Midterm 1 Review

Midterm 1 on Sept. 28th
will cover Chapters 1-5 and lecture material

Chapter 10 Reading Assignment due Monday, October 1st
& Chapter 11 Reading Assignment due Friday, October 5th
(in Canvas)

Are your grades in Canvas correct???

Office Hours

Mon 12-1pm	Zane
Tues 1:30-3pm	me
Tues 5-6pm	Randall
Wed 3-4pm	Randall
Thurs 11:45a-12:45pm	Zane
Fri 12-1pm	me

me: INSCC 320
Zane/Randall: JFB 325

Exam Format

50-60 min time limit: 10:45-11:35/45am

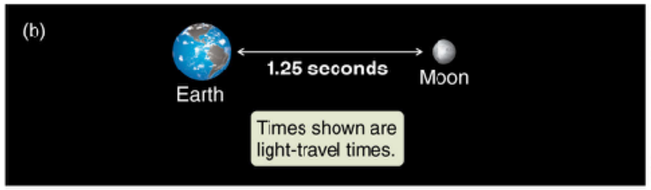
Multiple Choice Questions
60-75% of total score

Short Answer Questions
40-25% of total score
may require calculations, but calculators not needed (or allowed)

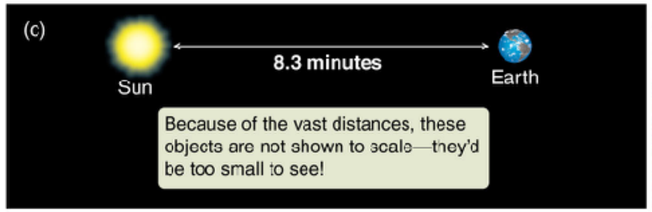
Chapter 1: Scales and How to Think Like a Scientist

Scale by light-speed

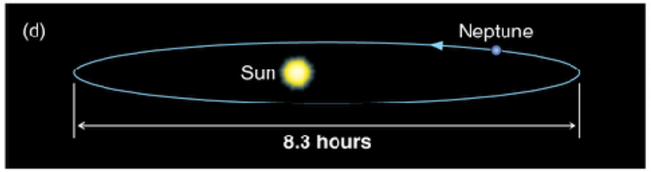
Moving outward through the universe at the speed of light, going around Earth is like a snap of your fingers.



The Moon is a little more than a second away.

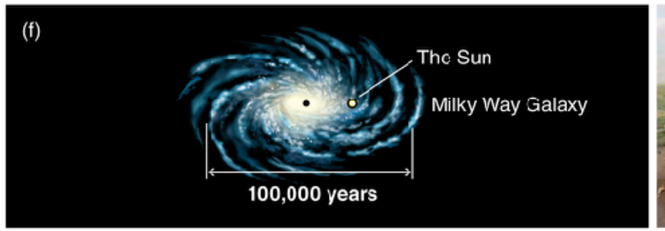


The Sun's distance is like a quick meal.

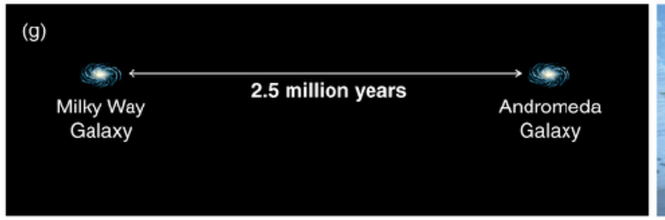


The diameter of Neptune orbit is a night's sleep.

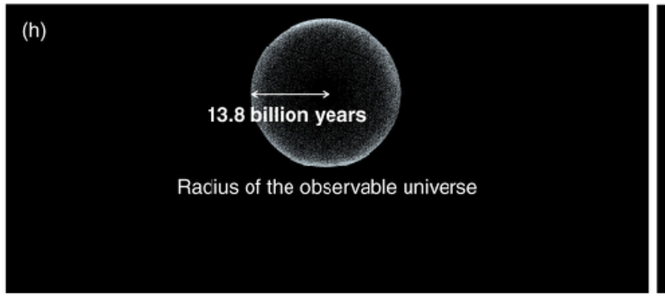
Leaving the Solar System, the distance to the nearest star is like the time you spend in high school.



The diameter of the galaxy is like the age of our species.

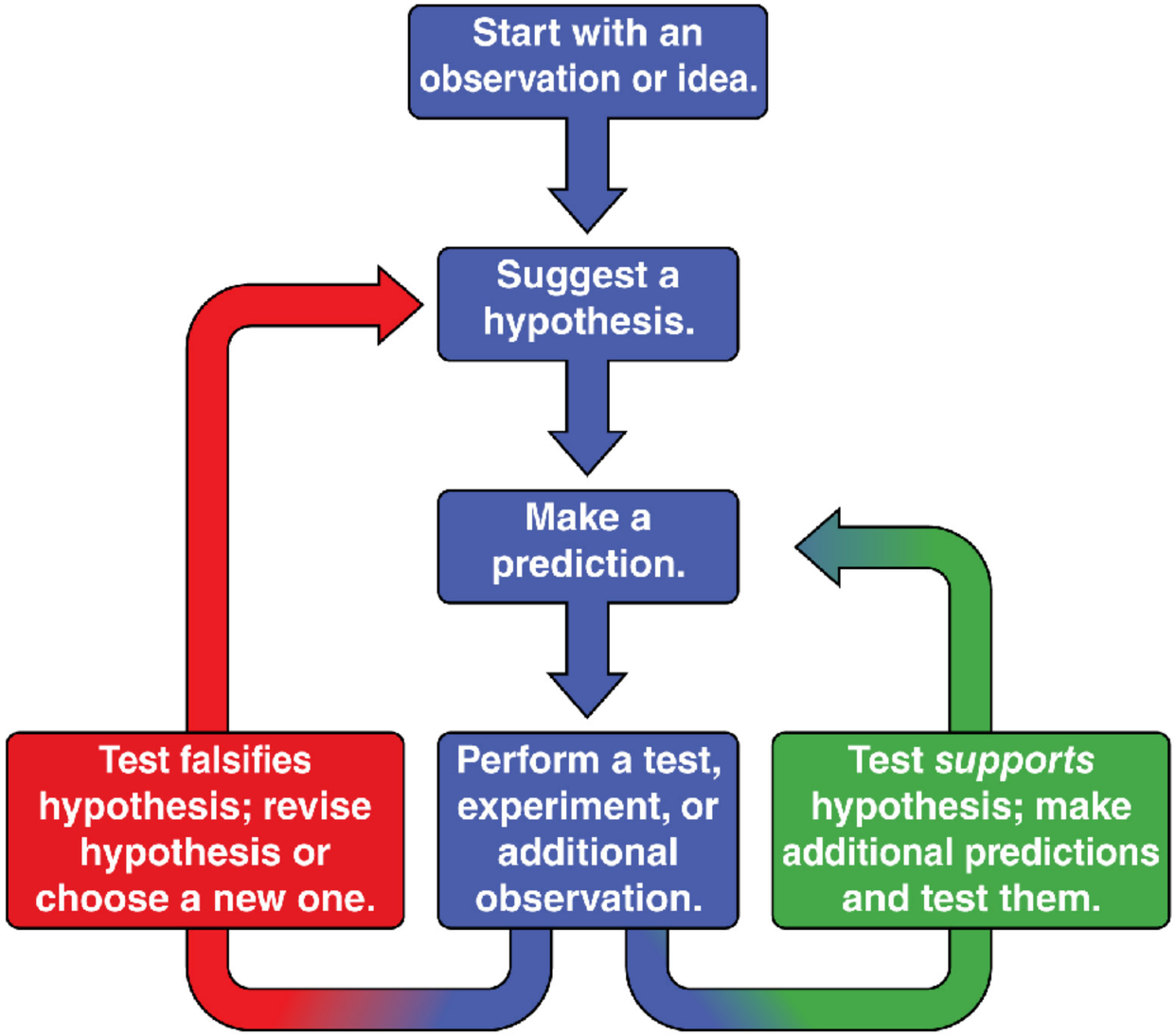


The distance between galaxies is like the time since our earliest human ancestors walked on Earth.



The size of the observable universe is like three times the age of Earth.

Scientific Method



Scientific Notation

10^6 = 1,000,000 = one million

5×10^9 = 5,000,000,000 = five billion

$2 \times 10^2 \times 3 \times 10^3 = 6 \times 10^5$ = 600,000 = six hundred thousand

Calculator / Computer shorthand: 2e-7 = 2×10^{-7} = 0.0000002
(on exams and assignments, use the correct notation, not this shorthand)

To conclude (or really, begin):

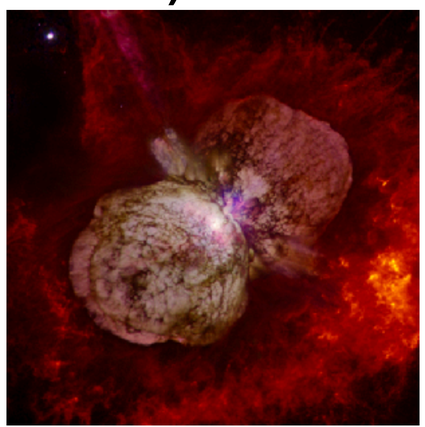
Because light travels at a finite speed, looking far away is looking into the past

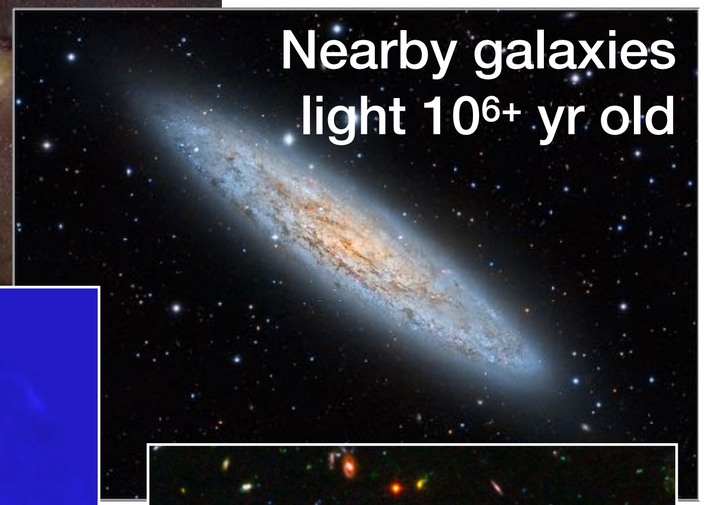
There are ~100 billion stars in our Galaxy, the Milky Way

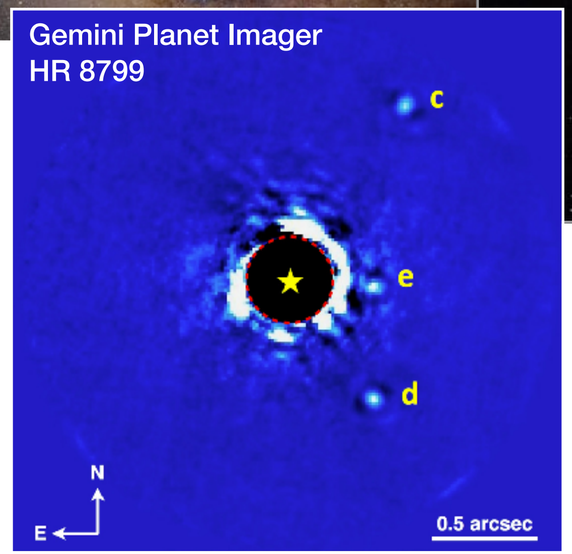
There are ~100 billion galaxies in the visible universe

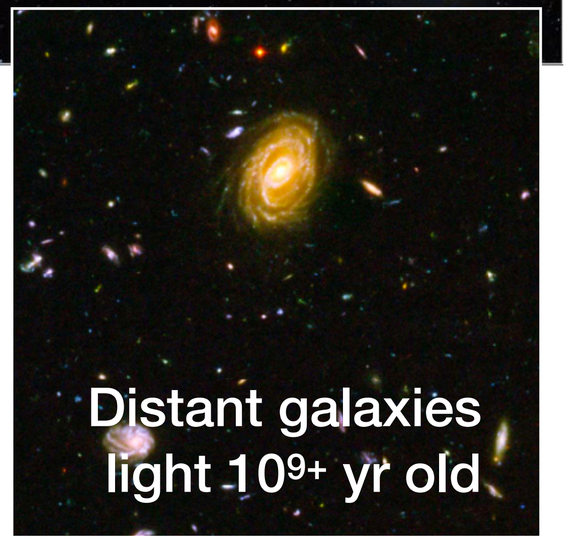
Most stars host planets (although mostly uninhabitable by our standards)

We are made of stardust



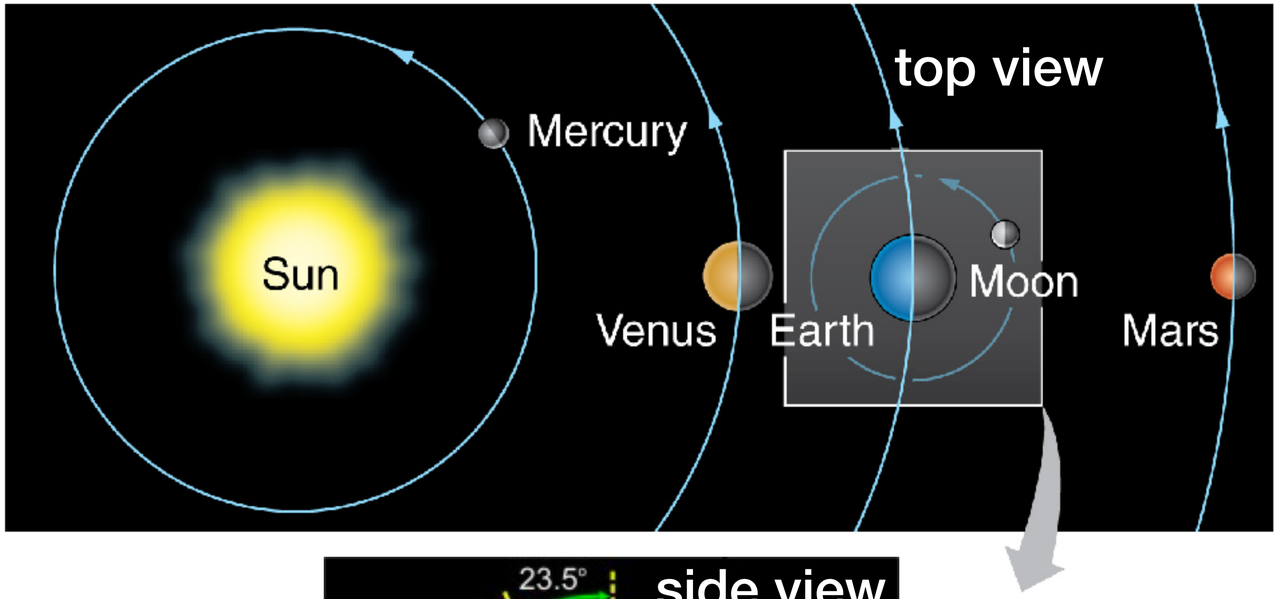


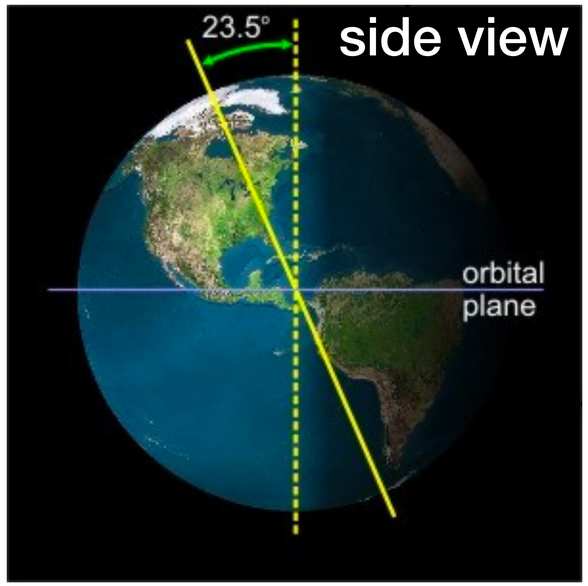


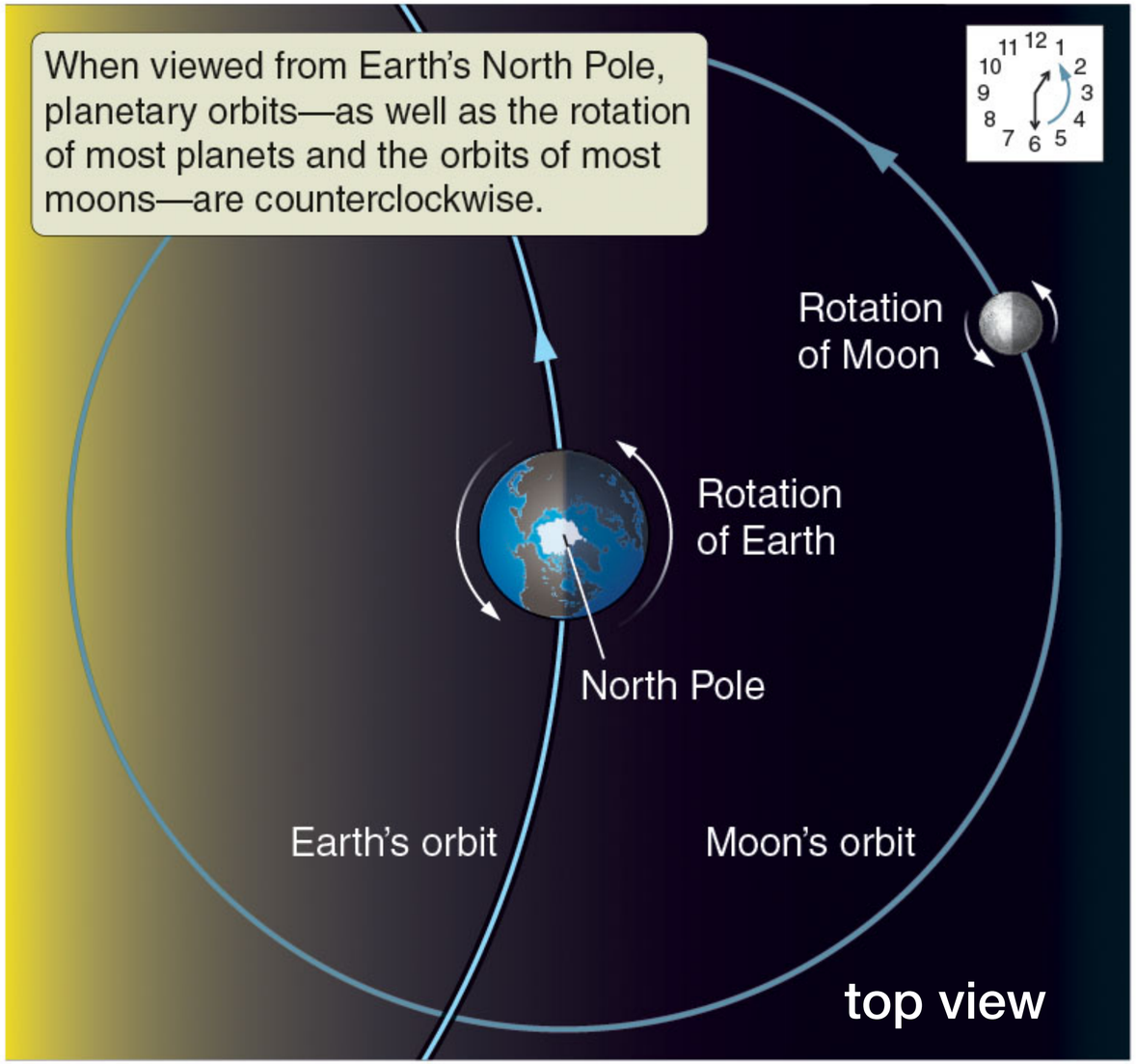


Chapter 2: Celestial Sphere and Phases of the Moon

It's all just geometry and timing



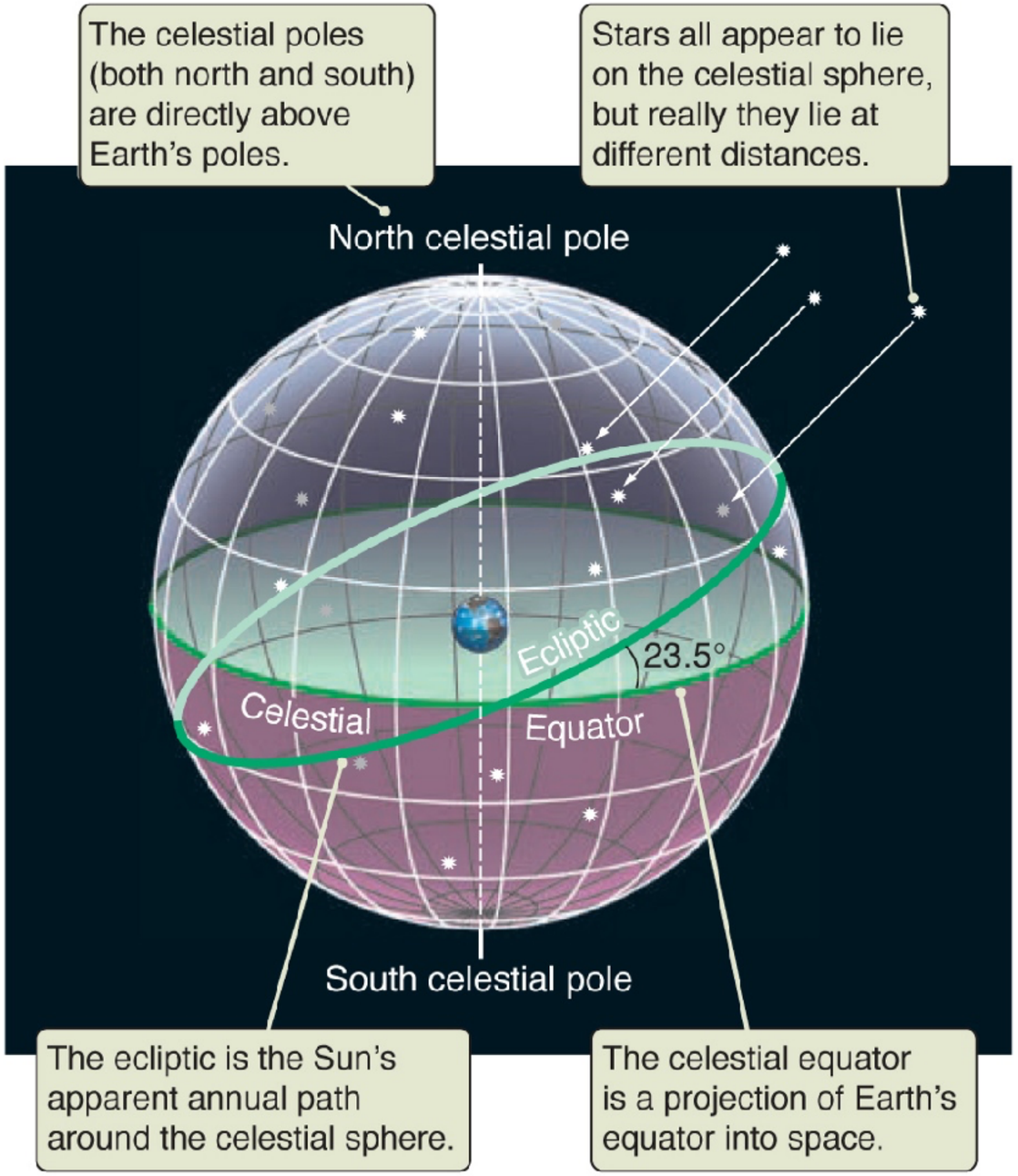




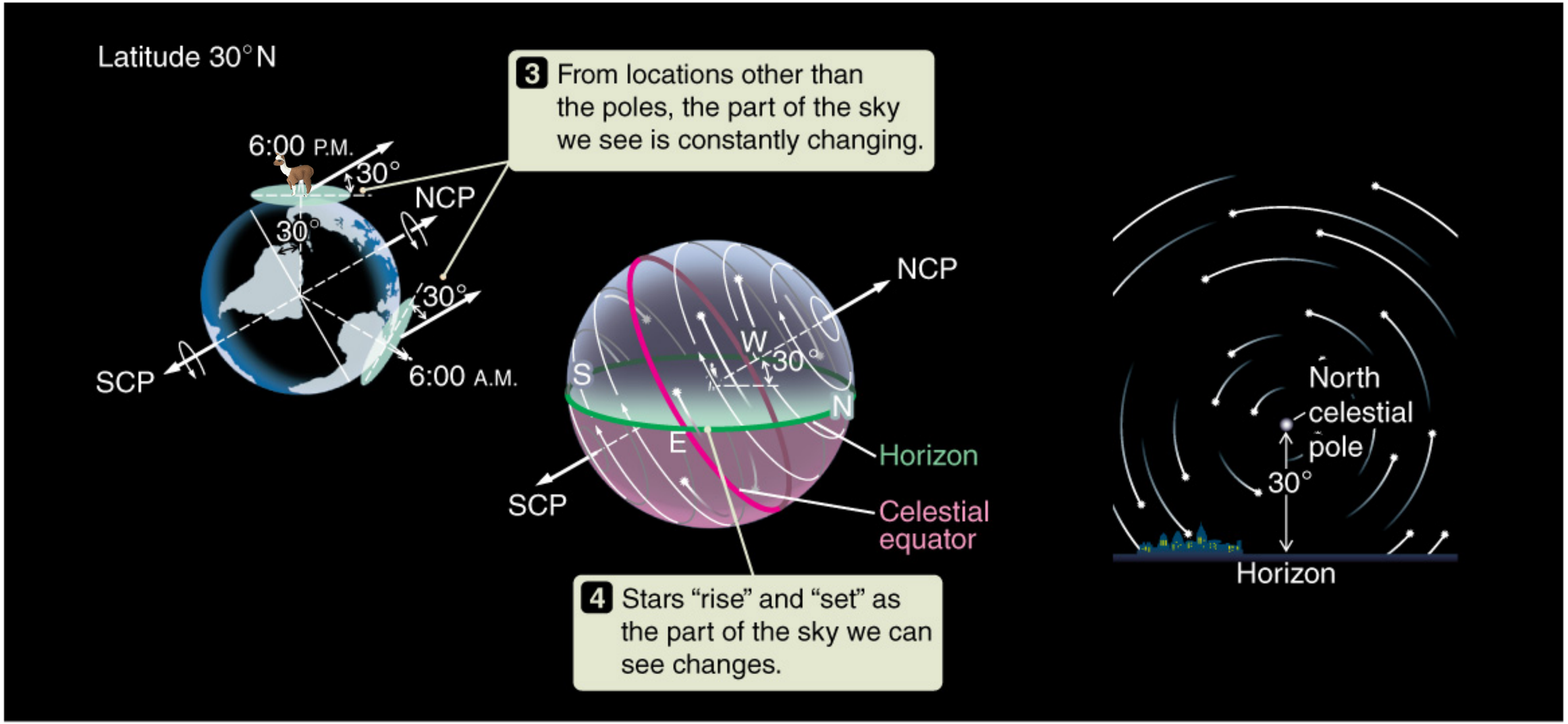
Important Points & Planes on the Celestial Sphere

Project stars and planets on a sphere surrounding the Earth

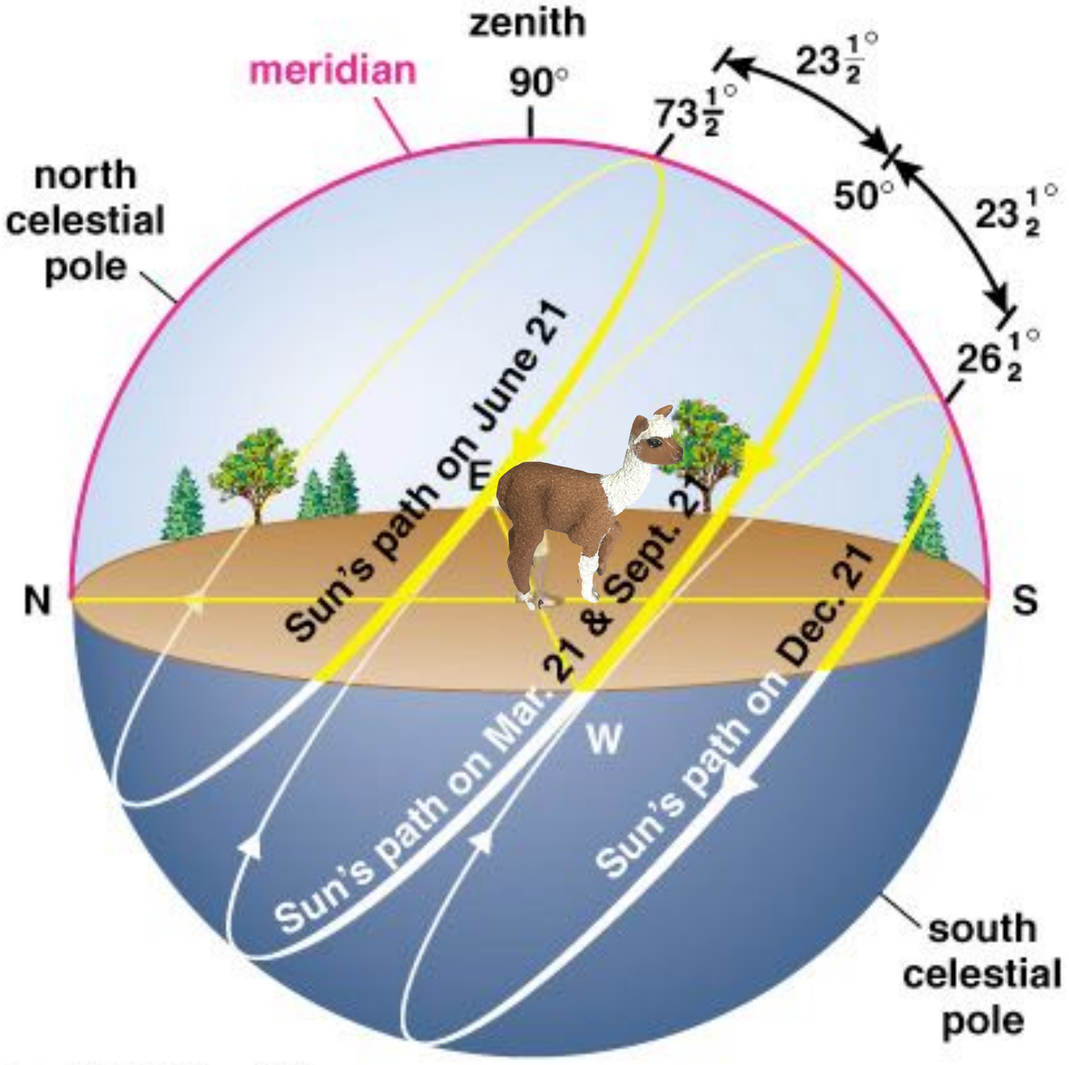
It is fictitious, but convenient for locating objects in the sky

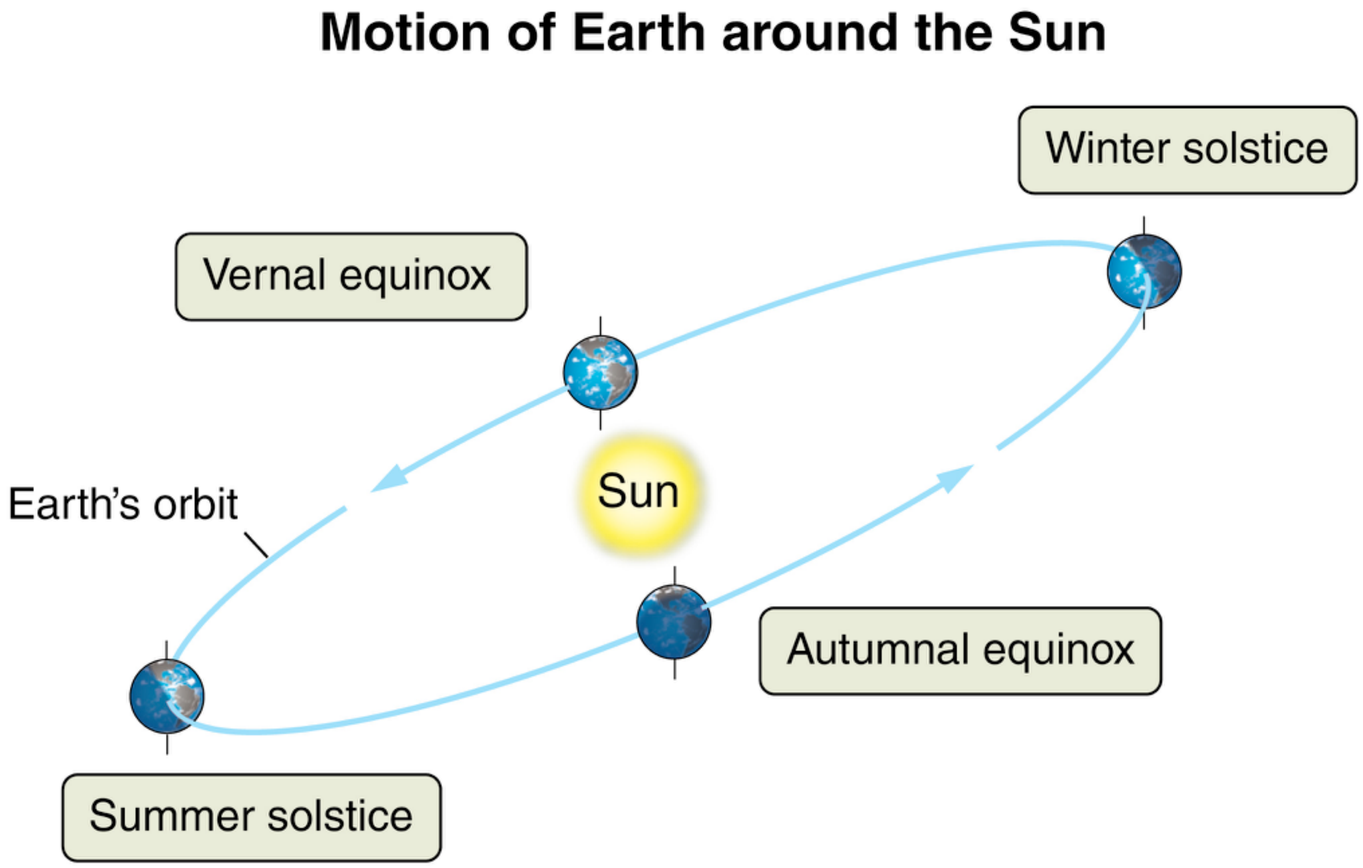


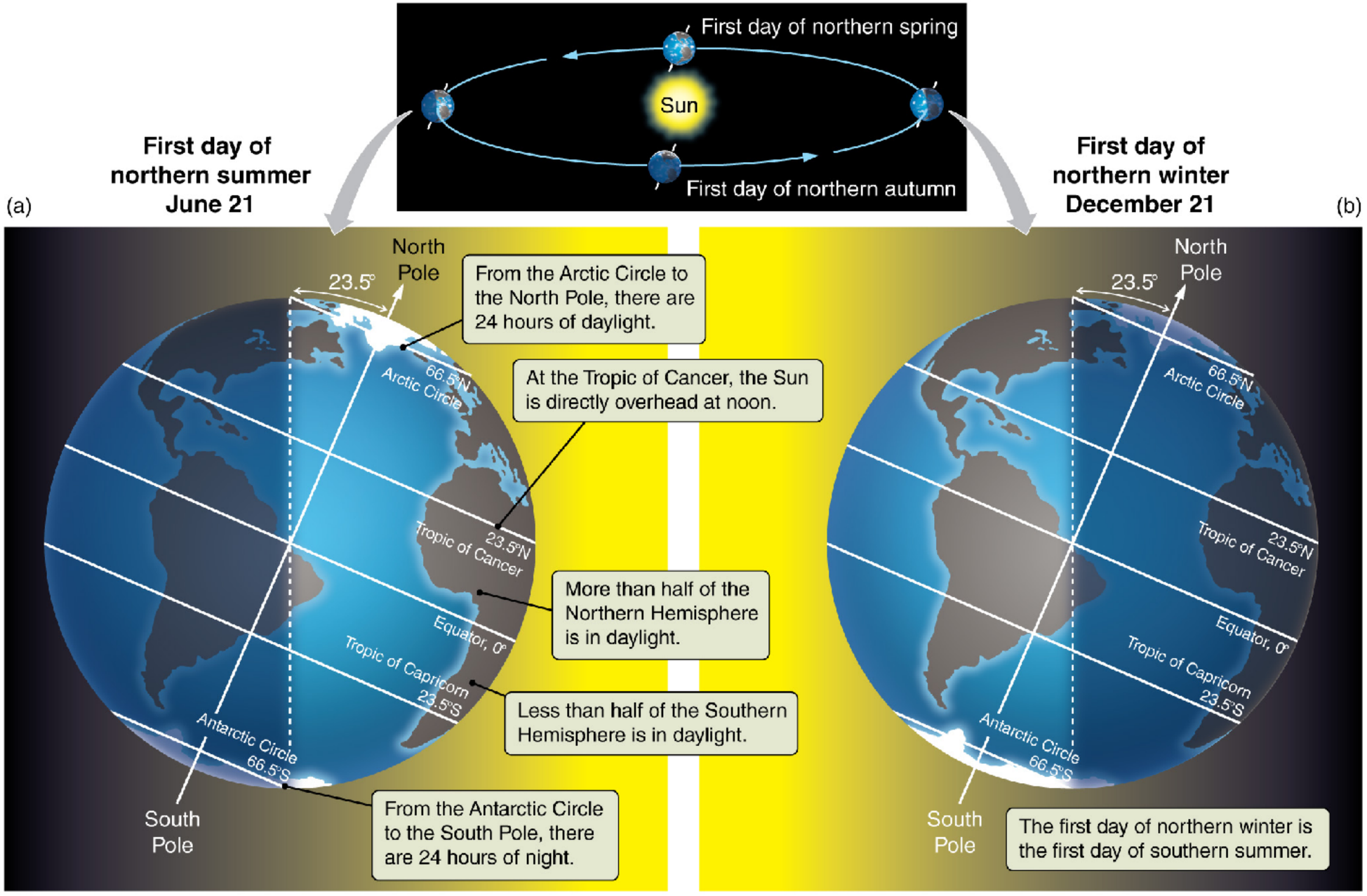
If you're 30 degrees north of the equator:



Max altitude of the Sun determined by where we are on Earth and where the Earth is in its orbit






First day of northern spring
Sun
First day of northern autumn
First day of northern summer June 21
First day of northern winter December 21
(a)
(b)
North Pole
23.5°
From the Arctic Circle to the North Pole, there are 24 hours of daylight.
66.5°N Arctic Circle
At the Tropic of Cancer, the Sun is directly overhead at noon.
23.5°N Tropic of Cancer
More than half of the Northern Hemisphere is in daylight.
Equator, 0°
Tropic of Capricorn 23.5°S
Less than half of the Southern Hemisphere is in daylight.
Antarctic Circle 66.5°S
South Pole
From the Antarctic Circle to the South Pole, there are 24 hours of night.
The first day of northern winter is the first day of southern summer.

Seasonal Poetry



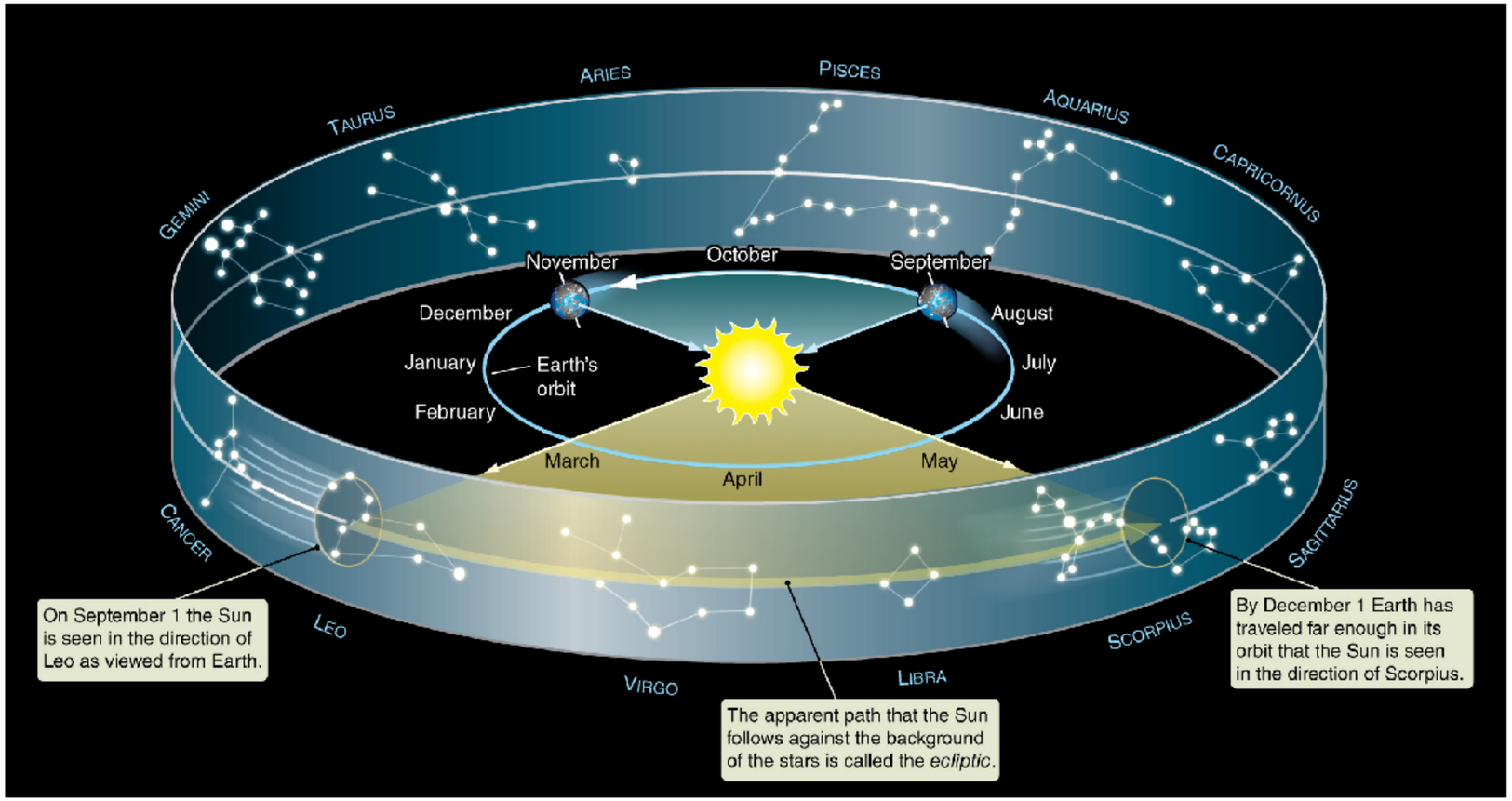

The two reasons we have seasons
Are both due to the Earth's tilt,
When our nearest pole
Points toward Sol
Its light shines to the hilt
And stays in the sky
Like a too-long deployed spy
At risk of committing treason!



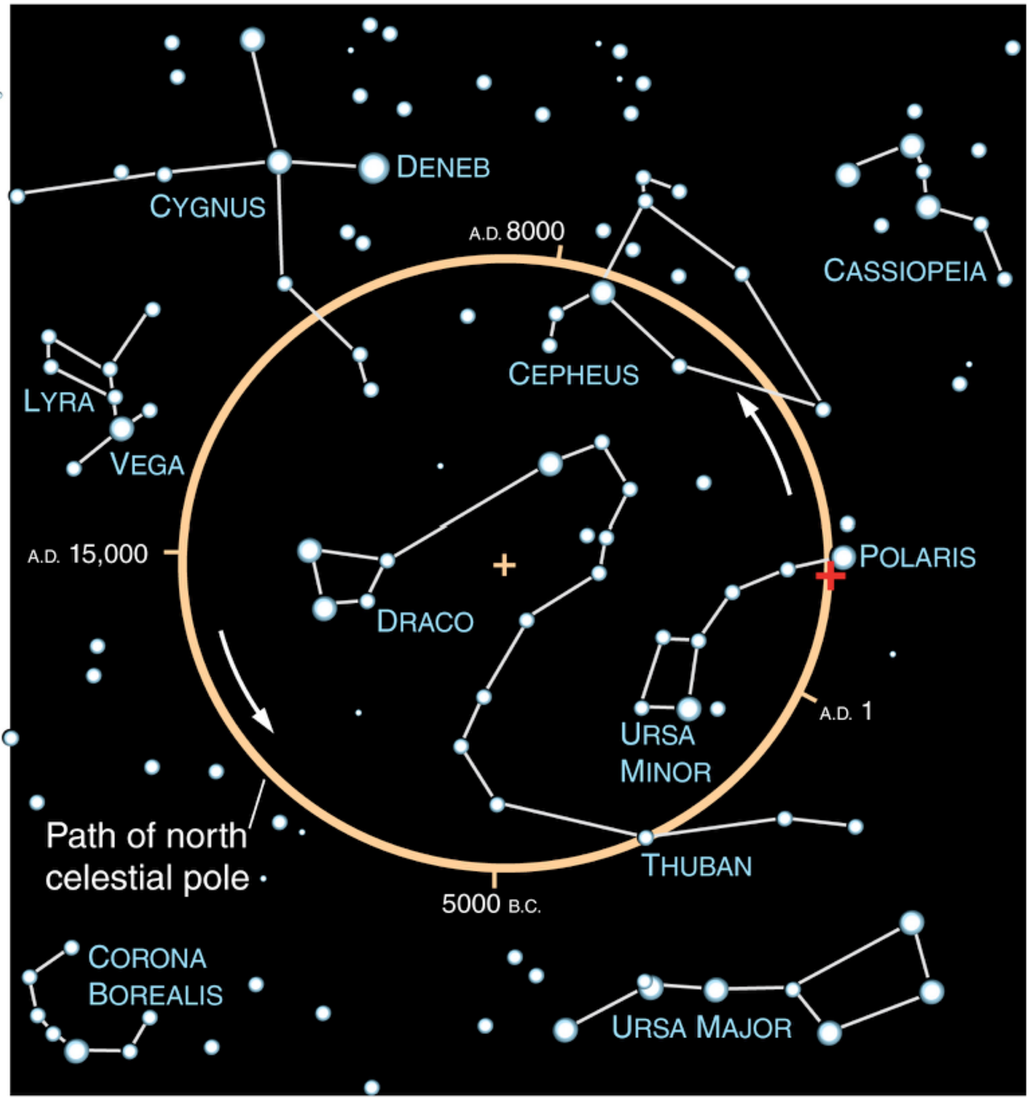

Hey you, what's your sign?

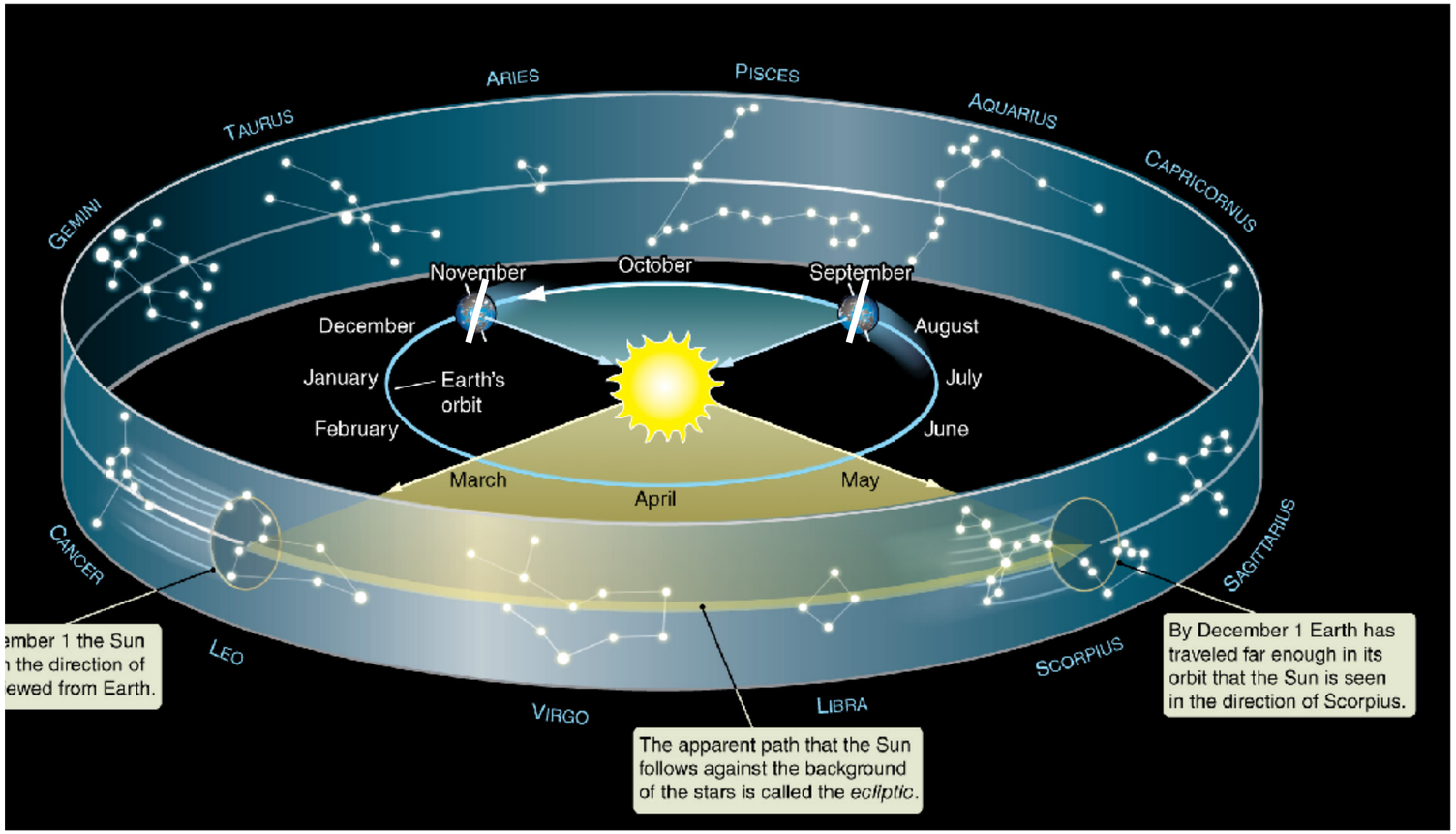
Astrology is bunk!

(HINT: This will be an exam question.)

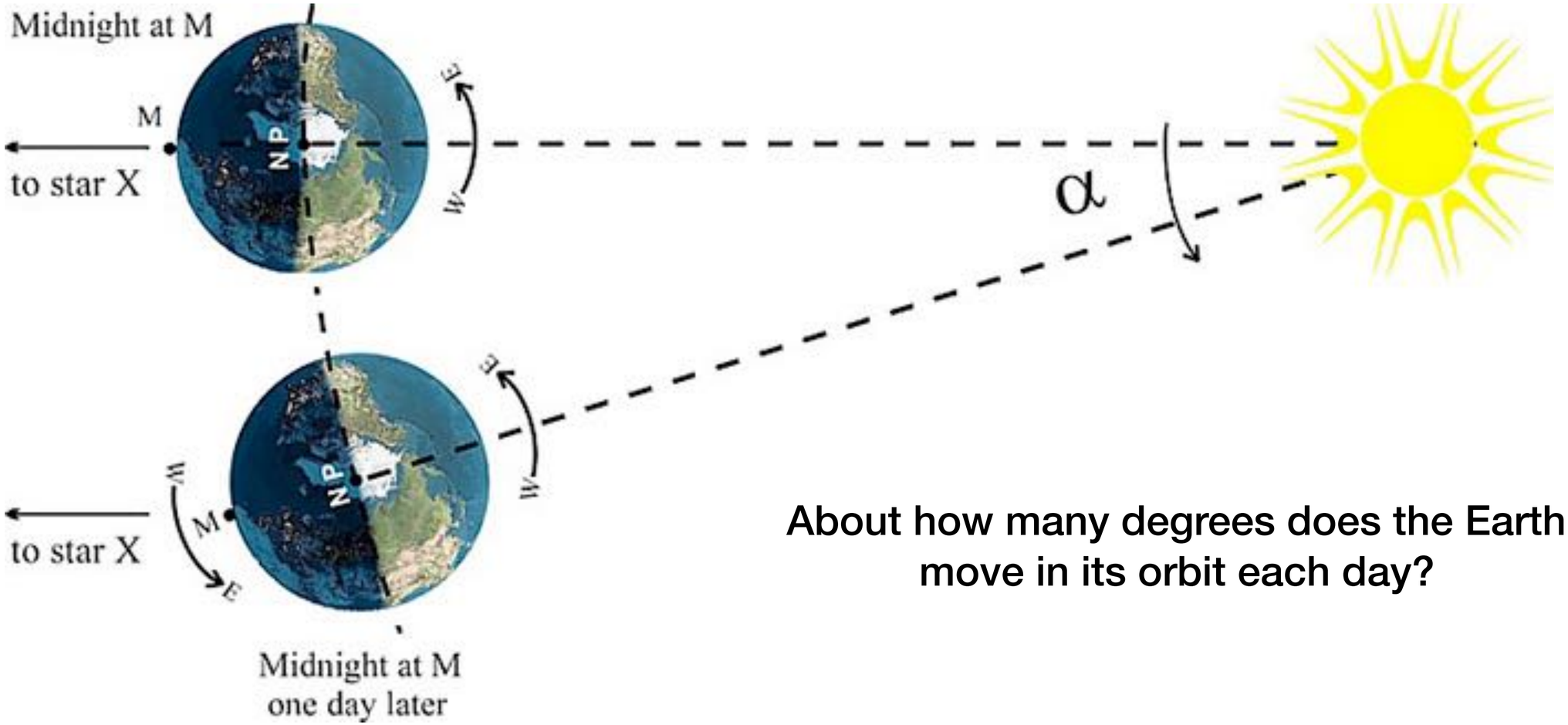


Earth's axis wobbles like a top: called Precession



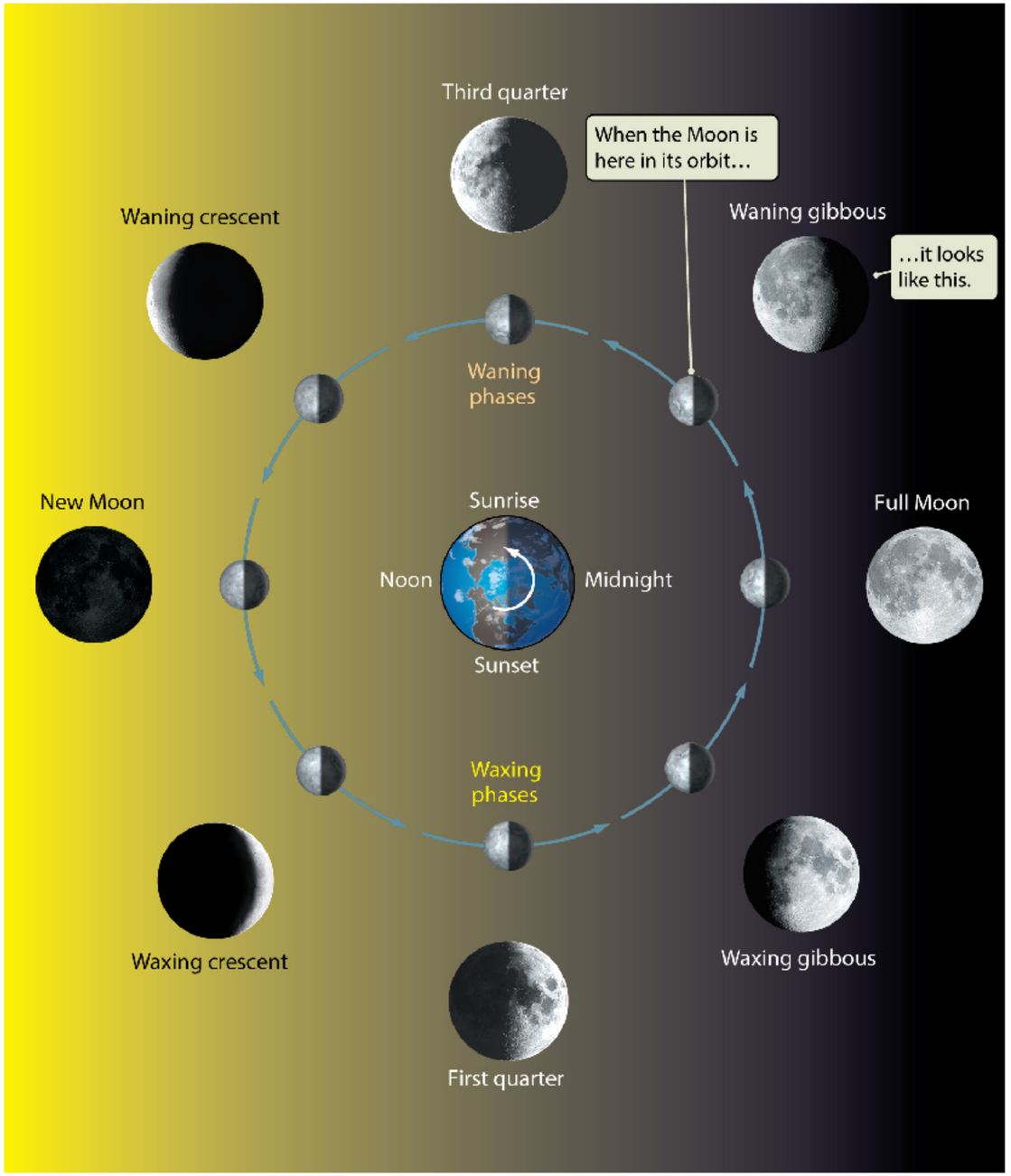


Why star rise/set times change

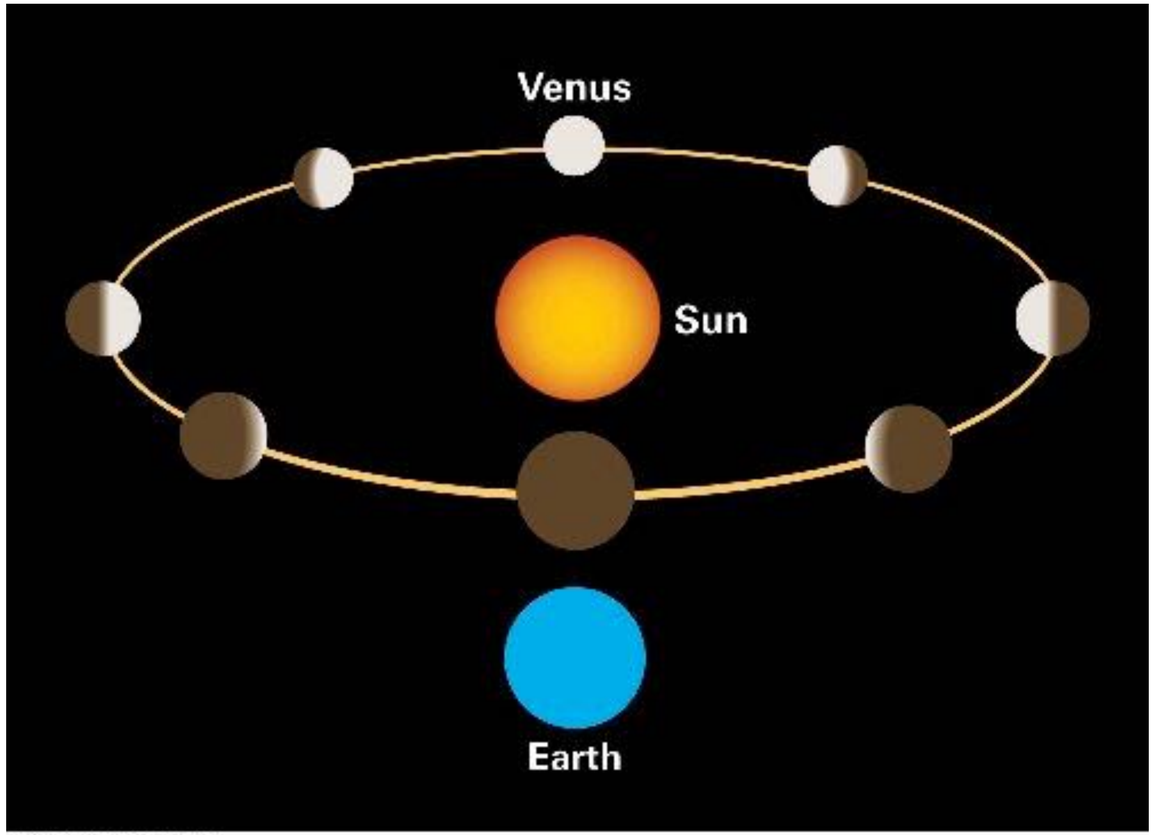


About how many degrees does the Earth move in its orbit each day?

Moon phases are easy to figure out once you have the right mental picture



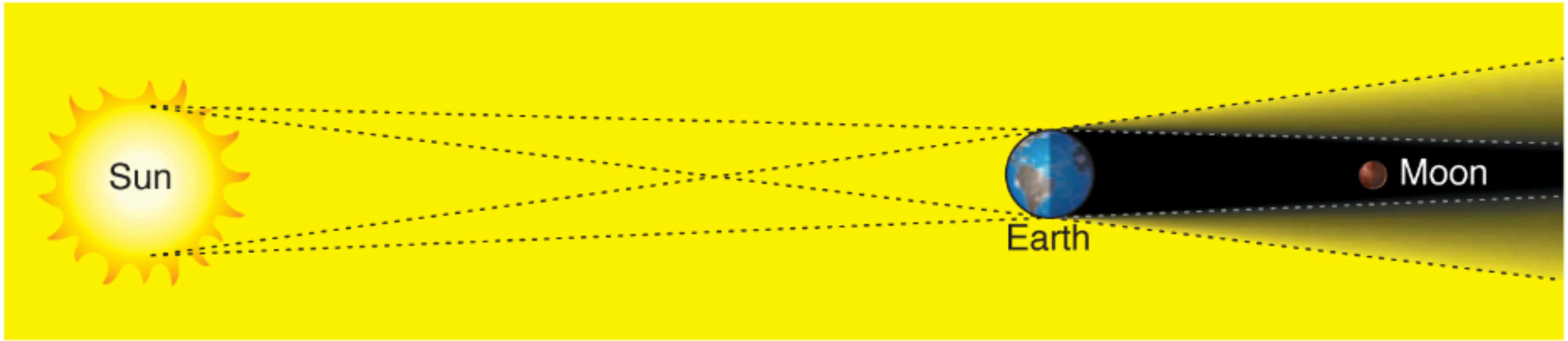
The apparent size of Venus correlates with its phase



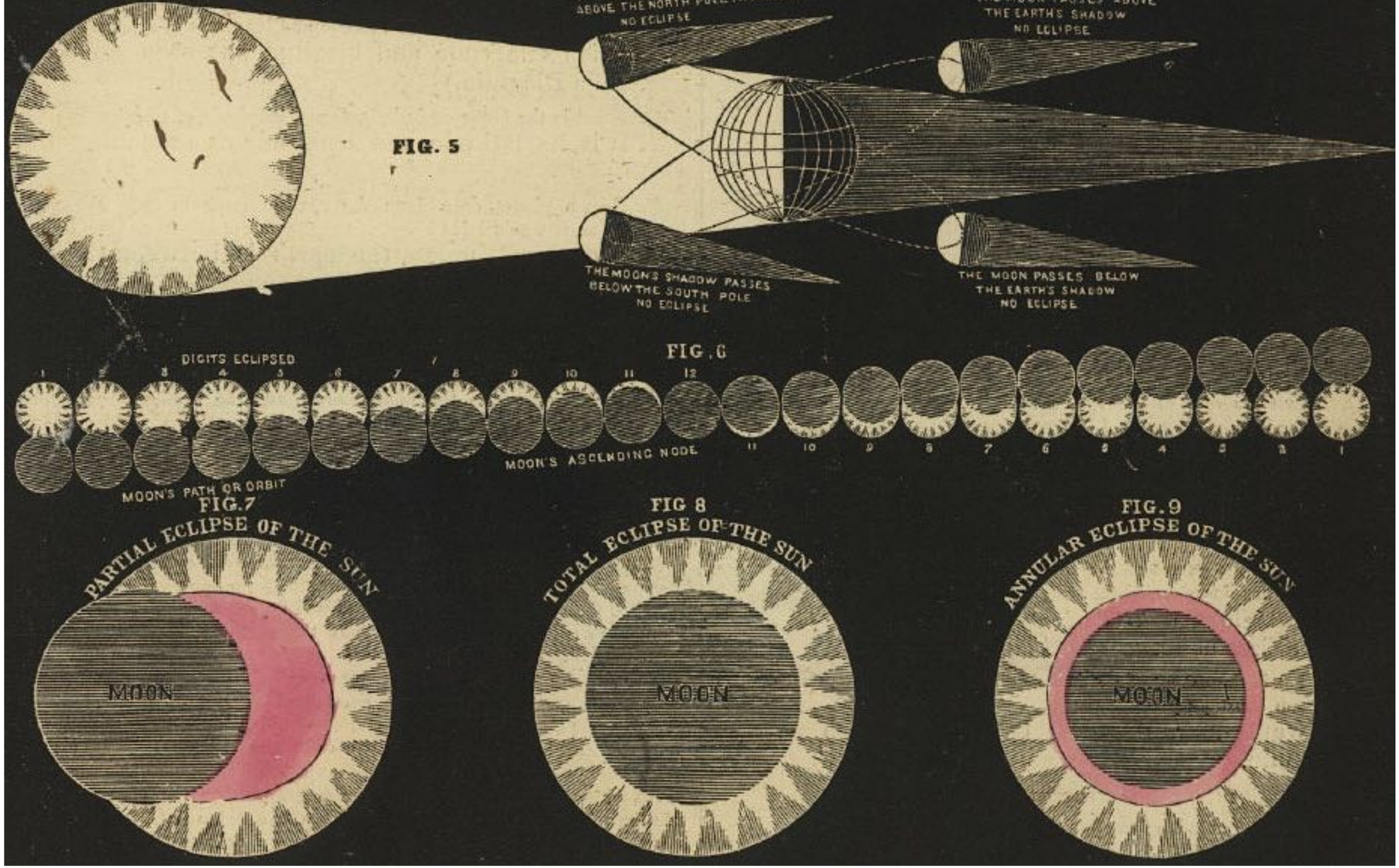
Eclipses

(a) Solar eclipse geometry (not to scale)

(c) Lunar eclipse geometry (not to scale)

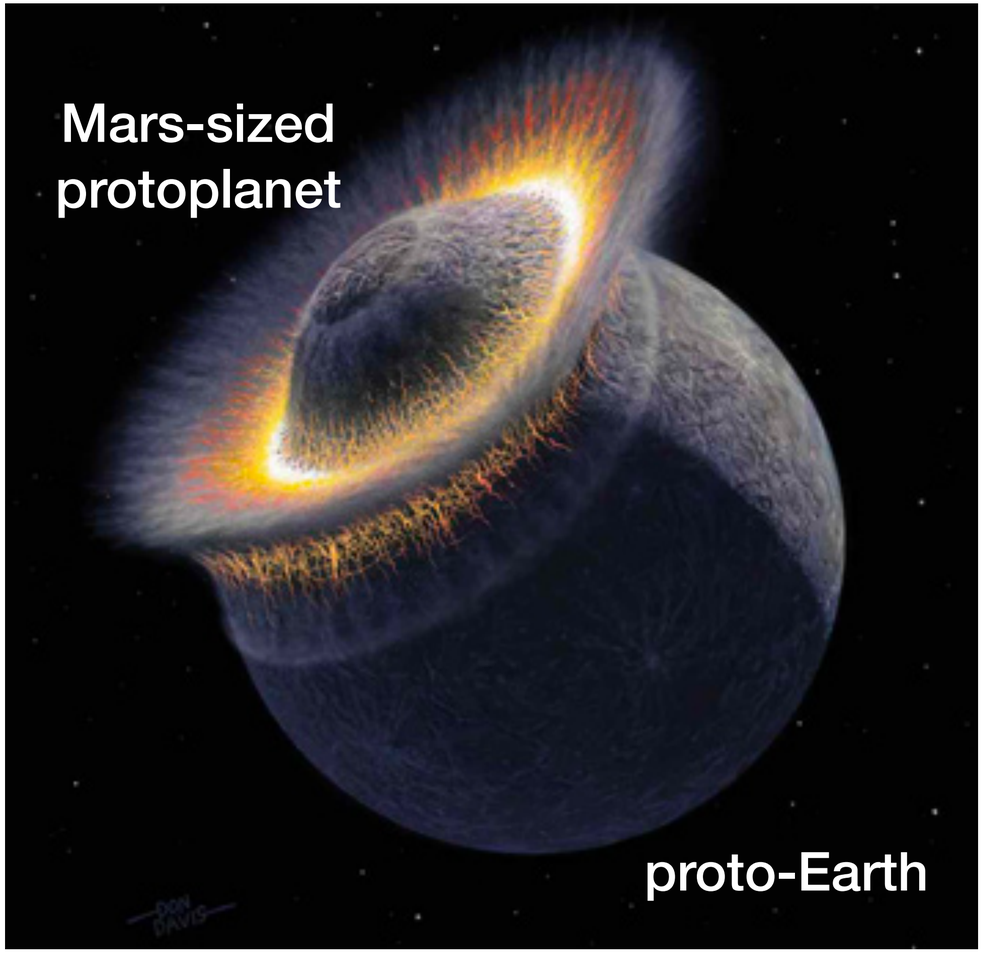


courtesy of your fellow student Megan Clasper



http://www.graphicine.com/asa-smiths-illustrated-astronomy-eclipses/

The reason it's two-faced is known, but how that happened is not!



The Moon's crust is thicker on the far side than the near side!

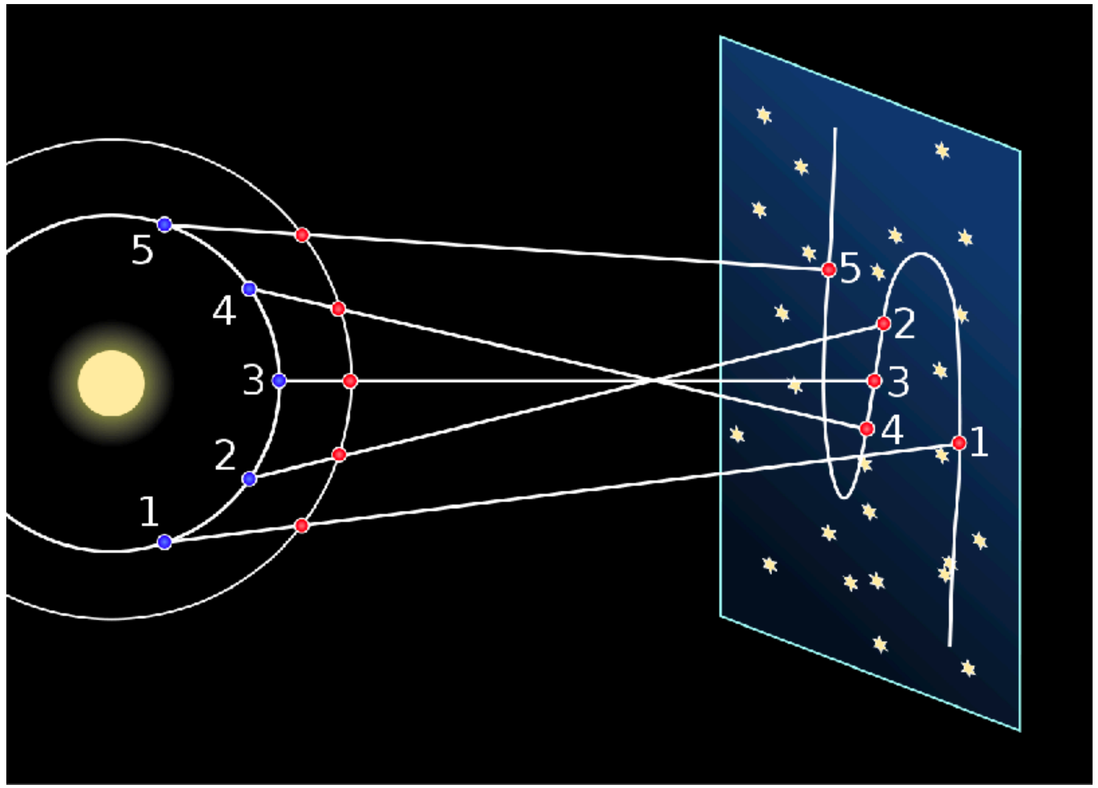
Theory 1) two proto-Moons formed from collision, which later "gently" coalesced

Theory 2) the Moon formed very close to the Earth, became tidally locked soon thereafter, and the heat from the Earth "evaporated" crust on the near side, which preferentially condensed on the cooler far side

http://www.slate.com/blogs/bad_astronomy/2014/07/01/the_moon_s_two_faces_why_are_they_so_different.html

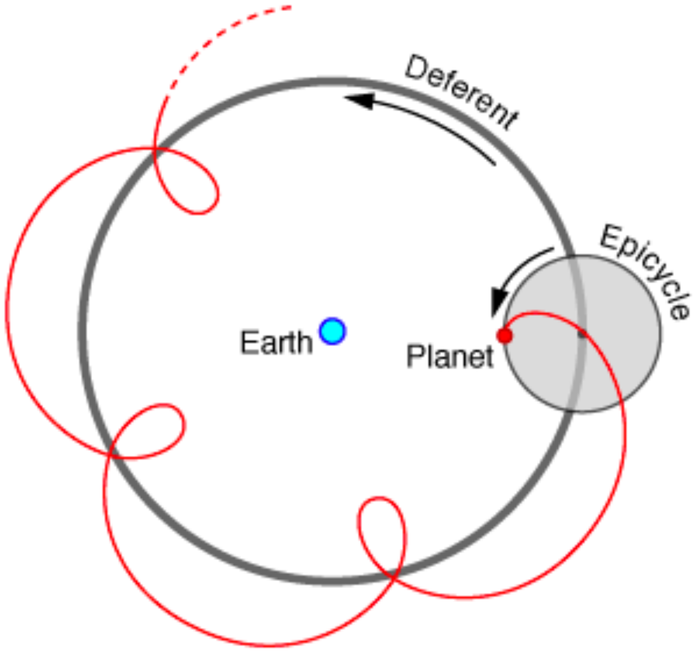
Chapter 3: Laws of Motion and Gravity

Epicycles



https://en.wikipedia.org/wiki/Apparent_retrograde_motion

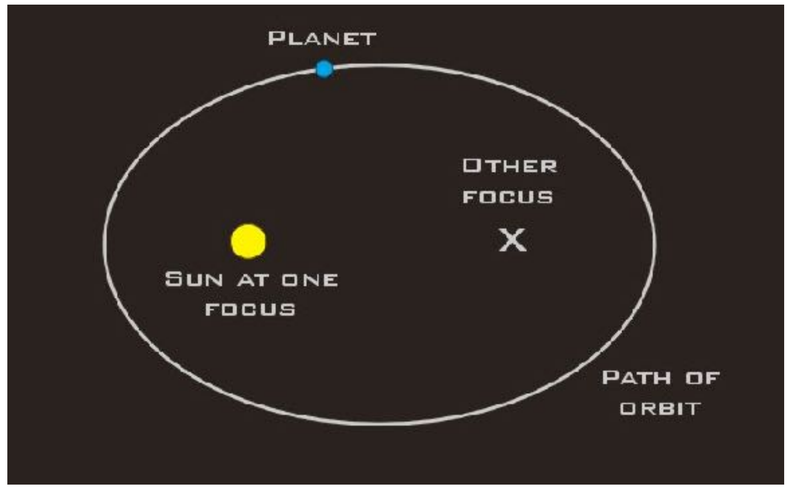
Retrograde motion of Mars in 2005.
Credit astrophotographer Tunc Tezel



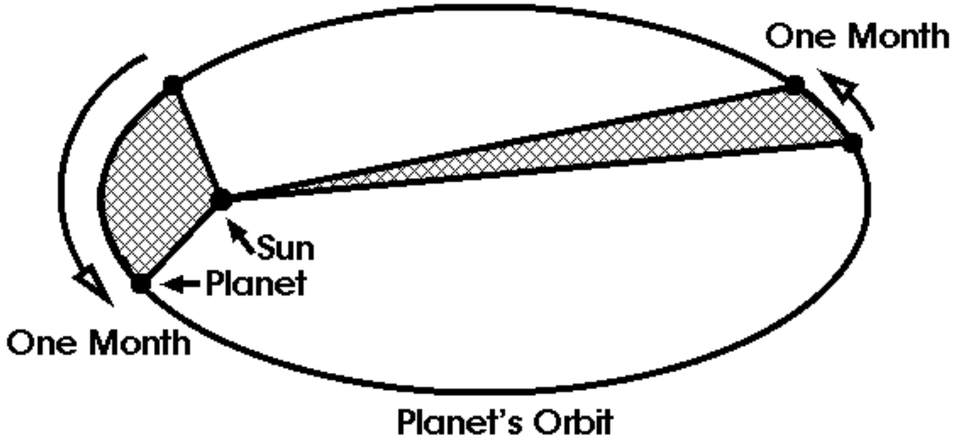
https://physics.weber.edu/schroeder/ua/BeforeCopernicus.html

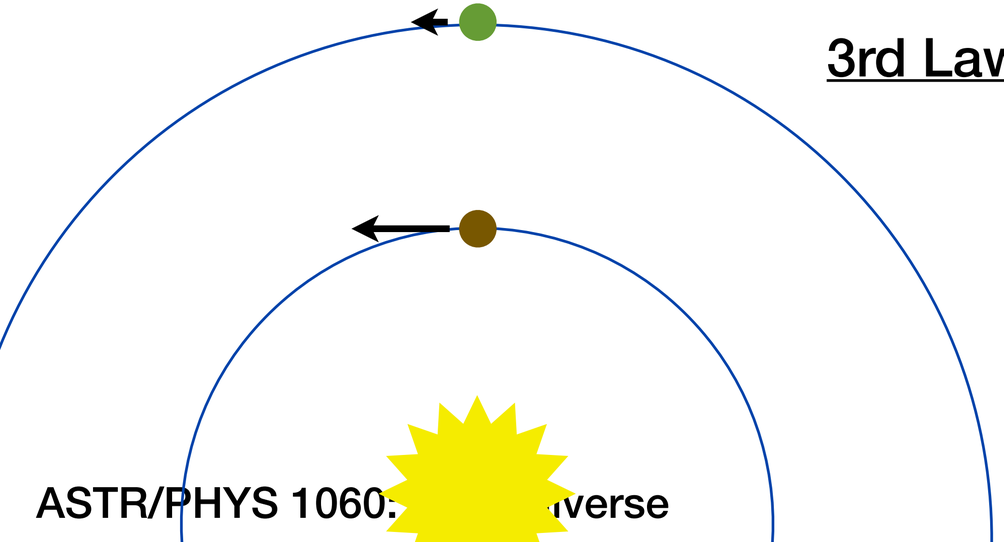
Kepler's 3 Laws

1st Law: Orbits are elliptical



2nd Law: equal areas in equal times





3rd Law: period depends on distance

$$(\text{Period of Planet [in years]})^2 = (\text{Average Distance of Planet from Star [in AU]})^3$$

Newton's 3 Laws

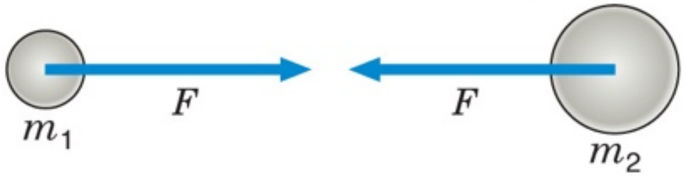
1) Law of Inertia: Objects at rest stay at rest, objects in motion stay in motion (Galileo figured this one out)
2) Motion is changed by unbalanced forces
   acceleration = force / mass
3) Forces always come in pairs and those pairs are always equal in strength but opposite in direction

Newton's Universal Law of Gravitation: $F = G \dfrac{m_1 m_2}{r^2}$

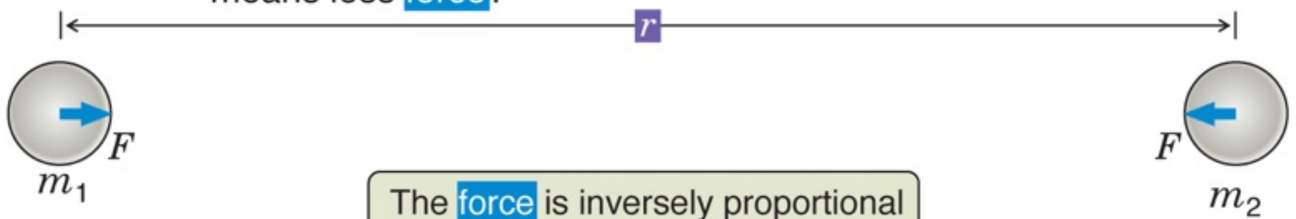
Gravity is an attractive force that acts along the line between two objects.

More mass means more force.

The force is proportional to the product of the two masses.

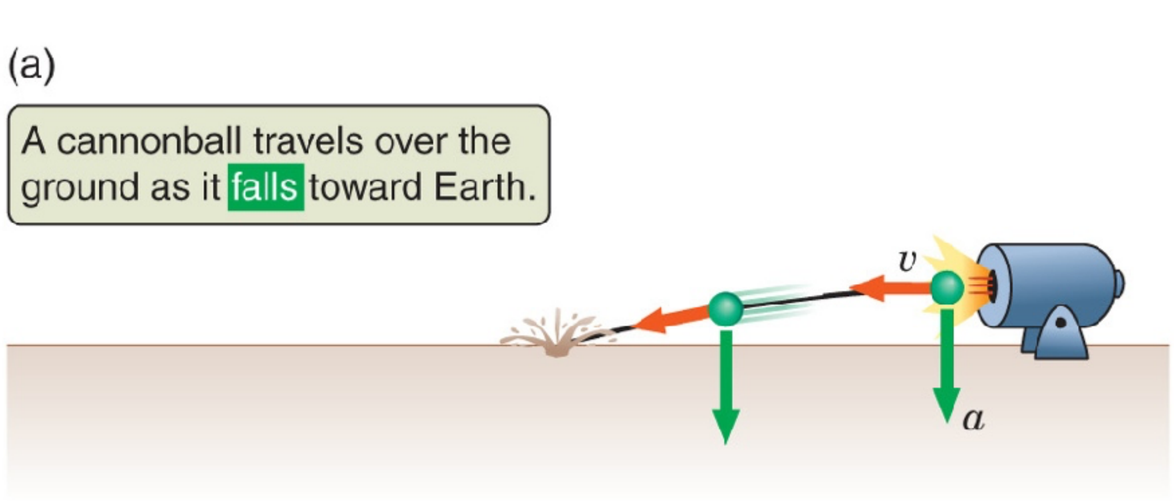


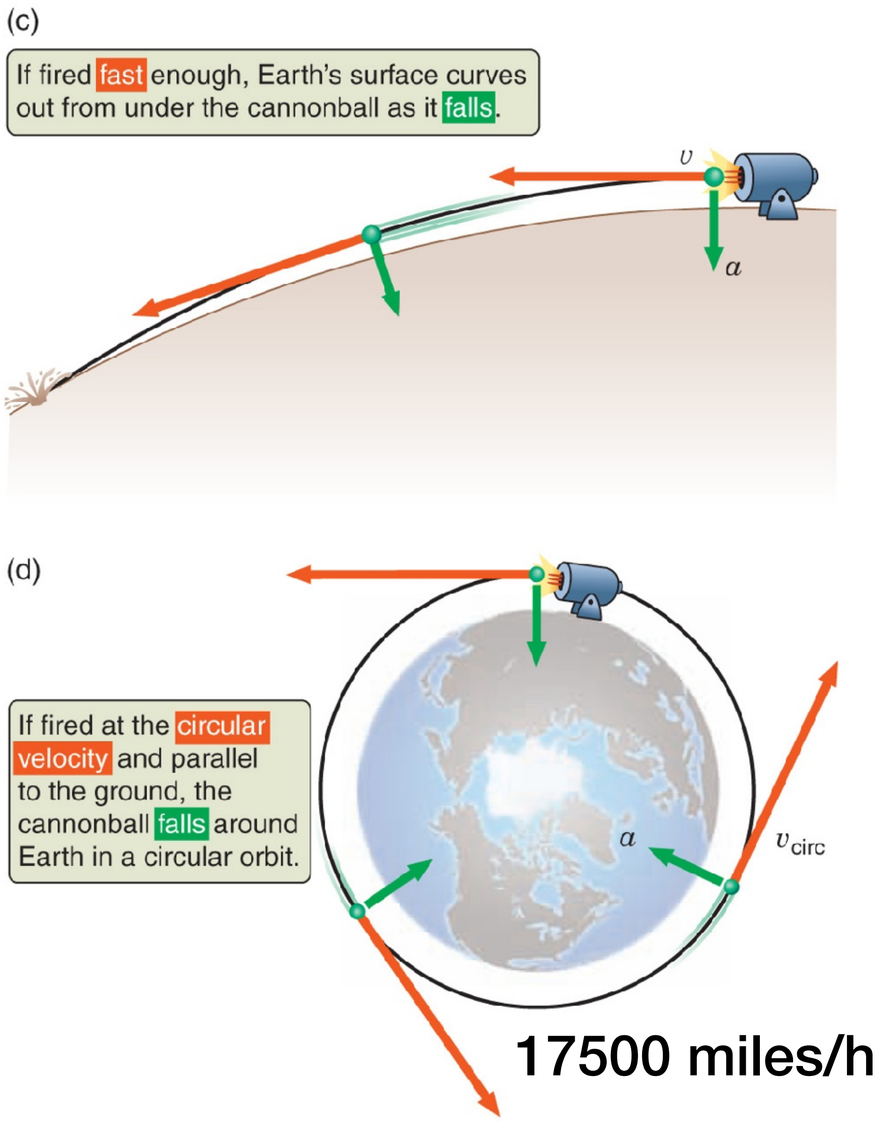
Greater separation means less force.



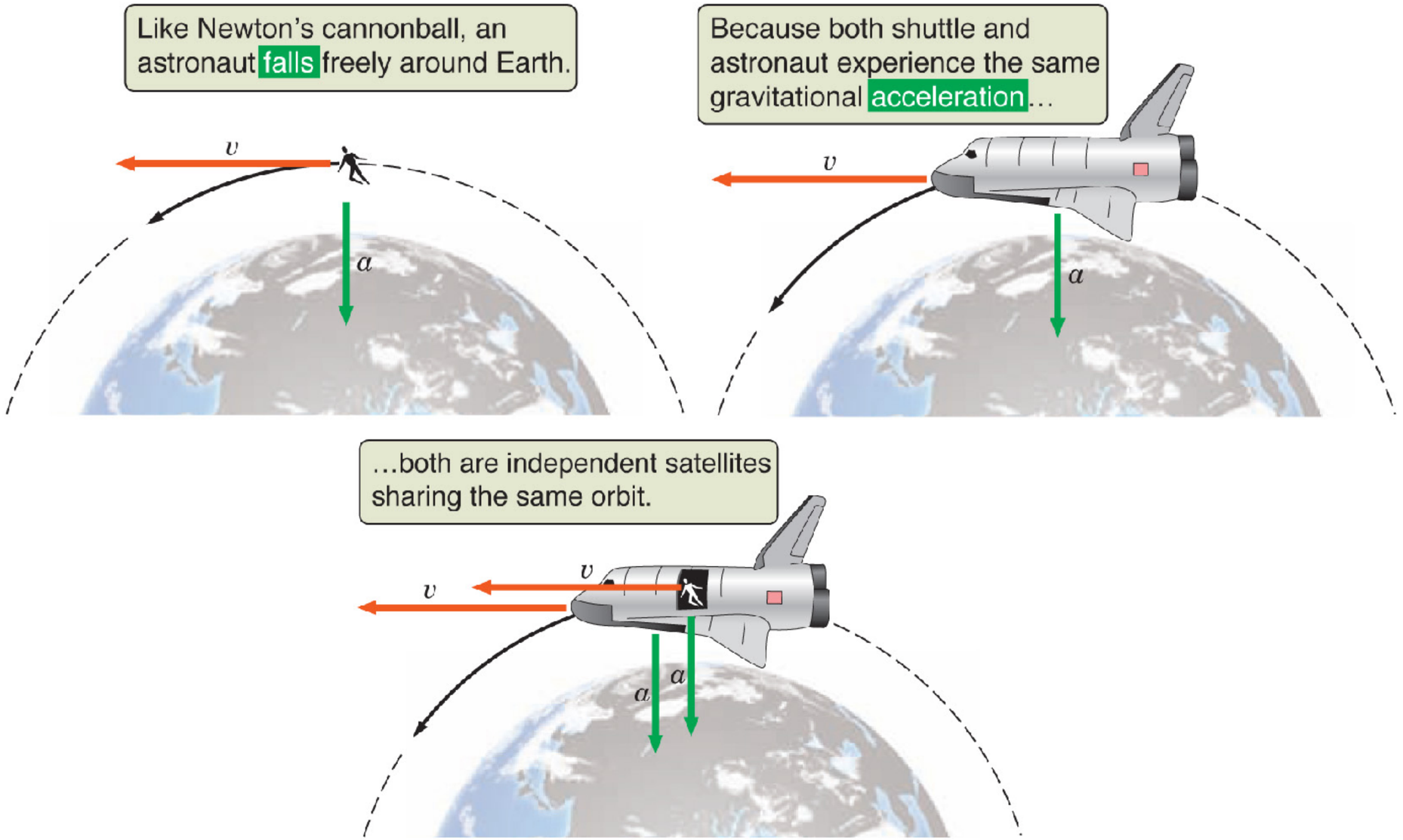
The force is inversely proportional to the square of the distance between the masses.

Gravity and Orbits

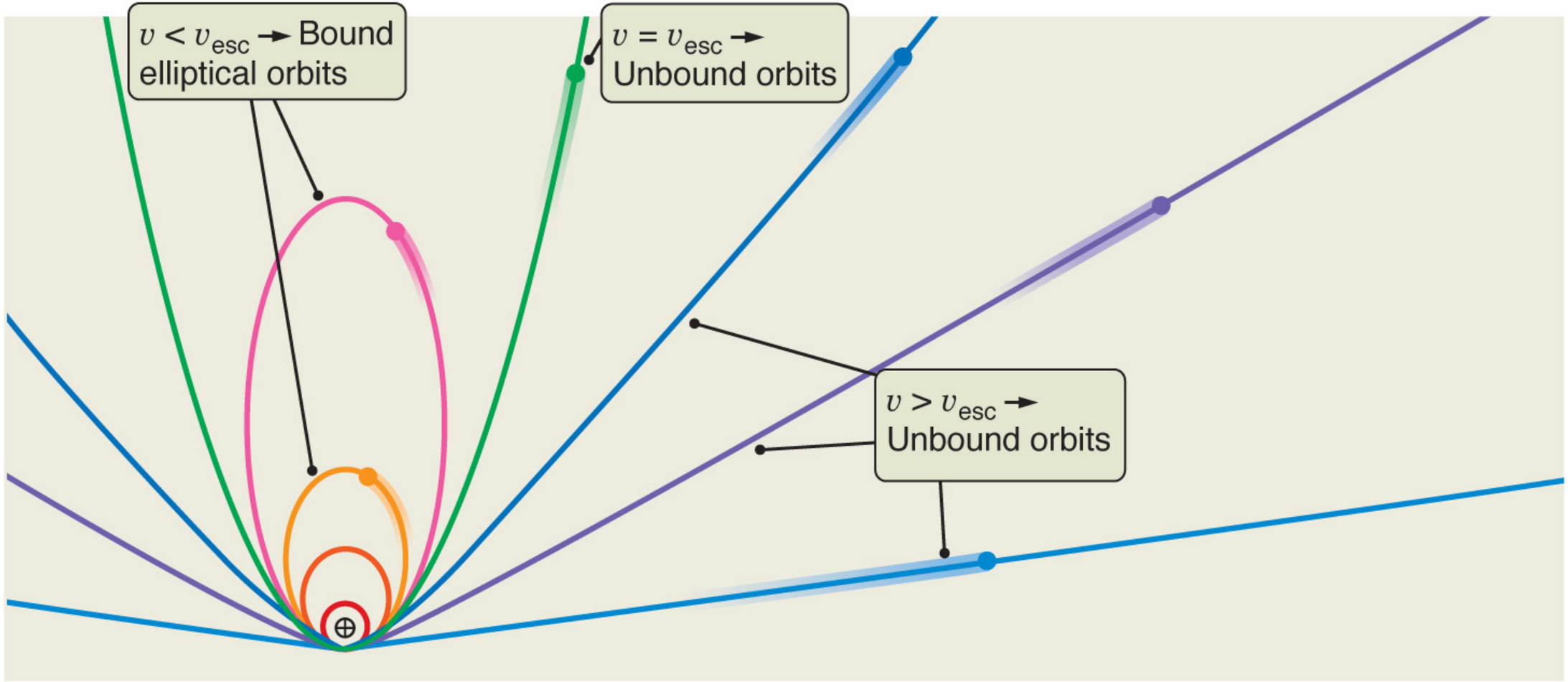




Not zero gravity. All objects are in free fall.

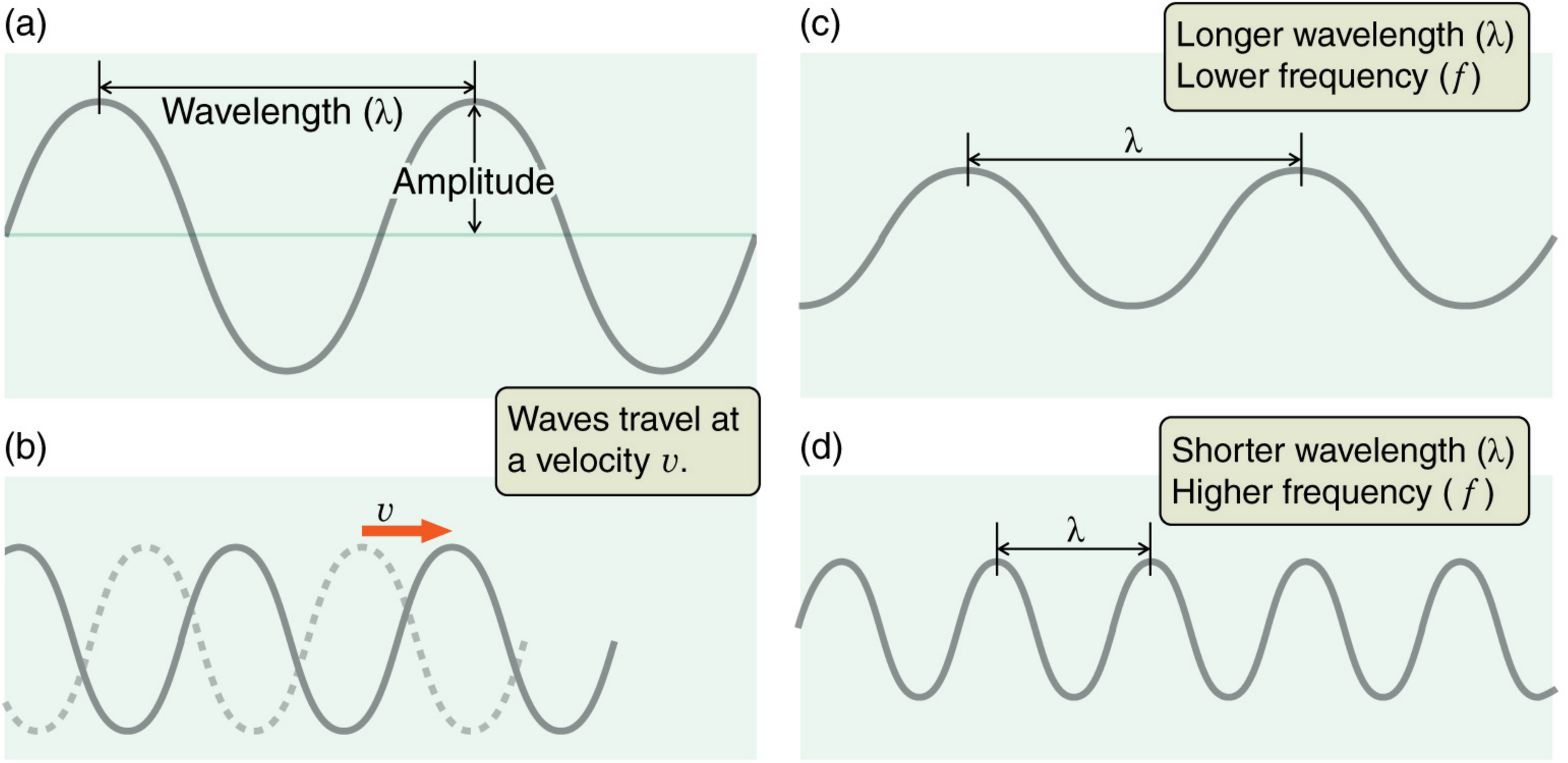


Escape Velocity

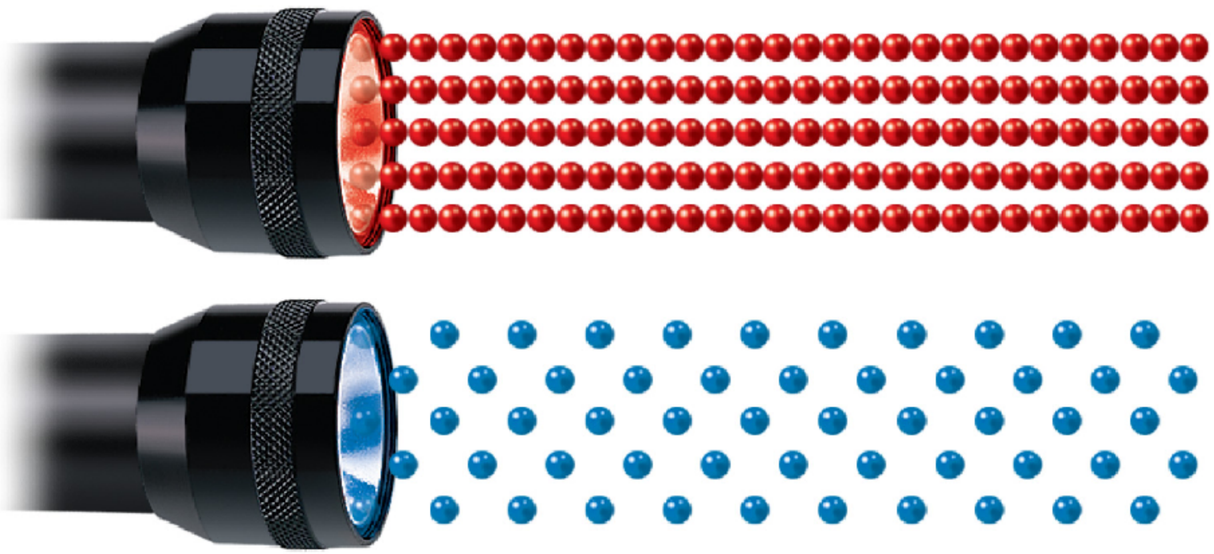


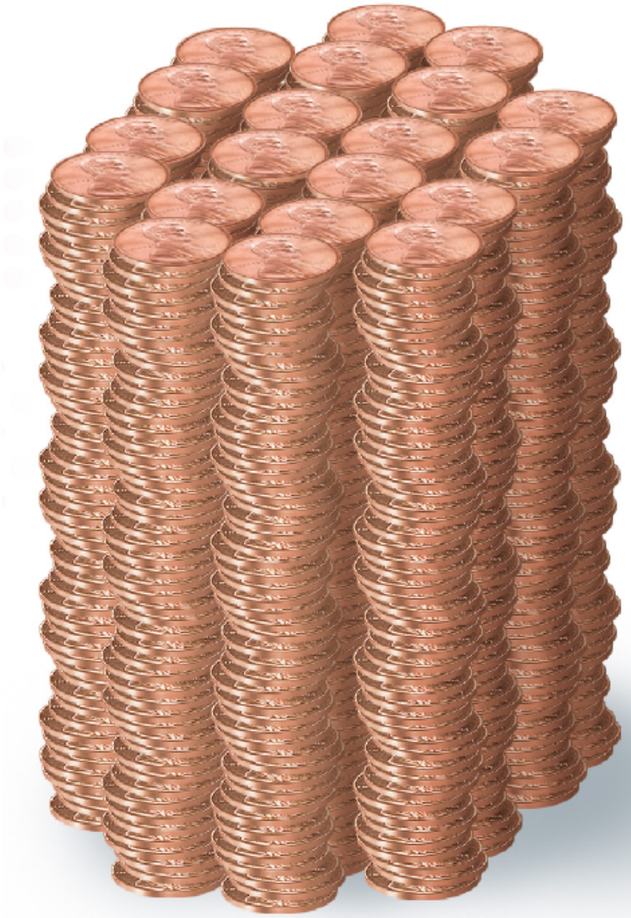
For Earth v_{esc} ~ 25,000 miles/hour

Chapter 4: Light and Telescopes

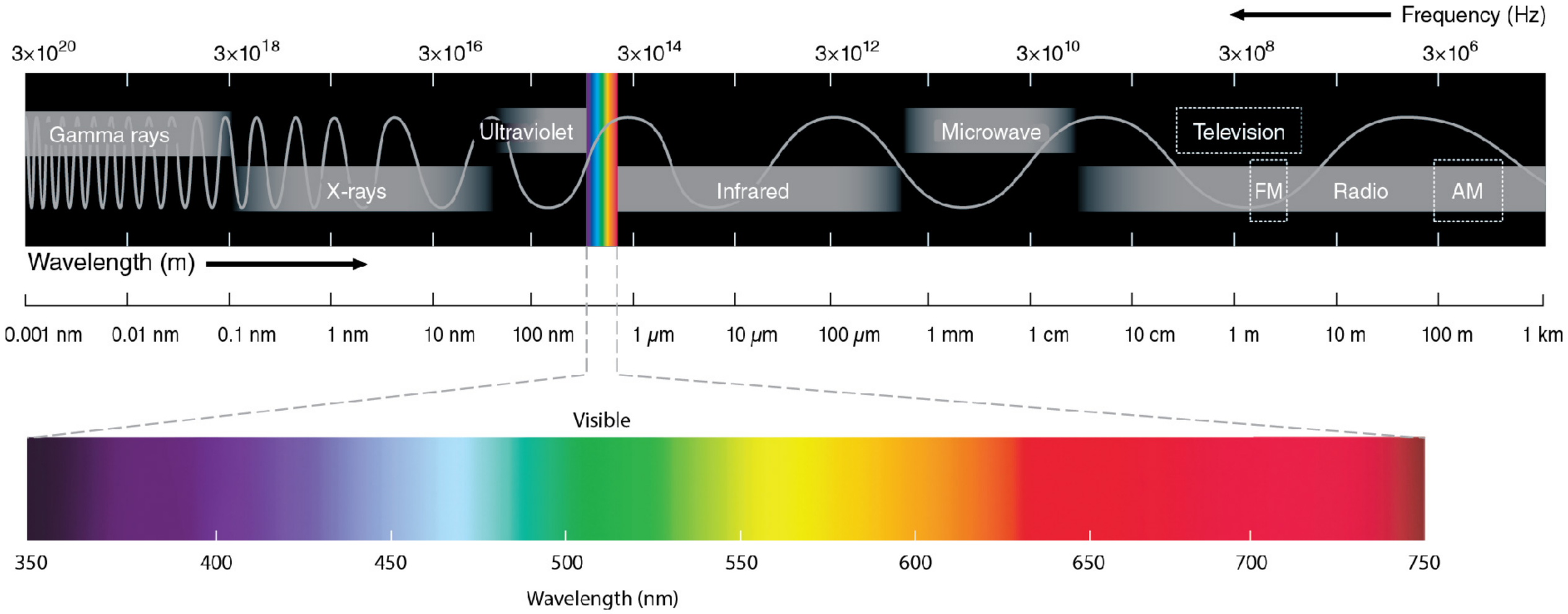

(a)
Wavelength (λ)
Amplitude
(b)
v
Waves travel at a velocity v.
(c)
Longer wavelength (λ)
Lower frequency (f)
λ
(d)
Shorter wavelength (λ)
Higher frequency (f)
λ

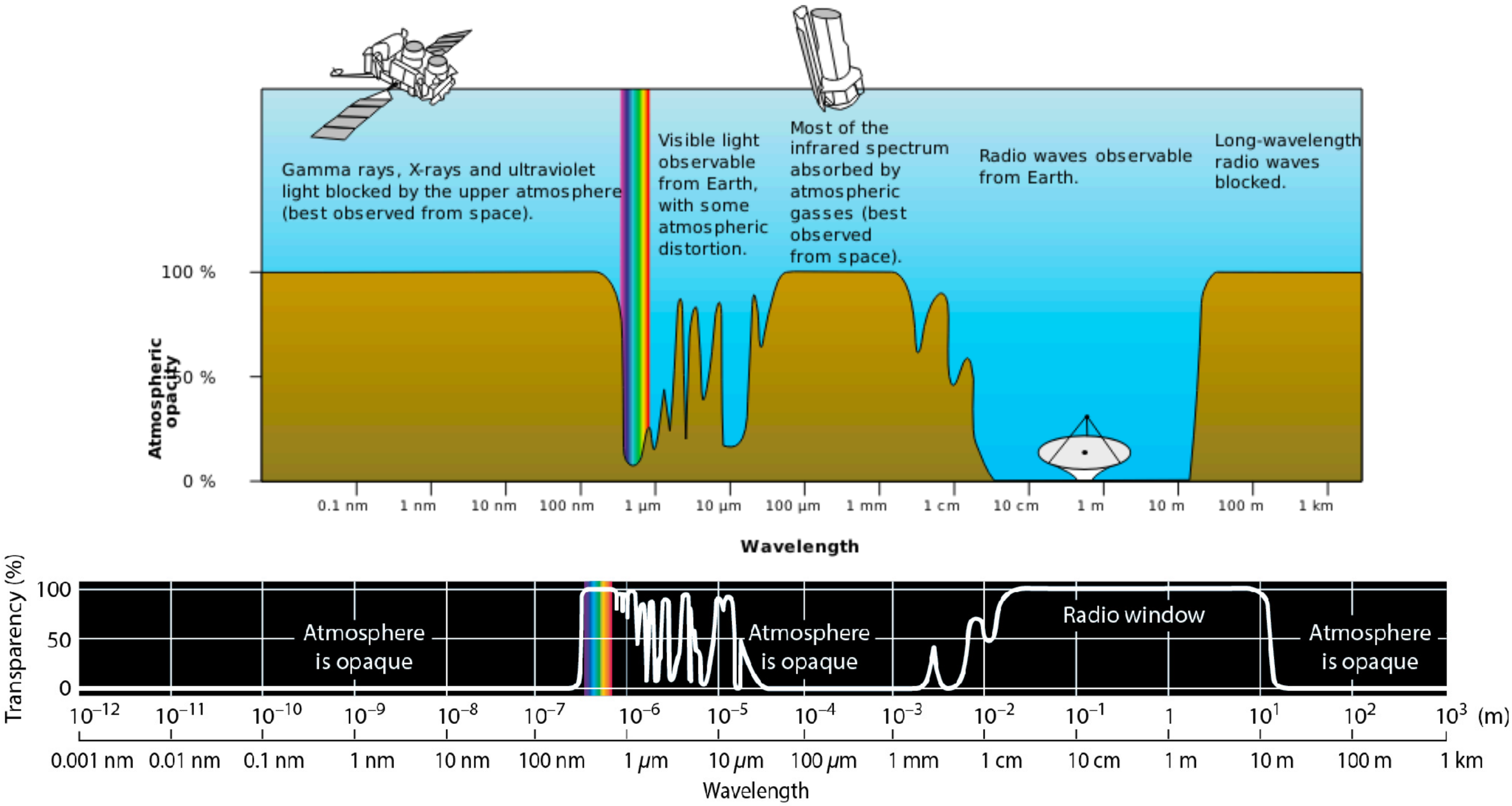
Light is “quantized”
Its energy is proportional to frequency

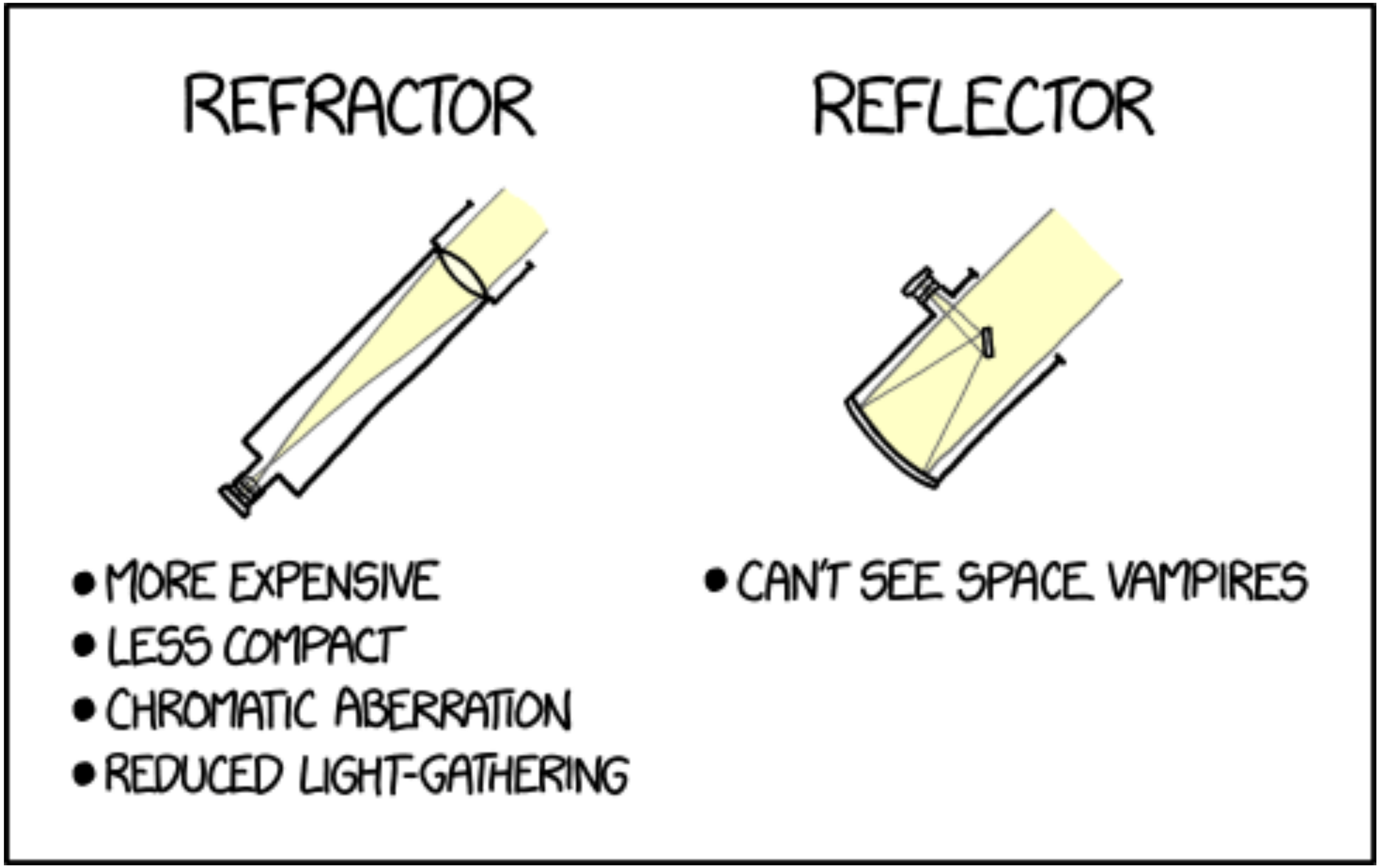




Electromagnetic Spectrum

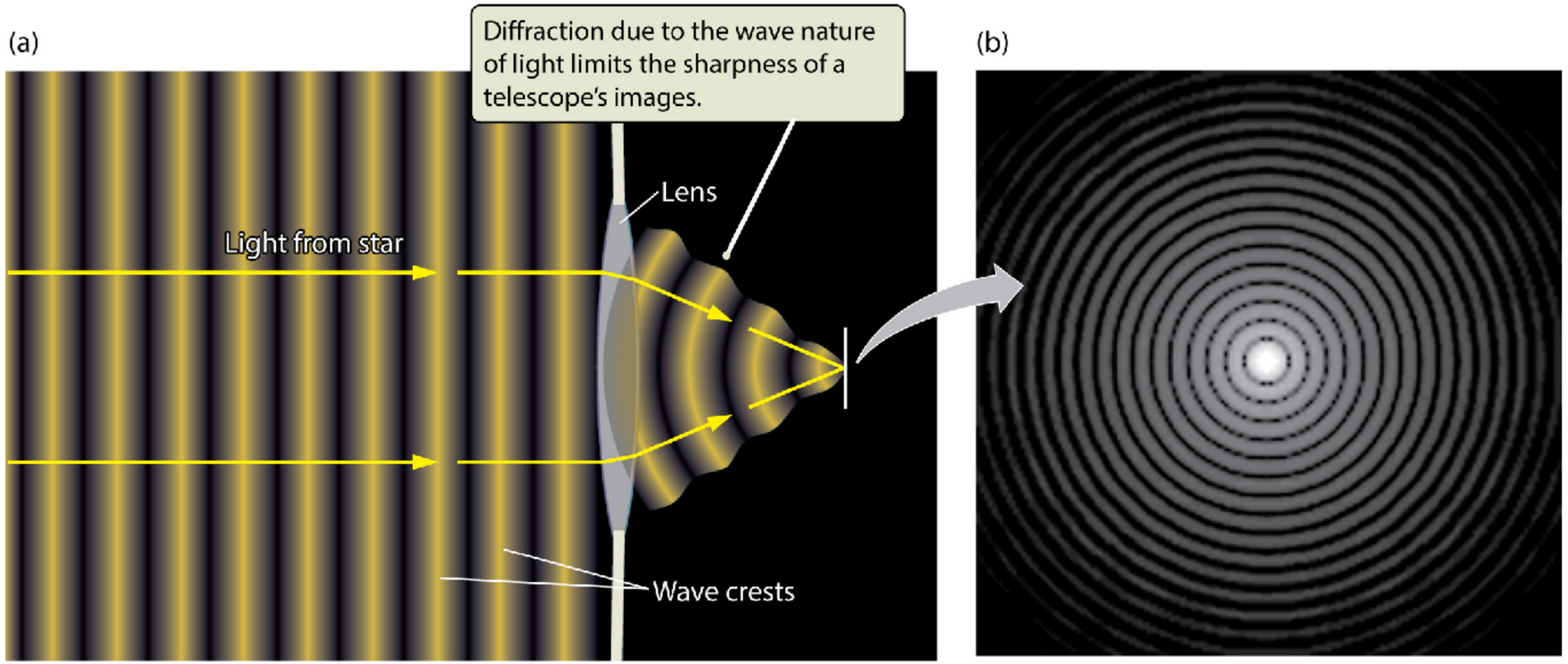


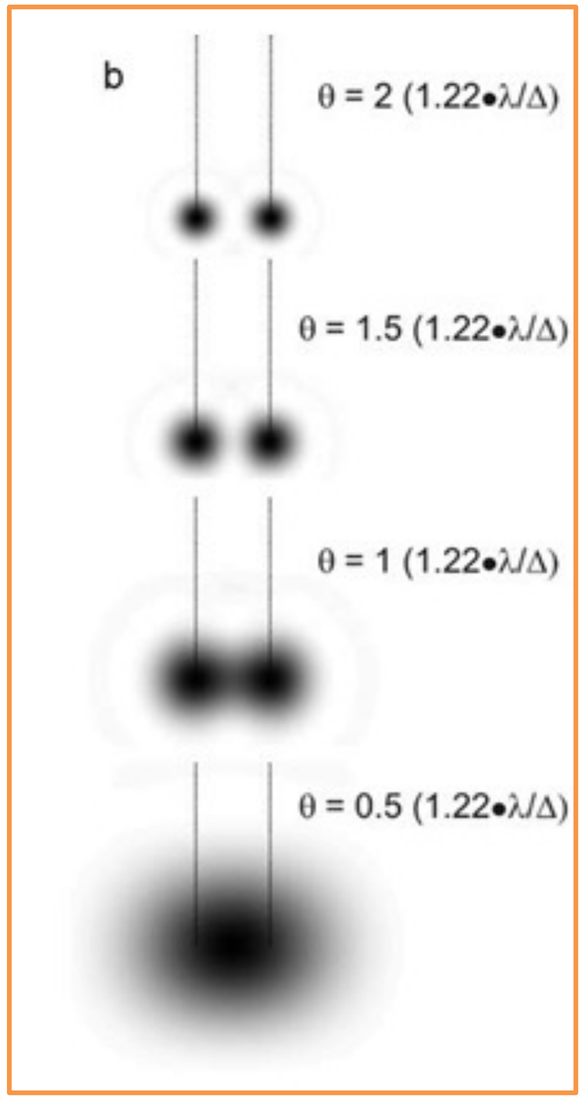

Gamma rays, X-rays and ultraviolet light blocked by the upper atmosphere (best observed from space).
Visible light observable from Earth, with some atmospheric distortion.
Most of the infrared spectrum absorbed by atmospheric gasses (best observed from space).
Radio waves observable from Earth.
Long-wavelength radio waves blocked.
100 %
50 %
0 %
Atmospheric opacity
0.1 nm
1 nm
10 nm
100 nm
1 μm
10 μm
100 μm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
Wavelength
Transparency (%)
100
50
0
Atmosphere is opaque
Atmosphere is opaque
Radio window
Atmosphere is opaque
10^{-12} 10^{-11} 10^{-10} 10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 1 10^{1} 10^{2} 10^{3} (m)
0.001 nm 0.01 nm 0.1 nm 1 nm 10 nm 100 nm 1 μm 10 μm 100 μm 1 mm 1 cm 10 cm 1 m 10 m 100 m 1 km
Wavelength


REFRACTOR
REFLECTOR
• MORE EXPENSIVE
• LESS COMPACT
• CHROMATIC ABERRATION
• REDUCED LIGHT-GATHERING
• CAN'T SEE SPACE VAMPIRES

xkcd.com

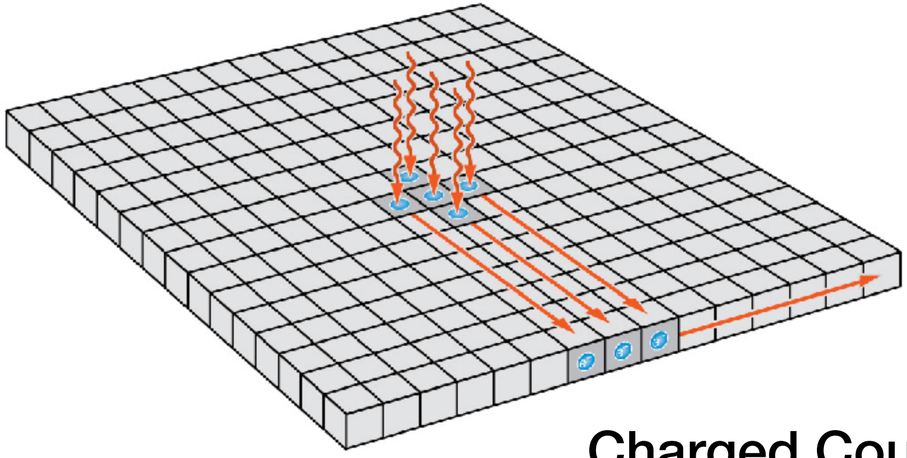
Telescope Resolution

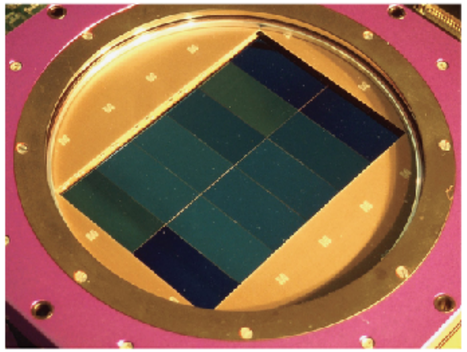




$$\text{angular resolution} = 206265 \text{ arcseconds} \frac{\text{wavelength}}{\text{telescope diameter}} \longrightarrow \theta \propto \frac{\lambda}{D}$$

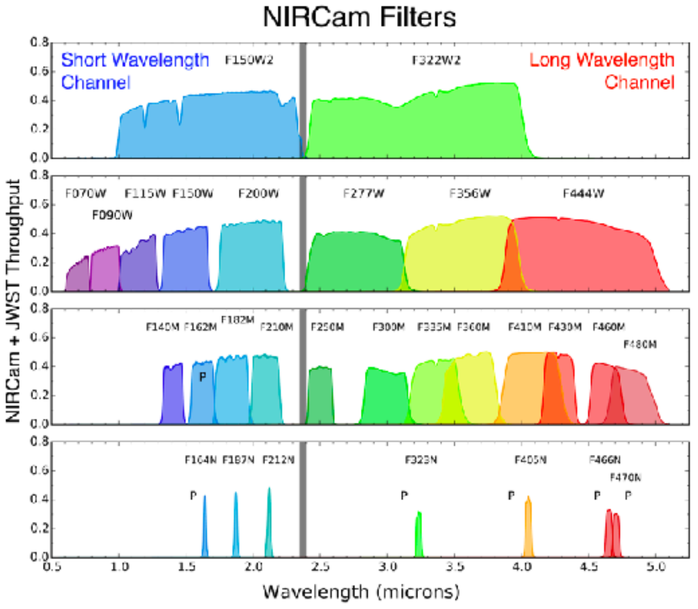
Making Images



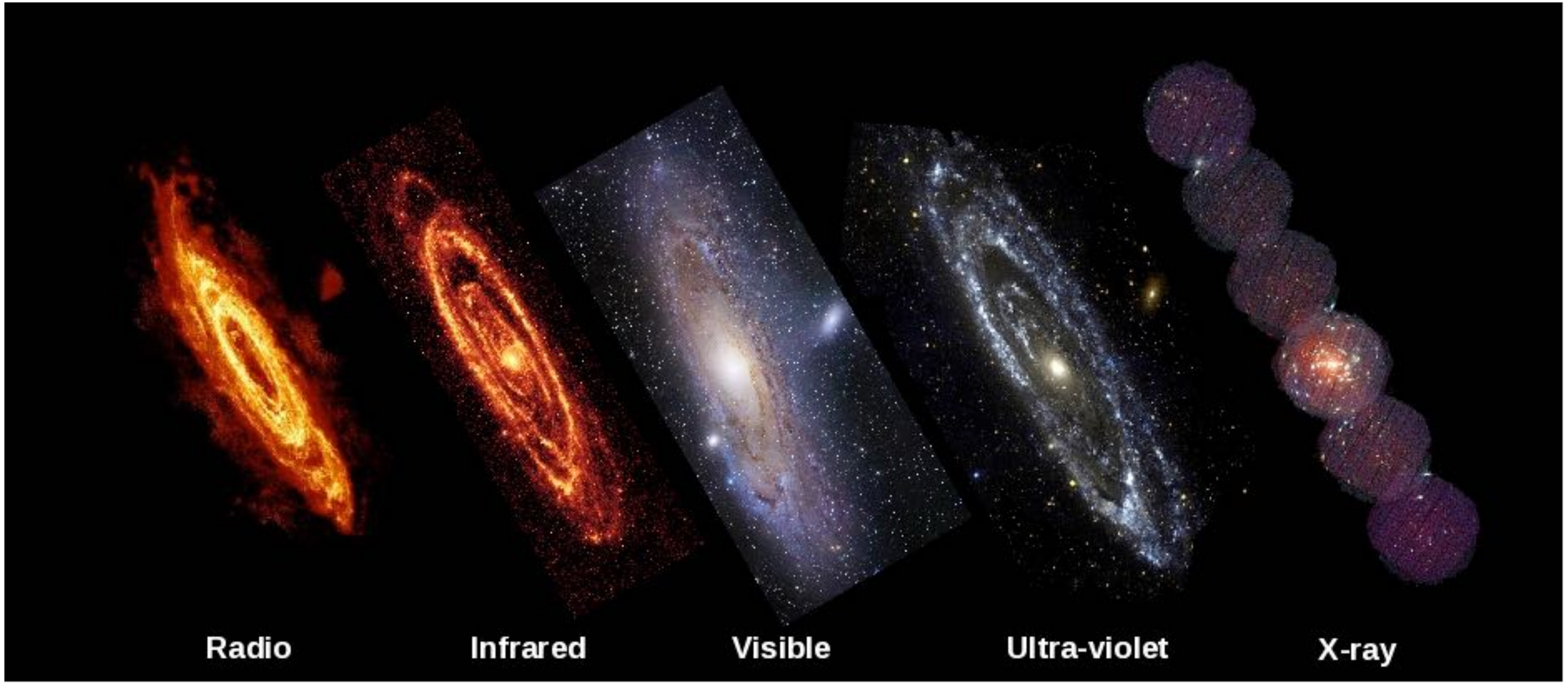


Charged Coupled Devices (CCDs)

Filters

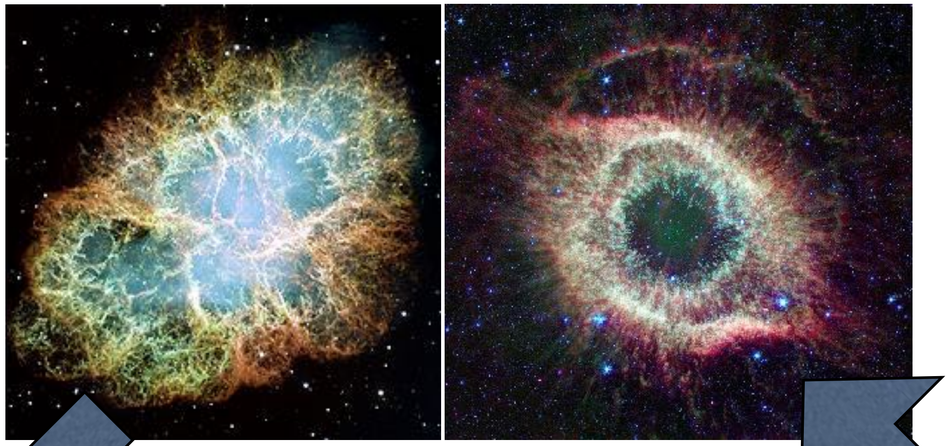


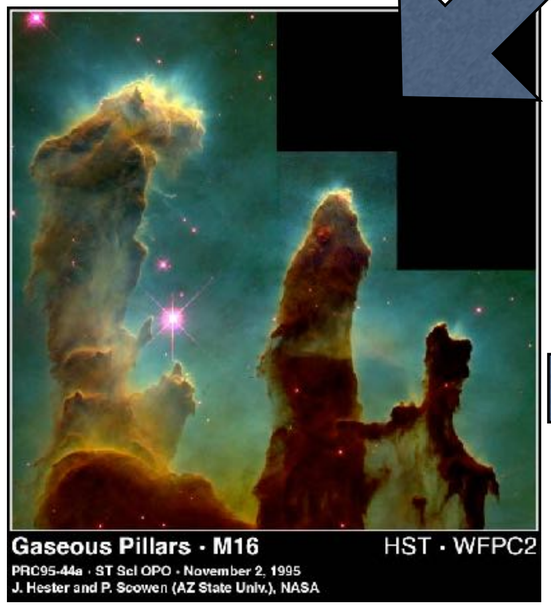
Andromeda Galaxy - Our Nearest Neighbor

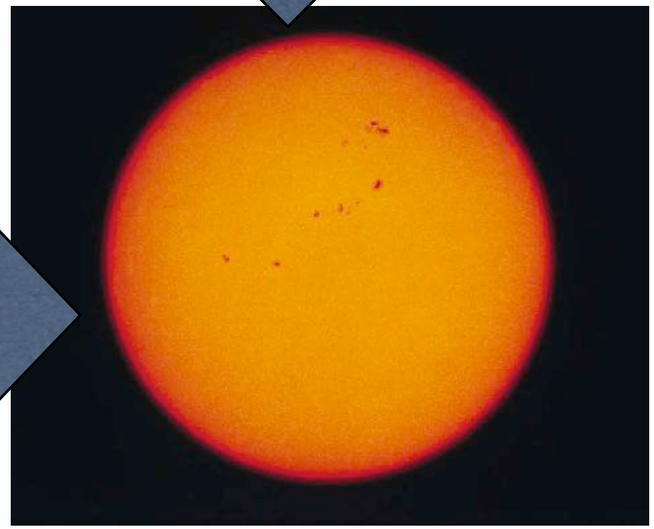


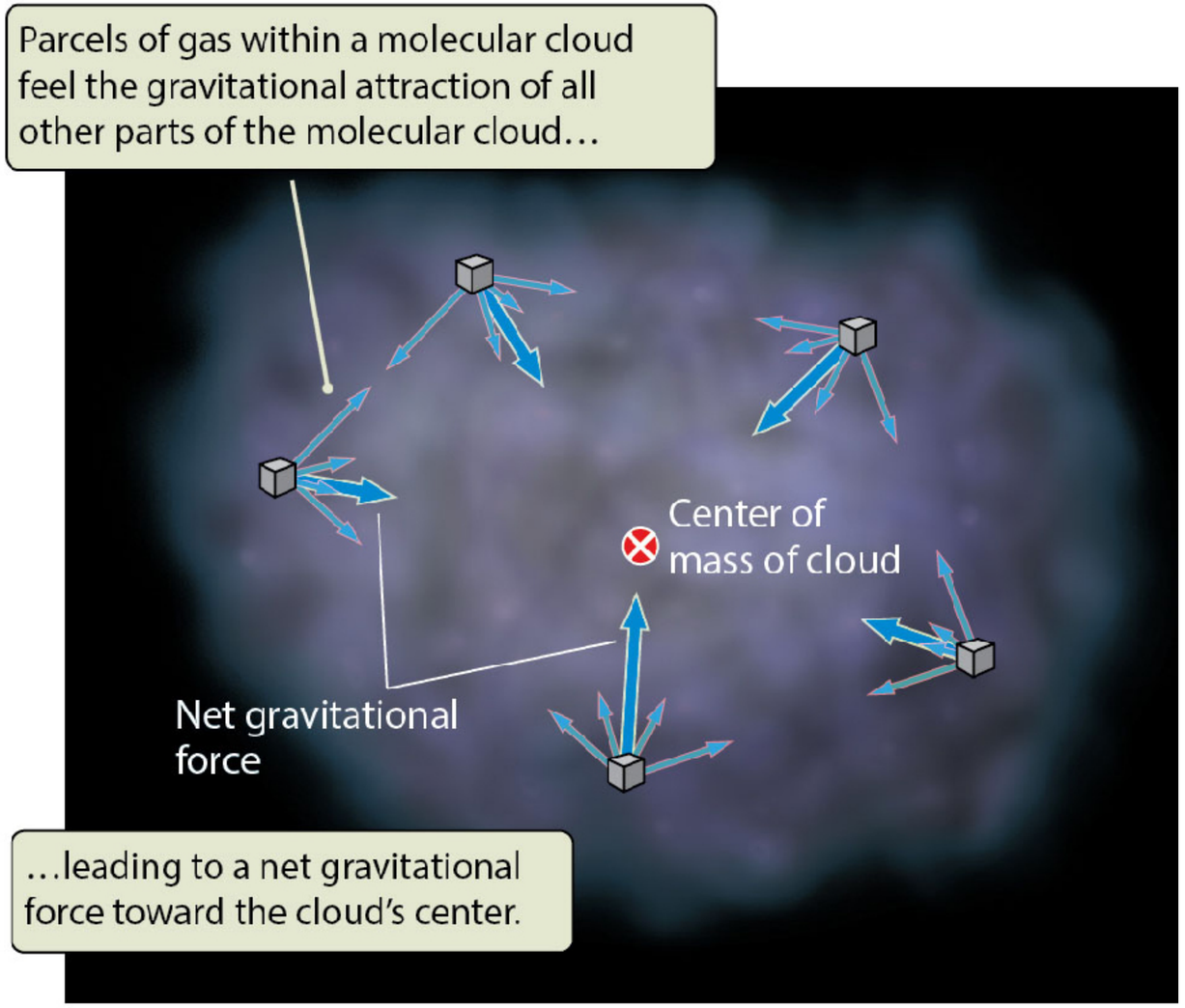
Chapter 5: Star and Planet Formation and Exoplanets

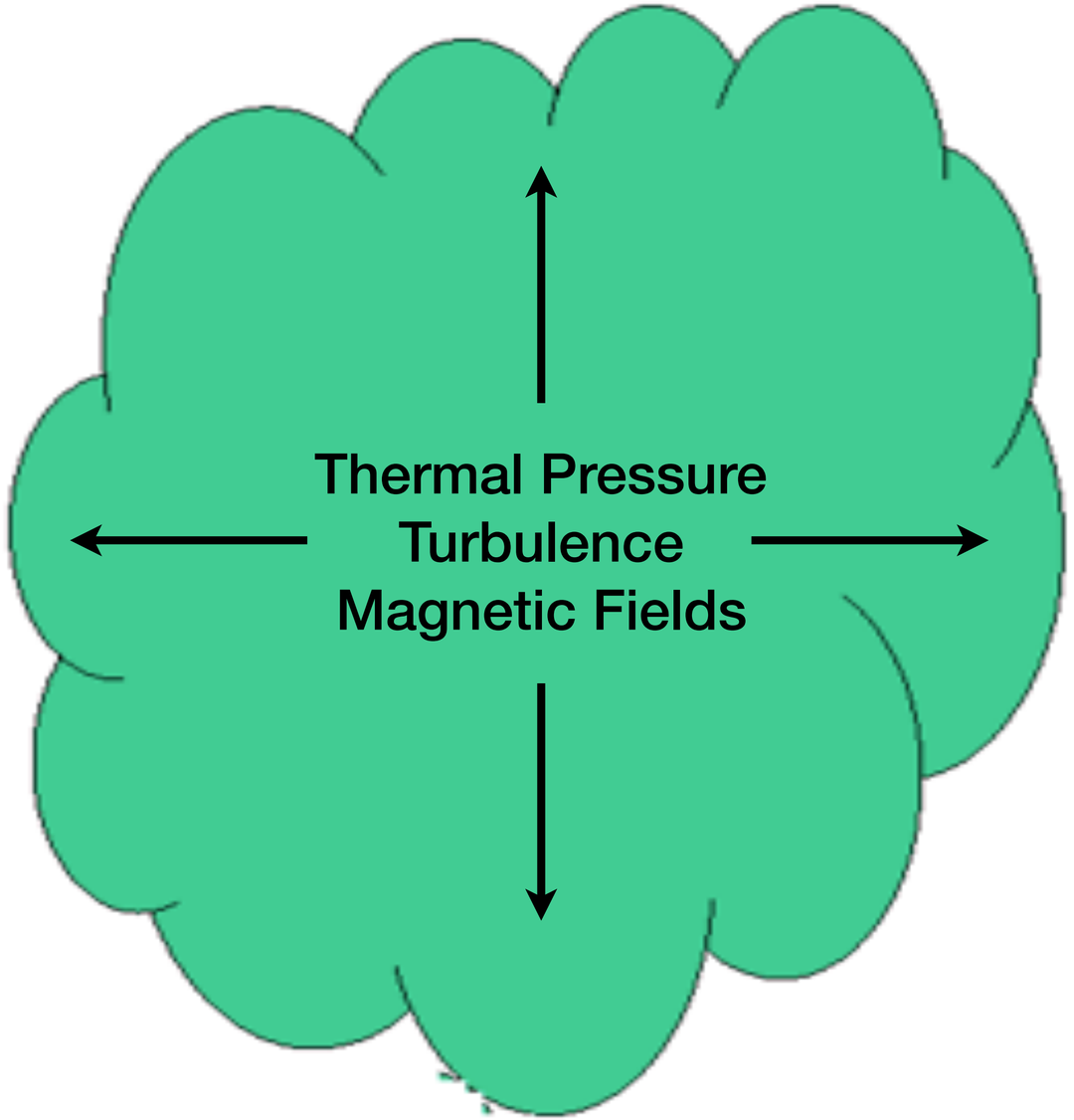
Life Cycle of Gas and Stars



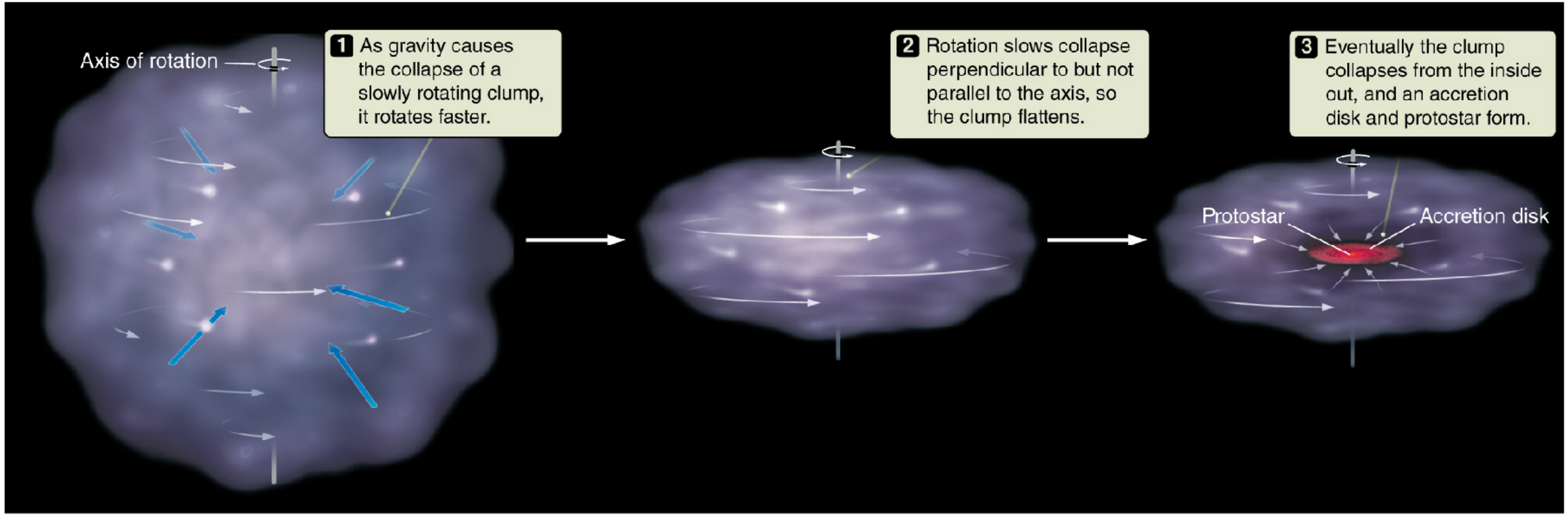




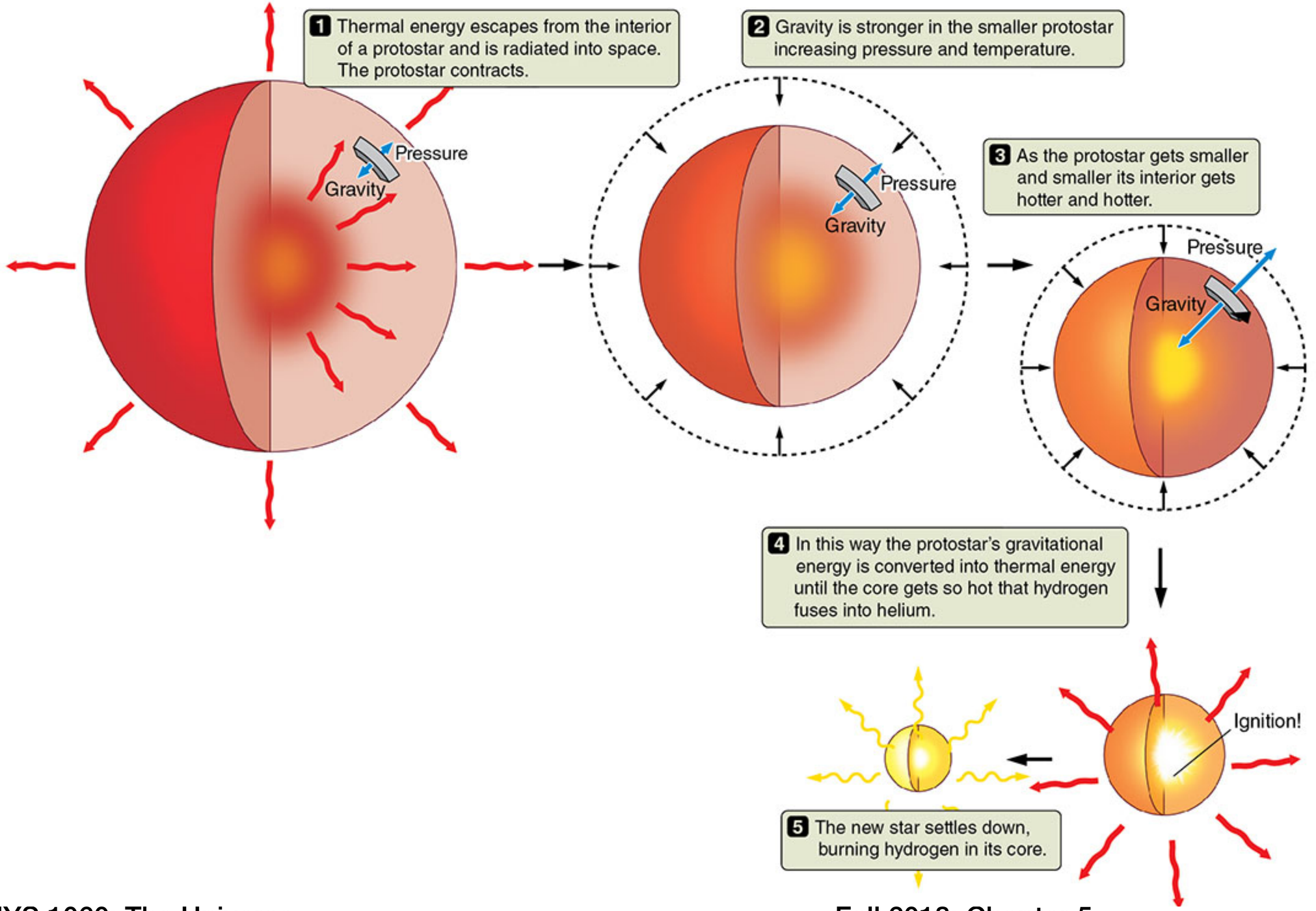

Parcels of gas within a molecular cloud feel the gravitational attraction of all other parts of the molecular cloud…
Center of mass of cloud
Net gravitational force
…leading to a net gravitational force toward the cloud's center.

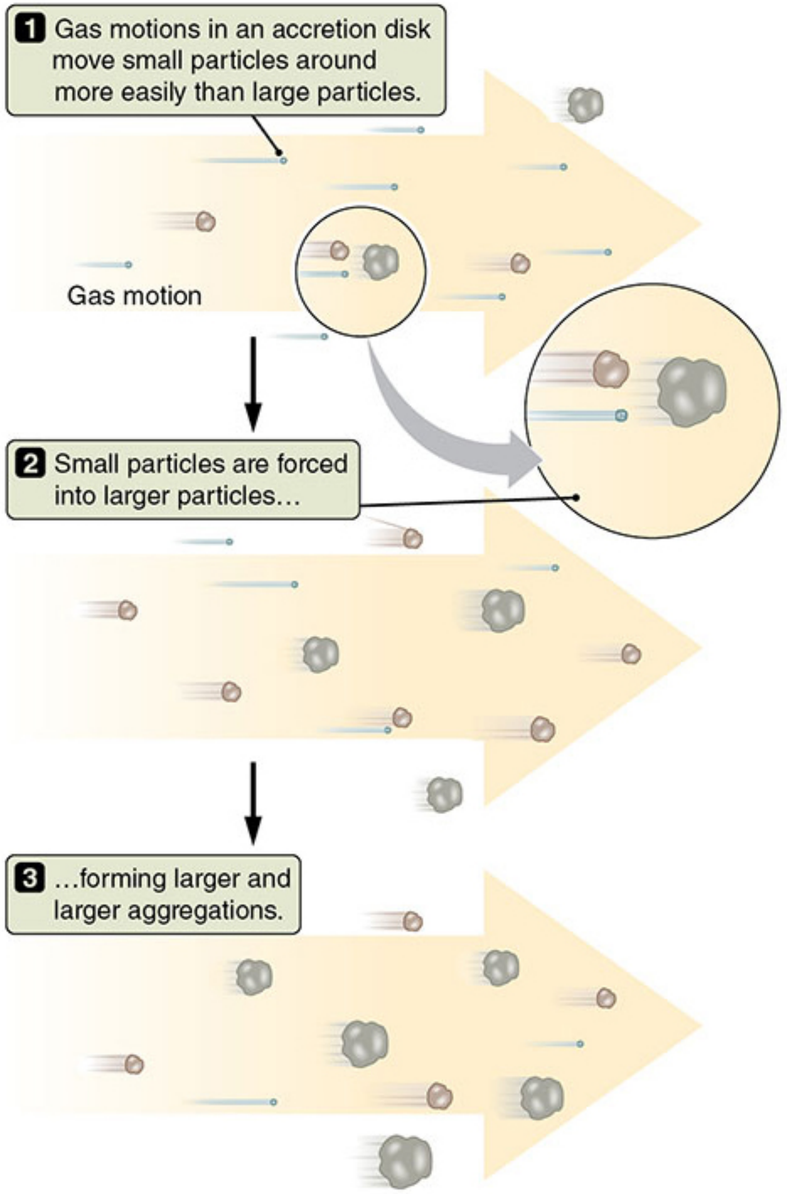

Thermal Pressure
Turbulence
Magnetic Fields

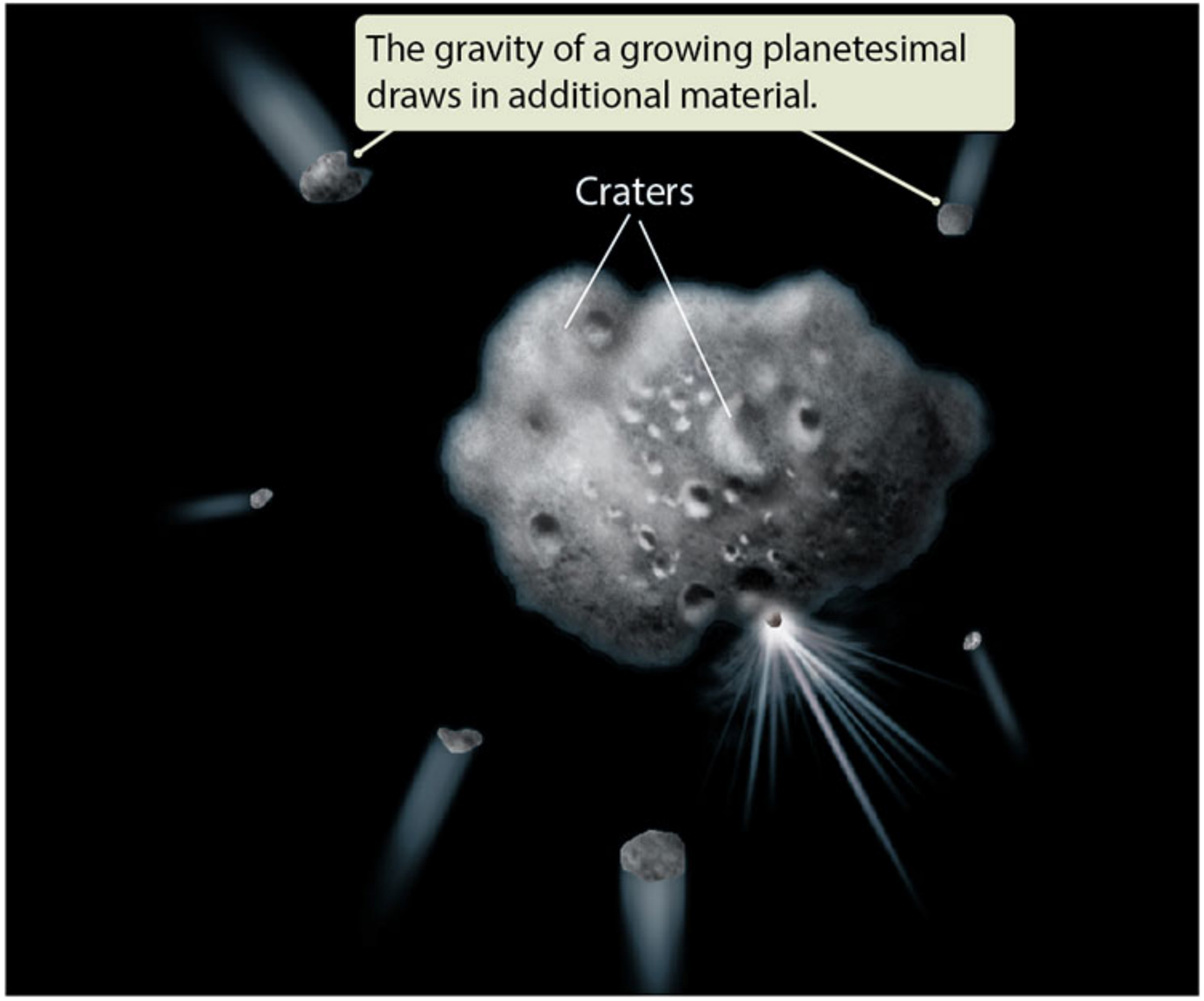
Any small net spin of the collapsing cloud is amplified as it becomes smaller



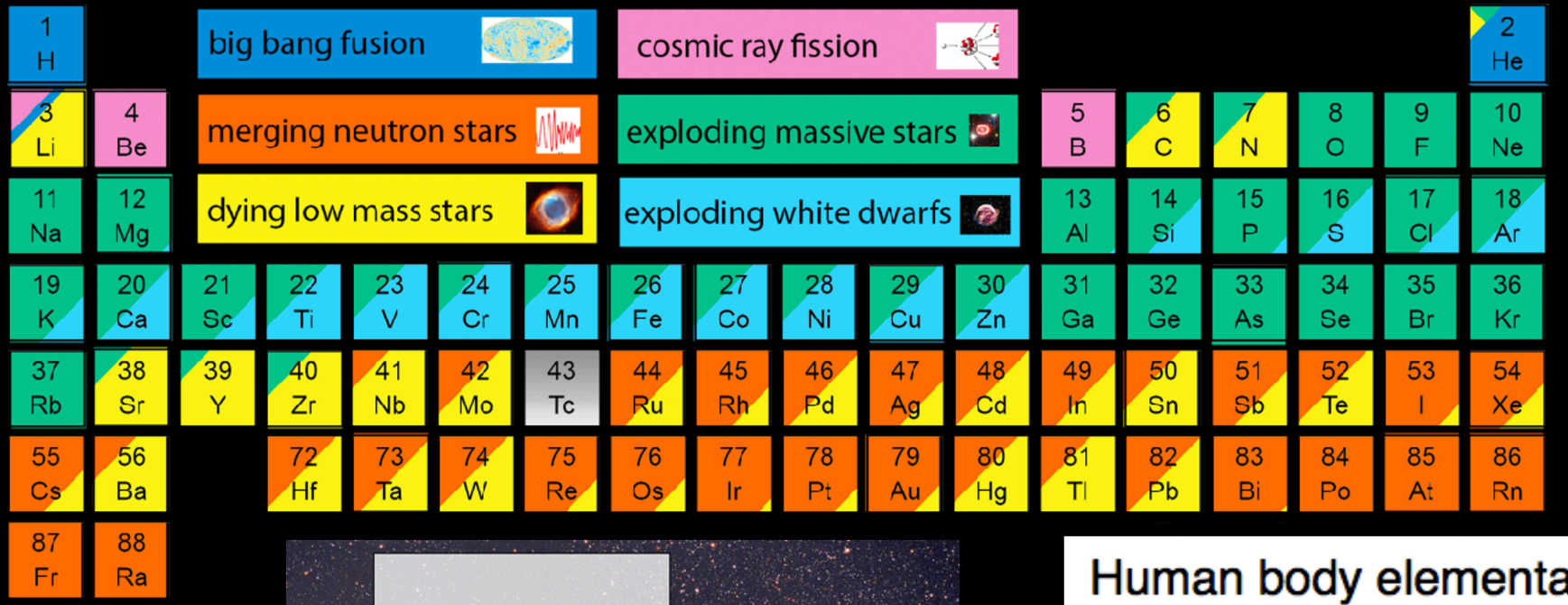
Conservation of Angular Momentum: $L = m\ v\ r$

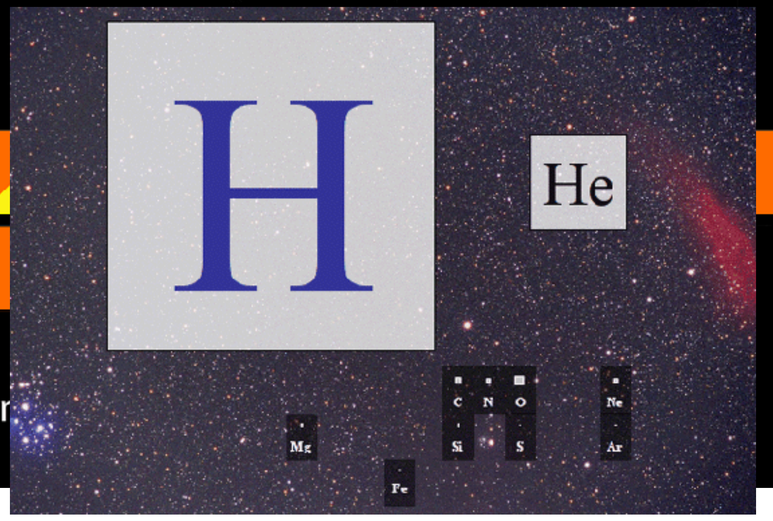

1 Thermal energy escapes from the interior of a protostar and is radiated into space. The protostar contracts.
Pressure
Gravity
2 Gravity is stronger in the smaller protostar increasing pressure and temperature.
Pressure
Gravity
3 As the protostar gets smaller and smaller its interior gets hotter and hotter.
Pressure
Gravity
4 In this way the protostar's gravitational energy is converted into thermal energy until the core gets so hot that hydrogen fuses into helium.
Ignition!
5 The new star settles down, burning hydrogen in its core.


1 Gas motions in an accretion disk move small particles around more easily than large particles.
Gas motion
2 Small particles are forced into larger particles…
3 …forming larger and larger aggregations.


The gravity of a growing planetesimal draws in additional material.
Craters

The Origin of the Solar System Elements

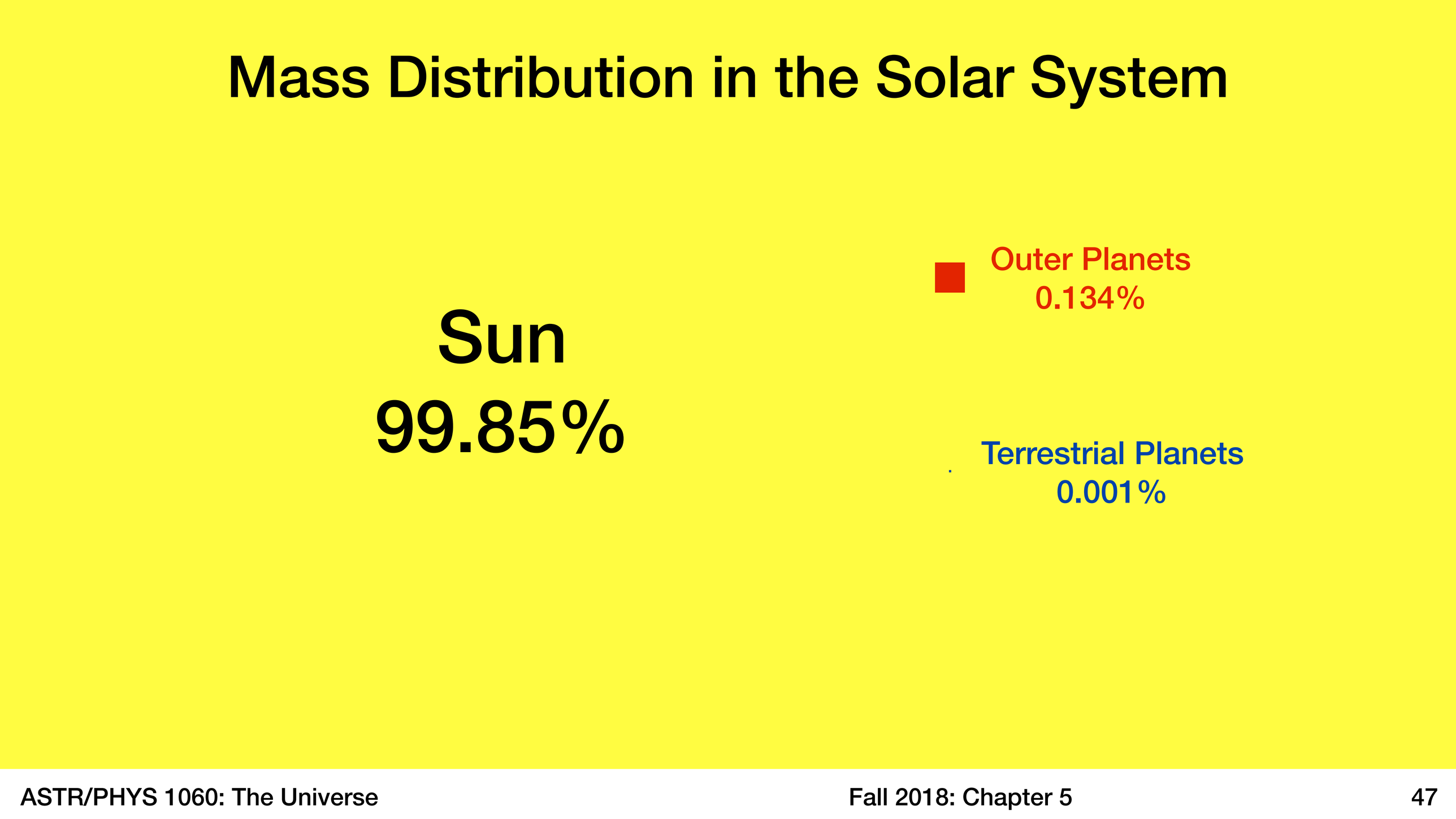




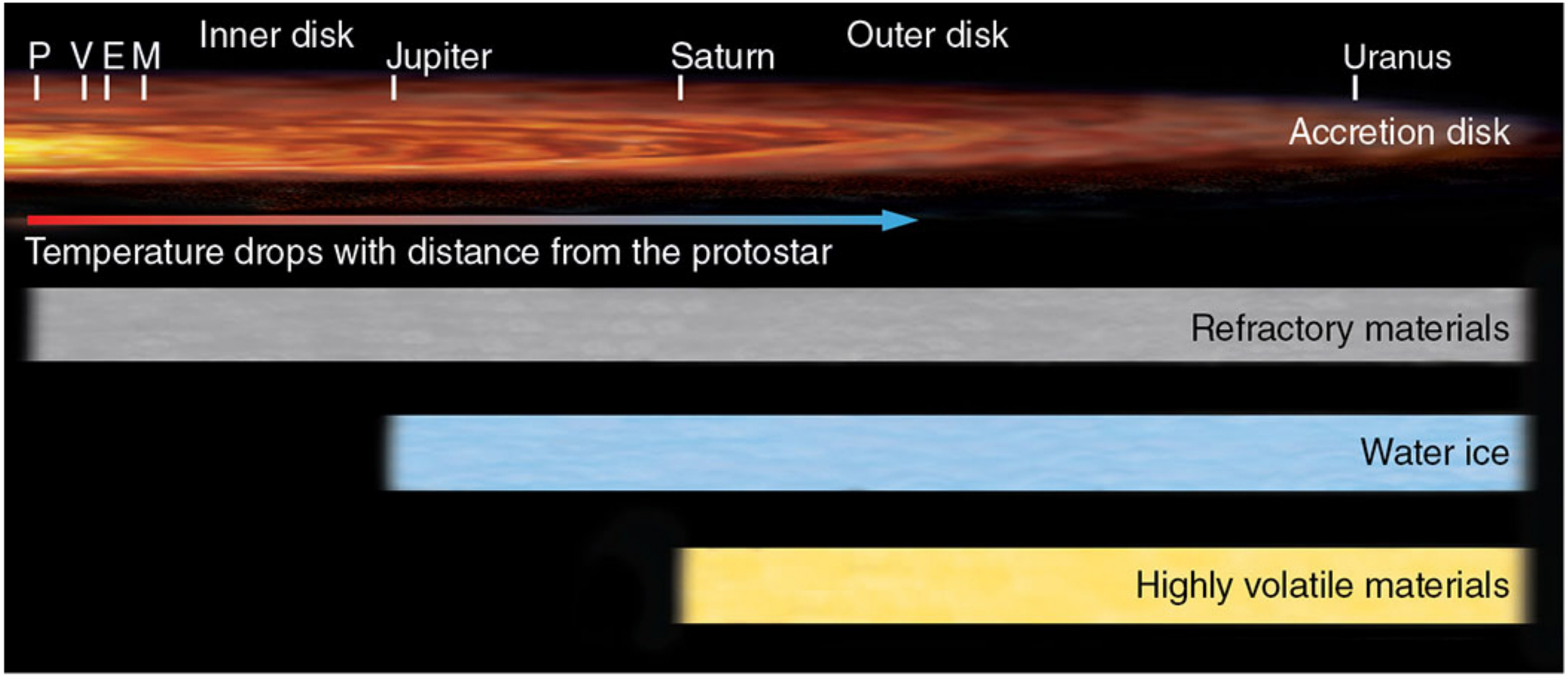
Human body elemental abundance

Element	Proportion (by mass)
Oxygen	65%
Carbon	18%
Hydrogen	10%
Nitrogen	3%

Mass Distribution in the Solar System



Inner versus outer planets



How to find planets

- Detect them directly

Direct Imaging

- Image the planet
- Detect its atmosphere in a spectrum

- Detect their influence on their star

Transit Method

- Measure light blocked from the star when the planet eclipses it
- Measure the star's motion due to the planet's gravity

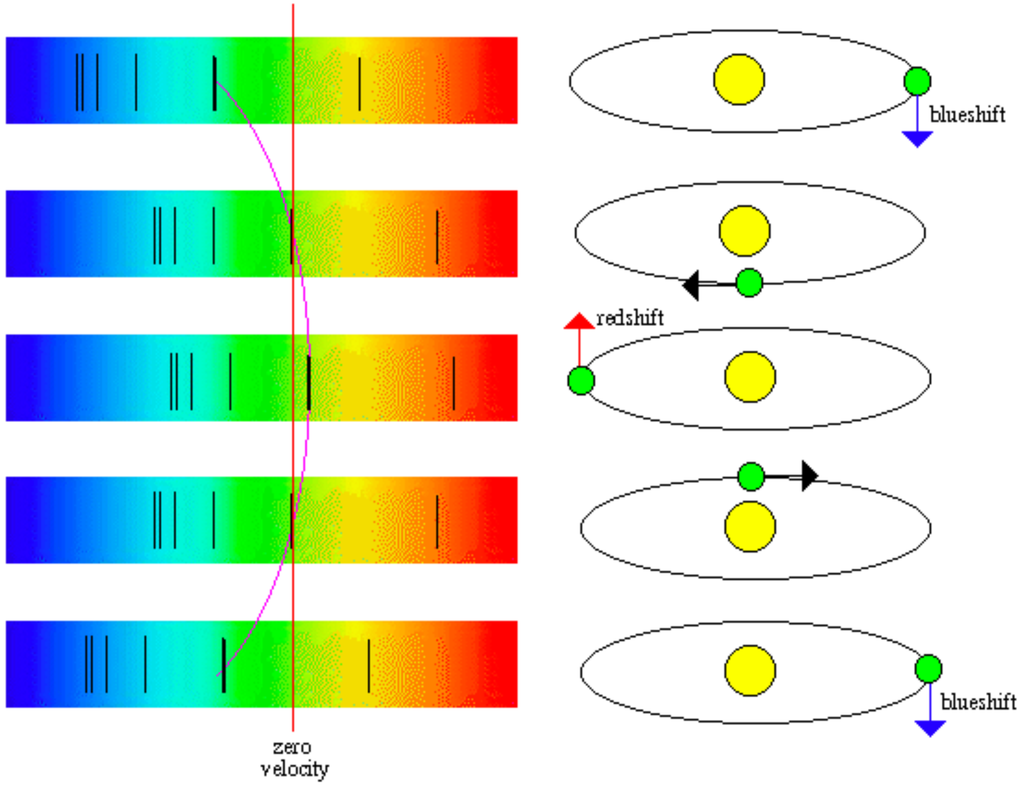
Radial Velocity Method

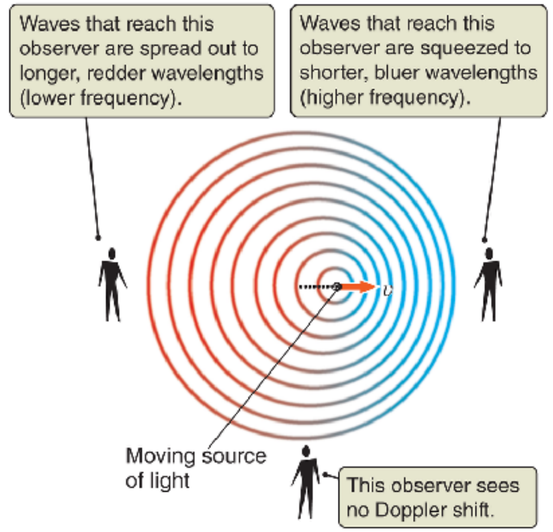
Doppler Shift of Light

$$\frac{\lambda_{observed} - \lambda_{emitted}}{\lambda_{emitted}} = \frac{v}{c}$$

Spectroscopic Binary

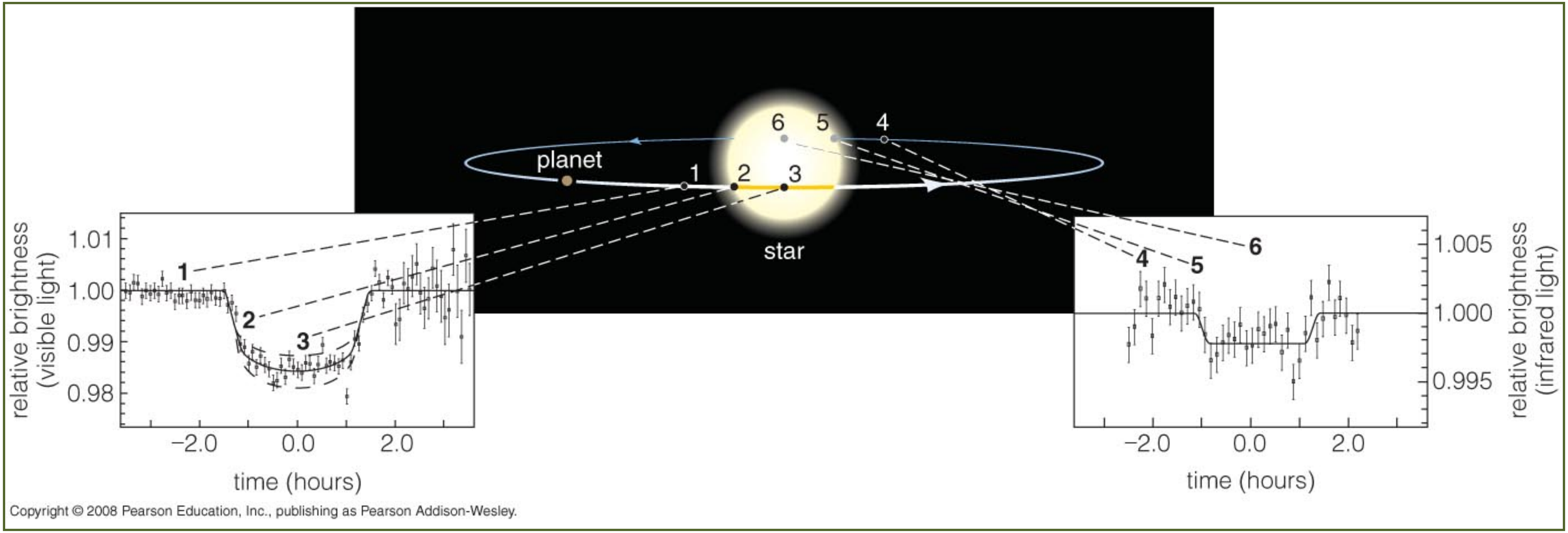
A spectroscopic binary is where there is evidence of orbital motion in the spectral features due to the Doppler effect



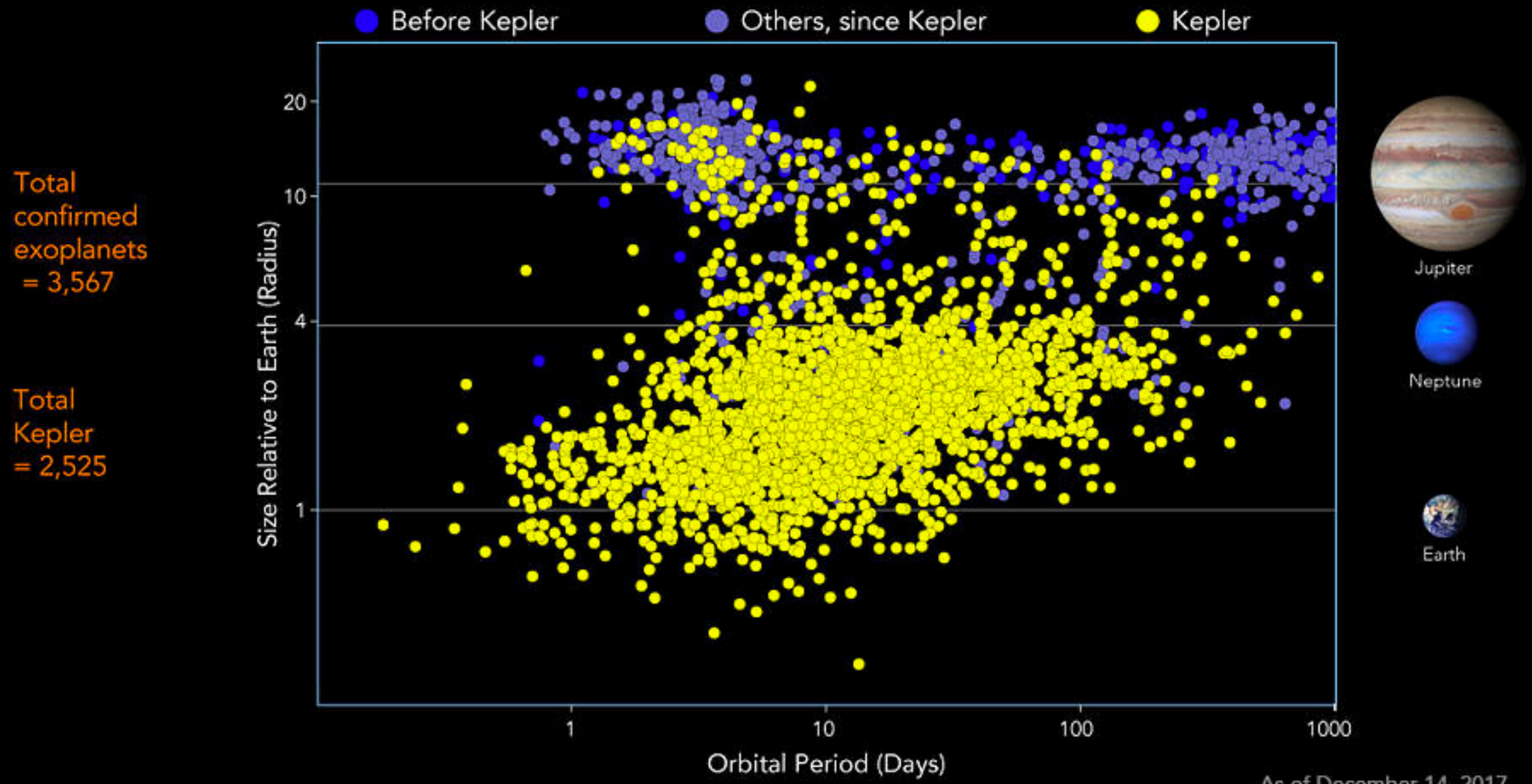


Transit Method

Starlight is blocked by the planet, reducing the amount of light detected from the star



Exoplanet Discoveries



Happy Studying!