ASTRONOMY

Goal: Students will understand what astronomy is,
and how to describe the locations of objects in the sky.

ASTRONOMY

THE STUDY OF OBJECTS BEYOND EARTH
AND ITS ATMOSPHERE

Goal: Students will understand what astronomy is,
and how to describe the locations of objects in the sky.

Goal: Students will understand what astronomy is,
and how to describe the locations of objects in the sky.

CELESTIAL OBJECTS

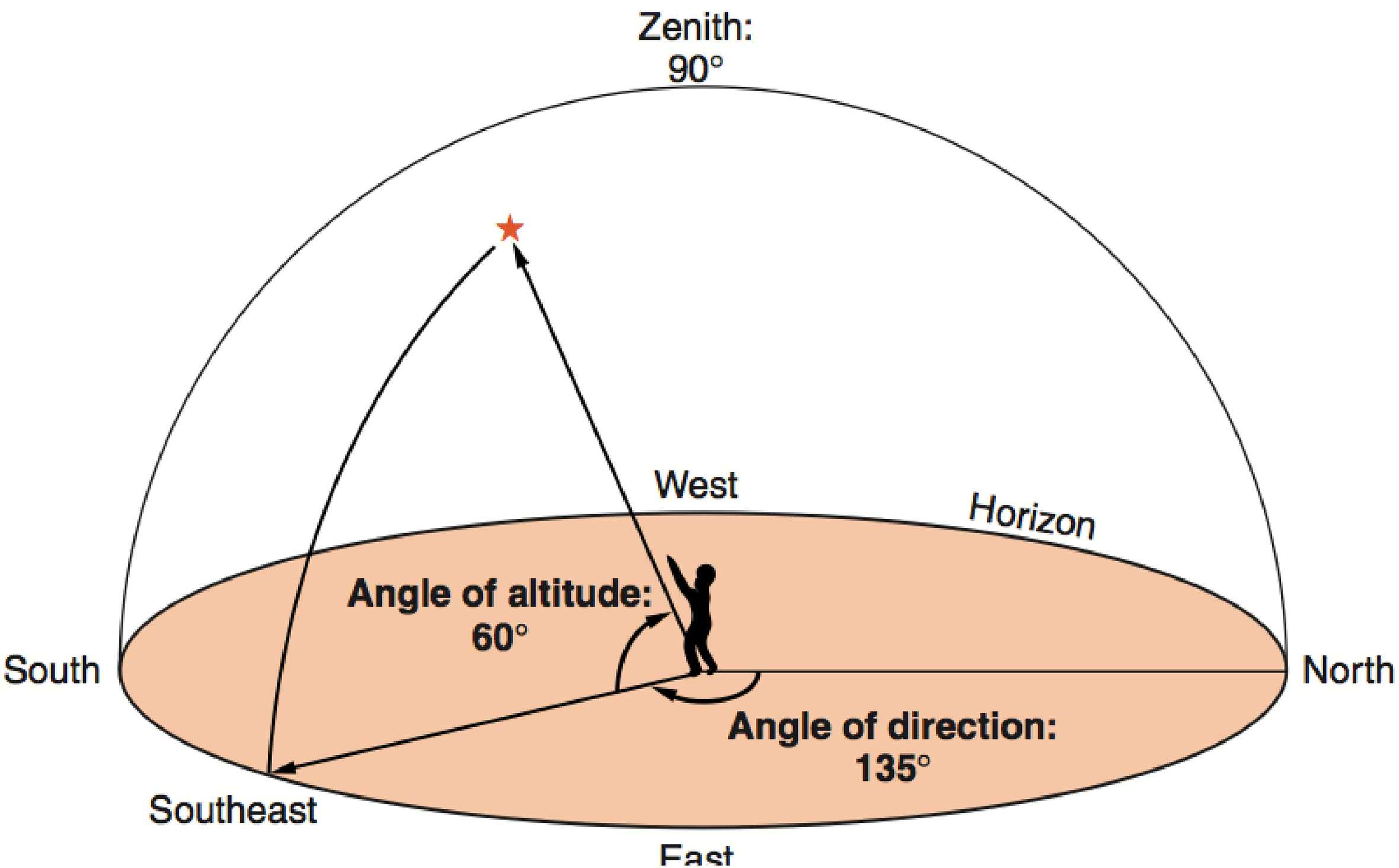
OBJECTS SEEN IN THE SKY THAT ARE OUTSIDE EARTH'S ATMOSPHERE.

Goal: Students will understand what astronomy is,
and how to describe the locations of objects in the sky.

HOW CAN WE LOCATE OBJECTS IN THE SKY?

- Altitude - the angle above the horizon.
- Zenith - 90° in altitude, or directly above an observer.
- Azimuth - compass direction expressed in degrees. (North (0° or 360°), East (90°), South (180°), and West (270°).)

Goal: Students will understand what astronomy is,
and how to describe the locations of objects in the sky.



Goal: Students will understand what astronomy is,
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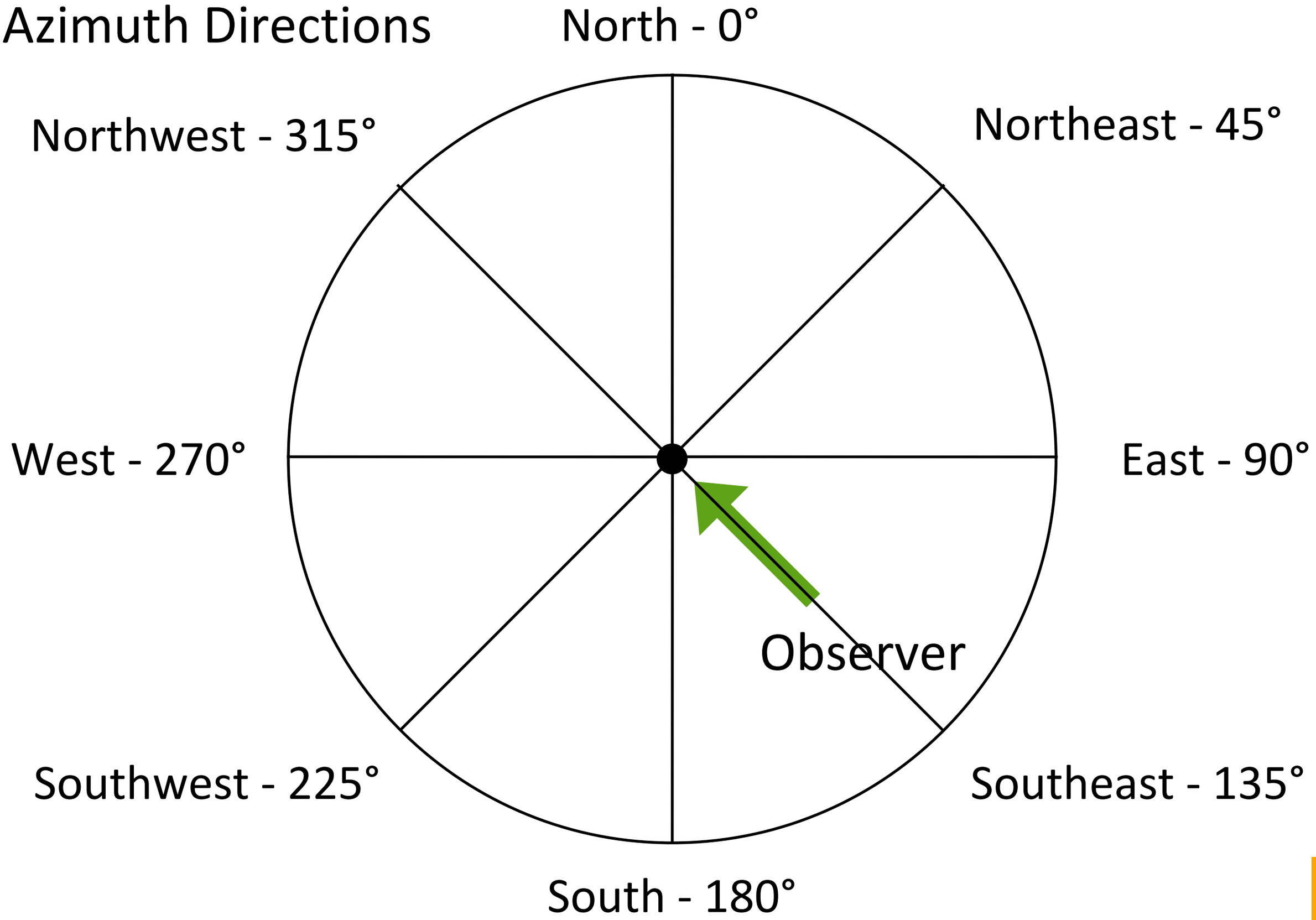
Azimuth Directions



Goal: Students will be able to describe the “motions” of the Sun.

THE SUN’S APPARENT PATH

Goal: Students will be able to describe the “motions” of the Sun.

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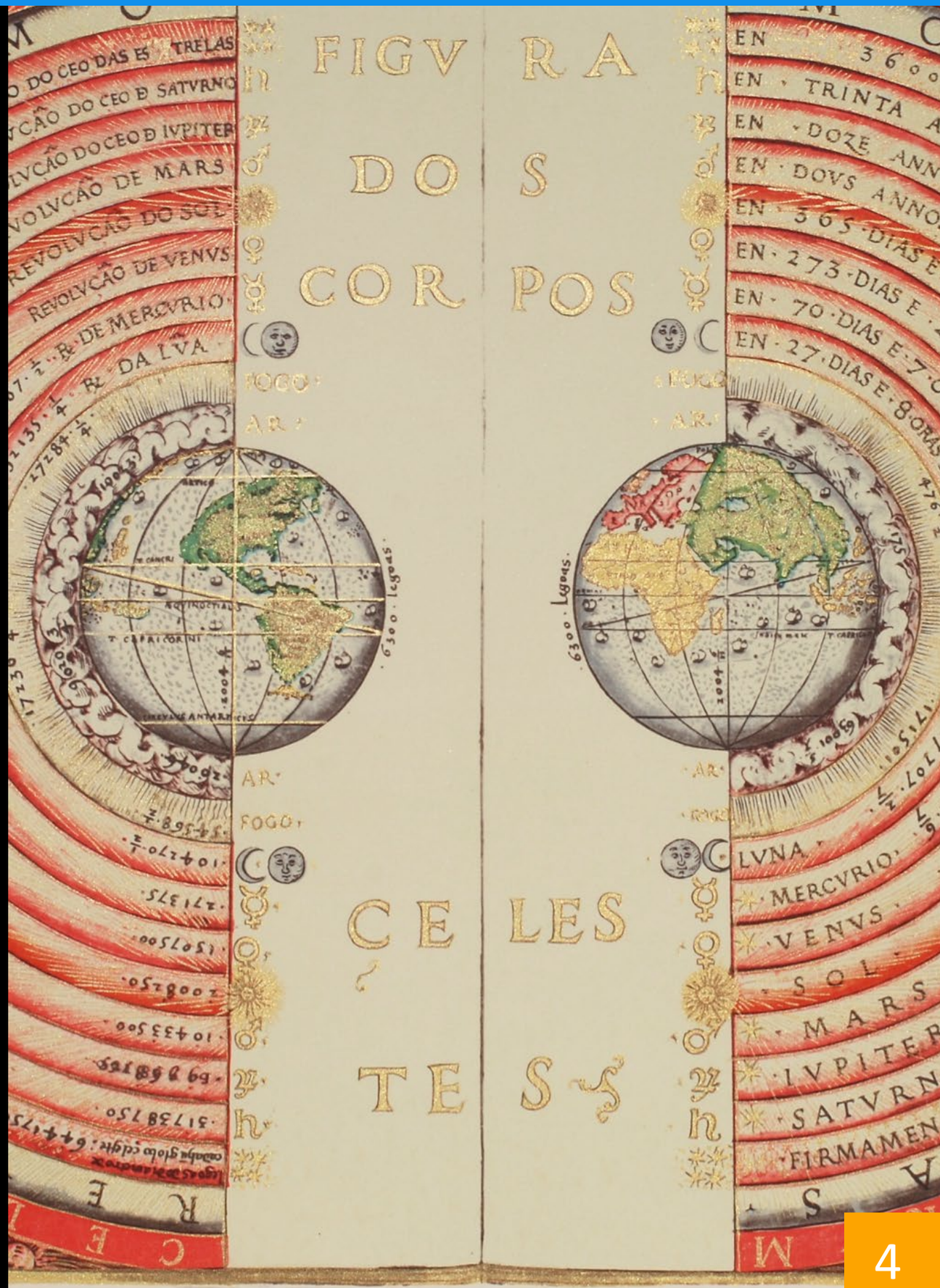
WHY DO THE SUN AND OTHER OBJECTS APPEAR TO MOVE ACROSS THE SKY?

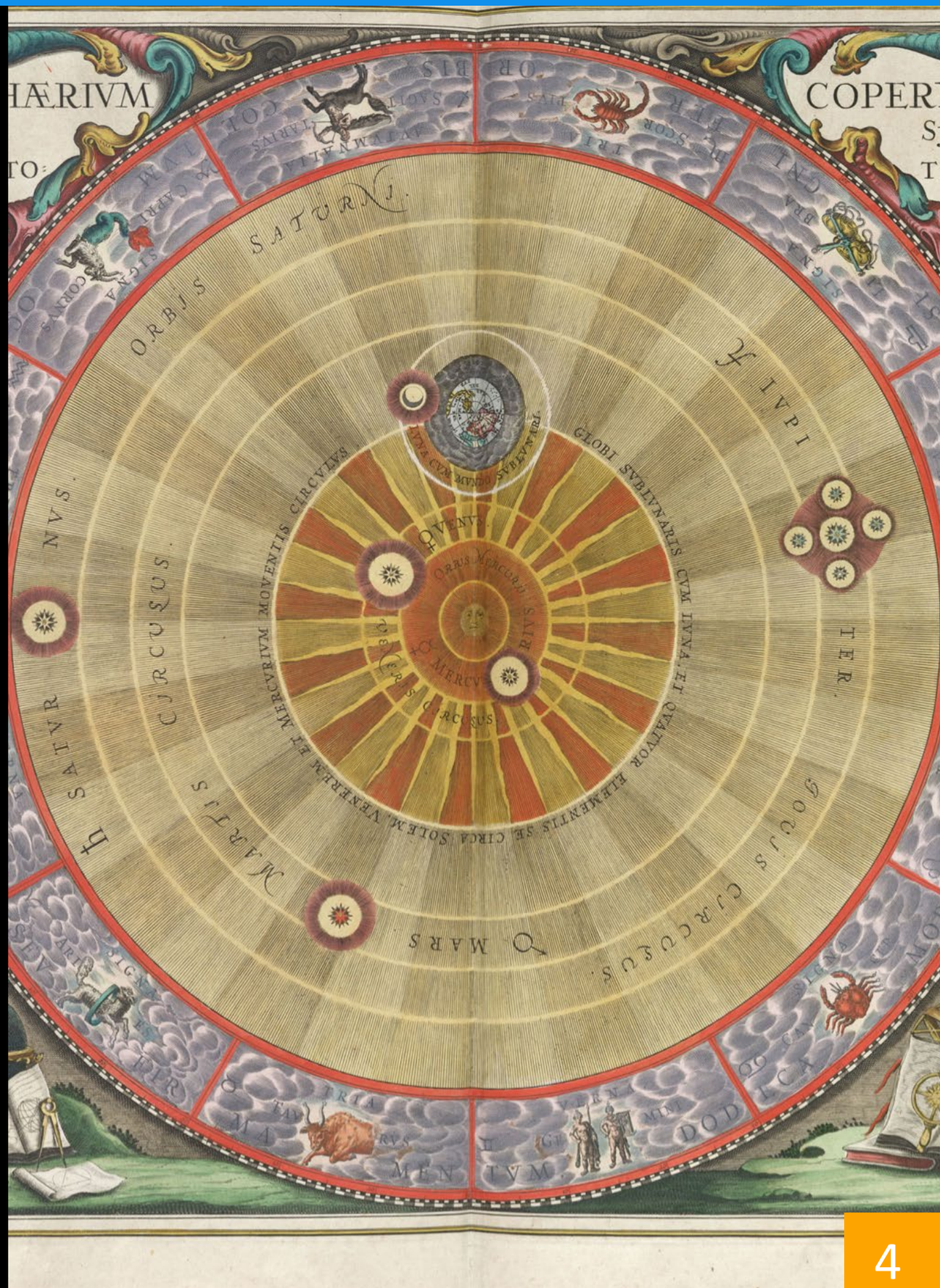
- Early people thought the entire Universe revolved around the Earth. This is called the geocentric model, and we now know that it was completely wrong.



Goal: Students will be able to describe the “motions” of the Sun.

THE HELIOCENTRIC MODEL

- Great scientists like Capernicus, Galileo, and Kepler proved that objects in our Solar System move around the Sun.
- This model is known as the heliocentric model.



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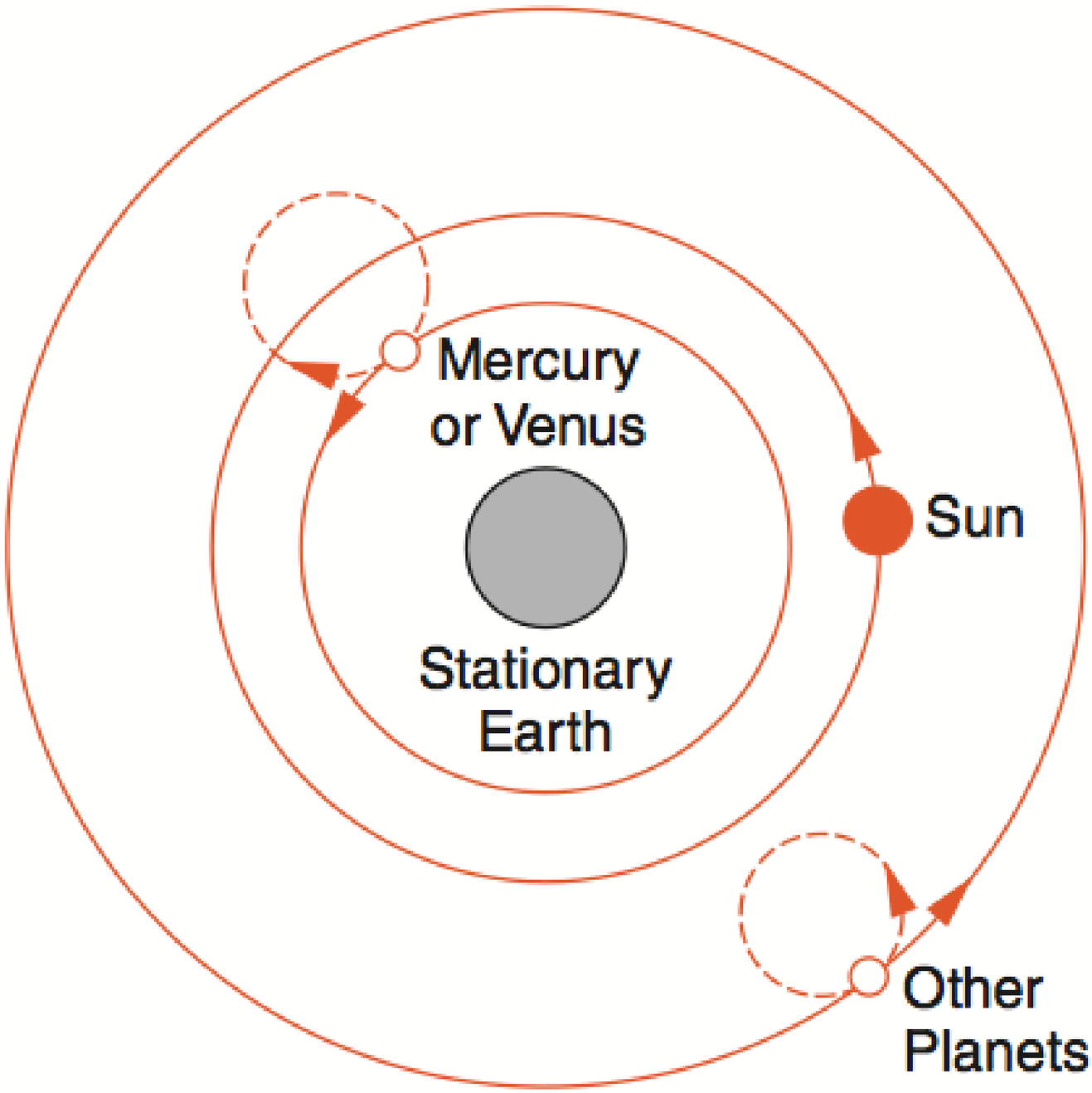
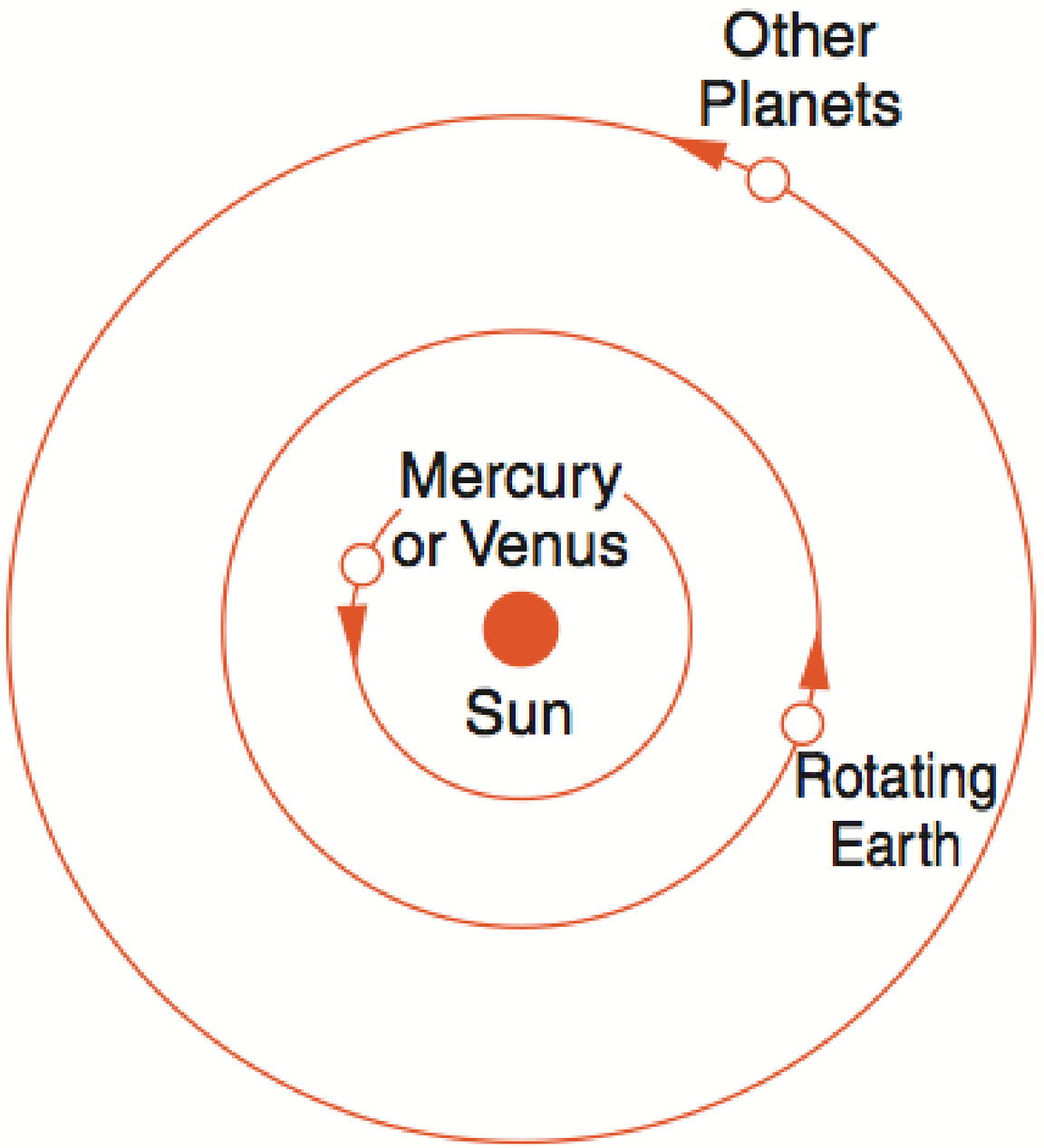


Geocentric



Heliocentric

Goal: Students will be able to describe the “motions” of the Sun.

WHY DO THE SUN AND OTHER OBJECTS APPEAR TO MOVE ACROSS THE SKY?

- Earth goes through two real motions that causes objects in space to appear to move.
  - The Earth revolves around the Sun.
  - The Earth rotates on its axis.
- Revolution - The motion of the planets in their orbits around the sun.
- Rotation - A spinning motion.

Goal: Students will be able to describe the “motions” of the Sun.

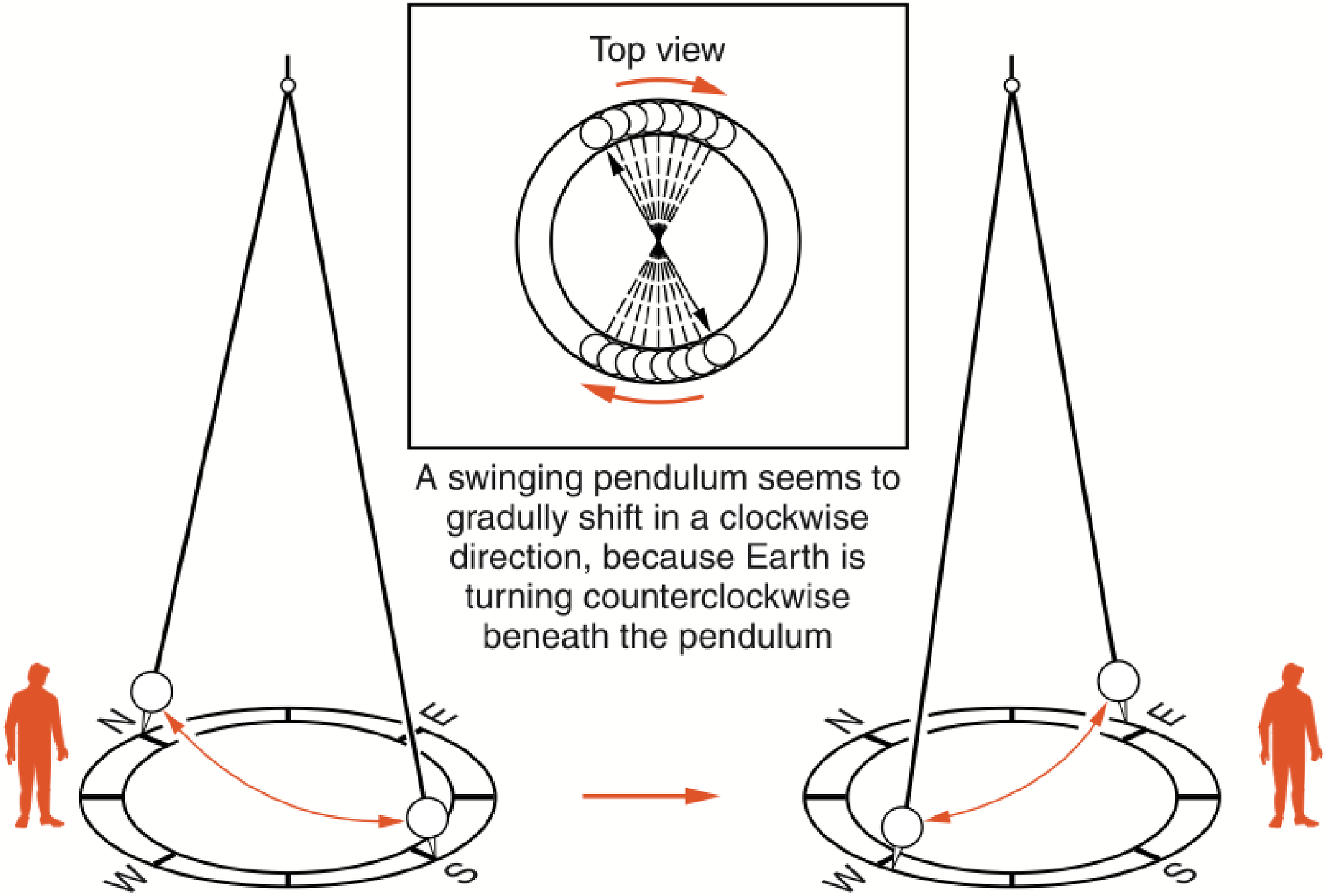
HOW DID SCIENTISTS PROVE THESE MOTIONS WITHOUT GOING INTO SPACE TO OBSERVE THEM?

Goal: Students will be able to describe the “motions” of the Sun.

PROOF THE EARTH ROTATES

- Foucault Pendulum
- Coriolis Effect - Moving objects on Earth’s surface deflect to the right in the Northern Hemisphere, and to the left in the Southern Hemisphere.

Goal: Students will be able to describe the “motions” of the Sun.



Goal: Students will be able to describe the “motions” of the Sun.

THE SUN’S APPARENT PATH

Goal: Students will determine why Earth experiences seasons.

WHAT CAUSES THE SEASONS?

Goal: Students will determine why Earth experiences seasons.

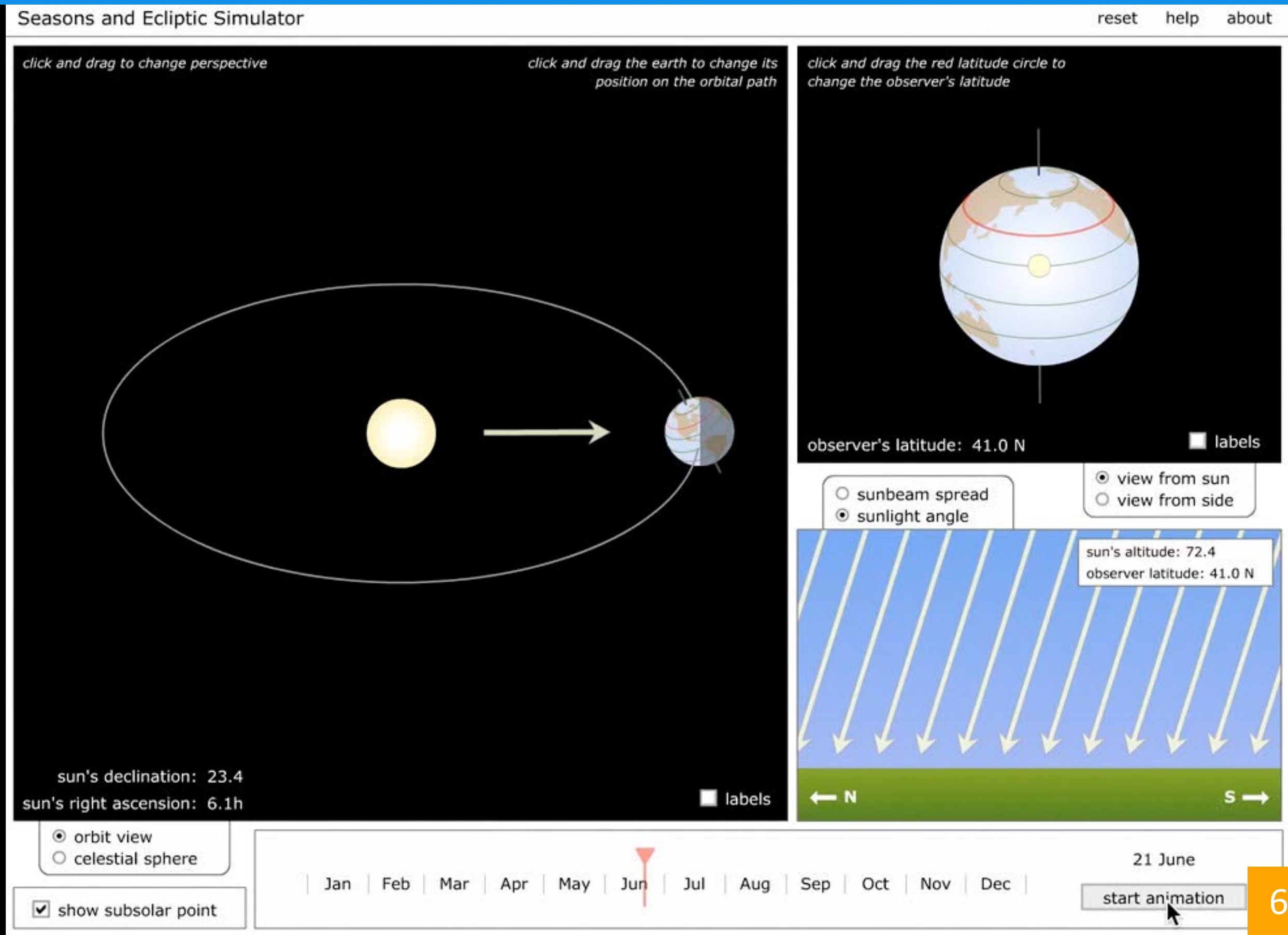
SEASONS ON EARTH ARE LINKED TO THE LOCATION ON EARTH THAT IS RECEIVING DIRECT SOLAR RADIATION.

- Spring (March 21) - Sun is directly overhead the equator (0°).
- Summer (June 21) - Sun is directly overhead the Tropic of Cancer (23.5°N).
- Autumn (September 21) - Sun is directly overhead the equator (0°).
- Winter (December 21) - Sun is directly overhead the Tropic of Capricorn (23.5°S).

Goal: Students will determine why Earth experiences seasons.

WHY DOES THE LOCATION OF DIRECT SOLAR RADIATION CHANGE?

Goal: Students will determine why Earth experiences seasons.



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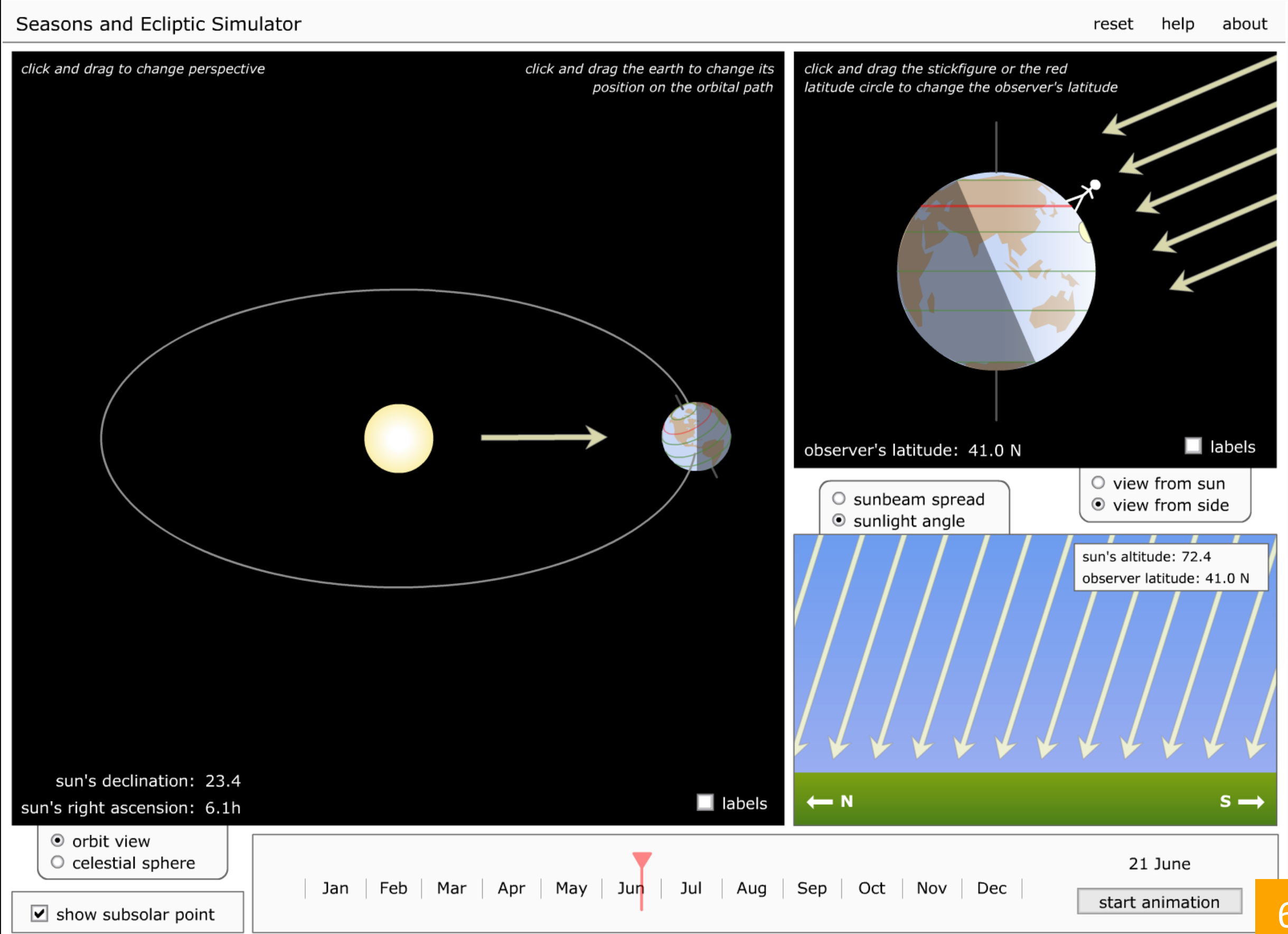

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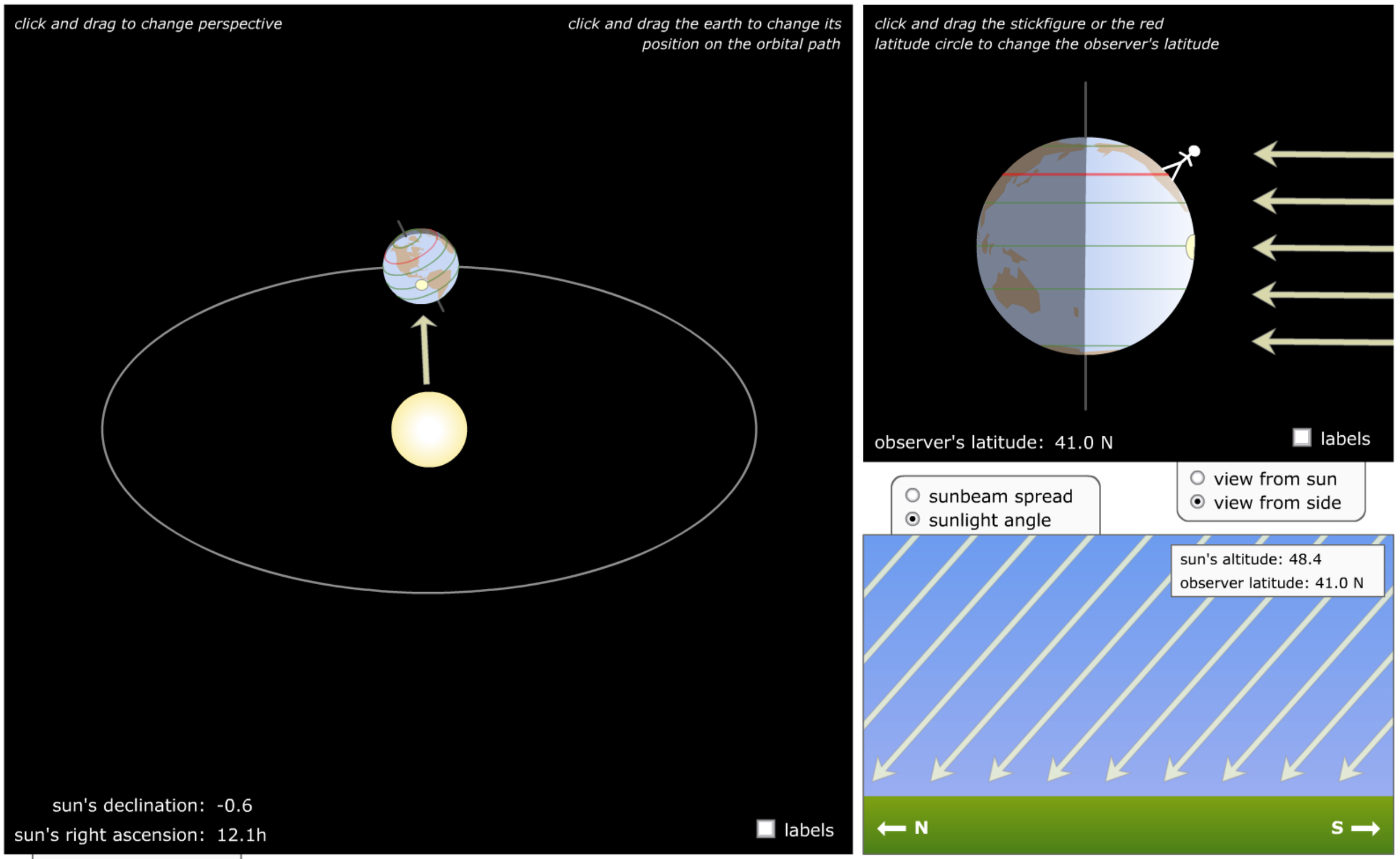

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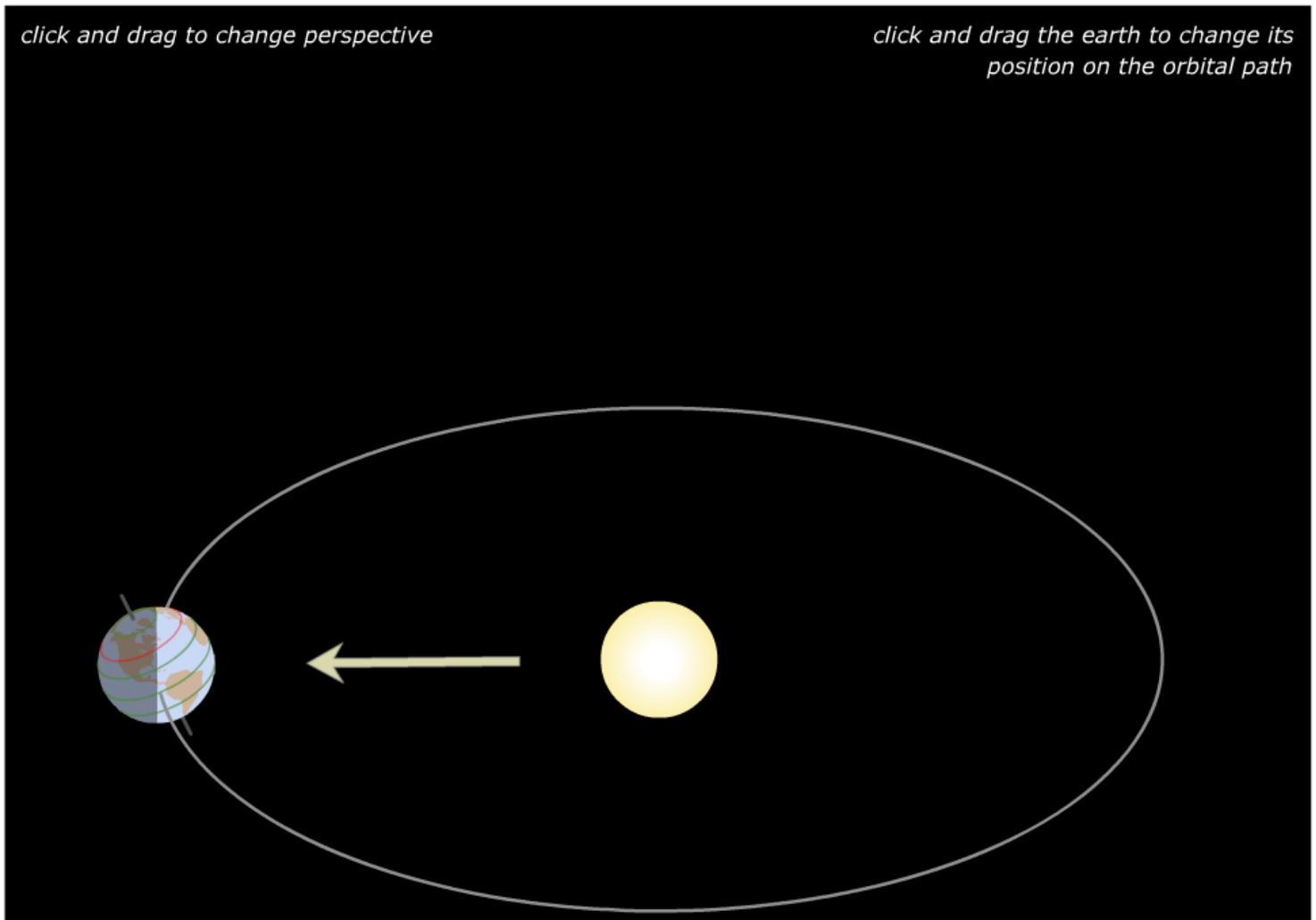
Seasons and Ecliptic Simulator

reset help about

click and drag to change perspective

click and drag the earth to change its position on the orbital path



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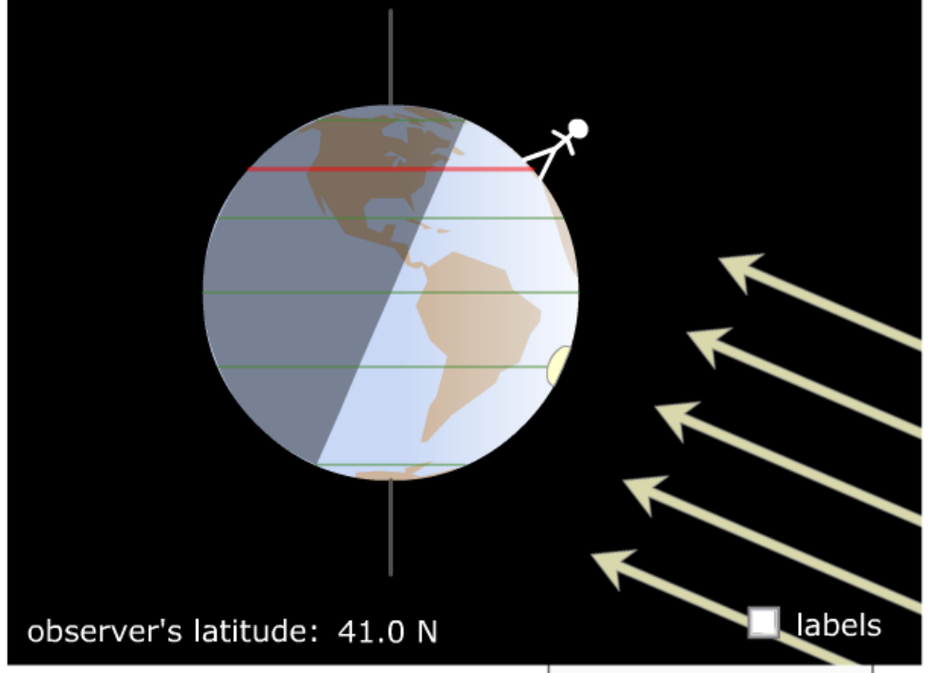
sun's right ascension: 18.1h

labels

orbit view
celestial sphere

show subsolar point

click and drag the stickfigure or the red latitude circle to change the observer's latitude

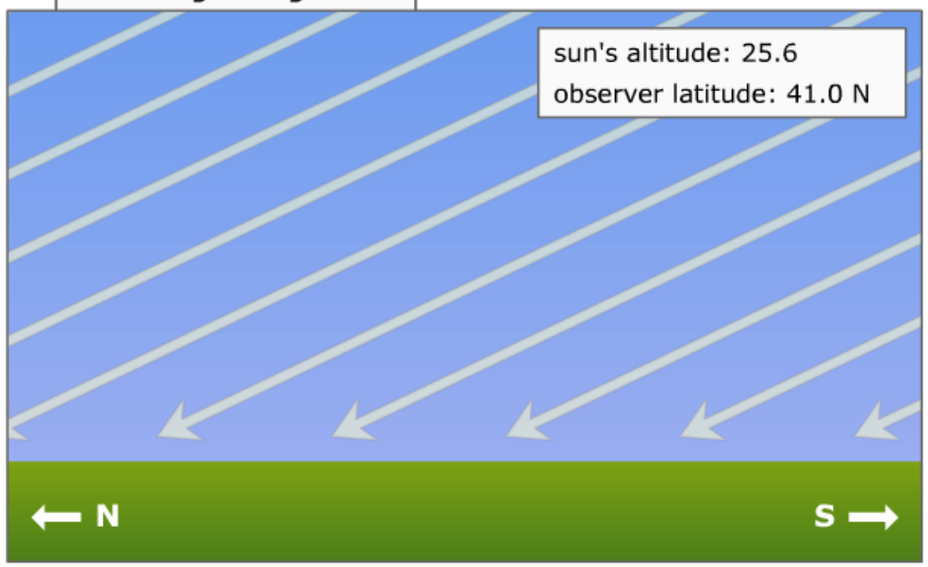


observer's latitude: 41.0 N

labels

sunbeam spread
sunlight angle

view from sun
view from side



Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec

21 December

start animation

Goal: Students will determine why Earth experiences seasons.

Seasons and Ecliptic Simulator

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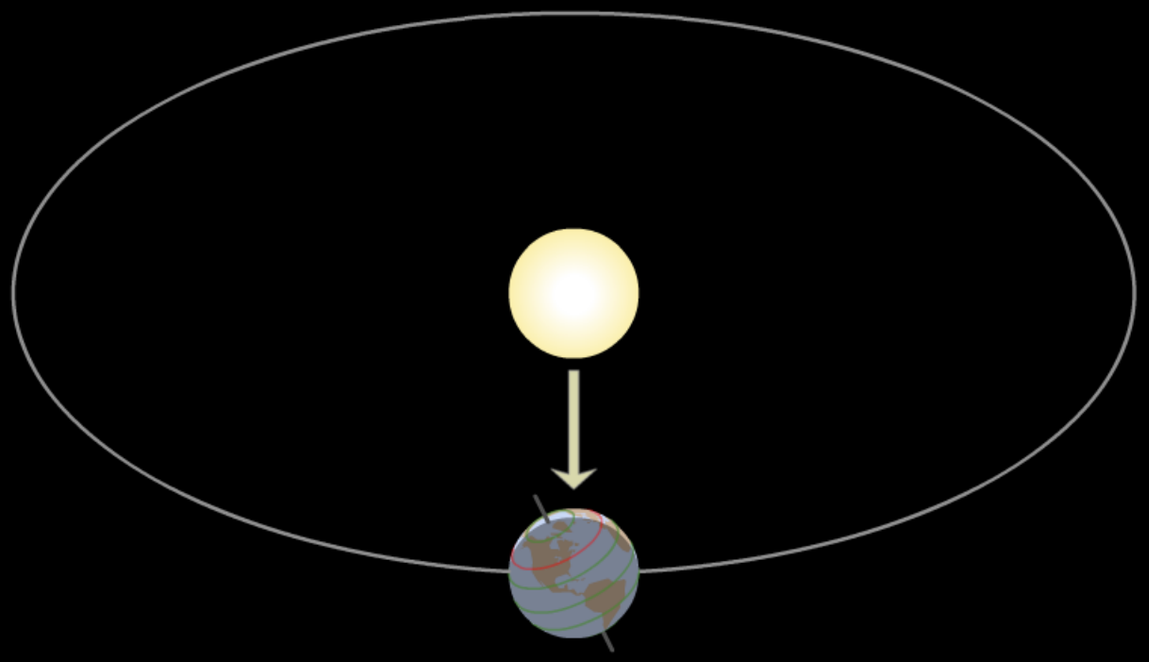


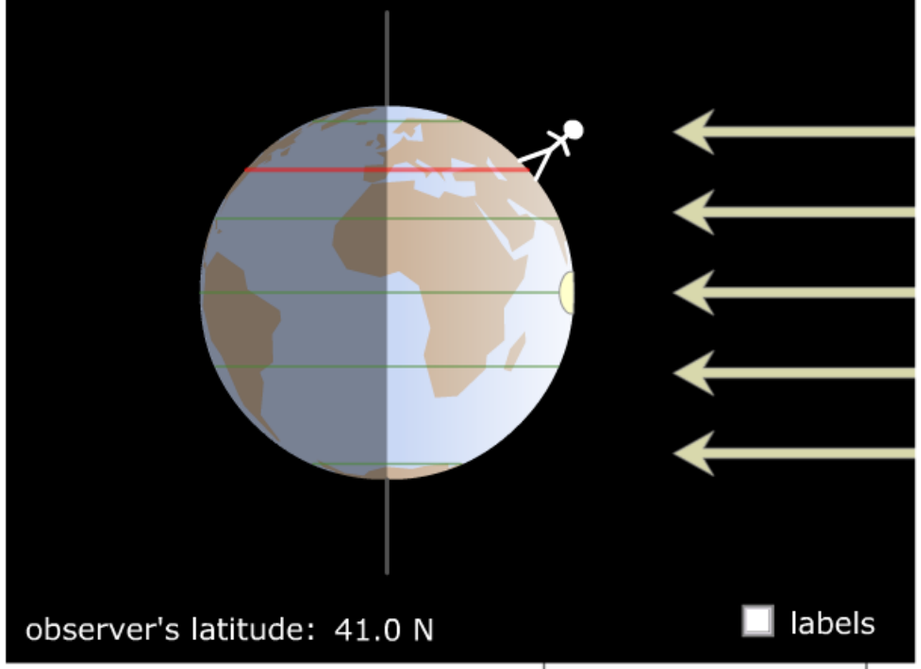
sun's declination: -0.0
sun's right ascension: 23.9h

labels

orbit view
celestial sphere

show subsolar point

click and drag the stickfigure or the red latitude circle to change the observer's latitude



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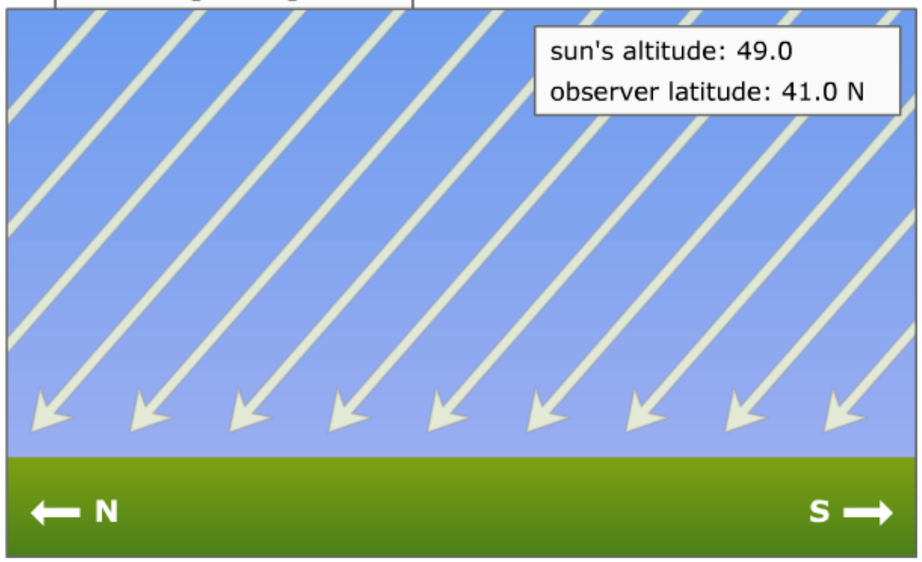

Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec

21 March

start animation

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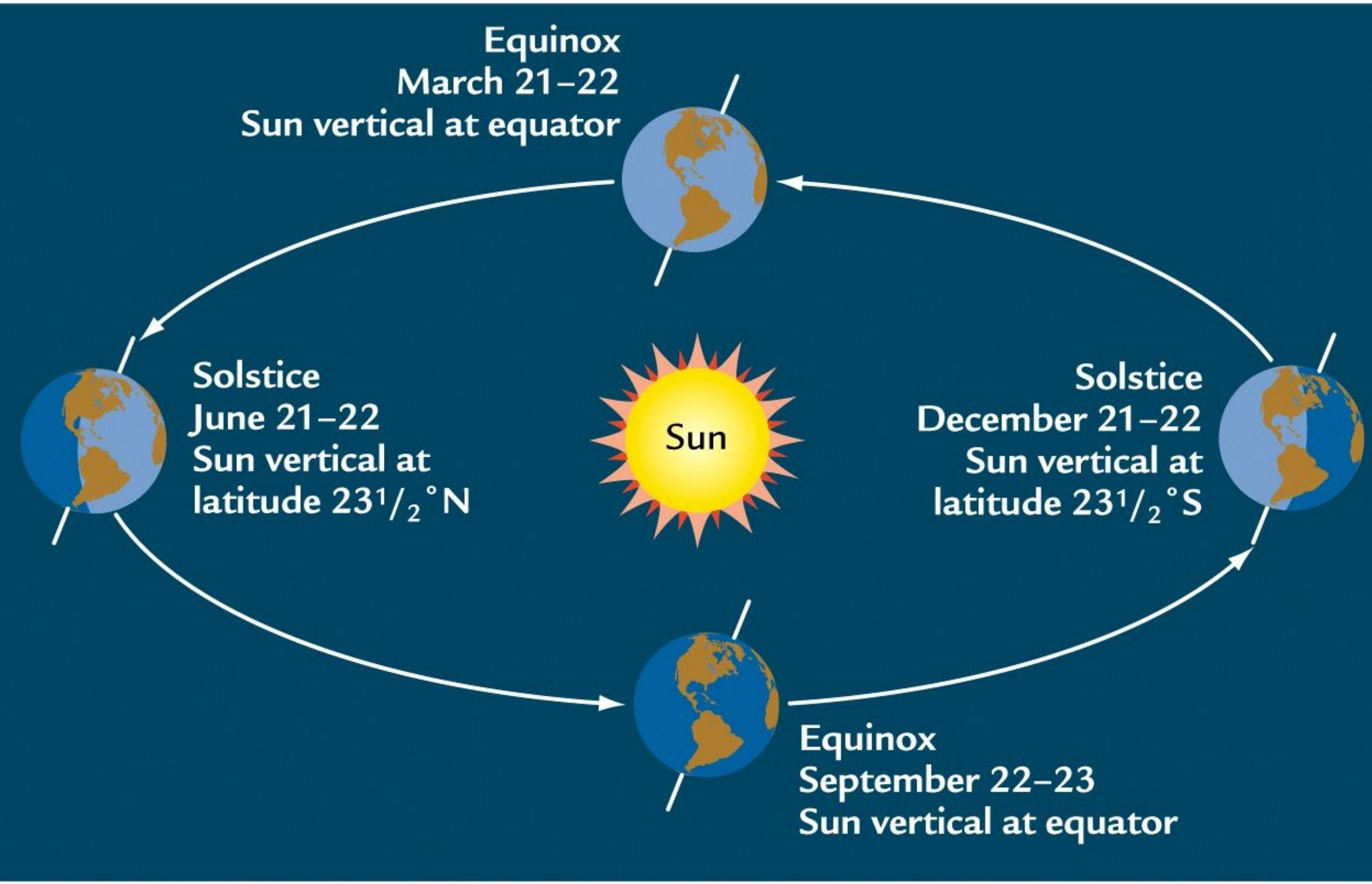
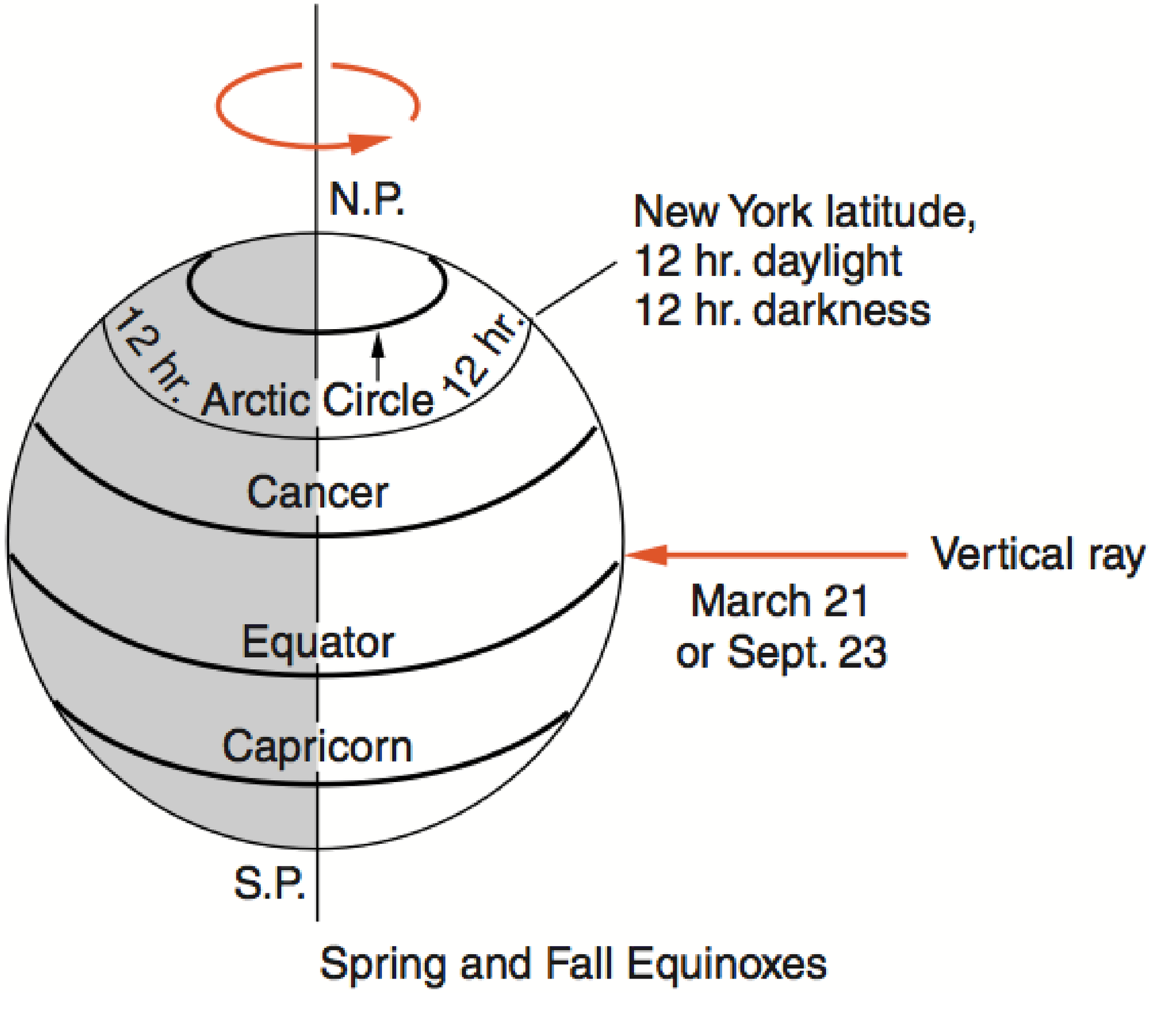
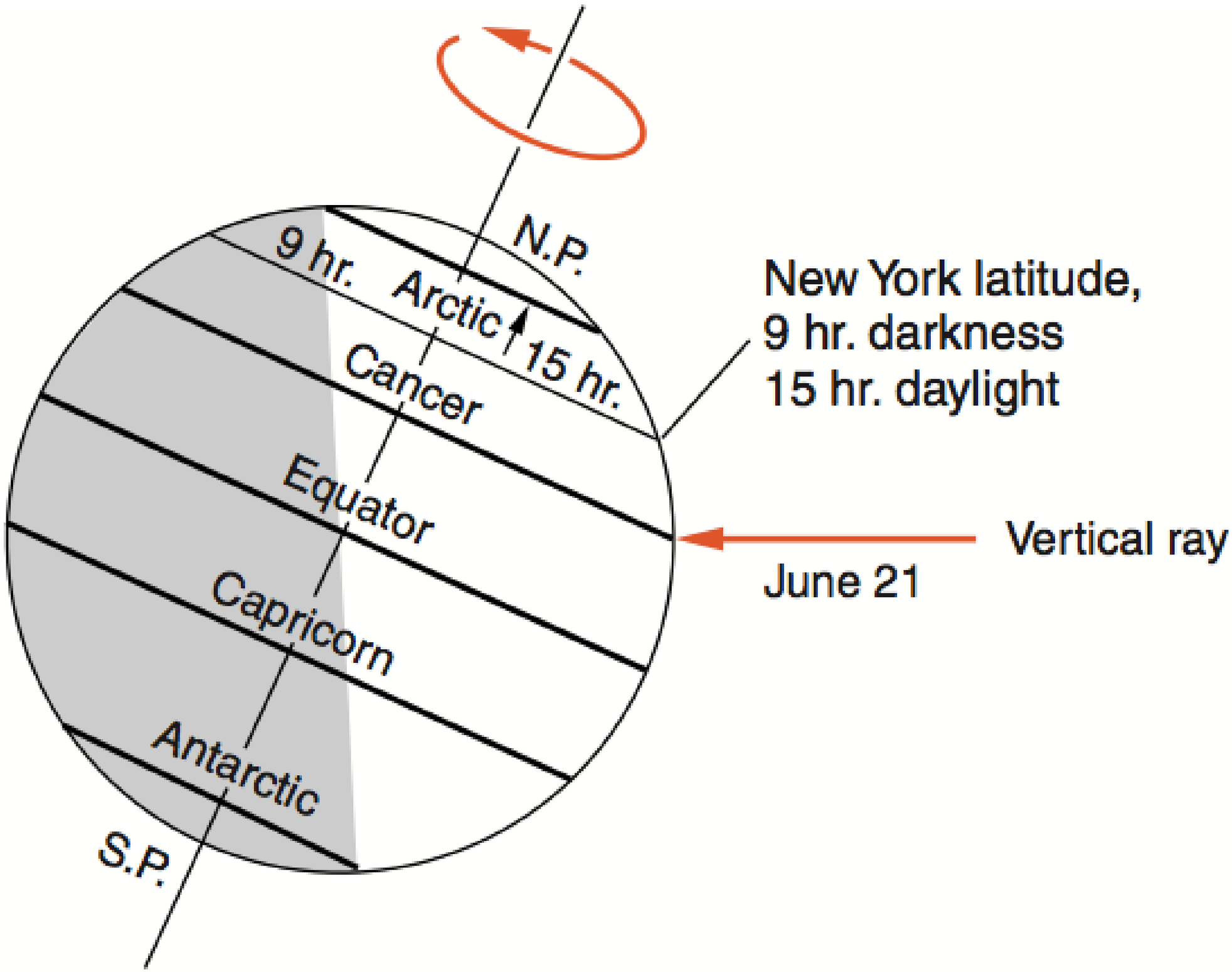


Earth's orbit

Goal: Students will determine why Earth experiences seasons.

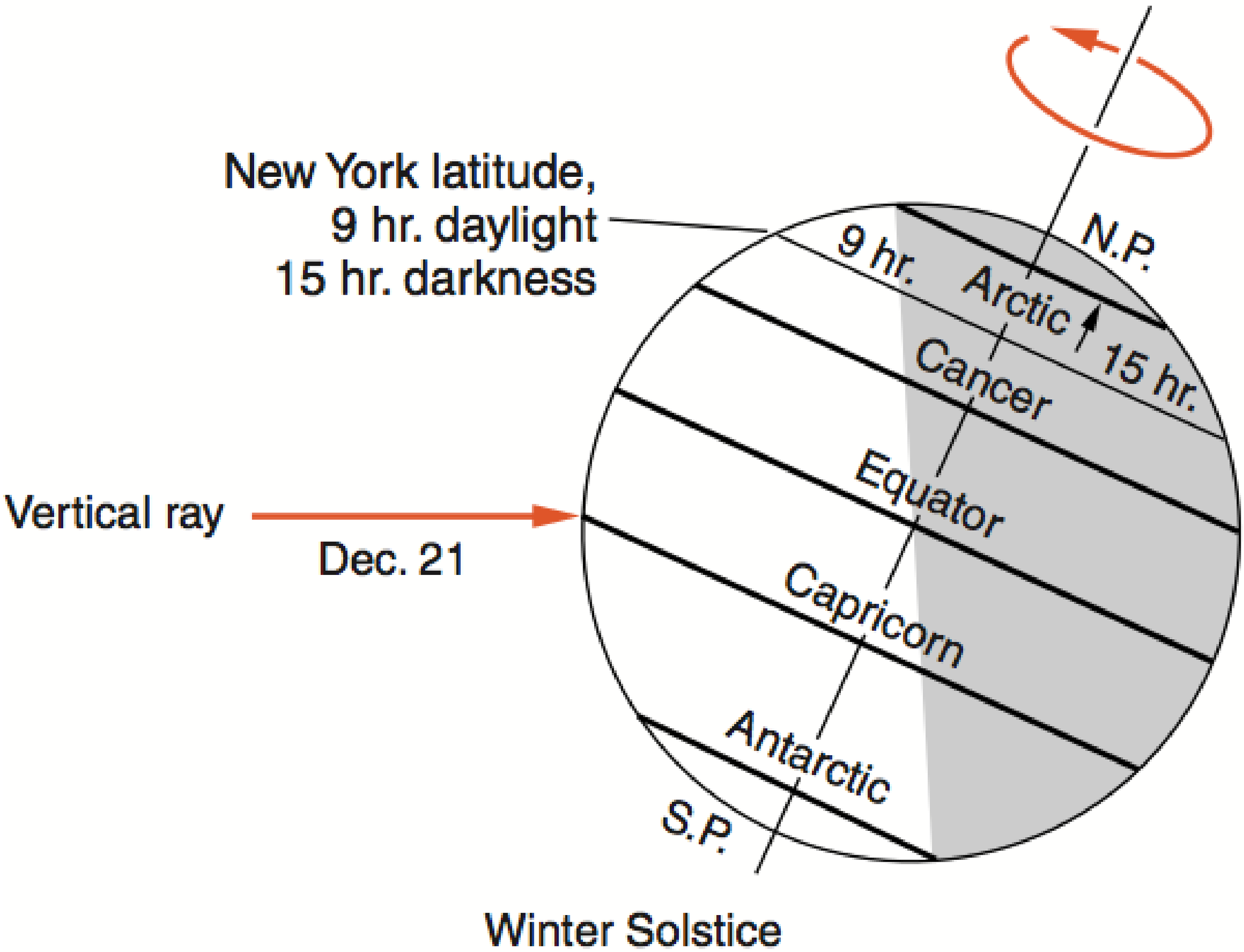


Goal: Students will determine why Earth experiences seasons.

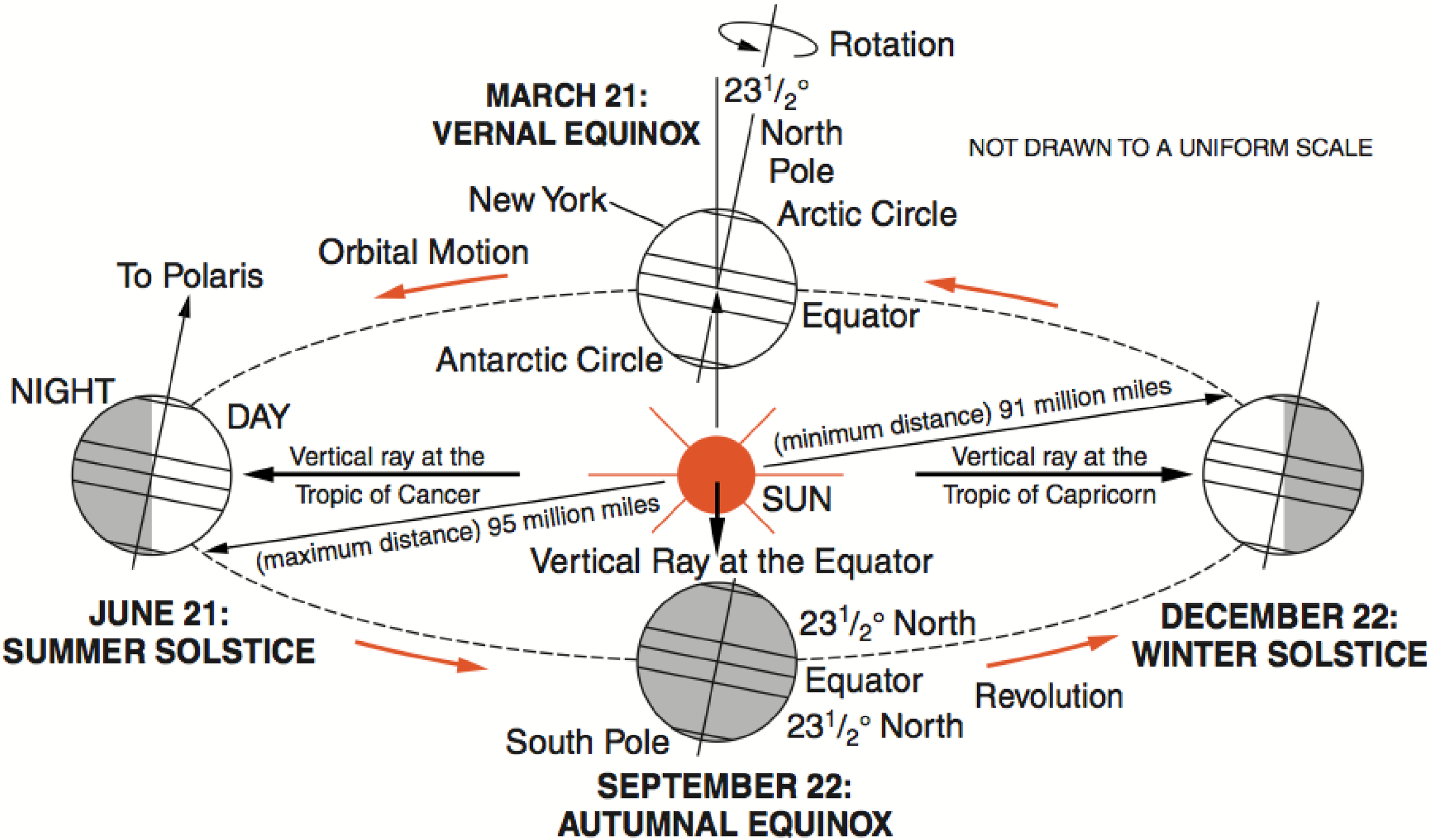


Summer Solstice

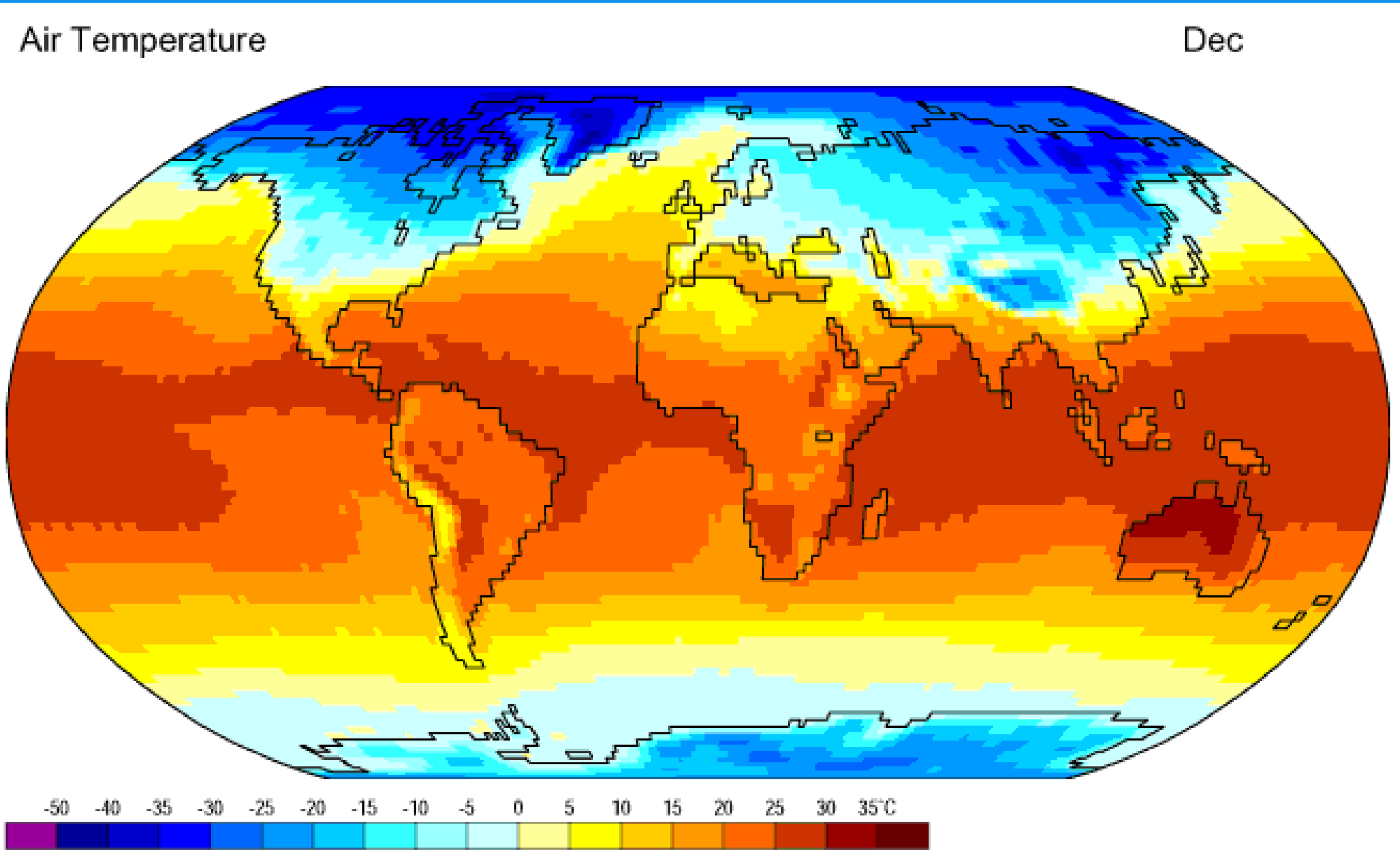
Goal: Students will determine why Earth experiences seasons.



Goal: Students will determine why Earth experiences seasons.



Goal: Students will determine why Earth experiences seasons.



Goal: Students will determine why Earth experiences seasons.

THROUGHOUT THE YEAR, DIFFERENT AREAS RECEIVE DIFFERENT AMOUNTS OF SUNLIGHT, AND SOME RECEIVE NO SUNLIGHT AT ALL FOR UP TO 6 MONTHS!

Goal: Students will determine why Earth experiences seasons.

THE SUN'S APPARENT PATH DURING DIFFERENT SEASONS

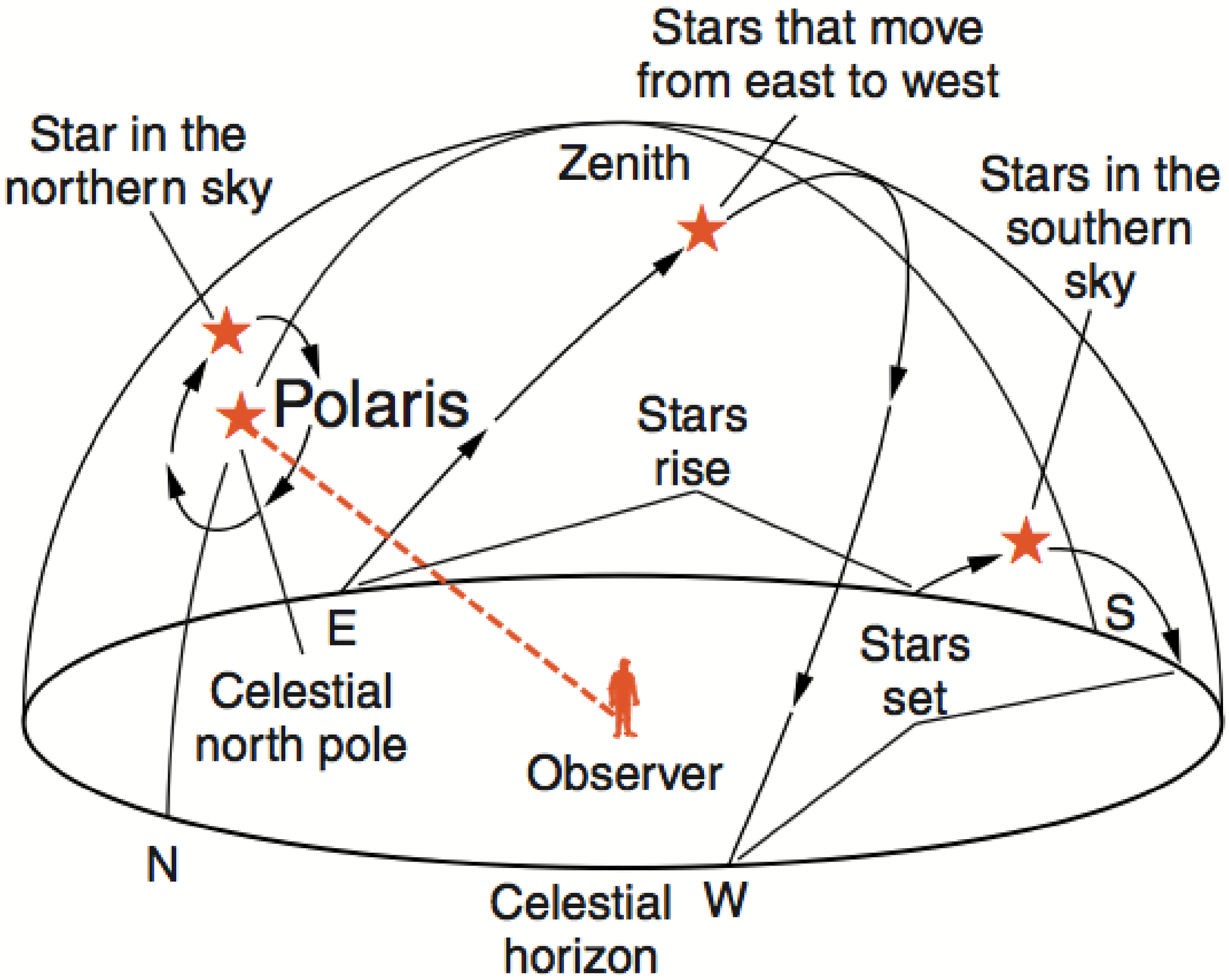
Goal: Students will determine why Earth experiences seasons.

WHERE DOES THE SUN RISE AND SET THROUGHOUT THE YEAR?

Goal: Students will determine how all celestial objects appear to move.

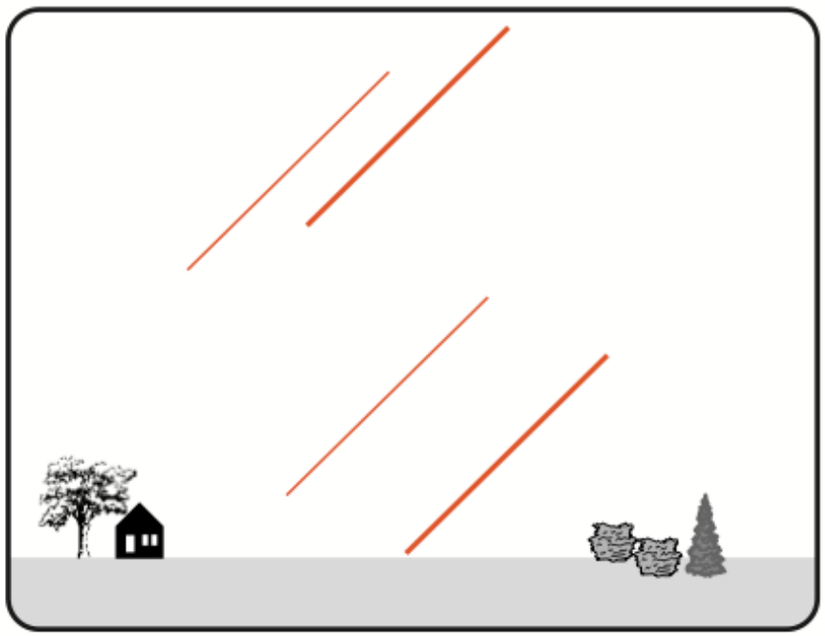
HOW DO OTHER CELESTIAL OBJECTS APPEAR TO MOVE?

Goal: Students will determine how all celestial objects appear to move.

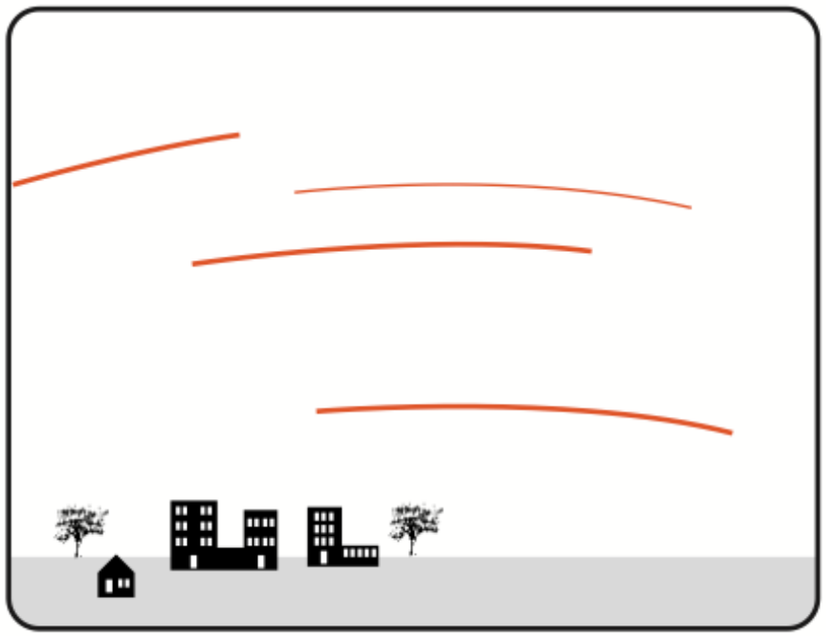


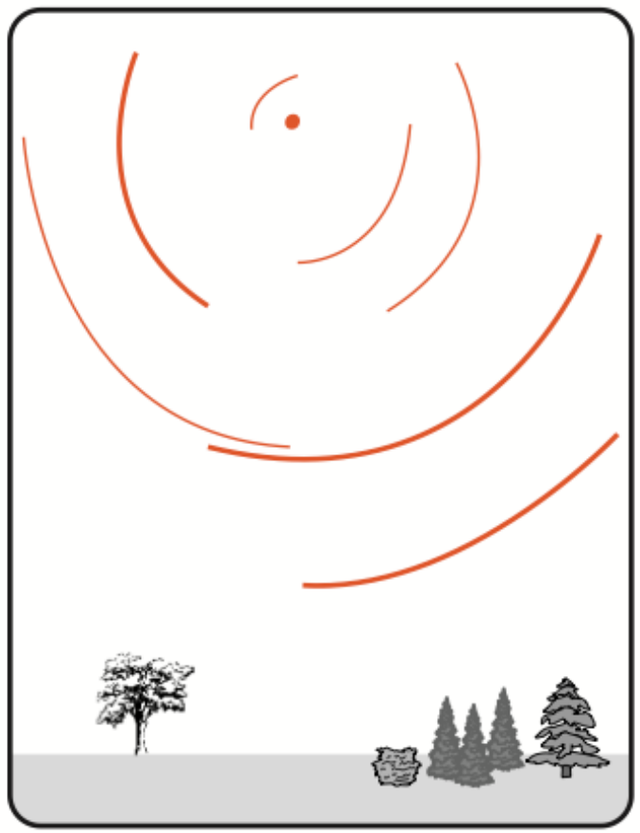
Goal: Students will determine how all celestial objects appear to move.

Looking East...
Stars rise and move to the right.



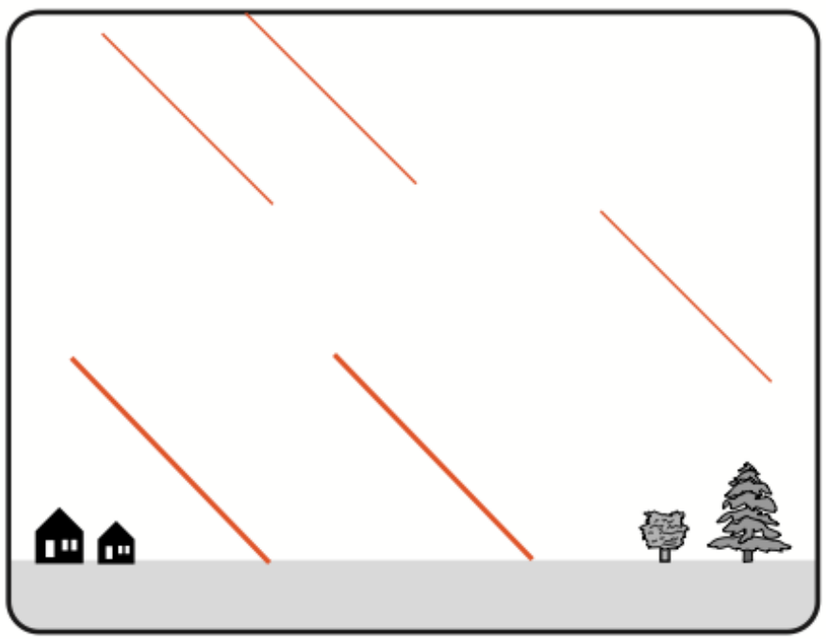
Looking South...
Stars circle to the right.





Looking North...
Stars circle counterclockwise around Polaris.

Looking West..
Stars set as they move to the right.



Goal: Students will determine how all celestial objects appear to move.

DAILY MOTIONS OF CELESTIAL OBJECTS

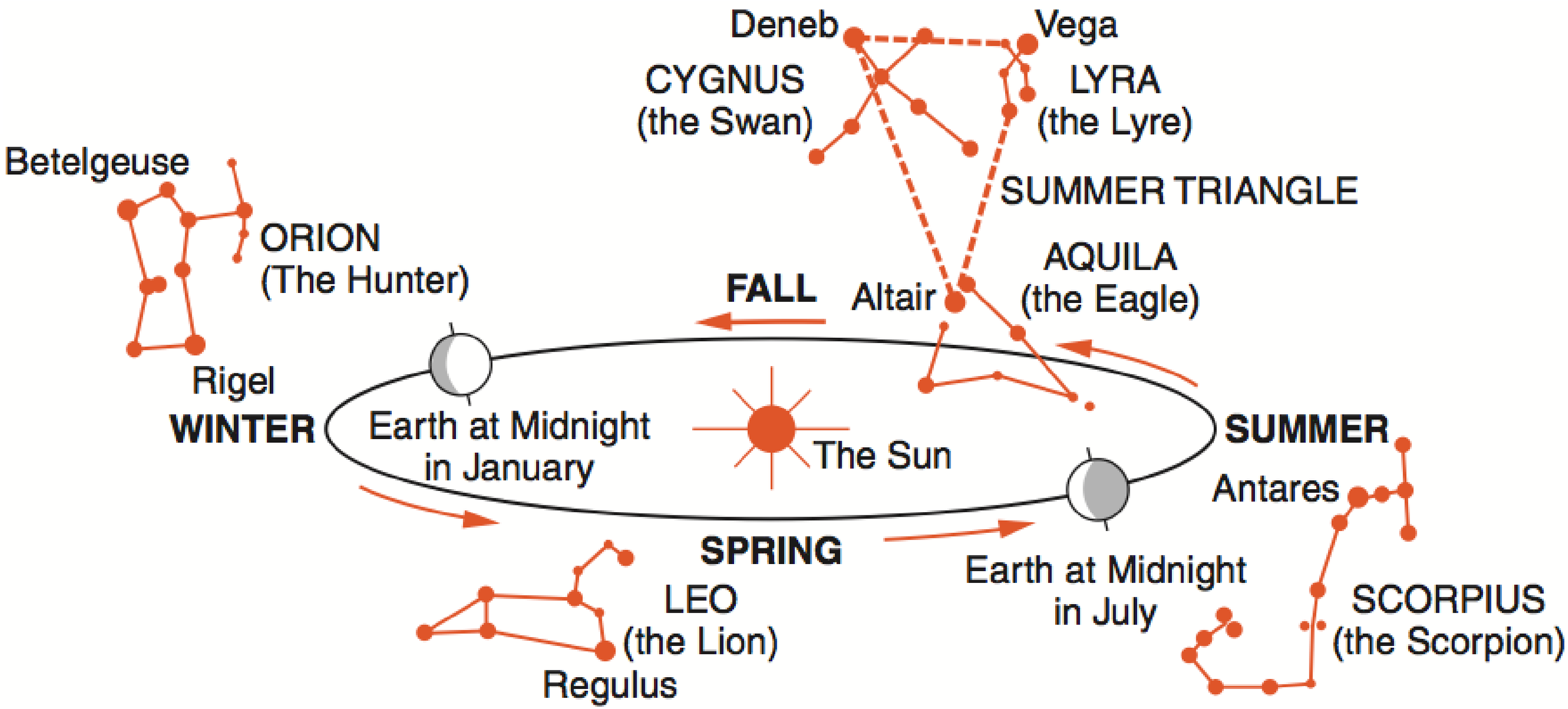
- Earth's rotation will make celestial objects appear to move on a daily basis.
- All objects appear to move around Polaris (The North Star) in the Northern Hemisphere.
- Some stars will stay in the sky and never set. These stars are called circumpolar stars.
- Other stars will rise in the east and set in the west, just like the Sun.

Goal: Students will determine how all celestial objects appear to move.

YEARLY MOTIONS OF CELESTIAL OBJECTS

- Earth's revolution will make celestial objects appear to move throughout the year.
- Some constellations will appear in the sky during certain months, but not in others.

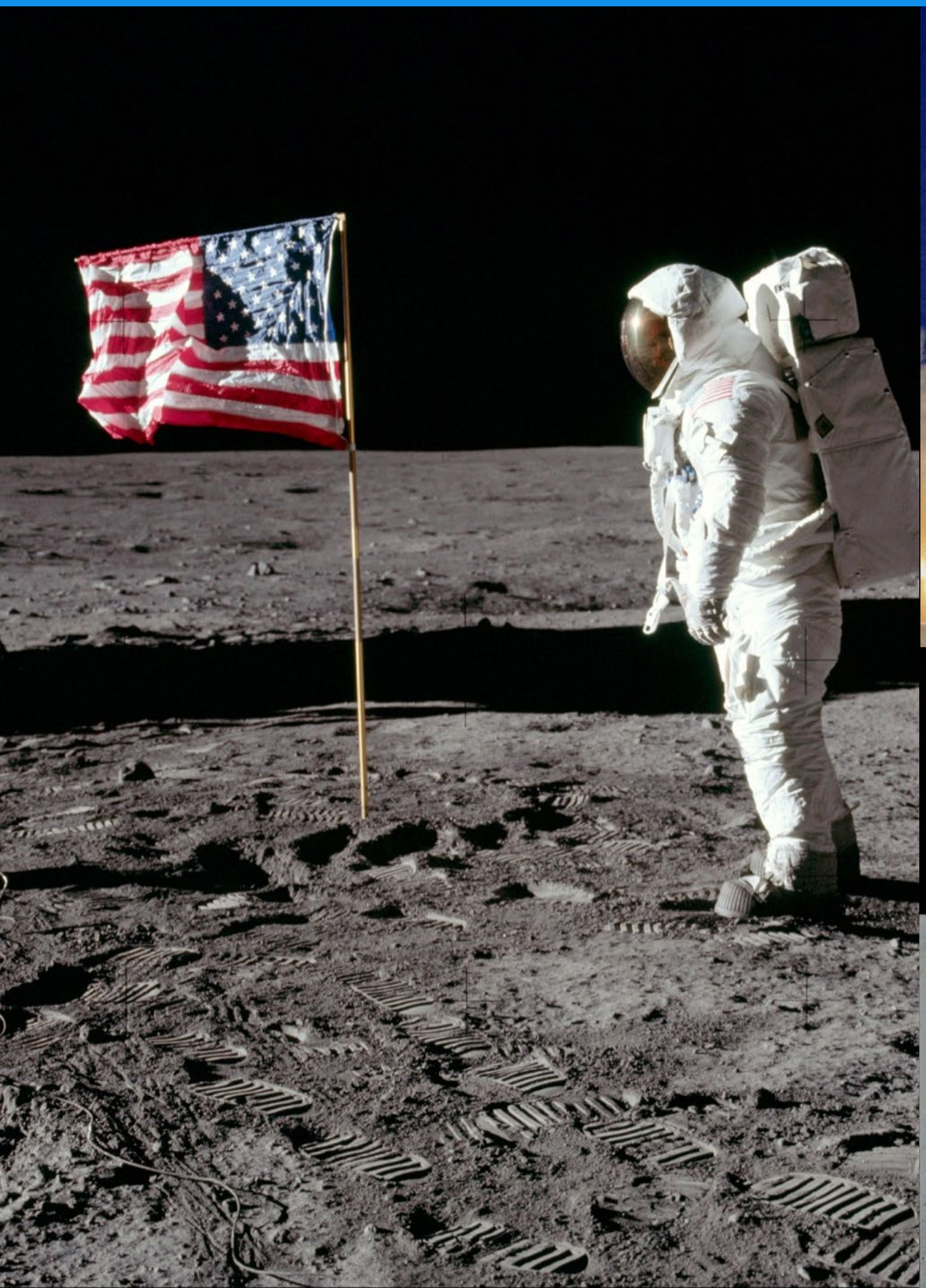
Goal: Students will determine how all celestial objects appear to move.

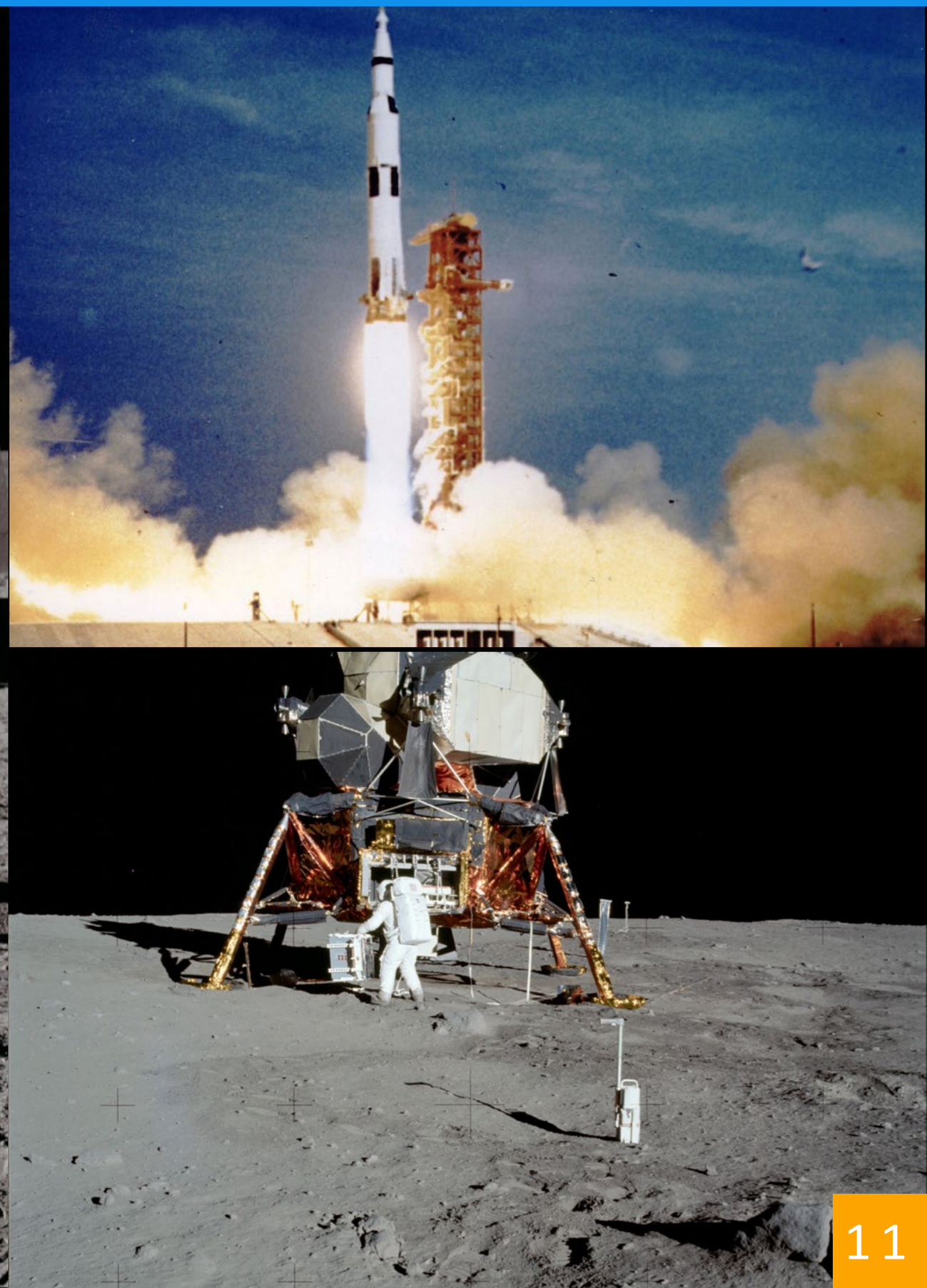


Goal: Students will define the Moon and describe its motions.

THE MOON

Goal: Students will define the Moon and describe its motions.





Goal: Students will define the Moon and describe its motions.

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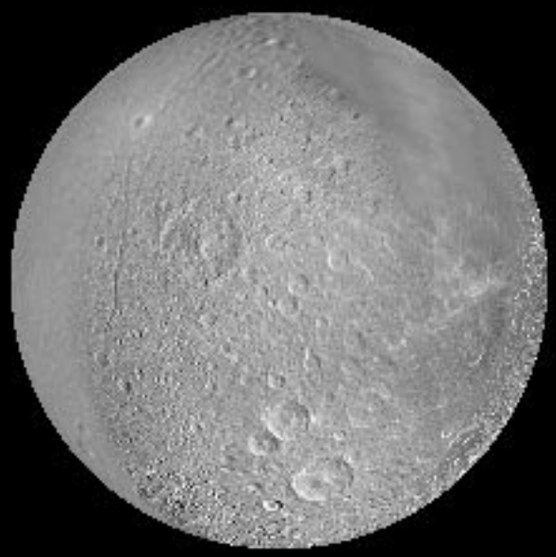
WHAT IS THE MOON?

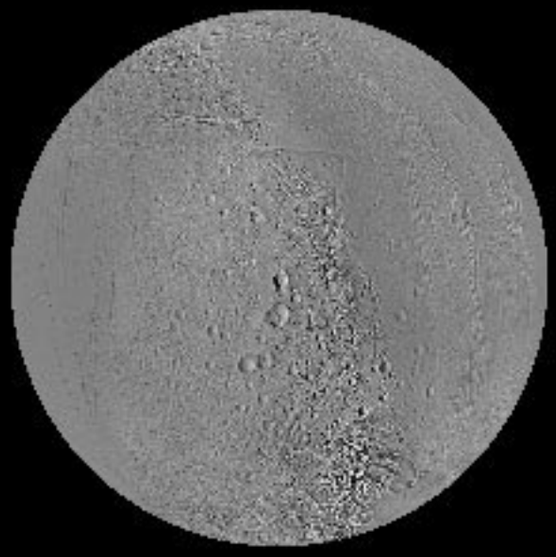
- Any moon is a natural satellite of a planet.
- A satellite is an object in space that revolves around another object under the influence of gravity.

Goal: Students will define the Moon and describe its motions.

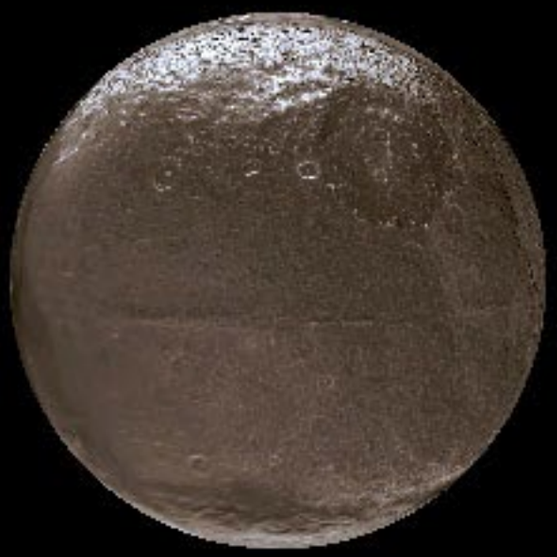
MOONS OF SATURN



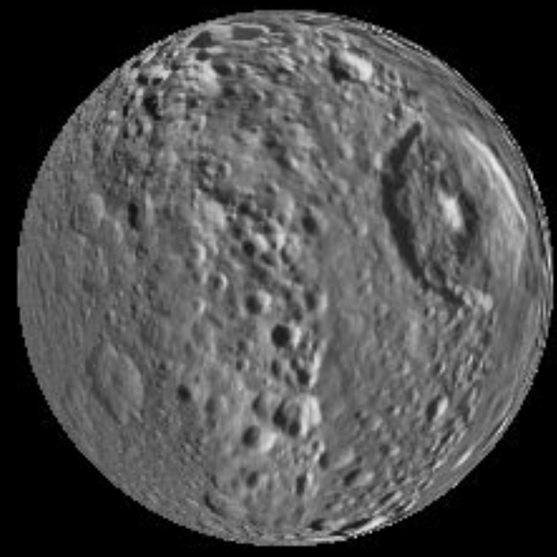
Dione



Enceladus



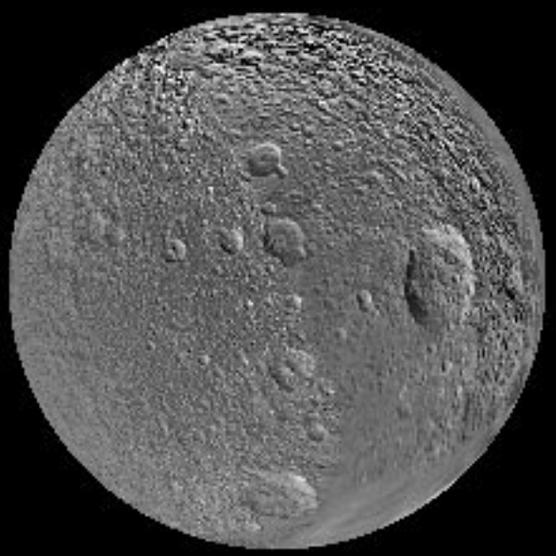
Iapetus



Mimas

Phoebe

Rhea



Tethys

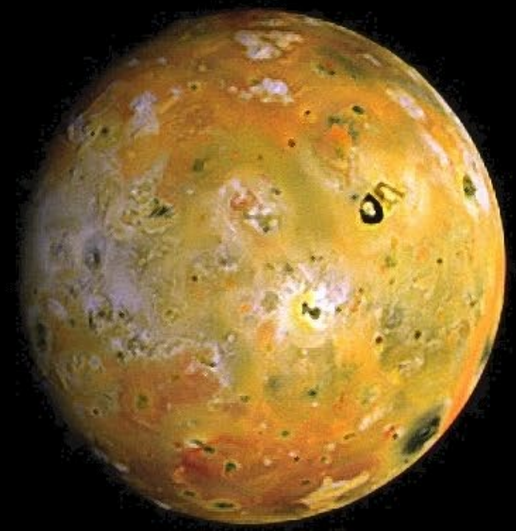
Titan

Goal: Students will define the Moon and describe its motions.

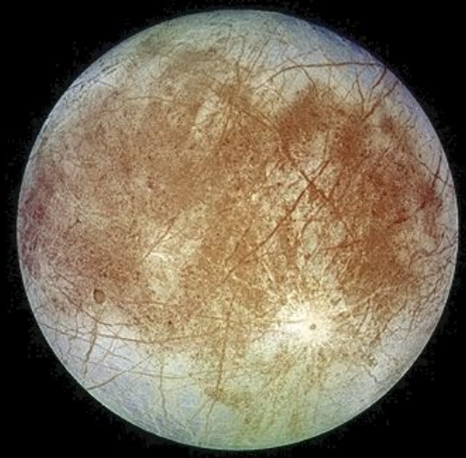
MOONS OF JUPITER

Ganymede

Callisto



Io

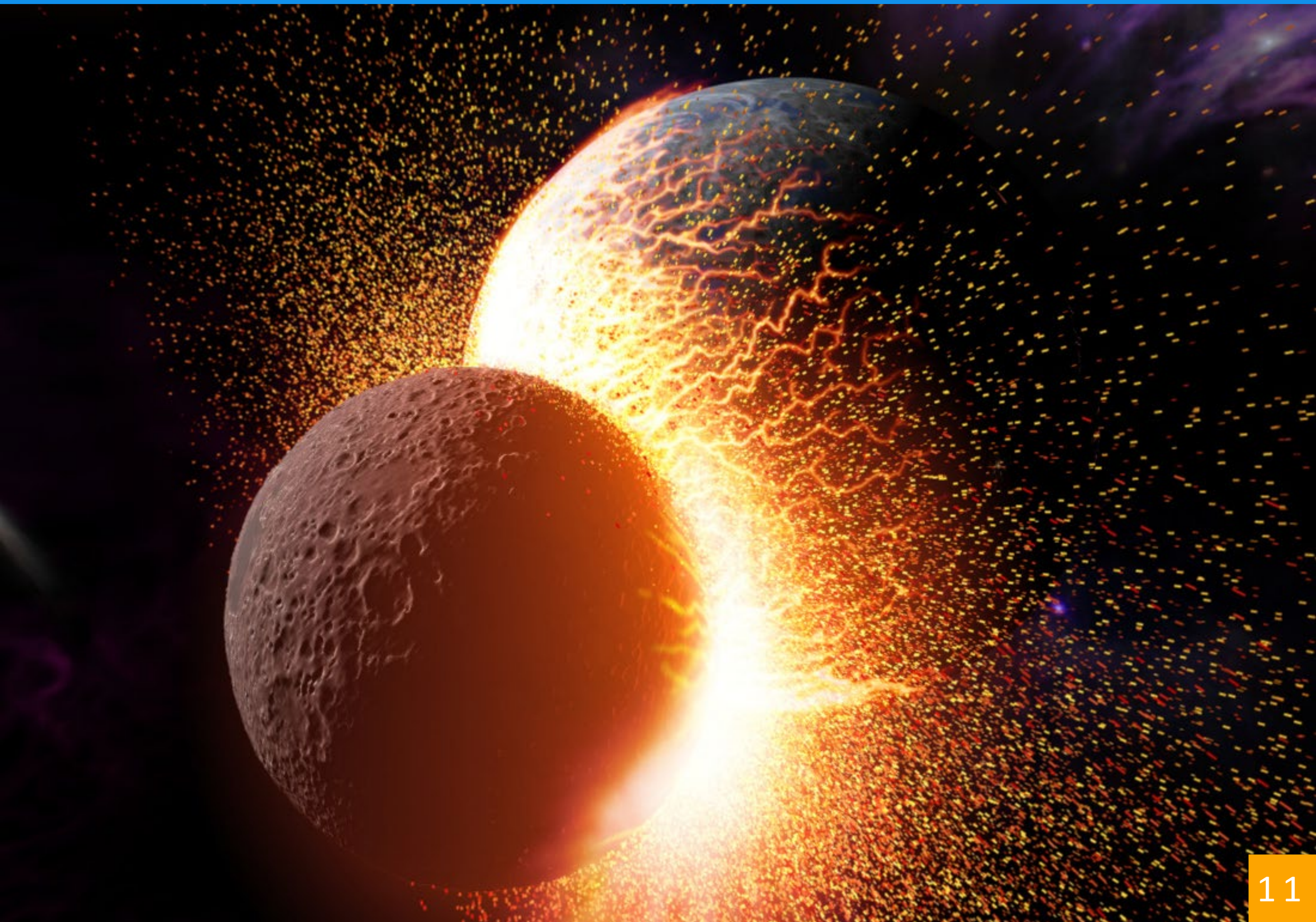


Europa

Goal: Students will define the Moon and describe its motions.

HOW DID OUR MOON GET THERE?

Goal: Students will define the Moon and describe its motions.



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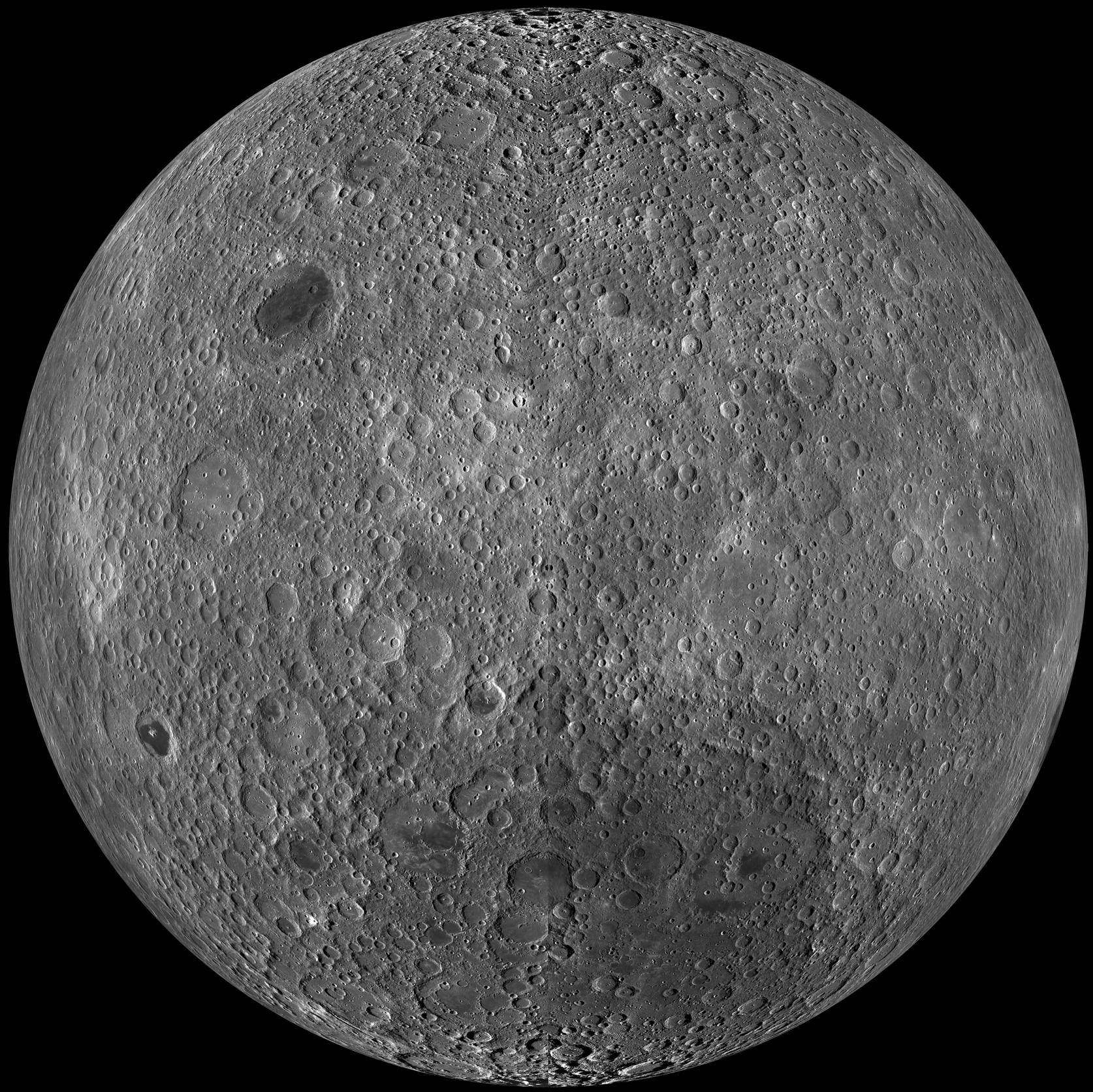


Goal: Students will define the Moon and describe its motions.

HOW DOES THE MOON MOVE?

- Like any planet, the orbits of moons are elliptical (not circular).
- The Moon takes 27.3 days to complete one orbit.
- An ellipse is an object drawn around two fixed points called foci. Each individual point is called a focus.

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

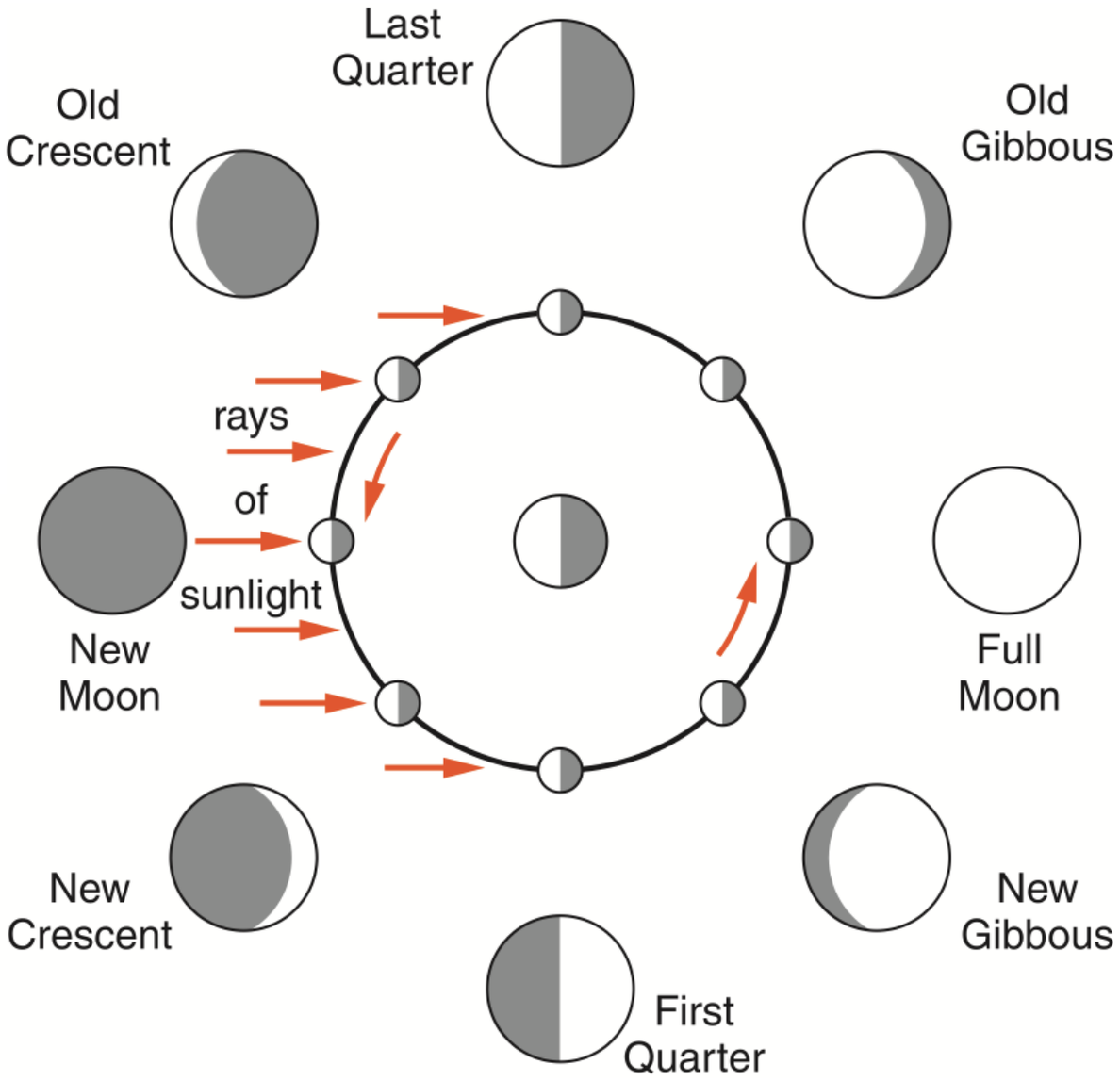
Goal: Students will define the Moon and describe its motions.

PHASES OF THE MOON

Goal: Students will define the Moon and describe its motions.

WHAT CAUSES THE PHASES OF THE MOON?

- Phase - the apparent shape of the moon, which is determined by the pattern of light and shadow.
- The Moon's phase is determined by how much of the lit side of the Moon is facing the Earth.
- It takes 29.5 days for the Moon to go through all of its phases.



Goal: Students will define the Moon and describe its motions.

WHY DOES IT TAKE 27.3 DAYS FOR THE MOON TO ORBIT THE EARTH, BUT 29.5 DAYS FOR THE MOON TO GO THROUGH ITS PHASES?

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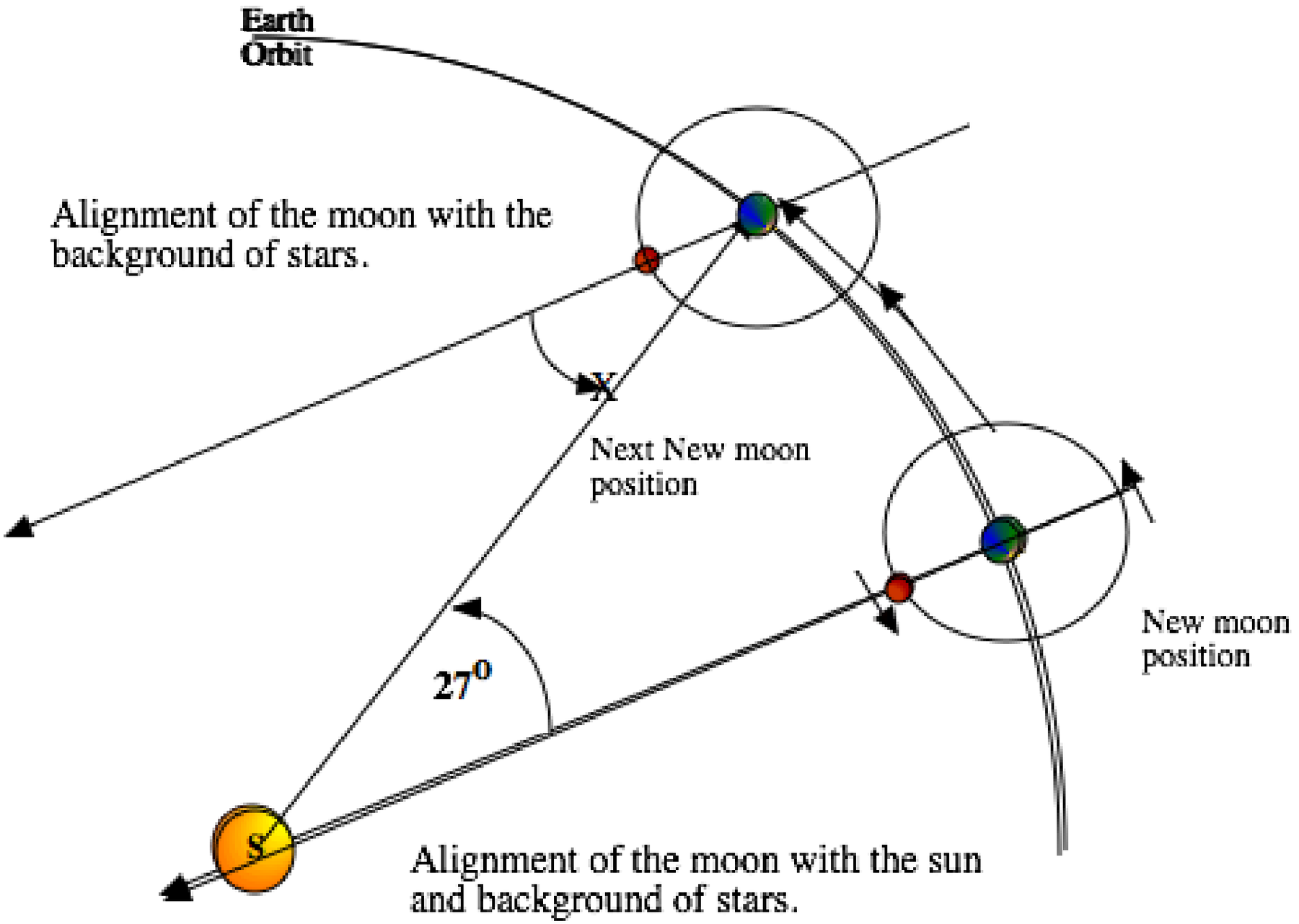
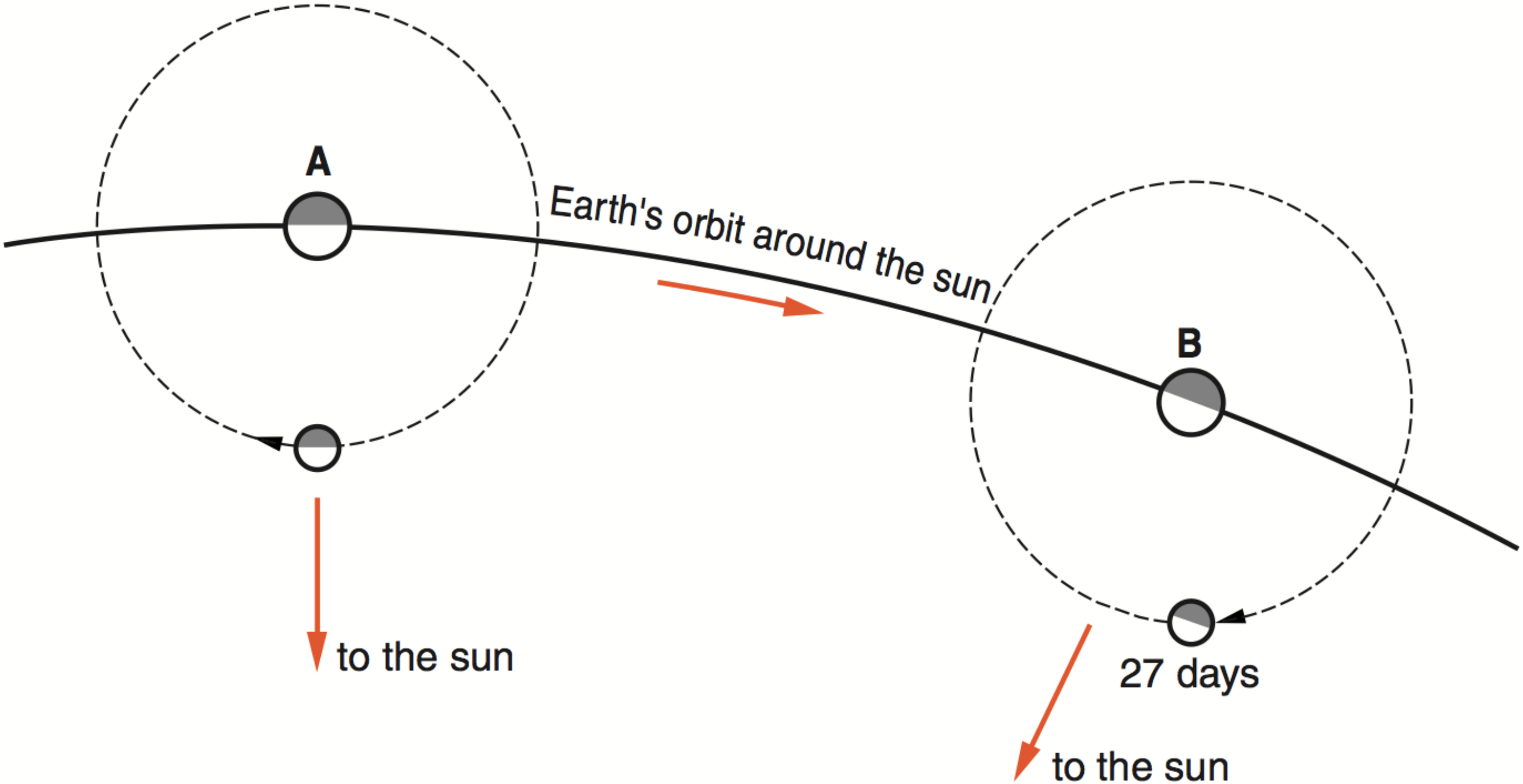


As moon orbits Earth, the Earth-Moon system moves relative to the sun. Moon has completed one revolution relative to the background of stars.

The moon moves 13.5 degrees per day .

Goal: Students will define the Moon and describe its motions.



Goal: Students will explain why eclipses occur.

ECLIPSES

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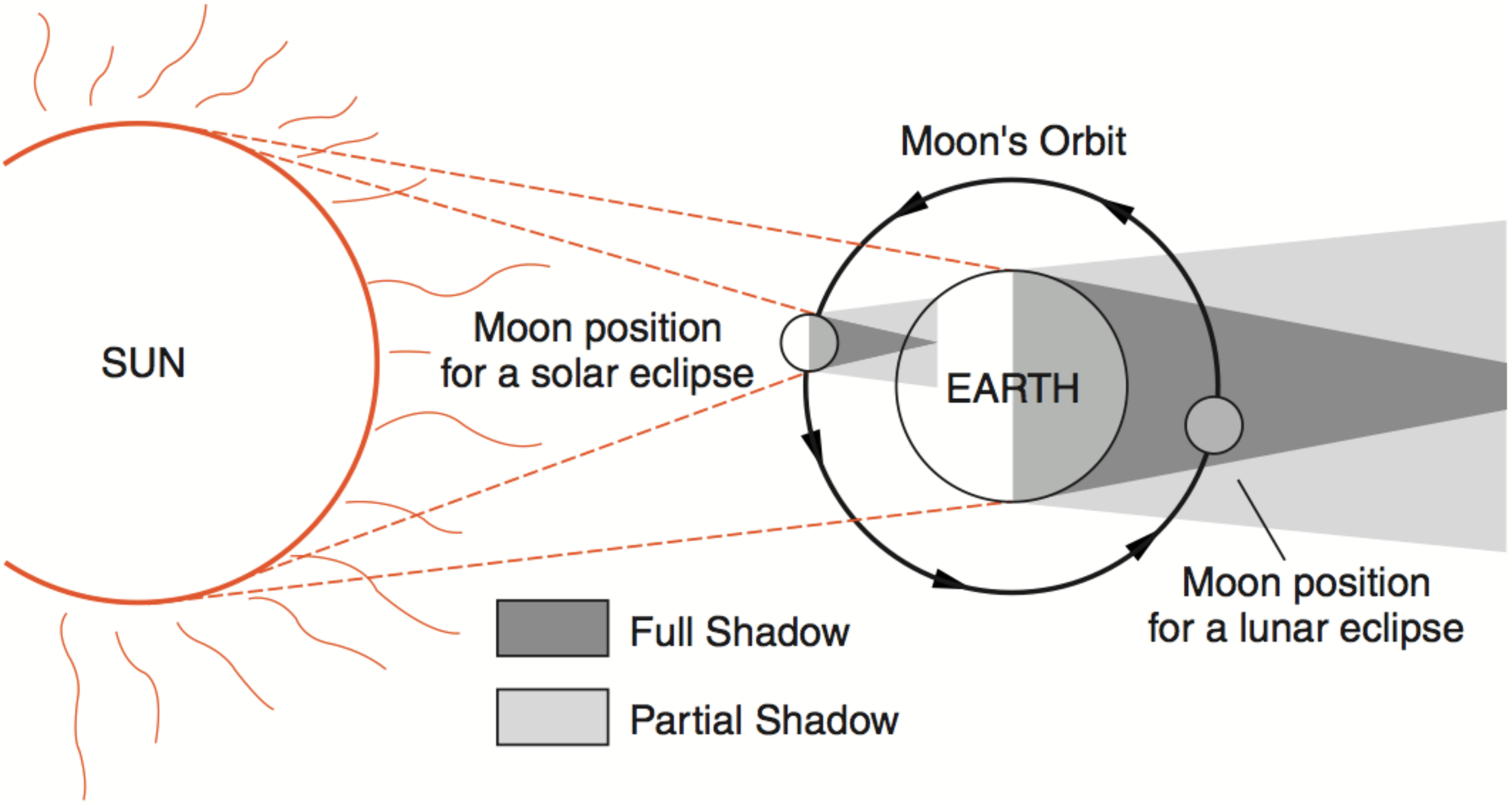
WHAT IS AN ECLIPSE?

- An eclipse occurs when one celestial object blocks the light of another.
- We have two types of eclipses:
  - Solar eclipse - when the Moon blocks sunlight from reaching the Earth.
  - Lunar eclipse - when the Earth blocks sunlight from reaching the Moon.

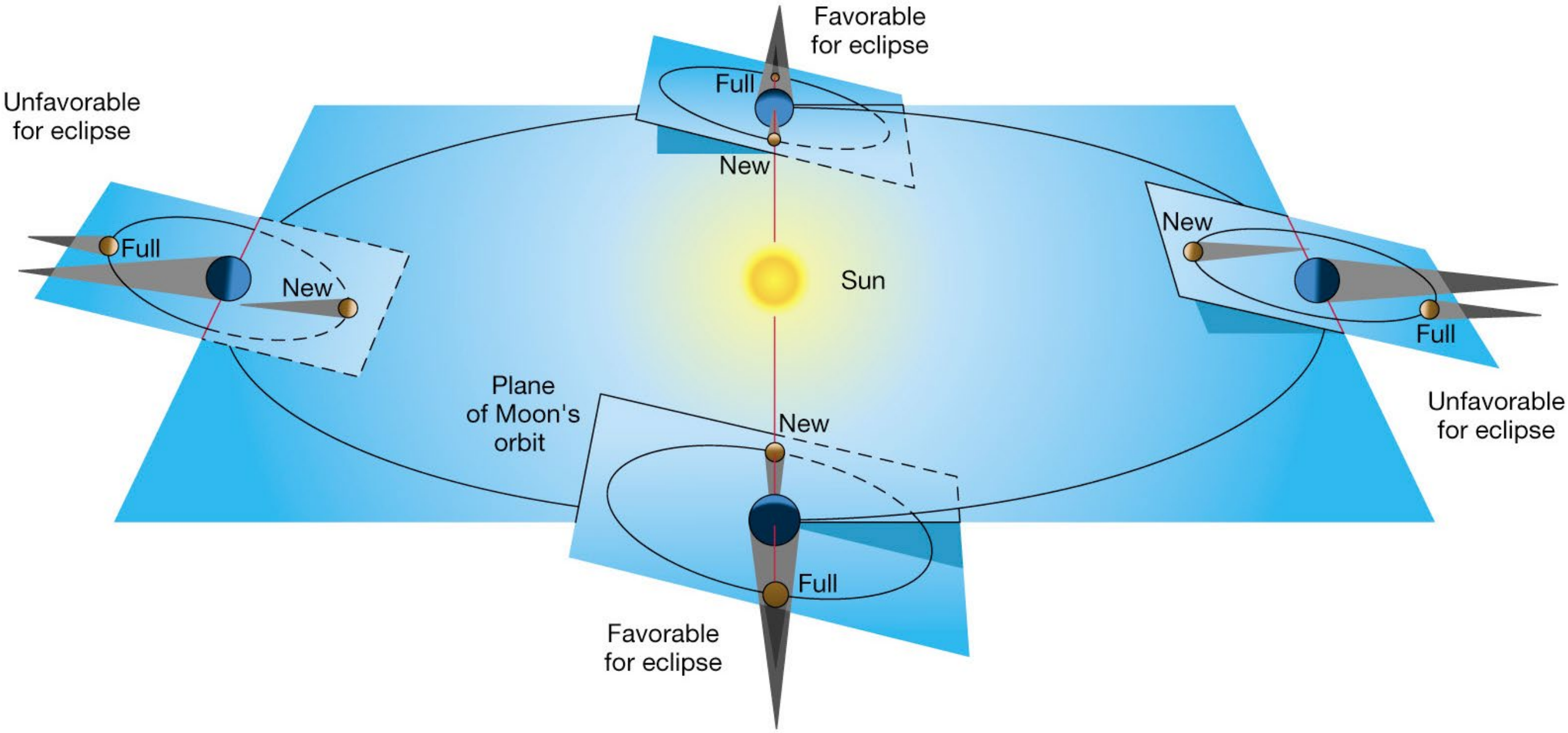
Goal: Students will explain why eclipses occur.



Goal: Students will explain why eclipses occur.

WHY DOESN'T AN ECLIPSE HAPPEN EVERY MONTH?

Goal: Students will explain why eclipses occur.



Goal: Students will discover how the Moon influences the Earth.

WHAT ELSE CAN THE MOON INFLUENCE ON EARTH?

Goal: Students will discover how the Moon influences the Earth.

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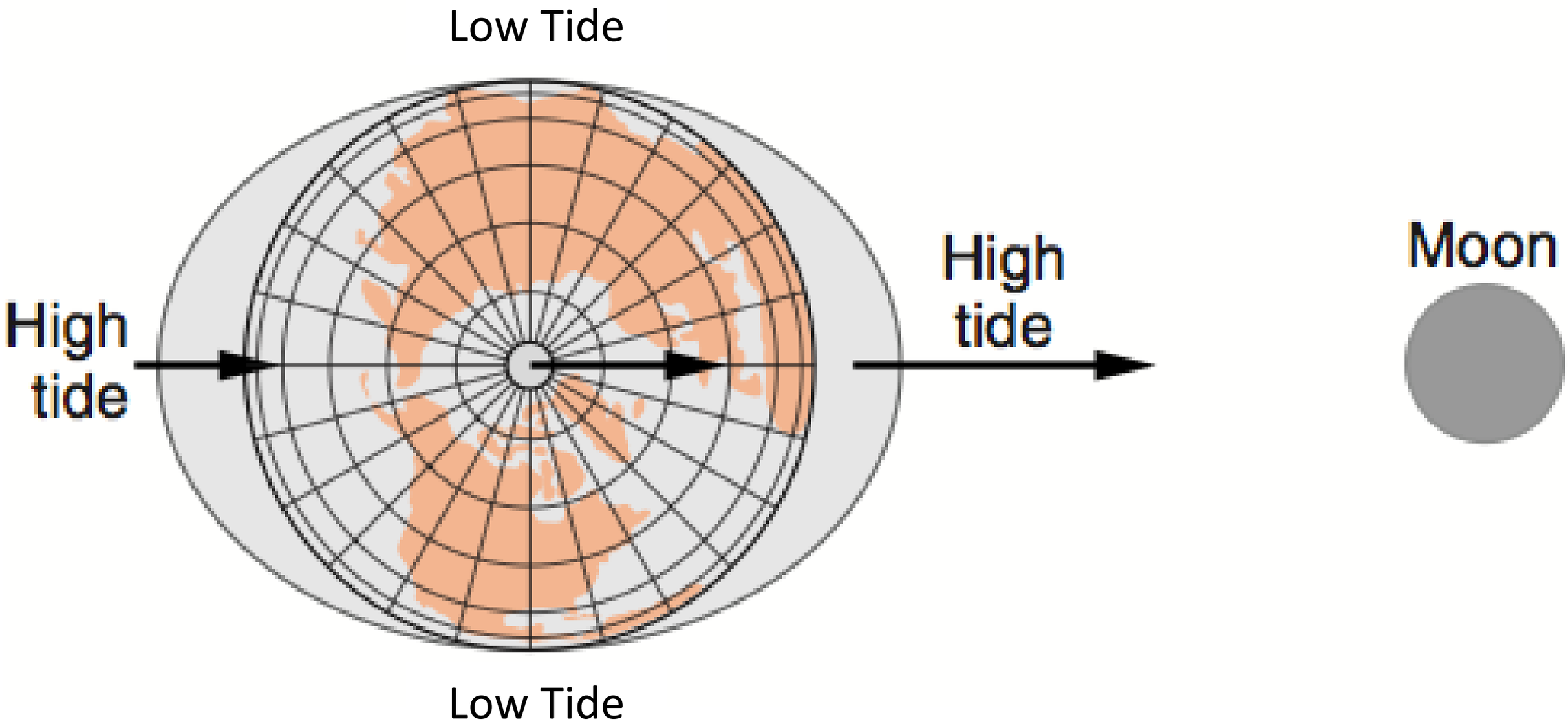
Goal: Students will discover how the Moon influences the Earth.

Goal: Students will discover how the Moon influences the Earth.

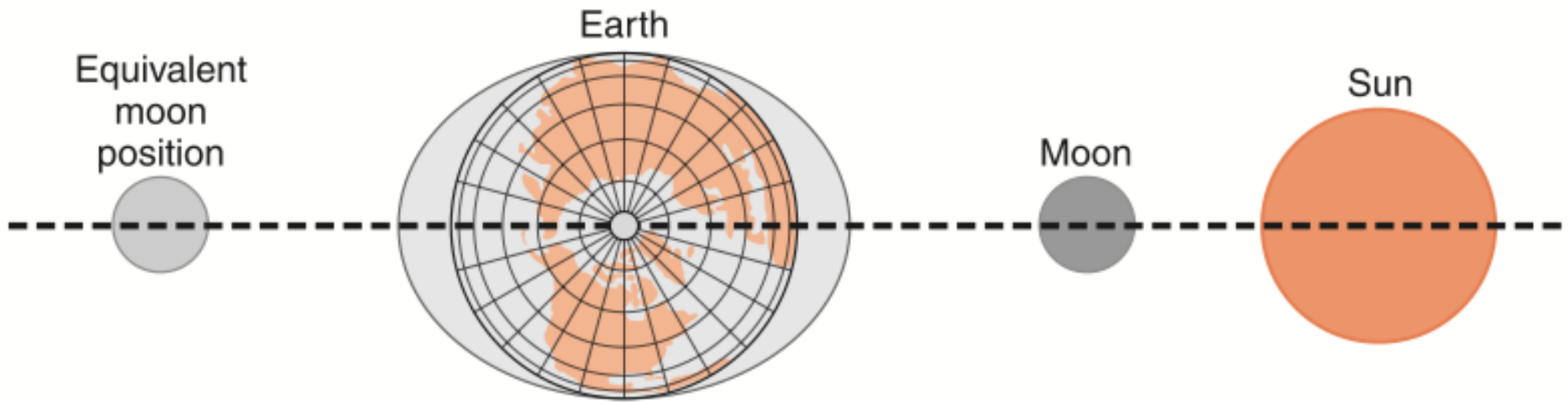
WHAT ARE TIDES?

- The twice-daily cycle of change in sea level.
- Tides are caused by the gravitational attraction between the Moon and Earth, as well as between the Sun and Earth.

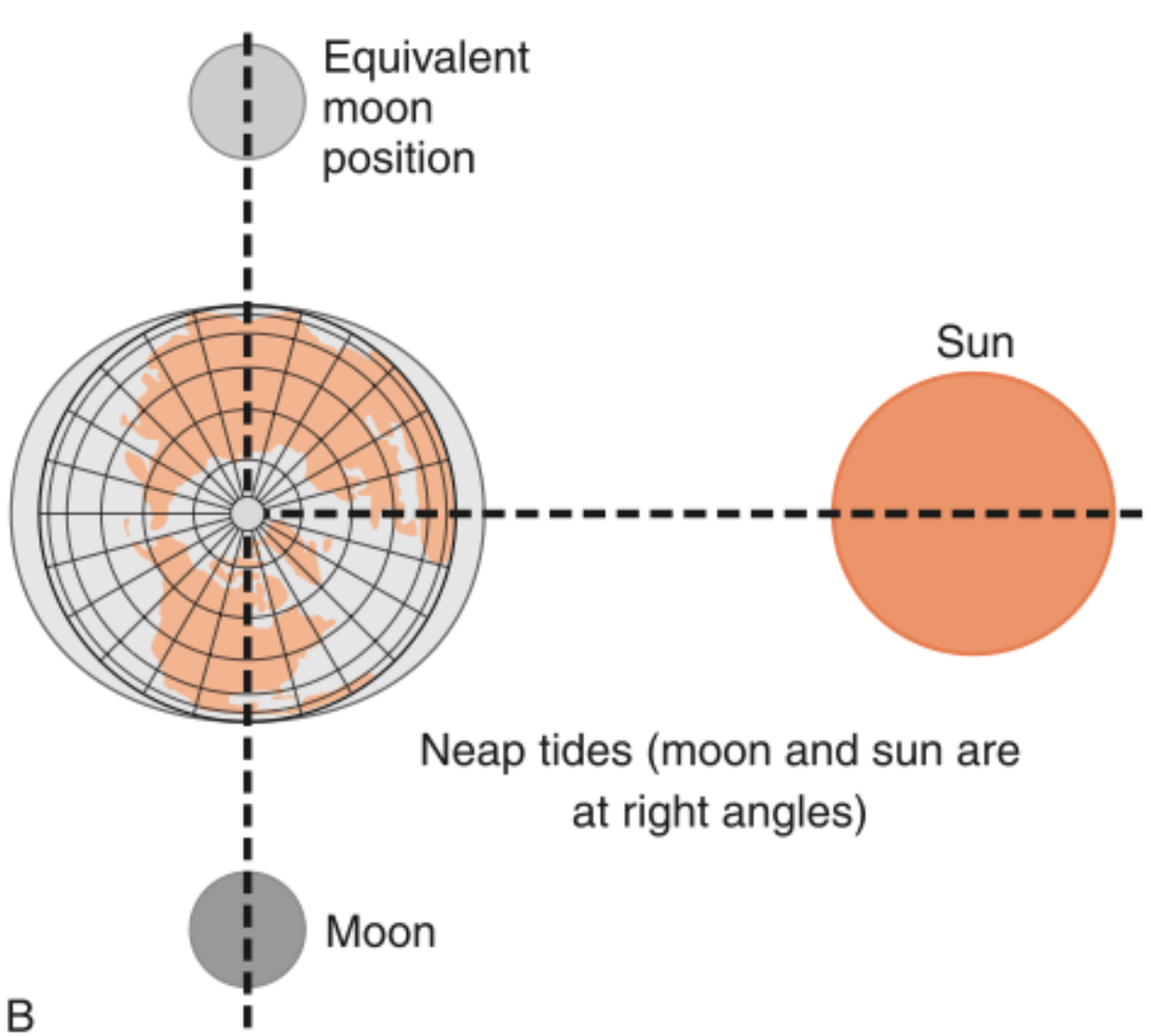
Goal: Students will discover how the Moon influences the Earth.



Goal: Students will discover how the Moon influences the Earth.



A Spring Tides (Earth, moon, and sun are in a line)



Neap tides (moon and sun are at right angles)

B

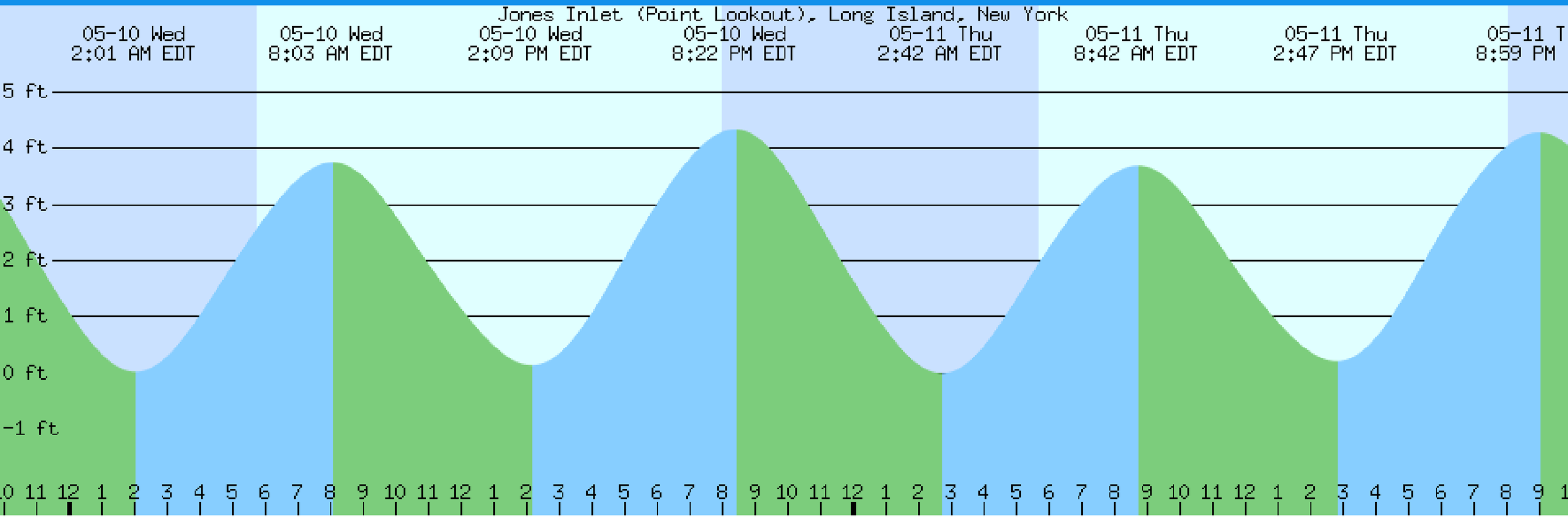
Goal: Students will discover how the Moon influences the Earth.

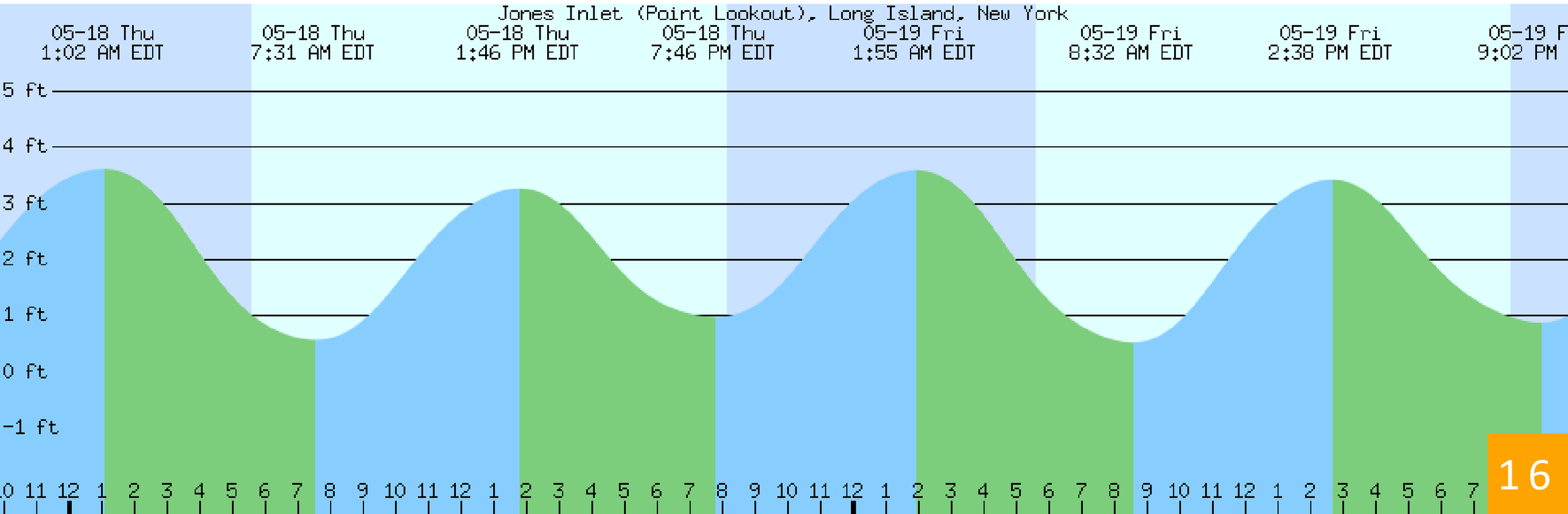
THERE ARE TWO SPECIAL TIDES

- Spring tide: When the Earth, sun, and moon are in a line with one another, and the range of the tides is highest (highest high tide and lowest low tide). (The sun and moon do not need to be on the same side of Earth.)

- Neap tide: When the sun and moon are at right angles to Earth, and the range of the tides is the lowest (lowest high tide and highest low tide).

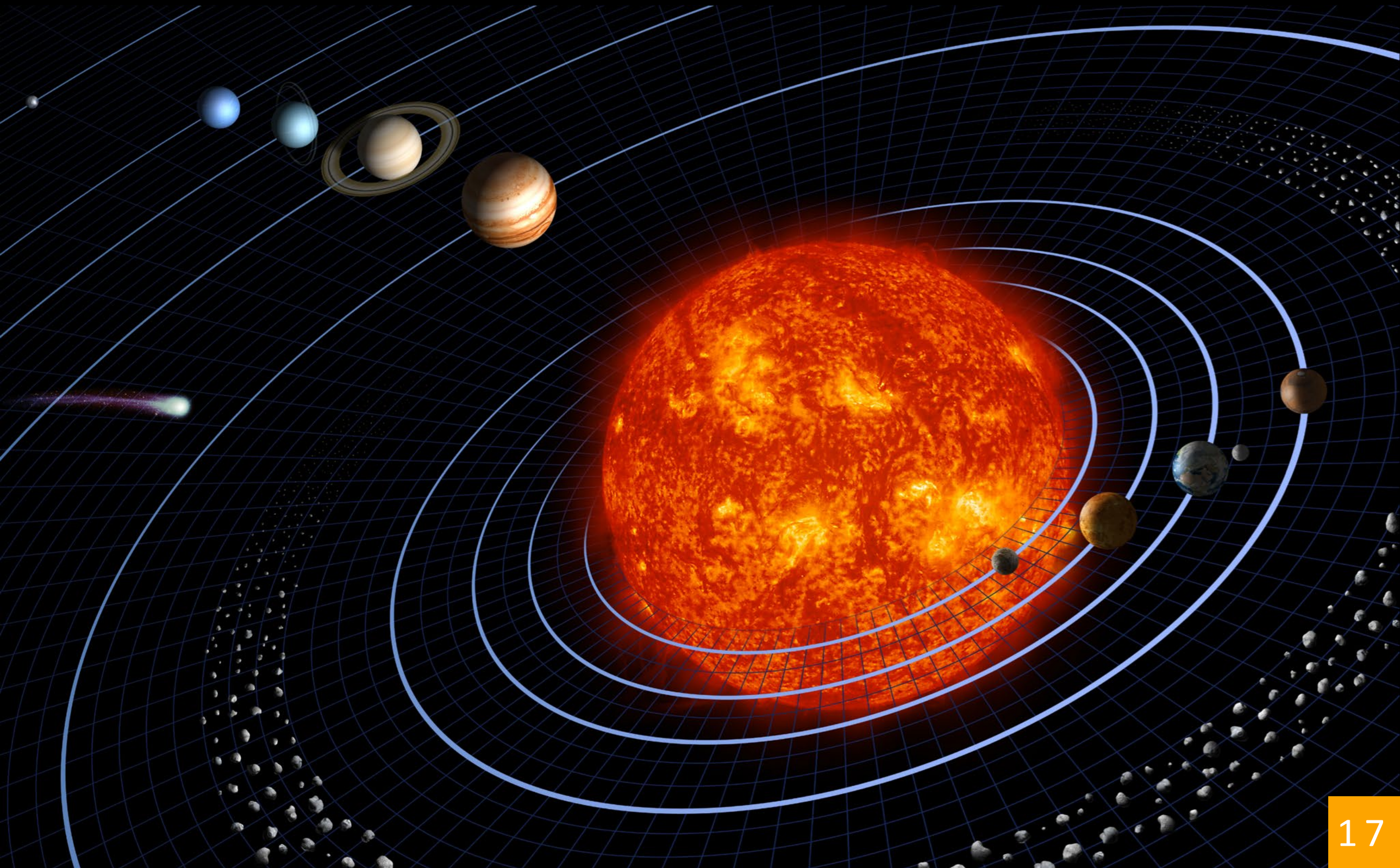
Goal: Students will discover how the Moon influences the Earth.





Goal: Students will be able to describe properties of solar system objects.

THE SOLAR SYSTEM



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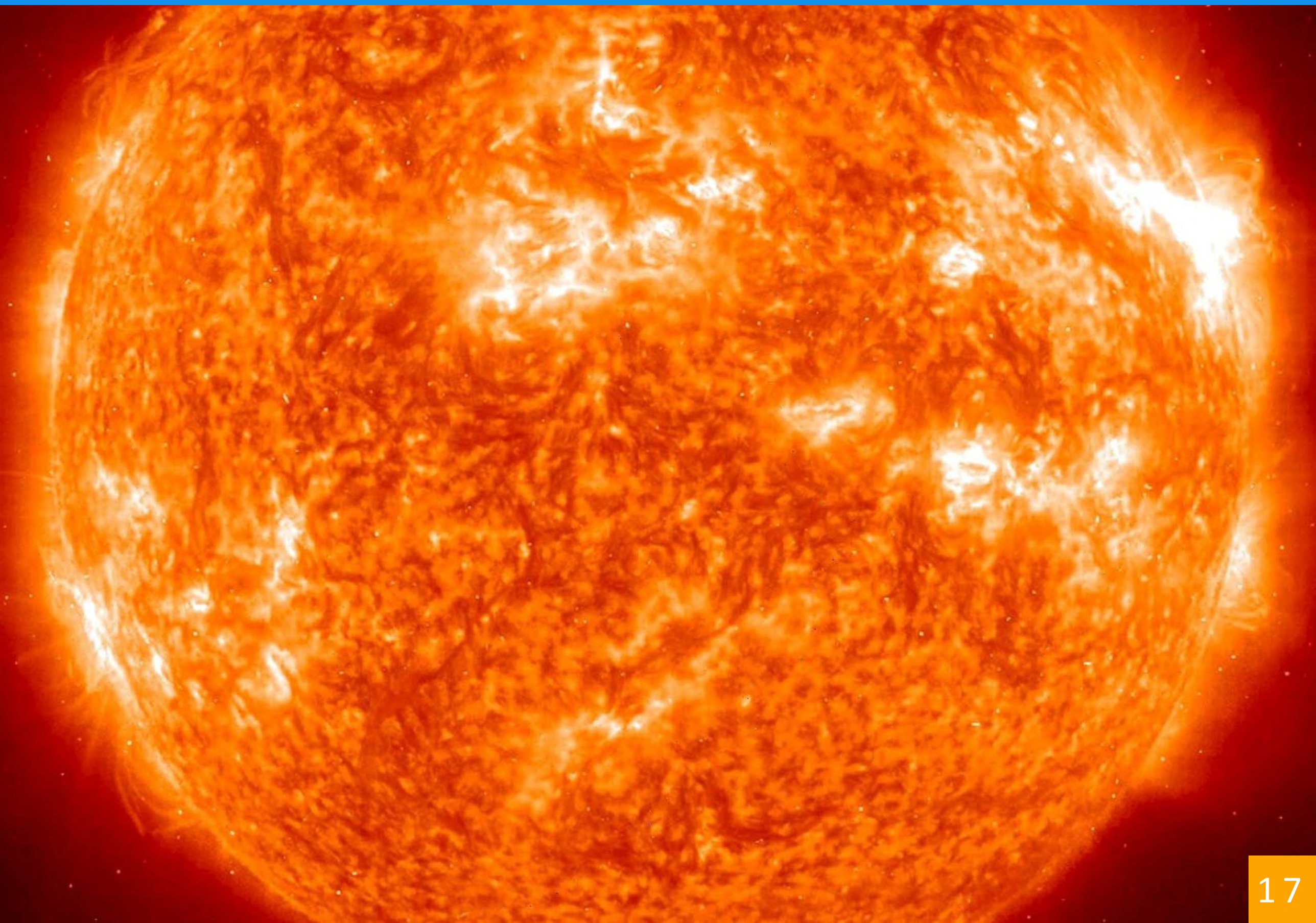

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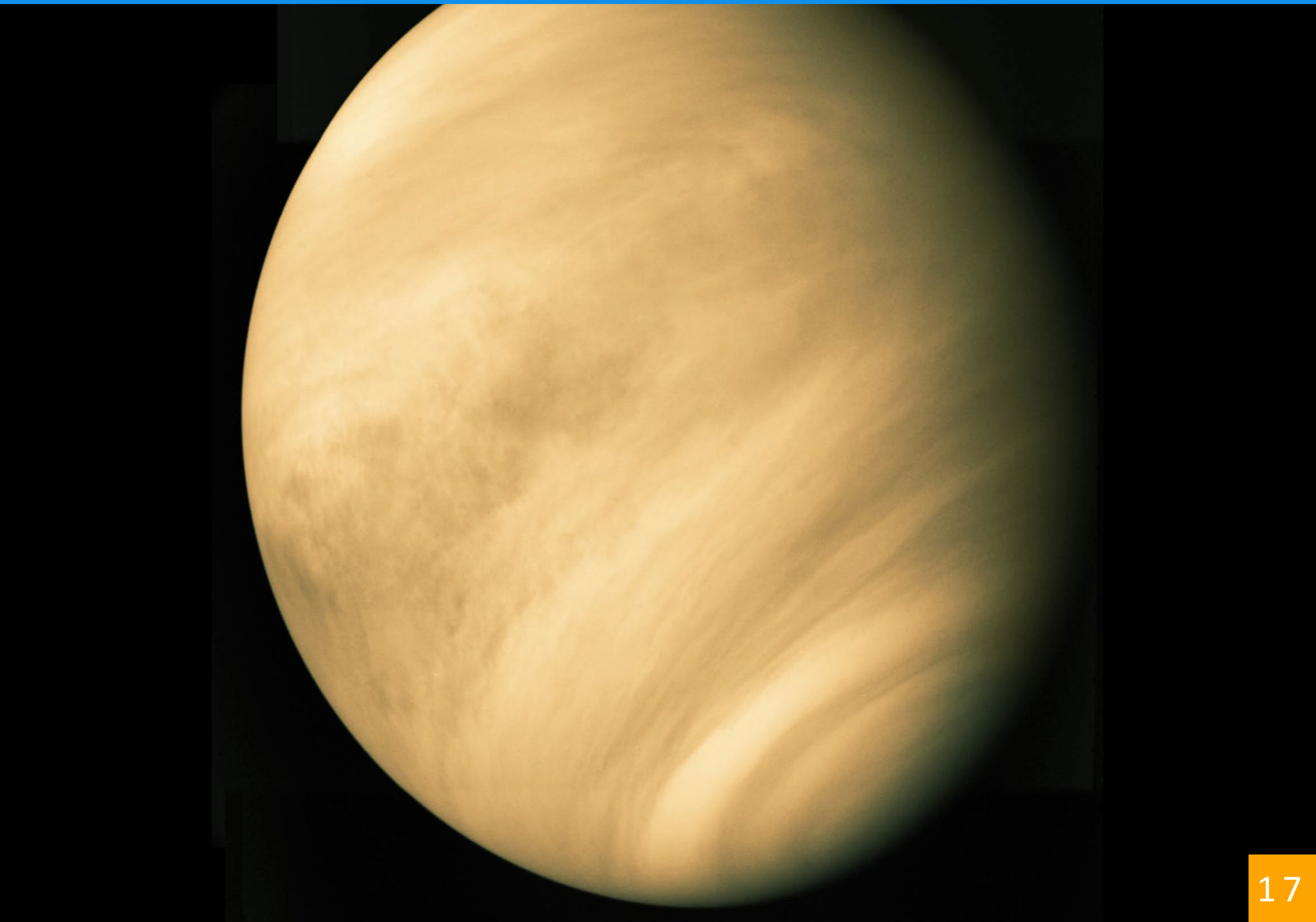

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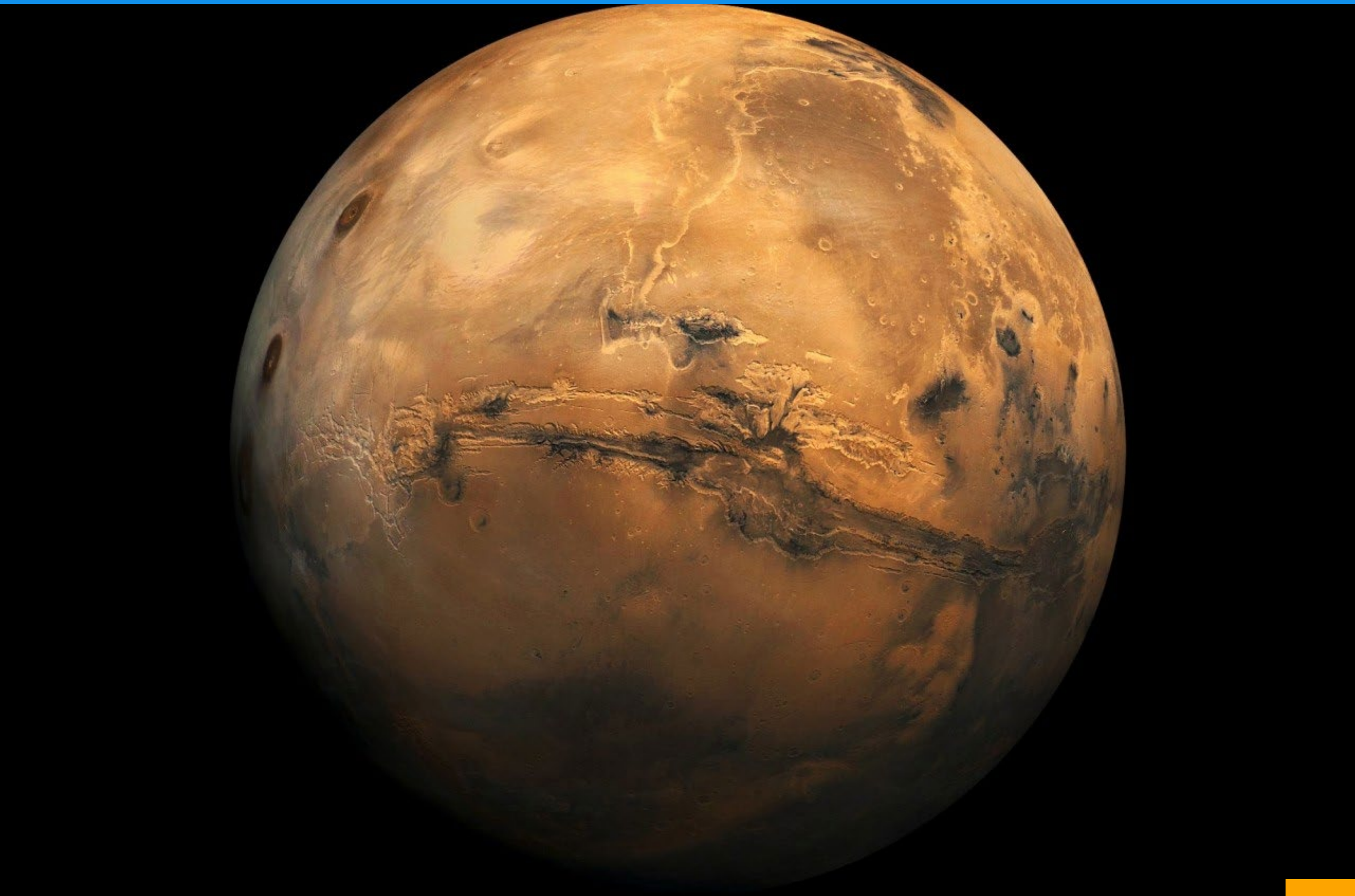

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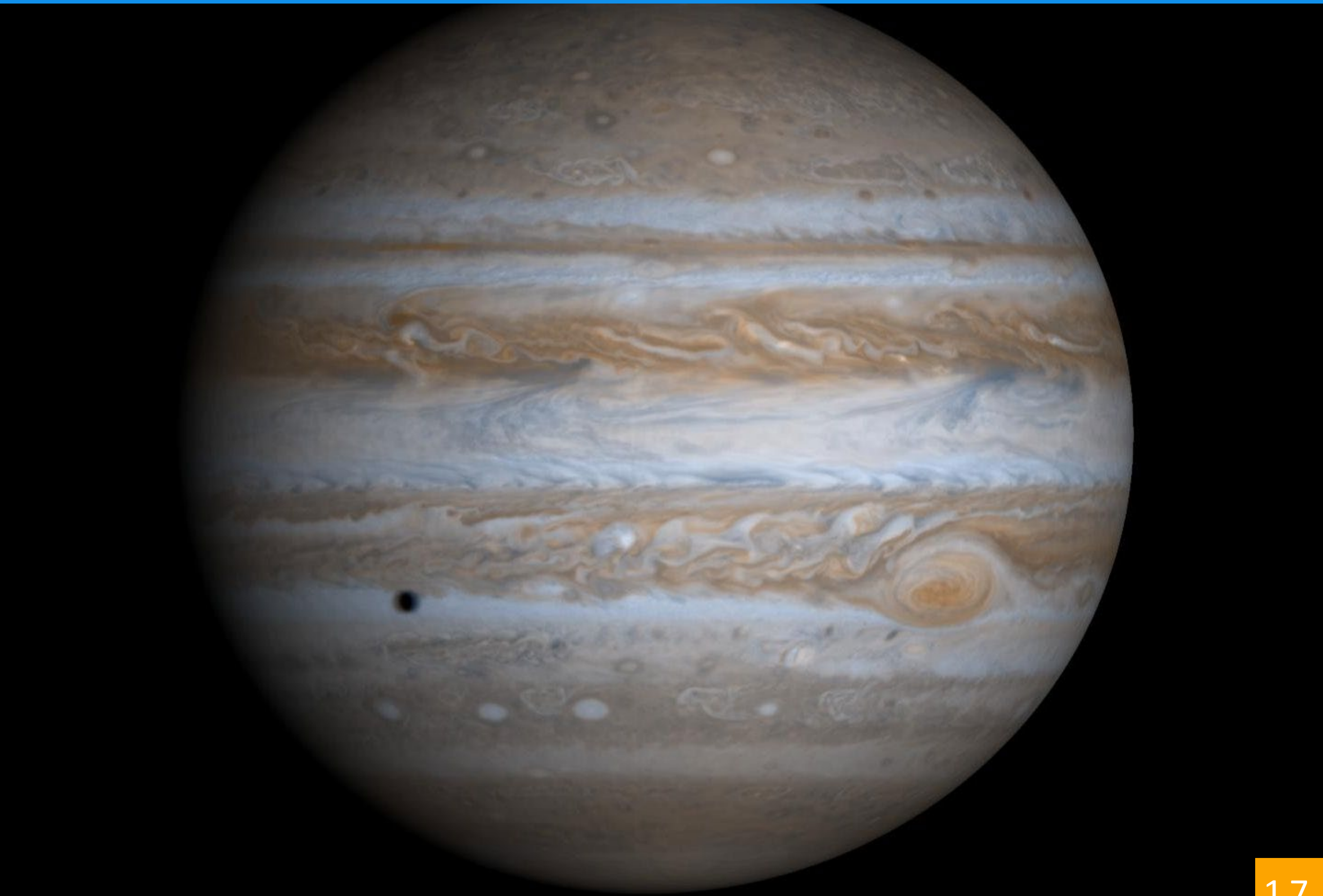

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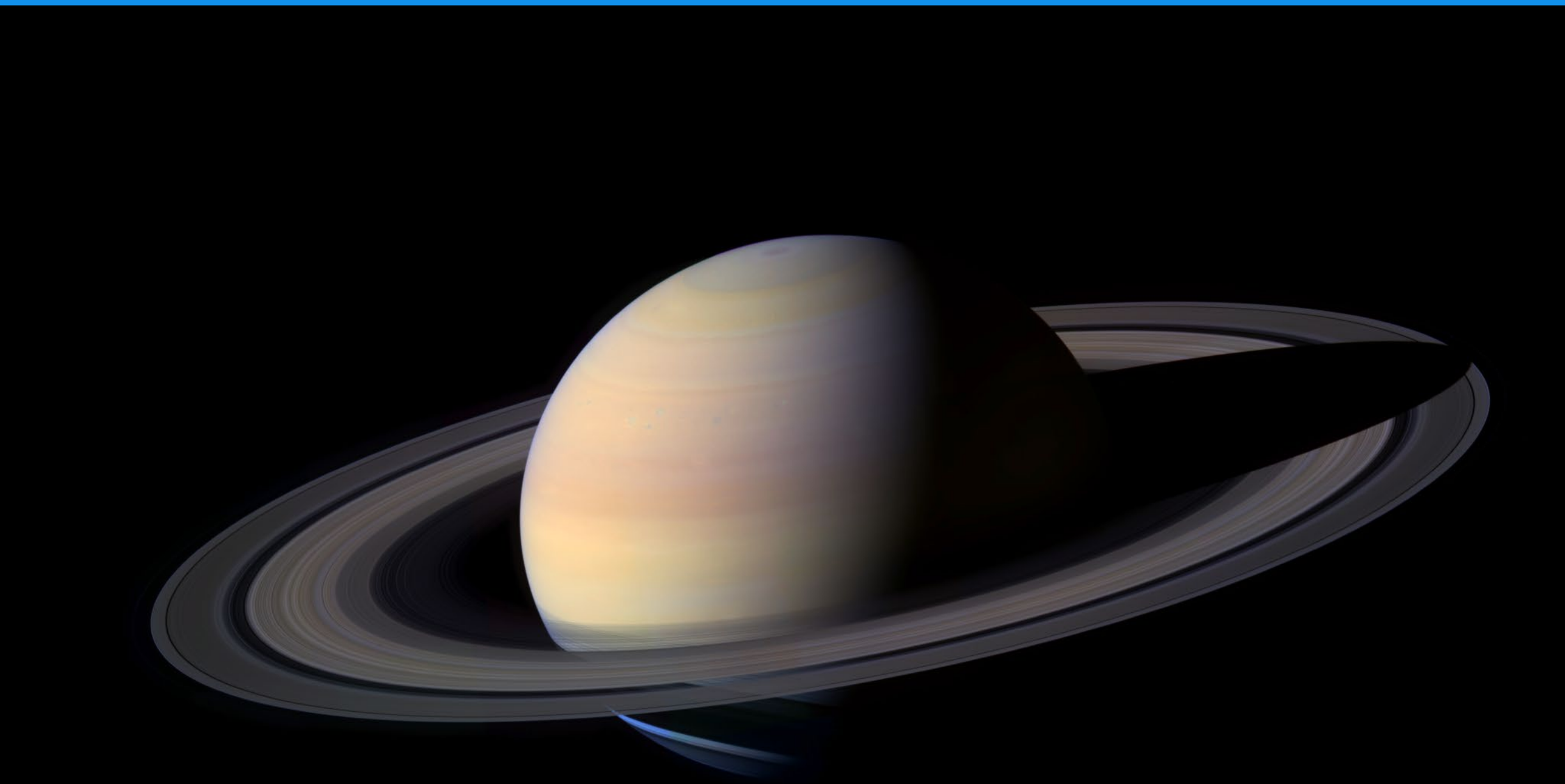

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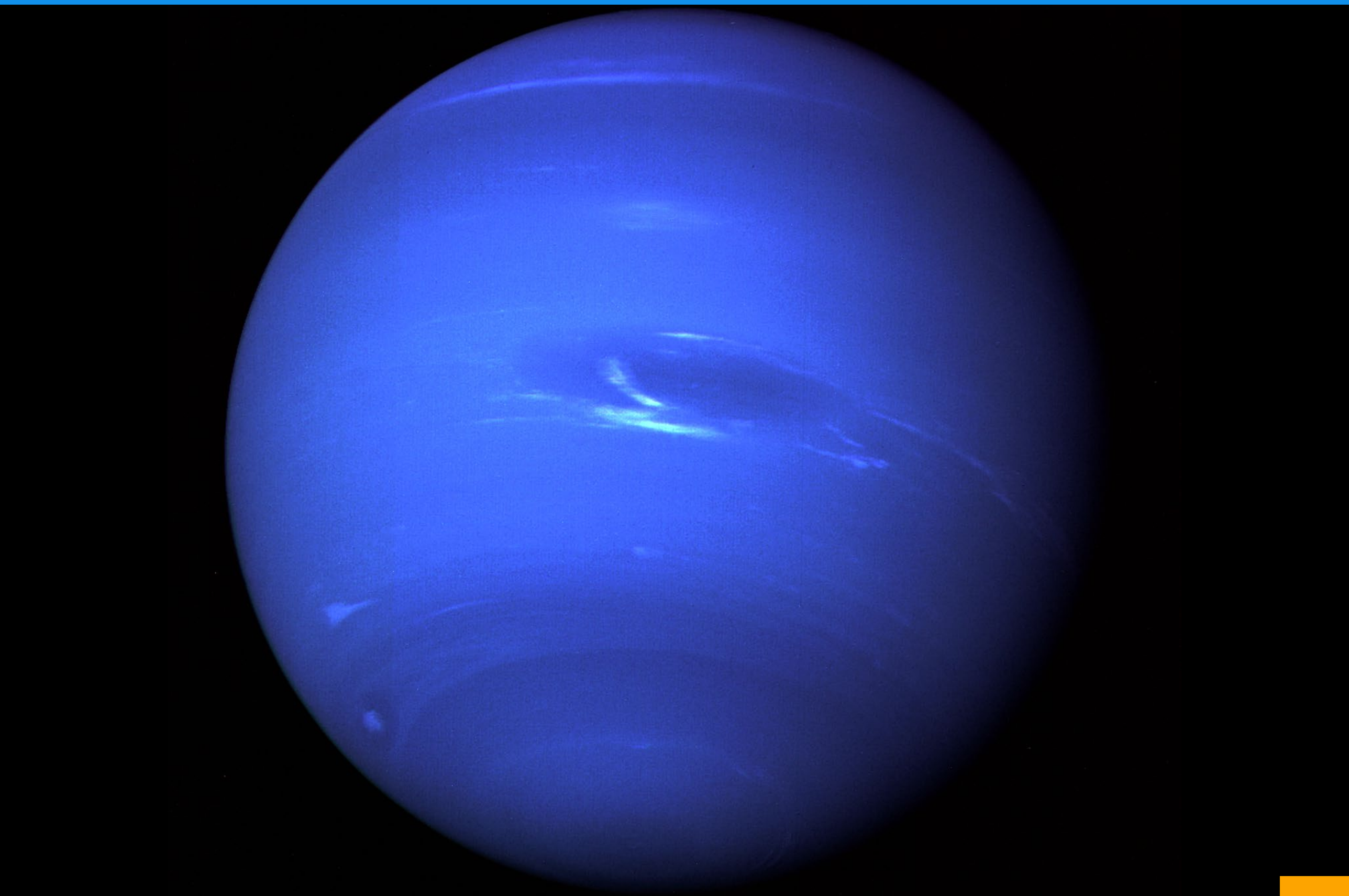

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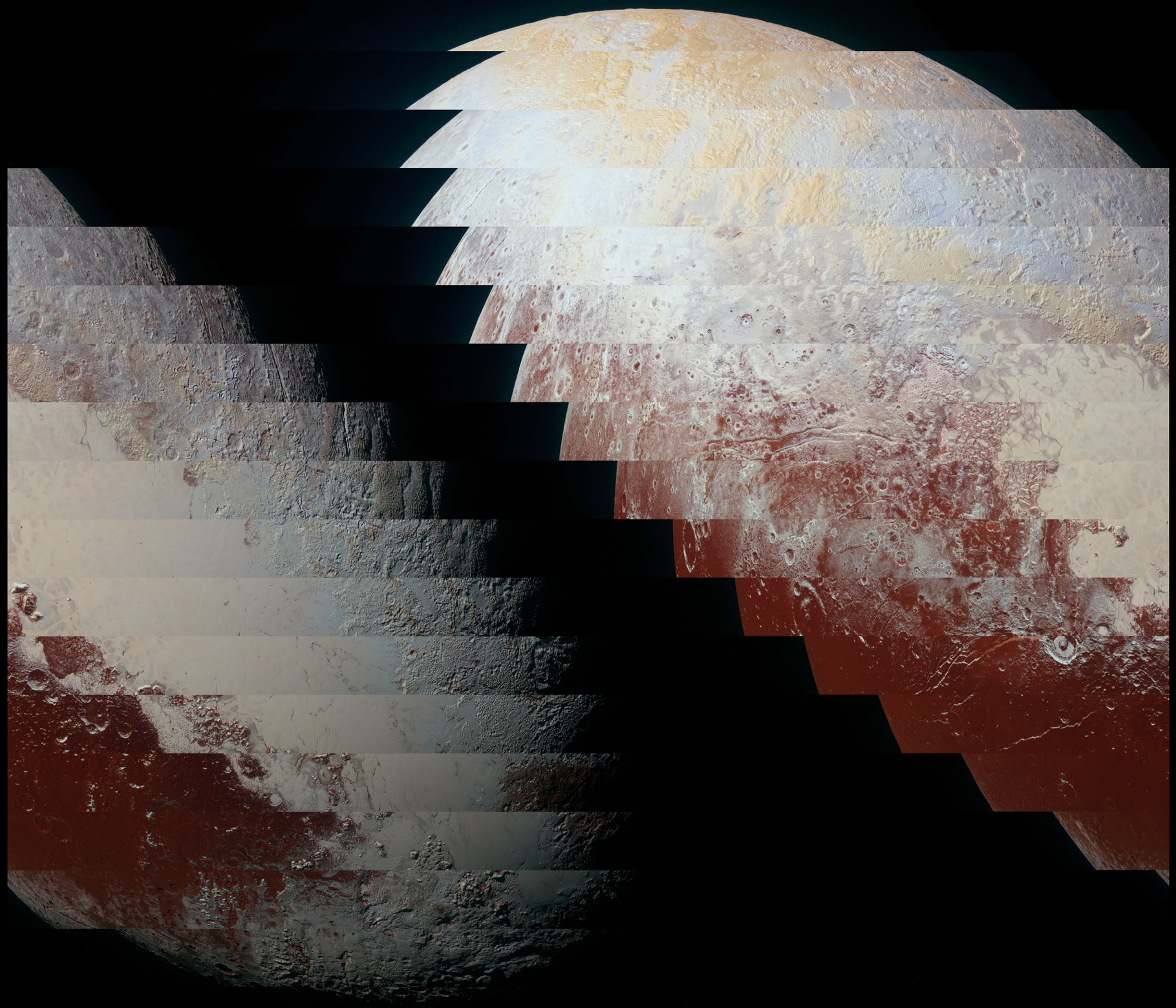

Goal: Students will be able to describe properties of solar system objects.

Astronomers continue to find sizable objects in the Kuiper Belt. This illustration shows some of the largest known bodies, including Neptune's captured moon Triton.

The Earth's moon has been included to give an indication of the size of the objects

Goal: Students will be able to describe properties of solar system objects.

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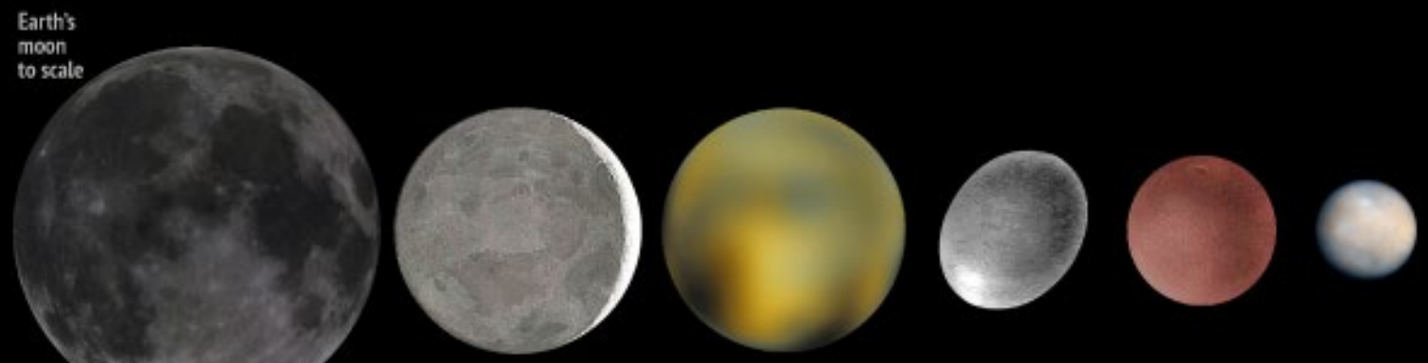
Dwarf Planets in the Solar System

In 2006, the organization responsible for classifying celestial bodies, the International Astronomical Union (IAU) decided that a new class of objects was needed. Pluto, considered a planet since its discovery in 1930, was reclassified into the new "dwarf planet" category. To date, five dwarf planets have been found, although some astronomers expect there may be as many as 50 in the solar system.



	ERIS	PLUTO	HAUMEA	MAKEMAKE	CERES
Year of discovery	2003	1930	2003	2005	1801
Diameter (mean)	1,445 miles 2,326 km	1,430 miles 2,302 km	892.3 miles 1,436 km	882 miles 1,420 km	591.8 miles 952.4 km
Orbital period (Earth years)	561.4	247.9	281.9	305.34	4.6
Distance from sun (times Earth's distance)	68	39.5	43.1	45.3	2.8
Orbital inclination (degrees)	46.9	17.14	28.2	29	10.59
Rotation period	25.9 hours	6.39 Earth days	3.9 hours	22.5 hours	9.1 hours
Moons	1	5	2	0	0

SOURCE: NASA

KARL TATE / © SPACE.com

Goal: Students will be able to describe properties of solar system objects.

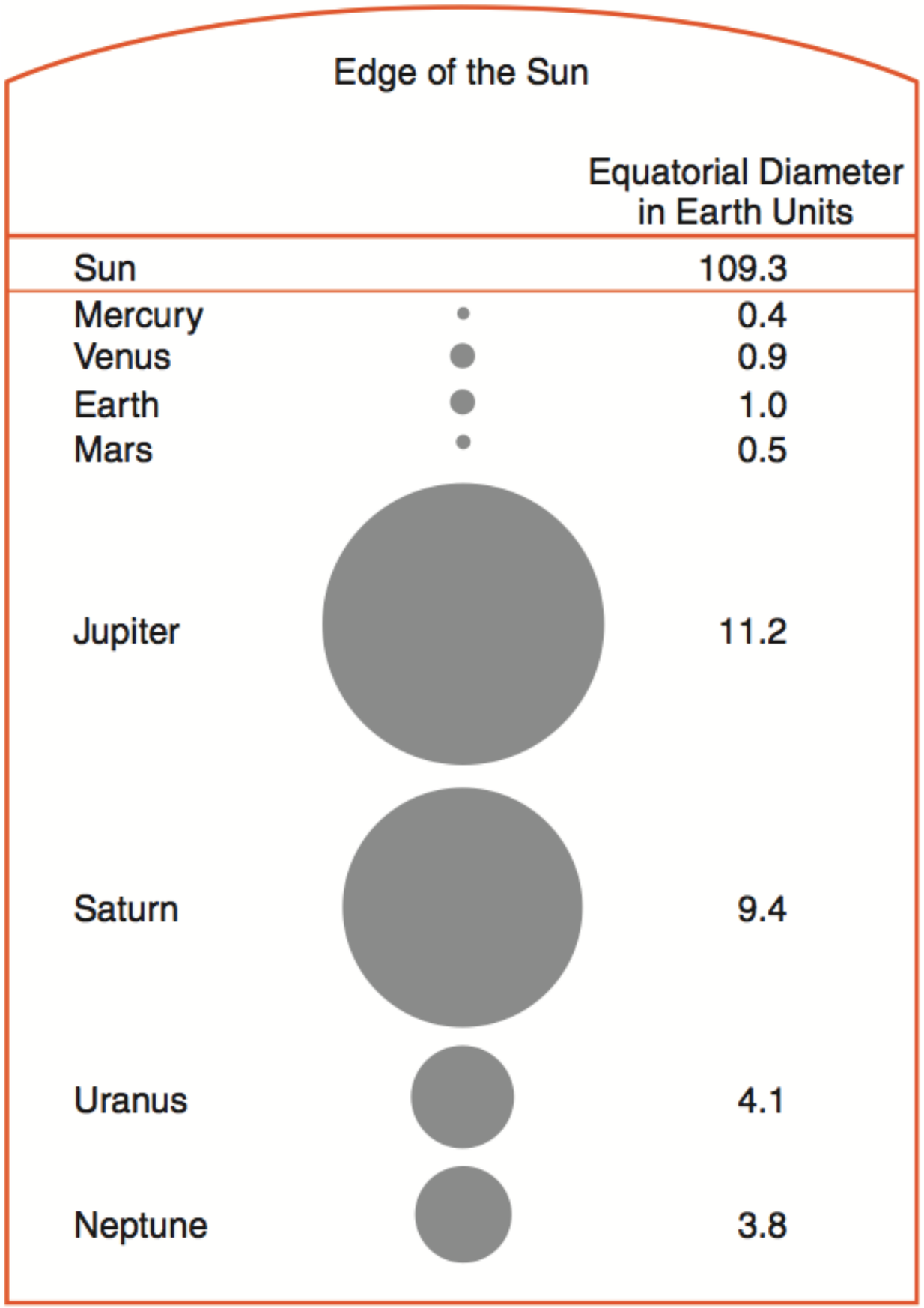
THE SOLAR SYSTEM

- Our Solar System has 8 planets that revolve around the Sun.
- Other objects in our Solar System include:
  - Asteroids
  - Comets
  - Moons

Goal: Students will be able to describe properties of solar system objects.

PLANETS

- Planets are:
- Objects that orbit around Stars.
- Have enough mass to have a “spherical” shape.
- Have cleared out their orbits of other objects.


Edge of the Sun
Equatorial Diameter in Earth Units
Sun
109.3
Mercury
0.4
Venus
0.9
Earth
1.0
Mars
0.5
Jupiter
11.2
Saturn
9.4
Uranus
4.1
Neptune
3.8

Goal: Students will be able to describe properties of solar system objects.

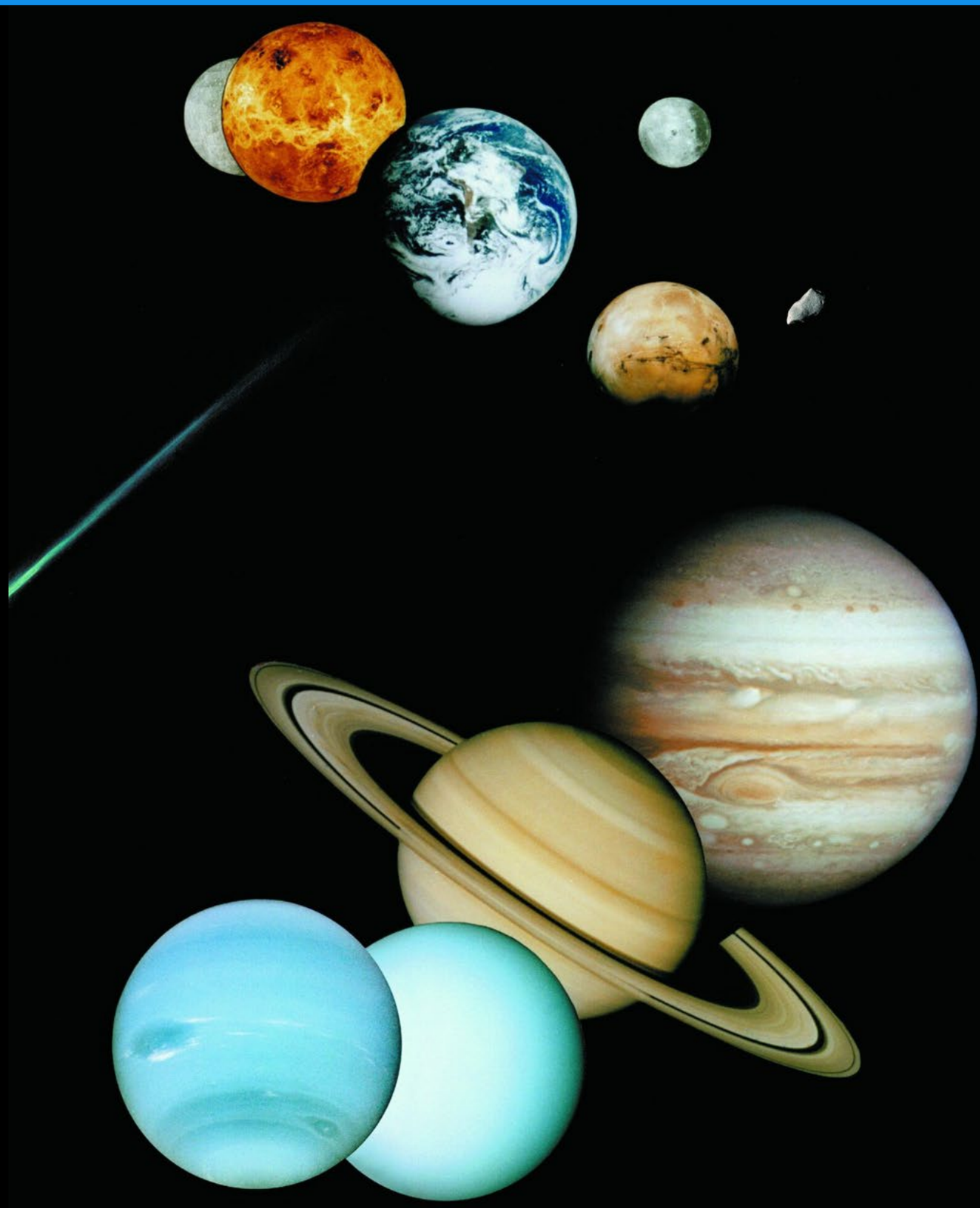
Solar System Data

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

Goal: Students will be able to describe properties of solar system objects.

TWO TYPES OF PLANETS

- Terrestrial Planets:
  - "Rocky" composition.
  - Small size.
  - High density.
  - Short periods of revolution.
- Jovian Planets:
  - "Gas Giants"
  - Large in size.
  - Low density.
  - Higher periods of revolution.



Goal: Students will be able to describe the orbits of planets.

ALL PLANETS ORBIT THE SUN IN AN ELLIPTICAL PATH.

Goal: Students will be able to describe the orbits of planets.

HOW DO PLANETS MOVE?

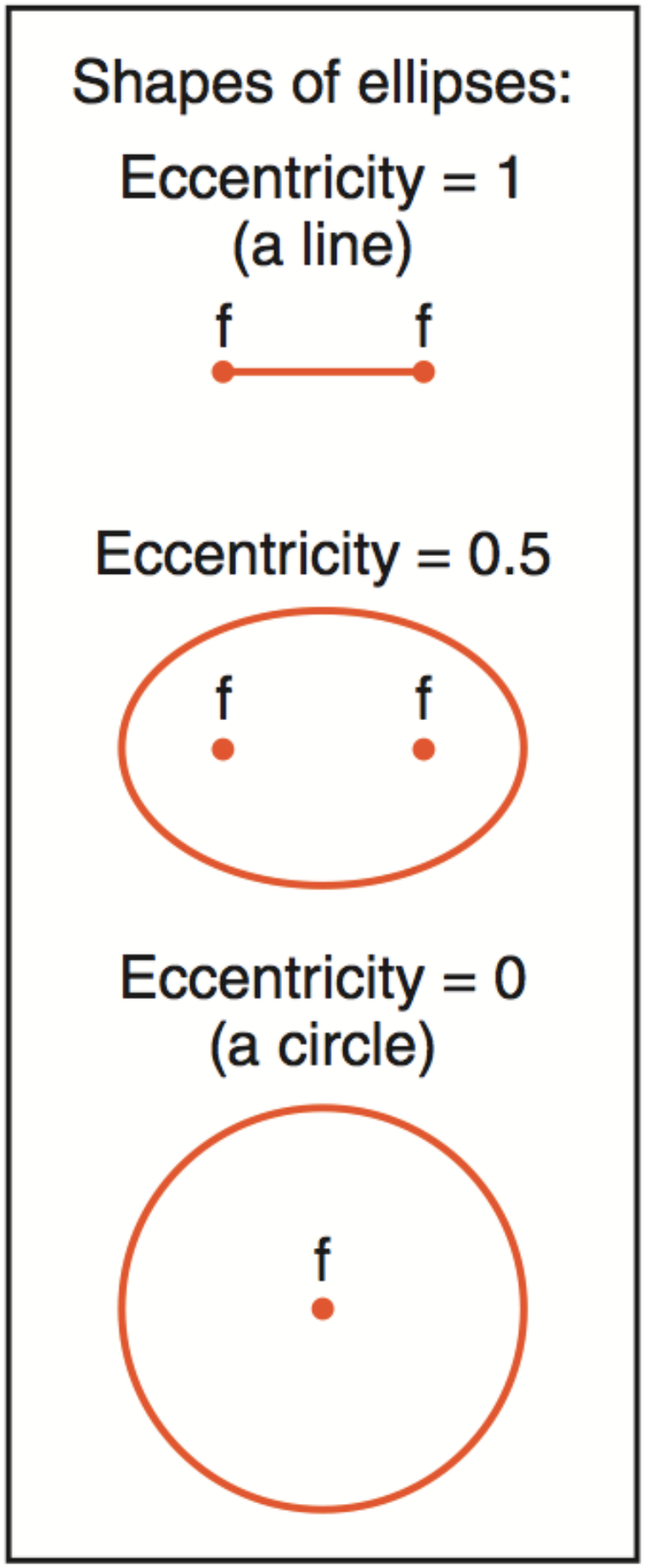
- The orbits of planets and moons are elliptical (not circular).
- An ellipse is an object drawn around two fixed points called foci. Each individual point is called a focus.

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

SAMPLE PROBLEMS

The distance between the foci of this ellipse is 3 cm. The distance across the ellipse (the major axis) is 4 cm.

Goal: Students will be able to describe the orbits of planets.



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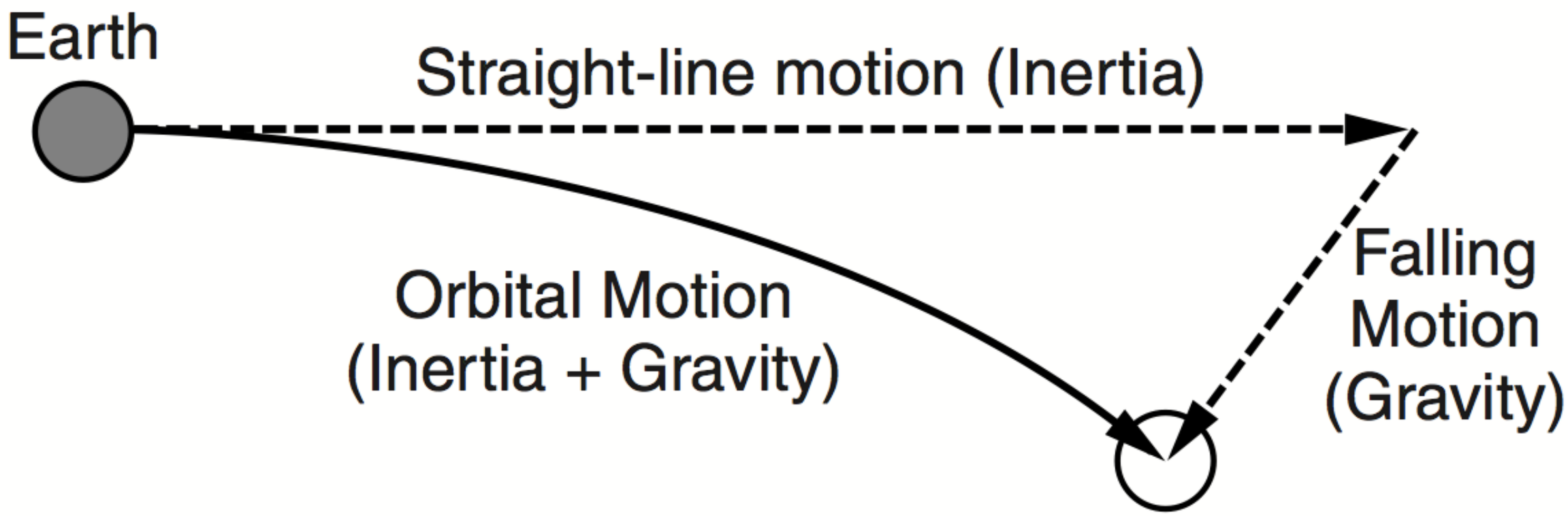
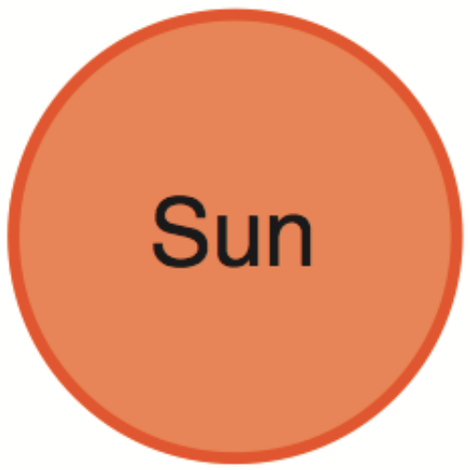
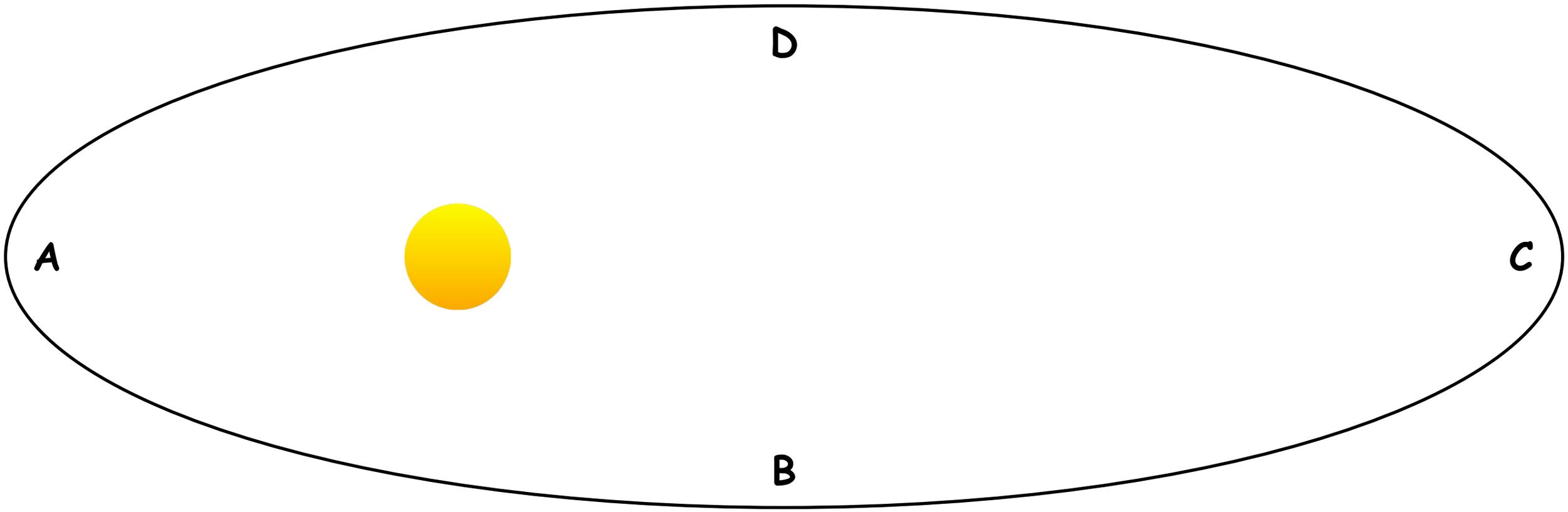


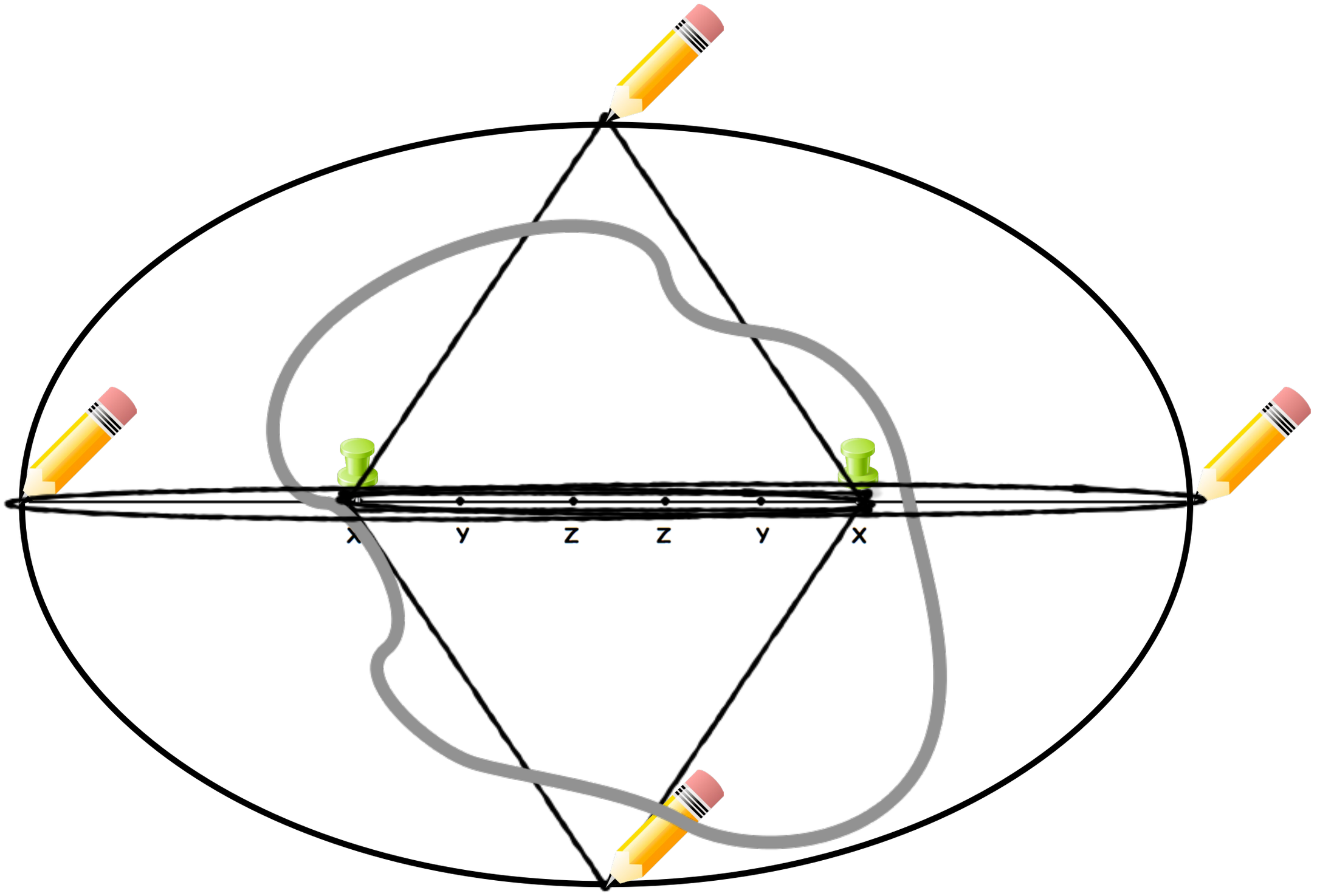


Goal: Students will be able to describe the orbits of planets.

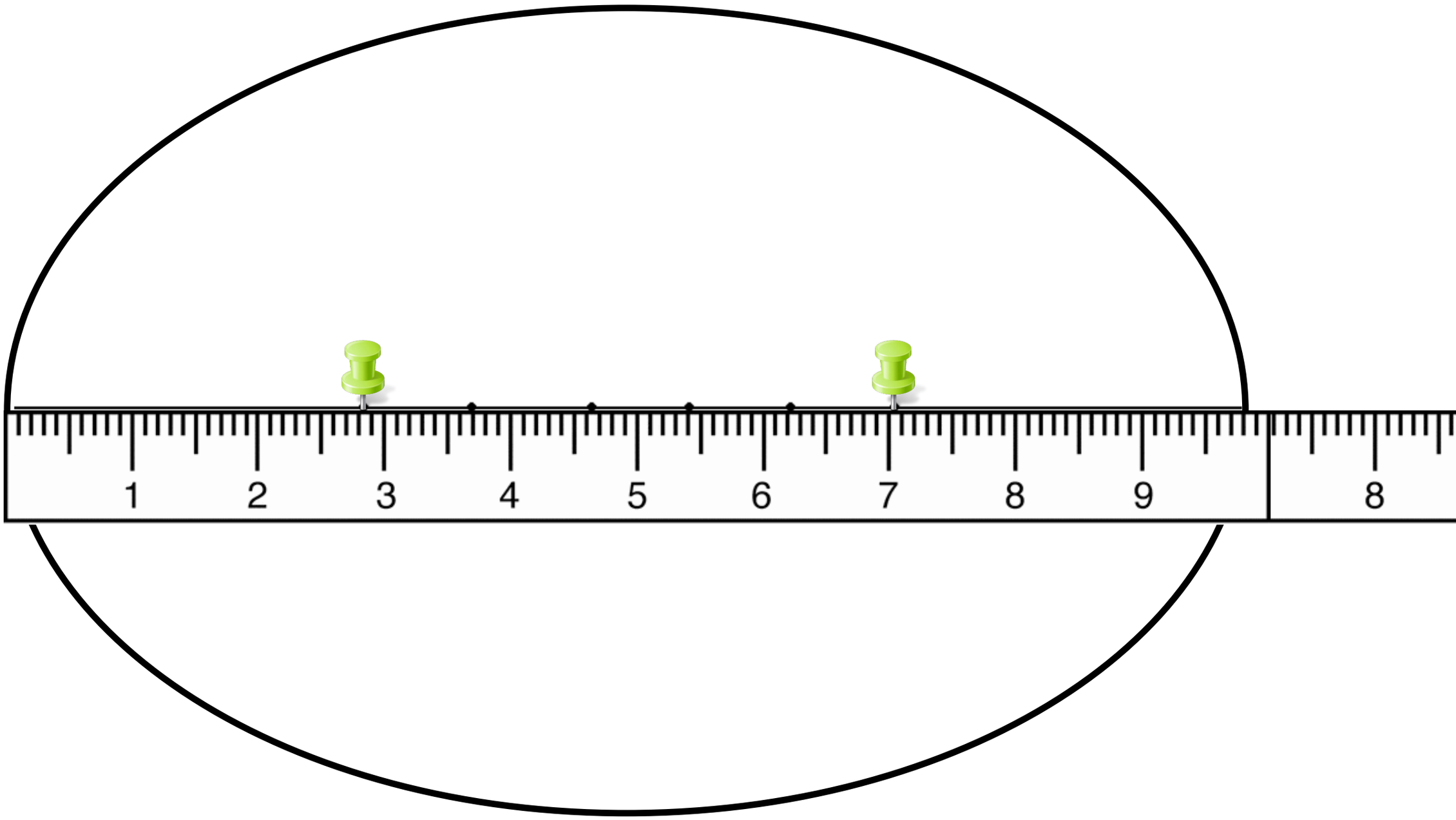


- Point A in the orbit is known as perihelion. This is when the object is at its closest point to the Sun, and moving the fastest.

- Point C in the orbit is known as aphelion. This is when the object is at its furthest point from the Sun, and moving the slowest.

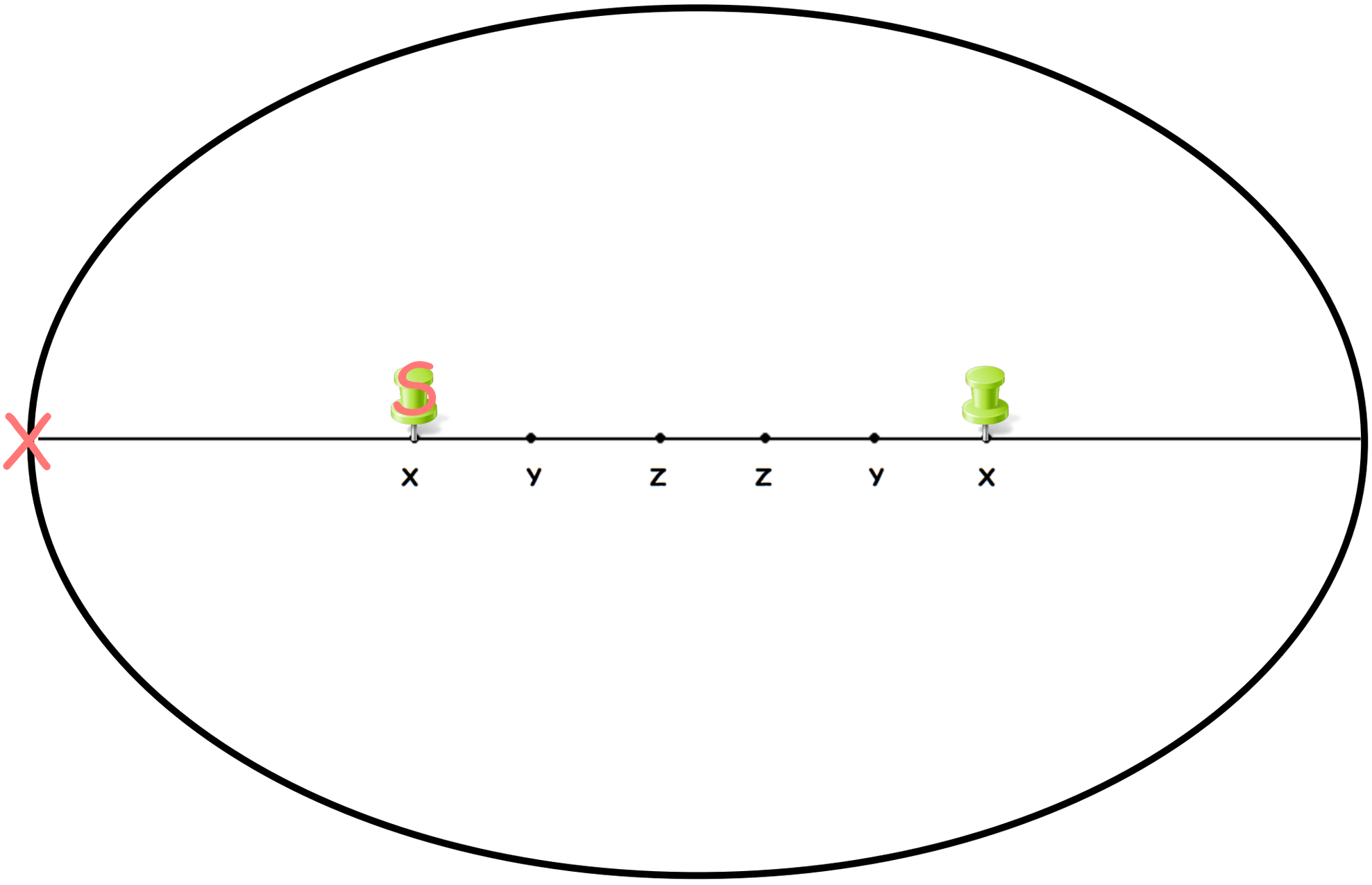

x
y
z
z
y
x

$$\text{Eccentricity} = \frac{\text{distance between foci}}{\text{length of major axis}} \qquad \frac{4.2 \text{ cm}}{9.8 \text{ cm}} = 0.429$$



Measure distance between foci.

$$\text{Eccentricity} = \frac{\text{distance between foci}}{\text{length of major axis}} \qquad \frac{4.2\text{ cm}}{9.8\text{ cm}} = 0.429$$

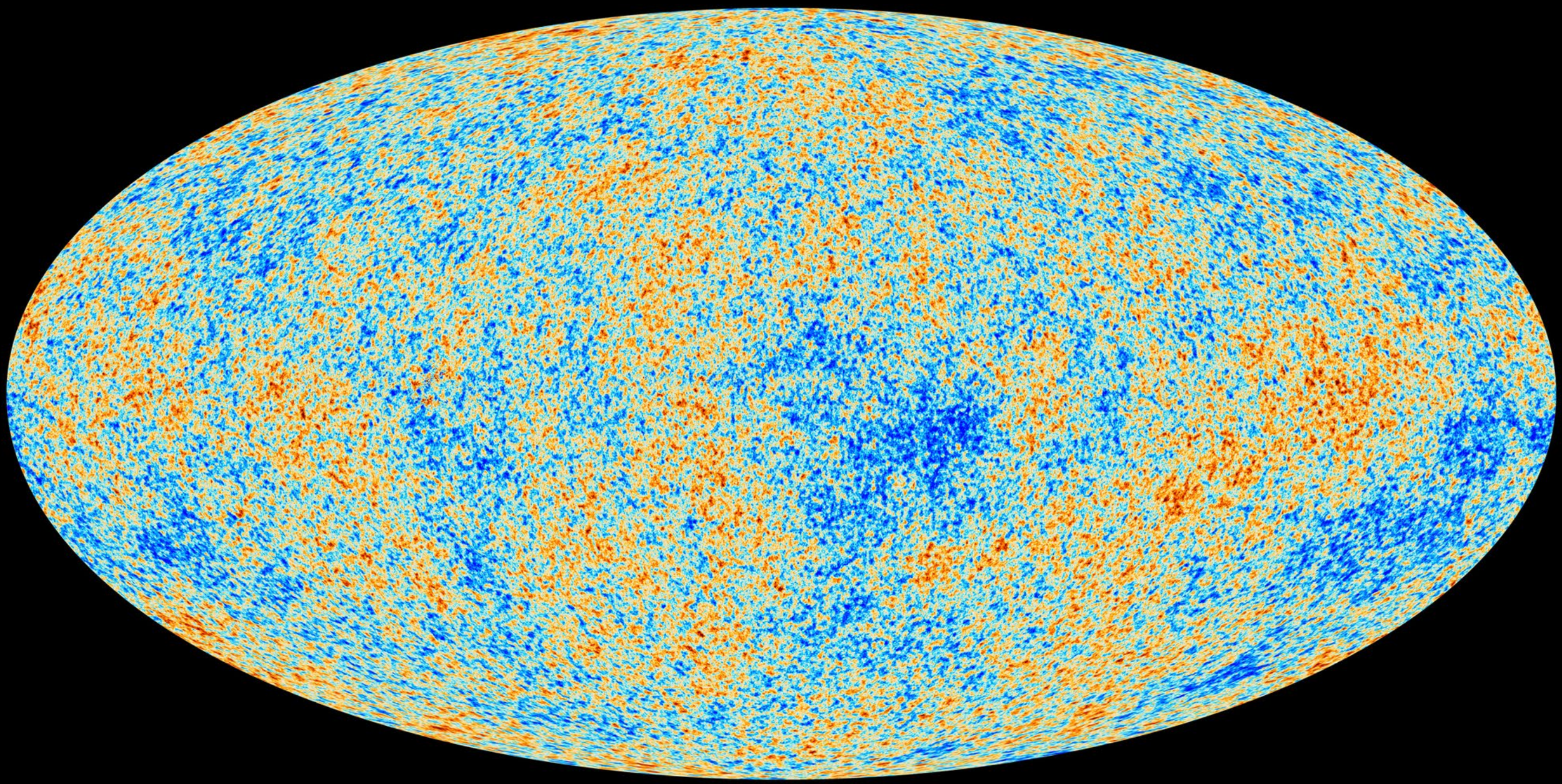


Place an X where the object is moving the fastest.

Place an S where the Sun is.

Goal: Students will be able to explain the origins of the Universe.

THE UNIVERSE



Goal: Students will be able to explain the origins of the Universe.

WE KNOW THE EARTH IS A MEMBER OF THE SOLAR SYSTEM. WHAT IS BEYOND THE SOLAR SYSTEM?

Goal: Students will be able to explain the origins of the Universe.

THE MILKY WAY GALAXY

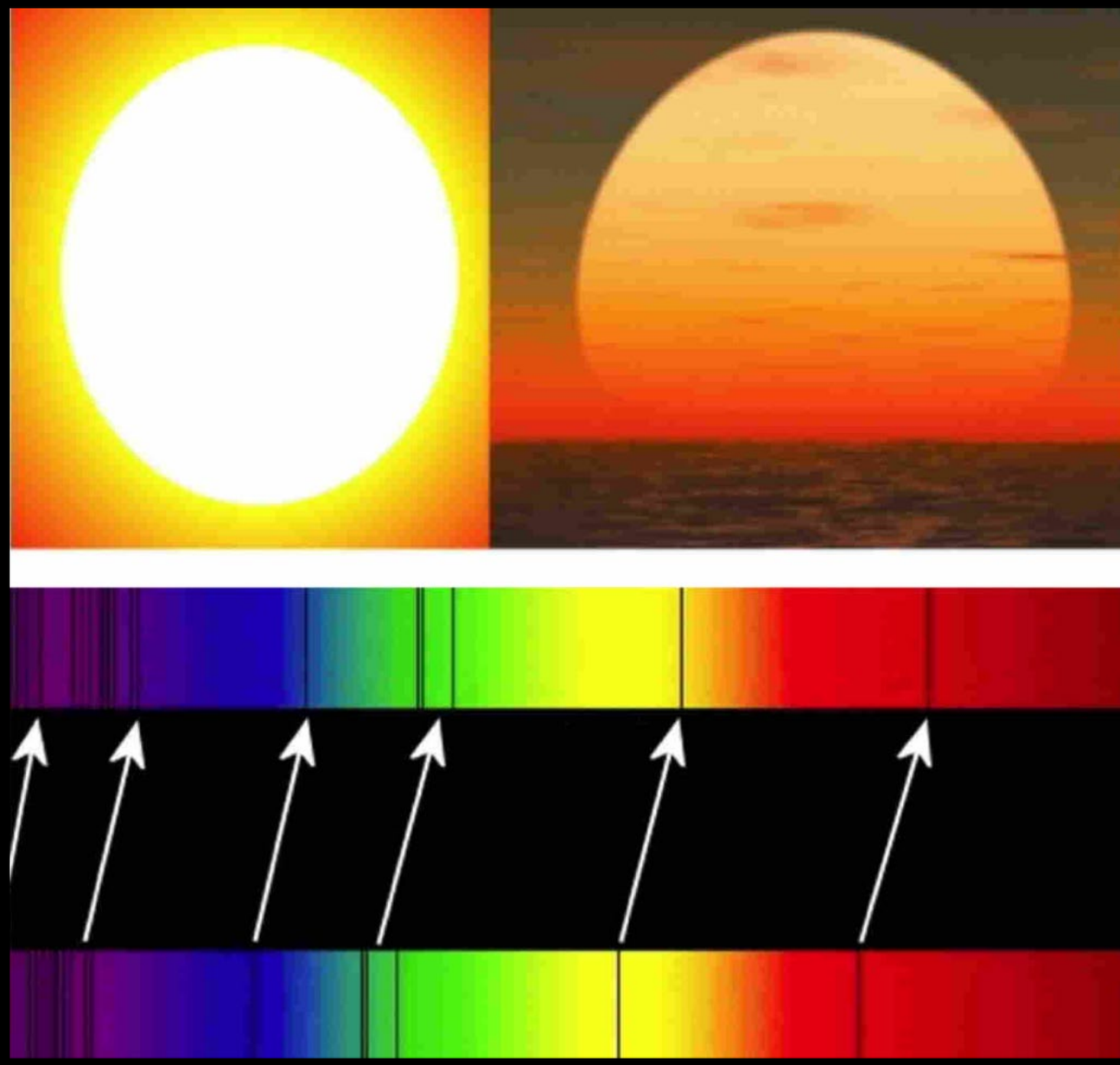
- Our Solar System is just one of billions of other systems of stars and planets that are drawn together by the force of gravity.
- This large group of stars that orbits a central point is known as the Milky Way Galaxy.
- There are millions, if not billions of galaxies in the Universe, each with millions of star systems in them.
- Most, if not all galaxies likely have a black hole at their centers.

Goal: Students will be able to explain the origins of the Universe.

HOW DID THE UNIVERSE FORM?

DOPPLER EFFECT

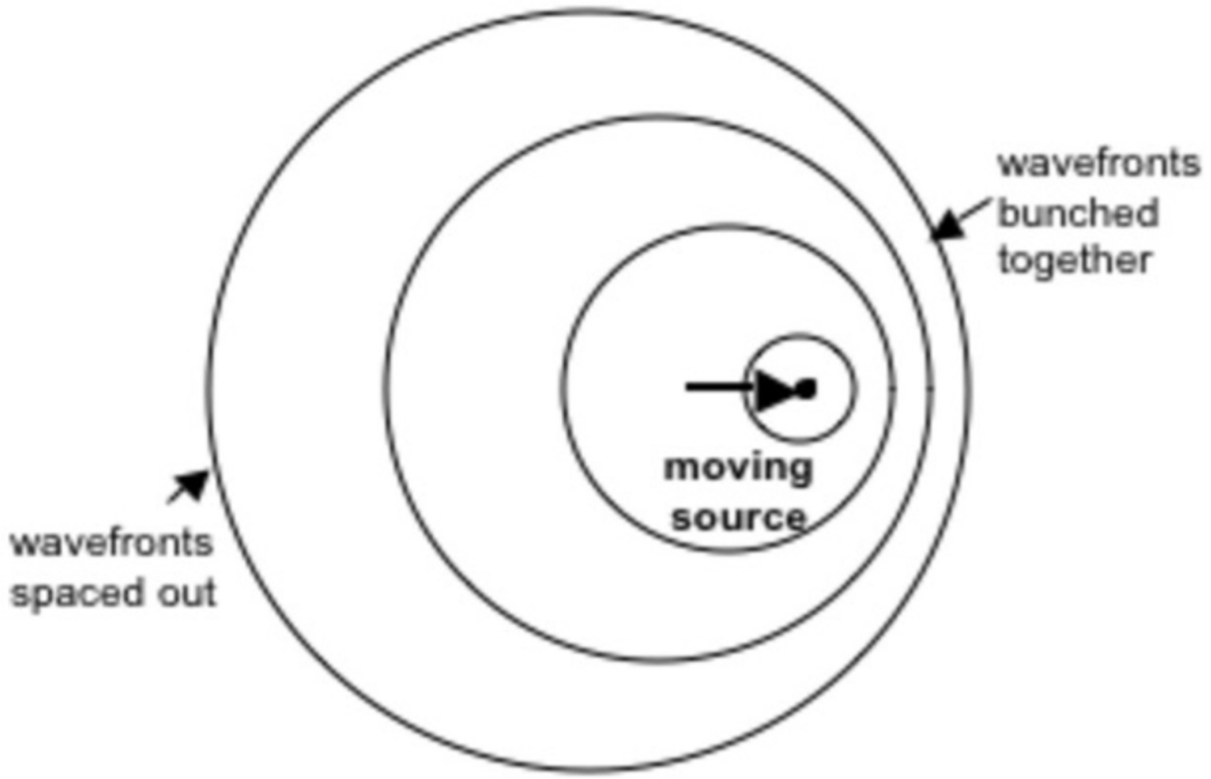
- All throughout the Universe, we know what color stars and galaxies should be.
- By observing the incoming radiation from these objects, scientists have realized that most objects in the Universe are more red than they should be.



Goal: Students will be able to explain the origins of the Universe.

DOPPLER EFFECT

- The Doppler Effect says that the wavelength of energy will appear to be longer when an object moves away from an observer. This is called the Red Shift.
- It also says that the wavelength of energy will appear to be shorter when an object moves toward an observer. This is called the Blue Shift.



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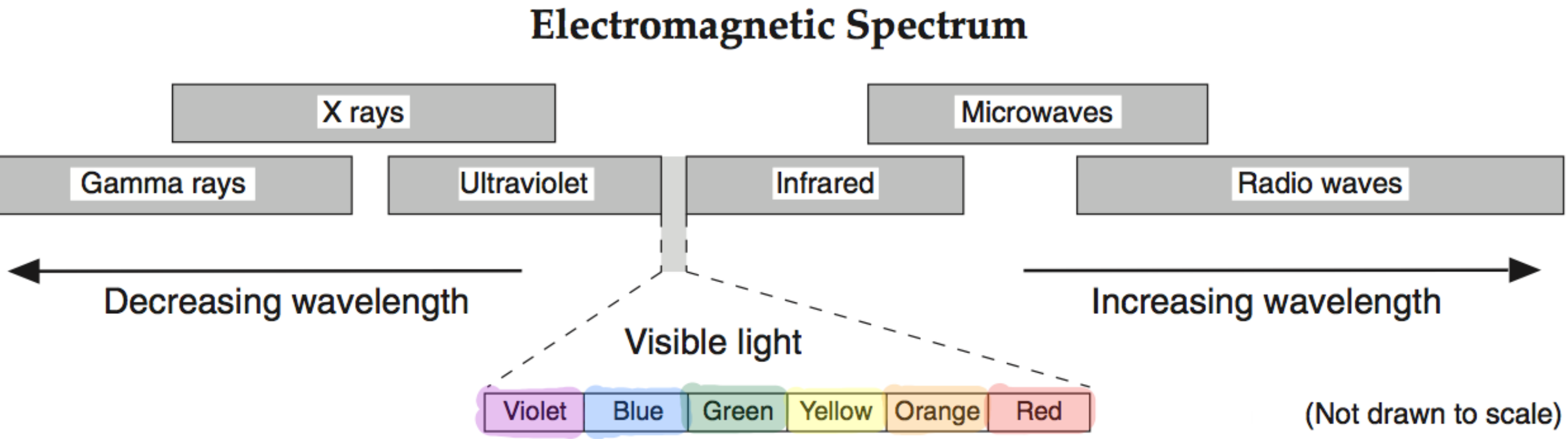
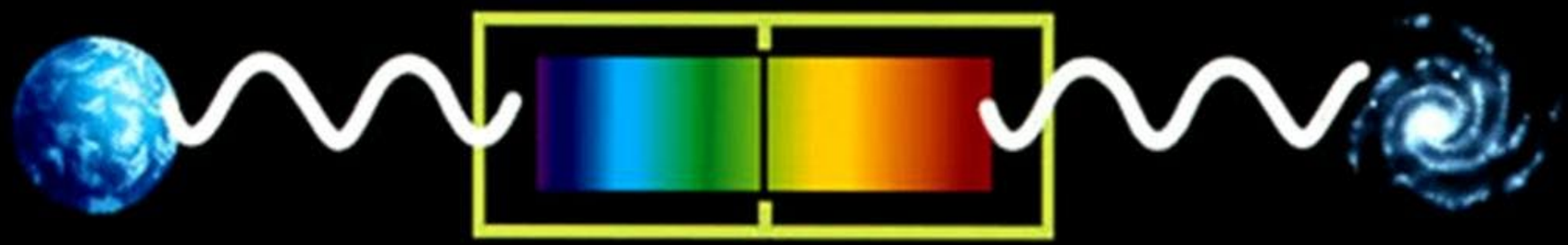
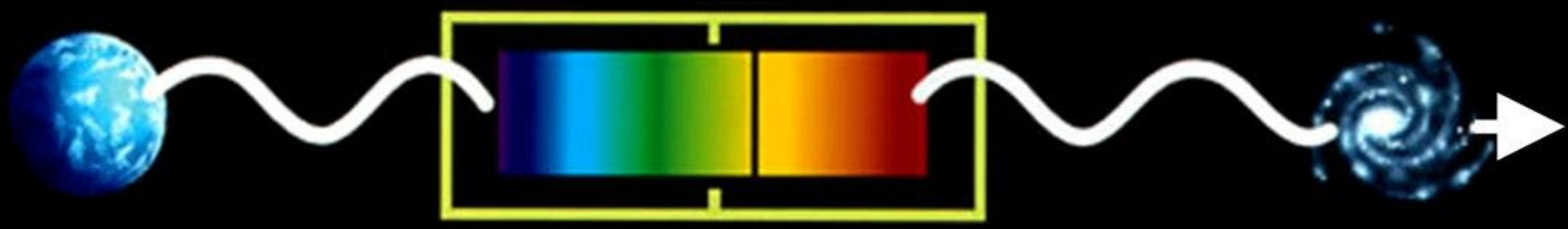


Goal: Students will be able to explain the origins of the Universe.

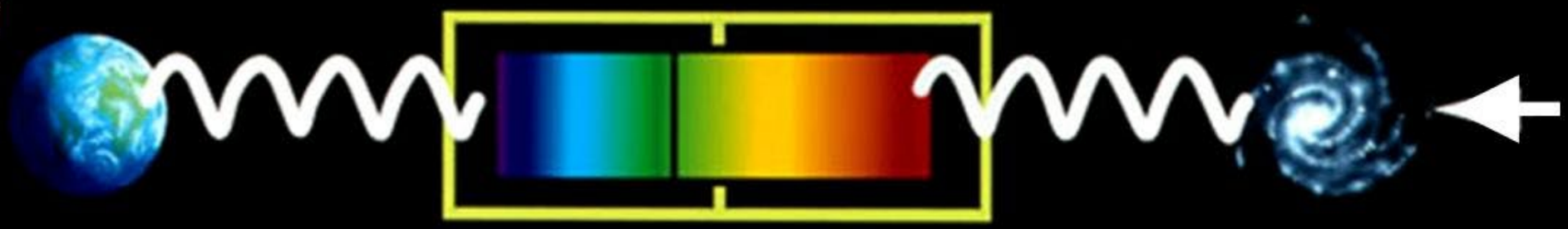
A light source at rest



The spectrum of a receding light source is redshifted



The spectrum of an approaching light source is blueshifted



THIS MUST MEAN MOST OBJECTS IN THE UNIVERSE ARE MOVING AWAY FROM US, AND THE UNIVERSE IS EXPANDING OUTWARDS IN ALL DIRECTIONS.

WHICH MEANS IT WAS ALL TOGETHER AT ONE POINT MANY YEARS AGO.

Goal: Students will be able to explain the origins of the Universe.

THE FORMATION OF THE UNIVERSE AND THE OUTWARD EXPANSION IS KNOWN AS THE BIG BANG.

Goal: Students will be able to explain the origins of the Universe.

Goal: Students will be able to explain the origins of the Universe.

SO WE ARE A TINY SPECK

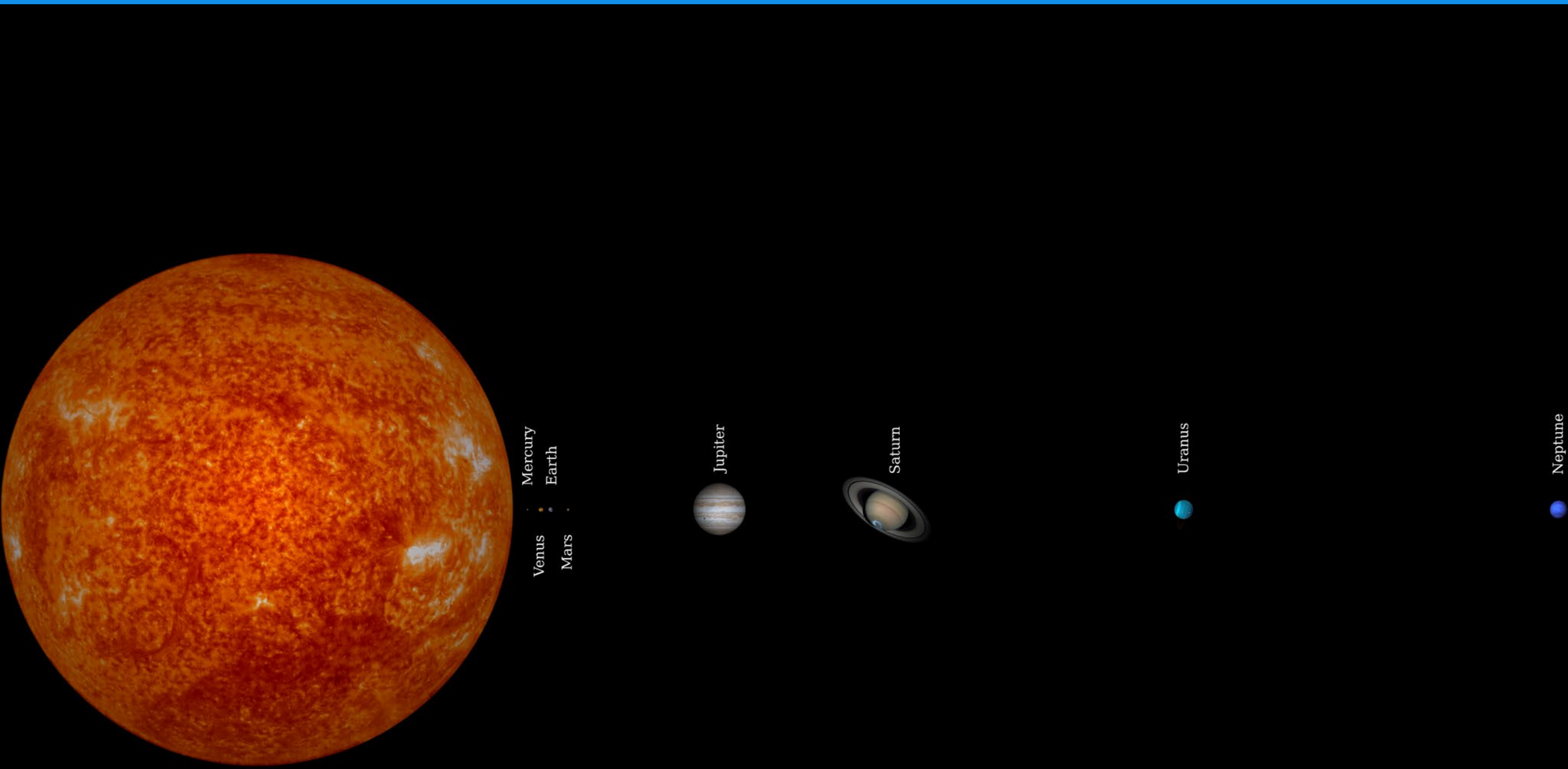
COMPARED TO EARTH…

Goal: Students will develop a sense of scale in the Universe.

Goal: Students will develop a sense of scale in the Universe.

WHICH IS A TINY PLANET IN OUR SOLAR SYSTEM…

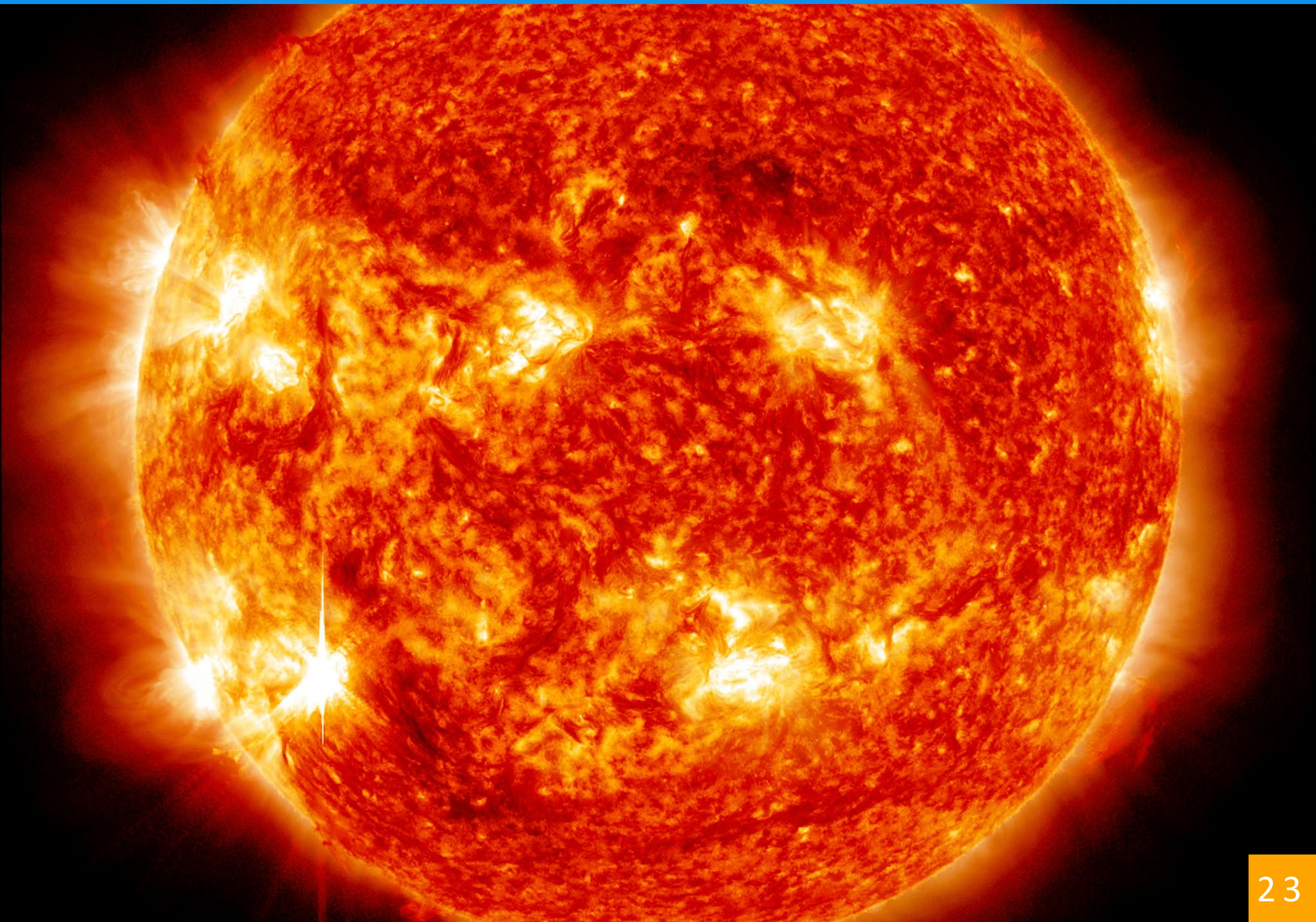
Goal: Students will develop a sense of scale in the Universe.



Goal: Students will develop a sense of scale in the Universe.

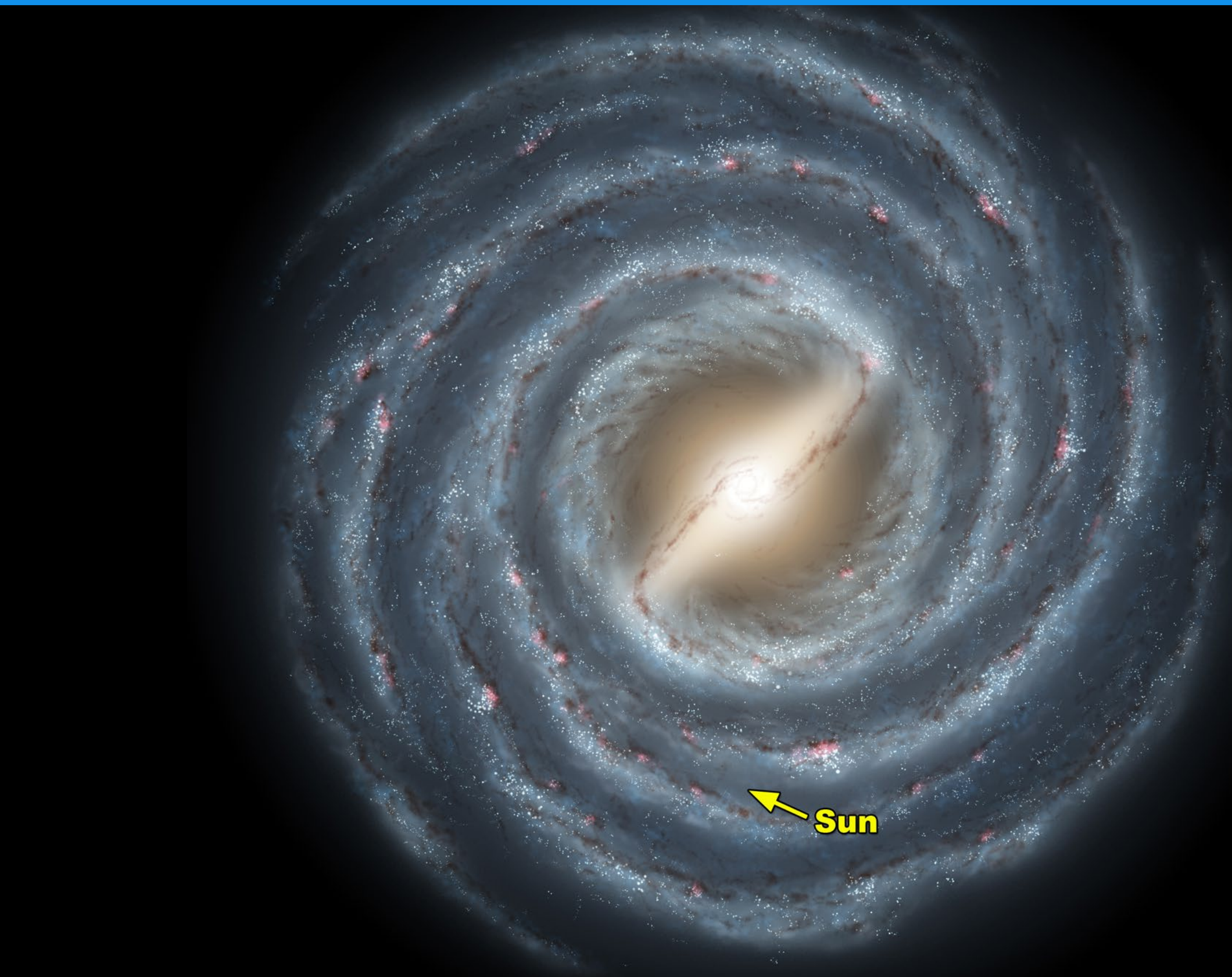
WHERE EVERY PLANET ORBITS AROUND A VERY AVERAGE STAR…

Goal: Students will develop a sense of scale in the Universe.



WHICH IS A MEMBER OF THE MILKY WAY GALAXY, WITH BILLIONS OF OTHER STARS IN IT THAT ARE JUST LIKE THE SUN…

Goal: Students will develop a sense of scale in the Universe.



AND THE MILKY WAY GALAXY IS JUST ONE OF MILLIONS, OR PERHAPS EVEN BILLIONS OF GALAXIES IN OUR UNIVERSE…

Goal: Students will develop a sense of scale in the Universe.

Goal: Students will develop a sense of scale in the Universe.

FEELING INSIGNIFICANT YET? THE UNIVERSE IS A HUGE PLACE!

Goal: Students will develop a sense of scale in the Universe.

DISTANCES IN THE UNIVERSE

- Distances in the Universe are so HUGE that we need a different way of measuring distance beyond meters or miles.

- We measure distance in space by using the unit light-year.

- One light-year is equal to the distance electromagnetic energy will travel in one year (6 trillion mi., 10 trillion km).

Goal: Students will develop a sense of scale in the Universe.

THE MILKY WAY GALAXY IS BETWEEN 100,000–120,000 LIGHT-YEARS IN DIAMETER.

Goal: Students will discover the processes involved in all stars.

IN A HUGE UNIVERSE WITH SO MANY UNANSWERED QUESTIONS, WHERE DO WE FIT IN?

Goal: Students will discover the processes involved in all stars.

Goal: Students will discover the processes involved in all stars.

Goal: Students will discover the processes involved in all stars.

BELIEVE IT OR NOT, WE OWE OUR EXISTENCE TO STARS.

Goal: Students will discover the processes involved in all stars.

WHAT ARE STARS?

Goal: Students will discover the processes involved in all stars.

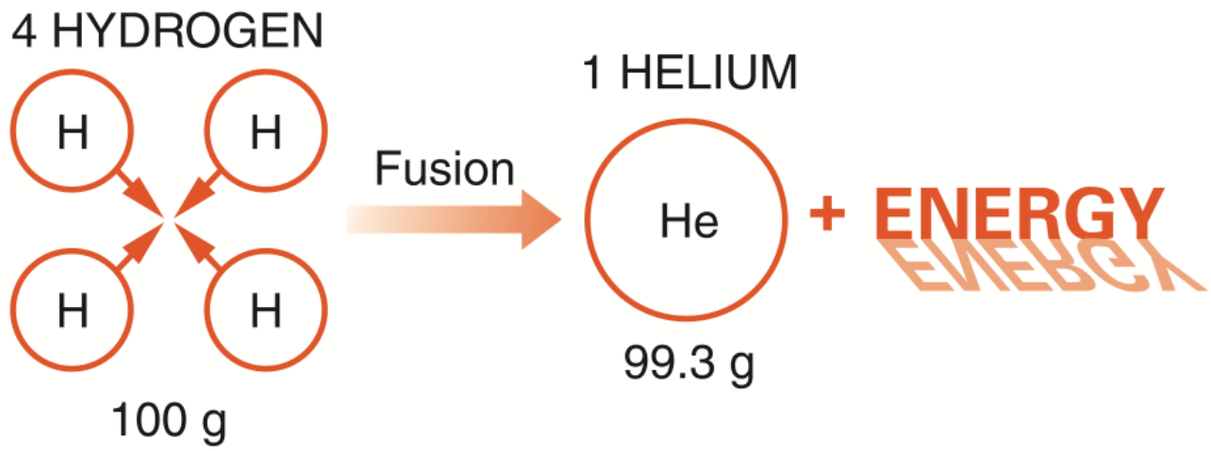
STARS

- A star is a massive object in space that creates energy and radiates it as electromagnetic radiation.
- The closest star to Earth is the Sun.
- Most visible objects in space are stars or collections of stars (galaxies).

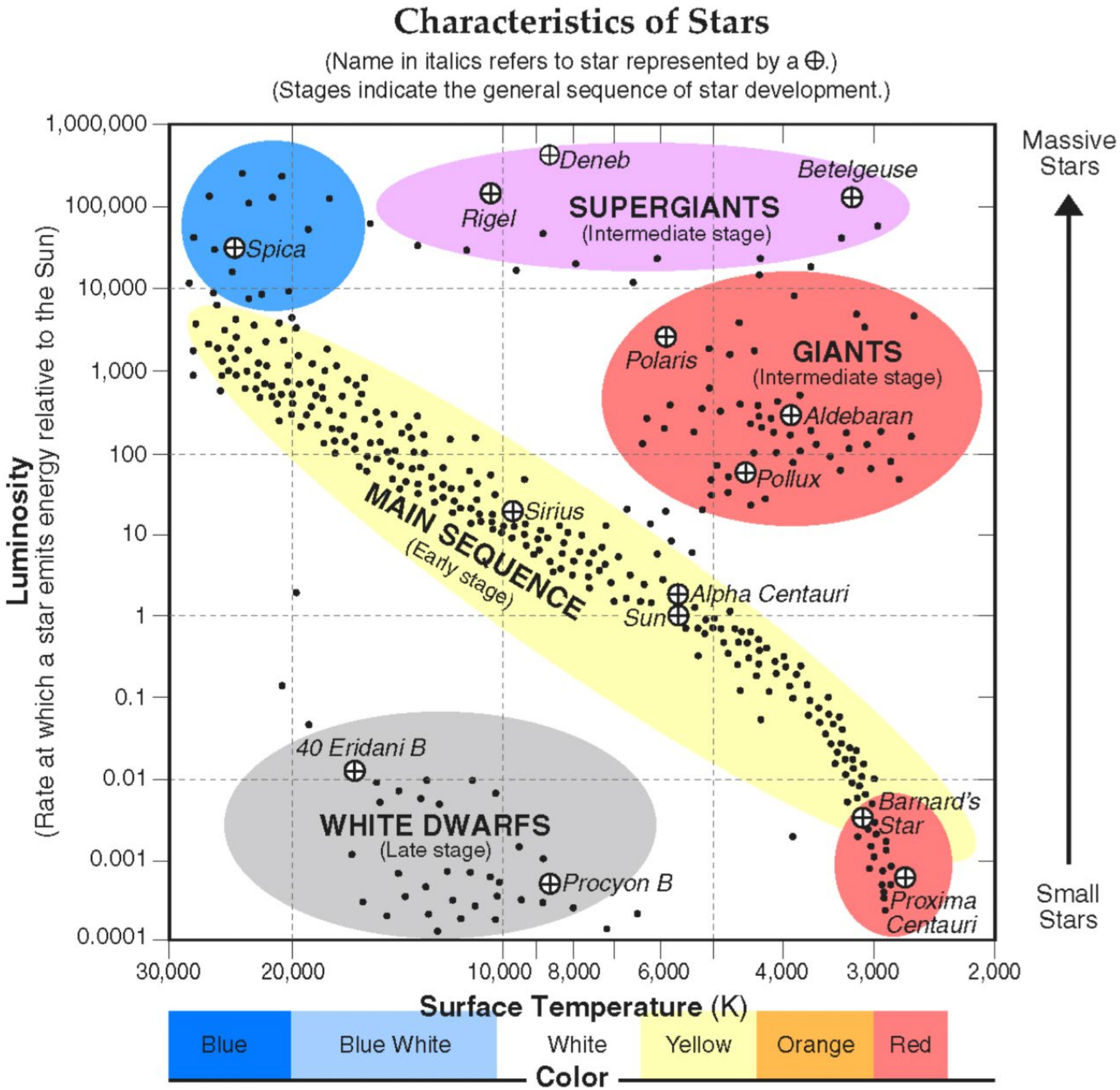
Goal: Students will discover the processes involved in all stars.

STARS

- Stars create energy using a process called nuclear fusion.
- Nuclear fusion - the process by which light elements join to make heavier elements.
- All the heavier elements in our cells were created because of nuclear fusion in stars many years ago.



Goal: Students will discover the processes involved in all stars.



Goal: Students will discover the processes involved in all stars.

MAIN SEQUENCE STARS

- Main sequence stars are young stars that are using hydrogen fusion.
- Most stars in the Universe are Main Sequence stars.
- Dwarf Stars:
  - Yellow Dwarf - Yellow dwarfs are small, main sequence stars. The Sun is a yellow dwarf.
  - Red Dwarf – A small, cool, very faint, main sequence star whose surface temperature is under about 4,000 K. The most common type of star.

Goal: Students will discover the processes involved in all stars.

GIANT AND SUPERGIANT STARS

- Giant and Supergiant stars are old Stars that have left the Main Sequence, and no longer use hydrogen fusion.

- Red Giant – A relatively old star whose diameter is about 100 times bigger than it was originally, and has become cooler (the surface temperature is under 6,500 K). They are frequently orange in color.

- Blue Giant – A huge, very hot, blue star. It is a post-main sequence star that burns helium.

- Supergiant – A rare type of star that is the largest known type of star. Some are almost as large as our entire solar system. When supergiants die they supernova and become black holes or neutron stars.

Goal: Students will discover the processes involved in all stars.

DEAD STARS

- Dead stars are stars that are no longer undergoing the process of fusion.
- White Dwarf – A small, very dense, hot star that is made mostly of carbon. These faint stars are what remains after a red giant star loses its outer layers. Will eventually cool down to become a black dwarf.
- Brown Dwarf – A "star" whose mass is too small to have nuclear fusion occur at its core (the temperature and pressure at its core are insufficient for fusion). A brown dwarf is not very luminous.
- Neutron Star - A neutron star is a very small, super-dense star which is composed mostly of tightly-packed neutrons.

Goal: Students will determine the life cycle of all stars.

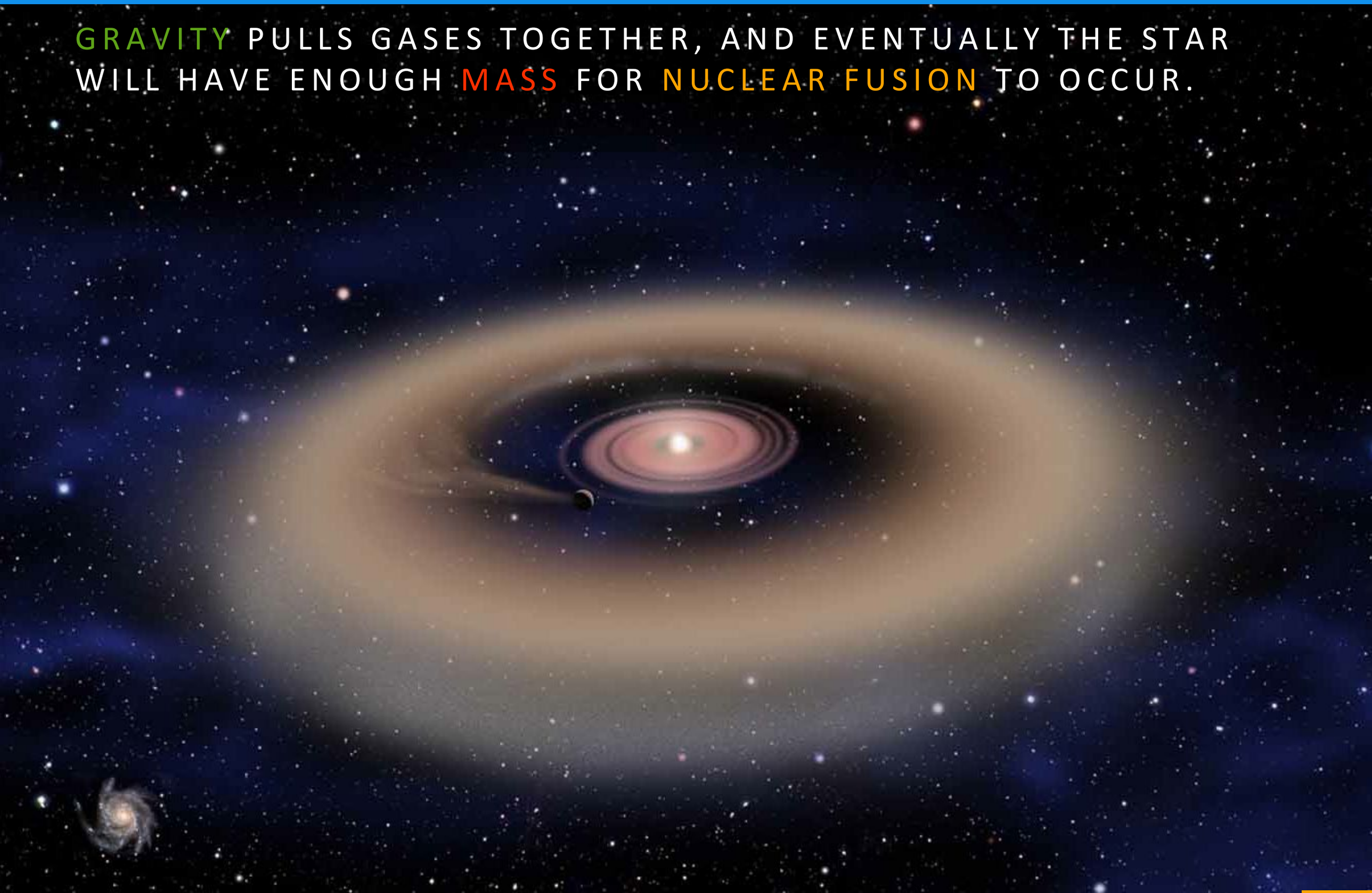
WHAT CONTROLS THE LIFE CYCLE OF A STAR?

Goal: Students will determine the life cycle of all stars.

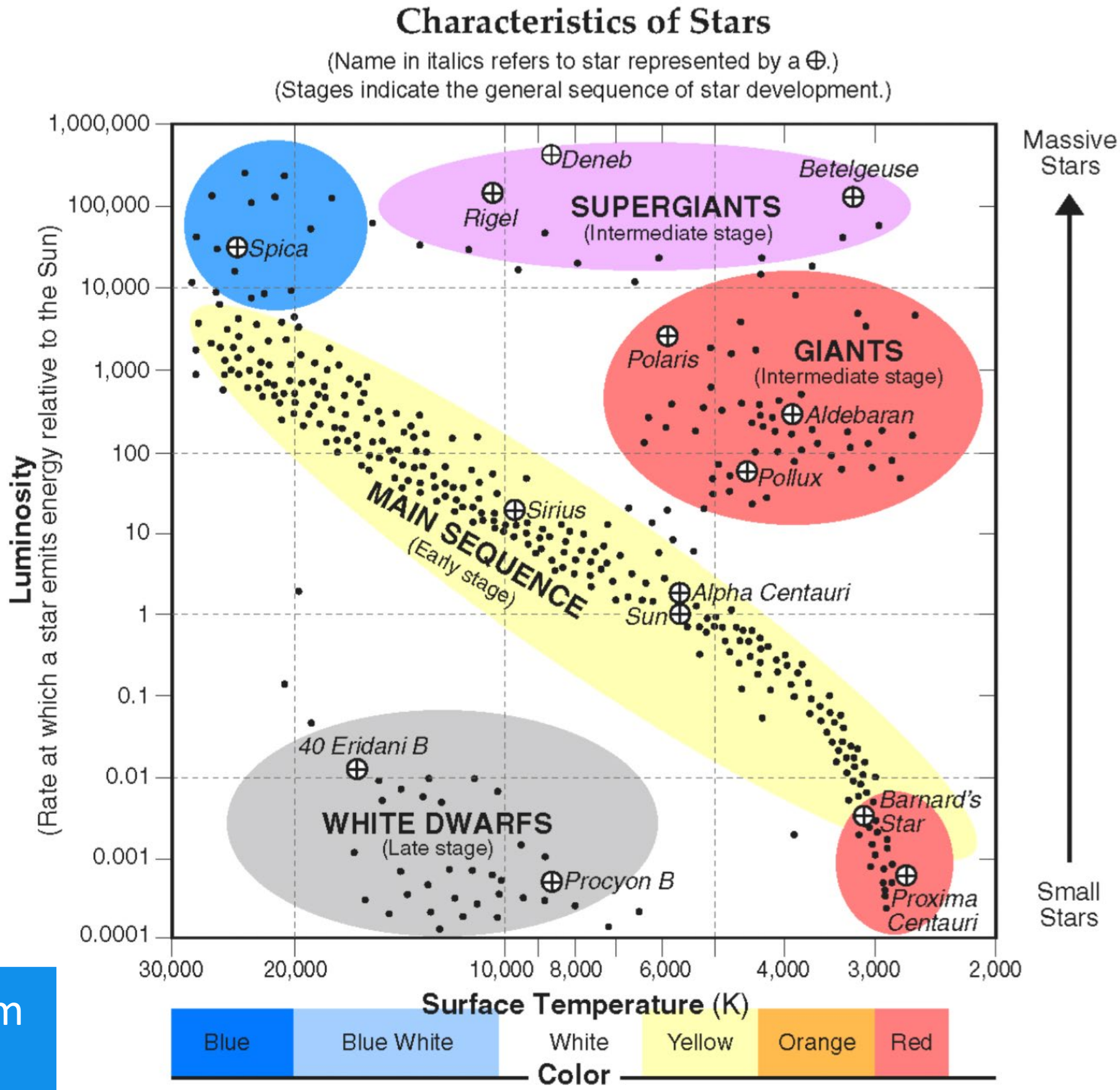
ALL STARS ARE BORN IN NEBULAE

Goal: Students will determine the life cycle of all stars.

GRAVITY PULLS GASES TOGETHER, AND EVENTUALLY THE STAR WILL HAVE ENOUGH MASS FOR NUCLEAR FUSION TO OCCUR.



Goal: Students will determine the life cycle of all stars.



HR Diagram Explorer

Goal: Students will determine the life cycle of all stars.

IF A STAR IS BIG…

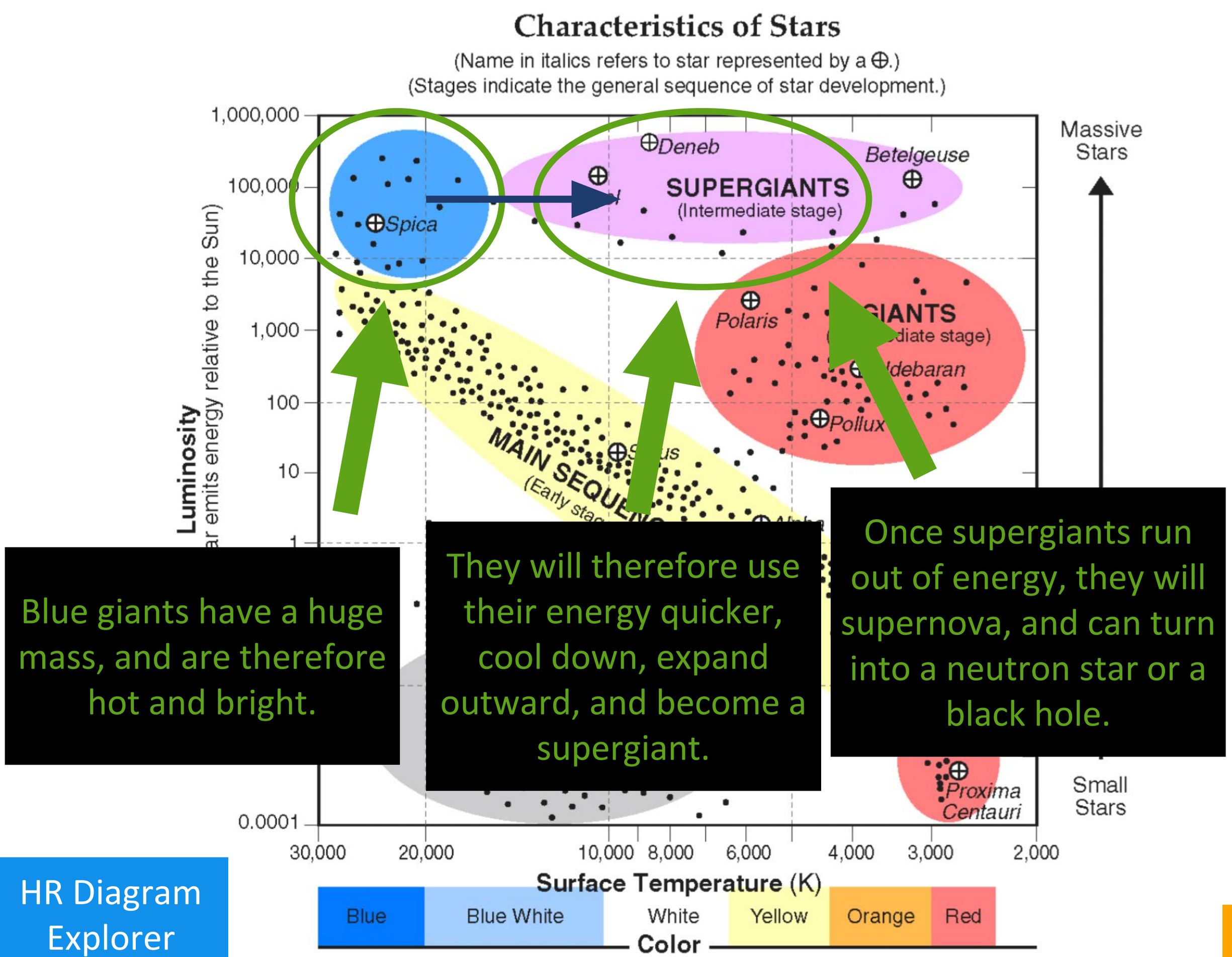
Goal: Students will determine the life cycle of all stars.

IT WILL BE HOTTER…

Goal: Students will determine the life cycle of all stars.

BRIGHTER…

AND USE UP ITS ENERGY QUICKER.



Blue giants have a huge mass, and are therefore hot and bright.

They will therefore use their energy quicker, cool down, expand outward, and become a supergiant.

Once supergiants run out of energy, they will supernova, and can turn into a neutron star or a black hole.

HR Diagram Explorer

Goal: Students will determine the life cycle of all stars.

IF A STAR IS SMALLER…

Goal: Students will determine the life cycle of all stars.

IT WILL BE COOLER…

Goal: Students will determine the life cycle of all stars.

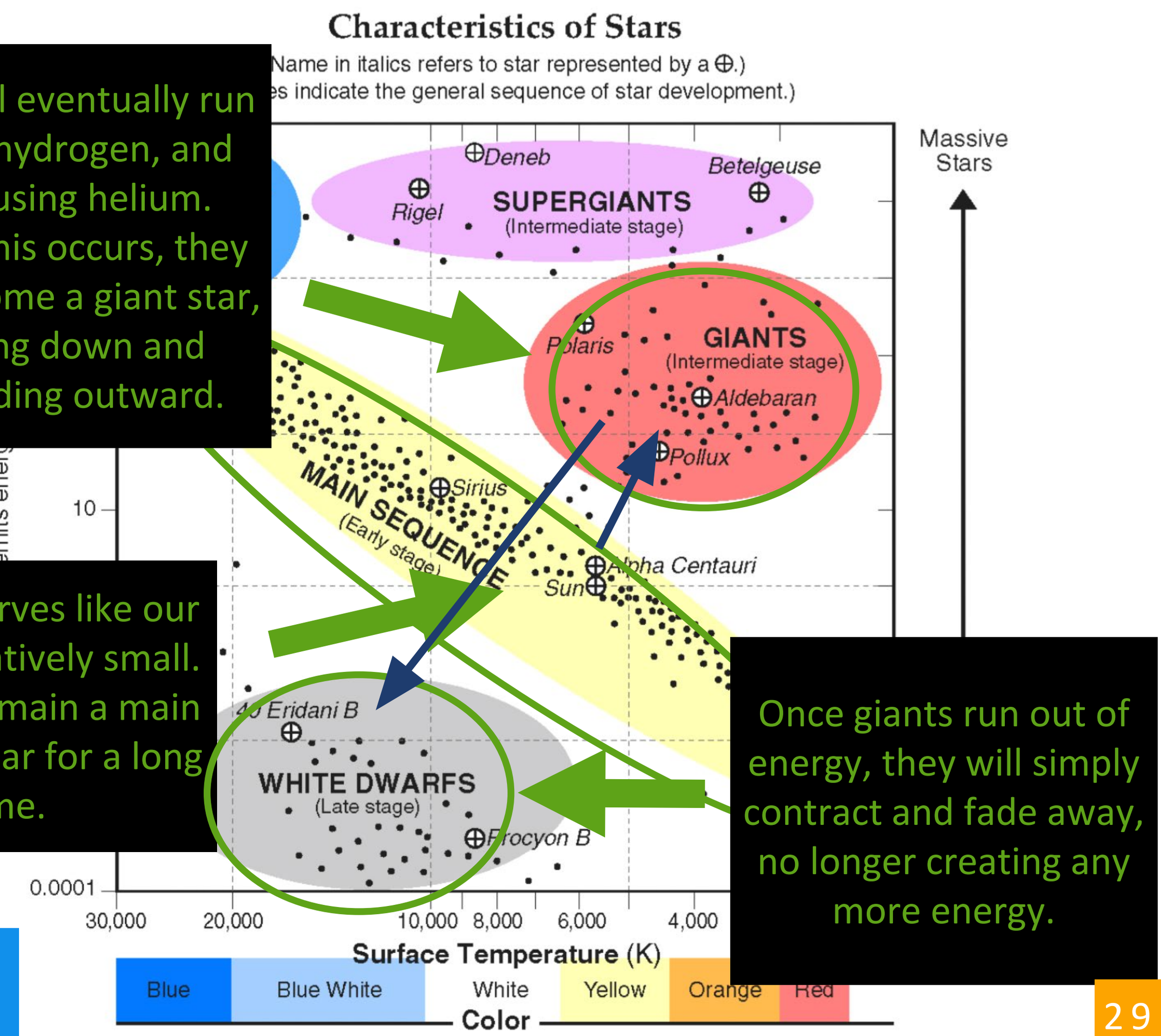
D I M M E R …

AND USE UP ITS ENERGY SLOWER.

They will eventually run out of hydrogen, and start using helium. When this occurs, they will become a giant star, cooling down and expanding outward.

Yellow dwarves like our Sun are relatively small. They will remain a main sequence star for a long time.

Once giants run out of energy, they will simply contract and fade away, no longer creating any more energy.



HR Diagram Explorer

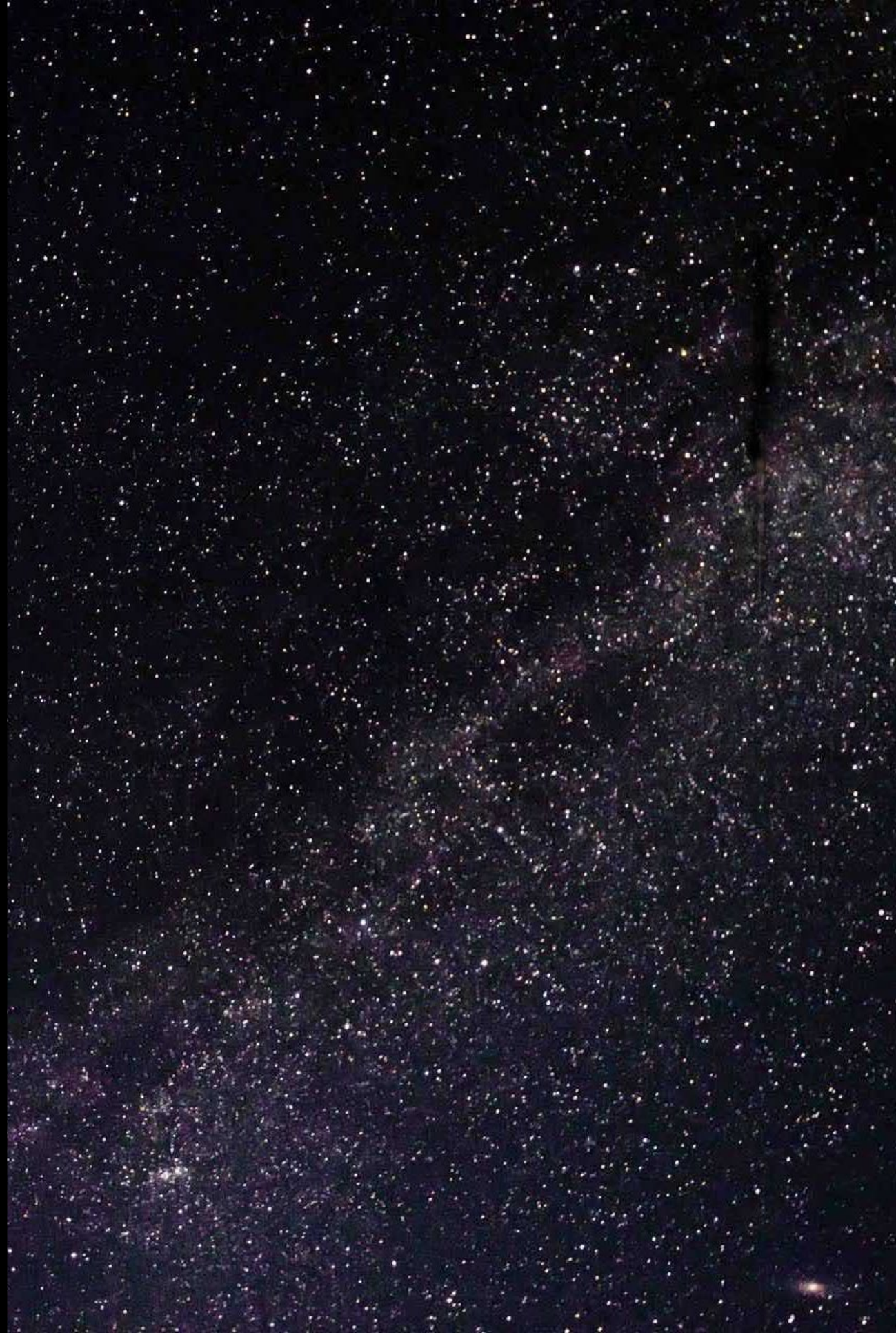
DO ALIENS EXIST?

SETI

SEARCH FOR EXTRA-TERRESTRIAL INTELLIGENCE

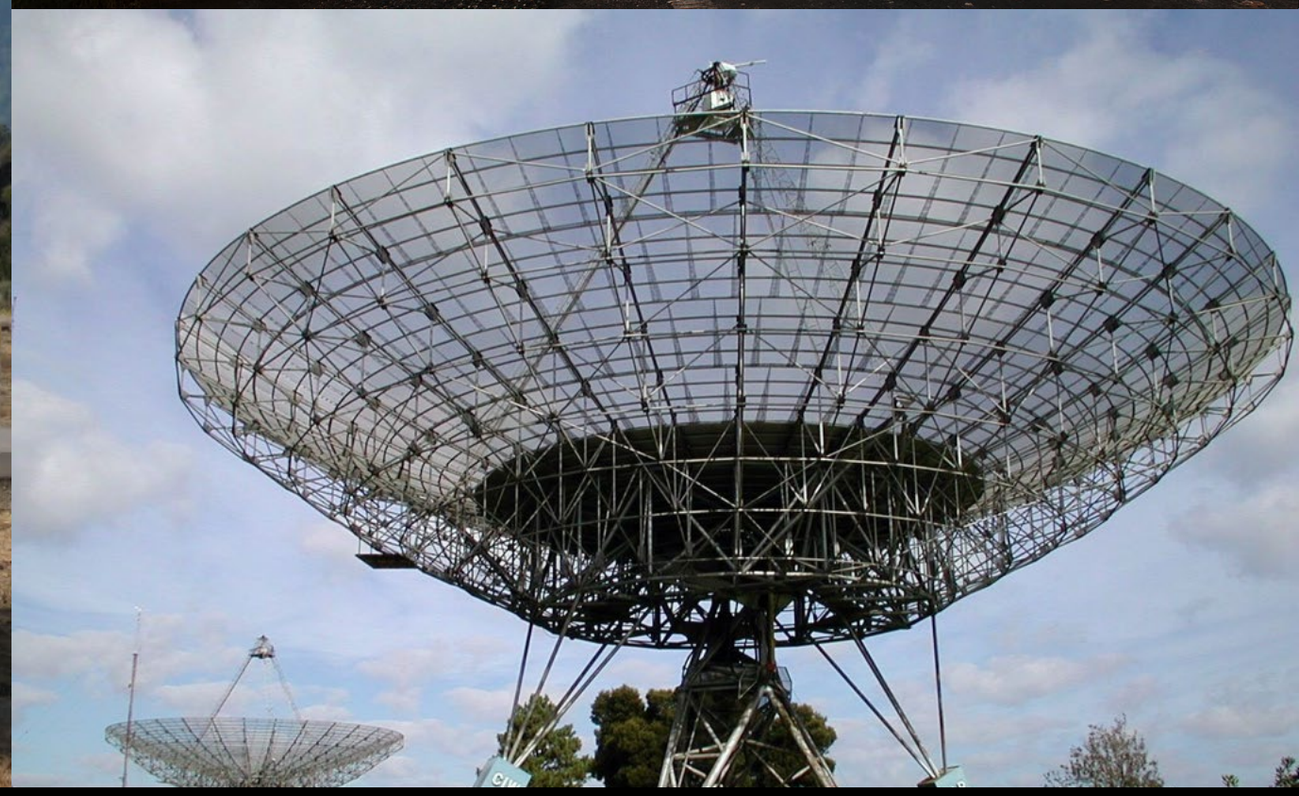
SETI

- Search for Extraterrestrial Intelligence
- The mission of the SETI Institute is to explore, understand and explain the origin, nature and prevalence of life in the universe.



SETI RESEARCH

SETI, the Search for Extraterrestrial Intelligence, is an exploratory science that seeks evidence of life in the universe by looking for some signature of its technology. Our current understanding of life's origin on Earth suggests that given a suitable environment and sufficient time, life will develop on other planets. Whether evolution will give rise to intelligent, technological civilizations is open to speculation. However, such a civilization could be detected across interstellar distances, and may actually offer our best opportunity for discovering extraterrestrial life in the near future.



SINCE THE 1960’S, RADIO TELESCOPES HAVE BEEN USED TO PICK UP RADIO SIGNALS COMING FROM SPACE.

IS ET OUT THERE?

BLAH, BLAH, BLAH…
BASICALLY OUR TECHNOLOGY ISN’T SOPHISTICATED ENOUGH TO TELL IF WE’RE ACTUALLY PICKING UP SIGNALS FROM ANOTHER CIVILIZATION.

THE FERMI PARADOX

THE FERMI PARADOX IS THE APPARENT CONTRADICTION BETWEEN THE HIGH PROBABILITY EXTRATERRESTRIAL CIVILIZATIONS' EXISTENCE AND THE LACK OF CONTACT WITH SUCH CIVILIZATIONS.

THE FERMI PARADOX

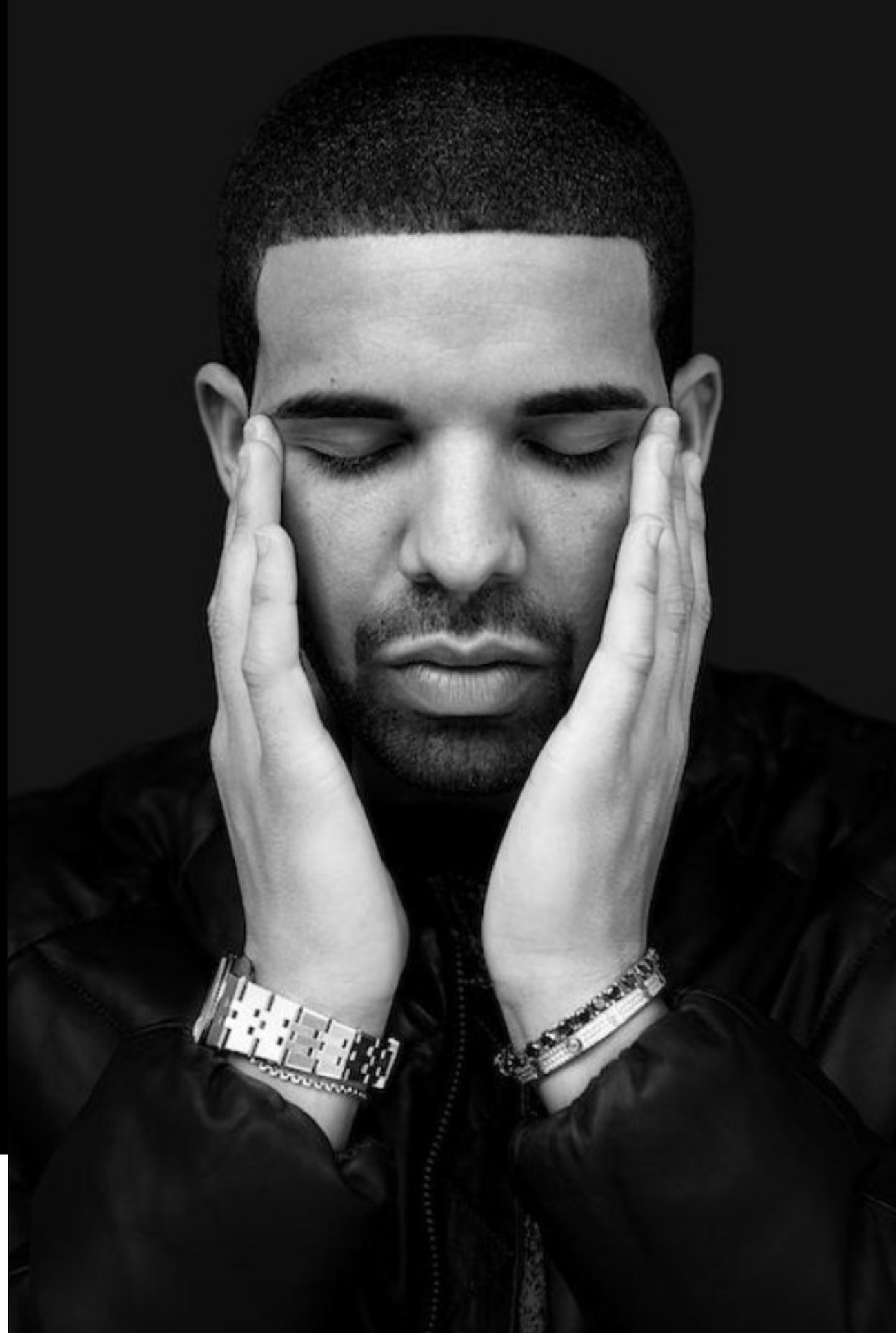
The basic points of the argument, made by physicists Enrico Fermi and Michael H. Hart, are:

- The Sun is a young star. There are billions of stars in the galaxy that are billions of years older;
- Some of these stars likely have Earth-like planets which, if the Earth is typical, may develop intelligent life;
- Presumably some of these civilizations will develop interstellar travel, a technology Earth is investigating even now;
- At any practical pace of interstellar travel, the galaxy can be completely colonized in a few tens of millions of years.
- According to this line of thinking, the Earth should have already been colonized, or at least visited. But no convincing evidence of this exists. Furthermore, no confirmed signs of intelligence elsewhere have been spotted, either in our galaxy or the more than 80 billion other galaxies of the observable universe. Hence Fermi's question, "Where is everybody?"

THE DRAKE EQUATION

- A formula derived by Dr. Frank Drake, Carl Sagan and other scientists to predict the number of civilizations that could receive and send technological communication.

$$N = R^* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$



$$N = R^{*} \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

- N = the number of active, communicative extraterrestrial civilizations in the Milky Way galaxy
- R_* = the average rate of star formation, in our galaxy
- f_p = the fraction of formed stars that have planets
- n_e = the average number of planets per star that has planets that can potentially support life
- f_l = the fraction of those planets that actually develop life
- f_i = the fraction of planets bearing life on which intelligent, civilized life, has developed
- f_c = the fraction of these civilizations that have developed communications, i.e., technologies that release detectable signs into space
- L = the length of time over which such civilizations release detectable signals

ORIGINAL

$$N = R^* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

ESTIMATES

- N = the number of active, communicative extraterrestrial civilizations in the Milky Way galaxy
- R_* = the average rate of star formation, in our galaxy — 1/year
- f_p = the fraction of formed stars that have planets
- n_e = the average number of planets per star that has planets that can potentially support life — 0.2-0.5
- f_l = the fraction of those planets that actually develop life — 1-5
- f_i = the fraction of planets bearing life on which intelligent, civilized life, has developed — 1
- f_c = the fraction of these civilizations that have developed communications, i.e., technologies that release detectable signs into space — 1
- L = the length of time over which such civilizations release detectable signals — 0.1-.0.2

1000 - 100,000,00 years

CURRENT

$$N = R^* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

LOW ESTIMATES

- N = the number of active, communicative extraterrestrial civilizations in the Milky Way galaxy
- R_* = the average rate of star formation, in our galaxy — 7/year
- f_p = the fraction of formed stars that have planets
- n_e = the average number of planets per star that has planets that can potentially support life — $f_p * n_e * f_l = 10^{-5}$
- f_l = the fraction of those planets that actually develop life
- f_i = the fraction of planets bearing life on which intelligent, civilized life, has developed — 10^{-9}
- f_c = the fraction of these civilizations that have developed communications, i.e., technologies that release detectable signs into space — 0.2
- L = the length of time over which such civilizations release detectable signals — 304 years

CURRENT

$$N = R^* \cdot f_p \cdot n_e \cdot f_l \cdot f_i \cdot f_c \cdot L$$

HIGH ESTIMATES

- N = the number of active, communicative extraterrestrial civilizations in the Milky Way galaxy
- R_* = the average rate of star formation, in our galaxy — 7/year
- f_p = the fraction of formed stars that have planets — 1
- n_e = the average number of planets per star that has planets that can potentially support life — 0.2
- f_l = the fraction of those planets that actually develop life — 0.13
- f_i = the fraction of planets bearing life on which intelligent, civilized life, has developed — 1
- f_c = the fraction of these civilizations that have developed communications, i.e., technologies that release detectable signs into space — 0.2
- L = the length of time over which such civilizations release detectable signals — 10^9 years


WHERE IS EVERYBODY?

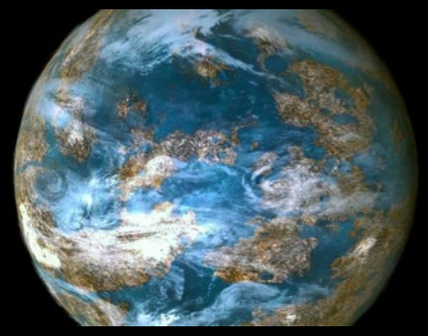
There should be many Earth-like planets in here…

Big Bang Occurs 14 Billion Years Ago

Earth Forms 4.54 Billion Years Ago

Present Day

Let’s say Planet X formed 8 billion years ago



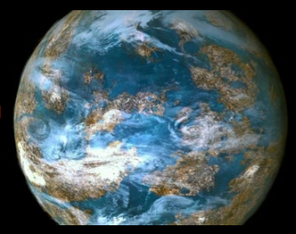
Big Bang Occurs 14 Billion Years Ago

Planet X Forms 8 Billion Years Ago

Earth Forms 4.54 Billion Years Ago

Present Day

Planet X was at our
current level of
intelligence and technology

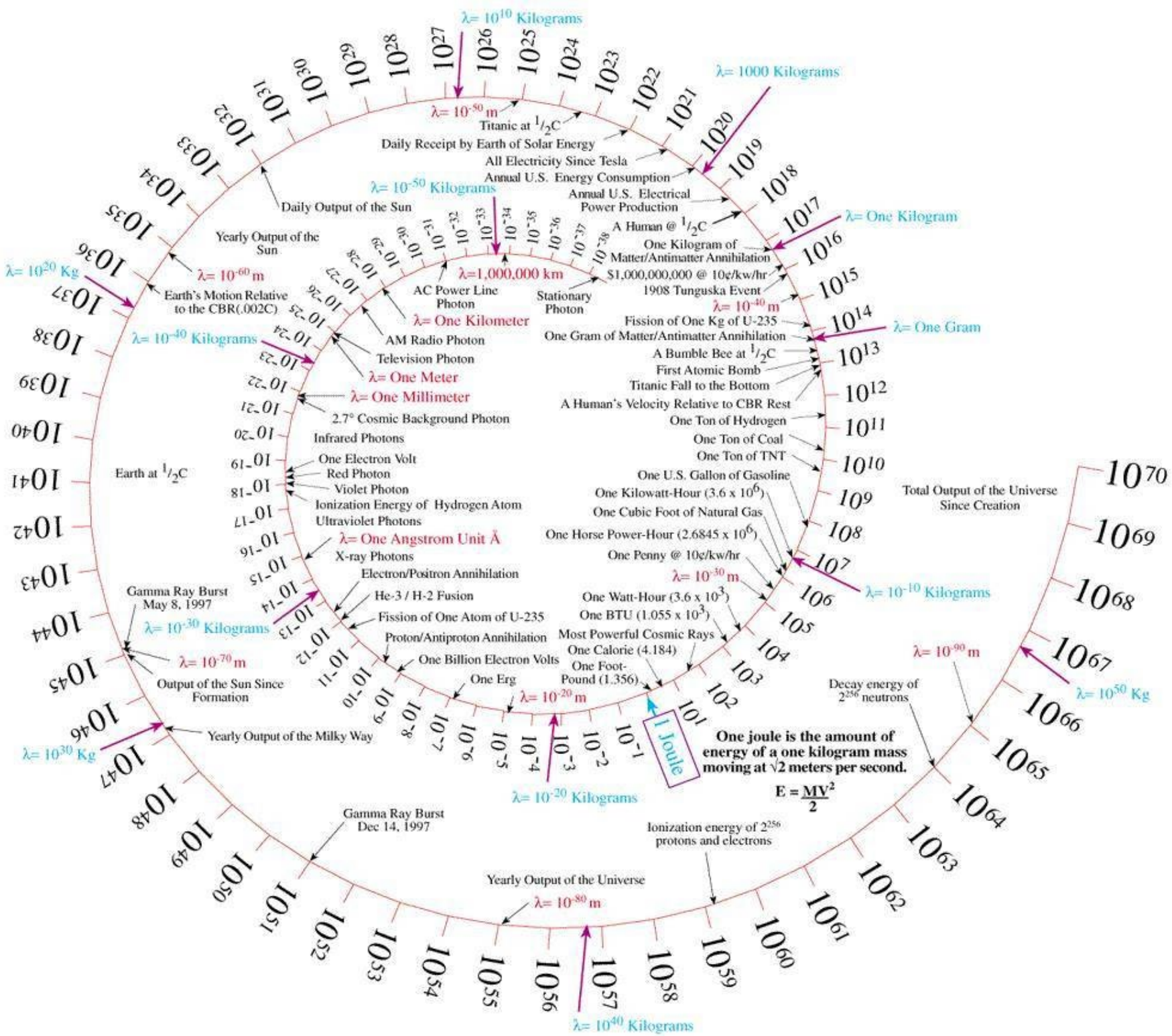


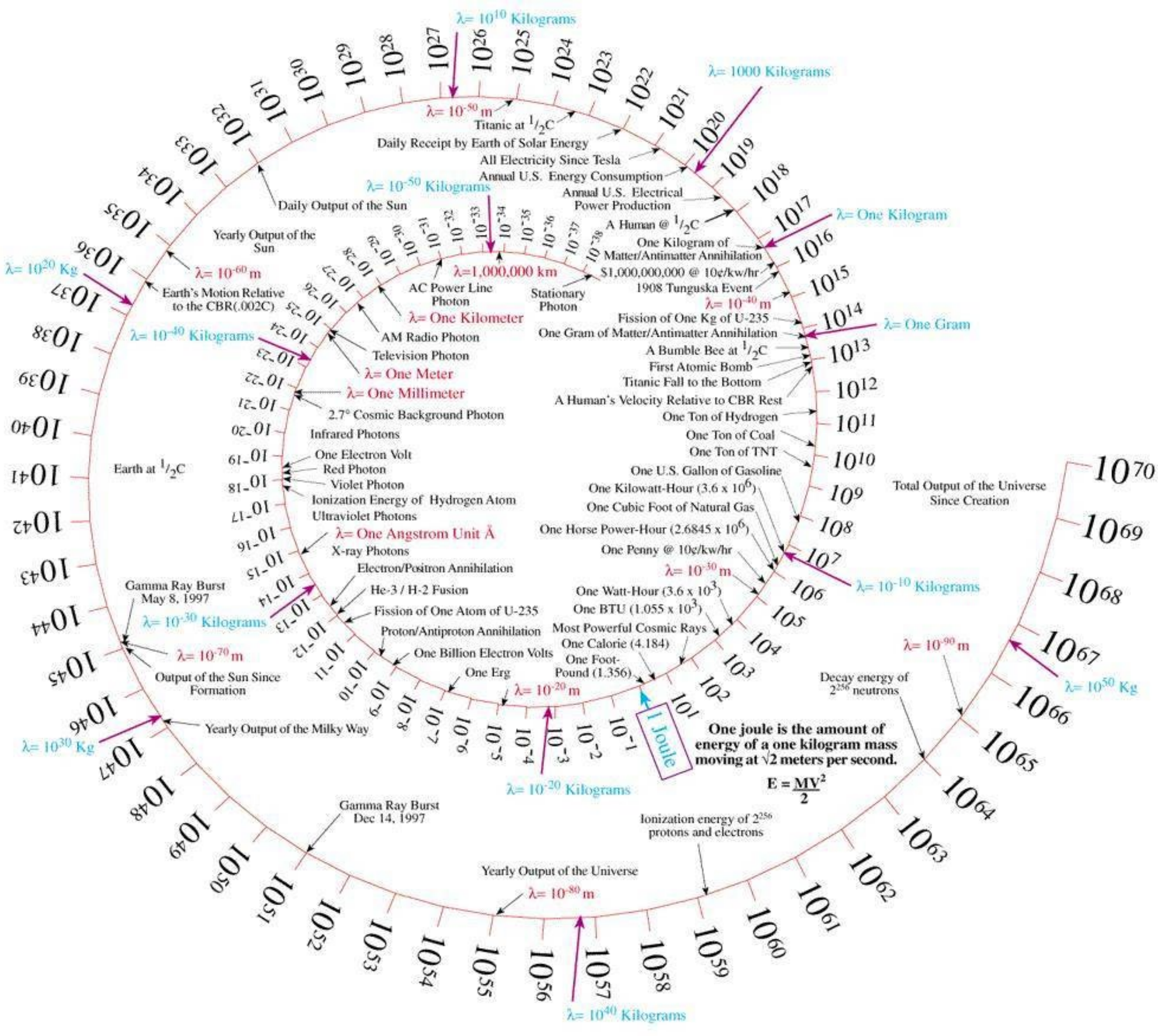
Planet X
Forms
8 Billion
Years Ago

3.46 billions
years of
development
beyond where
we are today

Earth’s Lifespan
4.54 Billion Years

KARDASHEV SCALE - A METHOD OF MEASURING A CIVILIZATION'S LEVEL OF TECHNOLOGICAL ADVANCEMENT, BASED ON THE AMOUNT OF ENERGY A CIVILIZATION IS ABLE TO UTILIZE DIRECTED TOWARDS COMMUNICATION.




λ= 10^10 Kilograms
λ= 1000 Kilograms
λ= One Kilogram
λ= One Gram
λ= 10^-10 Kilograms
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λ= 10^-50 Kilograms
λ= 10^20 Kg
λ= 10^30 Kg
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λ= 10^50 Kg
λ= 10^-50 m
λ= 10^-60 m
λ= 10^-70 m
λ= 10^-80 m
λ= 10^-90 m
λ= 10^-40 m
λ= 10^-30 m
λ=1,000,000 km
λ= One Kilometer
λ= One Meter
λ= One Millimeter
λ= One Angstrom Unit Å
Titanic at 1/2C
Daily Receipt by Earth of Solar Energy
All Electricity Since Tesla
Annual U.S. Energy Consumption
Annual U.S. Electrical Power Production
A Human @ 1/2C
One Kilogram of Matter/Antimatter Annihilation
$1,000,000,000 @ 10¢/kw/hr
1908 Tunguska Event
Fission of One Kg of U-235
One Gram of Matter/Antimatter Annihilation
A Bumble Bee at 1/2C
First Atomic Bomb
Titanic Fall to the Bottom
A Human's Velocity Relative to CBR Rest
One Ton of Hydrogen
One Ton of Coal
One Ton of TNT
One U.S. Gallon of Gasoline
One Kilowatt-Hour (3.6 x 10^6)
One Cubic Foot of Natural Gas
One Horse Power-Hour (2.6845 x 10^6)
One Penny @ 10¢/kw/hr
One Watt-Hour (3.6 x 10^3)
One BTU (1.055 x 10^3)
Most Powerful Cosmic Rays
One Calorie (4.184)
One Foot-Pound (1.356)
1 Joule
One joule is the amount of energy of a one kilogram mass moving at √2 meters per second.
E = MV²/2
Daily Output of the Sun
Yearly Output of the Sun
Earth's Motion Relative to the CBR(.002C)
Earth at 1/2C
Stationary Photon
AC Power Line Photon
AM Radio Photon
Television Photon
2.7° Cosmic Background Photon
Infrared Photons
One Electron Volt
Red Photon
Violet Photon
Ionization Energy of Hydrogen Atom
Ultraviolet Photons
X-ray Photons
Electron/Positron Annihilation
He-3 / H-2 Fusion
Fission of One Atom of U-235
Proton/Antiproton Annihilation
One Billion Electron Volts
One Erg
Total Output of the Universe Since Creation
Decay energy of 2^256 neutrons
Ionization energy of 2^256 protons and electrons
Yearly Output of the Universe
Yearly Output of the Milky Way
Output of the Sun Since Formation
Gamma Ray Burst May 8, 1997
Gamma Ray Burst Dec 14, 1997
10^70
10^69
10^68
10^67
10^66
10^65
10^64
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10^62
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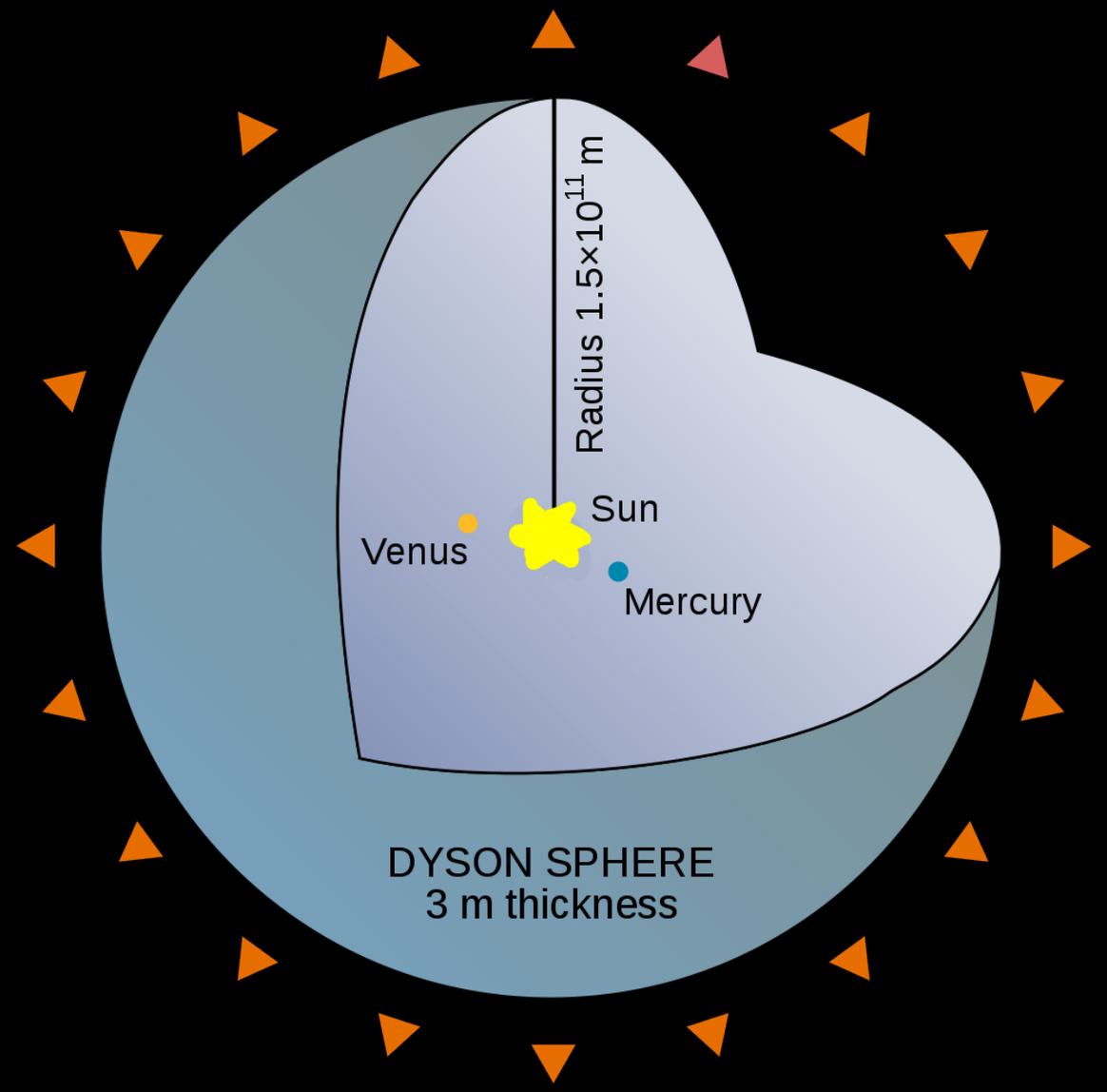
TYPES OF CIVILIZATIONS

- A Type I Civilization has the ability to use all of the energy on their planet. We're not quite a Type I Civilization, but we're close (Carl Sagan created a formula for this scale which puts us at a Type 0.7 Civilization).

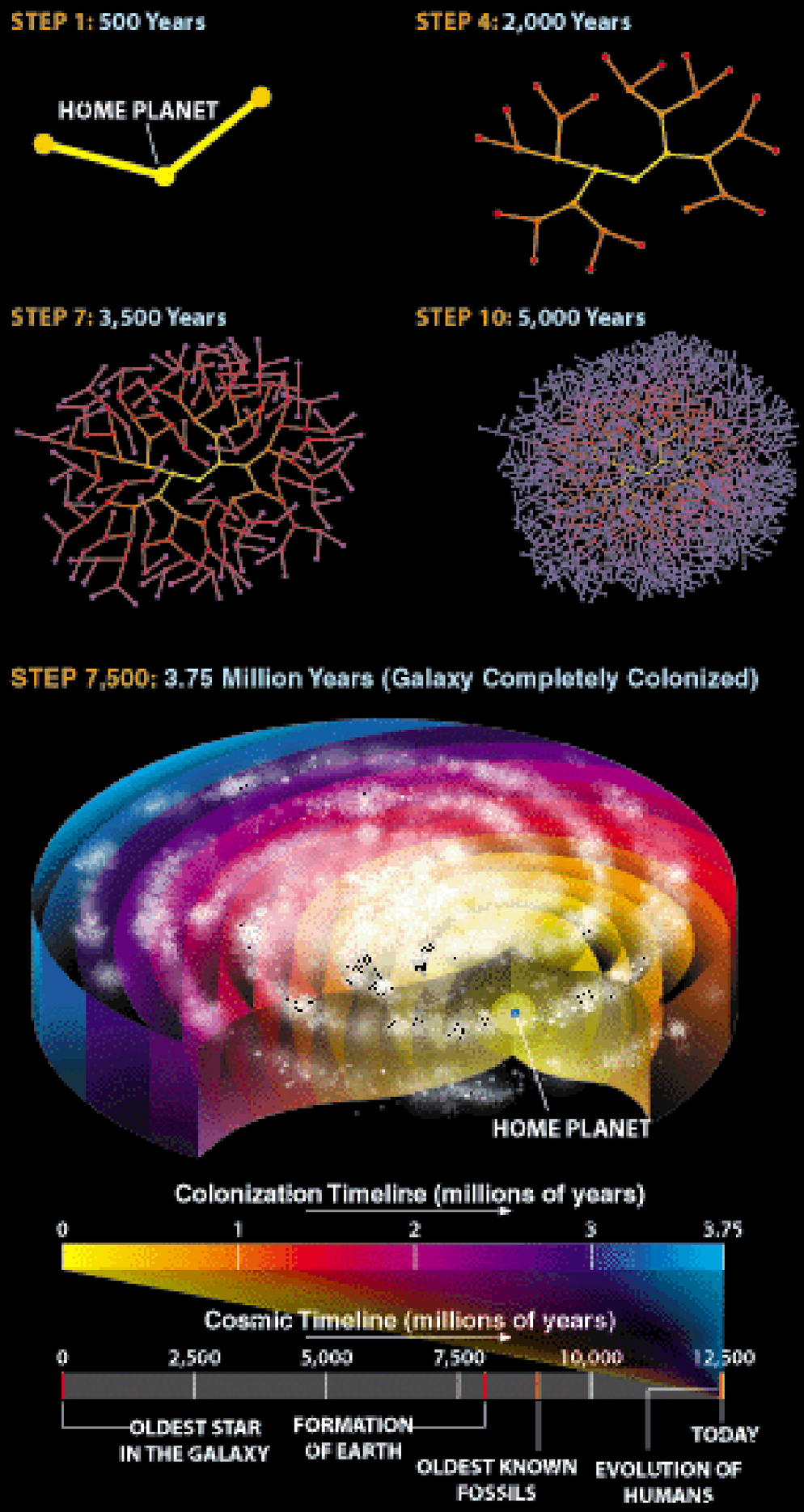
- A Type II Civilization can harness all of the energy of their host star. Our feeble Type I brains can hardly imagine how someone would do this, but we've tried our best, imagining things like a Dyson Sphere.

- A Type III Civilization blows the other two away, accessing power comparable to that of the entire Milky Way galaxy.

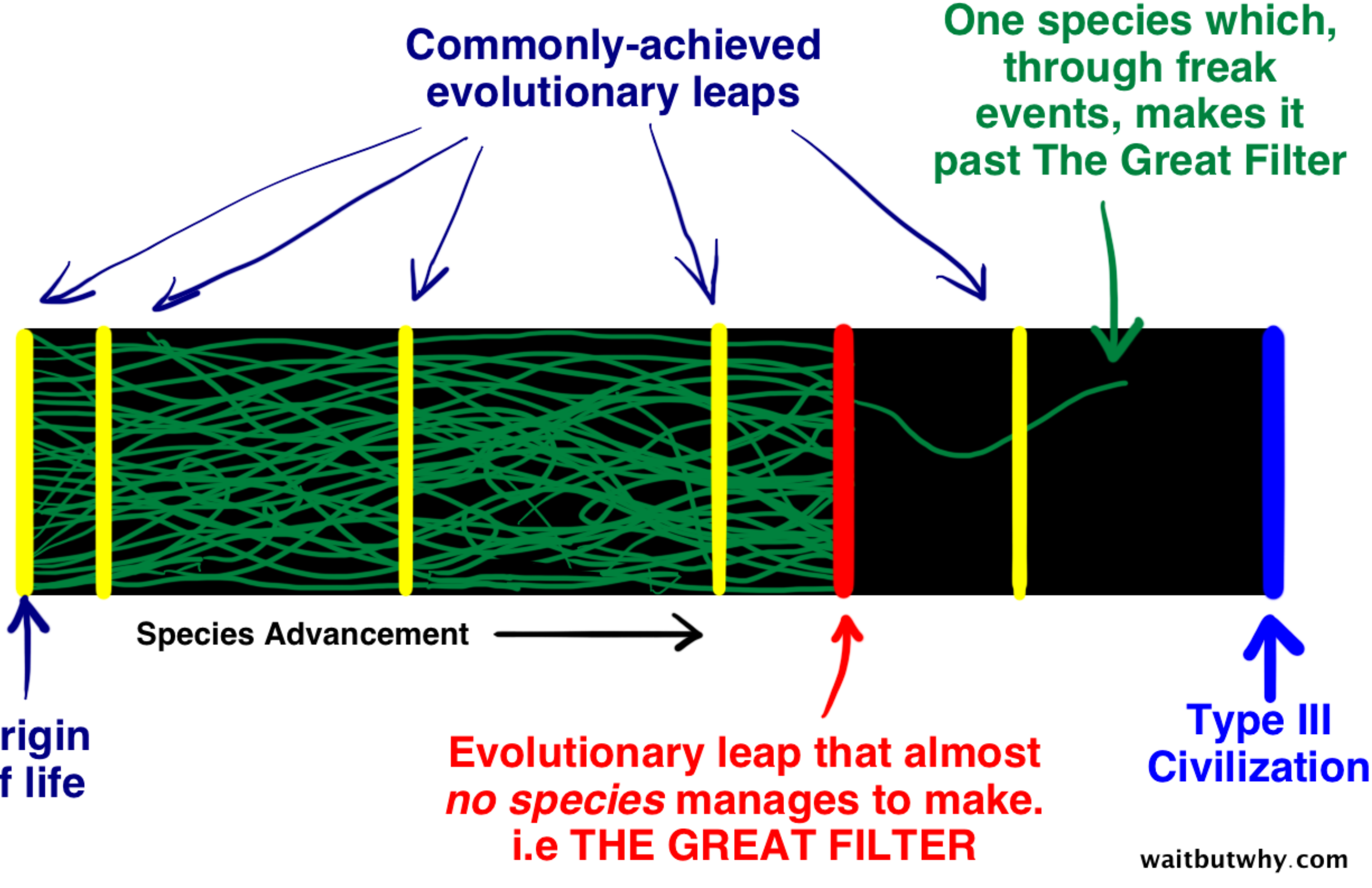


COLONIZATION THEORY

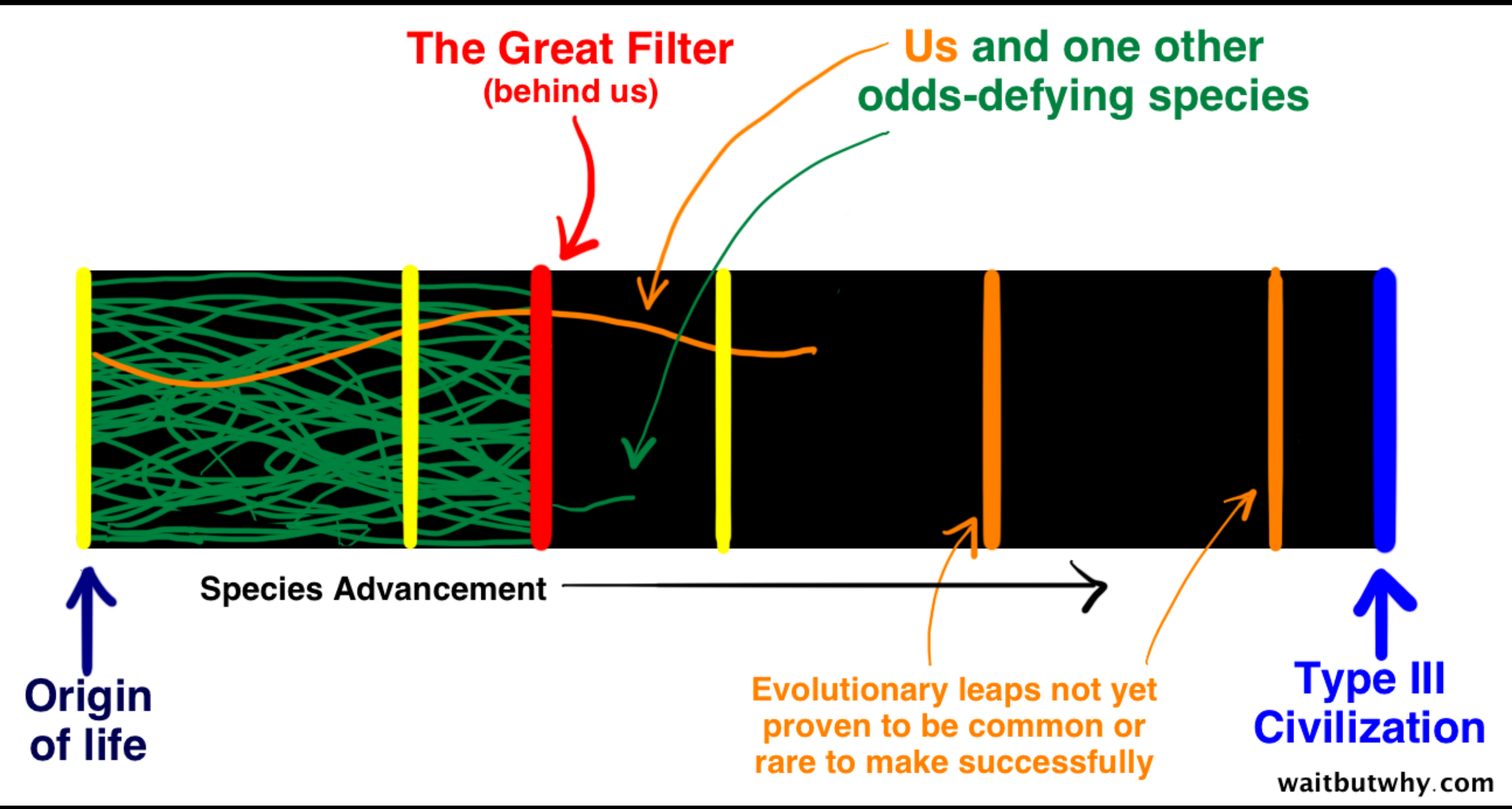
- If 1% of intelligent life survives long enough to become a potentially galaxy-colonizing Type III Civilization, our calculations from before suggest that there should be at least 1,000 Type III Civilizations in our galaxy alone—and given the power of such a civilization, their presence would likely be pretty noticeable. And yet, we see nothing, hear nothing, and we're visited by no one.



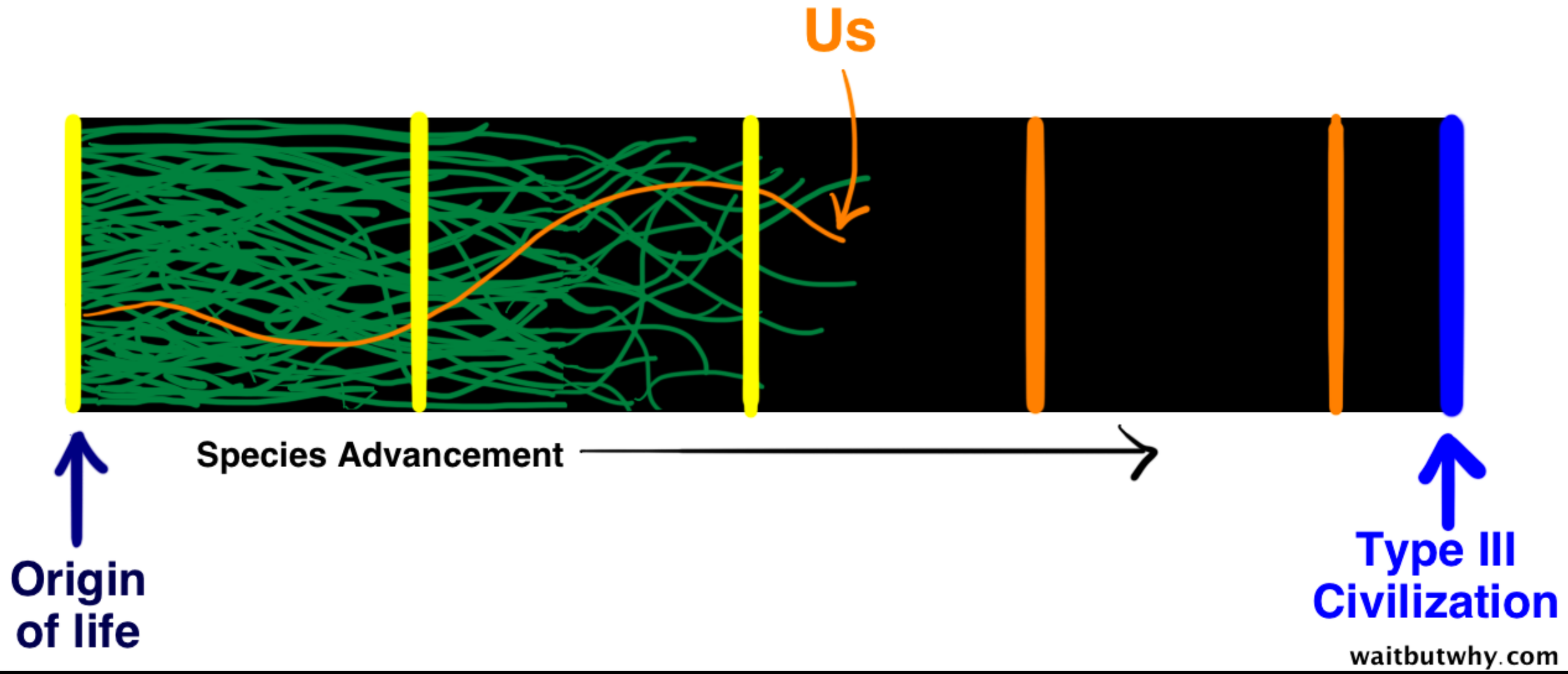
The Great Filter



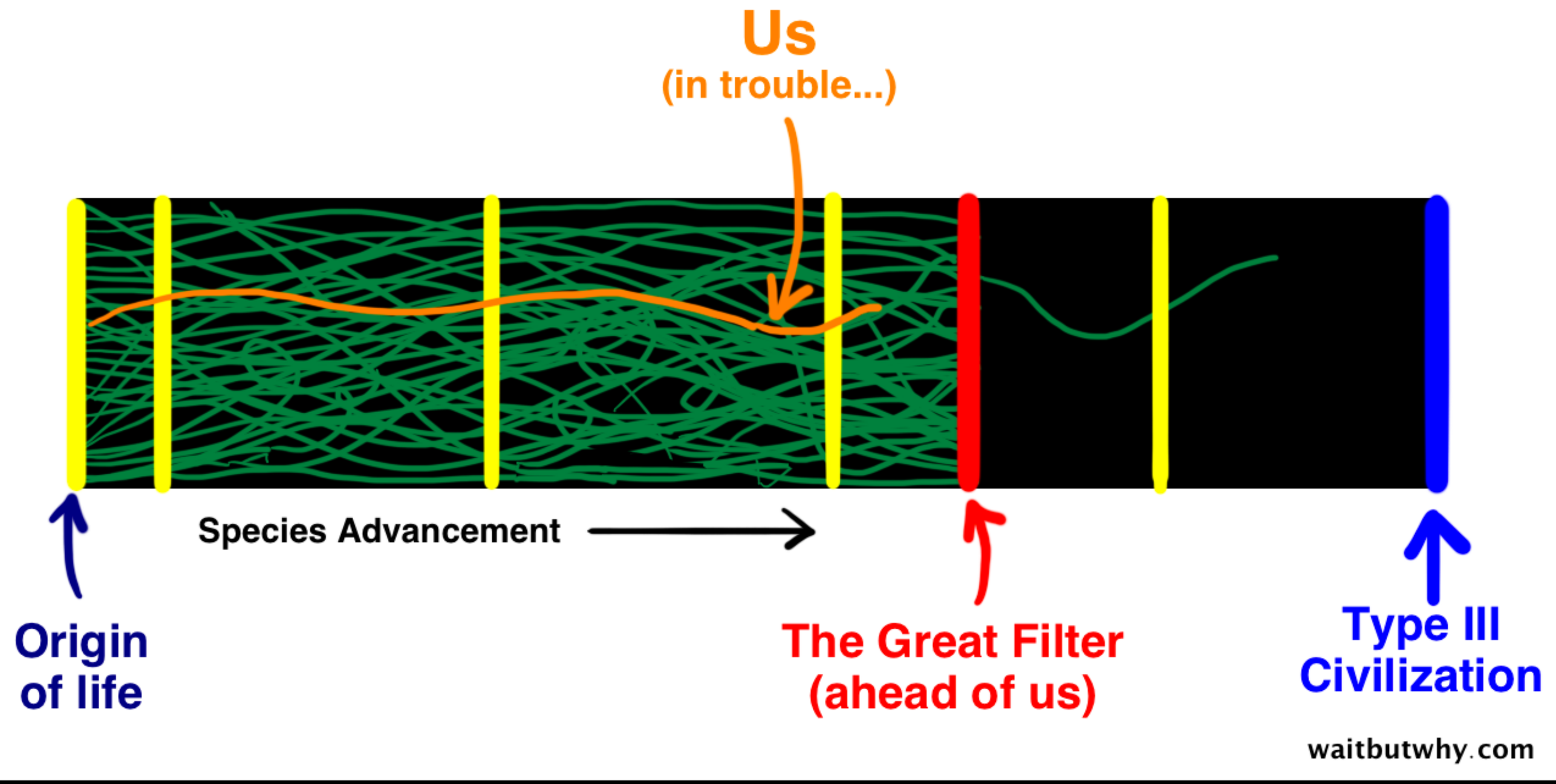
1. Maybe we are rare, and the great filter is behind us.



2. We are the first advanced civilization.



3. Uhoh… the great filter is ahead of us.



OTHER REASONS

Possibility 1) Super-intelligent life could very well have already visited Earth, but before we were here.

Possibility 2) The galaxy has been colonized, but we just live in some desolate rural area of the galaxy.

Possibility 3) The entire concept of physical colonization is a hilariously backward concept to a more advanced species.

Possibility 4) There are scary predator civilizations out there, and most intelligent life knows better than to broadcast any outgoing signals and advertise their location.

Possibility 5) There's only one instance of higher-intelligent life—a "superpredator" civilization (like humans are here on Earth)—who is far more advanced than everyone else and keeps it that way by exterminating any intelligent civilization once they get past a certain level.

Possibility 6) There's plenty of activity and noise out there, but our technology is too primitive and we're listening for the wrong things.

Possibility 7) We are receiving contact from other intelligent life, but the government is hiding it.

Possibility 8) Higher civilizations are aware of us and observing us (AKA the "Zoo Hypothesis").

Possibility 9) Higher civilizations are here, all around us. But we're too primitive to perceive them.

Possibility 10) We're completely wrong about our reality.

ASTRONOMY