes)
(2) With a partner, make a list of six facts from the reading.
(3) Review questions with your partner

Solar System Data

Overview:

Our solar system is mostly empty space. However, in the center of this "seemingly empty space" is the most massive body in our solar system - Our Sun, containing over 99% of the total mass of our solar system. Due to its large mass, all objects in our solar system are controlled by the gravitational attraction of the Sun. These objects consist of planets, asteroids, comets, dust, and other numerous small objects all revolving around the Sun. But, "What about Pluto?" It has been kicked out of the planet family and demoted to the dwarf planet classification. I hope Pluto doesn't take this too seriously and give us the cold shoulder (around –230°C) and starts looking for another solar system to be accepted. At least teachers can no longer ask students, "What planet is sometimes the 9th planet and sometimes the 8th planet?"

The Chart:

The measurements, numbers, etc. are obvious, but let me point out some information that might be less obvious. The Period of Revolution column shows that the farther a planet is from the Sun, the longer the period of revolution is for that planet. This is because the Sun's gravitational attraction decreases as the distance from the Sun increases. The Period of Rotation column shows the length of the planet's day. Notice that Jupiter has the shortest period of rotation, making its day just under ten hours, while Venus has the longest day of any planet. In fact, Venus' period of rotation is longer than its period of revolution, which makes Venus' day longer than its year. The Eccentricity column is extensively covered by the Eccentricity Equation section within this book. For a quick review, the lower the eccentricity value, the more circular the orbit will be. Since all planets have an eccentricity value greater than zero, they all orbit the Sun in elliptical

Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)
SUN	—	—	27 d	—	1,392,000	333,000.00	1.4
MERCURY	57.9	88 d	59 d	0.206	4,879	0.06	5.4
VENUS	108.2	224.7 d	243 d	0.007	12,104	0.82	5.2
EARTH	149.6	365.26 d	23 h 56 min 4 s	0.017	12,756	1.00	5.5
MARS	227.9	687 d	24 h 37 min 23 s	0.093	6,794	0.11	3.9
JUPITER	778.4	11.9 y	9 h 50 min 30 s	0.048	142,984	317.83	1.3
SATURN	1,426.7	29.5 y	10 h 14 min	0.054	120,536	95.16	0.7
URANUS	2,871.0	84.0 y	17 h 14 min	0.047	51,118	14.54	1.3
NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

orbits. For the Equatorial Diameter column, you will have to use the ratio of these diameter measurements to compare two or more diagrammed circles representing the planet's size. For example, circles representing Venus and Earth will be almost the same size, while a diagram of Mars will be half the size of the one representing the Earth. The Mass column gives the Earth's mass as 1. All other masses are compared to this standard. In the Density column an interesting fact is revealed. Saturn, one of the giant gaseous planets, has a density less than 1. This planet would float in water, assuming we can find a body of water large enough to place it in. Notice that the terrestrial planets (also known as the rocky planets), as expected, have a higher density than the Jovian planets (giant gaseous planets). The bottom row, Earth's Moon, gives information about our only natural satellite. Notice that the moon's period of revolution and period of rotation are the same. That is why we only see one side of the moon from Earth.

Solar System Data

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EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

Additional Information:

- The asteroid belt, consisting of thousands of large rocks, is located between Mars and Jupiter.
- Venus is the hottest planet due to its dense carbon dioxide atmosphere, producing a run-away greenhouse effect.
- Planet Earth is the only known planet to have abundant liquid water on its surface.
- Perigee and Apogee – Perigee is a point in which an object in orbit has its closest approach to the body it is orbiting. Apogee is a point in which an object in orbit is farthest from the the body it is orbiting. At perigee the object will have its greatest orbital speed. At apogee the orbiting object will have its slowest orbital speed.
- The apparent diameter is the size of the celestrial object as seen from the Earth. Its size appears to change as its orbital distance from the Earth increases or decreases. This is very evident by an apparently large full moon when it is in its perigee position.
- In the geocentric model of our solar system, all celestrial objects revolved around the non-rotating Earth.
- In the heliocentric model of our solar system, all celestrial objects revolve around the Sun.

1. Which planet is approximately 20 times farther from the Sun than Earth is?

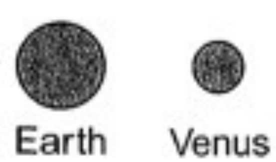
(1) Jupiter (3) Uranus
(2) Saturn (4) Neptune 1 ______

2. Which planet would float if it could be placed in water?

(1) Mercury (3) Saturn
(2) Earth (4) Jupiter 2 ______

3. Which scale diagram best compares the size of Earth with the size of Venus?

(1)


(2)


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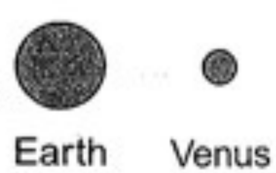

(4)


3 ______

4. Which planet's orbit around the Sun is most nearly circular?

(1) Mercury (3) Earth
(2) Neptune (4) Venus 4 ______

Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)
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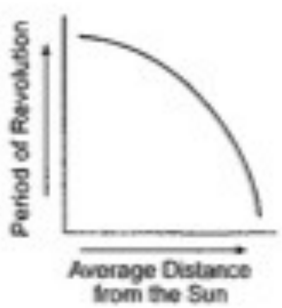
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

5. How do Jupiter's density and period of rotation compare to Earth's?

(1) Jupiter is less dense and has a longer period of rotation.
(2) Jupiter is less dense and has a shorter period of rotation.
(3) Jupiter is more dense and has a longer period of rotation.
(4) Jupiter is more dense and has a shorter period of rotation. 5 ______

6. Which graph best represents the relationship between a planet's average distance from the Sun and the time the planet takes to revolve around the Sun?

(1)


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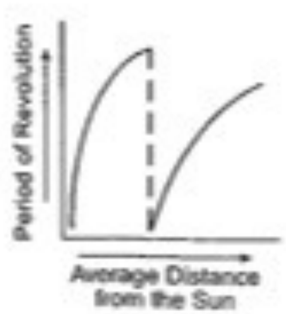

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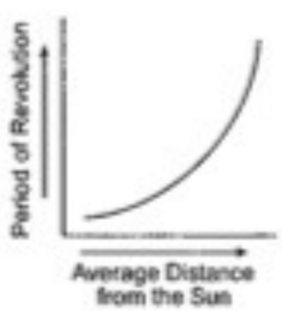

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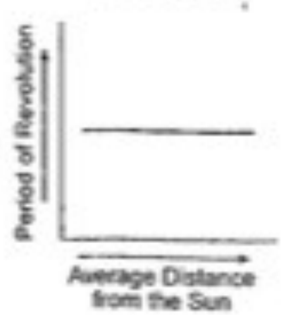

6 ______

7. Terrestrial planets move more rapidly in their orbits than the Jovian planets because terrestrial planets are

(1) rotating on a tilted axis
(2) more dense
(3) more massive
(4) closer to the Sun 7 ______

Solar System Data

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NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

8. Which of the following planets has the lowest average density?

(1) Mercury (3) Earth
(2) Venus (4) Mars 8 ______

9. Which statement correctly compares the size, composition, and density of Neptune to Earth?

(1) Neptune is smaller, more gaseous, and less dense.
(2) Neptune is larger, more gaseous, and less dense.
(3) Neptune is smaller, more solid, and more dense.
(4) Neptune is larger, more solid, and more dense. 9 ______

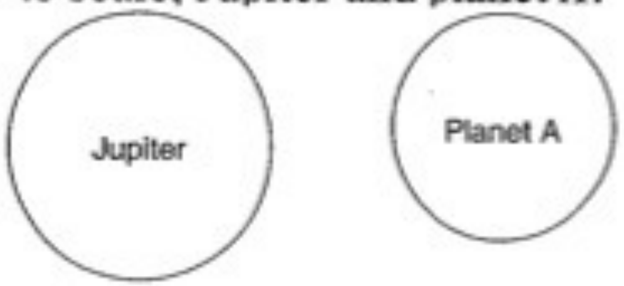
10. Compared to Mars, Mercury moves more rapidly in its orbit because Mercury

(1) is larger
(2) is more dense
(3) is closer to the Sun
(4) has a more elliptical orbit 10 ______

11. The planets known as "gas giants" include Jupiter, Uranus, and

(1) Venus (3) Mars
(2) Saturn (4) Earth 11 ______

12. The diagram below represents two planets in our solar system drawn to scale, Jupiter and planet *A*.



Planet *A* most likely represents

(1) Earth (3) Saturn
(2) Venus (4) Uranus 12 ______

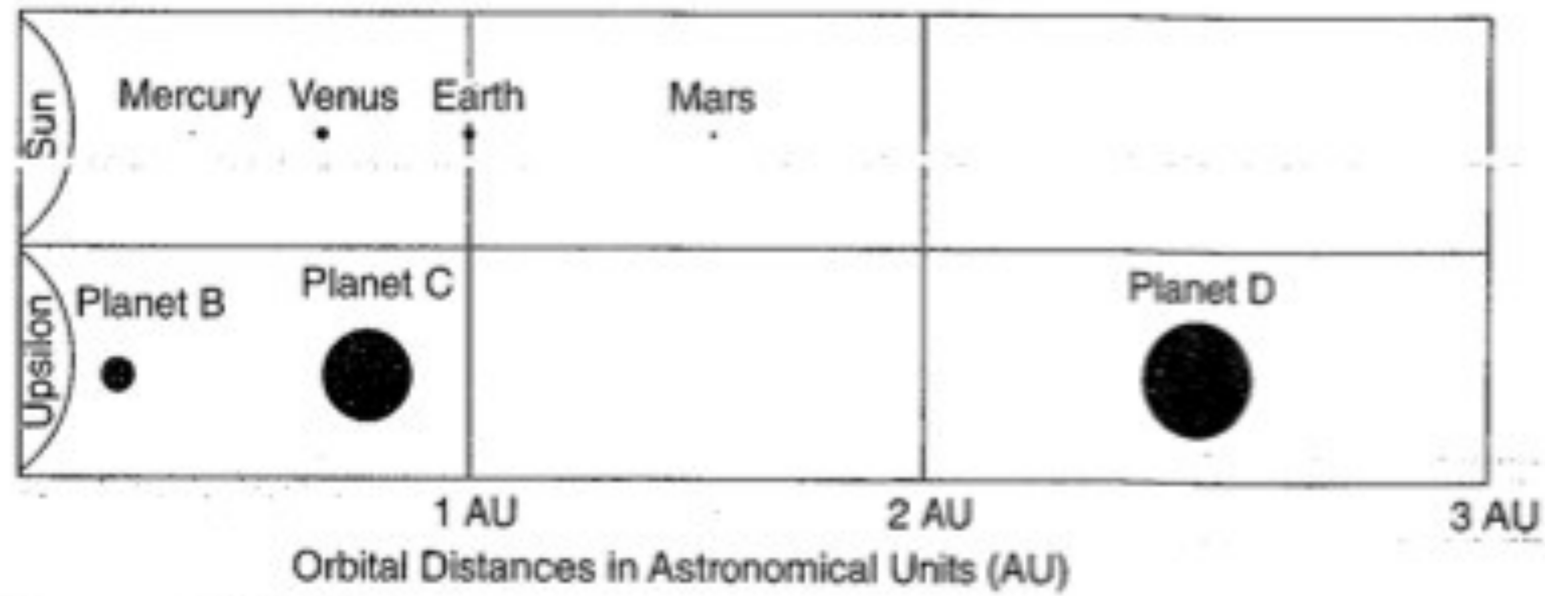
13. The same side of the Moon always faces Earth because the

(1) Moon's period of rotation is longer than its period of revolution around Earth
(2) Moon's period of rotation is shorter than its period of revolution around Earth
(3) Moon rotates once as it completes one revolution around Earth
(4) Moon does not rotate as it completes one revolution around Earth 13

14. Planet *D*'s diameter is 10 times greater than Earth's diameter.

What planet in our solar system has a diameter closest in size to the diameter of planet *D*?

____



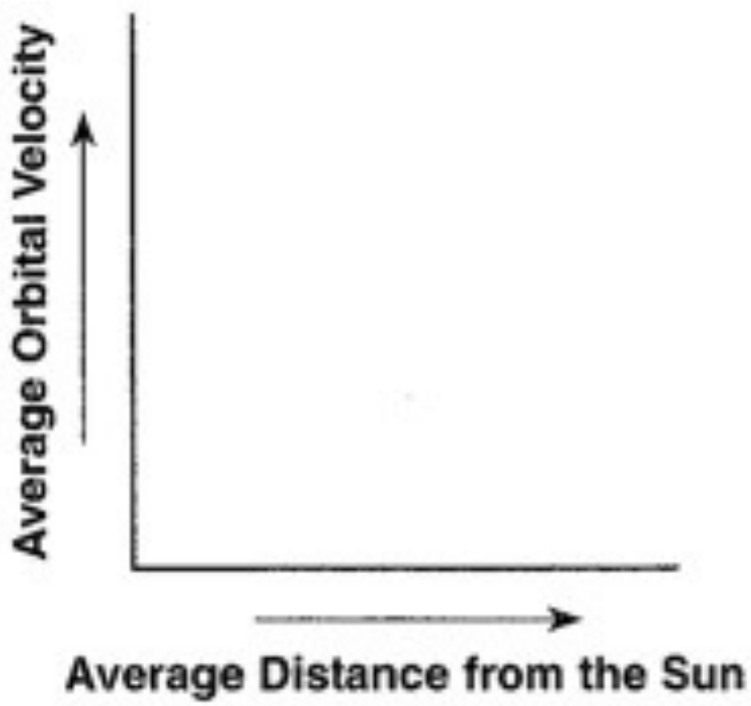
15. Why does Planet *B* revolve faster than Planet *C*? ______________________________

Base your answers to question 16 on the accompanying data table, which shows the average distance from the Sun, the average surface temperature, and the average orbital velocity for each planet in our solar system.

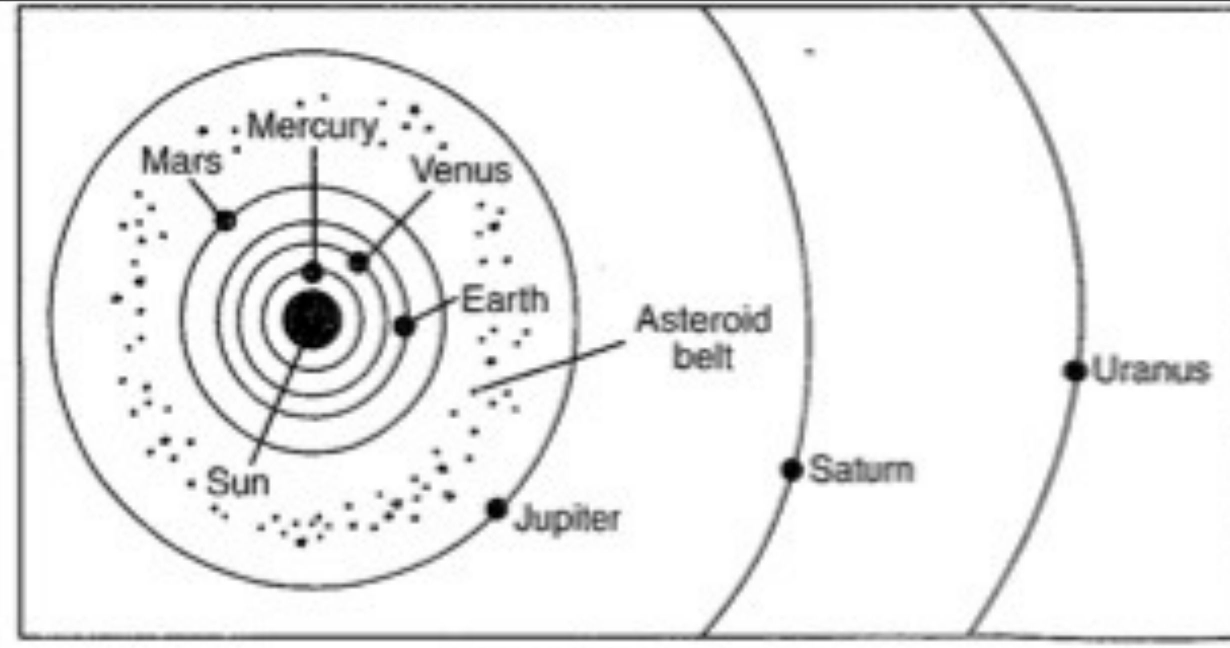
Data Table

Planet	Average Distance from Sun (millions of km)	Average Surface Temperature (°C)	Average Orbital Velocity (km/sec)
Mercury	58	167	47.9
Venus	108	457	35.0
Earth	150	14	29.8
Mars	228	–55	24.1
Jupiter	778	–153	13.1
Saturn	1427	–185	9.7
Uranus	2869	–214	6.8
Neptune	4496	–225	5.4

16. On the graph below, draw a line to indicate the general relationship between a planet's average distance from the Sun and its average orbital velocity.



Base your answer to question 17 on the accompanying diagram. This diagram shows a portion of the solar system.



(Not drawn to scale)

17. What is the average distance, in millions of kilometers, from the Sun to the asteriod belt? ___________

Base your answers to questions 18*a* and *b* on the accompanying data table, which provides information about four of Jupiter's moons.

Data Table

Moons of Jupiter	Density (g/cm^3)	Diameter (km)	Distance from Jupiter (km)
Io	3.5	3630	421,600
Europa	3.0	3138	670,900
Ganymede	1.9	5262	1,070,000
Callisto	1.9	4800	1,883,000

18. *a*) Identify the planet in our solar system that is closest in diameter to Callisto.

____

b) In 1610, Galileo was the first person to observe, with the aid of a telescope, these four moons orbiting Jupiter. Explain why Galileo's observation of this motion did not support the geocentric model of our solar system.

____

____

Wednesday, November 28, 12

11/19/12

Do Now: Read This -->

Agenda:
1. Do Now
2. Lab

Solar System Test on

The comet Temple-Tuttle was first identified in 1699 by Gottfried Kirch, a German shoemaker-turned astronomer working in Leipzig. It took on its name more than a hundred years later, when it was independently re-discovered by Ernst Tempel and Horace Tuttle in the 1860s. Every 33 years, the comet blows past the Earth as it swings around the Sun, leaving in its wake—and in Earth's path—a field of debris, shed from the slowly-decaying comet.

This field of debris, in turn, gives rise to the annual astronomical event known as the Leonid meteor shower. Every November, arcing in from the east out of the constellation Leo, some of the Tempel-Tuttle debris slams into Earth's atmosphere, burning up in a brilliant display. Space.com:

> While the Leonid meteor shower has a history of putting on stupendous displays, this year will not be one of them; at best 10 to 15 meteors per hour may be seen. This year is a bit unusual in that the Leonids are expected to show two peaks of activity, one on Saturday morning (Nov. 17) and another on Tuesday morning (Nov. 20).

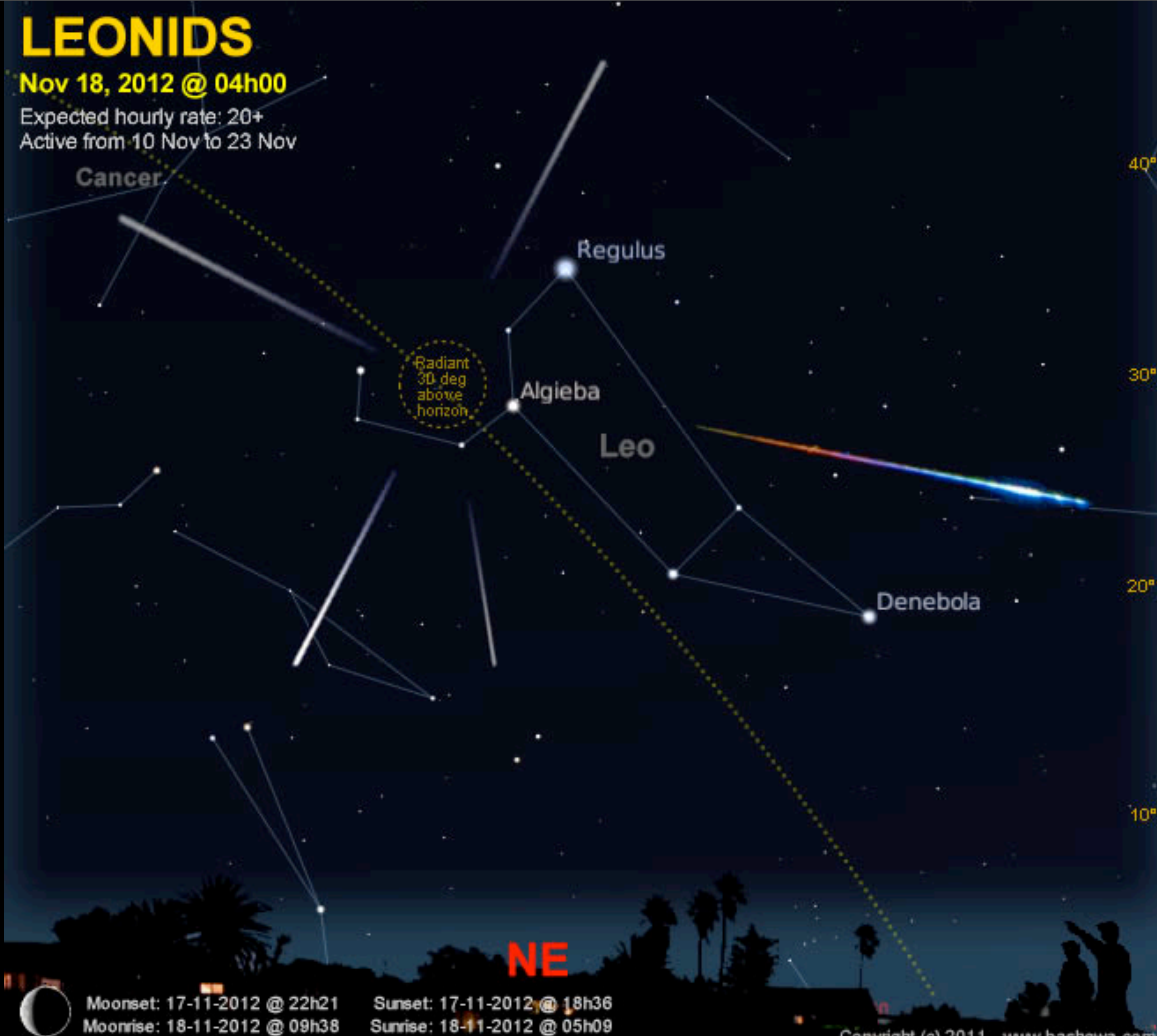
But don't let the low meteor count get you down, says *The Guardian*.

> In terms of numbers, the Leonids do not compare to the Perseids, which reach 100 meteors an hour, but it's quality not quantity that counts here. Whereas the Perseids can often be faint, the Leonids have a reputation for brightness.
>
> Extremely bright meteors, known as fireballs, are often associated with this shower. These are produced by dust grains about 10 millimetres across burning up in our atmosphere.

To find the best views for the Leonid shower, says Universe Today, you'll want to wait until the wee hours of the morning.

> If you wait until the hours before dawn this weekend, the Moon will be below the horizon, so its light will not interfere with seeing meteors. Astronomers says that with clear skies, viewers can expect to see about 15 to 20 meteors per hour, though the shower has proved highly variable in recent years.
>
> Though the meteors will appear to originate from the constellation Leo, which will be in the eastern sky in the early morning hours, the meteors can be seen in all parts of the sky.


DEBRIS
EARTH'S ORBIT
METEOR SHOWER
The "shooting stars" we see when Earth passes through a cometary or asteroidal debris trail.



LEONIDS
Nov 18, 2012 @ 04h00
Expected hourly rate: 20+
Active from 10 Nov to 23 Nov
Cancer
Regulus
Radiant 30 deg above horizon
Algieba
Leo
Denebola
40°
30°
20°
10°
NE
Moonset: 17-11-2012 @ 22h21
Moonrise: 18-11-2012 @ 09h38
Sunset: 17-11-2012 @ 18h36
Sunrise: 18-11-2012 @ 05h09
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Meteor Showers

Quadrantids	January 3 AM
Lyrids	April 21/22 PM
Eta Aquarids	May 5/6
Lyrids	June 14-16
Delta Aquarids	July 28/29
Capricornids	July 29/30
Perseids	August 12/13
Draconids	October 8/9
Orionids	October 21/22
Leonids	November 17/18
Geminids	December 13/14

9
Inner City sky
7
Suburban/urban transition
5
Suburban sky
3
Rural sky
1
Excellent dark sky site
Altair
Rasalhague
IC 4665
Cebalrai
Jupiter
Nunki
NGC 6530
Earth, York, 13m
FOV 60°
27.8 FPS
2008-09-24 20:20:54


Fireball Meteor © 1994 - 2010 John Chumack

Draw a line across the table between the terrestrial and jovian (gas giants) planets and label.

Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)
SUN	—	—	27 d	—	1,392,000	333,000.00	1.4
MERCURY	57.9	88 d	59 d	0.206	4,879	0.06	5.4
VENUS	108.2	224.7 d	243 d	0.007	12,104	0.82	5.2
EARTH	149.6	365.26 d	23 h 56 min 4 s	0.017	12,756	1.00	5.5
MARS	227.9	687 d	24 h 37 min 23 s	0.093	6,794	0.11	3.9
JUPITER	778.4	11.9 y	9 h 50 min 30 s	0.048	142,984	317.83	1.3
SATURN	1,426.7	29.5 y	10 h 14 min	0.054	120,536	95.16	0.7
URANUS	2,871.0	84.0 y	17 h 14 min	0.047	51,118	14.54	1.3
NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

Which are more dense?

Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)
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NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

Physical Setting/Earth Science Reference Tables — 2010 Edition 15

Which have more moons ?
Jovian or terrestrial

Which have longer periods of revolution? Jovian or terrestrial

Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm³)
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NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

Which are larger in size on average ? Jovian or terrestrial

Which planet has the longest day?

Which planet has the longest year?

Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)
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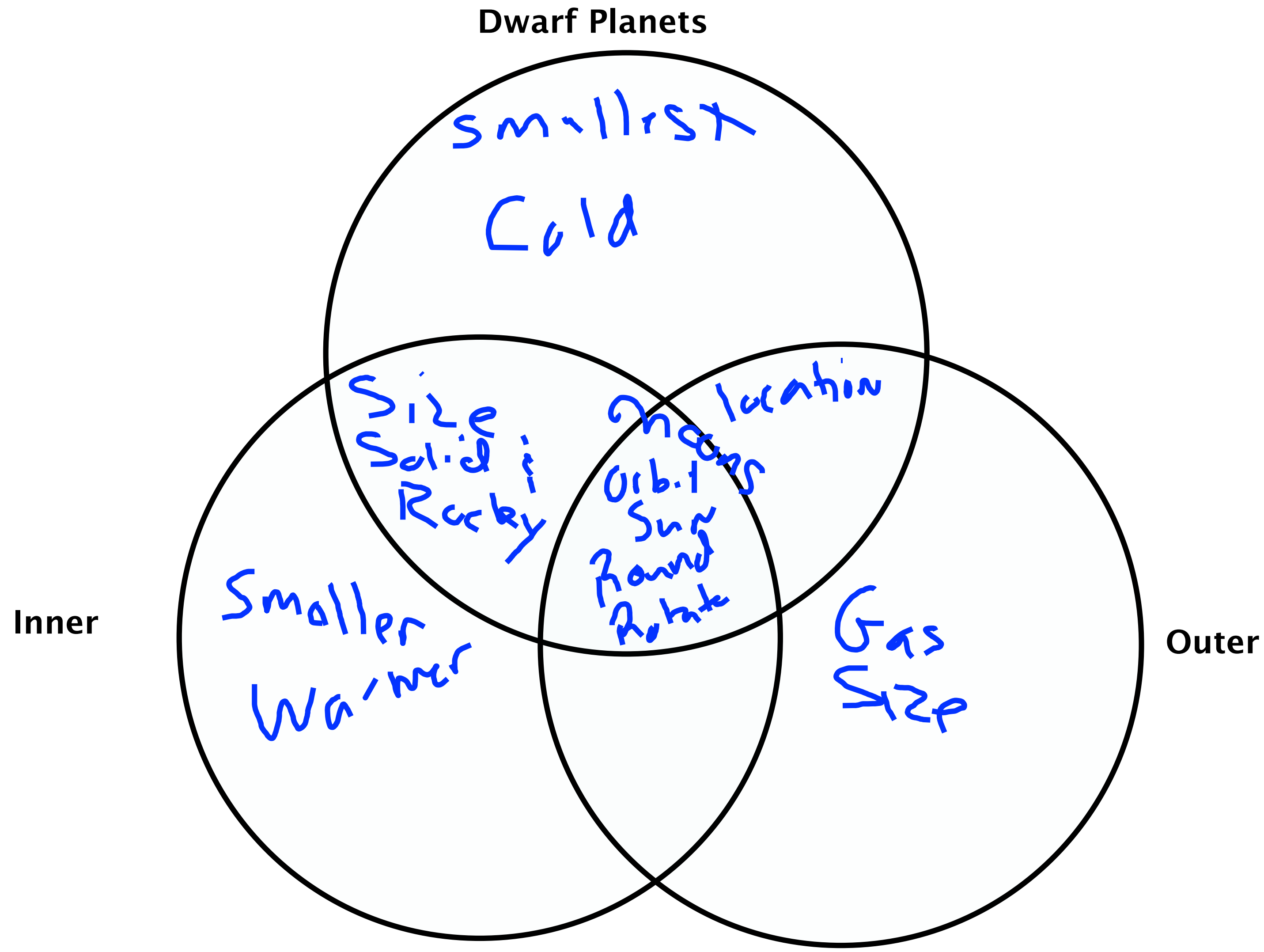
NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

Which planet has the most perfectly circular orbit?

ESRT Planet Lab #8
Due at the end of Class

READ DIRECTIONS

Solar System Cornell Notes due today


Dwarf Planets
Inner
Outer
Smallest
Cold
Size
Solid &
Rocky
Moons
Location
Orbit
Sun
Round
Rotate
Smaller
Warmer
Gas
Size

Do Now – Page 318

1. Which planets group together as the inner planets?

Mercury, Venus, Earth, and Mars

2. Which of the outer planets is more like an inner planet, and what does it have in common with the inner planets?

Pluto, it seems to be rocky.

3. How does the size of Jupiter compare to the size of Earth?

Jupiter has a diameter

about 11 times that of Earth and a volume 1331 times greater.

4. If these objects were all to the same scale, how would the size of the sun compare with the size of Earth?

The solar diameter is approximately 109 times Earth's.

5. Some astronomers have suggested that Pluto was at one time an asteroid or moon. Its status as a planet is in question. As we measure planets in order from Mercury to Neptune, what *generally* happens to the following?

a. Planetary diameter:

Diameters generally increase, then decrease.

b. Average surface temperature:

Surface temperatures generally decrease.

c. Period of revolution:

The period of revolution increases.

6. Ancient people had no telescopes or other ways to magnify celestial objects. Yet, they considered the planets as different from other the objects in the sky. How could you tell a planet from a star by watching it in the night sky without the use of instruments such as a telescope?

The planets change their position among the stars.

7. The sun has a diameter roughly 100 times the diameter of Earth. What is the volume ratio?

The volume ratio is about 1 million to 1.

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CHAPTER 27—SKILL SHEET 1: THE MYSTERY OF PLANET X

The goddess of love imitates the forms of Cynthia.

Who was Cynthia? Did Galileo have a secret lover? What does this have to do with astronomy? If this seems a little strange, stick with it. You will make sense out of Galileo's secret message. In his day, scientists such as Galileo wrote their most important ideas in mystical phrases of Latin text. Such writing was intended for a small group of educated people. (Most people were not educated.)

The English word for planet comes to us from the Greek term, *asteres planetai*, meaning the five special stars that wander among the other stars. (Ancient astronomers saw the planets as points of light and could not see Uranus, Neptune, or Pluto.)

Figure 27-11 shows a portion of the starry night sky over a period of 5 months. You may be able to identify several prominent constellations of the zodiac within this diagram. The zodiac is the region of the sky through which the sun, the moon, and the planets move. These constellations of the zodiac are always high overhead in the tropics. Astronomers prefer to look at negatives of the night sky rather than prints because they can lay one negative on top of another to compare the positions of the stars at different times. Observe the four objects, A, B, C, and D, in each of the five diagrams. One of them is a planet.

1. What is the origin of the word *planeta*?

Asteres planetai a Greek term meaning wandering stars.

2. How can you tell which object in Figure 27-11 is a planet?

The planet changes its position.

3. Therefore, which of these four objects is the planet?

Object D

4. Disregarding its changing position in the sky, in what two properties does this object seem to change during the period of observation?

Size and shape

This change in apparent shape is called a change in phase.

5. What other familiar celestial object shows phase changes?

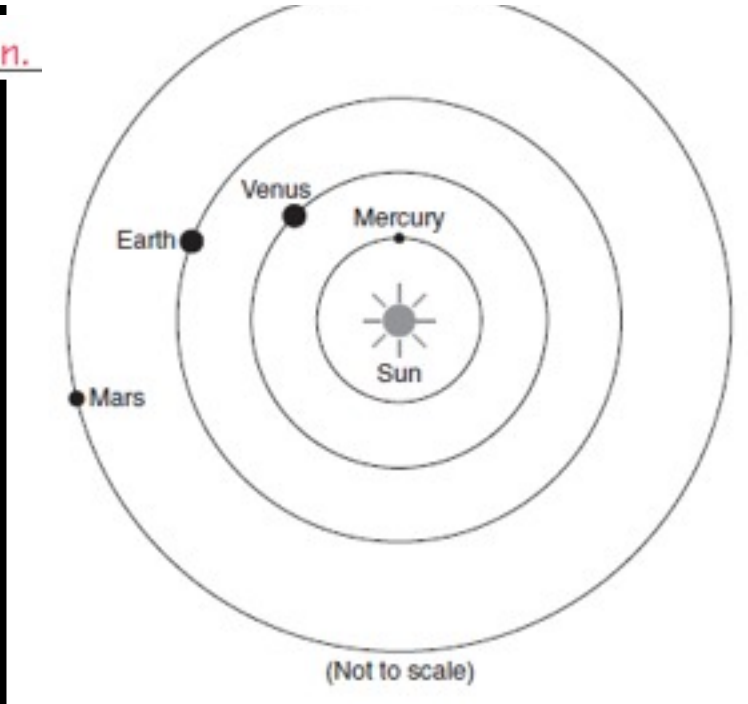
The moon

6. When the moon is in the new phase, what does it look like?

Its face is dark.

7. When the moon is in the new phase, where is the moon with respect to Earth and the sun?

The moon is between Earth and the sun.



8. According to Figure 27-13, which two planets are able to pass between Earth and the sun?

Mercury and Venus

9. What causes the angular diameter of these celestial objects to change?

Their changing distance from Earth.

10. According to Figure 27-13, which of the two innermost planets can come closest to Earth?

Venus

11. When it is on the opposite side of the sun, which of these planets can be the farthest from Earth? (Be sure to look at Figure 27-13.)

Venus

We have learned that Planet X shows the full range of phases and that it changes greatly in angular diameter as observed from Earth.

12. Planet X must be Venus

13. Who was the Roman goddess of love? Venus

14. What celestial object did ancient astronomers call Cynthia, or sometimes Selene?

The moon

15. Explain Galileo's secret message "The Goddess of Love Imitates the Forms of Cynthia."

Venus shows phases like the moon.

16. The largest planet is Jupiter

17. The smallest planet is Pluto. (unless Pluto is not considered a planet, then it's Mercury)

18. Which planet moves at the greatest velocity in its orbit? Mercury

19. Which planet moves at the slowest velocity in its orbit? Pluto

20. Why does Pluto move more slowly in its orbit than any other planet?

Pluto is farthest from the sun.

21. Which planet has the most moons?

Uranus

22. All the planets have night and day, so they must all (a type of motion)

rotate

CHAPTER 27—LAB 1: ORBITS, ELLIPSES, AND ECCENTRICITY

Introduction

Ancient observers of the night sky noticed that some of the stars did not move through the sky with the other stars. They called these objects the wanderers. Our modern word *planet* comes to us from the Greek word for a person who wanders from place to place.

In 1609 Johannes Kepler, based on years of careful observations and measurements, plotted the orbits of the five planets known in his time. Kepler showed that the orbits of the planets are not perfect circles; in fact, they are ellipses. Kepler found a way to characterize elliptical orbits with mathematical precision.

FIGURE 27-1. Johannes Kepler.

Objective

To construct ellipses and calculate eccentricity.

Materials

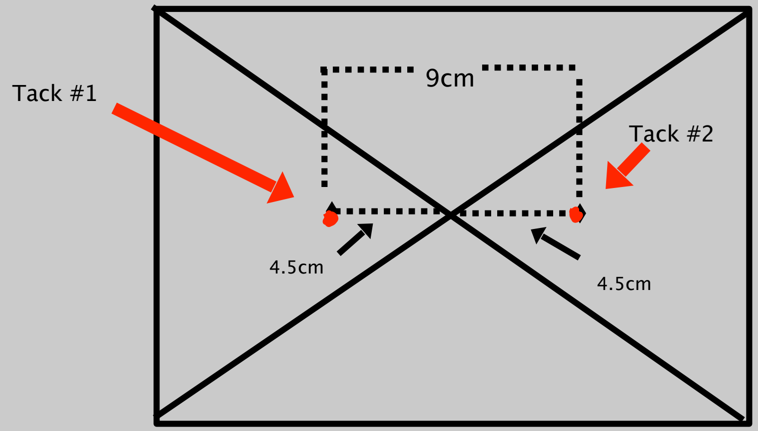
Approximately 30–40 cm of string, soft board about $8\frac{1}{2} \times 11''$, paper, 2 straight pins, metric ruler, pencil, safety compass

Procedure

1. Tie the string into a loop 10 cm long when stretched out as shown in Figure 27-2 (The loop must be ± 0.5 cm, that is, between 9.5 and 10.5 cm.)
2. Locate the center of the sheet of paper by drawing two very light diagonal lines (in pencil) from corner to corner as in Figure 27-3. (You will need one sheet of paper per person.)

FIGURE 27-2. Ten-centimeter loop of string.

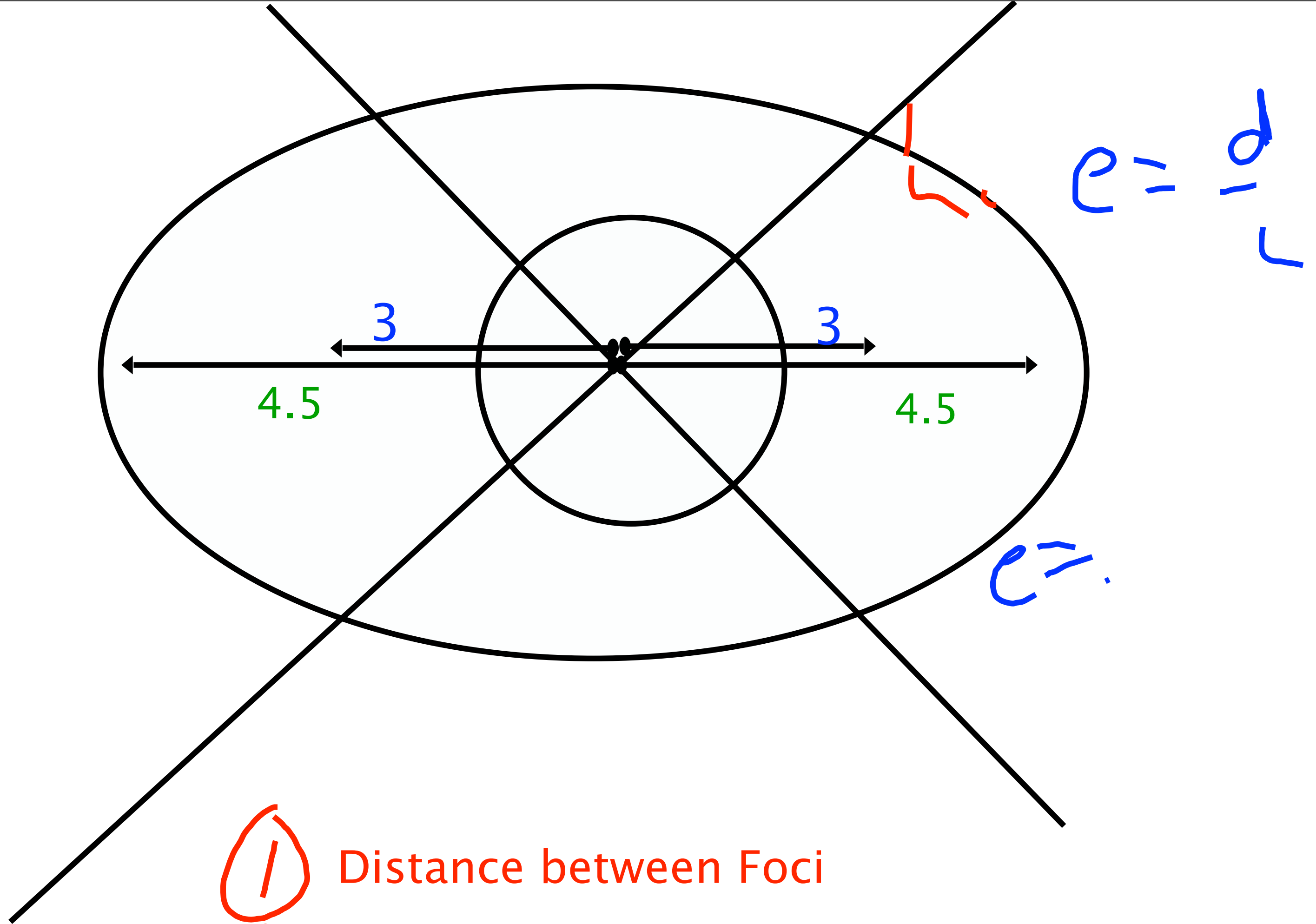
FIGURE 27-3. Finding the center of the paper.



3. Push the two pins through the paper and into the board as shown in Figure 27-4. (Do not push them all the way in.) Each pin should be located 4.5 cm from the center of the paper on a line passing through the center. (The two pins will be 9 cm apart.)

   Each pin will act as a focus (FO-cus) of the ellipse. The two pins are located at the foci (FO-sigh). Every ellipse has two foci.

4. Stretch the string around the bottom of the pins and use your pencil to draw the ellipse as shown in Figure 27-4.



① Distance between Foci

② Distance between Foci

③ Distance between Foci

In the next step, you will calculate the eccentricity of this ellipse using the equation given in the *Earth Science Reference Tables.* Eccentricity is a measure of the flatness of an ellipse. A circle is completely round, so a circle has an eccentricity of 0. A line, which is totally flat, has an eccentricity of 1. Therefore, eccentricity varies between 0 and 1, depending on the shape of the ellipse. Eccentricity is a ratio; therefore, it has no units.

1. Kepler found that the shape of all orbits are not perfect circles, but are ___ellipses___.

   Each pin is located at one ___focus___ of the ellipse. The ___eccentricity___ is a measure of the flatness of an ellipse. Eccentricity is always a value between ___0___ and ___1___.

2. Copy the equation for eccentricity from the *Earth Science Reference Tables* into the box below.

   $$\text{eccentricity} = \frac{\text{distance between foci}}{\text{length of major axis}}$$

distance between Foci / Length major Access

3. Calculate eccentricity to two significant figures. Show your calculation for the first ellipse you drew in the box below. Remember to start each calculation with the algebraic equation.

   9cm

4. The ellipse you drew represents the eccentric shape of the orbits of some comets. Most planets have more circular orbits. Label this ellipse with its eccentricity. Along the ellipse line write e = Answers depend on how close the loop of string is to 10 cm. e ≈ 0.9.

5. On the same page as your first ellipse, draw a second ellipse. This time make the distance between the two pins (the two foci) 6 cm. Each pin should be 3 cm from the center of the paper. Use the same loop of string for all your ellipses.

6. Calculate the eccentricity of your second ellipse. Show your work here as you did in step 3 above. Then label the second ellipse with its eccentricity ratio.

7. The third ellipse will show the true shape of Earth's orbit around the sun. Use the same side of the paper. This time put the pins 0.4 cm (4 mm) apart, 2 mm on either side of the center mark.

8. Label the third ellipse "Orbit of Earth." Then label either one of the two pin positions "Sun." Please note that the sun is not at the exact center of Earth's orbit. It is at one focus, which is why the sun's apparent diameter changes during the year. The other focus is just a point in space near the sun. Also note that the orbit of Earth is nearly a perfect circle.

9. Use a drawing compass to draw a circle over your ellipse that represents Earth's orbit. Does Earth's orbit come close to being a perfect circle, or is it very eccentric?

   Close to a perfect circle

10. Calculate the eccentricity of Earth's orbit around the sun in box below. Then label the drawing with its eccentricity ratio.

$$e = d/l$$
$$= 0.4\ cm/10\ cm$$
$$= 0.04$$

You have probably noticed that objects that are closer to you look larger than the same size object that is farther away. See Figure 27-5.

Throughout the year, the distance between Earth and the sun changes by about 2 percent. As seen from Earth, this causes the apparent size (angular diameter) of the sun to change (see Figure 27-6). The sun actually looks the largest in early January, when we

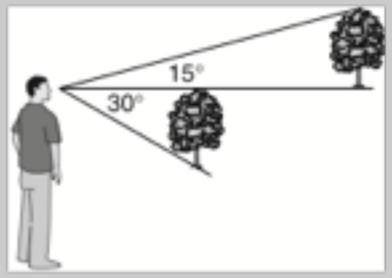


FIGURE 27-5. Angular diameter depends on size and distance.

FIGURE 27-6.

are the closest to it. The sun appears the smallest in July, when the distance between Earth and the sun is the greatest. However, this change in distance is too small to affect our seasons, which are caused by the tilt of Earth's axis.

As seen from Earth, the sun and the moon have an angular diameter of about 0.5° of angle. Figure 27-7 shows an angle of about 0.5°, or 30 minutes.

FIGURE 27-7.

Wrap-Up

1. Kepler discovered that orbits are not circles, they are ellipses.
2. Is the sun at the exact center of Earth's orbit? No
3. The sun is located at one focus of the ellipse. (The ellipse you drew should show this.)
4. Which of the following shapes best describes Earth's orbit to scale?
   football, egg, or bowling ball Bowling ball
5. What is the approximate angular diameter of the sun and the moon?
   0.5° (about 30 minutes of arc)
6. If Earth's orbit around the sun is an ellipse, not a perfect circle, how does this affect our observations of the sun from planet Earth?
   The sun seems to change in angular size.
7. In what month does the sun appear the largest to us?
   January (when it is closest)
8. Changes in the apparent size of the sun are (1) cyclic, (2) noncyclic?
   (1) cyclic
9. How long does a full cycle of changes in the angular diameter of the sun take?
   One year
10. If Earth's orbit became more eccentric, how would that affect our observations of the sun?
    The change in the angular diameter would be greater. (It might also influence the seasons.)

11. Accurately describe the shape of Earth's orbit around the sun.

So round that it looks like a perfect circle. (Accept any answer that is comparable.)

12. As Earth orbits the sun our position in space changes. During one night of observations, why do we not see the night stars change their relative positions?

The night stars are very distant compared with the size of Earth's orbit.

13. On a separate piece of paper, calculate the eccentricities of the ellipses shown in Figure 27-8. Make your measurements to the nearest whole millimeter and carry out your calculations to two significant figures. Show your work, including the algebraic formula, for each.

a. $e = d/l = 1.9\text{ cm}/5.4\text{ cm} = 0.35$

b. $e = d/l = 2.8\text{ cm}/4.2\text{ cm} = 0.67$

c. $e = d/l = 2.4\text{ cm}/4.8\text{ cm} = 0.50$

d. $e - d/l = 0\text{ cm}/6.0\text{ cm} = 0$

e. $e = d/l = 7.2\text{ cm}/7.2\text{ cm} = 1.0$

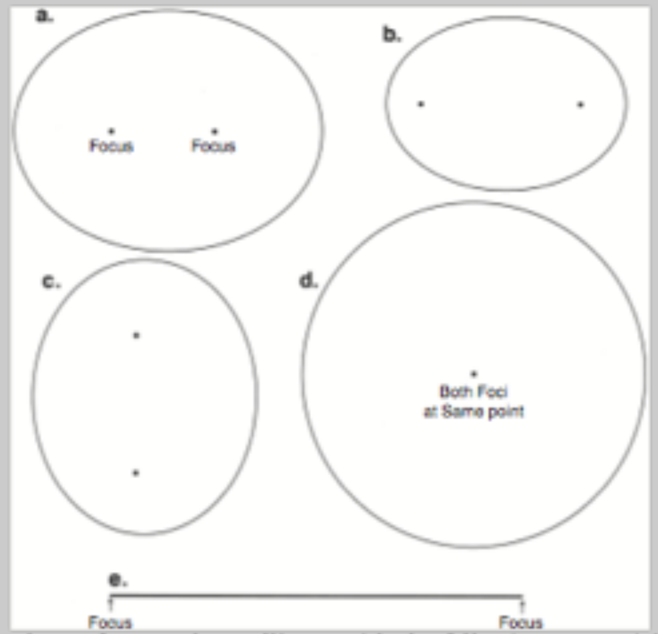
(A) $\frac{1.9}{5.4} =$

(b) $\frac{2.7}{4.7} =$

(c) $\frac{2.4}{4.8}$

(d) $\frac{0}{6}$

(e) $\frac{7.2}{7.2}$



14. On another sheet of paper, draw ellipses with the following eccentricities

a. e = 0.25

b. e = 0.5

c. e = 0.95

d. e = 0.99

15. Why is it impossible to use your string to draw an ellipse with an eccentricity greater than 1?

The two foci would be outside the ellipse.

CHAPTER 27—LAB 2: KEPLER'S LAWS

Introduction

Johannes Kepler was a brilliant astronomer and mathematician. Actually, Kepler was more interested in predicting the future based upon the positions of the stars (astrology) than he was in astronomy (the study of the motions of the these objects). Nevertheless, he needed to know and be able to predict the precise position of celestial objects to do his astrology. In spite of his objectives in celestial fantasy (for which he was actually employed), Kepler is best known today for his three precise and mathematical laws of planetary motion.

Objective

To discover the properties of ellipses.

Materials

None

Procedure

Kepler's First Law

The orbit of a planet about a star is an ellipse with the star at one focus.

The planets are satellites of the sun, which is their primary. Earth is the primary of the moon, but Earth is also a satellite of the sun. Figure 27-9 represents a satellite orbiting

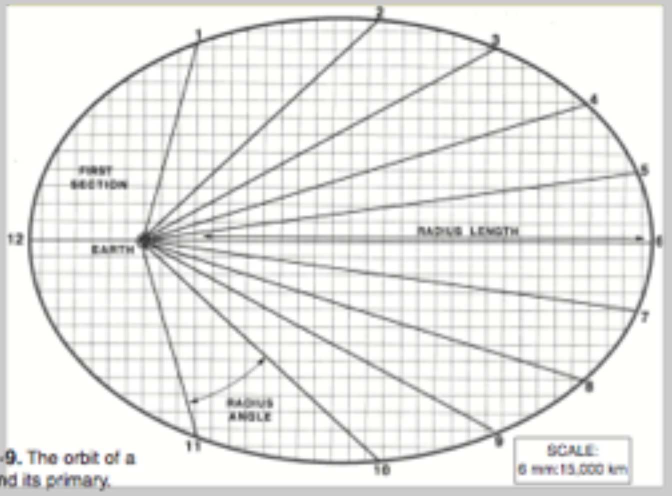


FIGURE 27-9. The orbit of a satellite around its primary.

Earth. Each number shows the position of the satellite on successive days. How long does it take this satellite to orbit Earth? 12 days

The next section will help you discover how the areas of the 12 sectors compare. Count the number of squares in each section of the orbit. Count each square for which half the square is inside the section you are counting. Record your data in Table 27-1.

TABLE 27-1. Relative Area Swept Out by the Satellite Each Day.

Section	12–1	1–2	2–3	3–4	4–5	5–6	6–7	7–8	8–9	9–10	10–11	11–12
Number of squares												

1. Are the number of squares (the area) approximately the same in each section?

   Yes (The number of squares counted depends upon judgments of the students.)

Kepler's Second Law

The radius between a satellite (such as a planet) and its primary (such as the sun) sweeps out equal areas in equal times.

That is why each section of the orbit in Figure 27-9 had about the same number of little squares (area).

2. The Solar System Data Table in the *Earth Science Reference Tables* lists the mean distance of each planet from the sun. The same table gives the planets' period of rotation. Construct a graph to show how the time needed for one orbital circuit relates to the average distance of each planet from the sun.

3. Look again at Figure 27-9. What is the relationship between the distance of a satellite from its primary and the speed of the satellite in its orbit? (That is, when does the satellite move the fastest, when it is closest to its primary, or when it is far away?)
The satellite moves fastest when it is closest to its primary.

Kepler's Third Law

The closer a satellite is to its primary, the faster it moves in its orbit. The closest planets move the fastest.

Just as Kepler had used the theories of Copernicus and Galileo for his work, the astronomers who followed used Kepler's discoveries. Sir Isaac Newton used Kepler's three laws in developing his theory of gravitation, and later Albert Einstein used Kepler's laws in his theories of relativity. Sir Isaac Newton wrote to his rival, Robert Hooke, "If I have seen farther than others, it is because I was standing on the shoulders of giants."

4. The shape of Earth's orbit is a(an) ellipse with the sun located at one focus.

5. Earth is a satellite of the sun. What is Earth's major satellite? The moon.

6. Earth is the closest to the sun in the month of January.

7. Earth travels in its orbit most slowly in the month of July.

8. In equal times, the radius to a planet sweeps out equal areas.

9. Which planets travel faster in their orbits, the inner, or outer planets?
Inner planets travel faster.

10. Label each of the following as a cyclical or a noncyclical change:
   a. the changing distance between Earth and the sun Cyclic
   b. the changing speed of Earth in its orbit Cyclic
   c. the changing angular diameter of the sun Cyclic

11. What length of time is required for one complete cycle of the changes listed above?
One (Earth) year

12. The planets can be separated into two groups based on their sizes and densities: the terrestrial (rocky) planets and the gas giants.
   a. Which planets are "terrestrial"? Mercury, Venus, Earth, Mars, and possibly Pluto (Some astronomers have suggested that Pluto formed originally as a moon or is an asteroid.)
   b. Which are gas giants? Jupiter, Saturn, Uranus, and Neptune

13. *a.* Which of the gas giants has the greatest density? Jupiter
   b. What is its density? 1.3 g/cm^3
   c. Which of the terrestrial planets has the lowest density?
   Mars (or Pluto)
   d. What is its density? 3.9 g/cm^3 (2.0 g/cm^3 if Pluto is a terrestrial planet.)

14. According to Newton, what force holds all satellites in their orbit around their primary?
Gravity

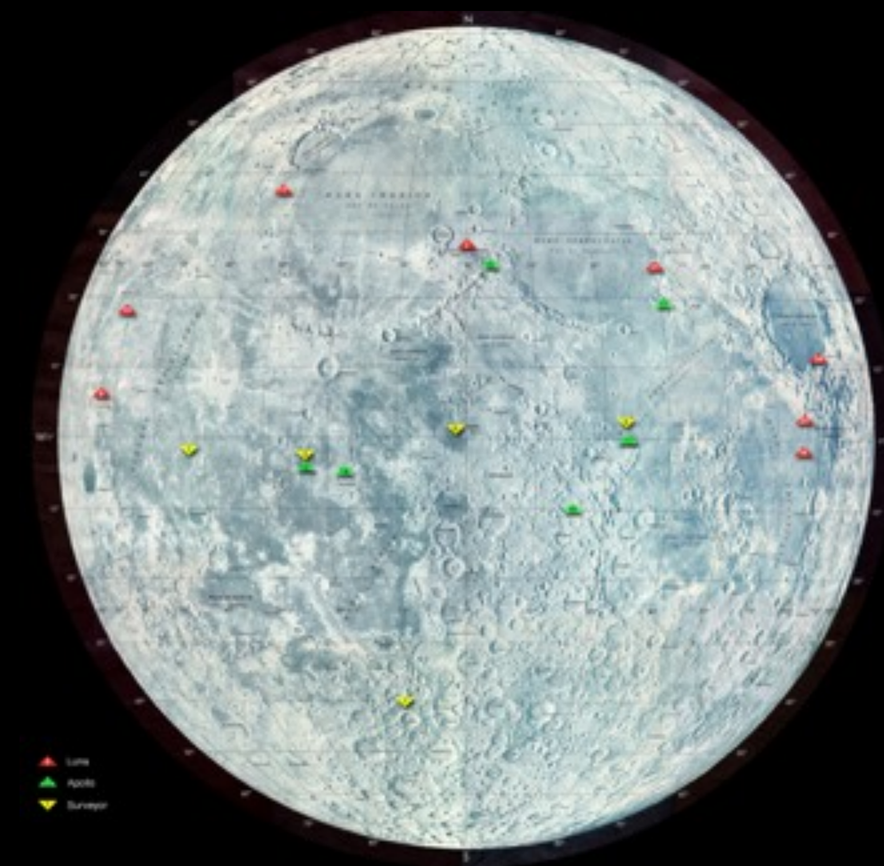
15. Is the orbital period of a planet affected by its mass? How do you know?
No, there is no affect. The Reference Tables show that the massive planets, such as Jupiter, are not the fastest planets.

The Moon & Earth System

Objectives

- **Explain** the theory of how the Moon formed.
- **Identify** the relative positions and motions of the Earth, and Moon.
- **Explain** eclipses of the Sun and Moon.

The Moon & Earth System

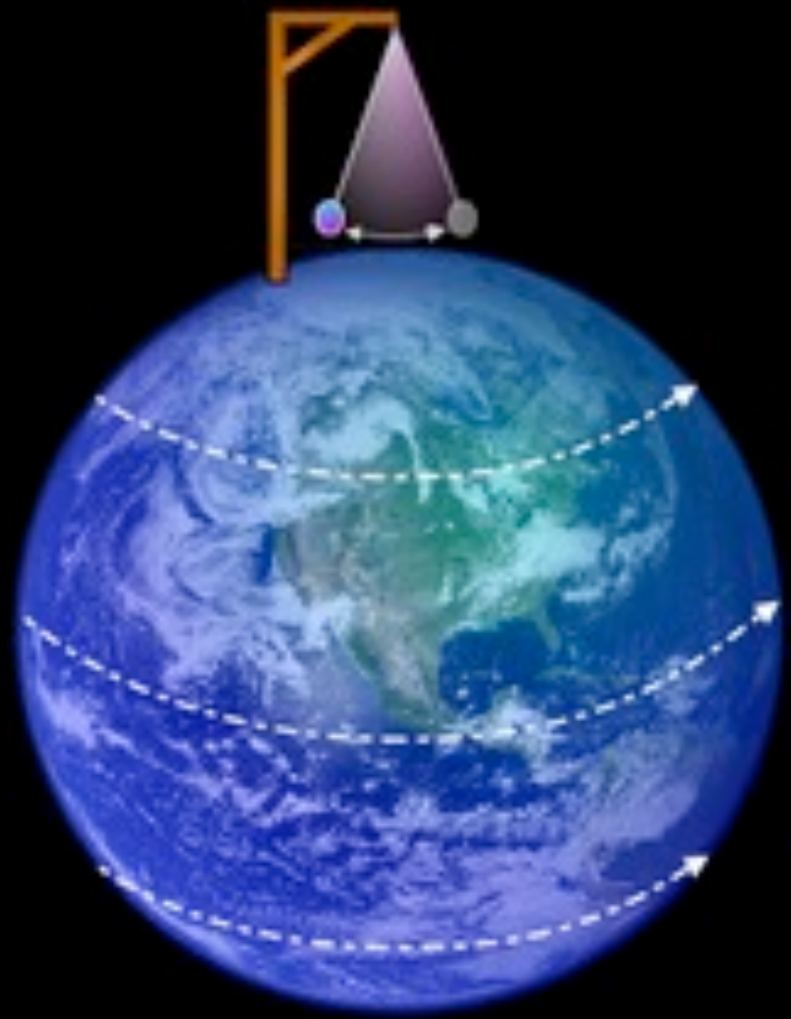


Objectives

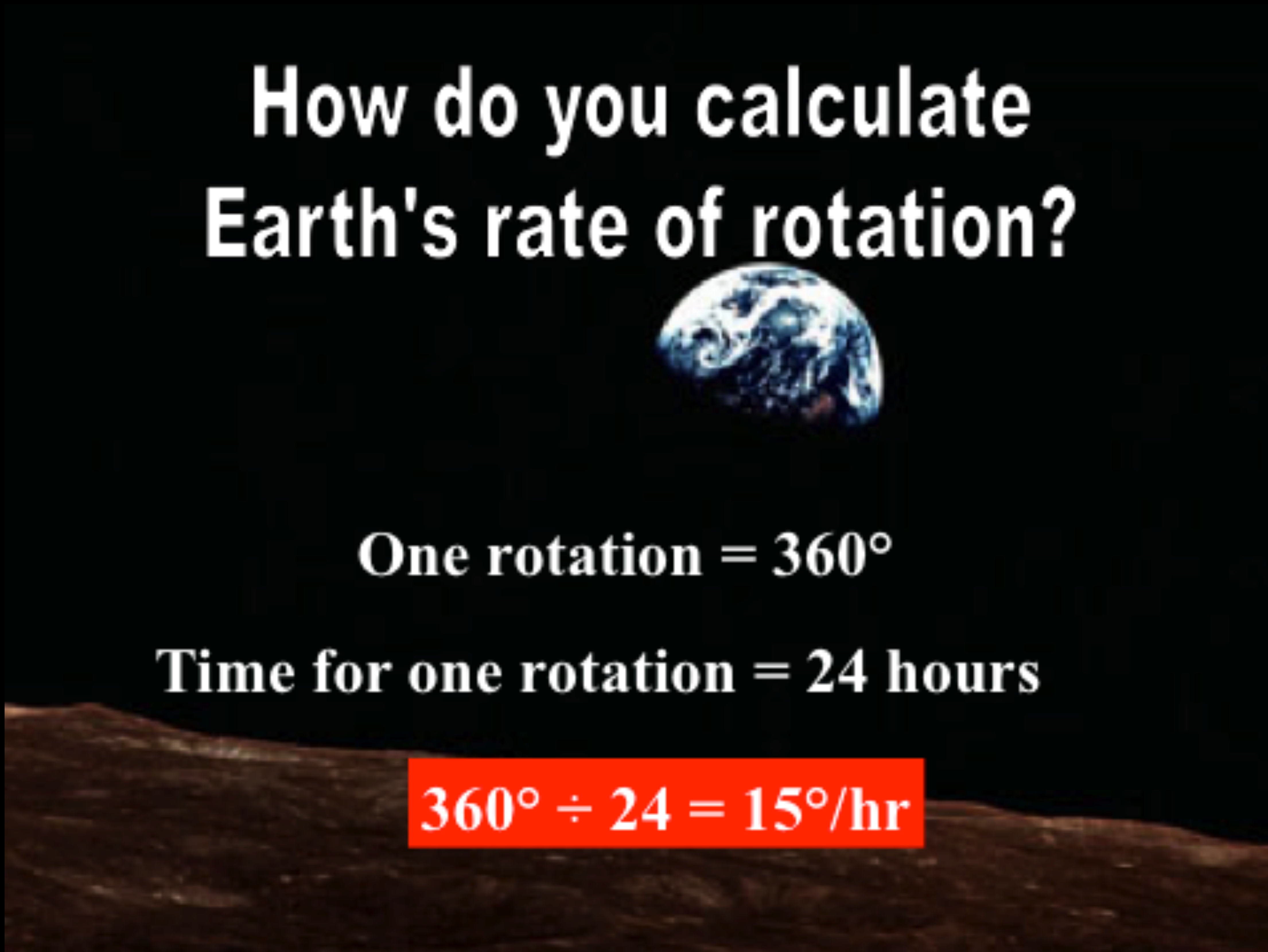
- **Explain** the theory of how the Moon formed.
- **Identify** the relative positions and motions of the Earth, and Moon.
- **Explain** eclipses of the Sun and Moon.

How do we know the Earth rotates?

1. Foucault Pendulum
2. Coriolis Effect



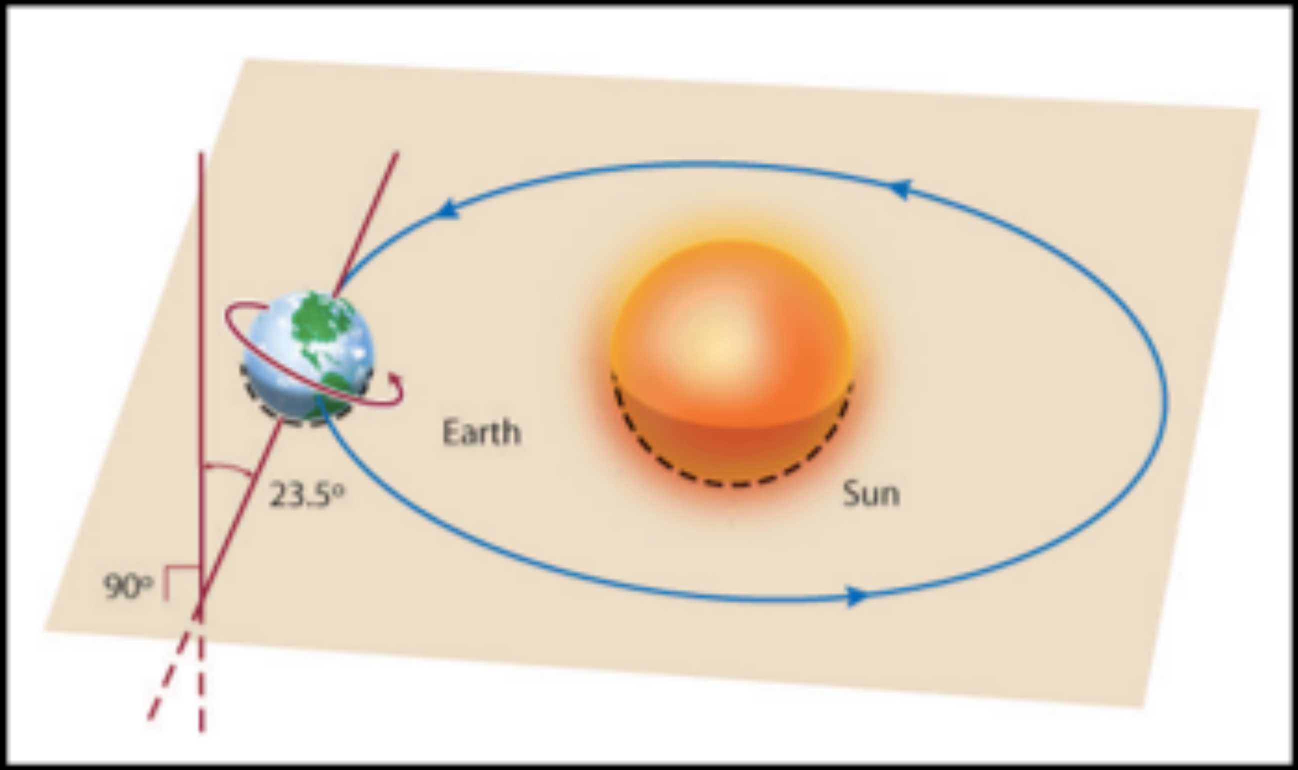
The time period from one noon to the next is called a solar day.


How do you calculate Earth's rate of rotation?
One rotation = 360°
Time for one rotation = 24 hours
360° ÷ 24 = 15°/hr

Annual Motions

Earth orbits the Sun in a slightly elliptical orbit.

Earth's axis 23.5



Earth's tilt and orbital motion around the Sun result in a cycle of the seasons.

Revolution: time it takes for a planetary body to make one orbit around another.

Earth's Revolution

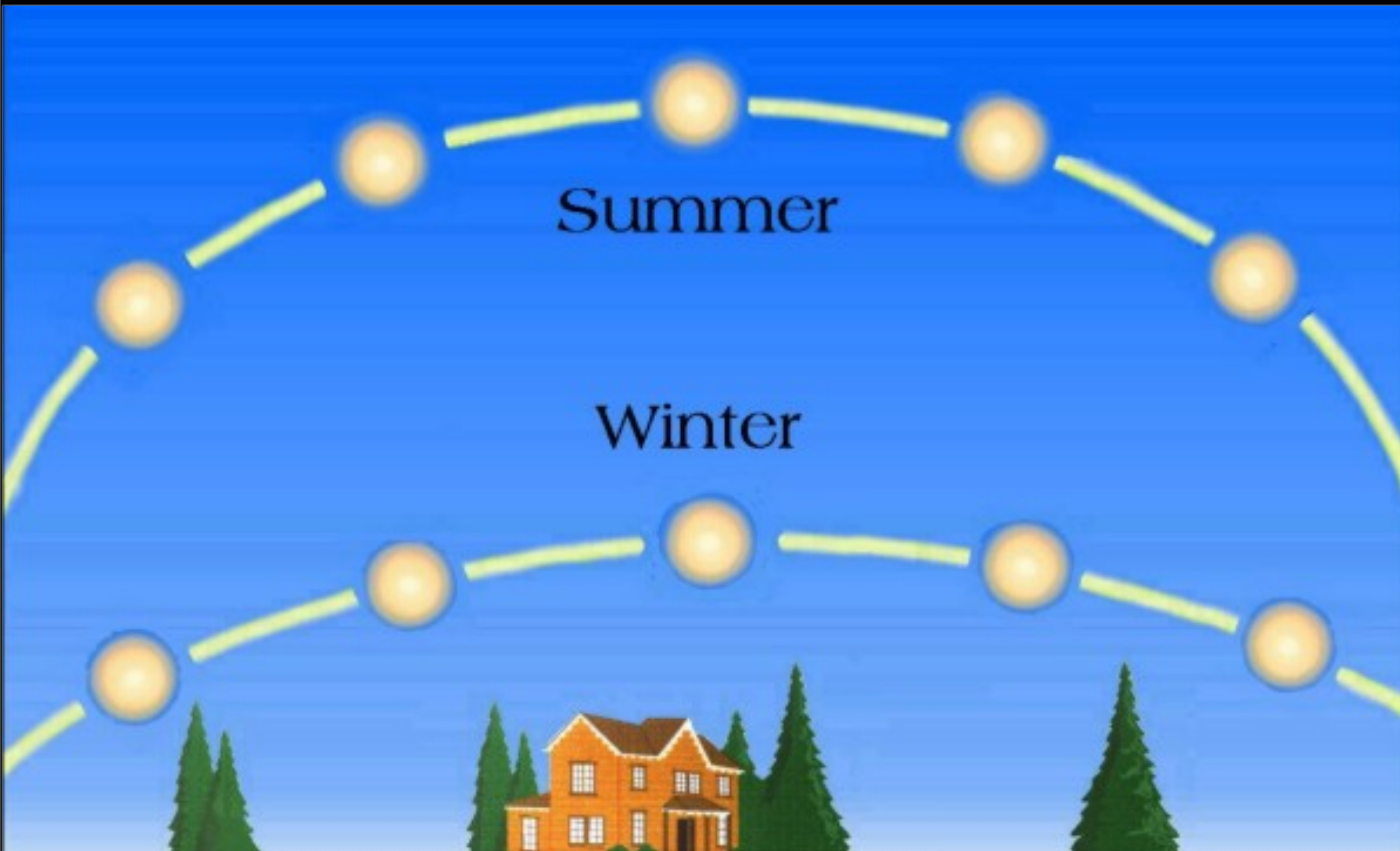
Earth revolves around the sun in a slightly eccentric elliptical orbit or path once a year

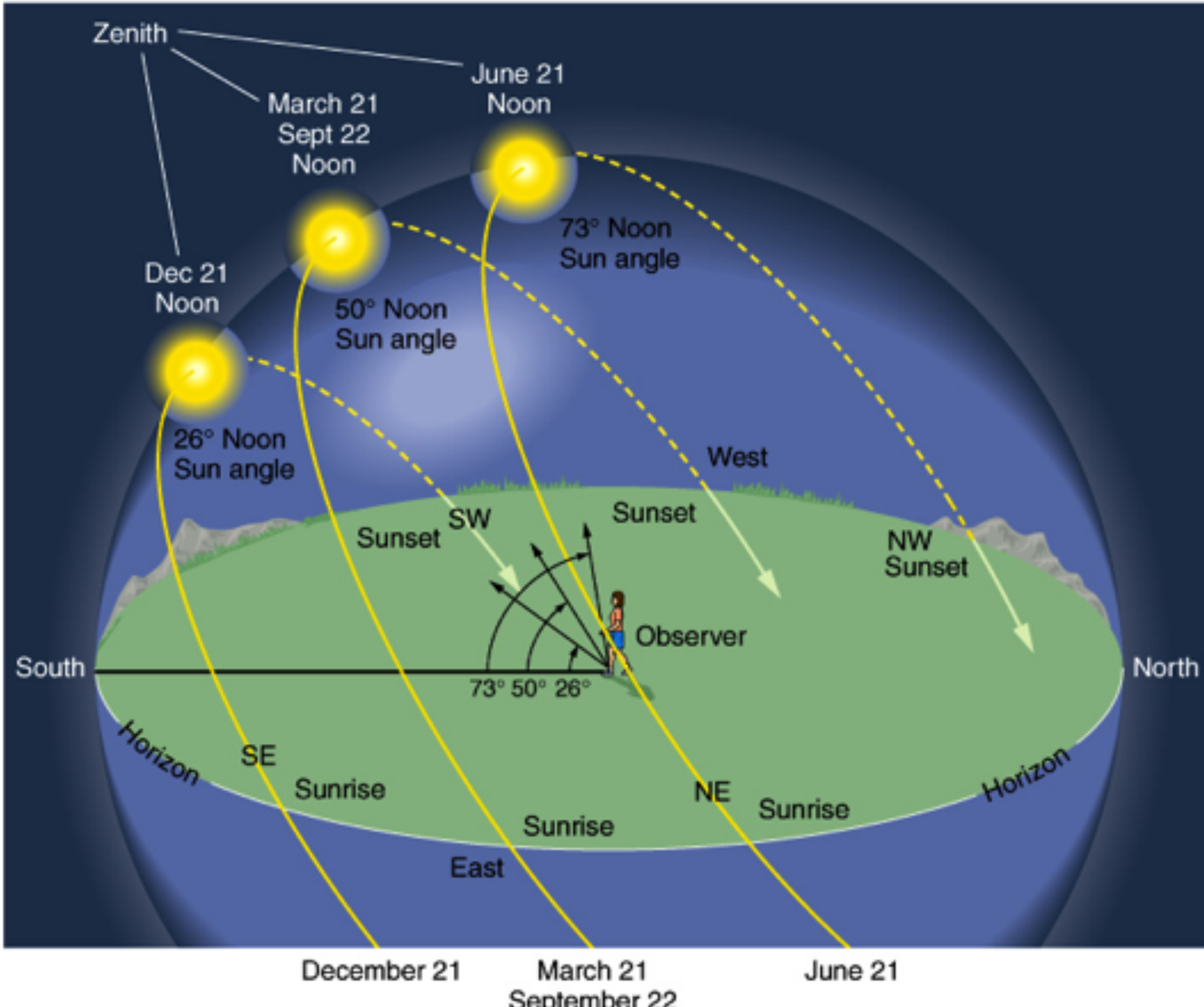
It takes Earth 365.25 days to revolve 360° in its orbit around the sun. It moves approximately 1° per day. (360°/365.26 days = 1° per day)

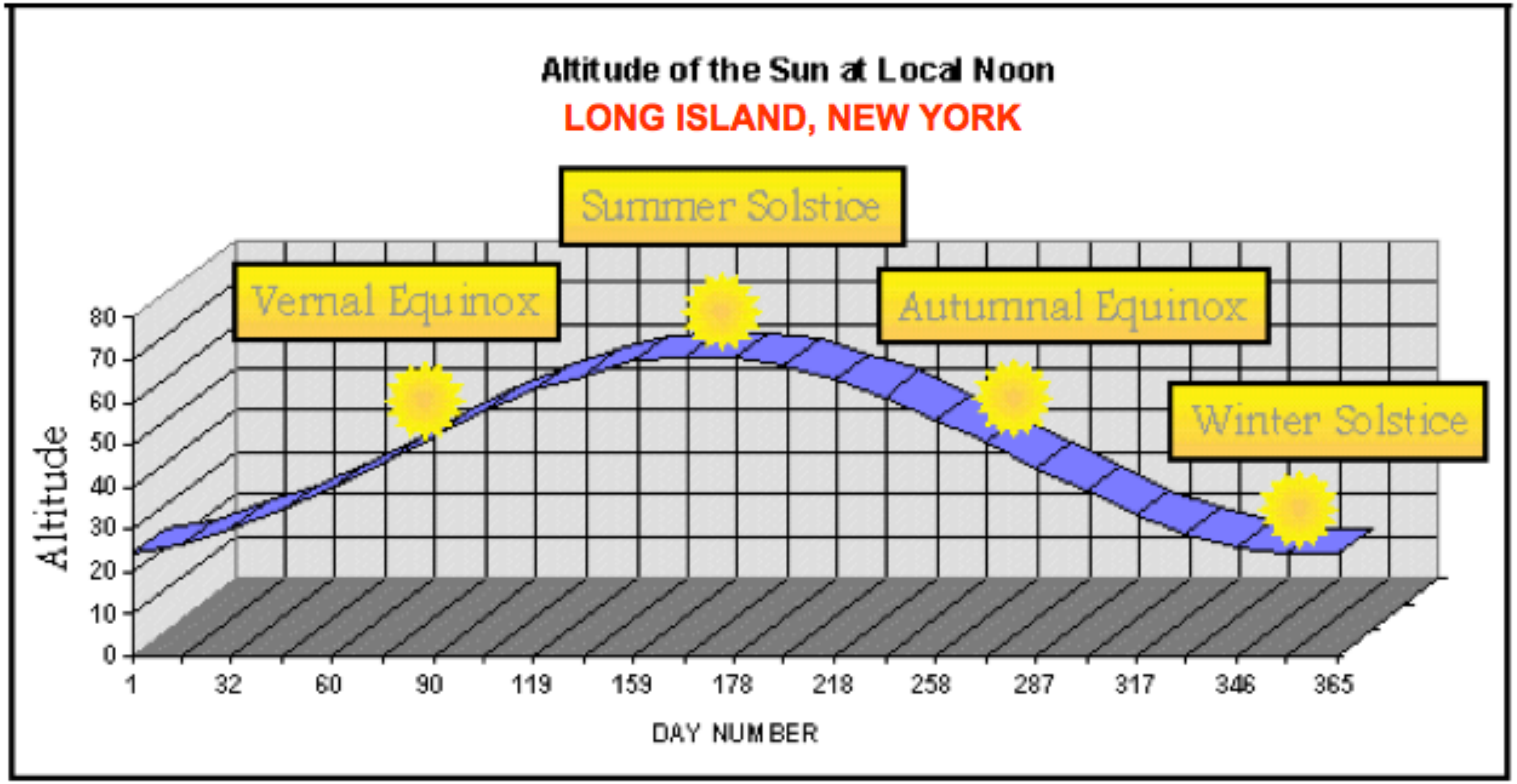
Evidence of Earth's Revolution around the Sun

Seasonal Constellations: Because of the Sun's annual motion, some constellations are visible at night only during certain seasons. Constellations are visible when the dark side of Earth (away from sun) faces toward the constellation.

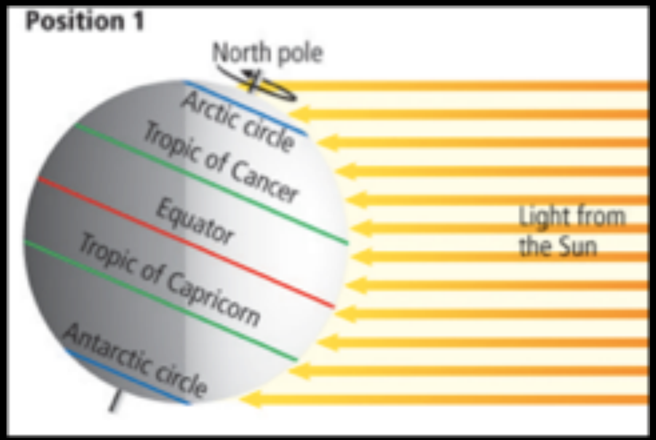
Summer maximum altitude of noon sun is 73°, Winter is 26° Spring/Autumn?




Zenith
June 21
Noon
March 21
Sept 22
Noon
Dec 21
Noon
73° Noon
Sun angle
50° Noon
Sun angle
26° Noon
Sun angle
West
Sunset
SW
Sunset
NW
Sunset
Observer
South
North
73° 50° 26°
Horizon
SE
Sunrise
NE
Sunrise
Sunrise
Horizon
East
December 21
March 21
September 22
June 21

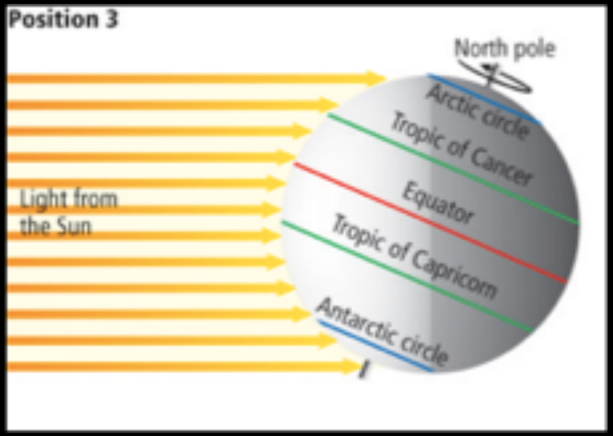

Altitude of the Sun at Local Noon
LONG ISLAND, NEW YORK
Summer Solstice
Vernal Equinox
Autumnal Equinox
Winter Solstice
Altitude
80
70
60
50
40
30
20
10
0
1
32
60
90
119
159
178
218
258
287
317
346
365
DAY NUMBER

Solstice -

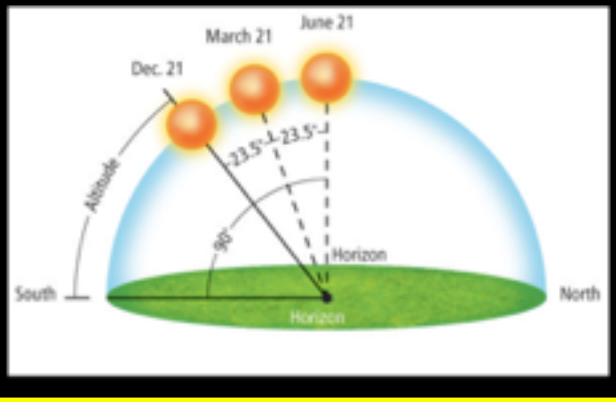


Summer Solstice
Northern hemisphere, when the Sun is directly overhead at the Tropic of Cancer, 23.5°N

Winter solstice occurs in the northern hemisphere when the Sun is directly overhead at the Tropic of



At an **equinox,** Earth's axis is perpendicular to the Sun's rays



zenith - the Sun's maximum height

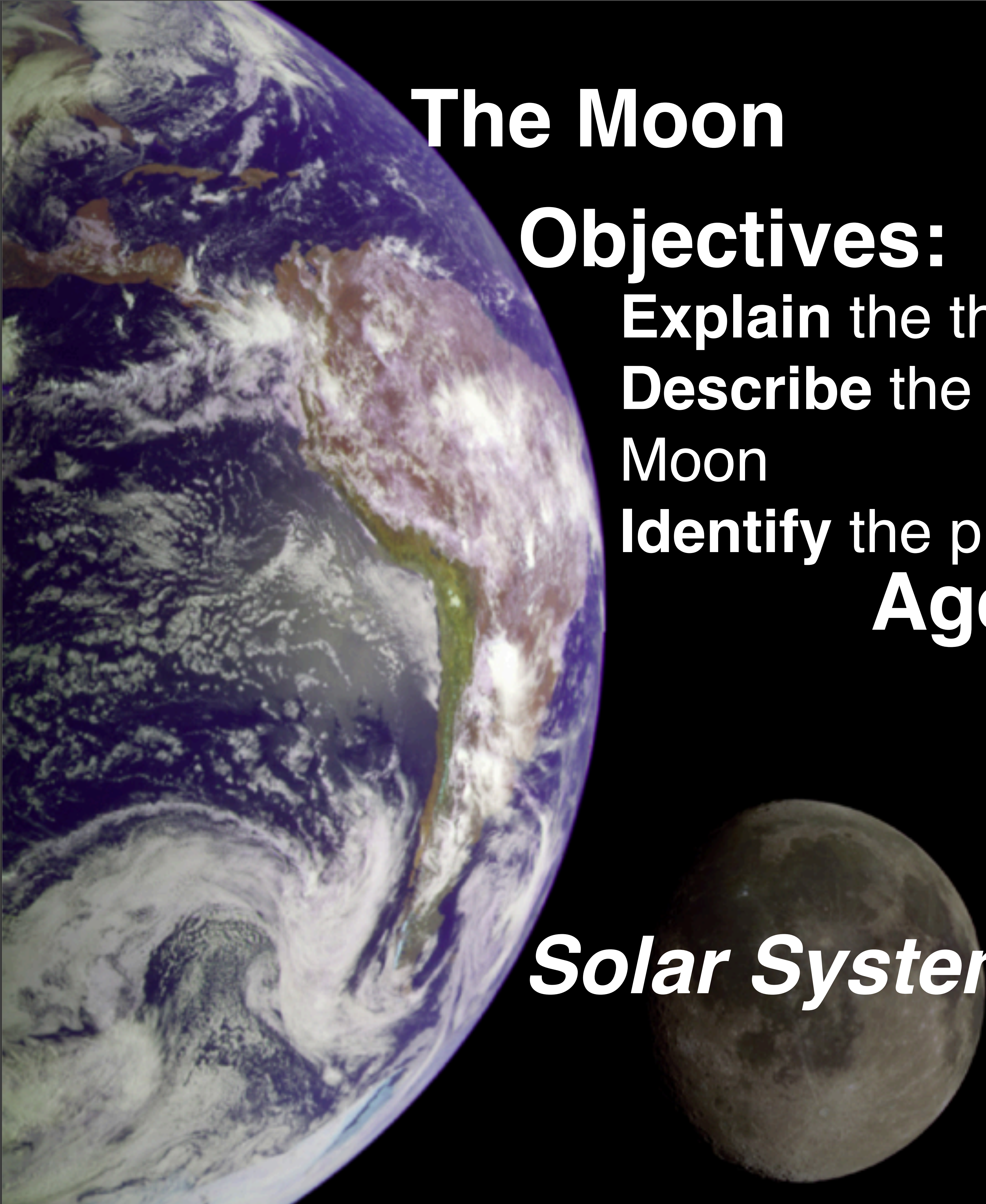
Solar System Data

Celestial Object	Mean Distance from Sun (million km)	Period of Revolution (d=days) (y=years)	Period of Rotation at Equator	Eccentricity of Orbit	Equatorial Diameter (km)	Mass (Earth = 1)	Density (g/cm^3)
SUN	—	—	27 d	—	1,392,000	333,000.00	1.4
MERCURY	57.9	88 d	59 d	0.206	4,879	0.06	5.4
VENUS	108.2	224.7 d	243 d	0.007	12,104	0.82	5.2
EARTH	149.6	365.26 d	23 h 56 min 4 s	0.017	12,756	1.00	5.5
MARS	227.9	687 d	24 h 37 min 23 s	0.093	6,794	0.11	3.9
JUPITER	778.4	11.9 y	9 h 50 min 30 s	0.048	142,984	317.83	1.3
SATURN	1,426.7	29.5 y	10 h 14 min	0.054	120,536	95.16	0.7
URANUS	2,871.0	84.0 y	17 h 14 min	0.047	51,118	14.54	1.3
NEPTUNE	4,498.3	164.8 y	16 h	0.009	49,528	17.15	1.8
EARTH'S MOON	149.6 (0.386 from Earth)	27.3 d	27.3 d	0.055	3,476	0.01	3.3

Do Now - Compare the Earth to the Moon

Use your ESRT

Earth	Moon



November 20

The Moon

Objectives:

Explain the theory of the Moon's origin.
Describe the geologic features of the Moon
Identify the phases of the Moon

Agenda:

1. **Do Now**
2. **Lecture**
3. **Classwork**
4. **Homework**

Solar System Test tomorrow

Myths about the Moon

The Moon is made of cheese!
There is a Man in the Moon.
The Moon and the Sun chase each other across the sky.
The Moon disappears during certain days of the month.
There are men or other creatures living on the Moon.
The Moon was put in the sky by a person or animal.
The Moon is a living creature or a god.
The Moon controls how we act and how we feel.
During a full moon, some people turn into werewolves.
The Moon is pulled across the sky by a person, animal, or force.

Do Not Copy


Moonlight is reflected Sunlight

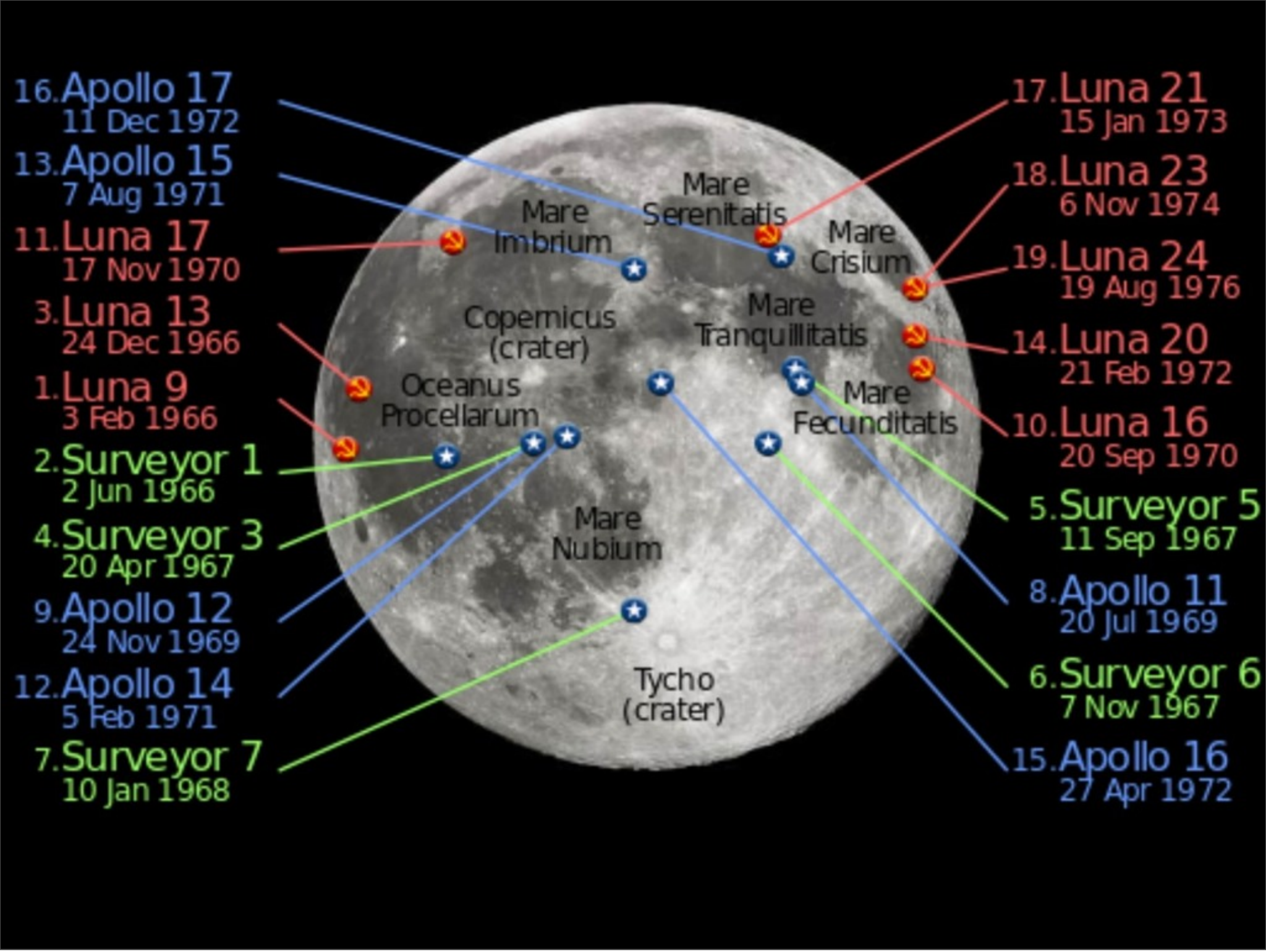
Exploring the Moon

On July 20, 1969, the Apollo program landed Neil Armstrong and Edwin "Buzz" Aldrin on the Moon during the Apollo 11 mission.

THE SELECT 12

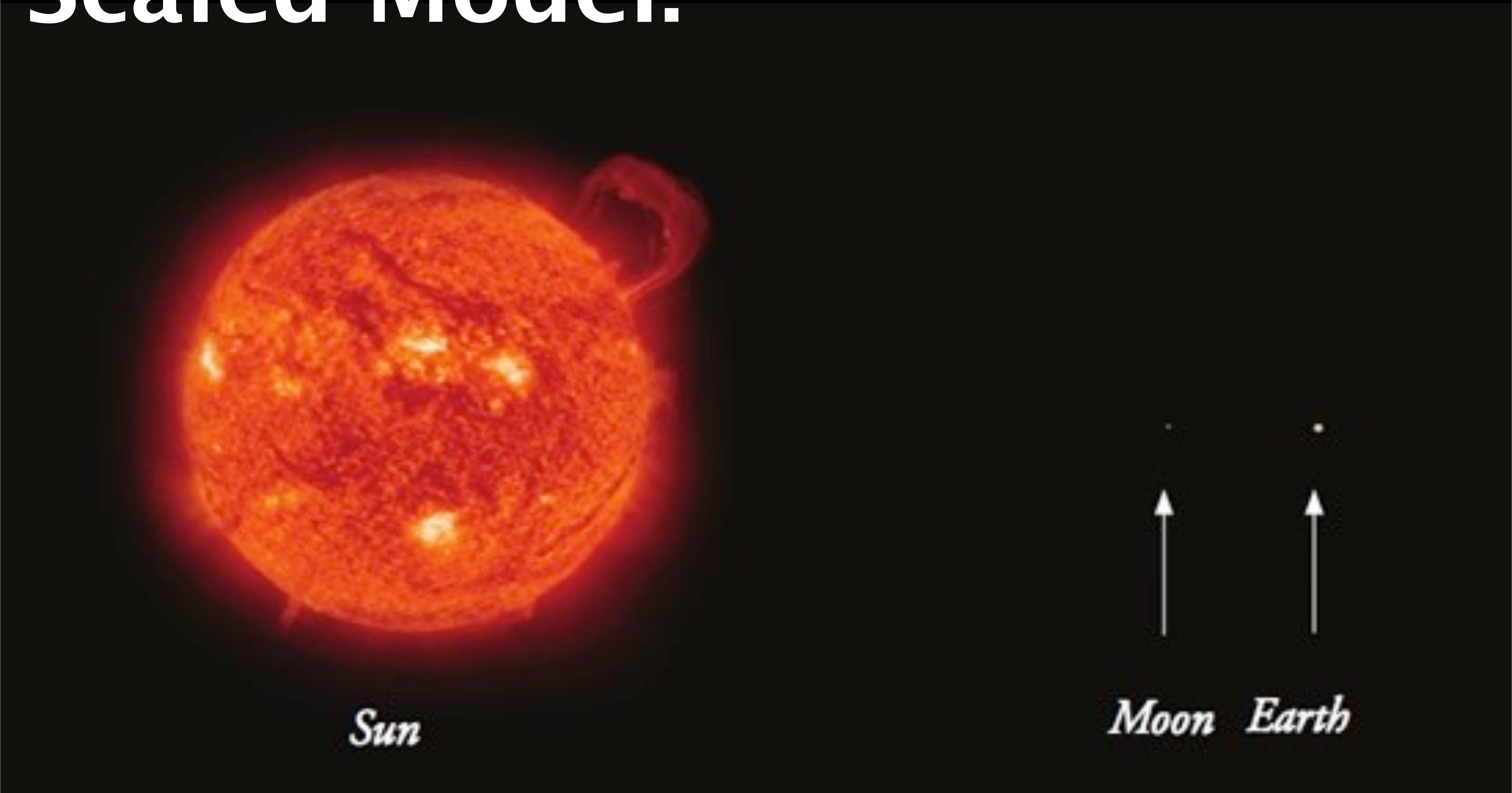
Who	When	How Long
Neil Armstrong	7/20/69	2 hr. 31 min. 40 sec.
Edwin "Buzz" Aldrin	7/20/69	2 hr. 31 min. 40 sec.
Charles (Pete) Conrad	11/19/69	7 hr. 45 min. 18 sec.
Alan Bean	11/19/69	7 hr. 45 min. 18 sec.
Alan Shepard	2/5/71	9 hr. 22 min. 31 sec.
Edgar Mitchell	2/5/71	9 hr. 22 min. 31 sec.
James Irwin	7/30/71	18 hr. 34 min. 46 sec.
David Scott	7/30/71	18 hr. 34 min. 46 sec.
Charles Duke	4/21/72 to 4/23/72	20 hr. 14 min. 16 sec.
John Young	4/21/72 to 4/23/72	20 hr. 14 min. 16 sec.
Harrison	12/11/72 to 12/13/72	22 hr. 3 min. 57 sec.
Eugene Cernan	12/11/72 to 12/13/72	22 hr. 3 min. 57 sec.

Of the billions and billions of people that have walked on the Earth, only a select 12 have walked on the Moon. If you combined all the time that they spent walking on the Moon, it is still less than 4 days!


16. Apollo 17
11 Dec 1972
13. Apollo 15
7 Aug 1971
11. Luna 17
17 Nov 1970
3. Luna 13
24 Dec 1966
1. Luna 9
3 Feb 1966
2. Surveyor 1
2 Jun 1966
4. Surveyor 3
20 Apr 1967
9. Apollo 12
24 Nov 1969
12. Apollo 14
5 Feb 1971
7. Surveyor 7
10 Jan 1968
17. Luna 21
15 Jan 1973
18. Luna 23
6 Nov 1974
19. Luna 24
19 Aug 1976
14. Luna 20
21 Feb 1972
10. Luna 16
20 Sep 1970
5. Surveyor 5
11 Sep 1967
8. Apollo 11
20 Jul 1969
6. Surveyor 6
7 Nov 1967
15. Apollo 16
27 Apr 1972
Mare Imbrium
Mare Serenitatis
Mare Crisium
Copernicus (crater)
Mare Tranquillitatis
Oceanus Procellarum
Mare Fecunditatis
Mare Nubium
Tycho (crater)

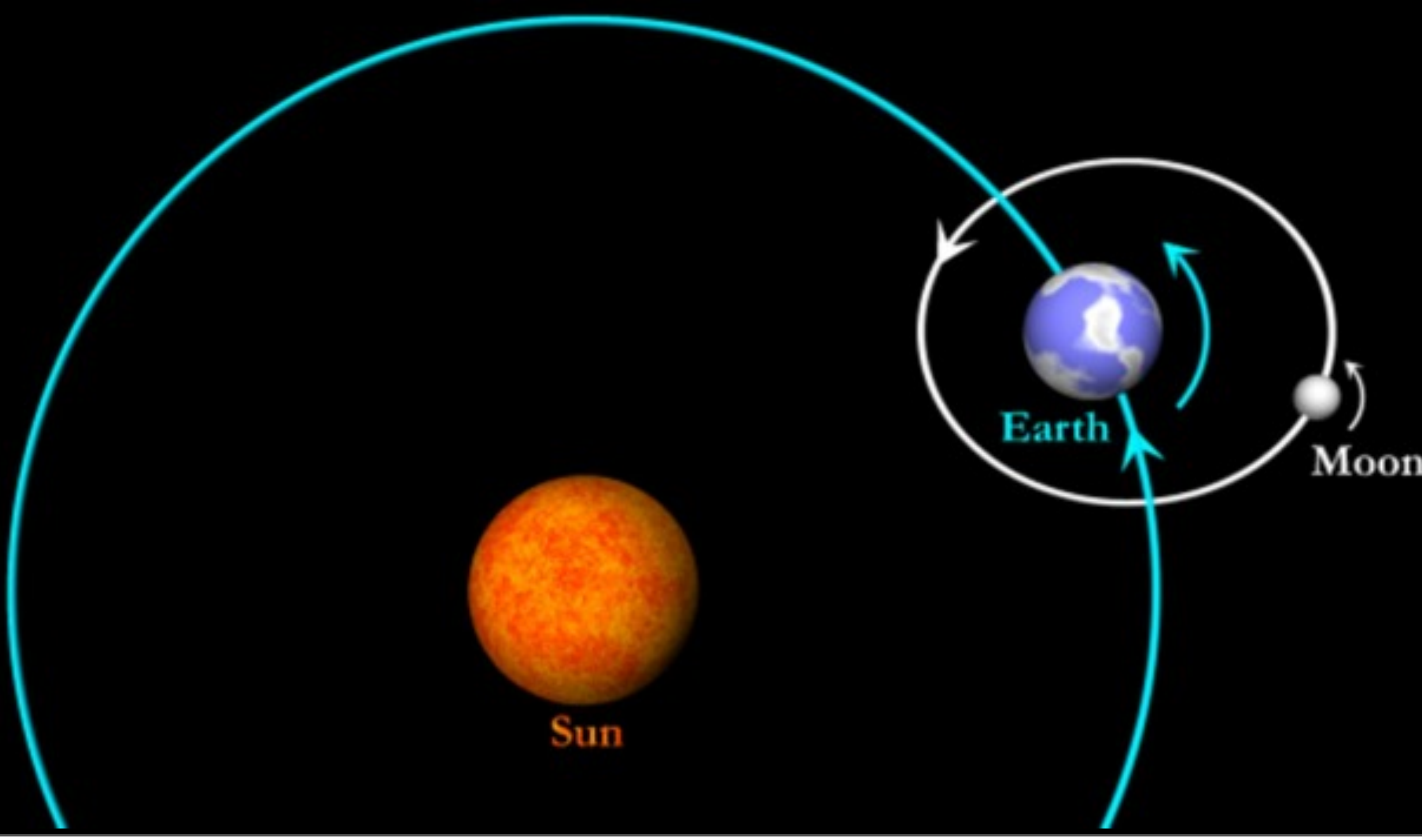
View of Earth from the Moon

Scaled Model:



What is the Moon?

A natural satellite (solid & rocky)
One of more than 96 moons in our Solar System



Moons of our Solar System

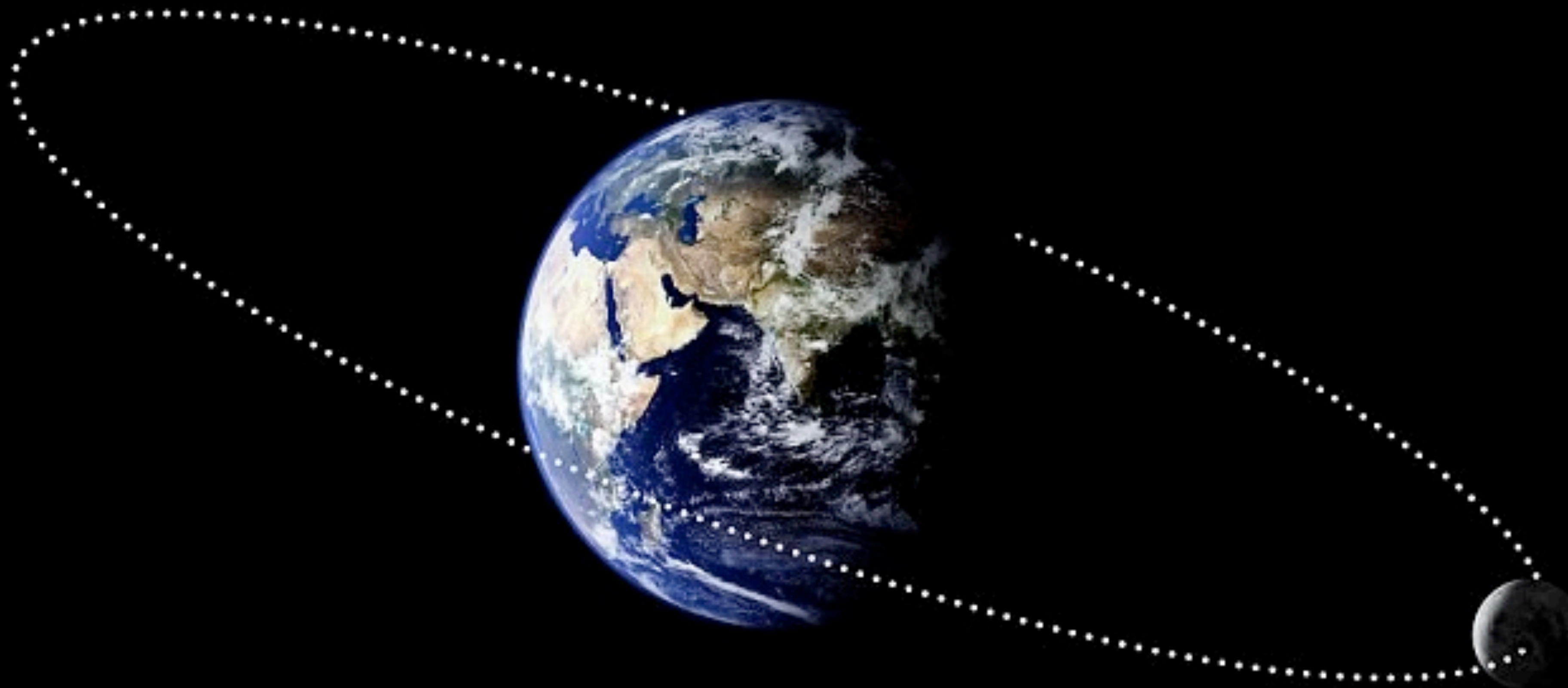

How did
the moon
form?

The Impact Theory

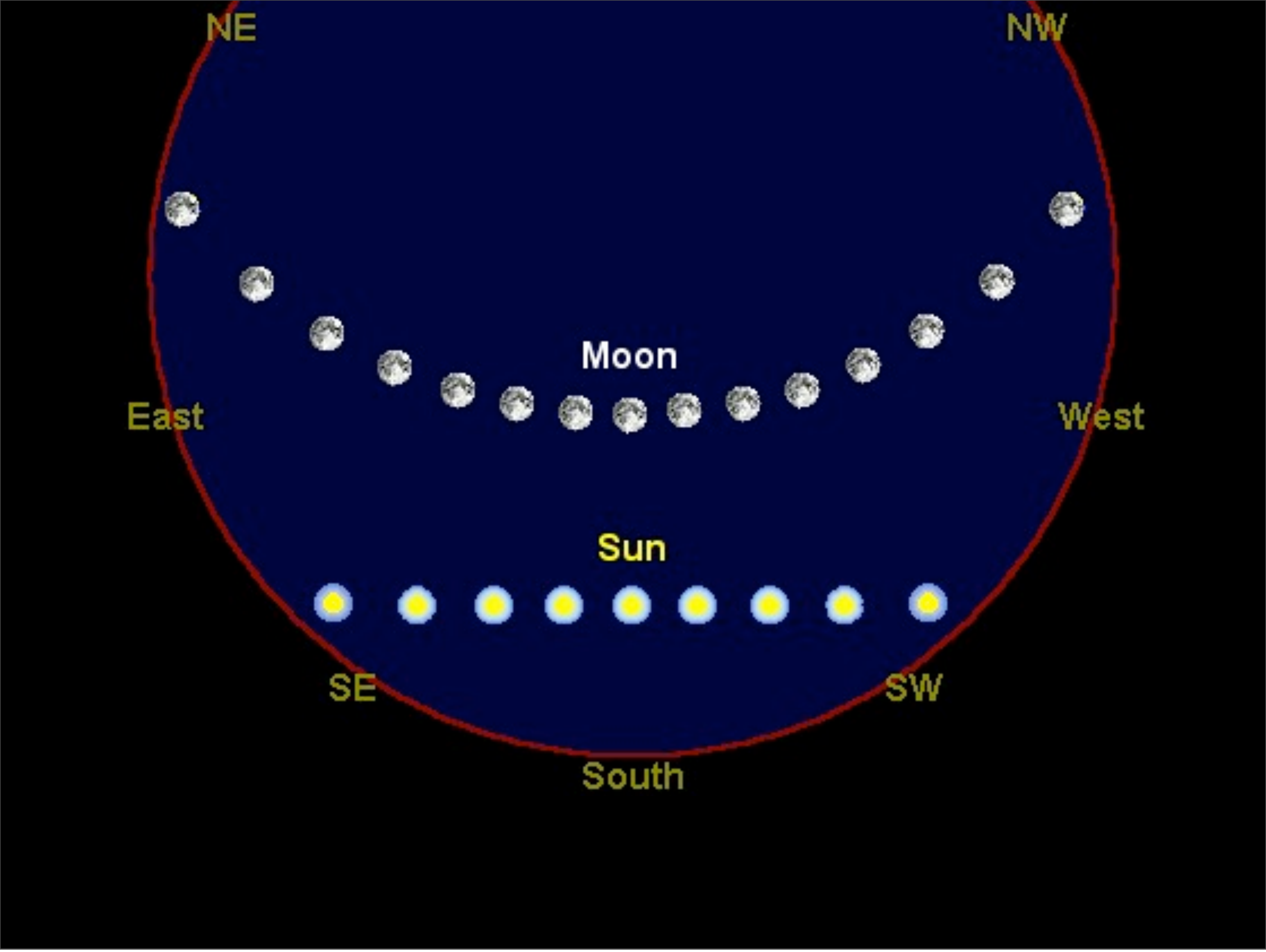
Impact by *Mars-sized* proto-planet
(collides into earth, 4.5 billion years ago)

The Impact

The Moon's Orbit is 5 ^{0} (counterclockwise)

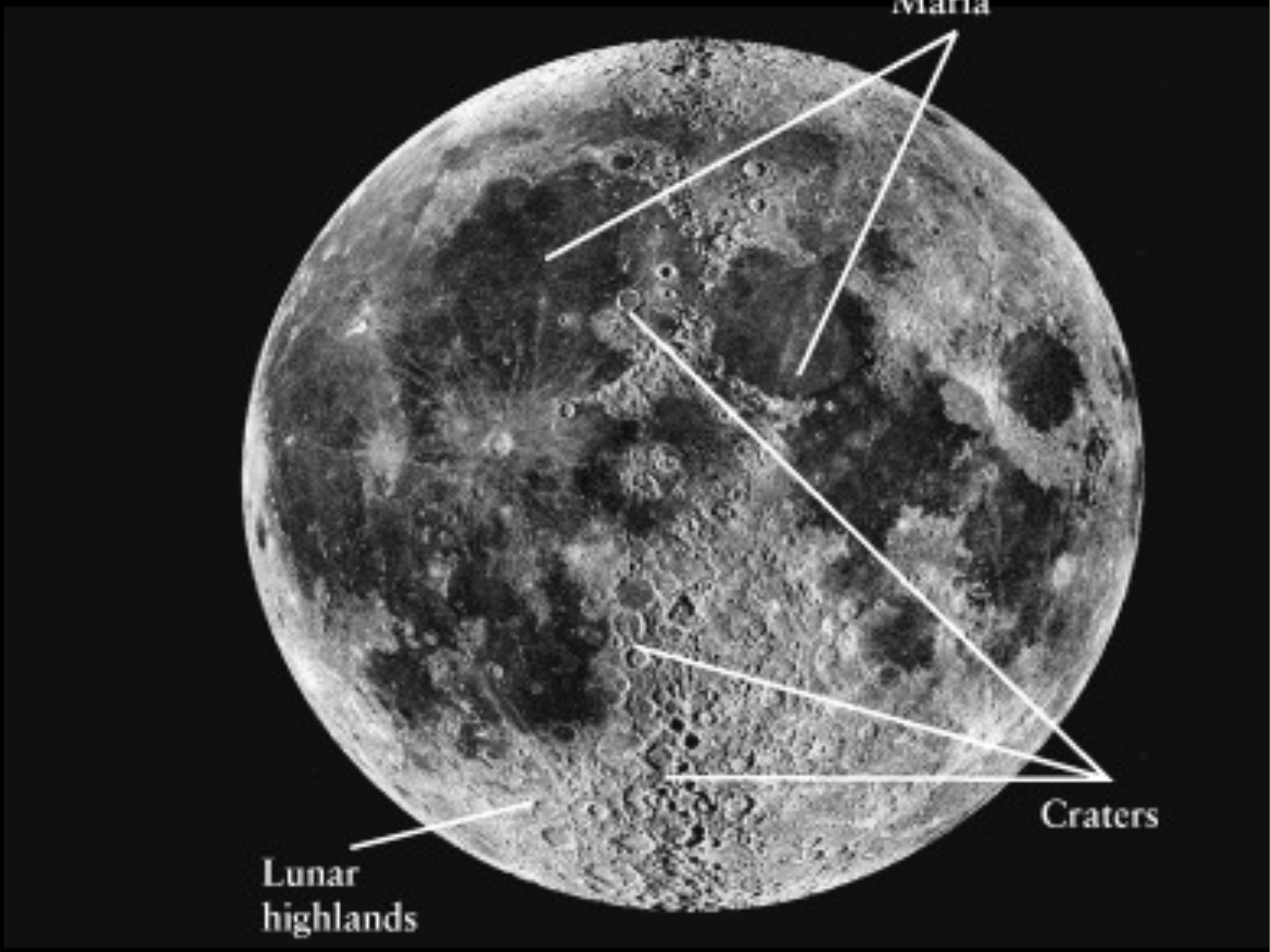


The moon rises in the east and sets in the west
(50 minutes later each day)
Visible for 12 hours per day


NE
NW
Moon
East
West
Sun
SE
SW
South

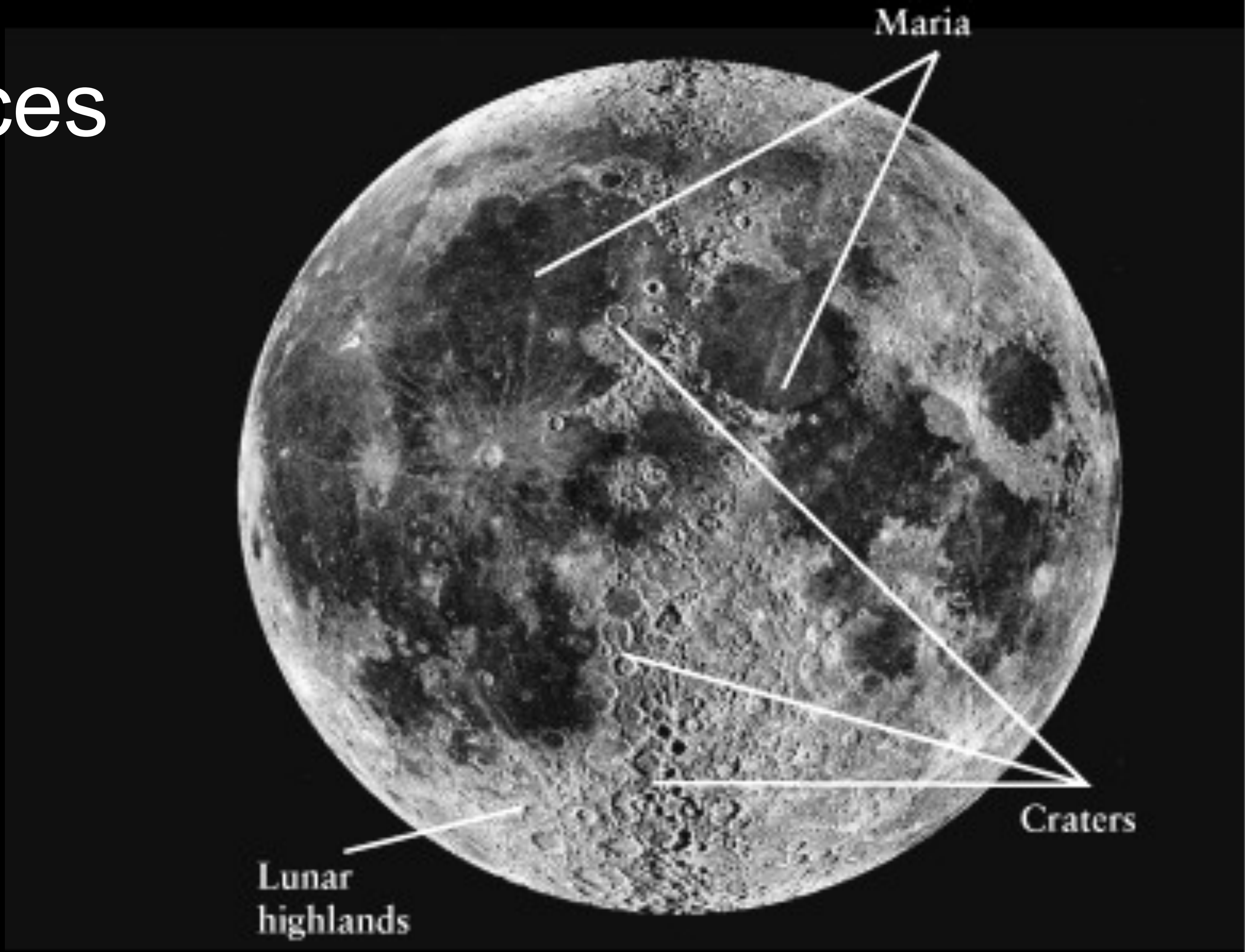
Surface Features

Surface Features on the Moon



Surface Features on the Moon

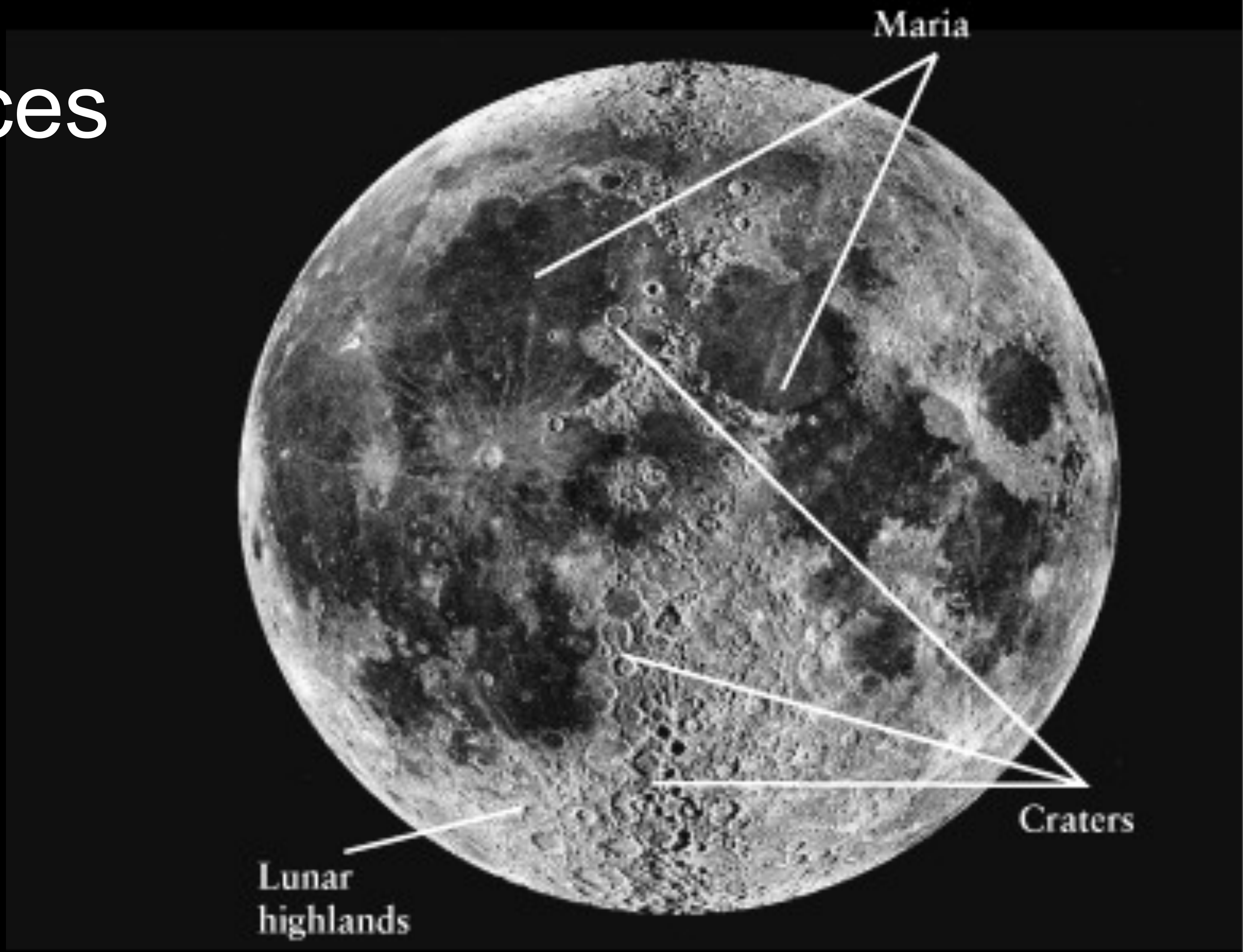
Two types of Surfaces



Surface Features on the Moon

Two types of Surfaces

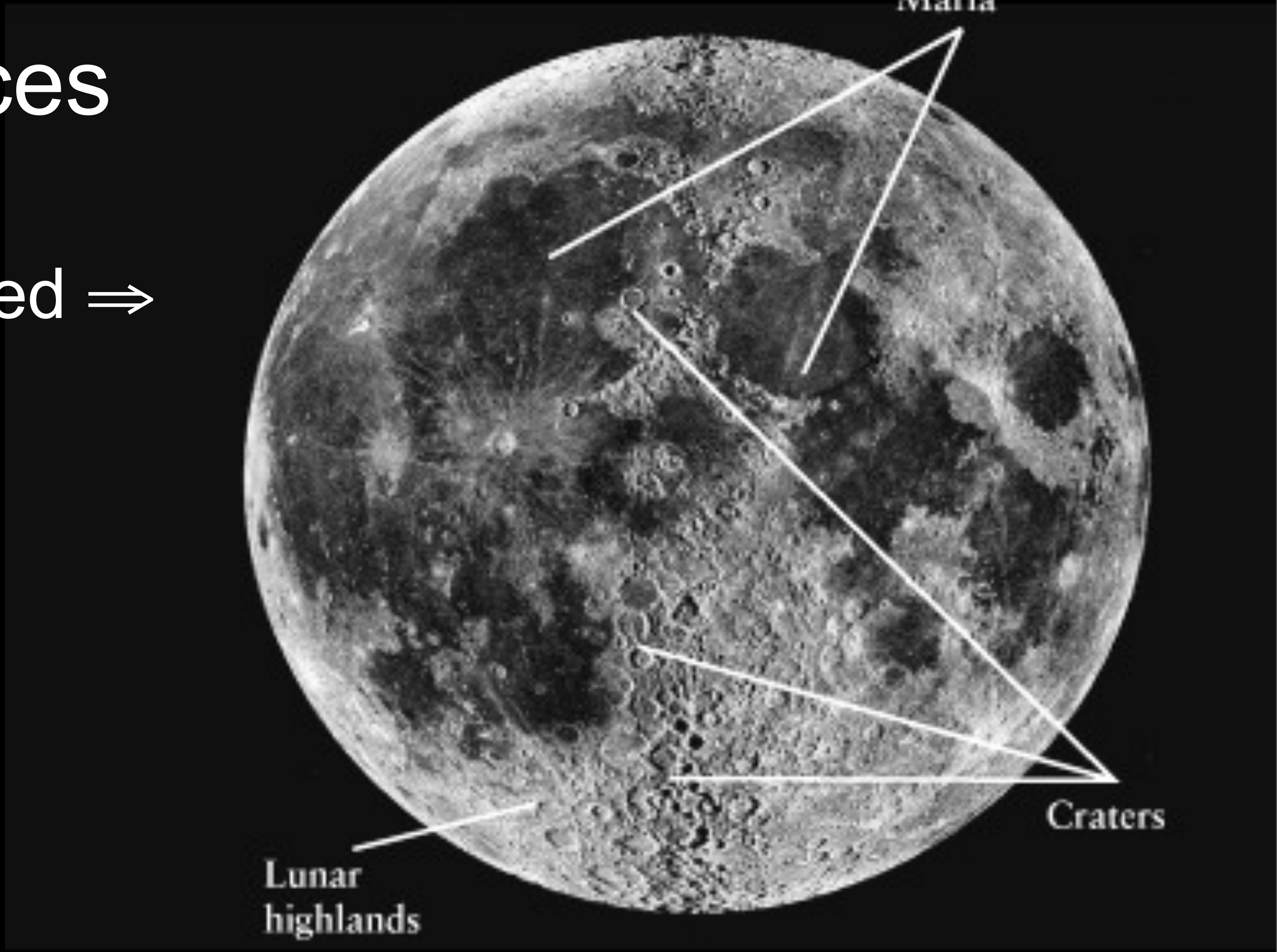
- Highlands



Surface Features on the Moon

Two types of Surfaces

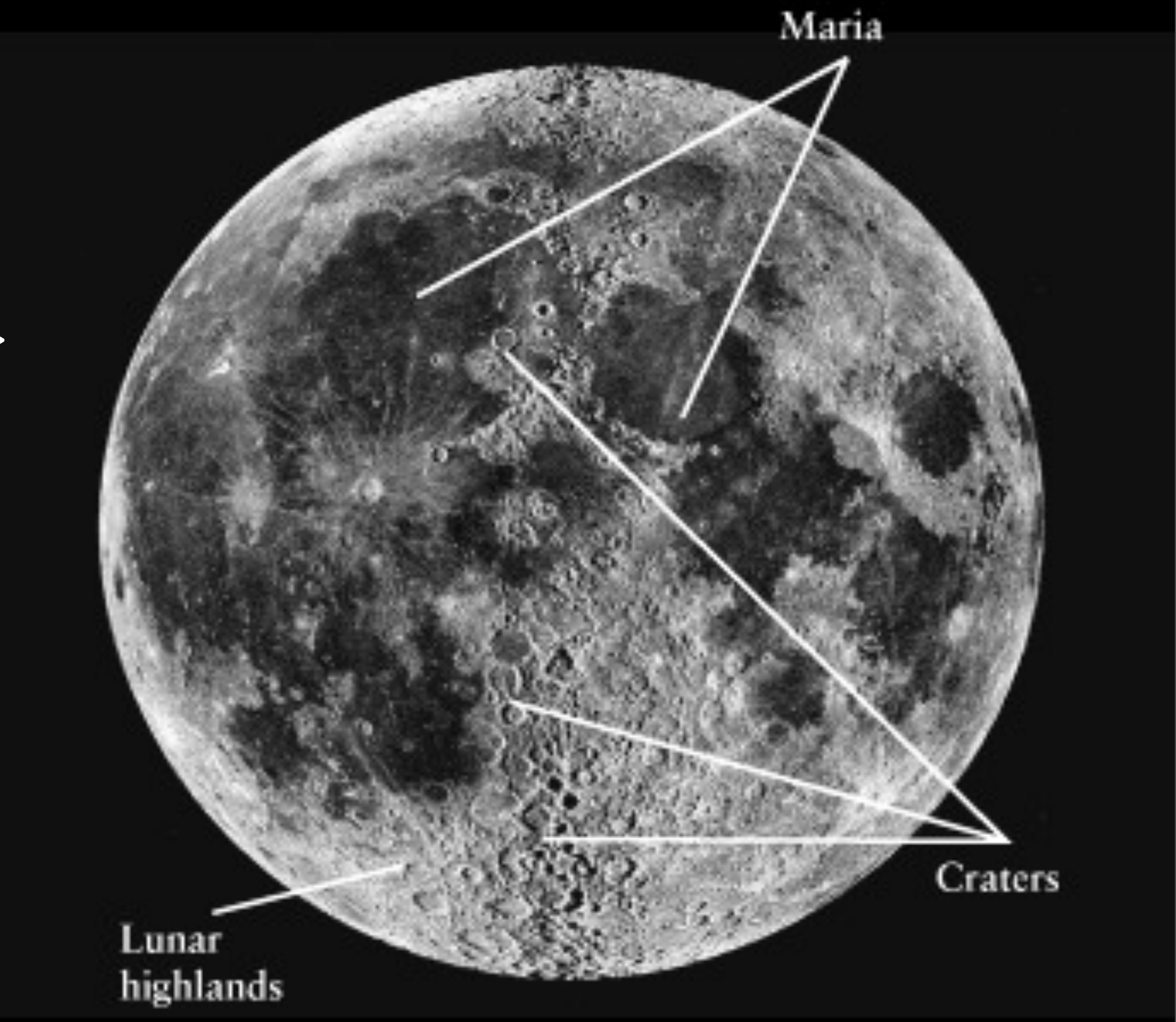
- Highlands
  - More heavily cratered ⇒ surface is older.



Surface Features on the Moon

Two types of Surfaces

- Highlands
  - More heavily cratered ⇒ surface is older.
- Maria (“Seas”)

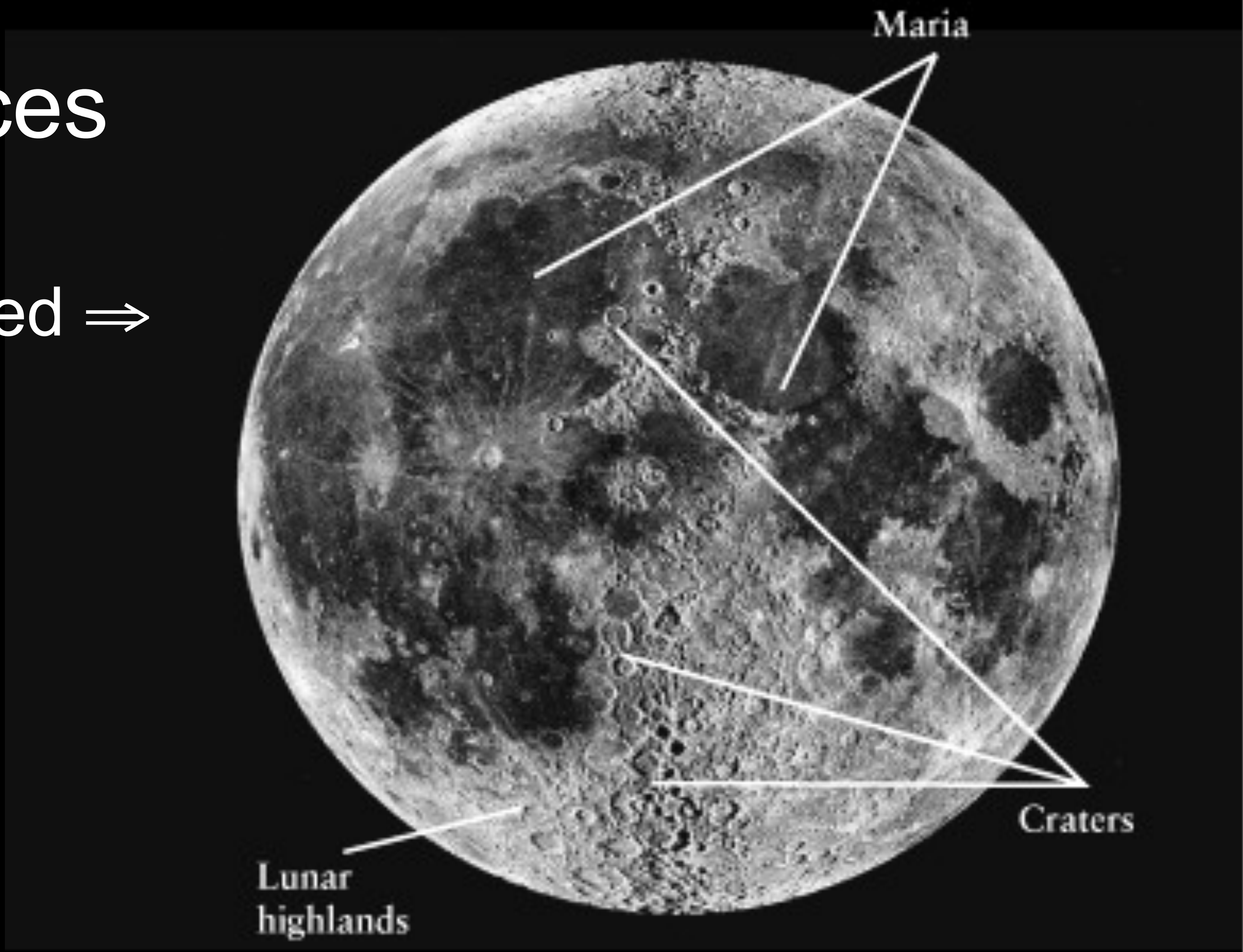


Surface Features on the Moon

Two types of Surfaces

– Highlands
  - More heavily cratered ⇒ surface is older.

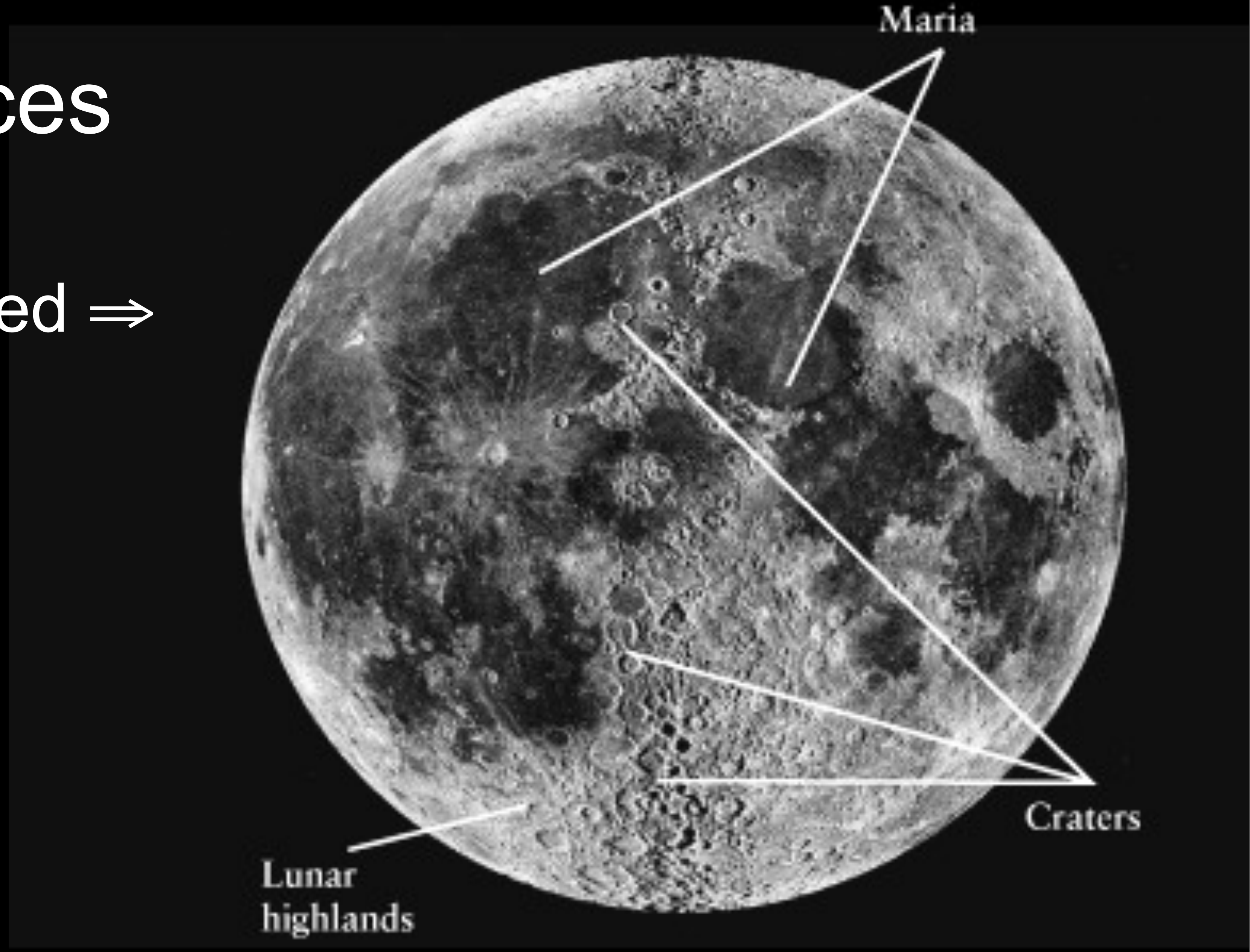
– Maria ("Seas")
  - Less cratered ⇒



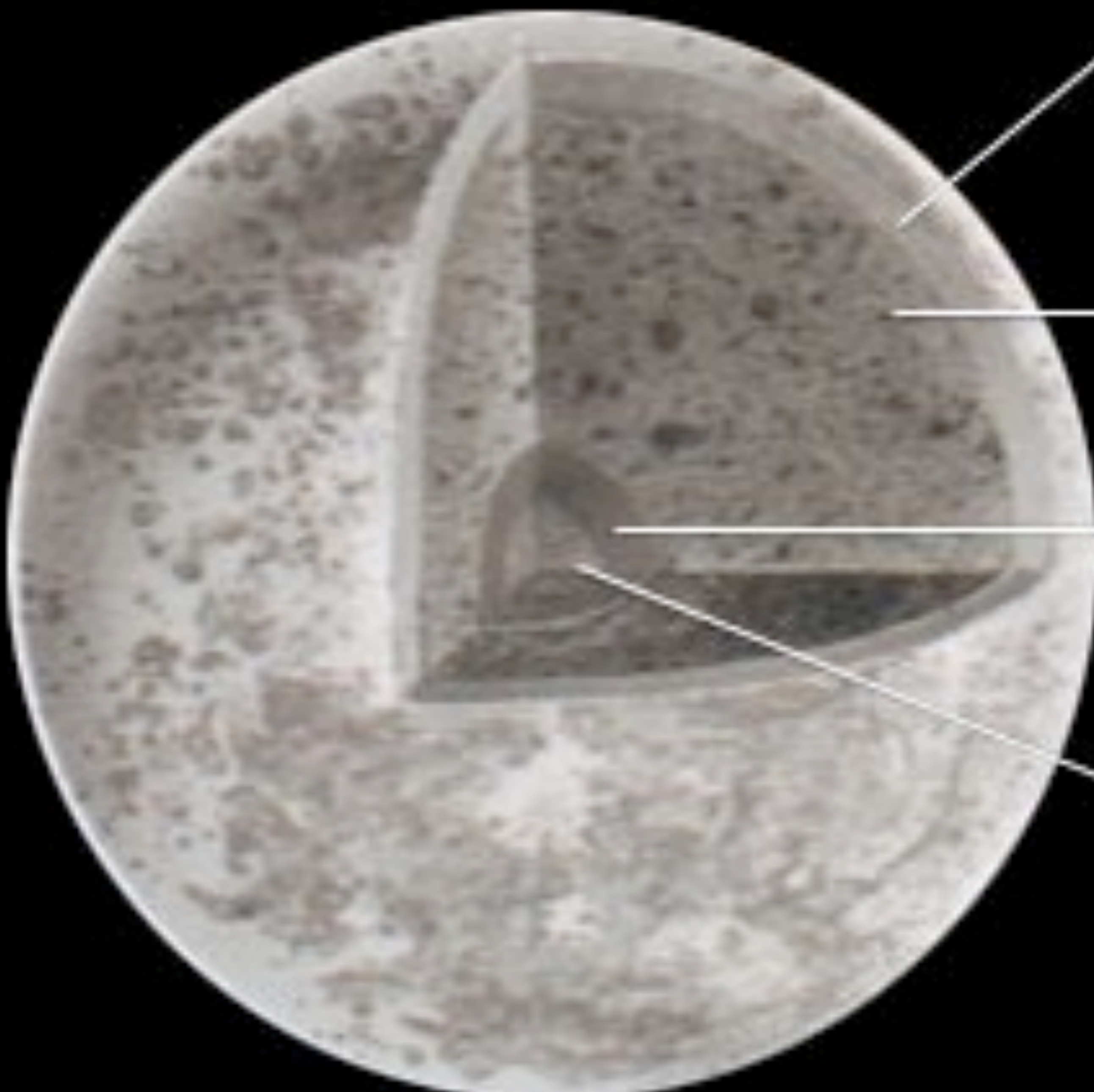
Surface Features on the Moon

Two types of Surfaces

- Highlands
  - More heavily cratered ⇒ surface is older.
- Maria ("Seas")
  - Less cratered ⇒
  - surface is younger.



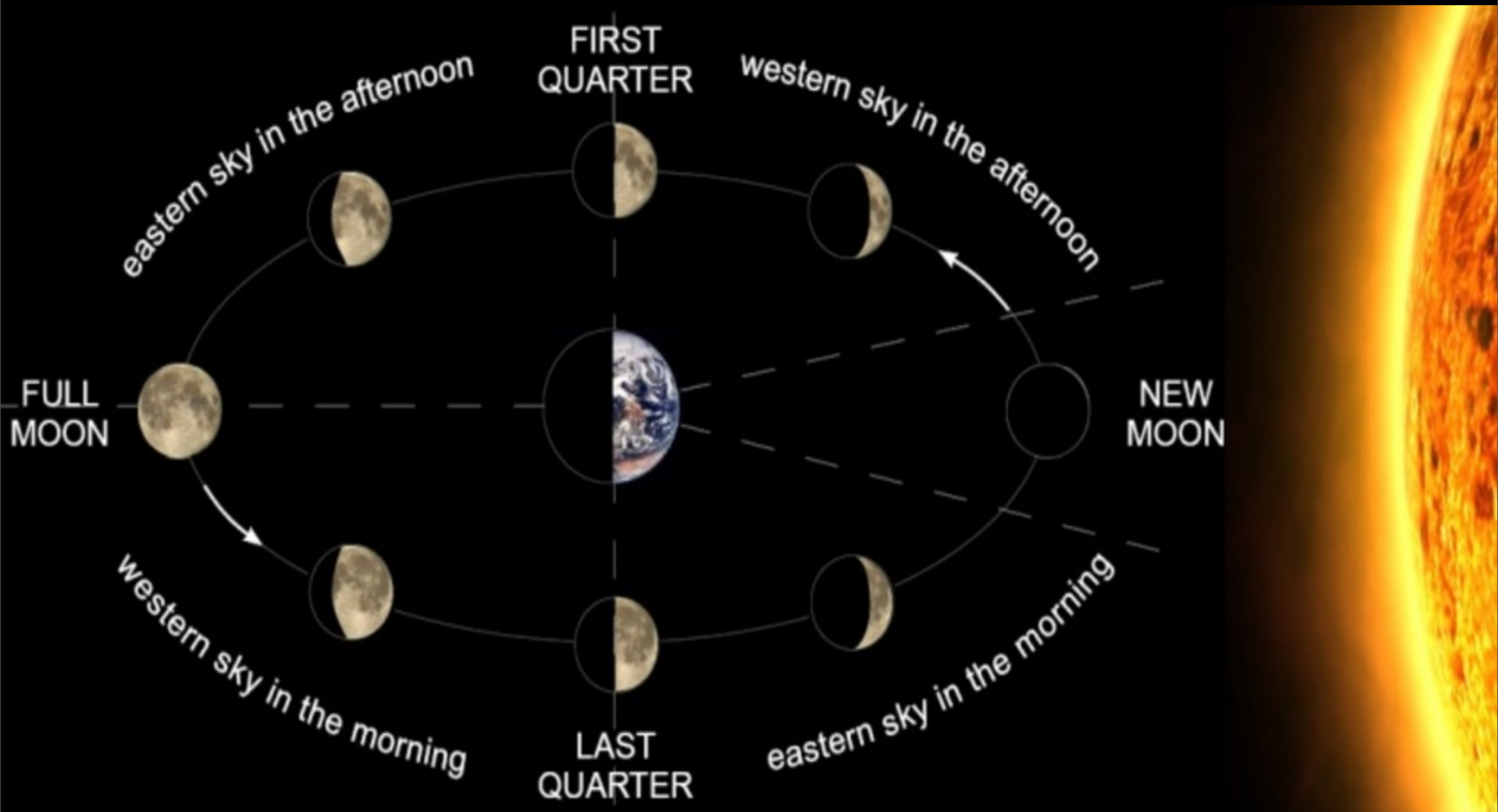
Moon's Internal Structure



Phases "faces" of the Moon

The amount of the Moon seen from Earth

- Half the moon’s surface is always reflecting light
- From Earth we see different amounts of the Moon’s lit surface depending on Moon's location



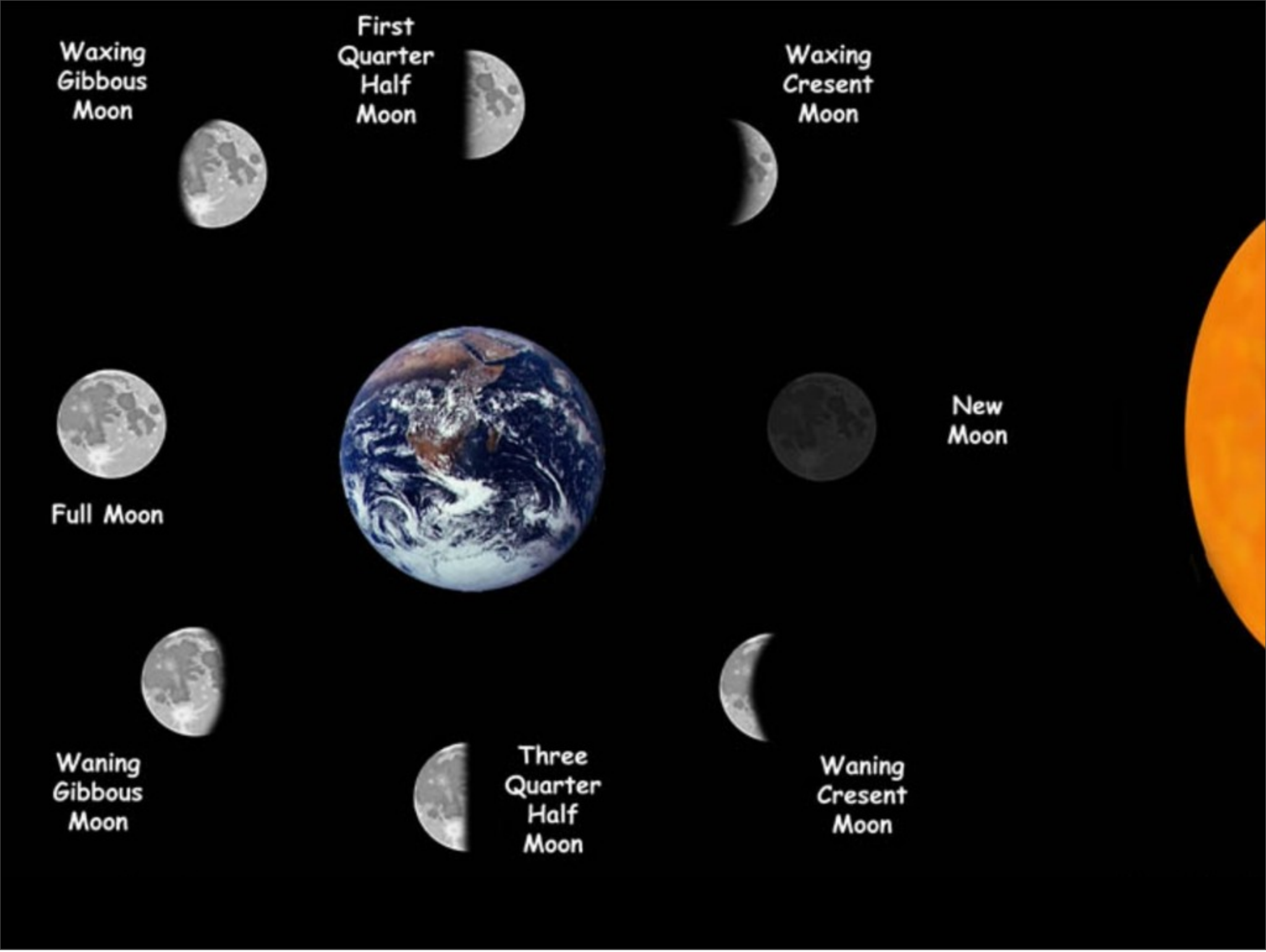
What is Waxing?

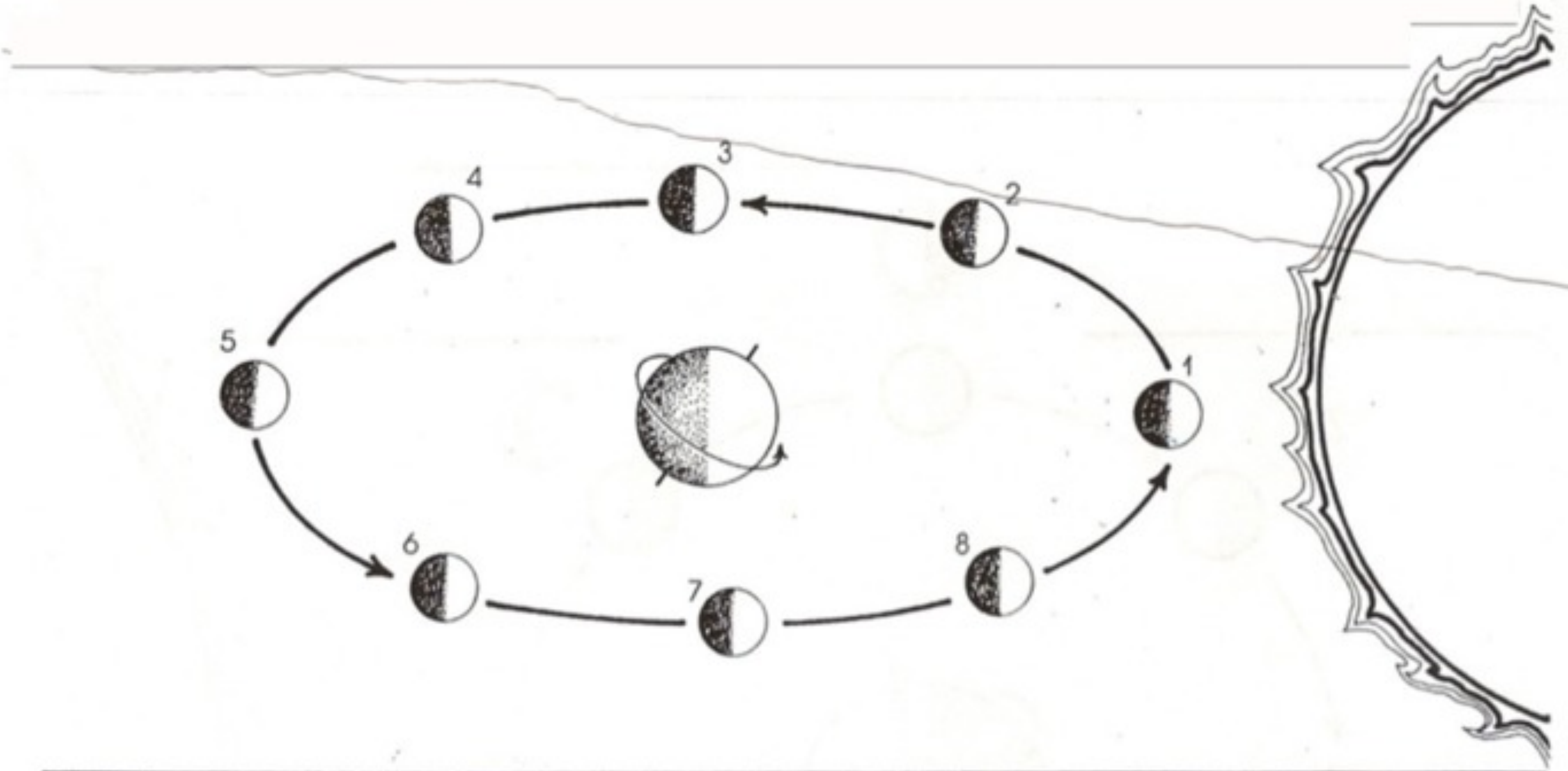
More of the moon's surface (right side) can be seen

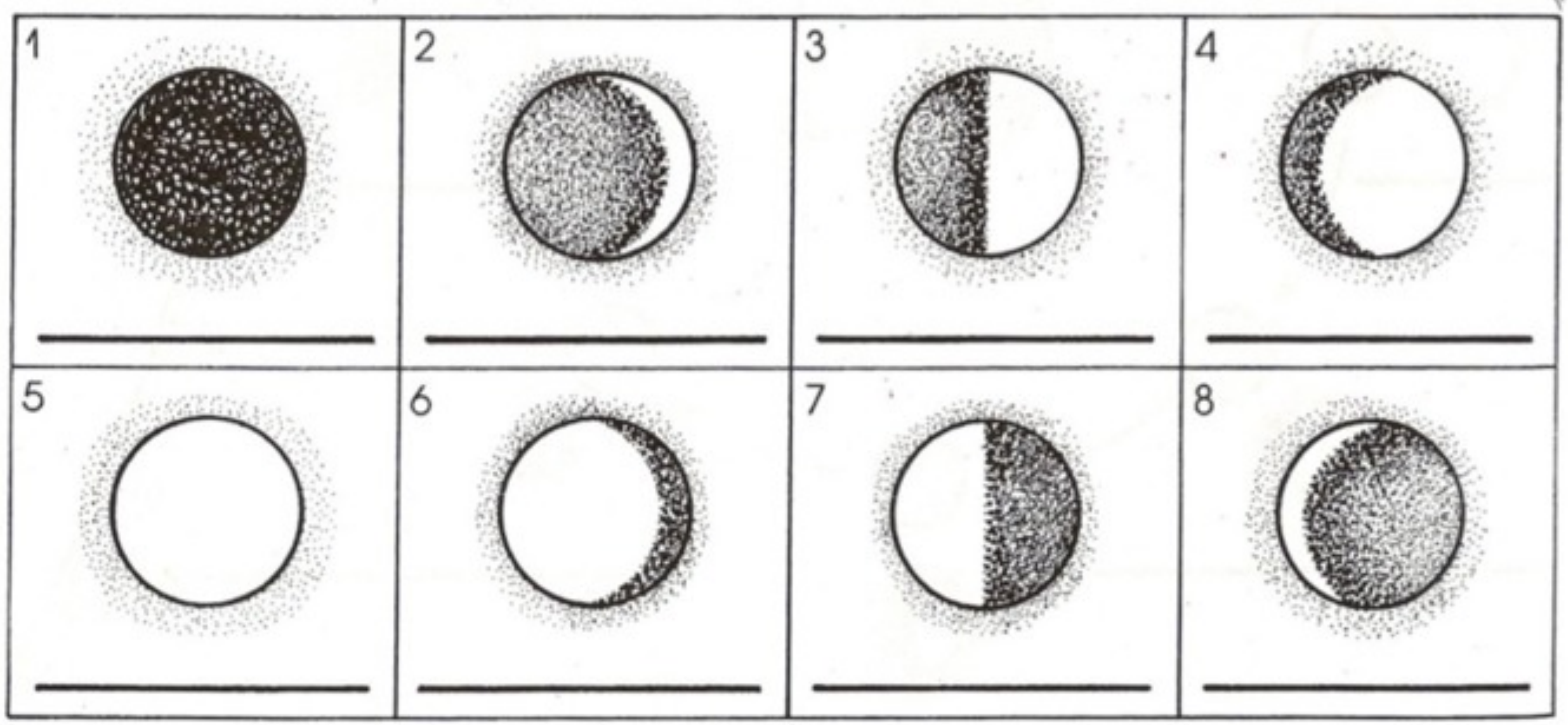
What is

Less of the moon's surface (left side) can

Gibbous – more than half


Waxing Gibbous Moon
First Quarter Half Moon
Waxing Cresent Moon
Full Moon
New Moon
Waning Gibbous Moon
Three Quarter Half Moon
Waning Cresent Moon





Word Bank

New Moon	Waxing Crescent	First Quarter
Waxing Gibbous	Full Moon	Waning Gibbous
Last Quarter	Waning Crescent	

Cycle of Lunar Phases

Takes 29.53 days

(*when moon gets back to its original position in 27.3 days, the earth has moved 1°*/day or about 27°.

The moon moving at 13° per day takes about 2 days to catch up with Earth

November 2012

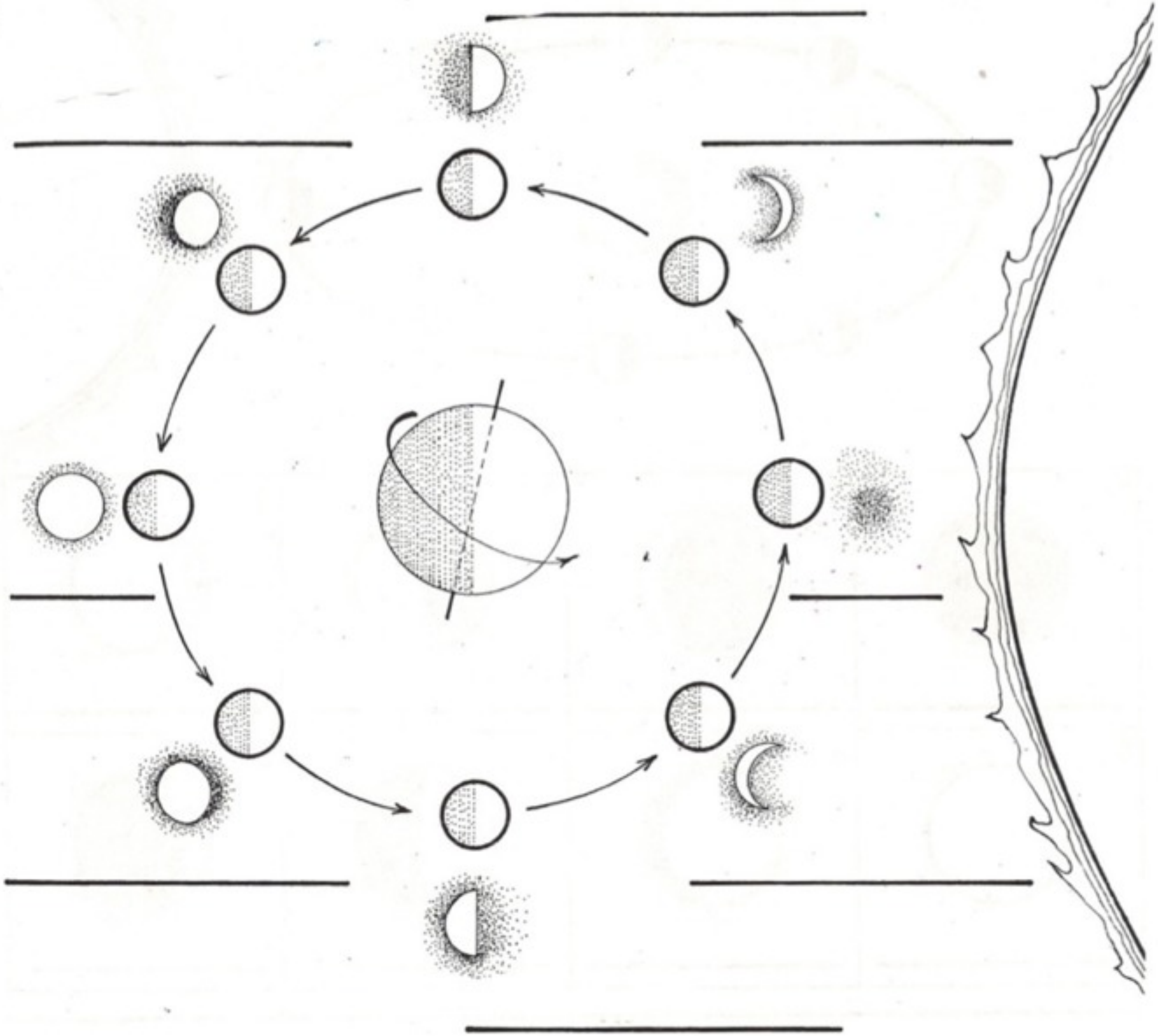
Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
				1	2	3
4	5	6	7 LQ	8	9	10
11	12	13 NM	14	15	16	17
18	19	20 FQ	21	22	23	24
25	26	27	28 FM	29	30	

Moon Names: Month by Month

Over the years, people have assigned named to the full moons of each month..

January	Wolf Moon
February	Snow Moon
March	Storm Moon
April	Pink Moon
May	Flower Moon
June	Strawberry Moon
July	Buck Moon
August	Sturgeon Moon
September	Harvest Moon
October	Hunter's Moon
November	Beaver Moon
December	Cold Moon

Blue Moon: when you have a 4th full moon in a quarter.



Word Bank

New Moon	Waxing Crescent	First Quarter
Waxing Gibbous	Full Moon	Waning Gibbous
Last Quarter	Waning Crescent	

What phase of the moon is this?

New Crescent

New Gibbous

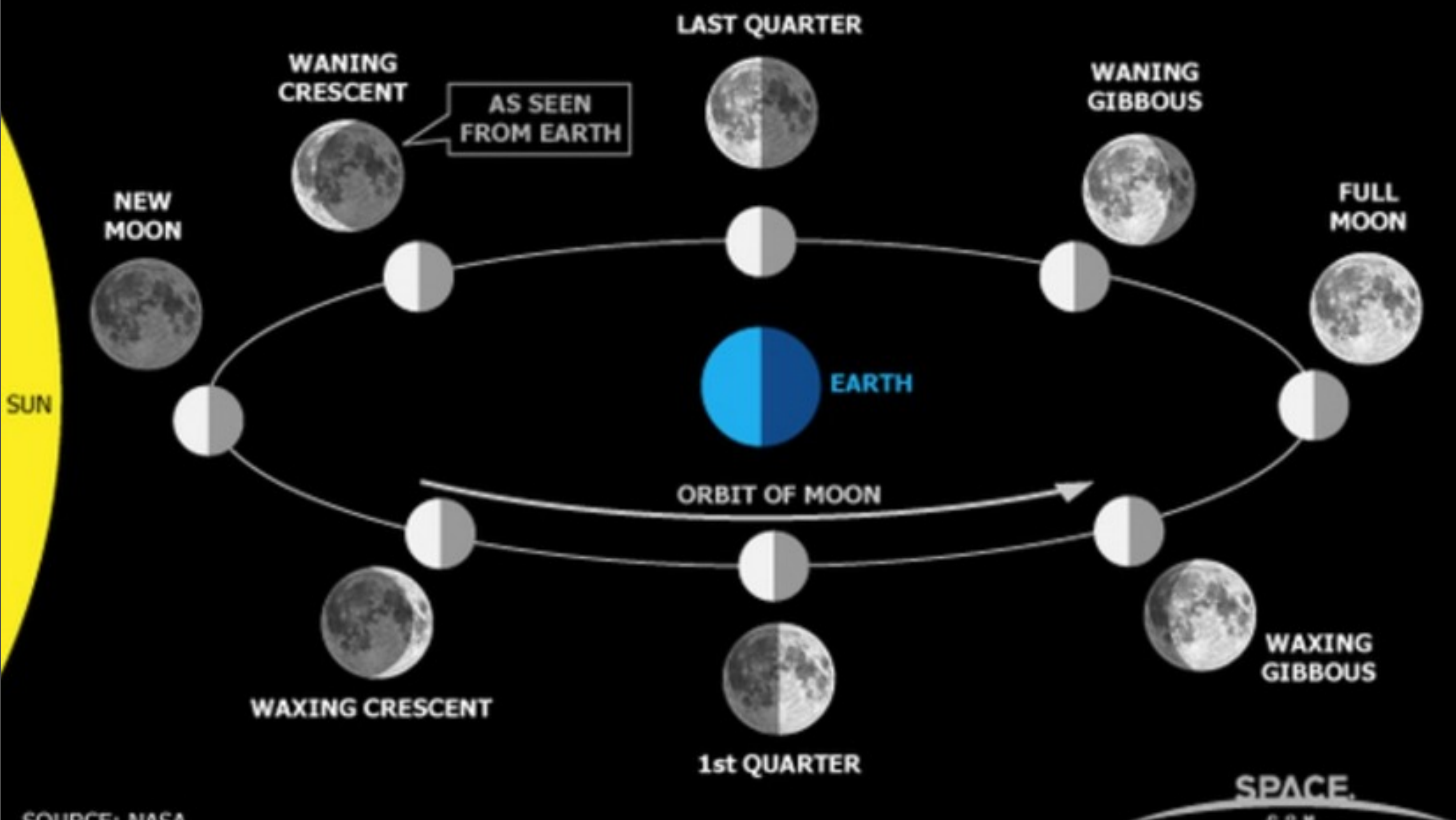
3rd Quarter

The moon's endless dance

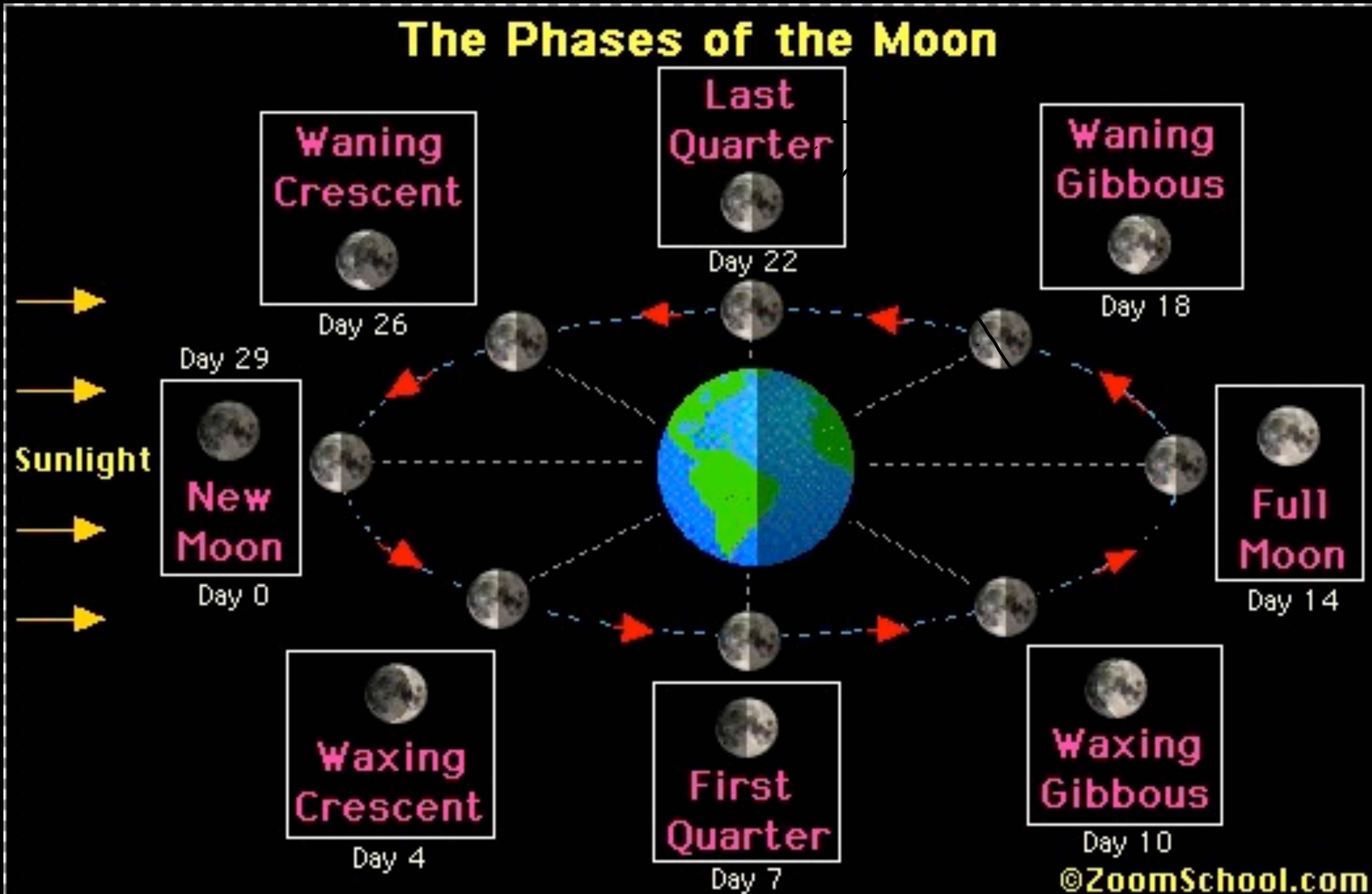
As the Earth and moon orbit the sun together, the pattern of day and night on the lunar surface constantly changes. We refer to the percentage of illumination on the visible face of the moon as the moon's "phase." There are 8 major named phases that have been known throughout human history.

MOON'S "NEAR" SIDE, VISIBLE FROM EARTH

MOON'S "FAR" SIDE, HIDDEN FROM EARTH



SOURCE: NASA


The Phases of the Moon
Last Quarter
Day 22
Waning Crescent
Day 26
Waning Gibbous
Day 18
Day 29
New Moon
Day 0
Sunlight
Full Moon
Day 14
Waxing Crescent
Day 4
First Quarter
Day 7
Waxing Gibbous
Day 10
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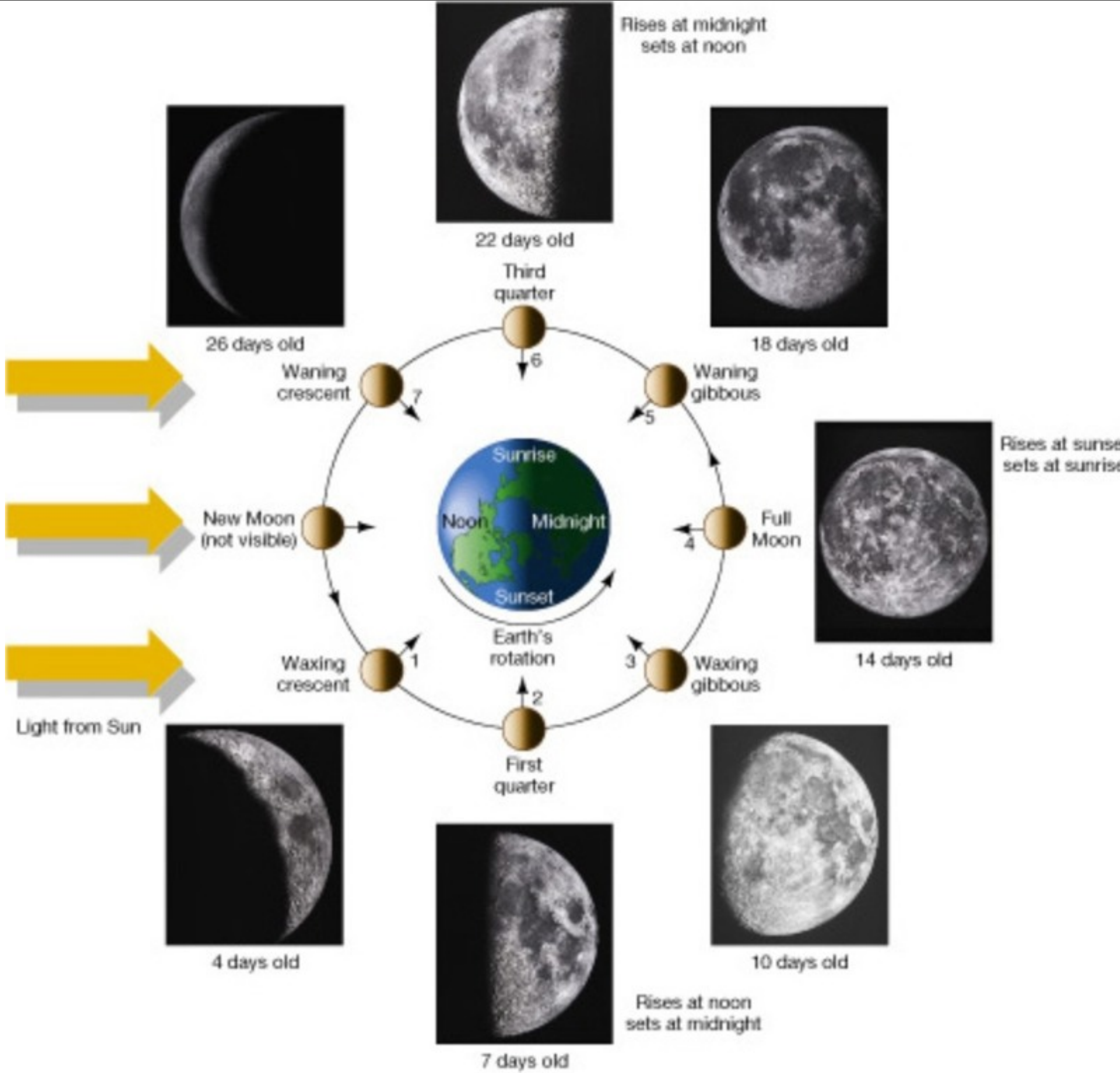
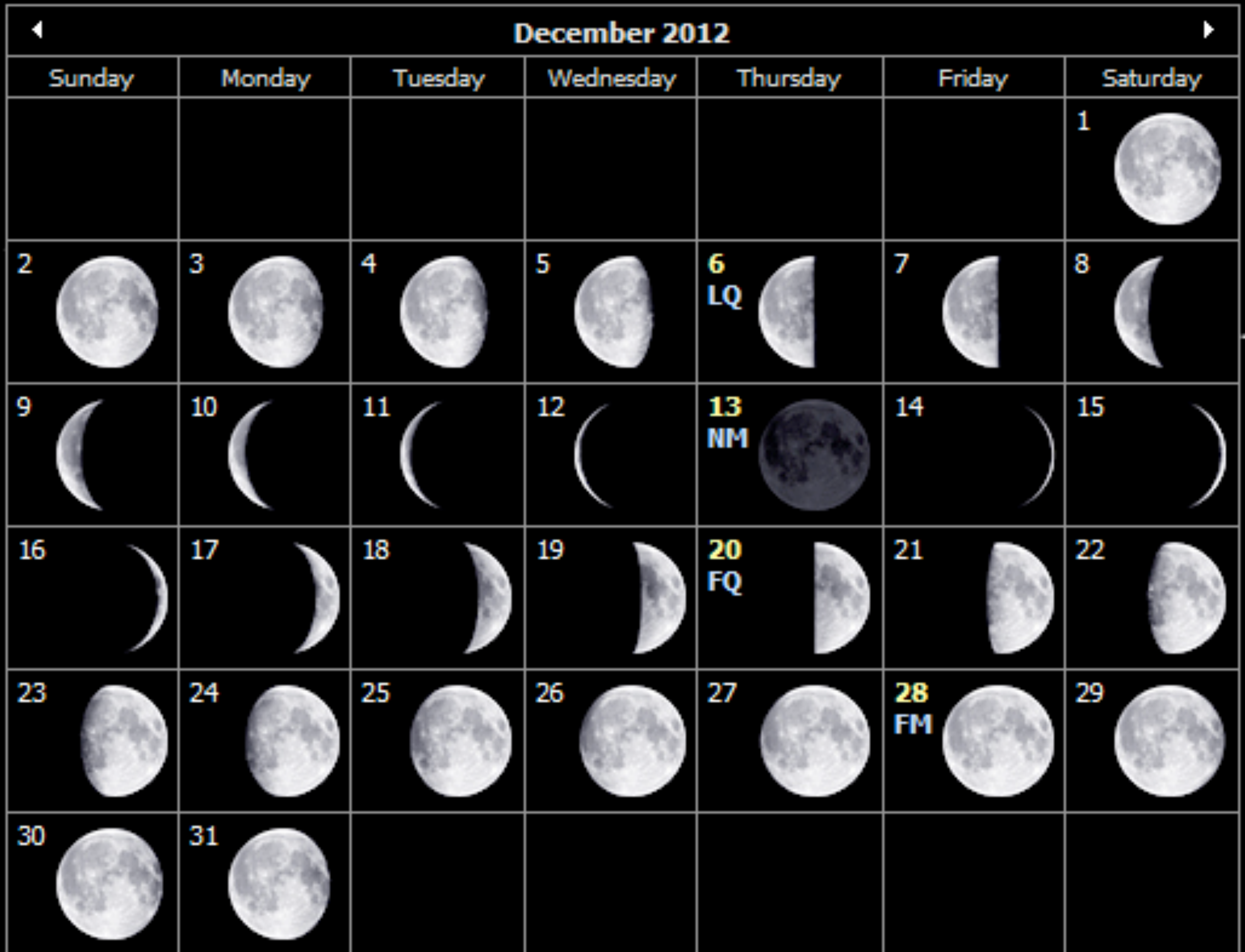

Rises at midnight
sets at noon
22 days old
Third
quarter
26 days old
18 days old
Waning
crescent
Waning
gibbous
6
7
5
Rises at sunset
sets at sunrise
Sunrise
New Moon
(not visible)
Noon
Midnight
Full
Moon
4
Sunset
Earth's
rotation
14 days old
Waxing
crescent
1
3
Waxing
gibbous
2
Light from Sun
First
quarter
4 days old
10 days old
Rises at noon
sets at midnight
7 days old


December 2012
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday
1
2
3
4
5
6 LQ
7
8
9
10
11
12
13 NM
14
15
16
17
18
19
20 FQ
21
22
23
24
25
26
27
28 FM
29
30
31

Review - The Moon's Surface

No atmosphere

No liquid water

Extreme temperatures

- Daytime = 130°C (265°F)
- Nighttime = -190°C (-310°F)

1/6 Earth's gravity

Basic Properties of the Moon

1) How big is it?

A) Diameter = 1/4 the diameter of the Earth.

B) Mass = 1/100

2) How old it it?

4.5 billion years

3) What's it doing?

- **Rotation**

4) How far is it?

About 384,000 km (240,000 miles) from Earth

beam of light traveling from Earth to Moon takes 1.26 seconds

Earth ——— **Moon**

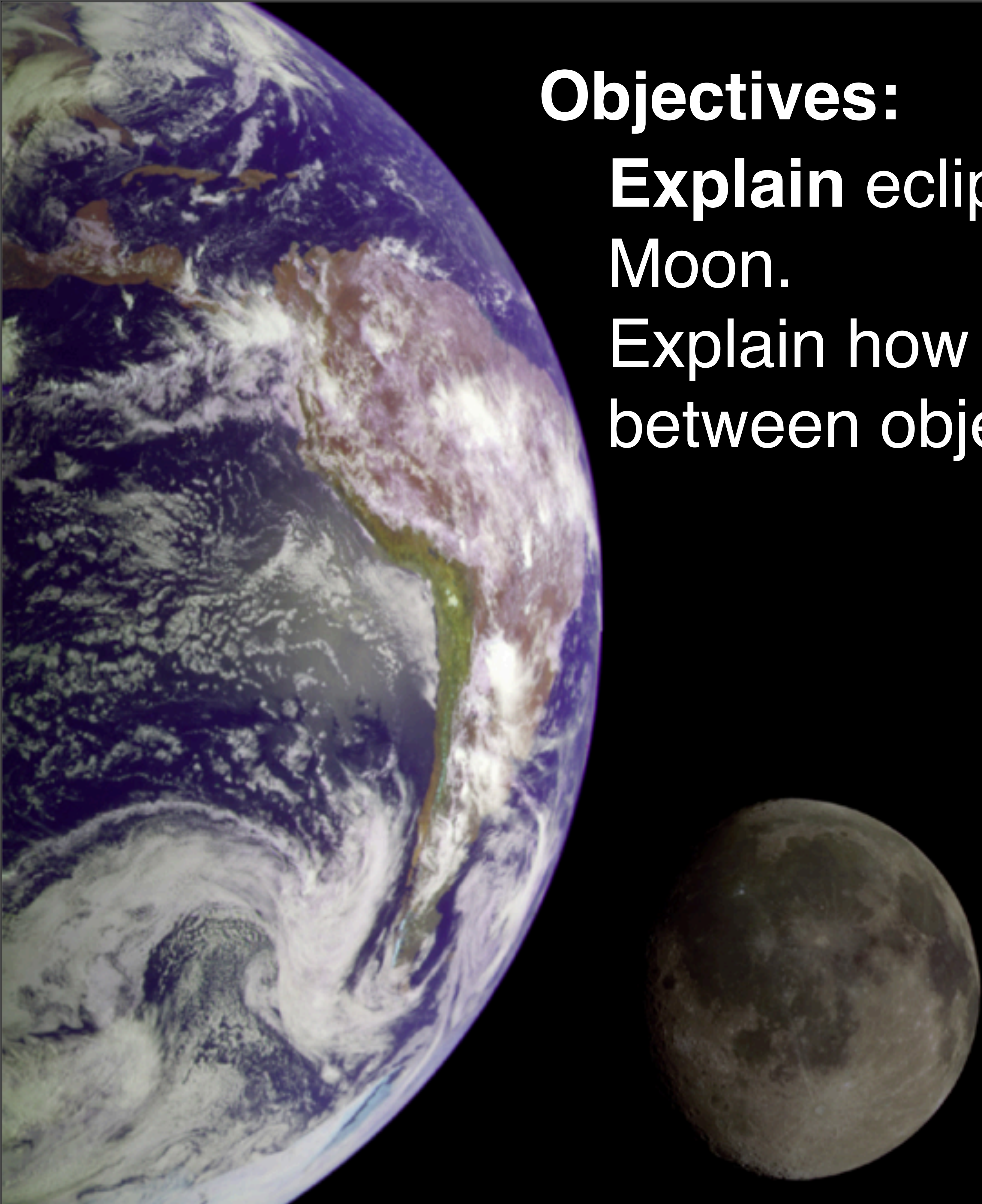
12,756.3 km diameter
23 degree axis tilt (seasons!)
Surface temps –73º to 48ºC (-100º to 120ºF)
Thick atmosphere, mild greenhouse effect
Liquid water – lots! - at surface

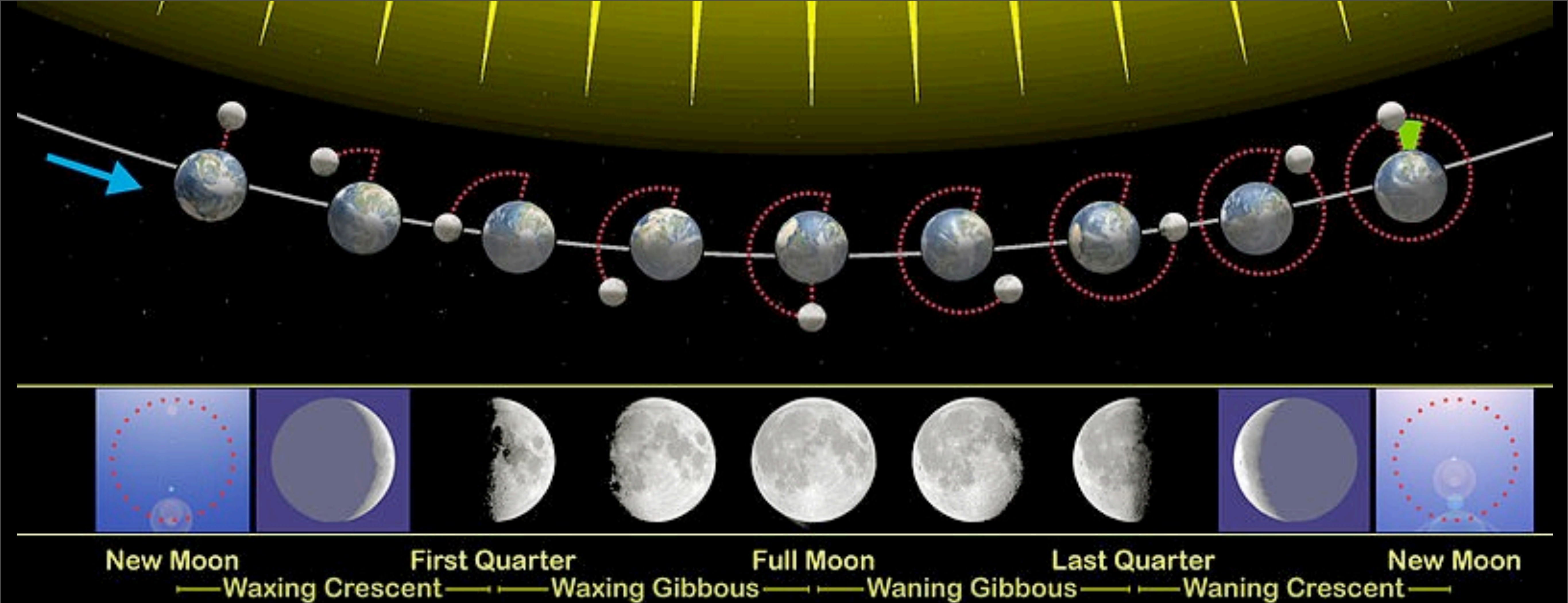
3,476 km diameter
7 degree tilt (~no seasons)
Surface temps - 107º to –153ºC (224ºF to –243ºF)
No atmosphere
No liquid water … Ice at poles in shadows?
Solid & Rock
Iron Core

Objectives:

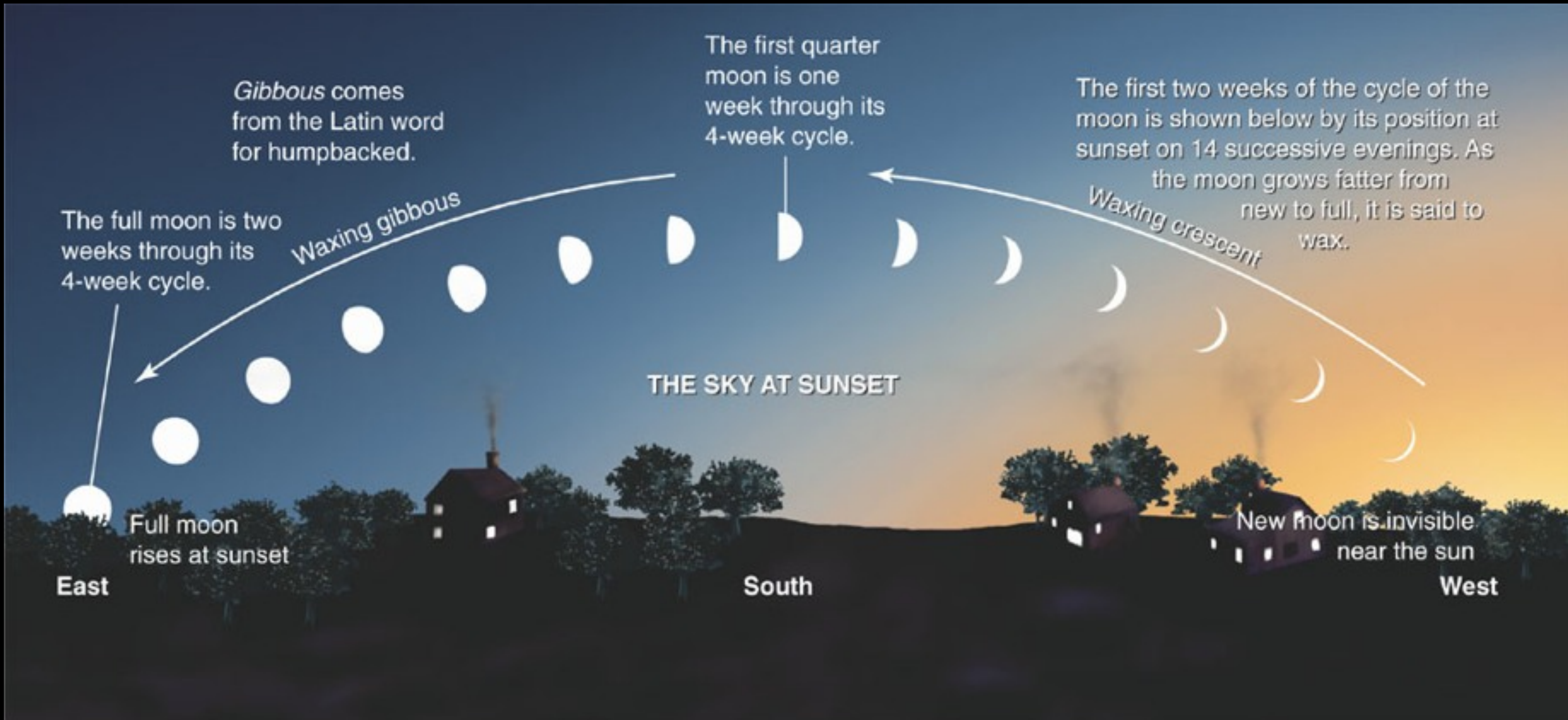
Explain eclipses of the Sun and Moon.

Explain how gravitational force between objects causes tides




New Moon
First Quarter
Full Moon
Last Quarter
New Moon
Waxing Crescent
Waxing Gibbous
Waning Gibbous
Waning Crescent

Moon's Orbit



Perigee - Closest point in the Moon's orbit to Earth

The farthest point is called **apogee**

“SUPER MOON” ON SATURDAY

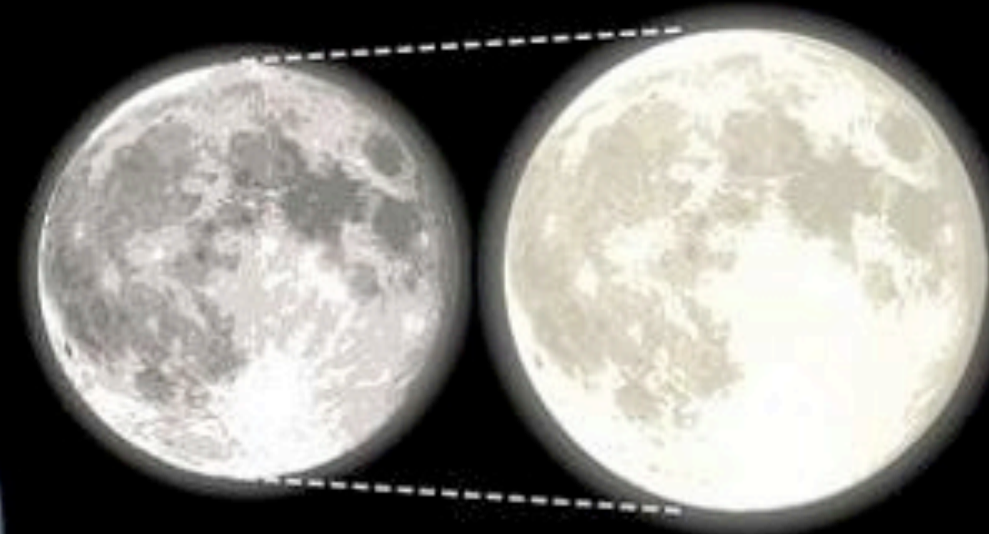
A rare full moon will be at its closest distance to Earth in two decades on Saturday

(Earth and moon’s size to orbit distance, not to scale)

Saturday’s super moon occurs at around 19:10 GMT

“SUPER MOON”

Super moons are basically the occurence of a full moon when it is at its lunar perigee – the closest distance in its orbit to Earth



Can appear 14% wider and 30% brighter than at apogee

CLOSEST PERIGEE FULL MOONS

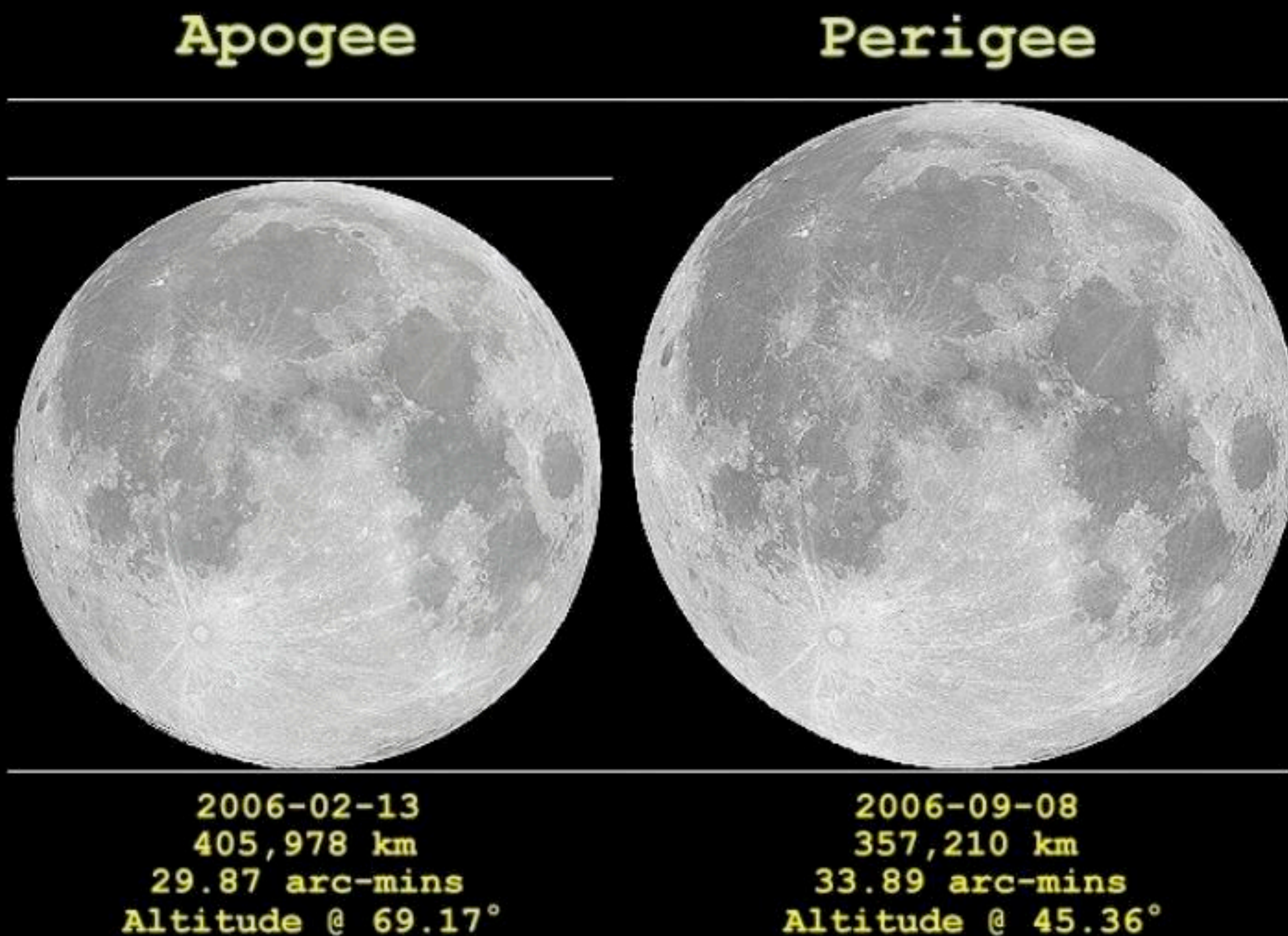
1992, Jan, 20	**356,548 km**
2001, Feb. 07	356,852 km
2010, Jan. 30	356,592 km
2011, Mar. 19	**356,577 km**
2016, Nov. 14	356,511 km
2034, Nov. 25	356,447 km

Source: www.fourmilab.ch

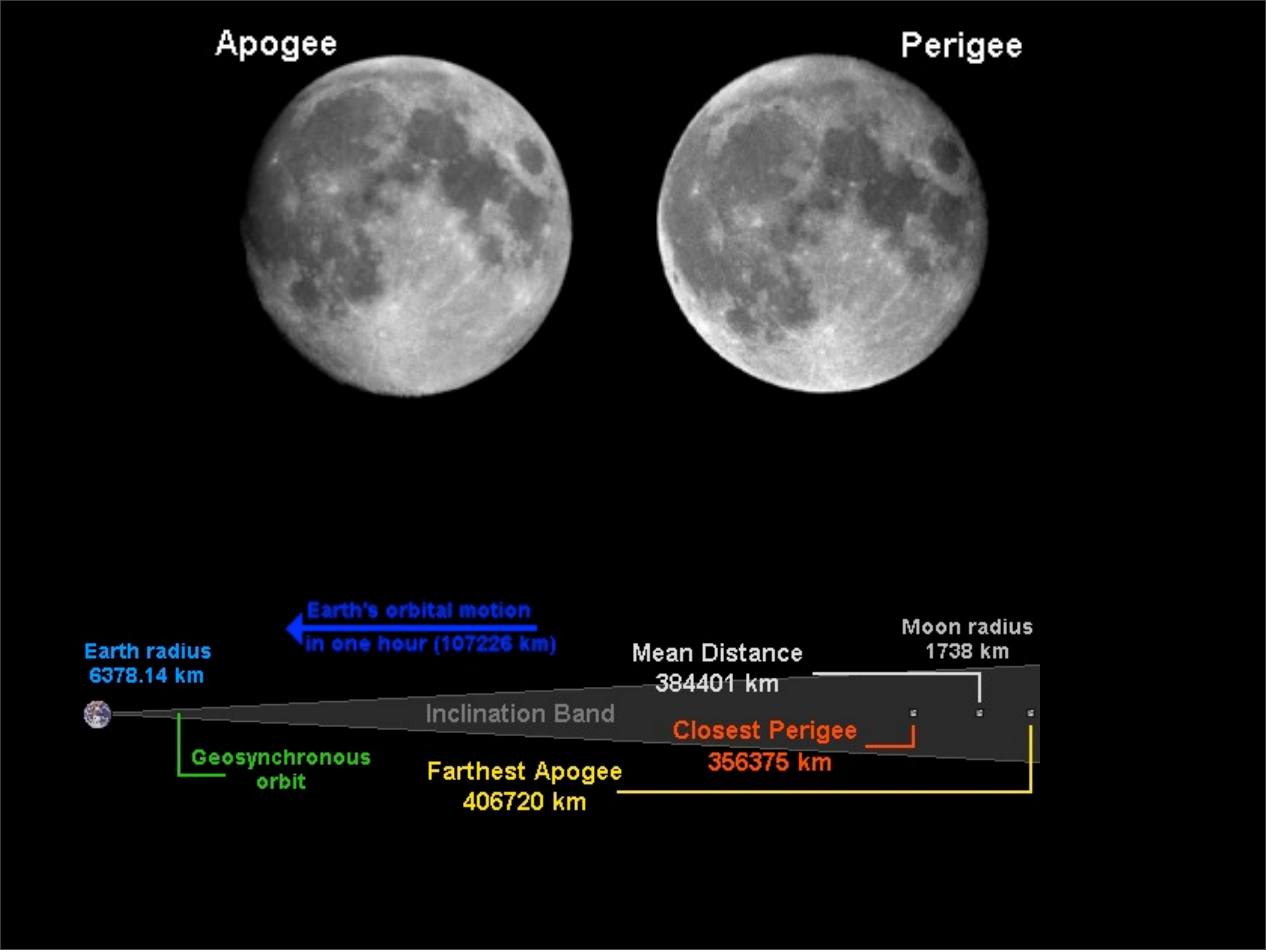
REUTERS


Super Moon
100% full
©Reuel Norman A. Marigza, Jr.
6 May 2012, 22:05 PST. Quezon City, Philippines
Skywatcher Explorer 150PL with Nikon D3100 at prime
focus. ISO 100 Exposure 0.006s

(Far) (Close)


Apogee
Perigee
2006-02-13
405,978 km
29.87 arc-mins
Altitude @ 69.17°
2006-09-08
357,210 km
33.89 arc-mins
Altitude @ 45.36°


7:35pm
25 August 2010
Moon 15,68 days old
406.127,40km
Altitude 1°
Arcmin 29
3:40am
19 March 2011
Moon 13,96 days old
354.262,60km
Altitude 26°
Arcmin 34



Apogee
Perigee
Earth's orbital motion
in one hour (107226 km)
Earth radius
6378.14 km
Moon radius
1738 km
Mean Distance
384401 km
Inclination Band
Closest Perigee
356375 km
Geosynchronous
orbit
Farthest Apogee
406720 km

We always see the same side of the moon!

Precisely speaking 59% of the surface during the whole period of the moon revolution. (Reason: **libration**)

libration - oscillating motion of orbiting bodies relative to each other

Near Side

Far Side

What's the difference between solar and lunar eclipses?

Solar

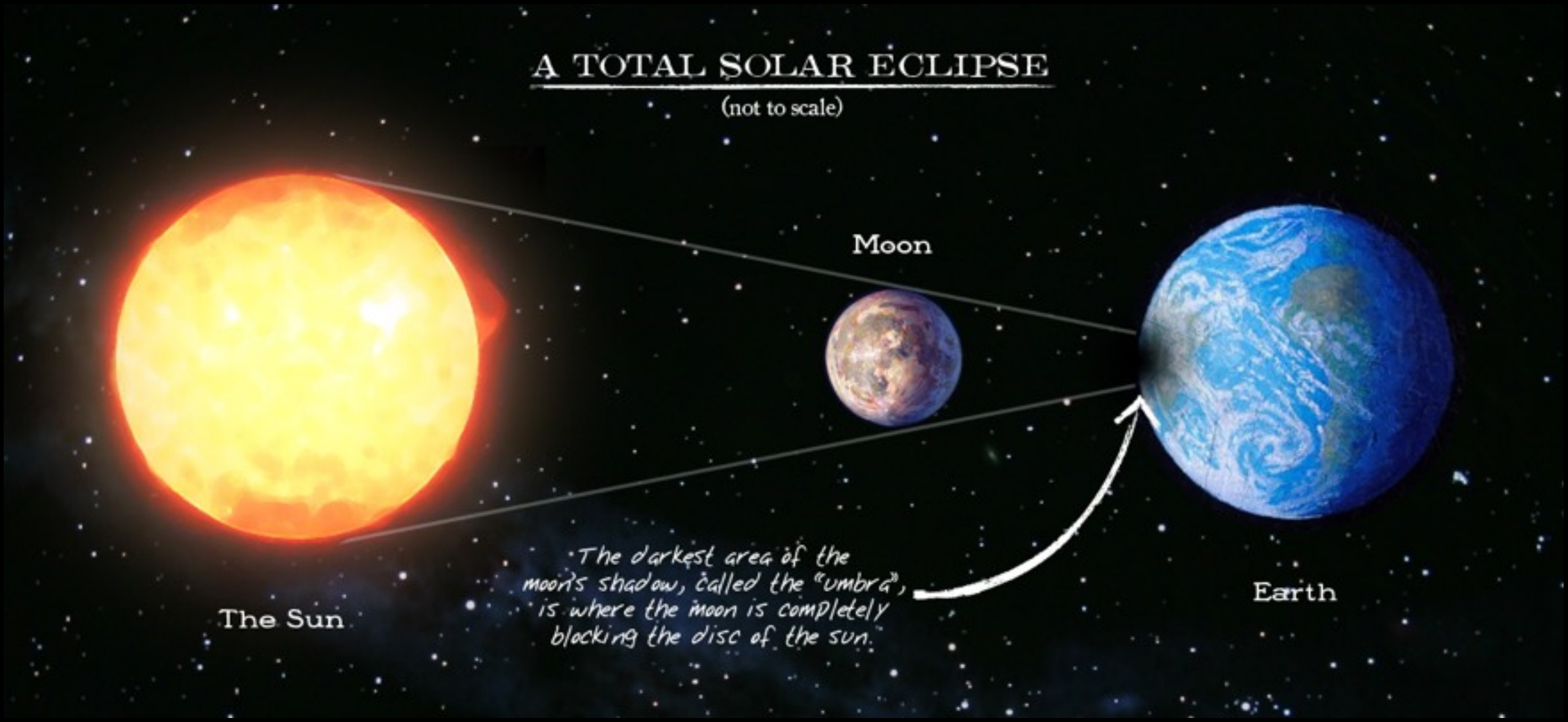
Earth goes into moon's shadow

Lunar

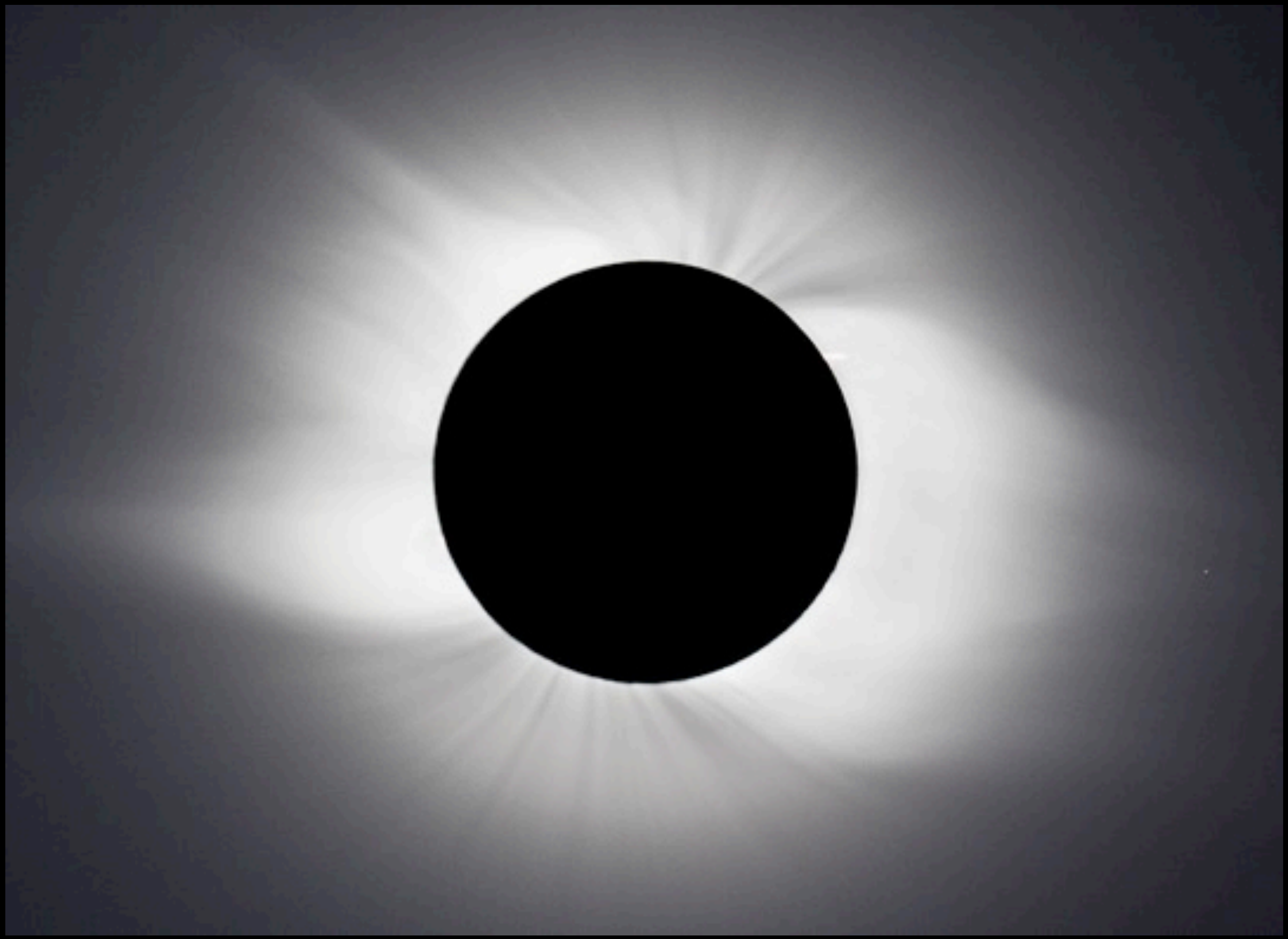
moon goes into Earth's shadow

Solar Eclipses

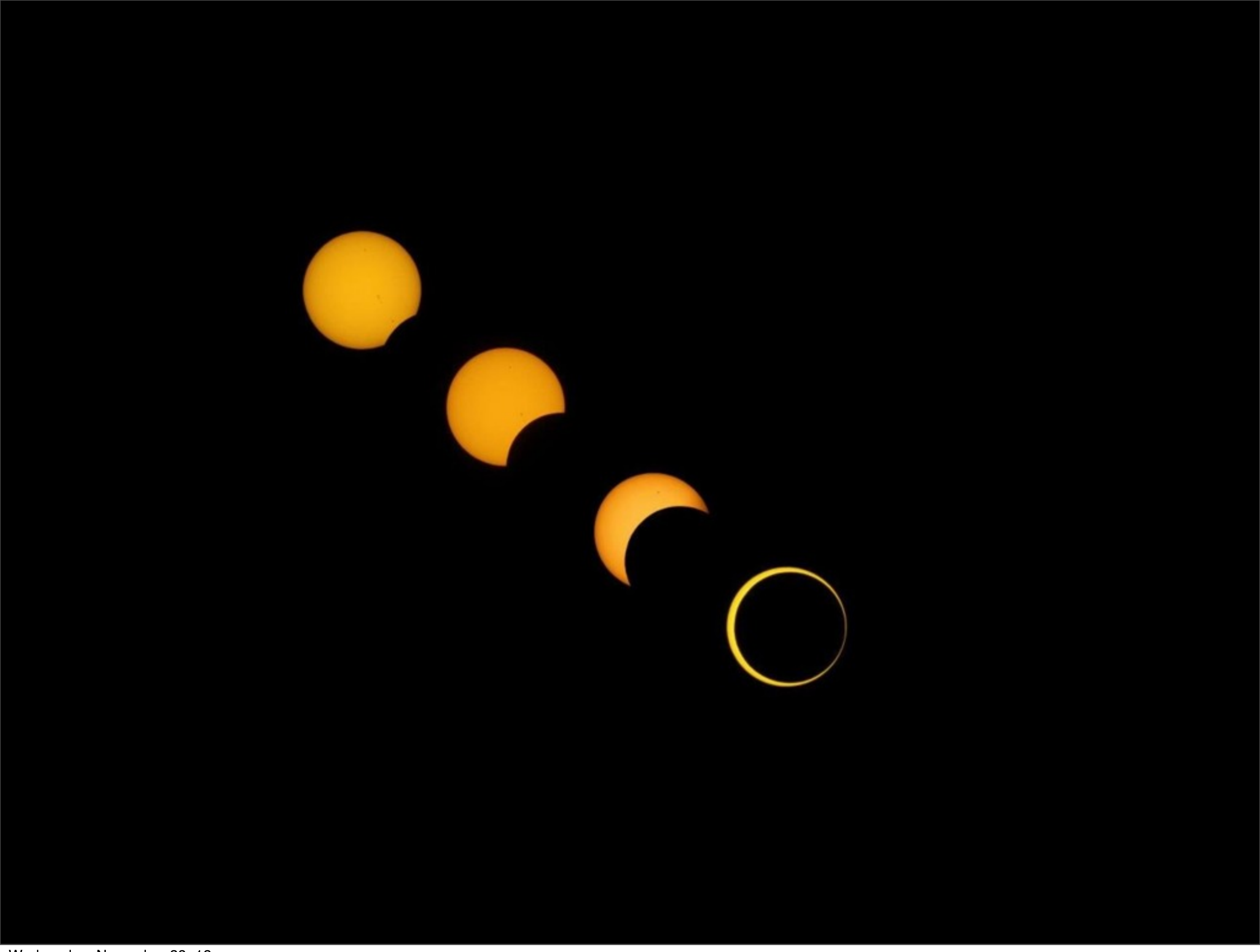
- occurs when the Moon passes directly between the Sun and Earth and blocks the Sun from view.



Solar Eclipses



Moon moves between Earth and Sun
Moon casts a shadow on part of the Earth
Total eclipses rare – only once every 360 years from one location!




2nd Contact: 19:34:13 MDT
(01:34:13 UT)
Central Phase: 19:36:25 MDT
(01:36:25 UT)
3rd Contact: 19:38:37 MDT
(01:38:37 UT)
Annular Solar Eclipse - 20/21 May 2012, Elida, New Mexico, USA
© Kosmas Gazeas

Solar Eclipses: 2006 - 2012

Calendar Date *(Link to Global Map)*	TD of Greatest Eclipse *(Link to Animation)*	Eclipse Type *(Link to Google Map)*	Saros Series *(Link to Saros)*	Eclipse Magnitude	Central Duration *(Link to Path Table)*	Geographic Region of Eclipse Visibility *(Link to RASC Observers Handbook)*
2006 Mar 29	10:12:23	Total	139	1.052	04m07s	Africa, Europe, w Asia **[Total: c Africa, Turkey, Russia]**
2006 Sep 22	11:41:16	Annular	144	0.935	07m09s	S. America, w Africa, Antarctica **[Annular: Guyana, Suriname, F. Guiana, s Atlantic]**
2007 Mar 19	02:32:57	Partial	149	0.876	-	Asia, Alaska
2007 Sep 11	12:32:24	Partial	154	0.751	-	S. America, Antarctica
2008 Feb 07	03:56:10	Annular	121	0.965	02m12s	Antarctica, e Australia, N. Zealand **[Annular: Antarctica]**
2008 Aug 01	10:22:12	Total	126	1.039	02m27s	ne N. America, Europe, Asia **[Total: n Canada, Greenland, Siberia, Mongolia, China]**
2009 Jan 26	07:59:45	Annular	131	0.928	07m54s	s Africa, Antarctica, se Asia, Australia **[Annular: s Indian, Sumatra, Borneo]**
2009 Jul 22	02:36:25	Total	136	1.080	06m39s	e Asia, Pacific Ocean, Hawaii **[Total: India, Nepal, China, c Pacific]**
2010 Jan 15	07:07:39	Annular	141	0.919	11m08s	Africa, Asia **[Annular: c Africa, India, Malymar, China]**
2010 Jul 11	19:34:38	Total	146	1.058	05m20s	s S. America **[Total: s Pacific, Easter Is., Chile, Argentina]**
2011 Jan 04	08:51:42	Partial	151	0.858	-	Europe, Africa, c Asia
2011 Jun 01	21:17:18	Partial	118	0.601	-	e Asia, n N. America, Iceland
2011 Jul 01	08:39:30	Partial	156	0.097	-	s Indian Ocean
2011 Nov 25	06:21:24	Partial	123	0.905	-	s Africa, Antarctica, Tasmania, N.Z.
2012 May 20	23:53:54	Annular	128	0.944	05m46s	Asia, Pacific, N. America **[Annular: China, Japan, Pacific, w U.S.]**
2012 Nov 13	22:12:55	Total	133	1.050	04m02s	Australia, N.Z., s Pacific, s S. America **[Total: n Australia, s Pacific]**

Geographic abbreviations (used above): n = north, s = south, e = east, w = west, c = central


ANNULAR SOLAR ECLIPSE
Sunday, 20th May 2012
Россия
Russia
Mongolia
中国
China
대한민국
S Korea
India
Thailand
Indonesia
Papua New Guinea
Total
Partial
North Pacific Ocean
Canada
United States
México
Venezuela
Colombia
Perú
Bolivia
Indian Ocean
Australia
South Pacific Ocean
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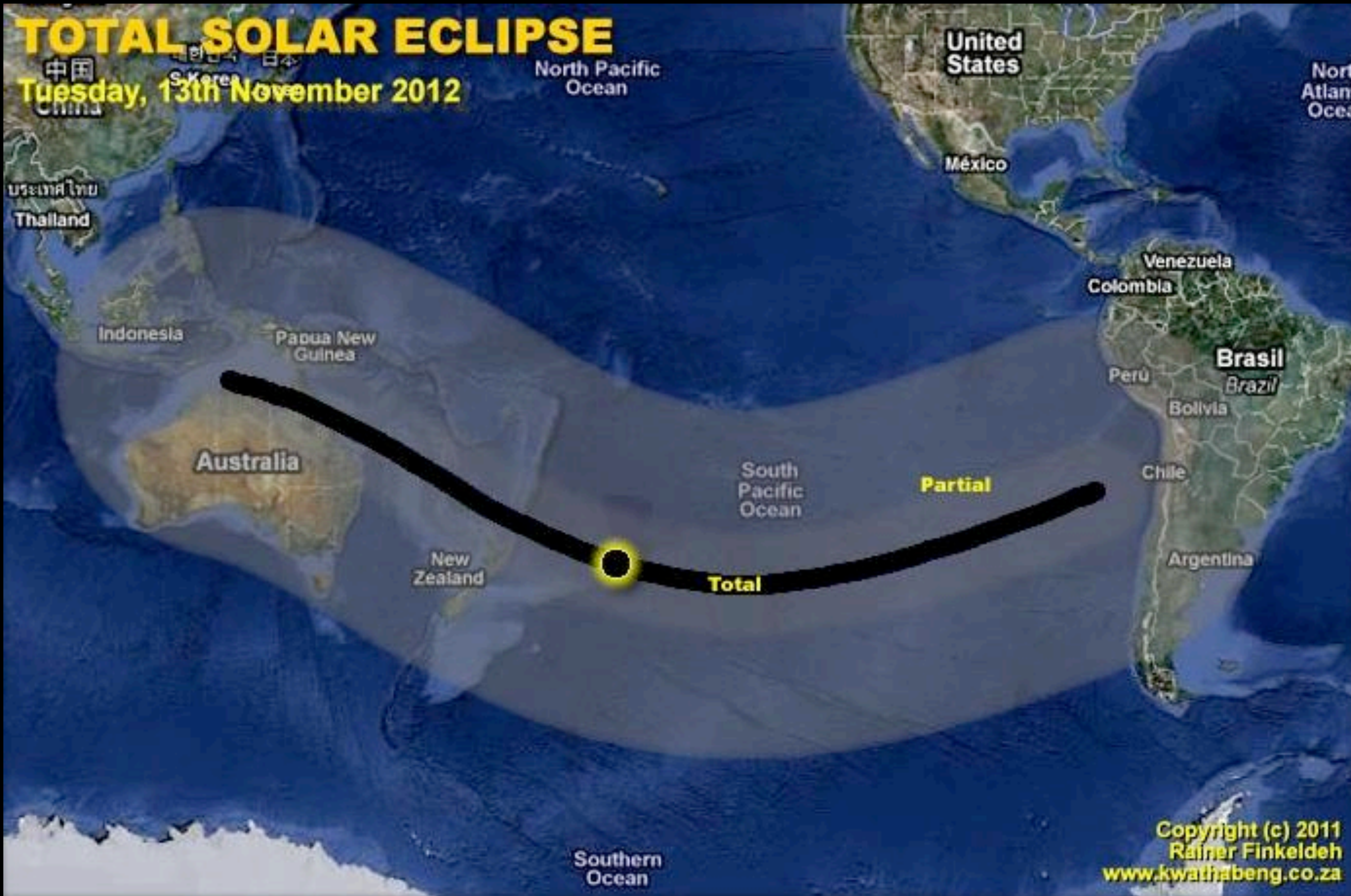
TOTAL SOLAR ECLIPSE
Tuesday, 13th November 2012
North Pacific Ocean
United States
México
Thailand
Venezuela
Colombia
Indonesia
Papua New Guinea
Brasil
Brazil
Peru
Bolivia
Australia
South Pacific Ocean
Partial
Chile
New Zealand
Total
Argentina
Southern Ocean
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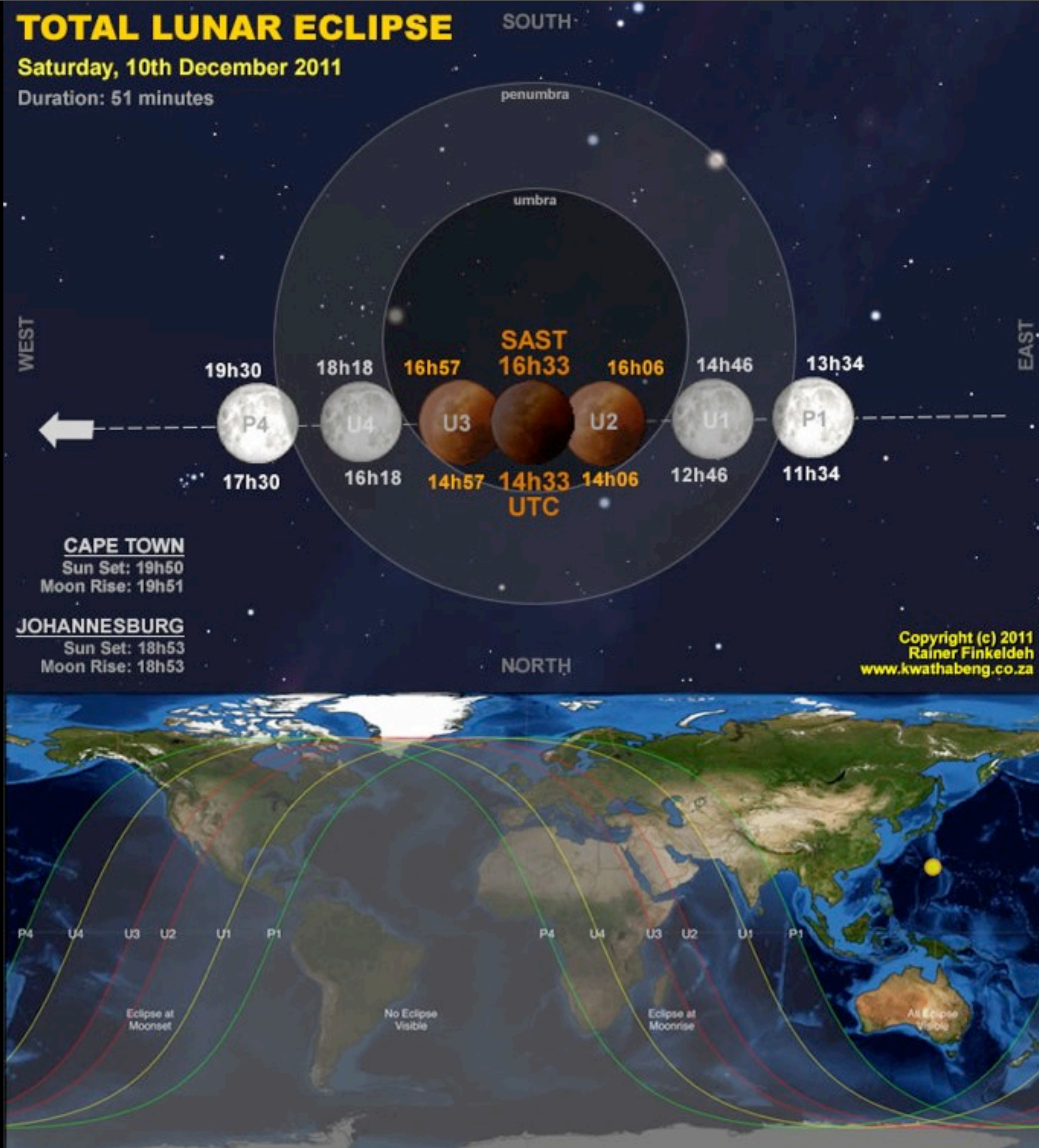
TOTAL LUNAR ECLIPSE
Saturday, 10th December 2011
Duration: 51 minutes
SOUTH
penumbra
umbra
WEST
EAST
SAST
16h33
19h30
18h18
16h57
16h06
14h46
13h34
P4
U4
U3
U2
U1
P1
17h30
16h18
14h57
14h33
14h06
12h46
11h34
UTC
CAPE TOWN
Sun Set: 19h50
Moon Rise: 19h51
JOHANNESBURG
Sun Set: 18h53
Moon Rise: 18h53
NORTH
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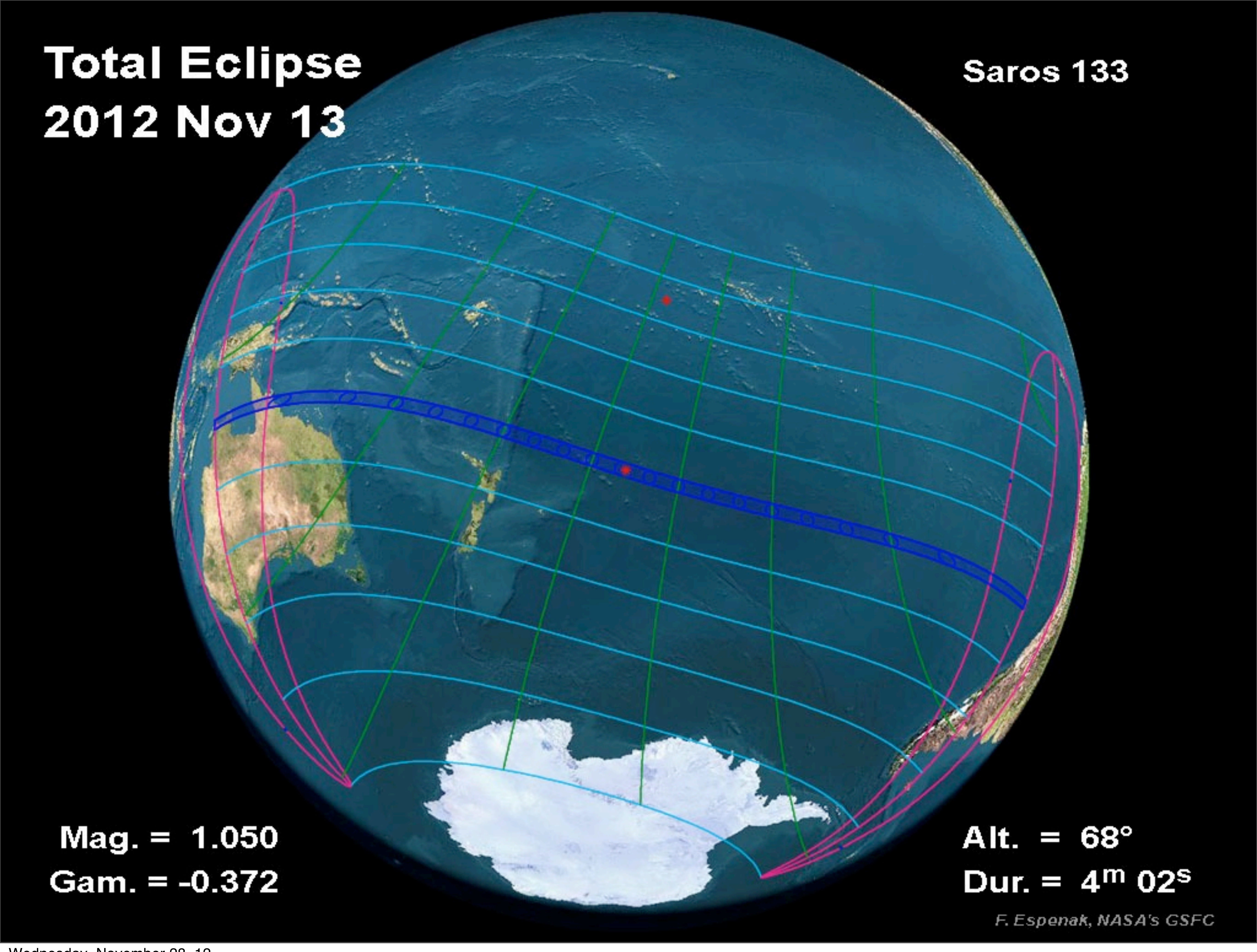
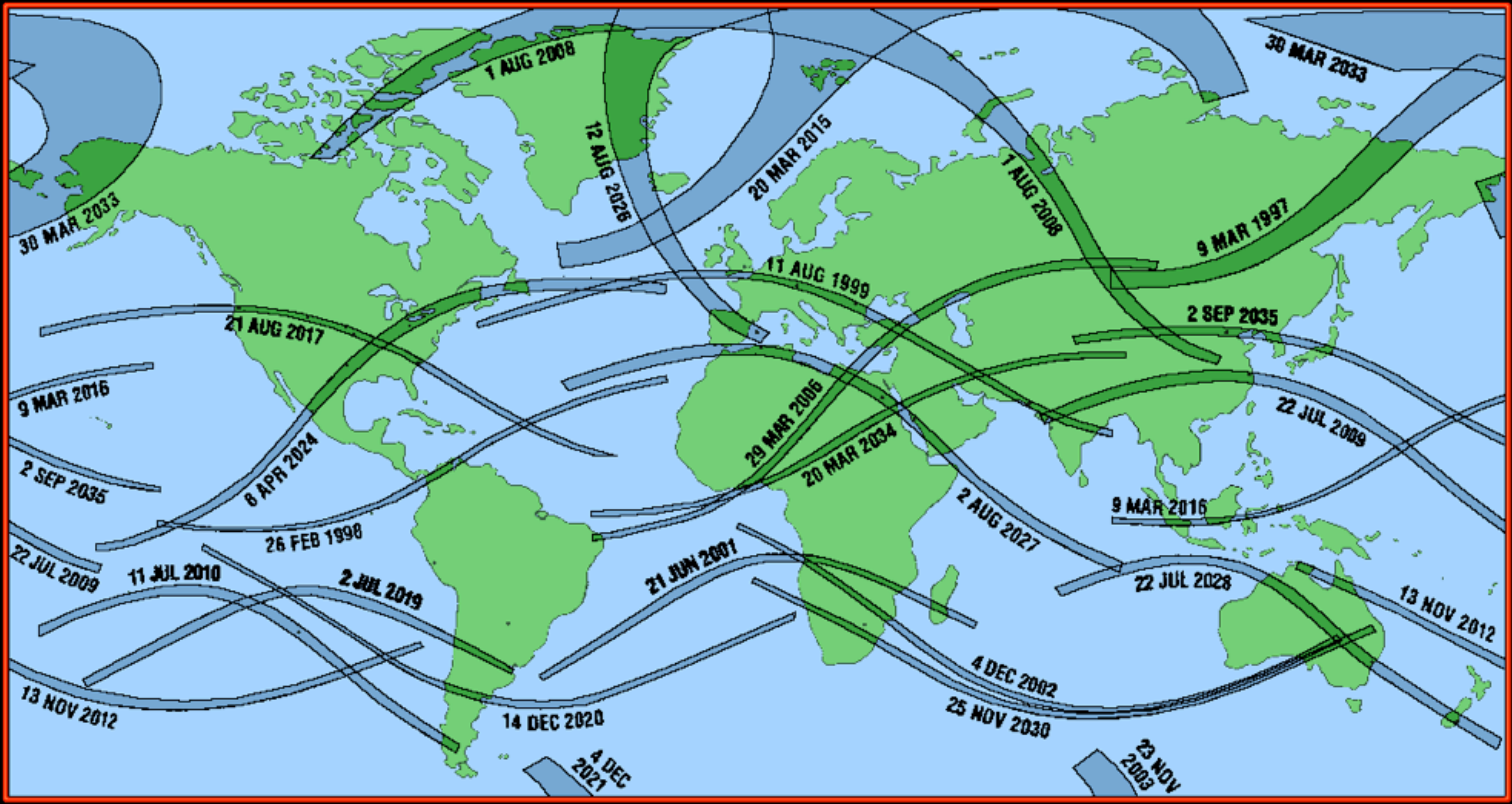
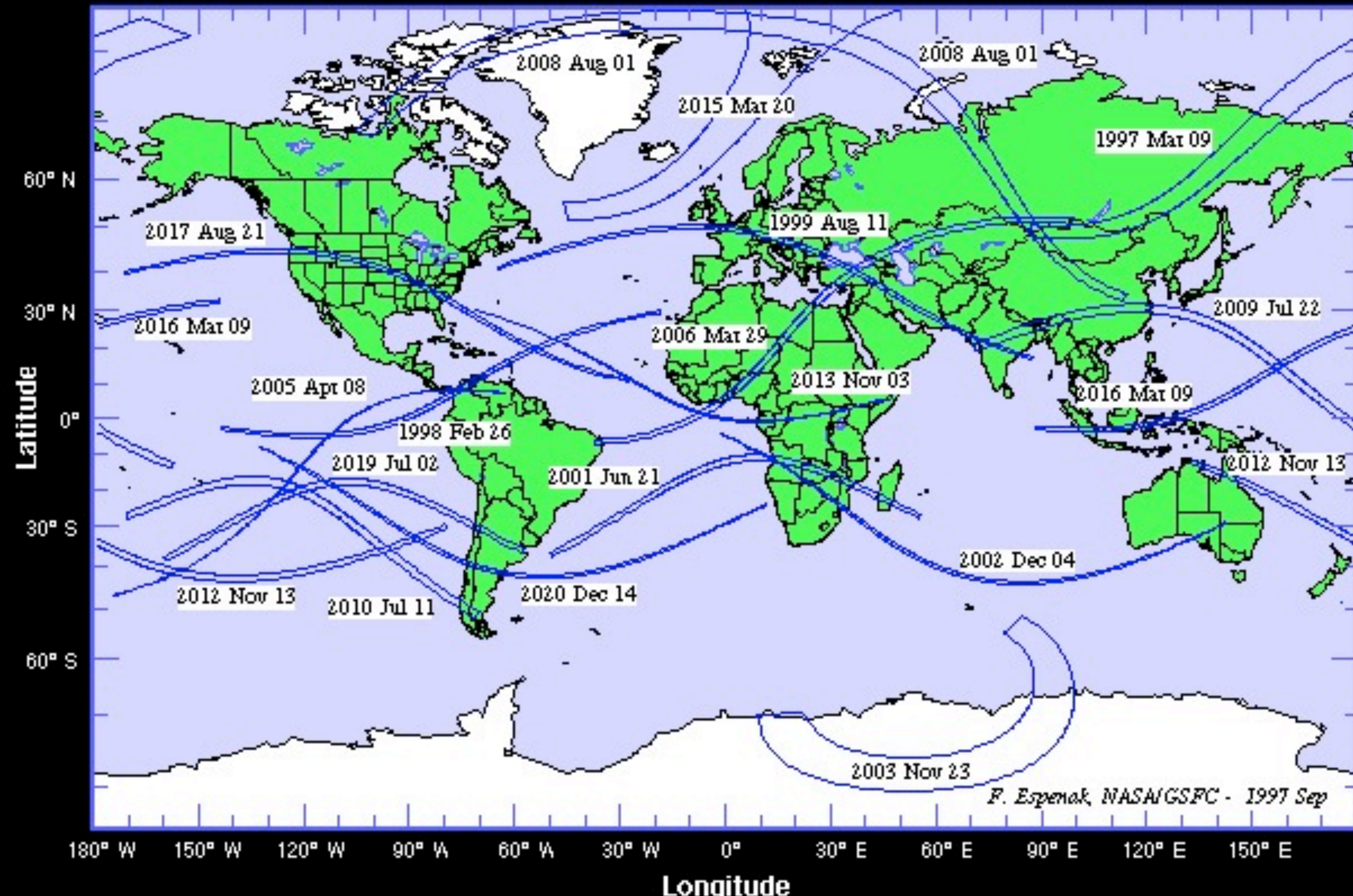
P4 U4 U3 U2 U1 P1
P4 U4 U3 U2 U1 P1
Eclipse at Moonset
No Eclipse Visible
Eclipse at Moonrise
All Eclipse Visible


Total Eclipse
2012 Nov 13
Saros 133
Mag. = 1.050
Gam. = -0.372
Alt. = 68°
Dur. = 4m 02s
F. Espenak, NASA's GSFC

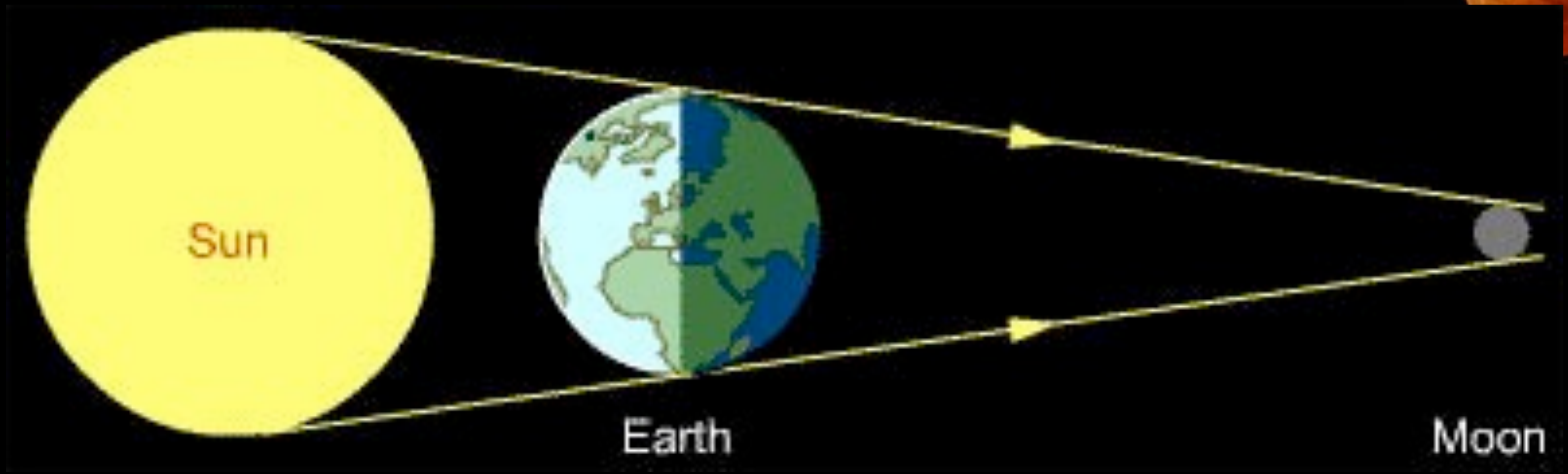
When will our next eclipse be?



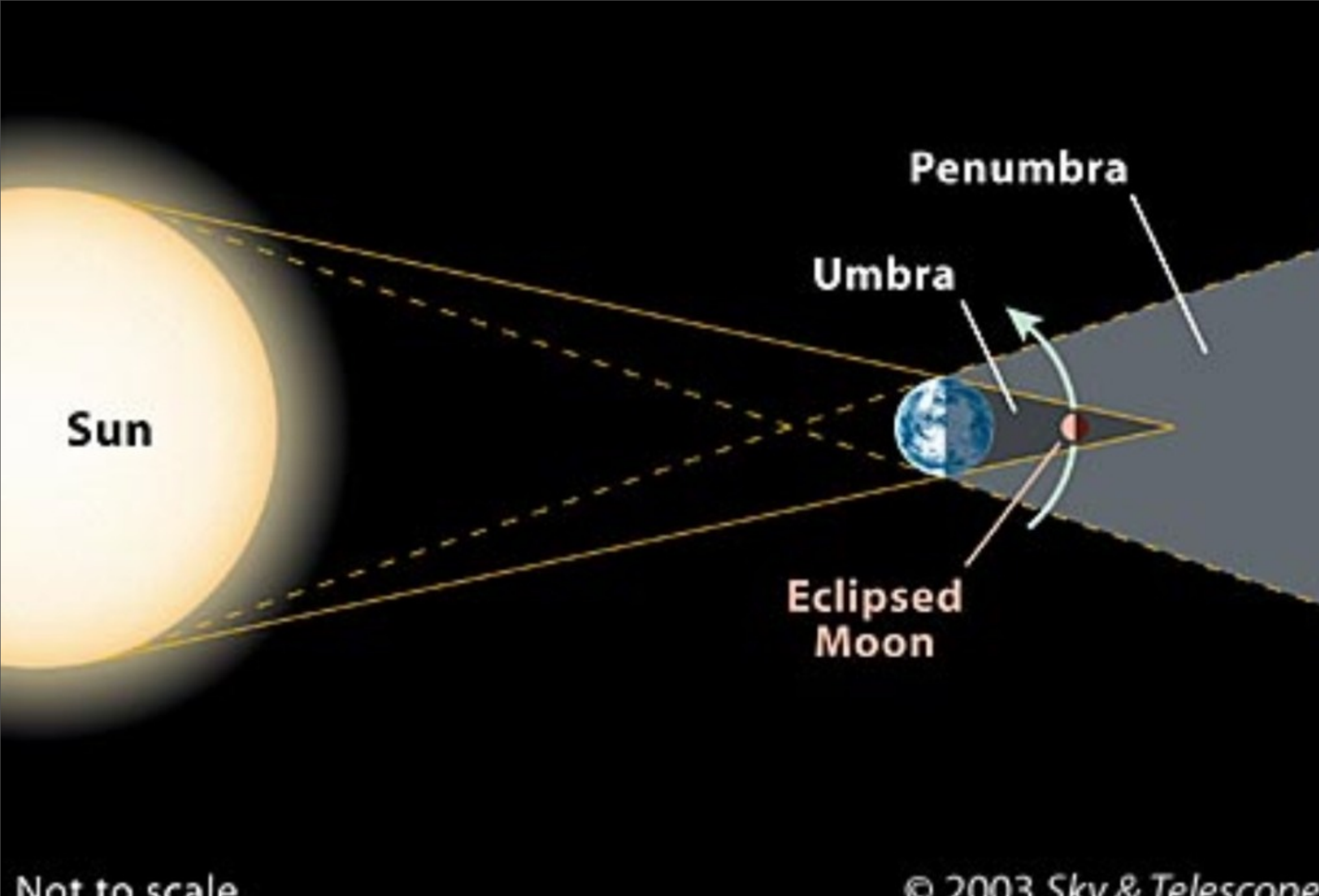
Total Solar Eclipses: 1996 - 2020



Lunar



- occurs when the Moon passes through Earth's shadow.


Penumbra
Umbra
Sun
Eclipsed Moon
Not to scale
© 2003 Sky & Telescope

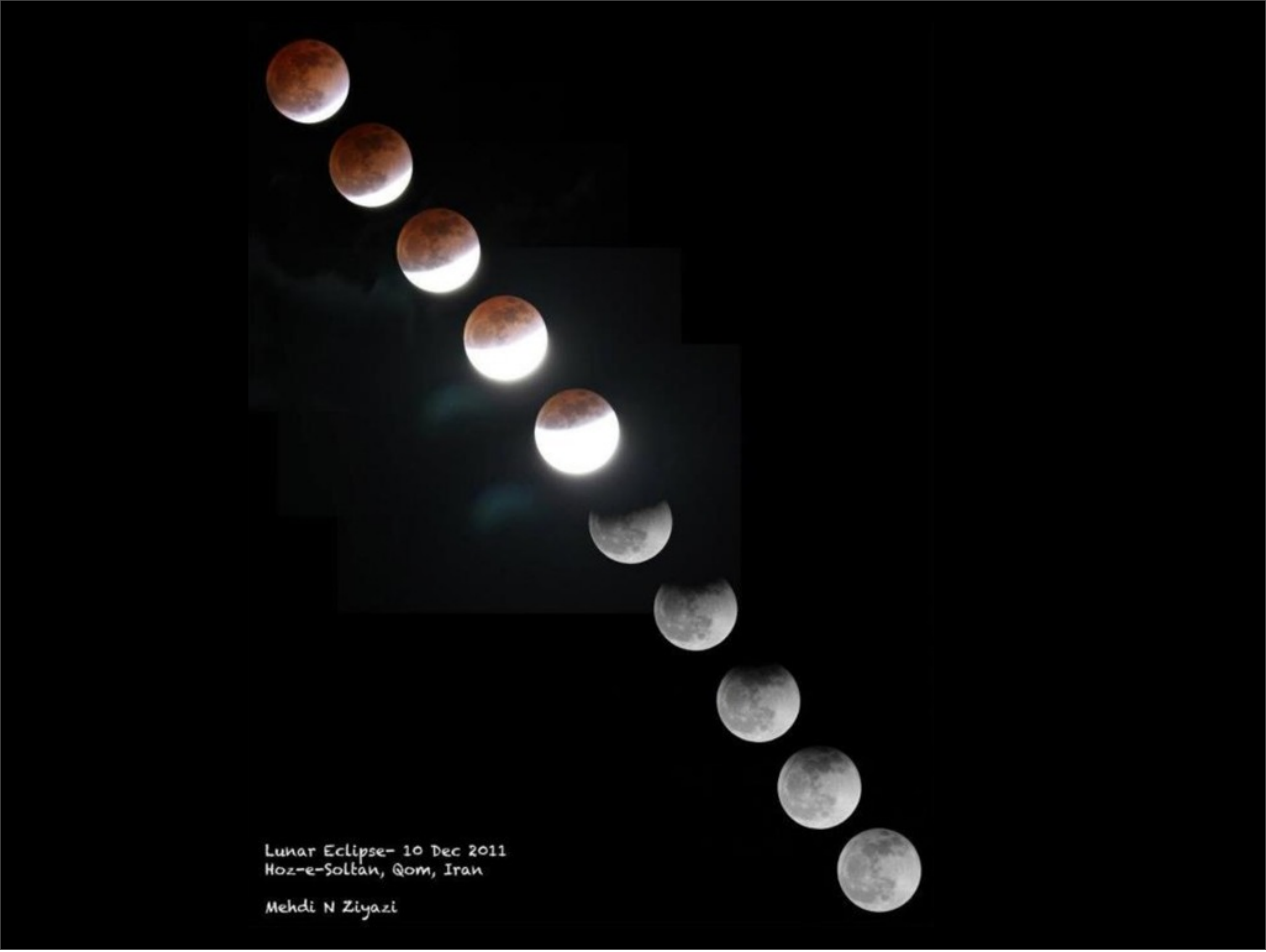
Lunar Eclipses

Moon moves into Earth's shadow – this shadow darkens the Moon

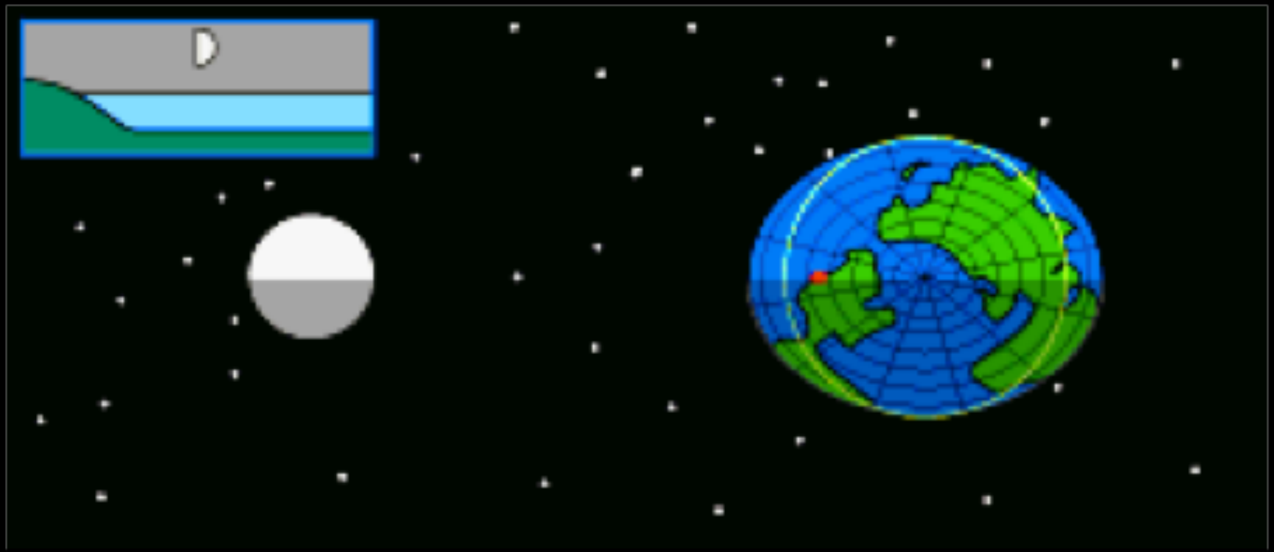
Umbra
Penumbra

About 2-3 per year
Last up to 4 hours

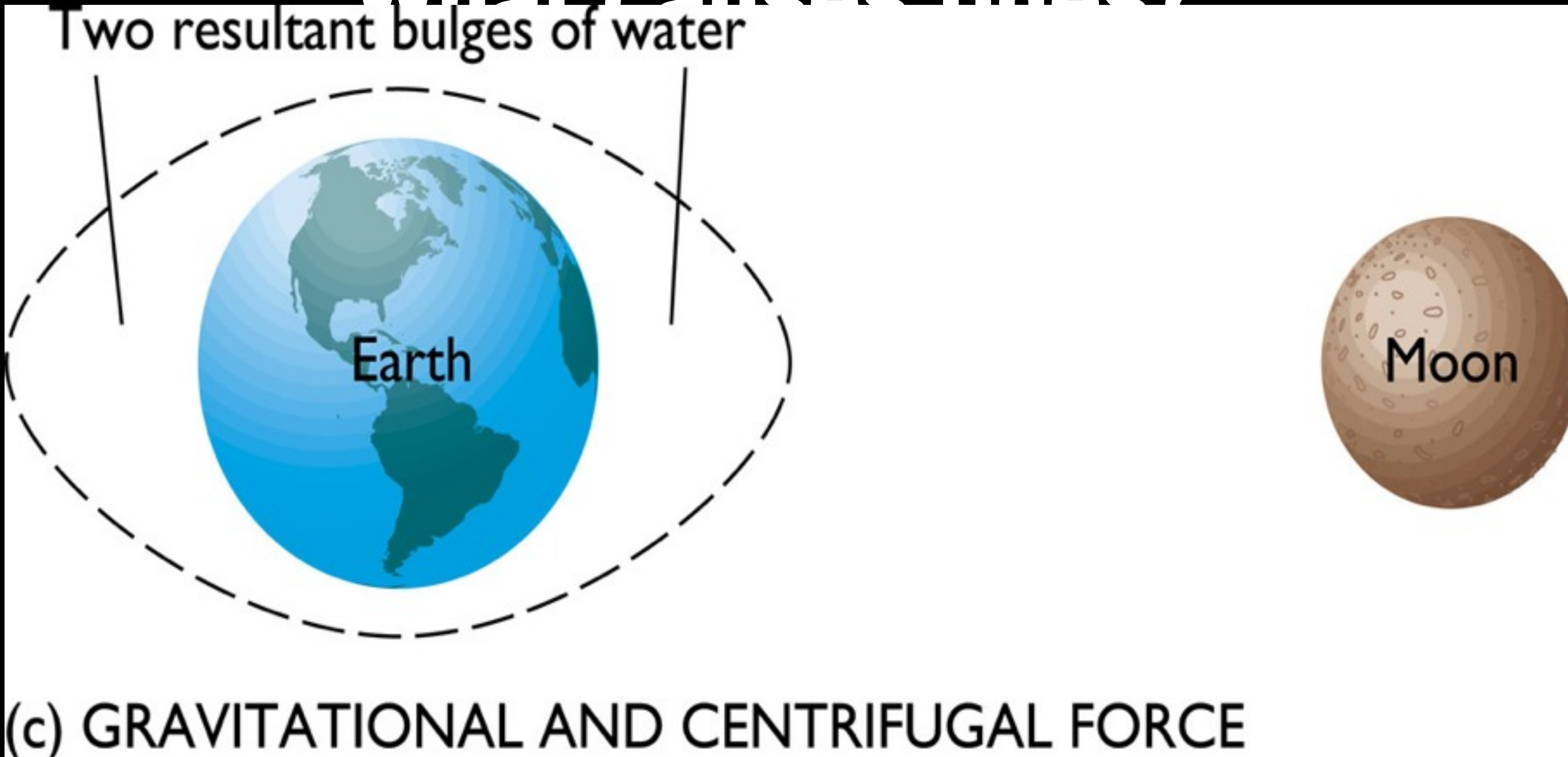

Photographed by Keith Burns, winner of NASA/JPL's I'm There: Lunar Eclipse Wallpaper Contest 2010


Lunar Eclipse- 10 Dec 2011
Hoz-e-Soltan, Qom, Iran
Mehdi N Ziyazi

The Tides



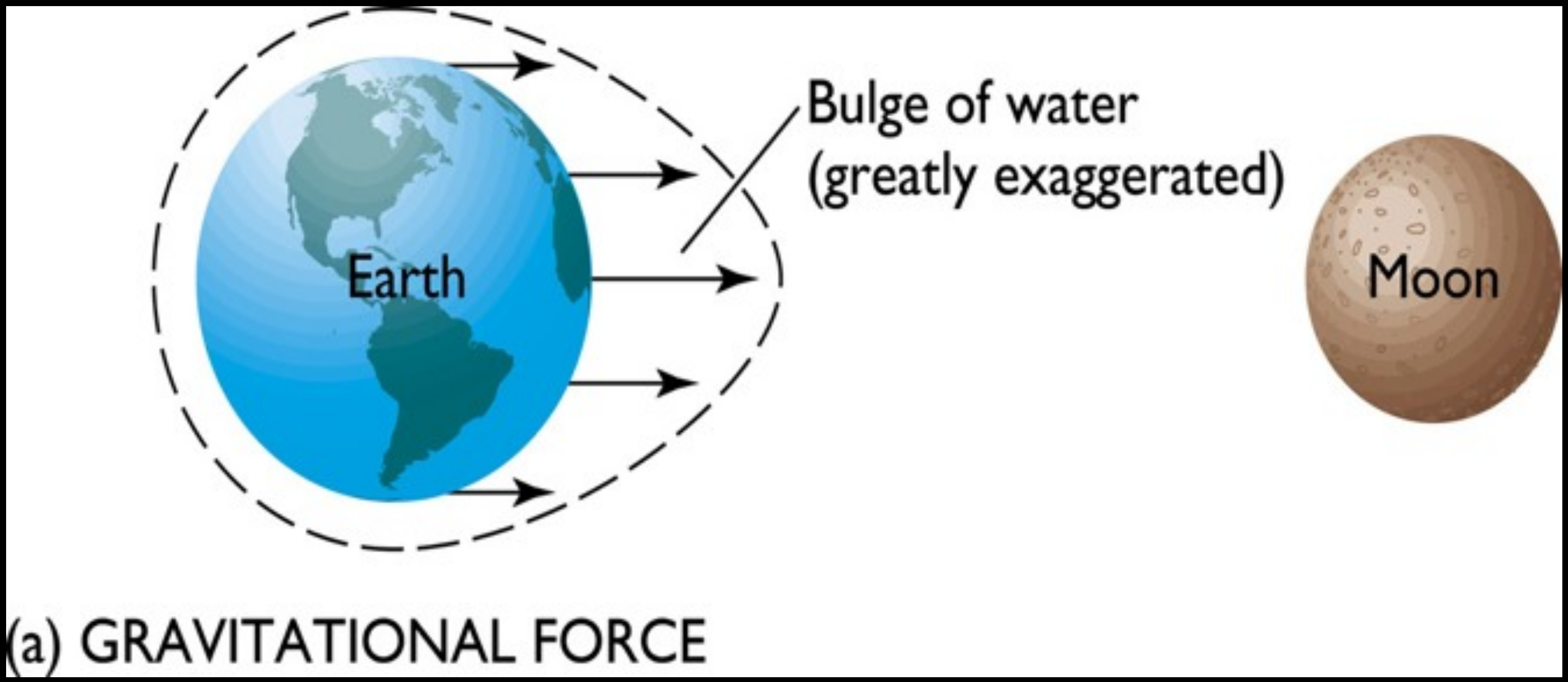
What causes tides?



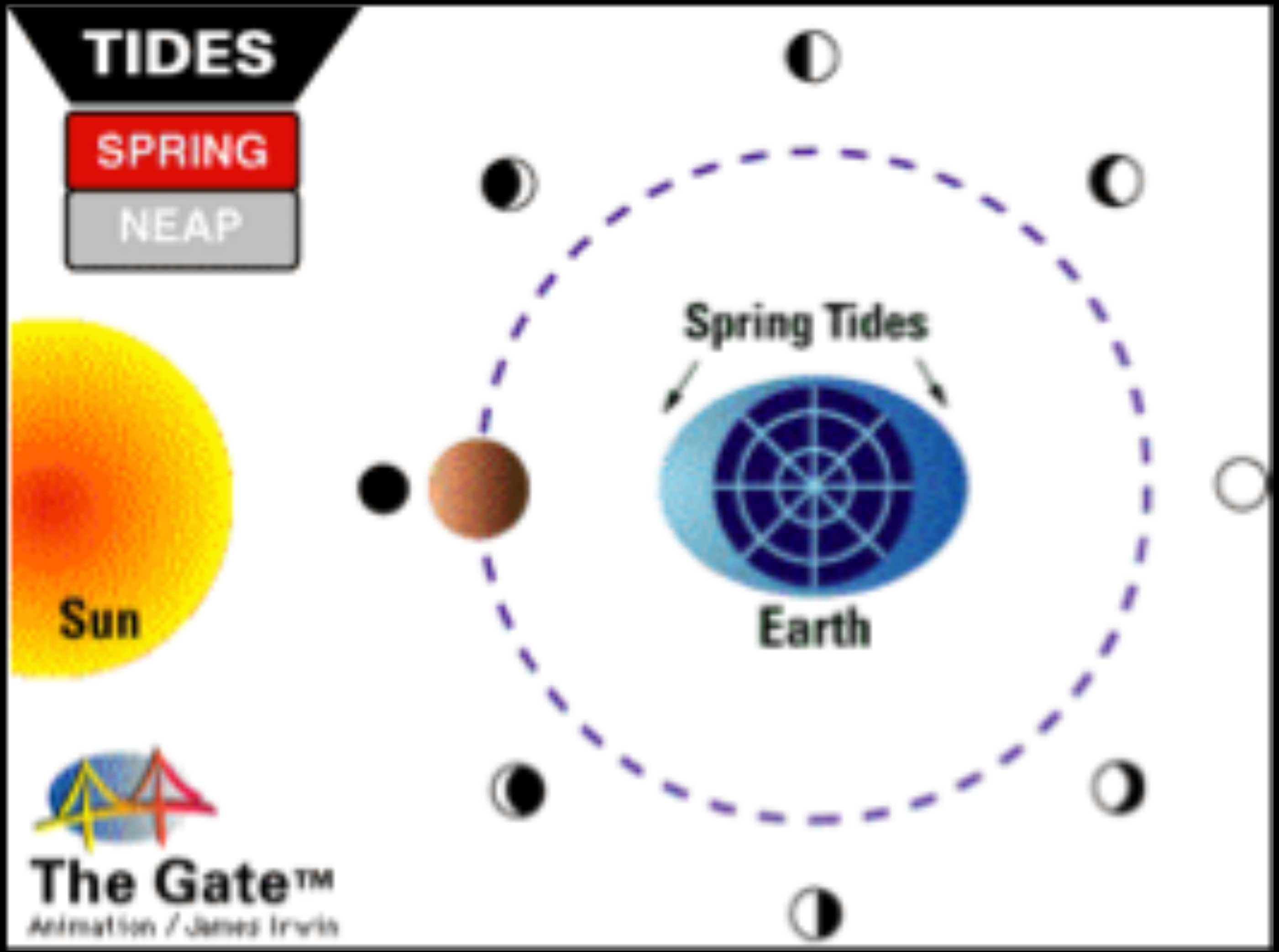
2 Bulges from Gravitational Attraction & Centrifugal Force

Gravitational Attraction

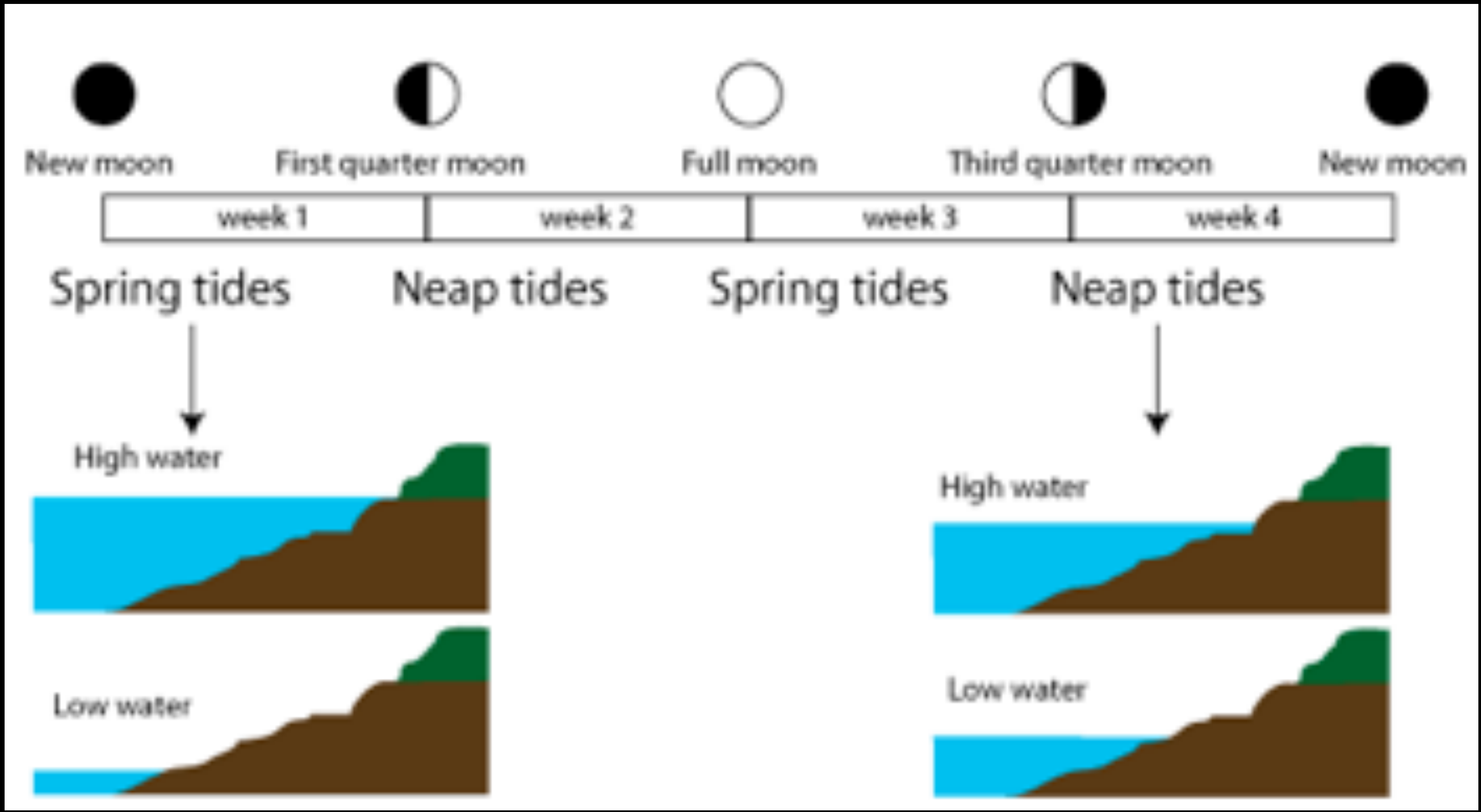
- All masses are drawn to each other.
- The moon because of its closeness to the Earth exerts a greater gravitational effect on the Earth than the Sun, despite the fact that the Sun is much more massive than the Moon.



Tides

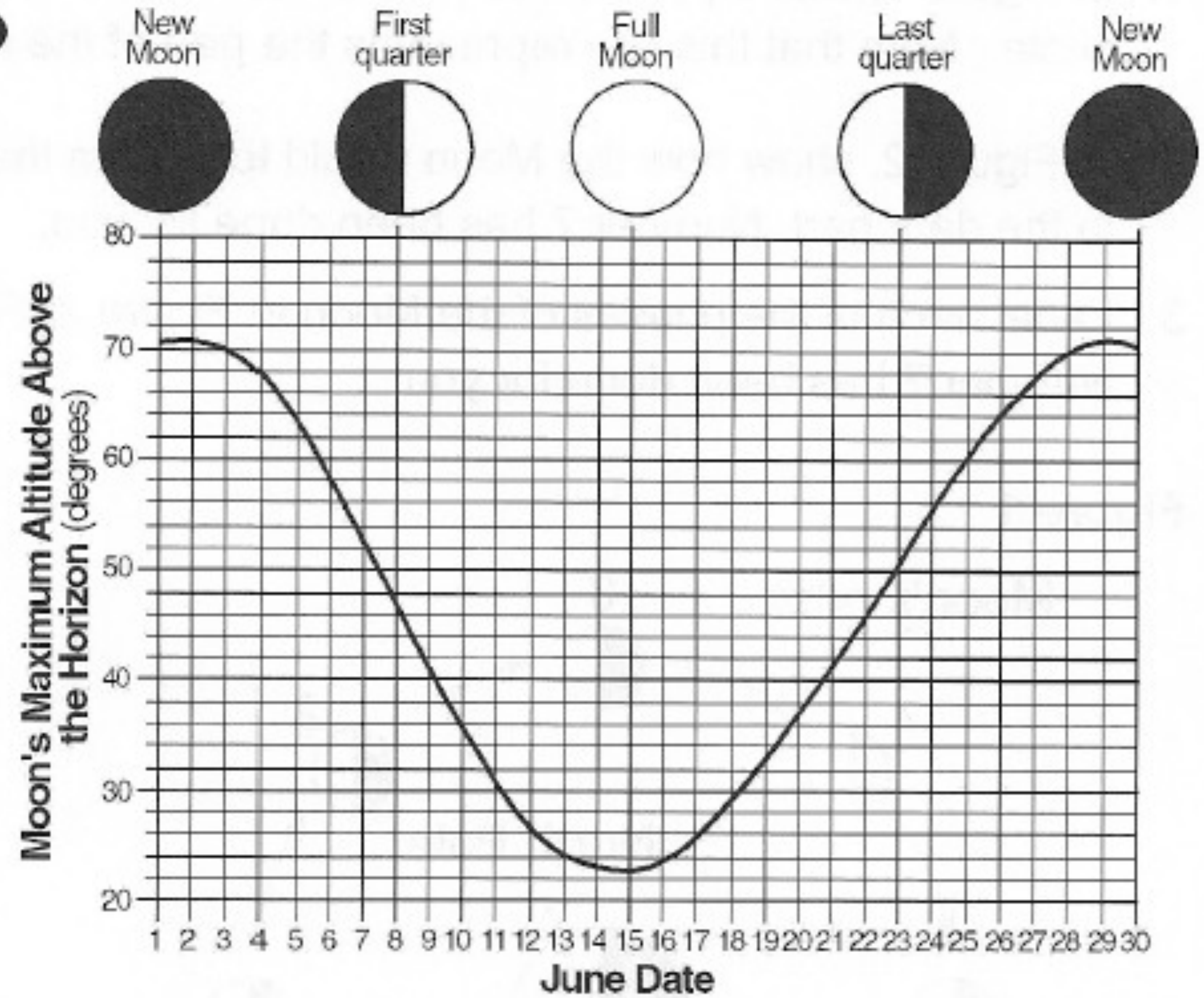


·As earth rotates, the tides move around the Earth alternating between high and low tides approximately every 6 hours.


New moon
First quarter moon
Full moon
Third quarter moon
New moon
week 1
week 2
week 3
week 4
Spring tides
Neap tides
Spring tides
Neap tides
High water
Low water
High water
Low water

37 Lunar Orbit and Phases

NAME ____________________



An observer can see only 50% of the Moon's entire surface. However, an additional 9% can be seen from time to time around the apparent edge because of the relative motion called libration. Libration is a slow rocking back and forth of the face of the moon as viewed from the Earth.

One revolution of the Moon around Earth takes a little over 27 days 8 hours. The Moon rotates on its axis in this same period of time, so the same face of the Moon is always presented to Earth.

Over a period a little longer than 29 1/3 days, the Moon goes through phases. These phases cause the lighted part of the Moon that we see from Earth, to appear to change. The phases are caused by the changing angle of sunlight hitting the Moon.

Vocabulary:

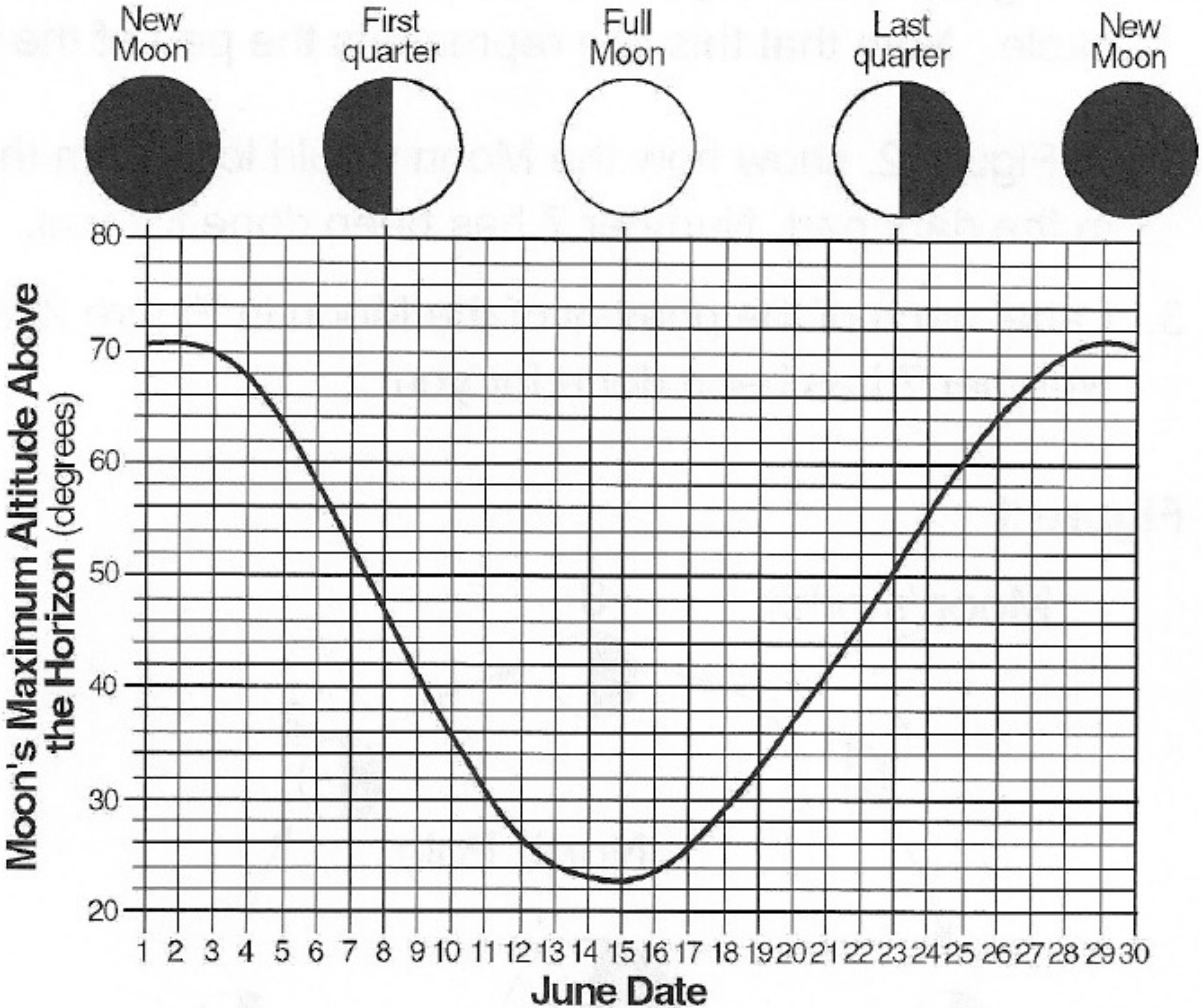
libration: a real or apparent fluctuation in the orbit as seen in the Moon from the Earth

sidereal month: the time it takes for the Moon to make one complete revolution; 27 1/3 days

synodic month: the time from one full Moon to the next; 29 ½ days

Objective:

The objective of this lab is to determine the lunar phase relative to the Moon's position in orbit.

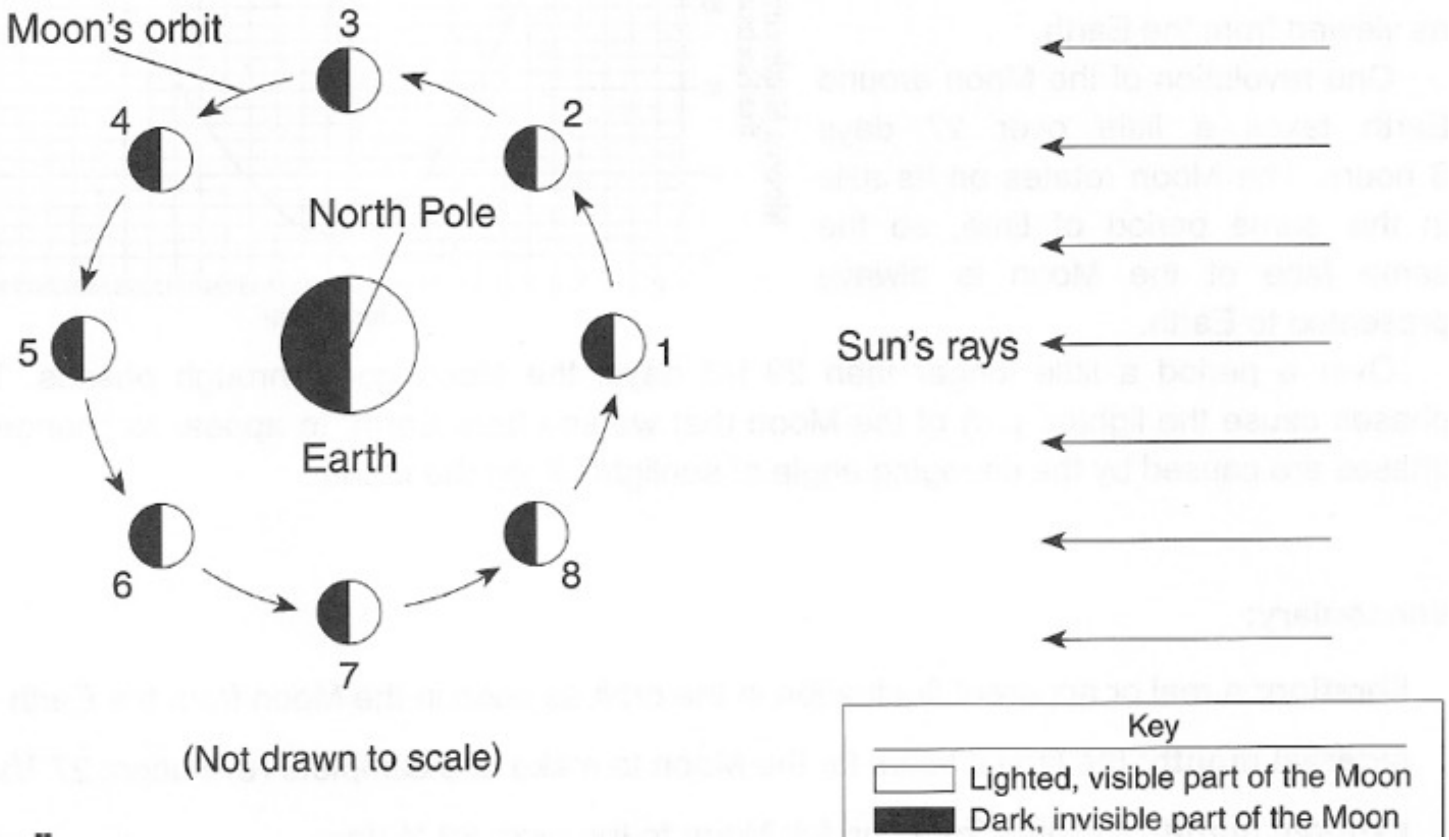

New Moon
First quarter
Full Moon
Last quarter
New Moon
Moon's Maximum Altitude Above the Horizon (degrees)
80
70
60
50
40
30
20
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
June Date

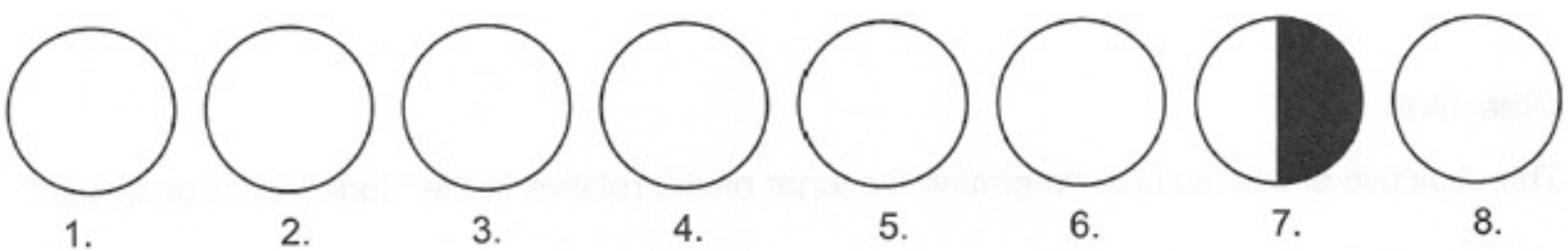
Procedure:

1. In Figure 1, with a pencil, extend the arrows between moon phases to make a complete circle. Note that this line represents the part of the Moon visible from the Earth.

2. In Figure 2, show how the Moon would look from the Earth at each position, by shading in the dark part. Number 7 has been done for you.

3. Label each of the phases of the Moon in Figure 2: *Full, Gibbous, Quarter, Crescent or New*. Number 7 has been done for you.





1. ______________________   5. ______________________

2. ______________________   6. ______________________

3. ______________________   7. *Last Quarter*

4. ______________________   8. ______________________

Observations:

1. Does the Moon's shadow change relative to the Sun? ______________________________

2. Which side is lit when the Moon is waxing or getting larger?_________________________

3. In figure 1, what month(s) is it on Earth?____

4. During which lunar phases do we see only 50% of the Moon lit? ___________________

5. How long is a synodic month?____

6. Why is there a difference between a synodic month and a sidereal month?

____

7. What is it called when a Moon appears to get larger?______________________________

8. What phase is the Moon when it is highest at solar noon?

____

____

9. Why do we always see the same side of the Moon? ______________________________

10. A classmate of yours was absent on the day your teacher discussed lunar phases. In talking to your classmate on the phone that evening, you talked about what was discussed in class that day. In the space below describe your conversation to your classmate about how the lunar phases change.

Astronomy Unit Test Today

Check out class website for updates & regents review sites

Extra Credit

Bring your ESRT to class every day between now and June 14 & Earn 100% on a unit test

Today is the last day to turn in Astronomy

Earth Science Performance Test Tuesday, June 7th (in class)

15% Regents Score

Earth Science Regents Exam

85% of Regents Score

Why Do We Think This?

- The moon has no **iron**
  - Earth's iron had already concentrated in the core by the time of the impact
  - The iron core of the impactor melded with that of the Earth, leaving the moon with no iron of its own
- The moon and Earth share **isotopes** of oxygen that are not found on other planets or objects far from Earth