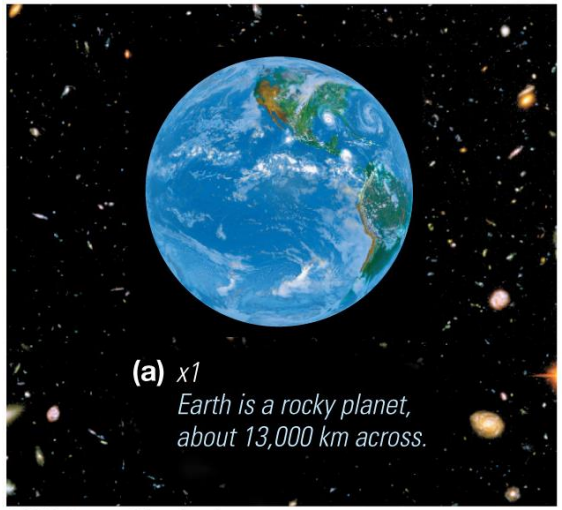
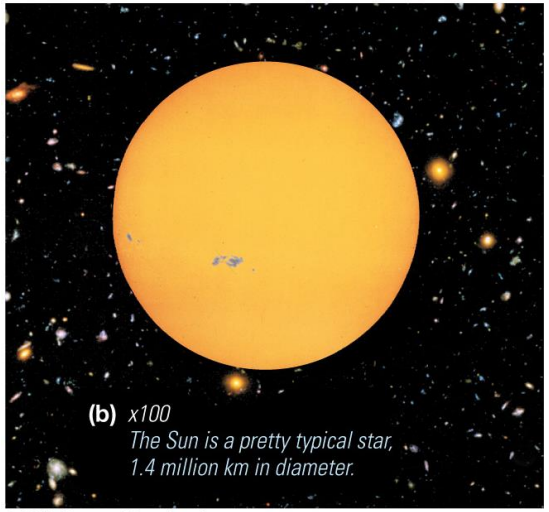
Chapter 1:
The Night Sky

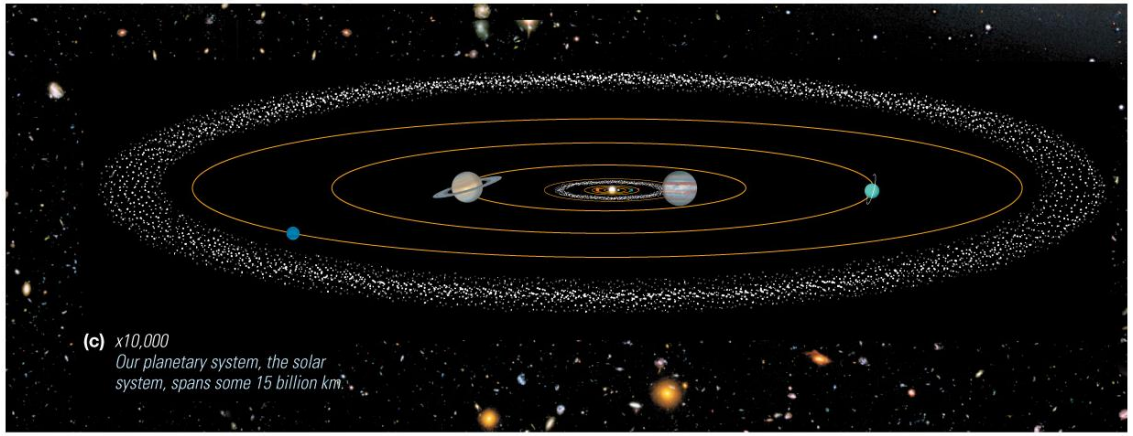
Prof. Douglas Laurence

AST 1002

Order of Magnitude

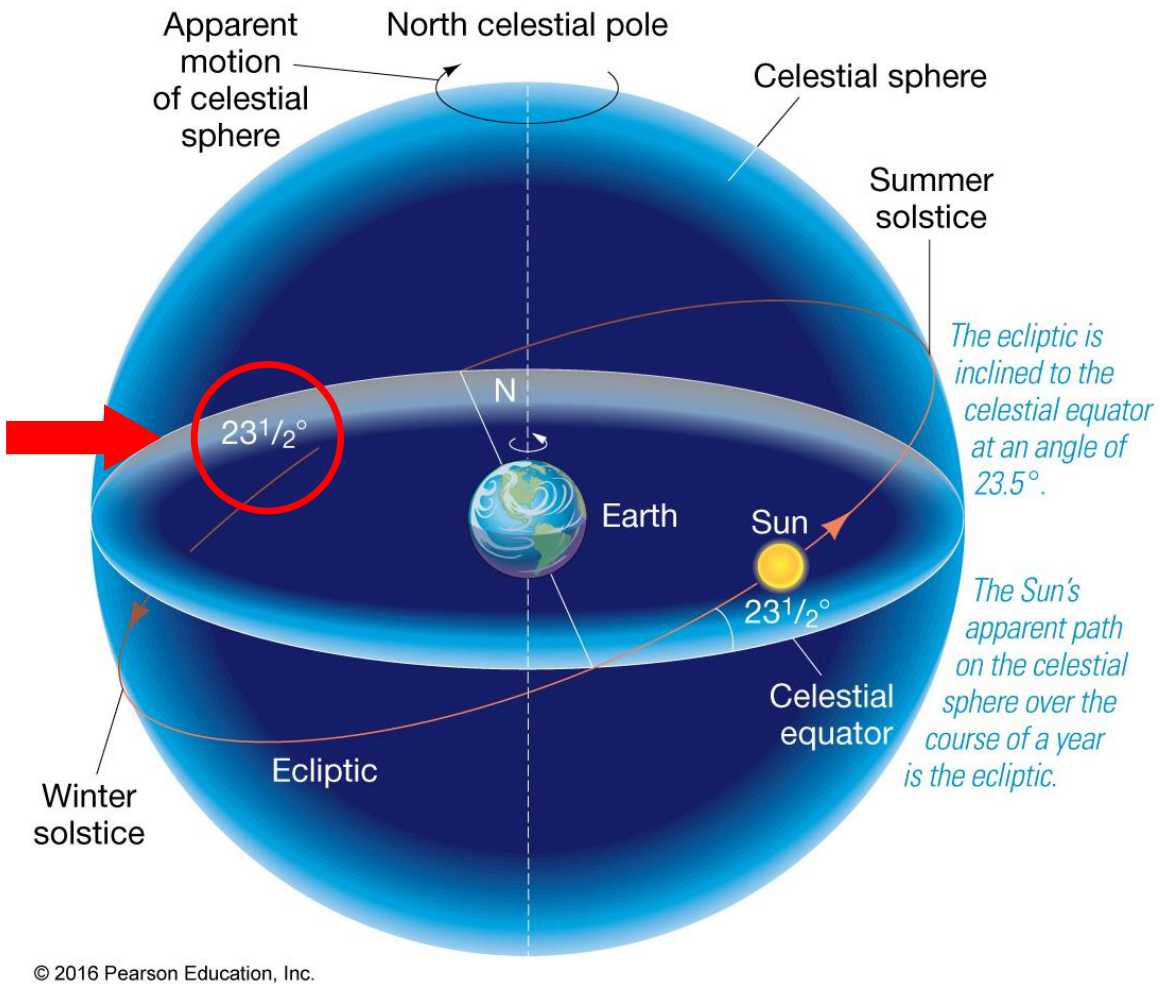






Geocentric View

Same as orbital tilt in heliocentric view.

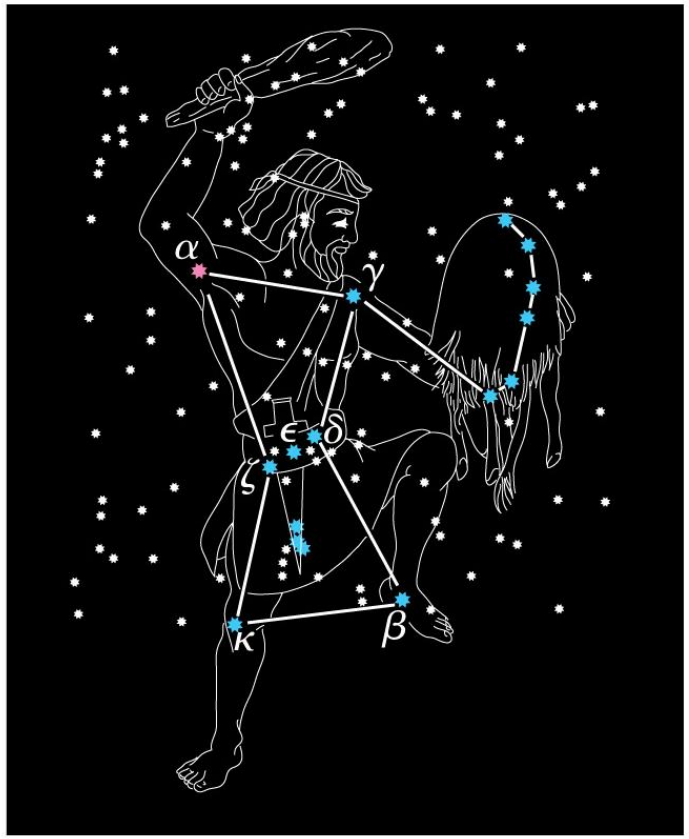


Constellations

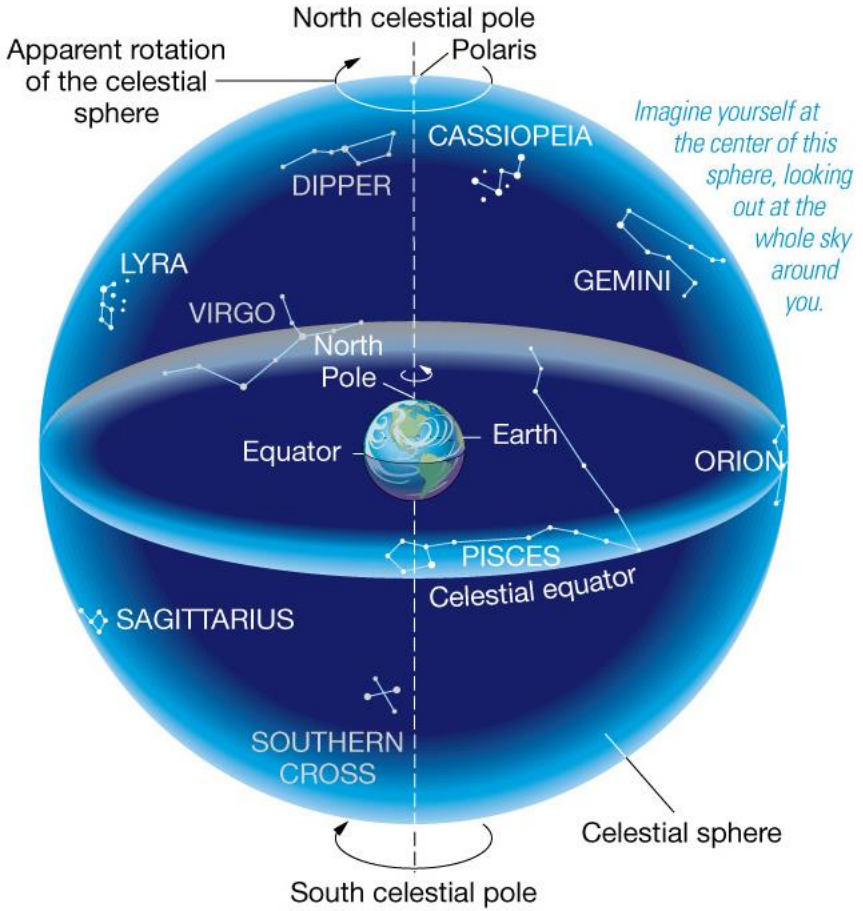
This is a real photo of the Orion constellation . . .

(a)

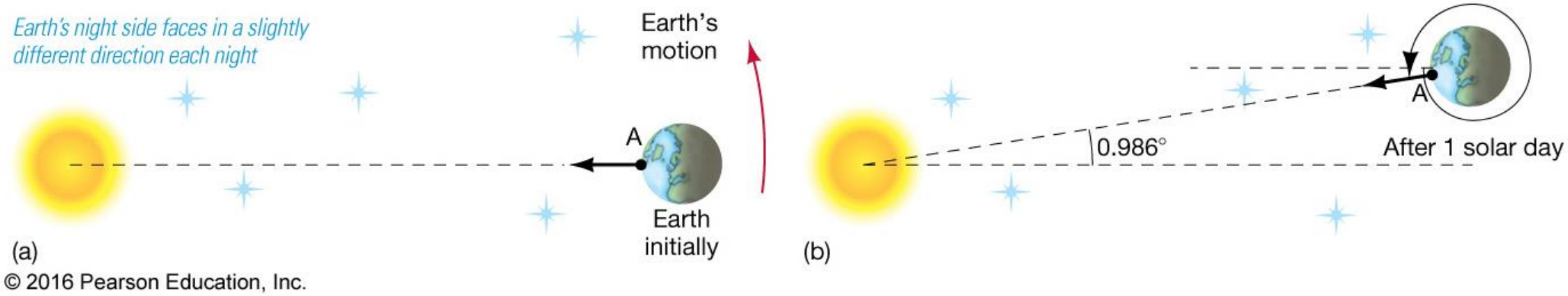
. . . and this is a mapped interpretation, to exactly the same scale.



(b)

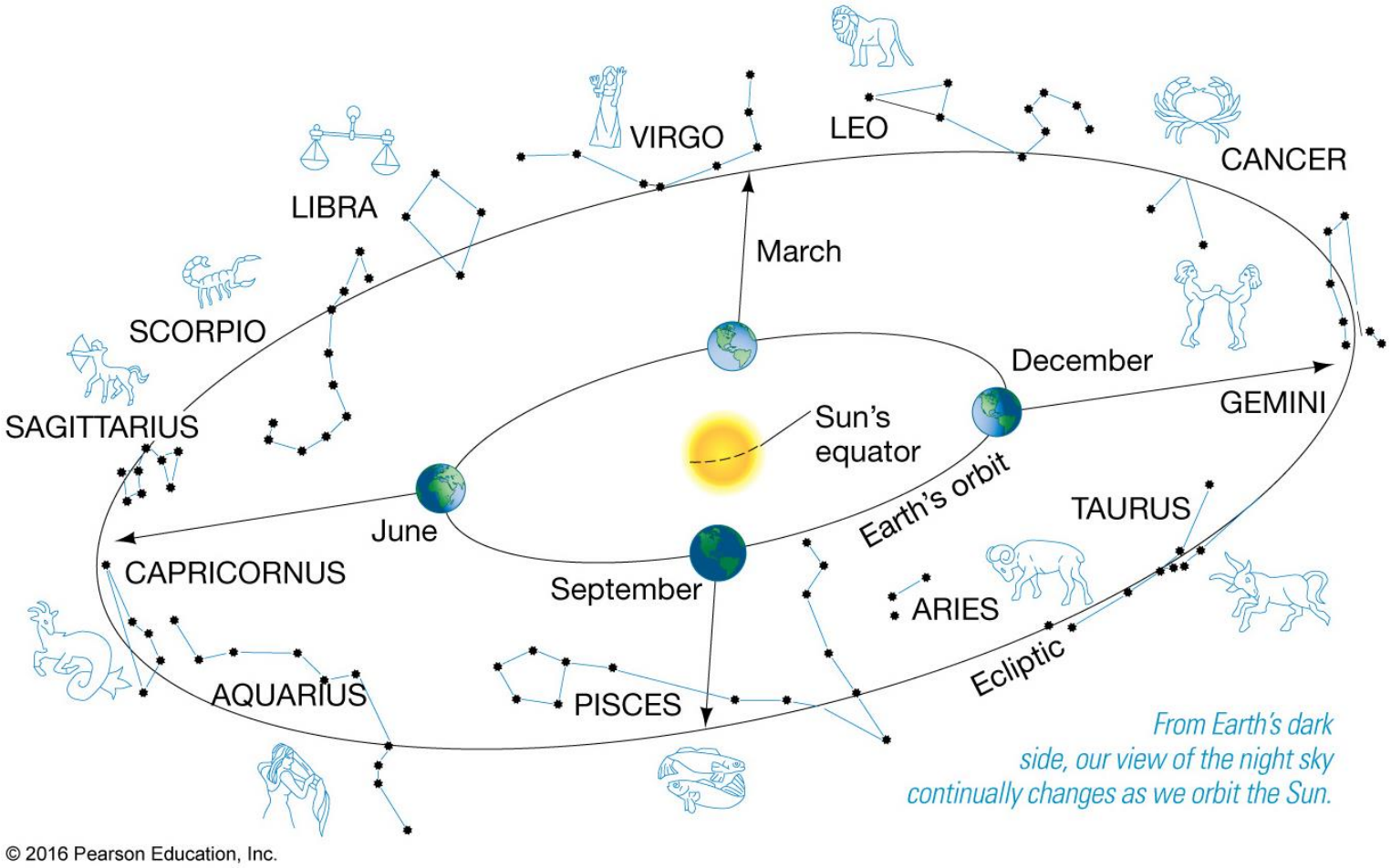


Sidereal vs. Solar Time

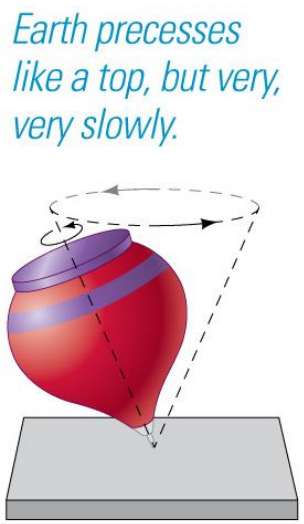


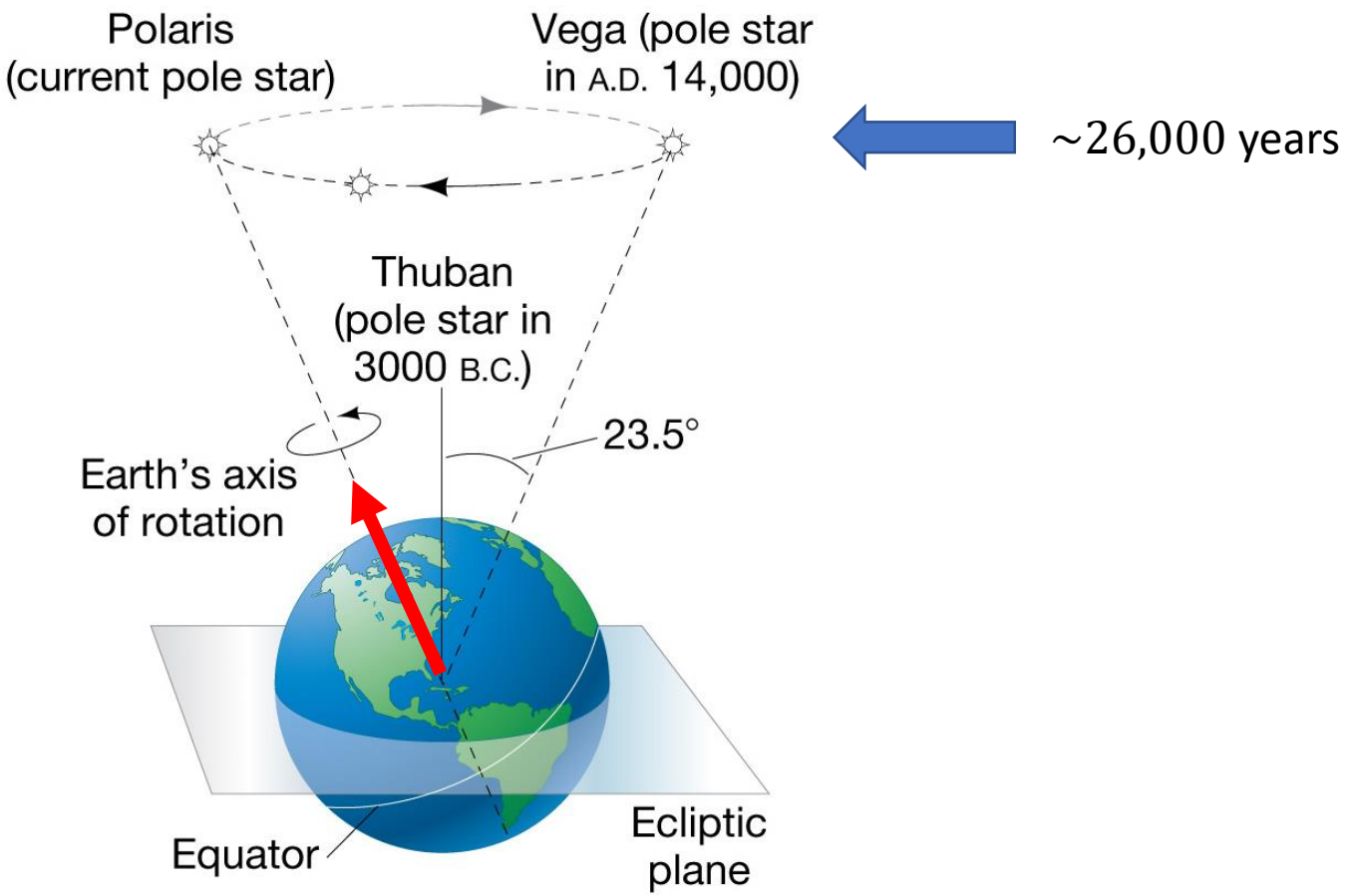
24 solar hours = 23 h 56 min sidereal time

Seasons and the Night Sky

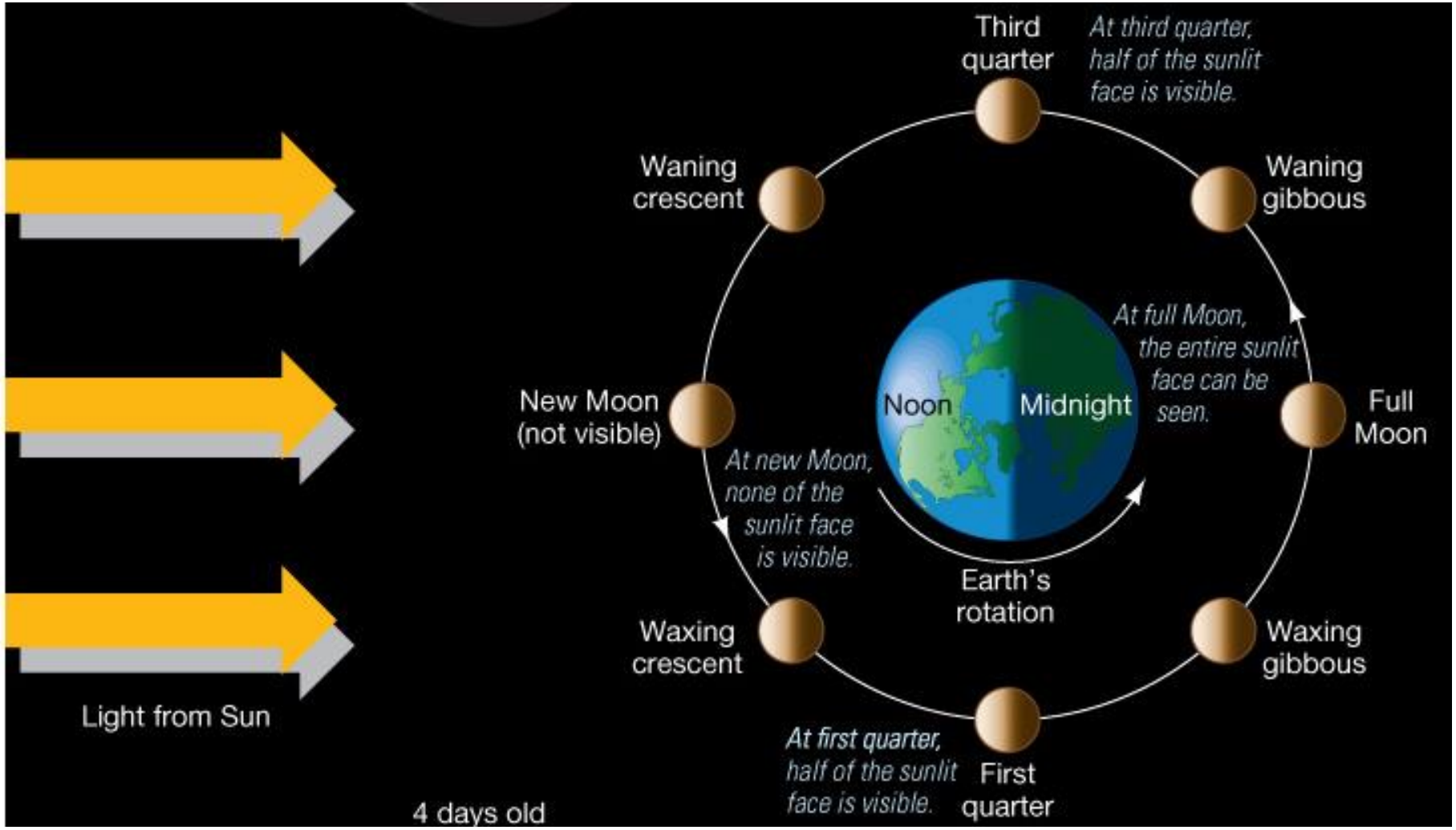


Orbital Procession



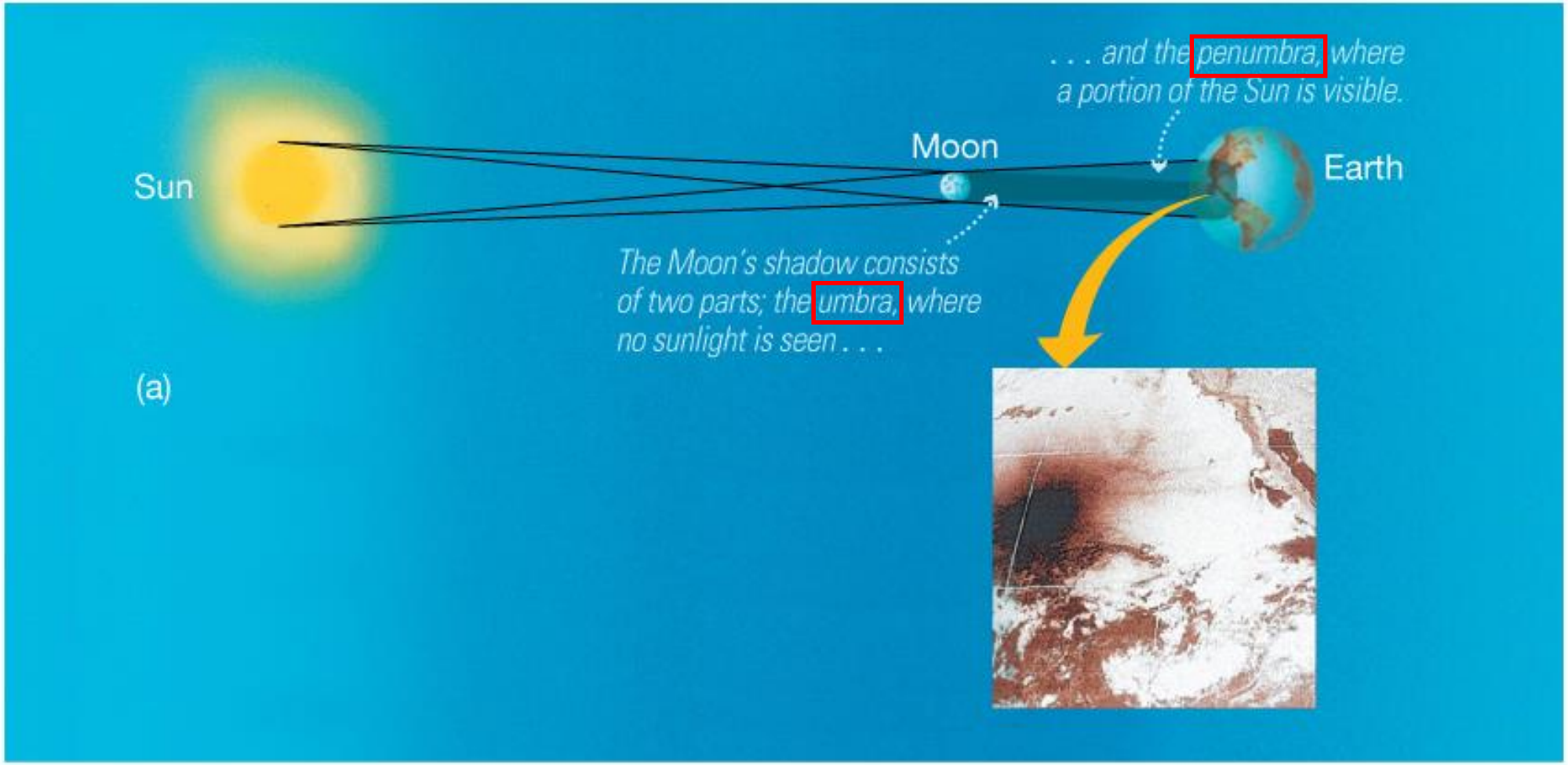


Phases of the Moon

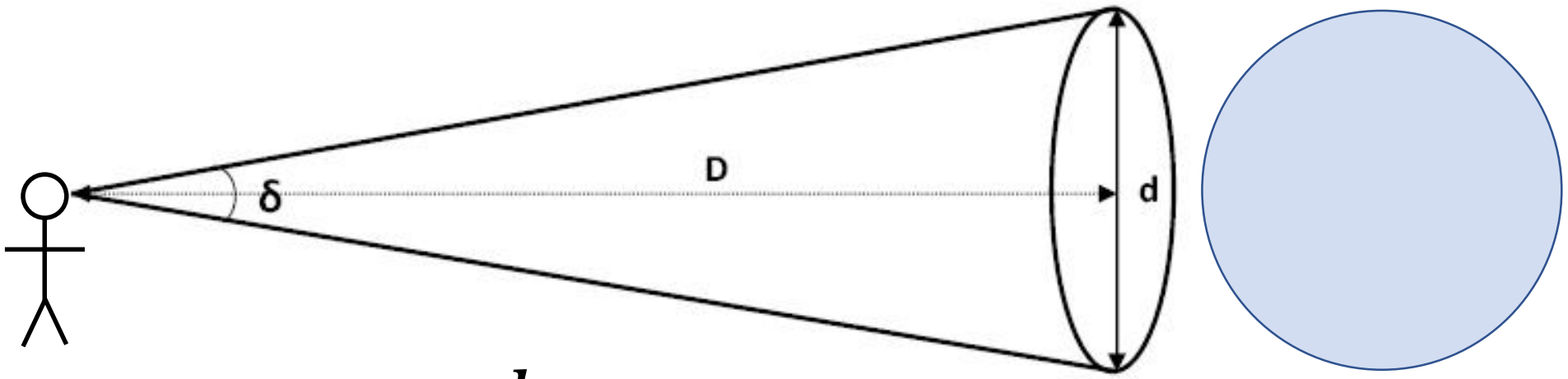


Phases of the Moon (cont'd)

Solar Eclipses

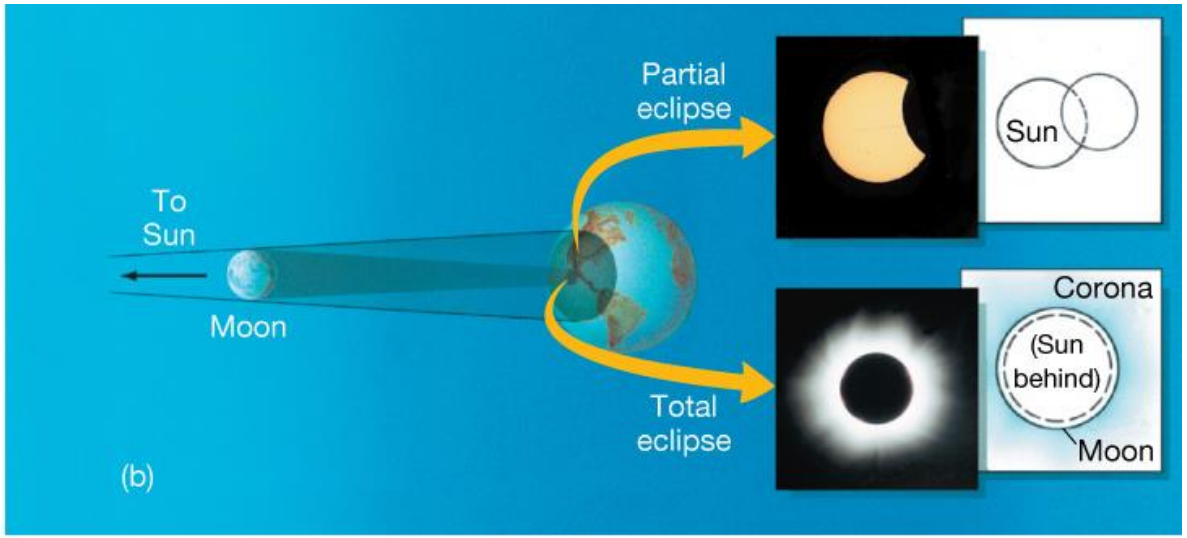


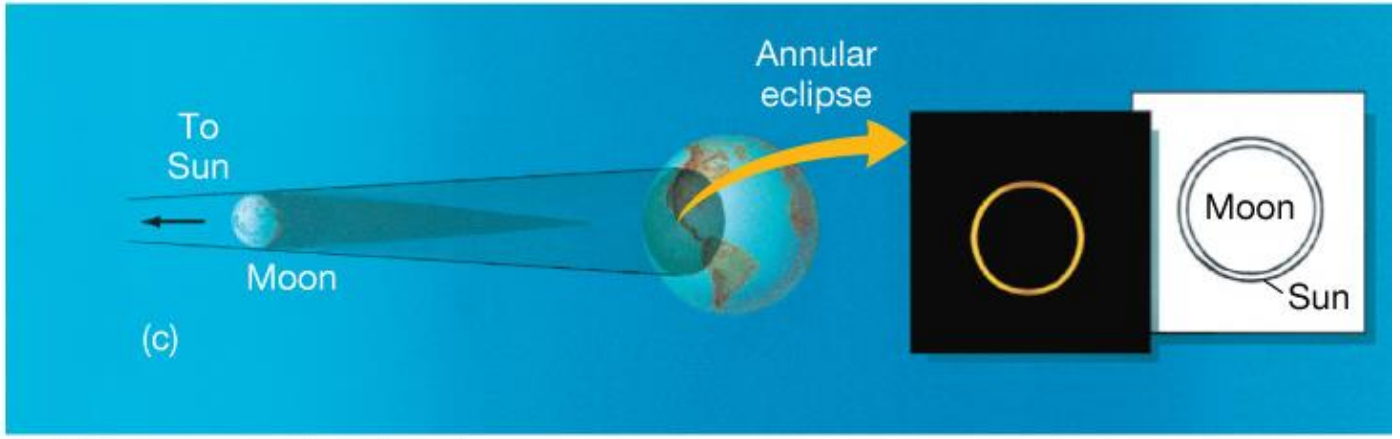
Angular Size



$$\delta \approx \frac{d}{D}$$

Total vs. Annular Solar Eclipses

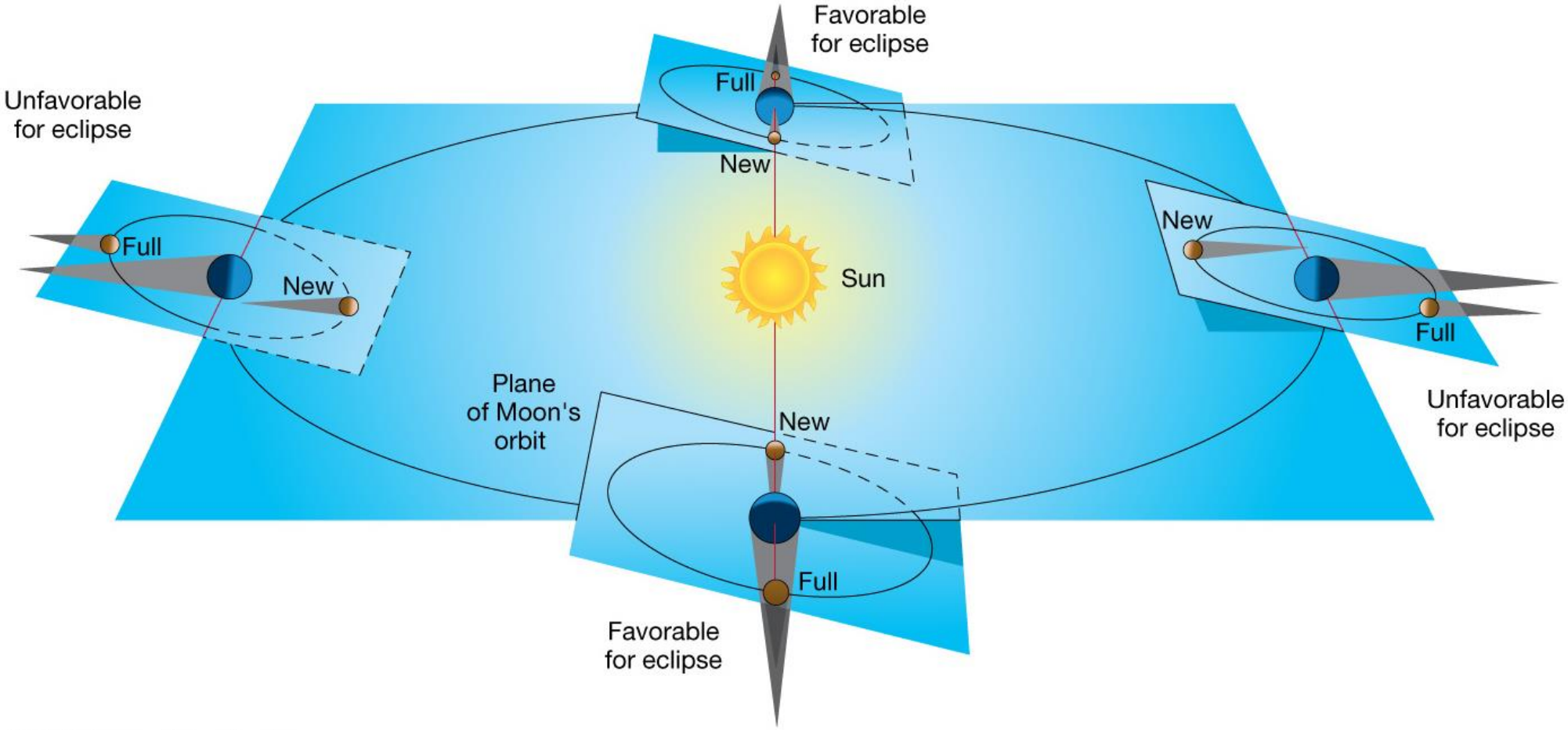




Eclipse Interactive Applet:

https://highered.mheducation.com/olcweb/cgi/pluginpop.cgi?it=swf::640::480::/sites/dl/free/007299181x/220730/eclipse_interactive.swf::Eclipse%20Interactive

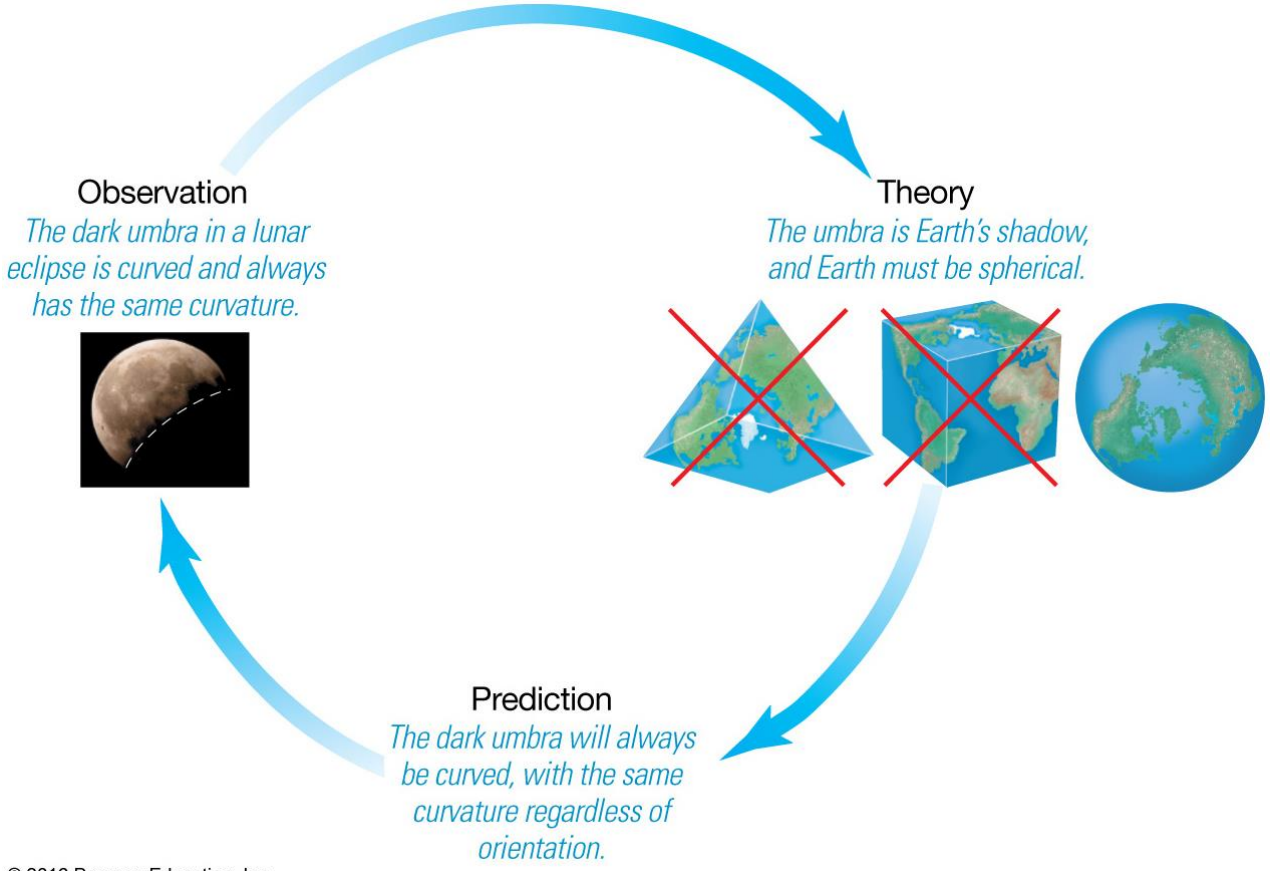
Conditions for Eclipse

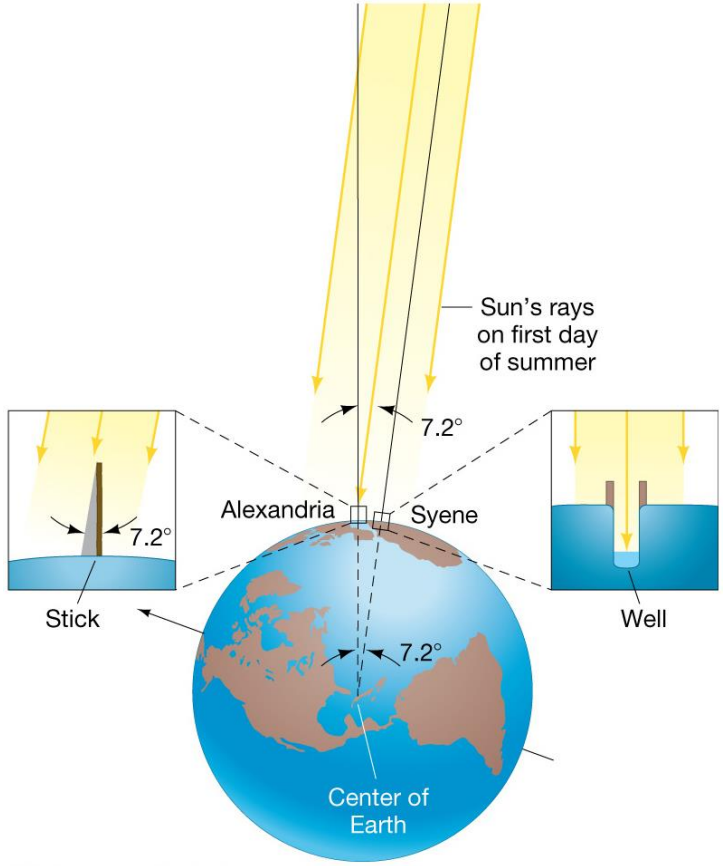


Frequencies of Eclipses

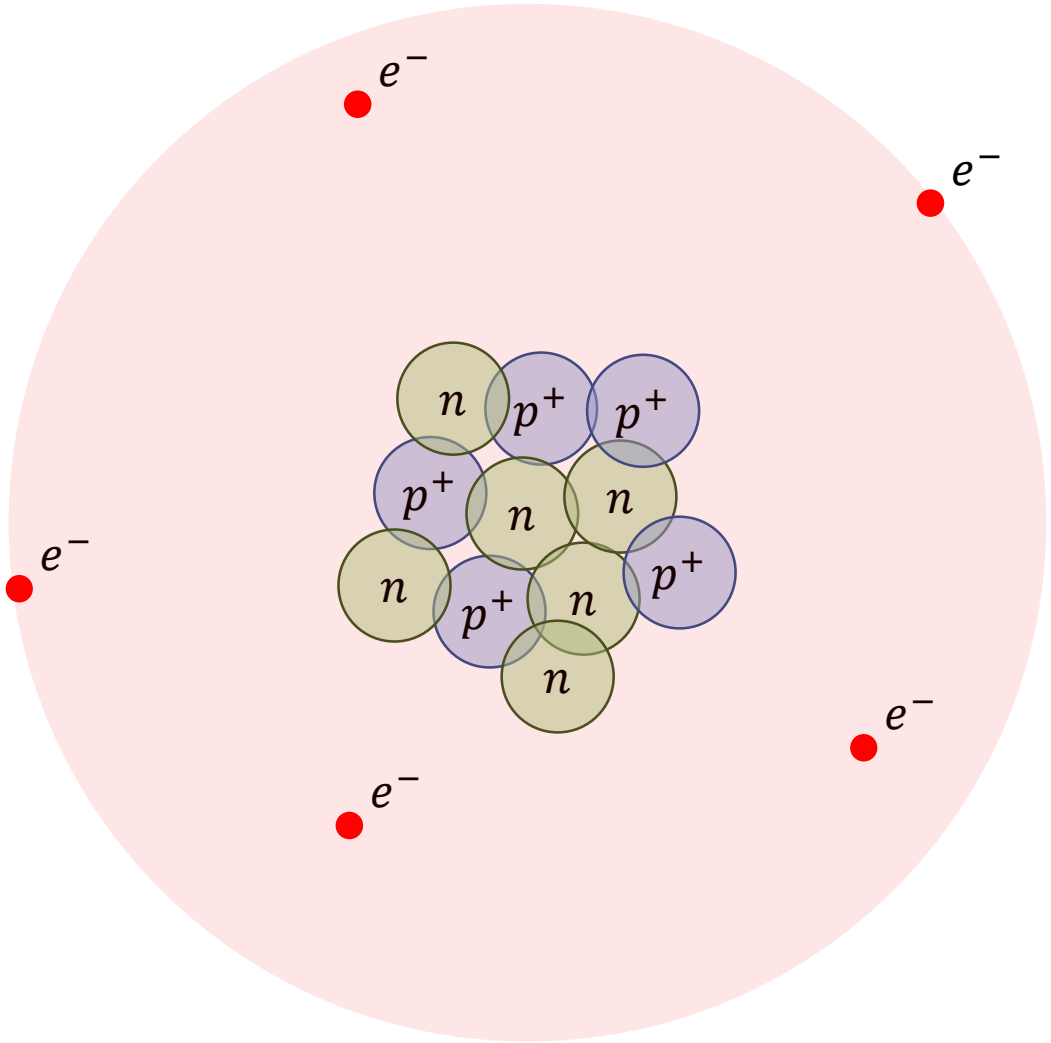
- 2 – 5 solar eclipses occur per year of various types.
  - ~240 per century.
- Total solar eclipses occur somewhere on Earth every ~18mo.
  - But only recur at a given location every ~400yr.
- The moon actually gets further from the Earth each year (3.8 cm/yr) and the sun gets brighter (grows in angular size), so between 650M – 1.4B yr from now, total eclipse will be impossible.

Scientific Method

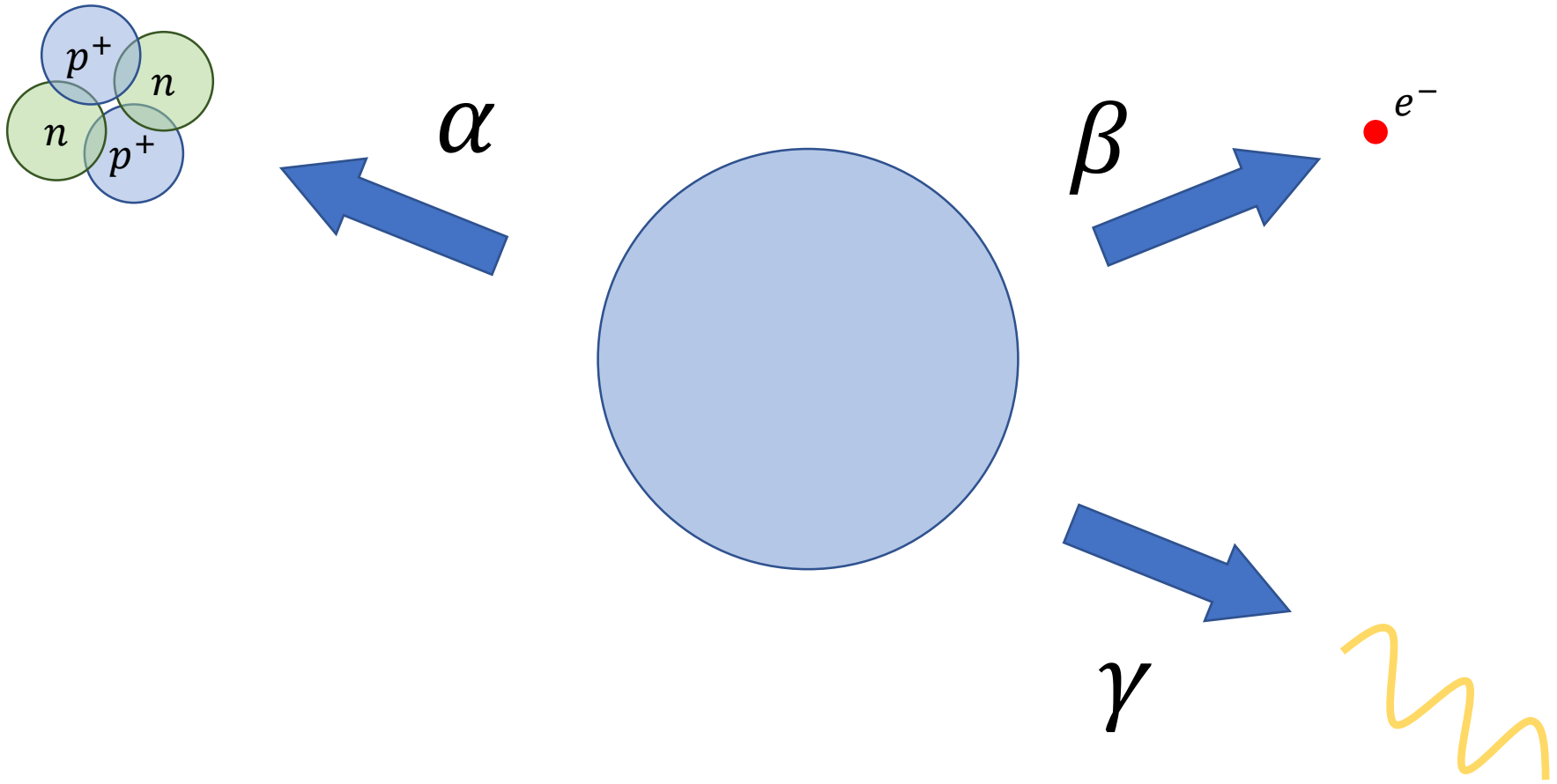




Atoms



Types of Radiation



Mass-Energy Equivalence

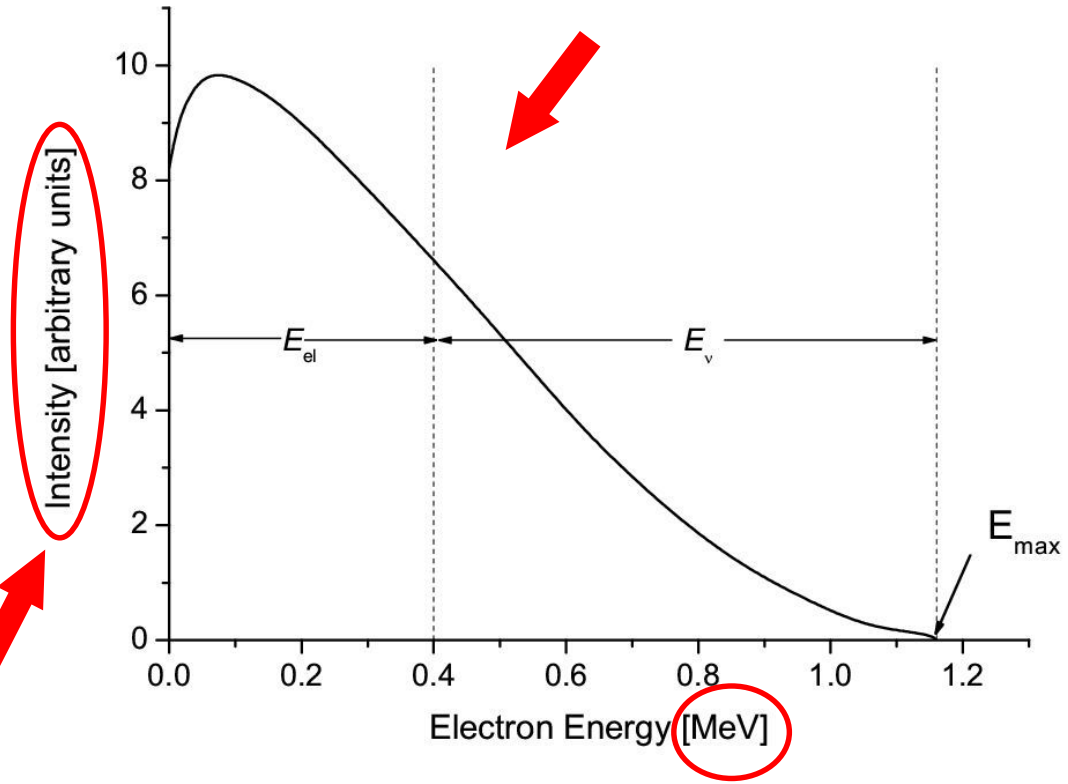
$$E = mc^2$$

β-Decay

$$n \rightarrow p^+ + e^-$$

$$\Delta E = 1.252 \times 10^{-13}\ \text{J}$$

There must be a *third* particle here



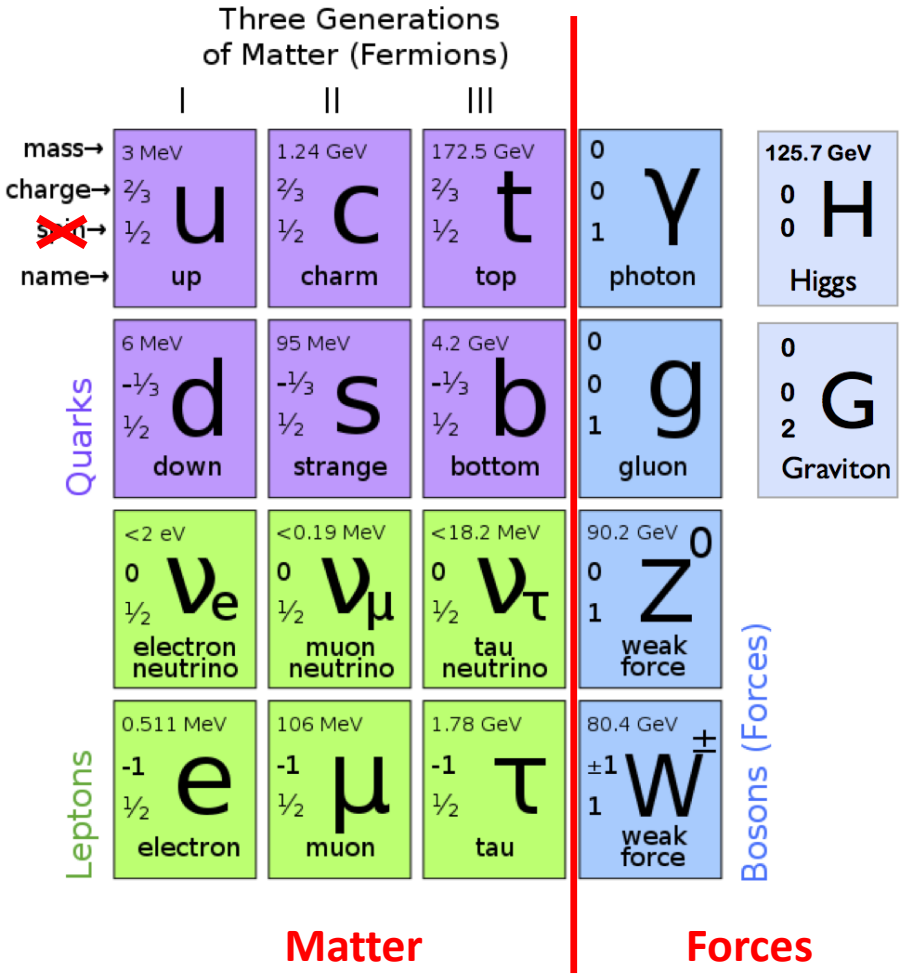
Number of electrons

Weird energy unit, $1\ \text{MeV} = 1.62 \times 10^{-19}$ J

Elementary Particles

2 Types of Matter:

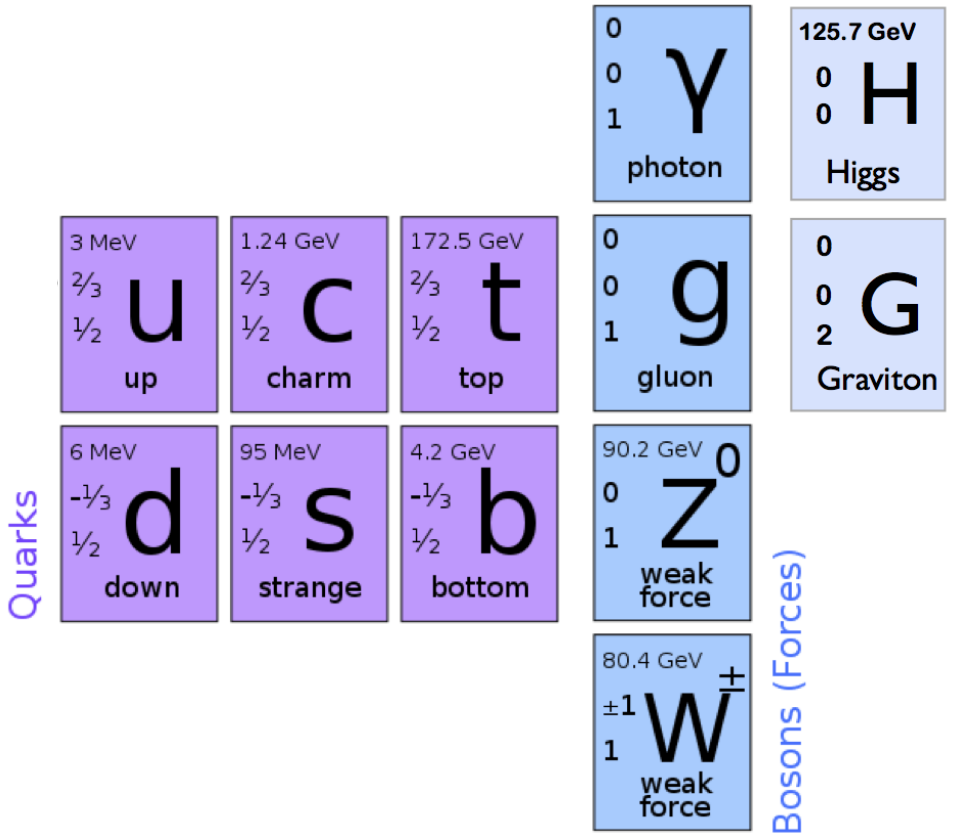
- Quarks
- Leptons



4 Fundamental Forces:

- Strong Force
- Weak Force
- Electromagnetic Force
- Gravity

Quarks

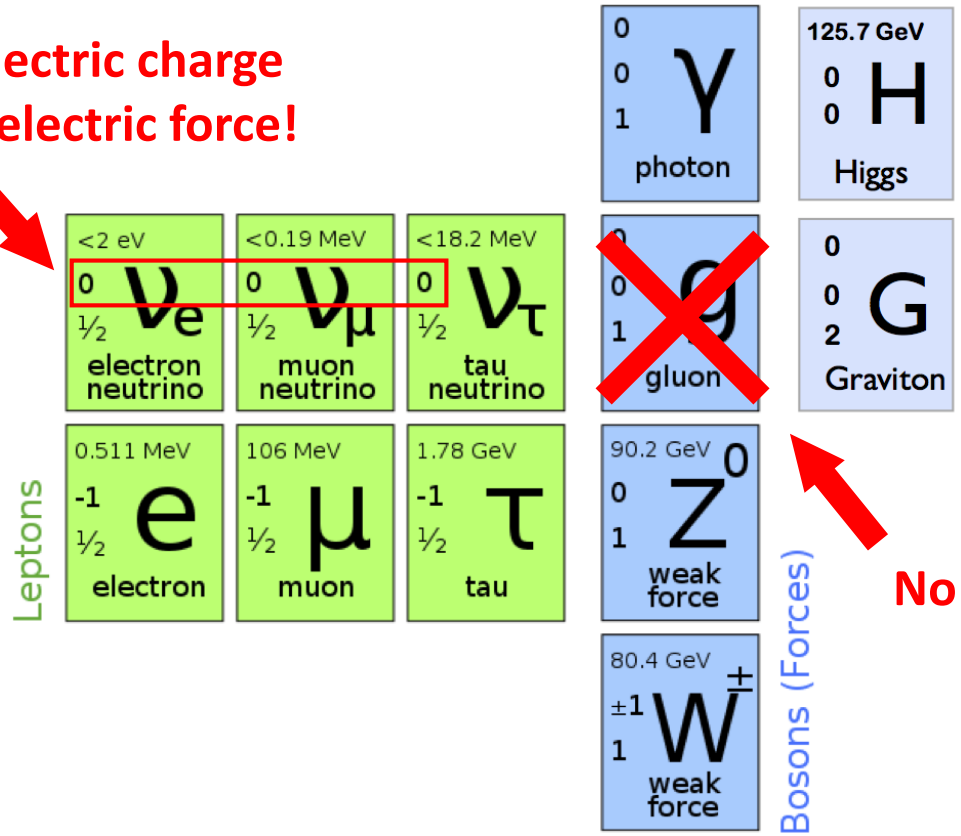


$$u + u + d + (\text{gluons}) \rightarrow p^{+}$$

$$u + d + d + (\text{gluons}) \rightarrow n$$

Leptons

No electric charge
= no electric force!



No strong force!

$$e^- + p^+ + (\text{photon}) \rightarrow \text{H}$$

$$n \rightarrow p^+ + e^- + \bar{\nu}_e$$

Chapter 2:
Light and Telescopes

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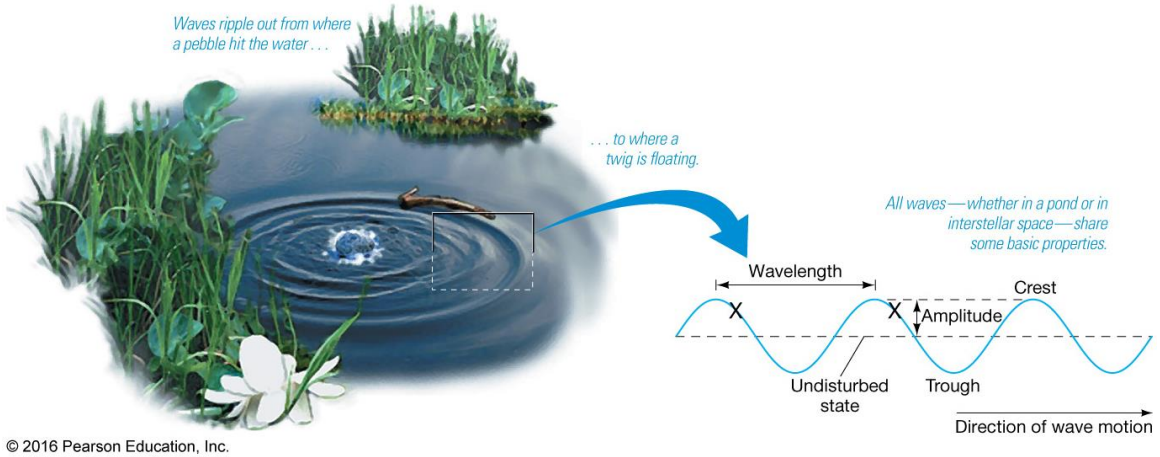
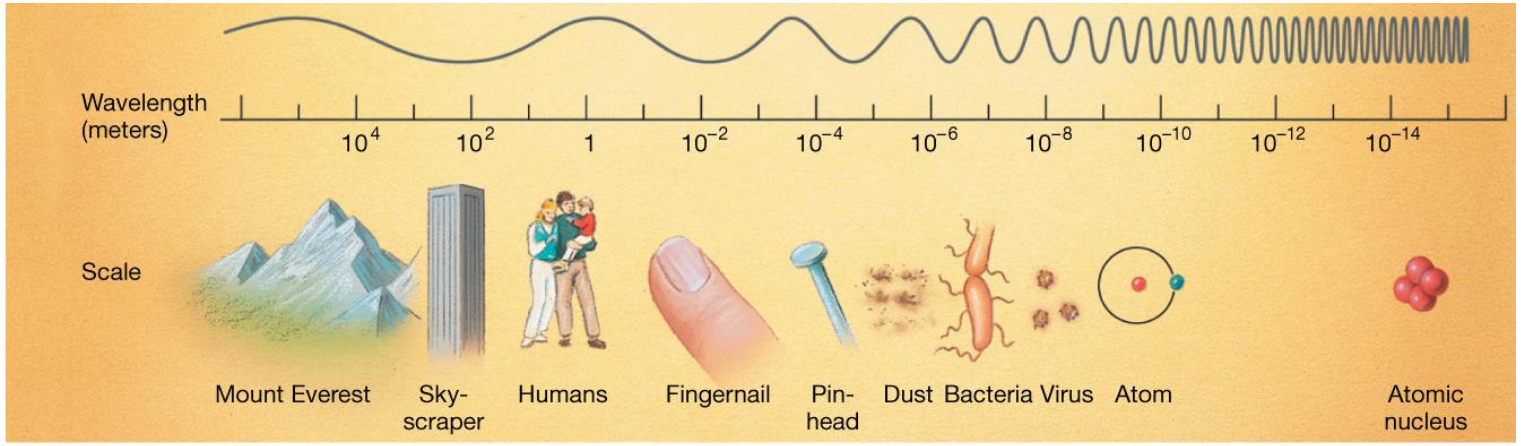
Electromagnetic Radiation

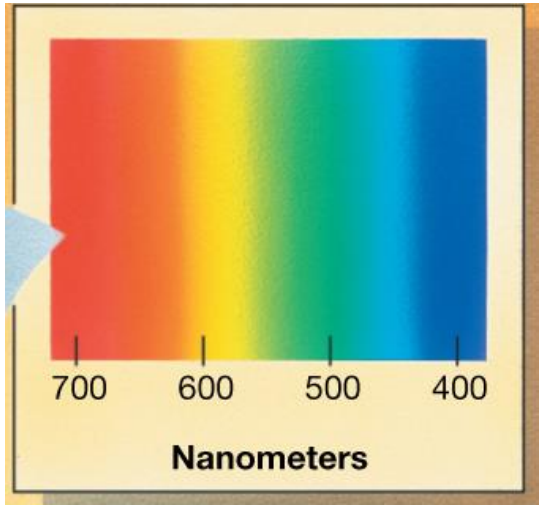


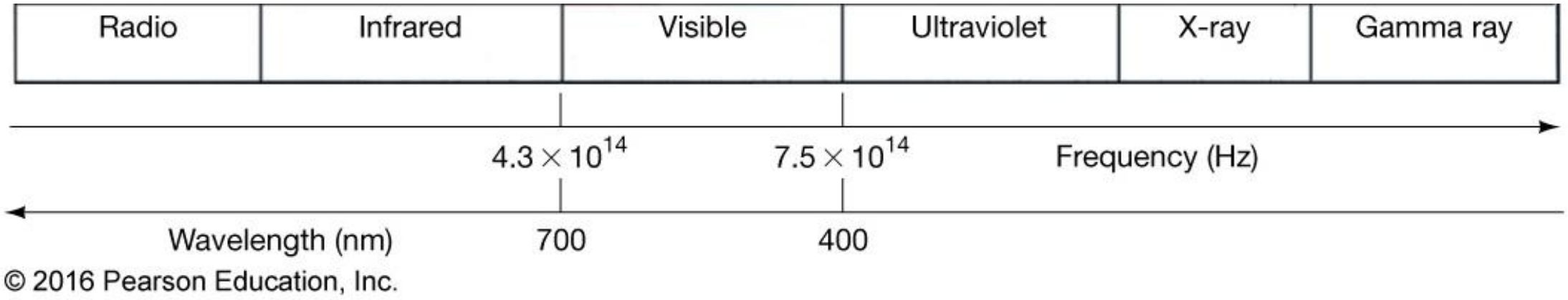
$$v = \lambda f$$

$$E = hf$$

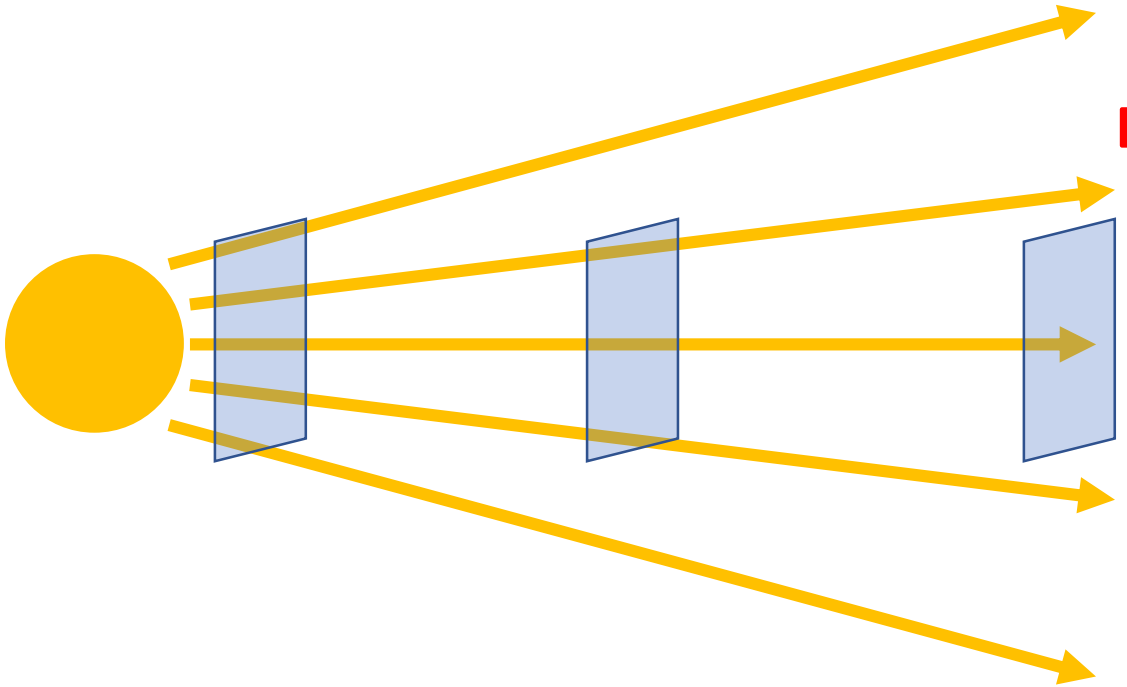


Visible Light Spectrum





Isotropic Emission



Brightness *decreases* with distance (squared)

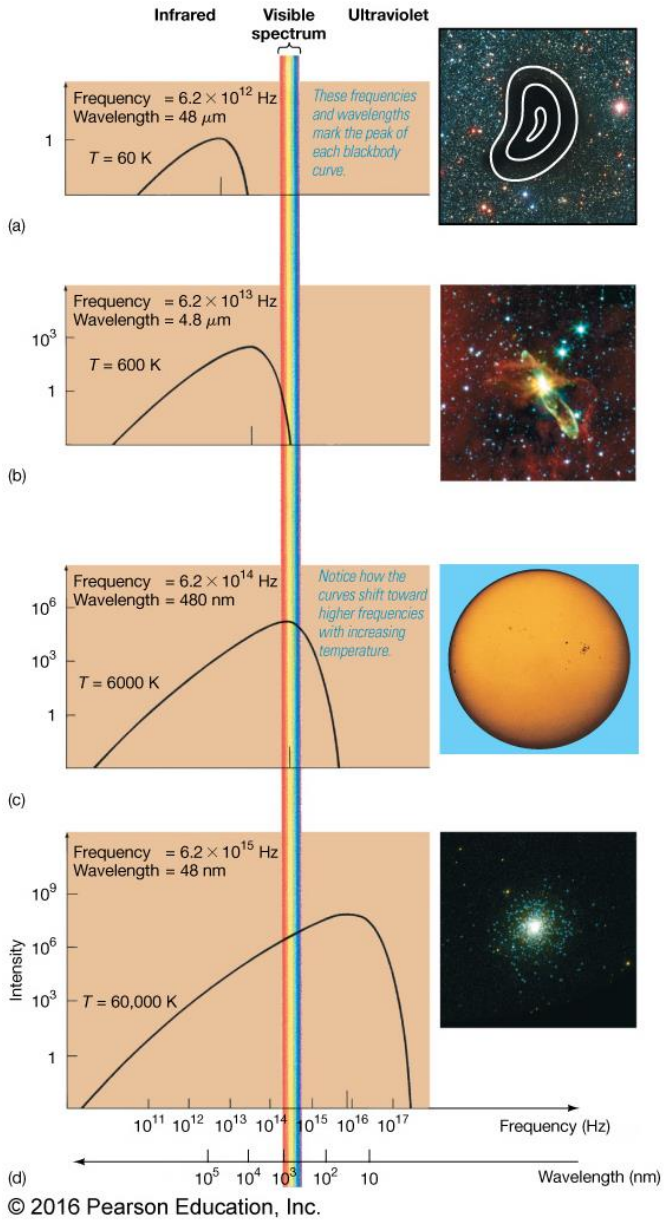
Blackbody Radiation

Stefan-Boltzmann Law:

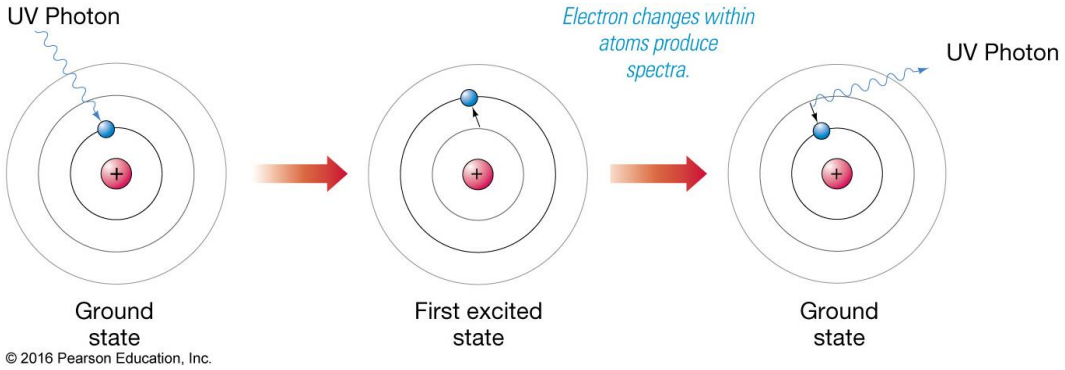
$$I = \sigma T^4$$

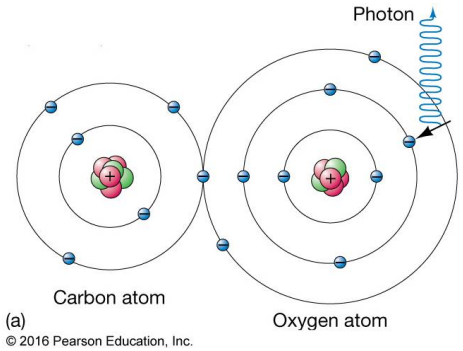
Wein's Law:

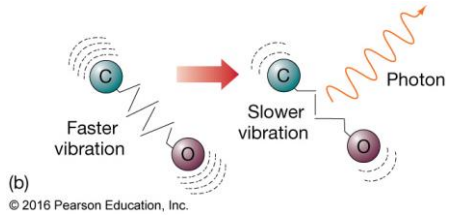
$$\lambda_{max} = \frac{b}{T}$$

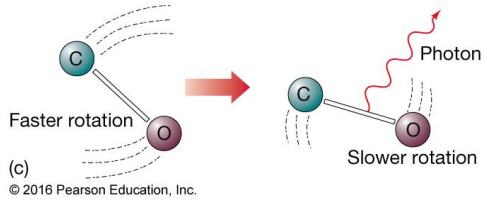


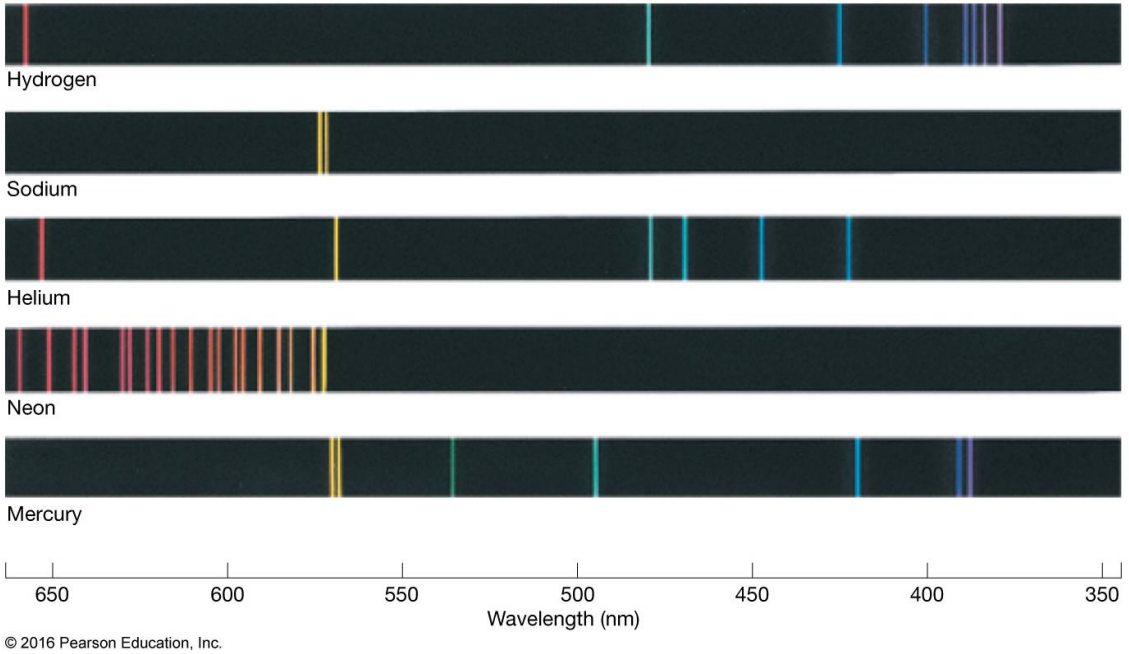
Emission and Absorption of Photons



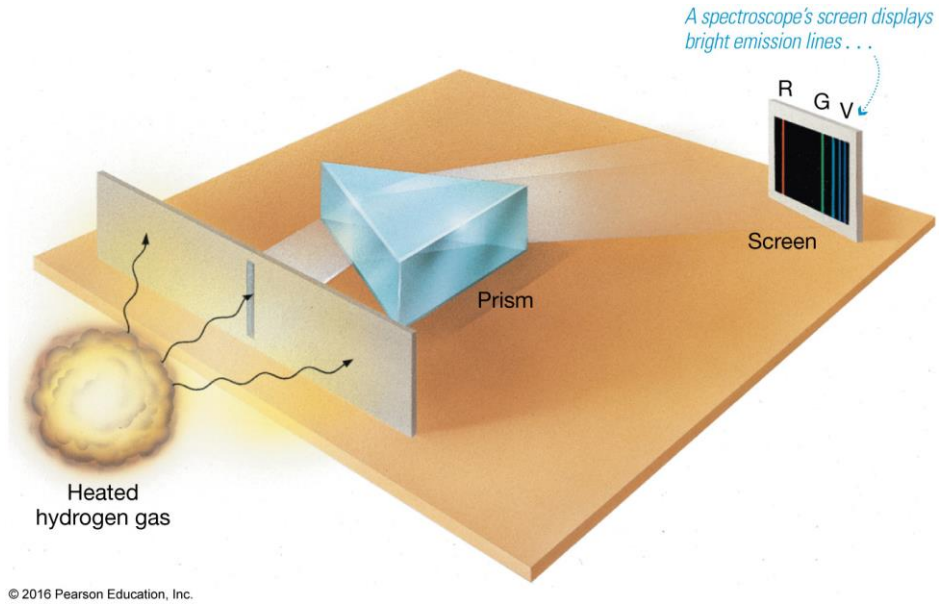


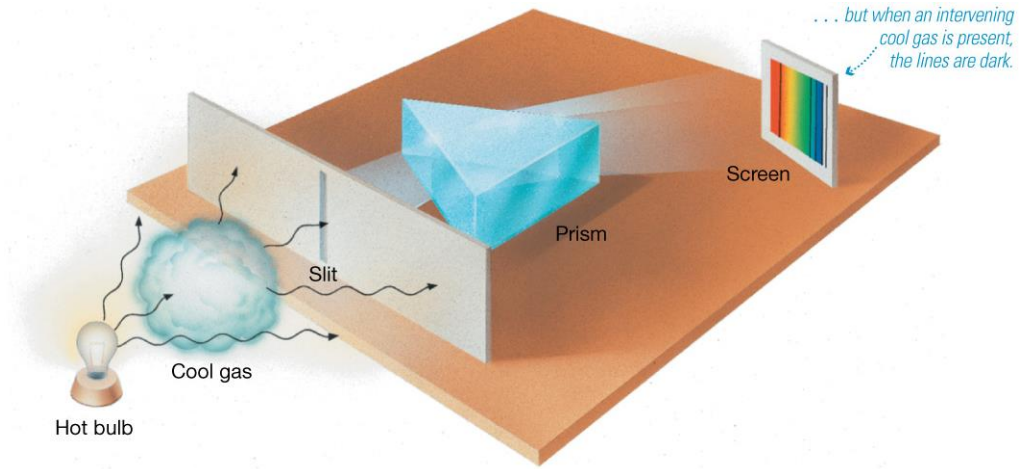




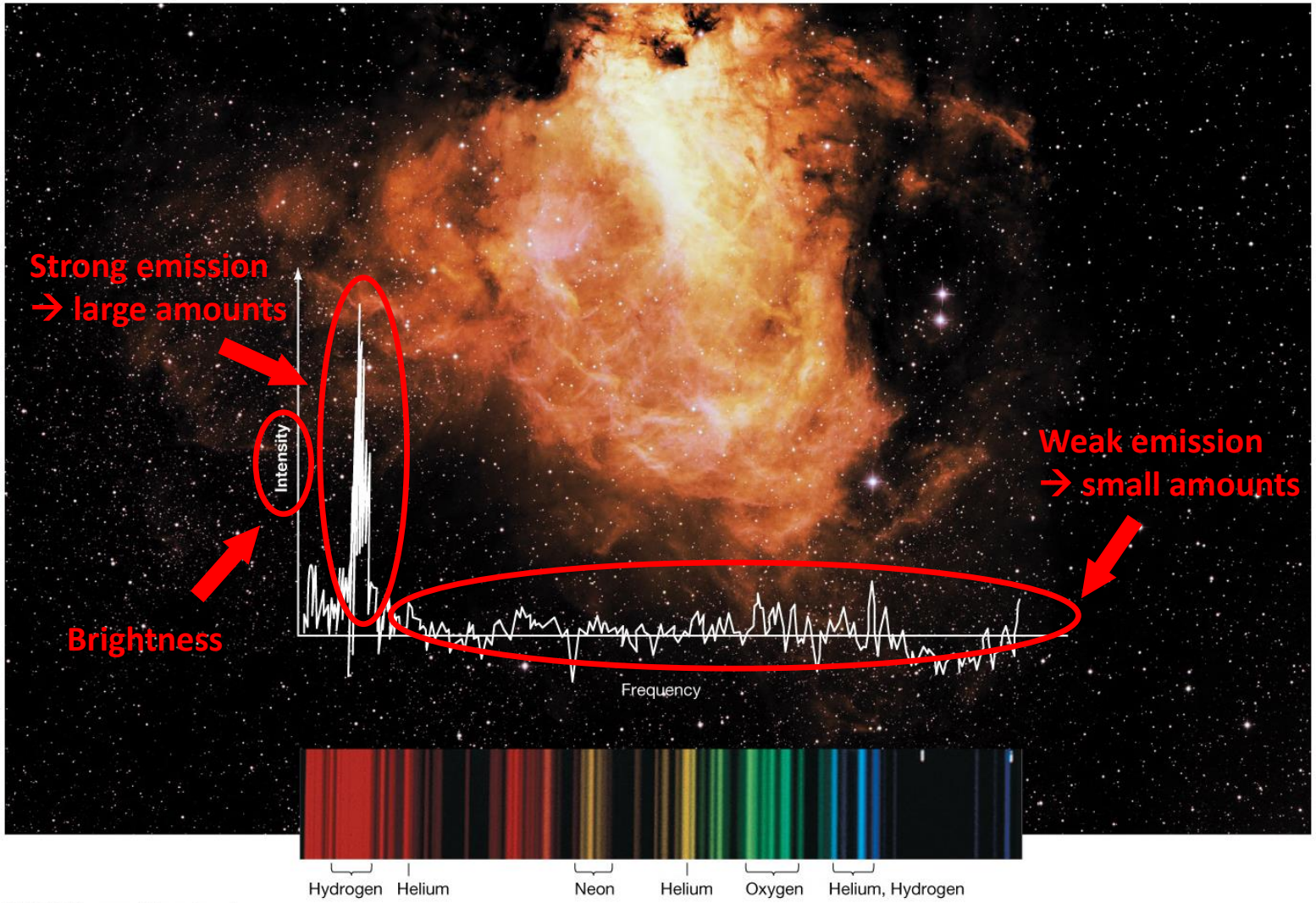


Spectroscopy

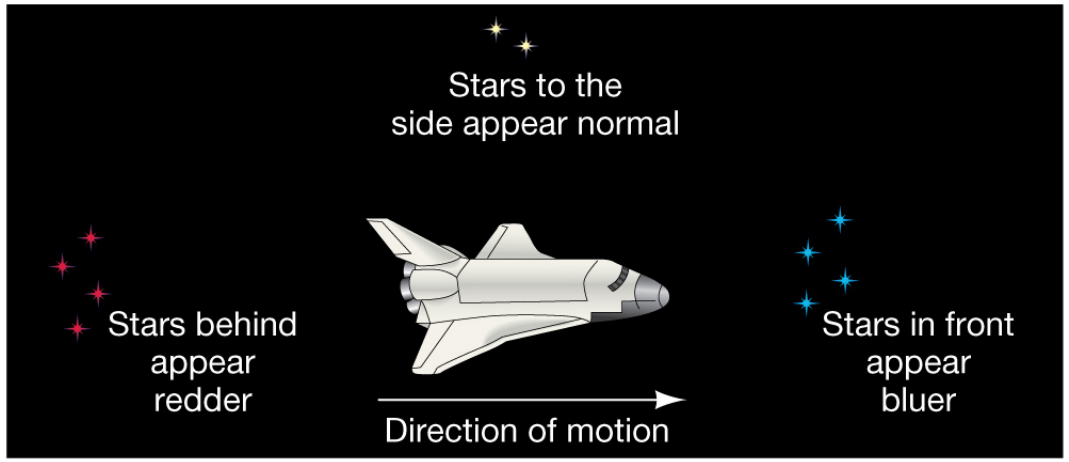




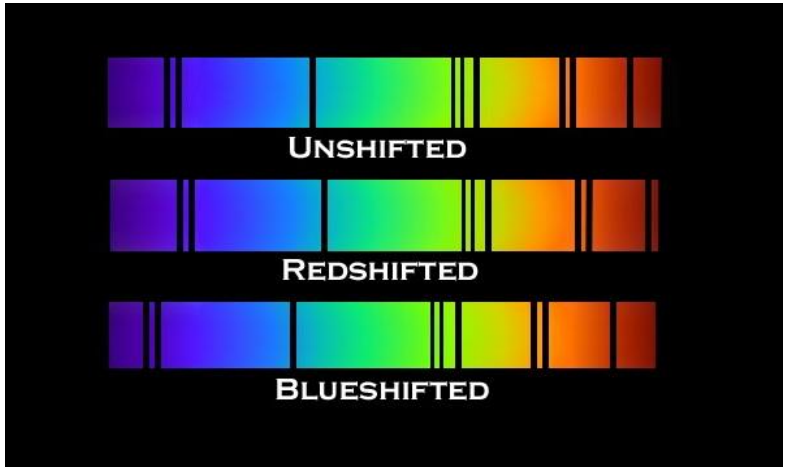
Detecting Chemical Elements



Doppler Effect

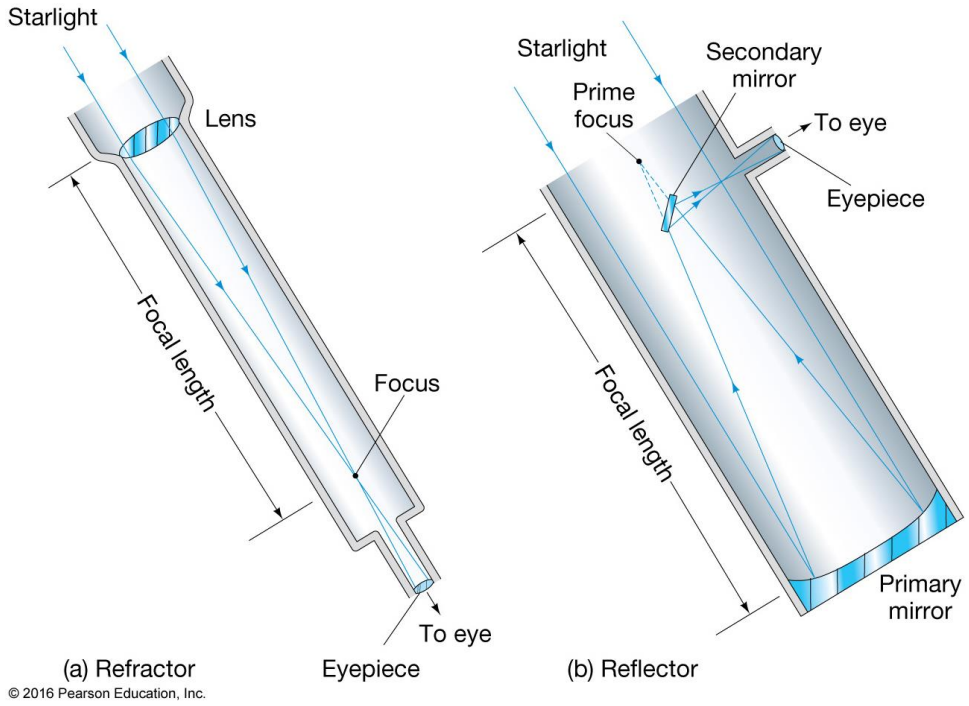


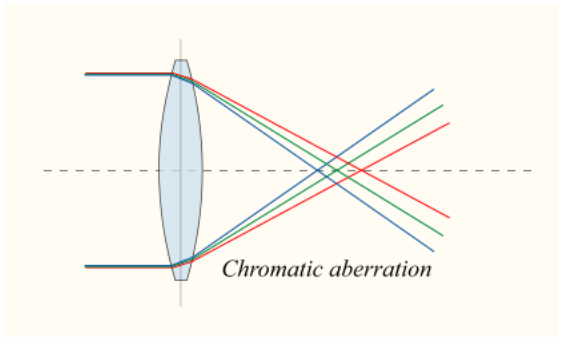
(a)

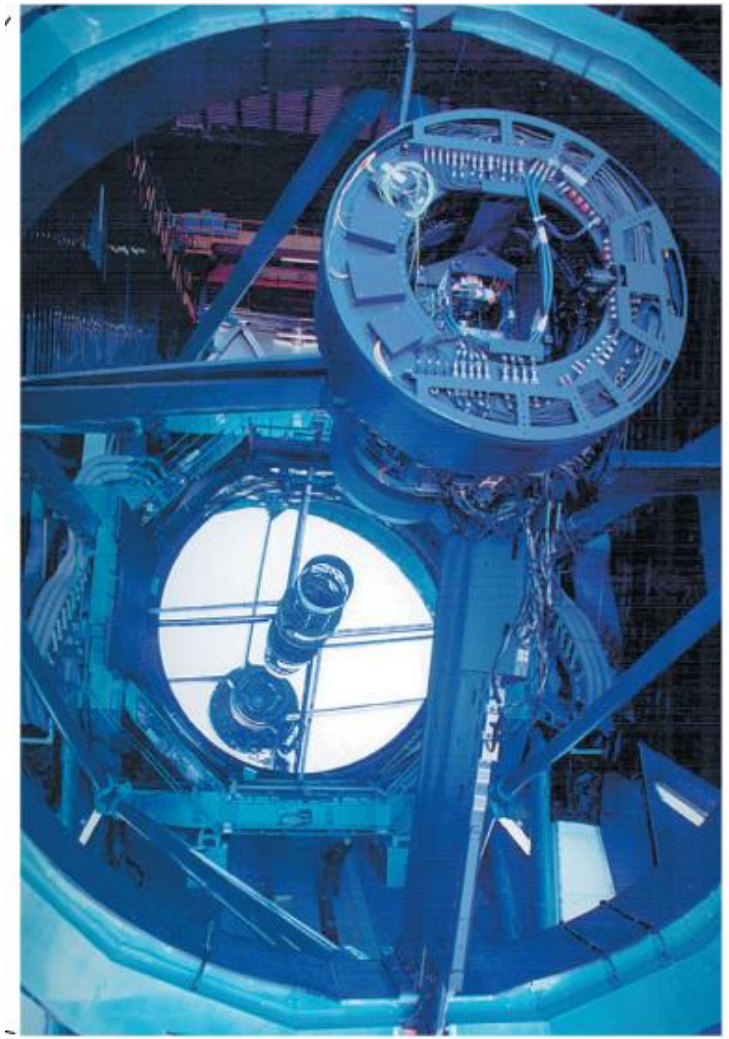


$$\Delta f = \frac{v}{c} f_0$$

Optical Astronomy

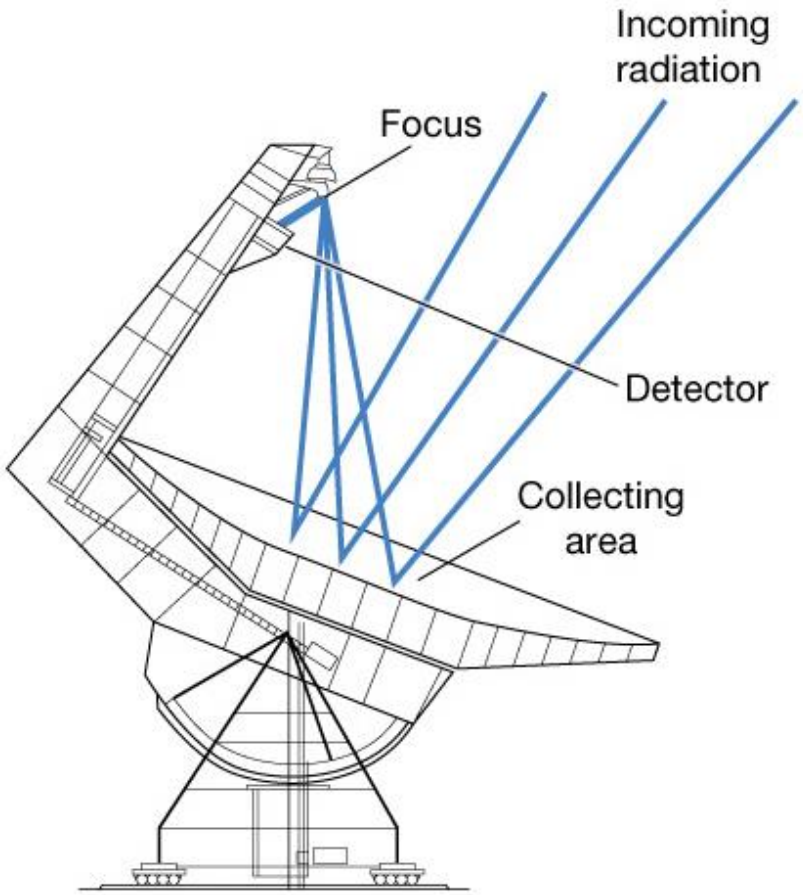






An inside look at the Subaru telescope

Radio Astronomy

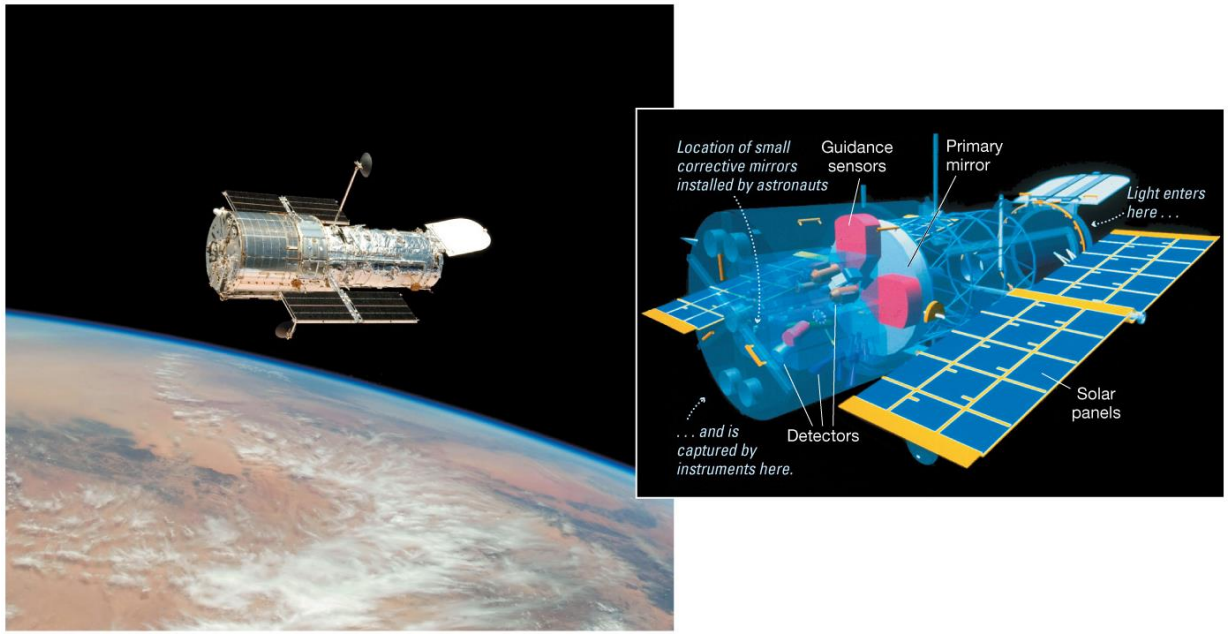


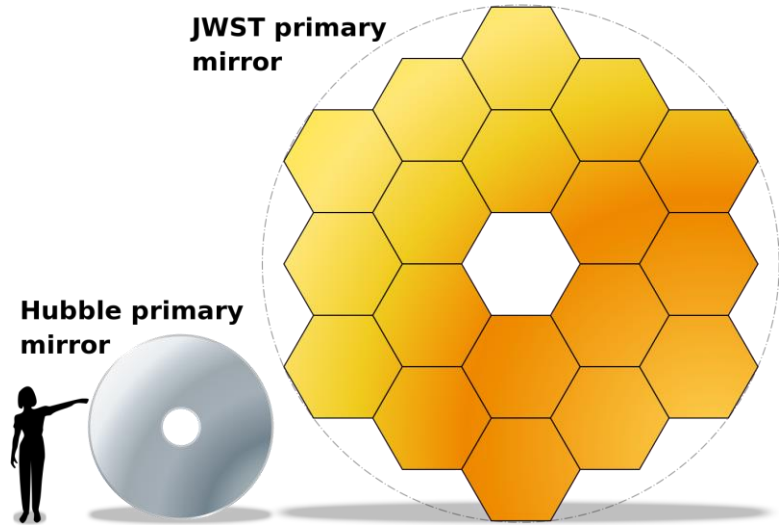
IR and UV Astronomy

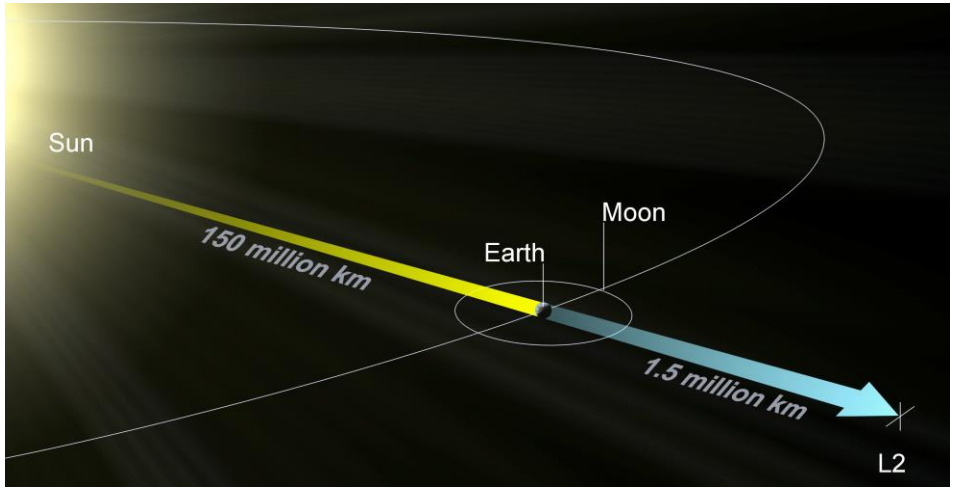
(a)

(b)

Space-Based Telescopes







Chapter 3:
The Solar System

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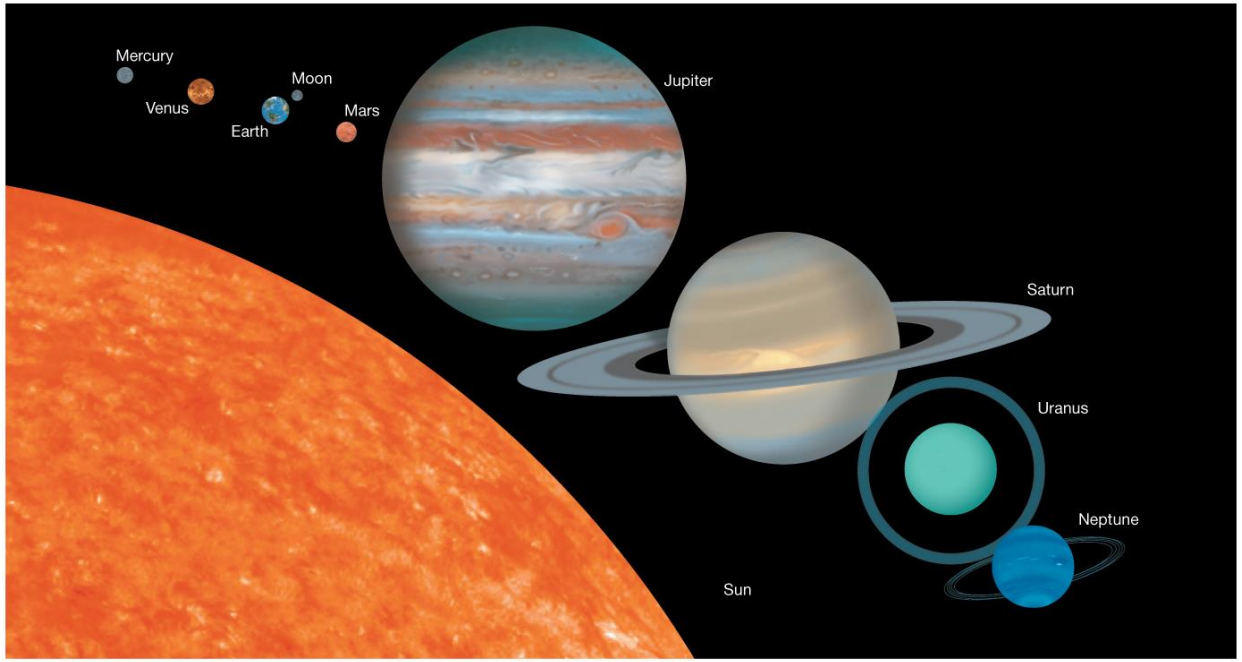
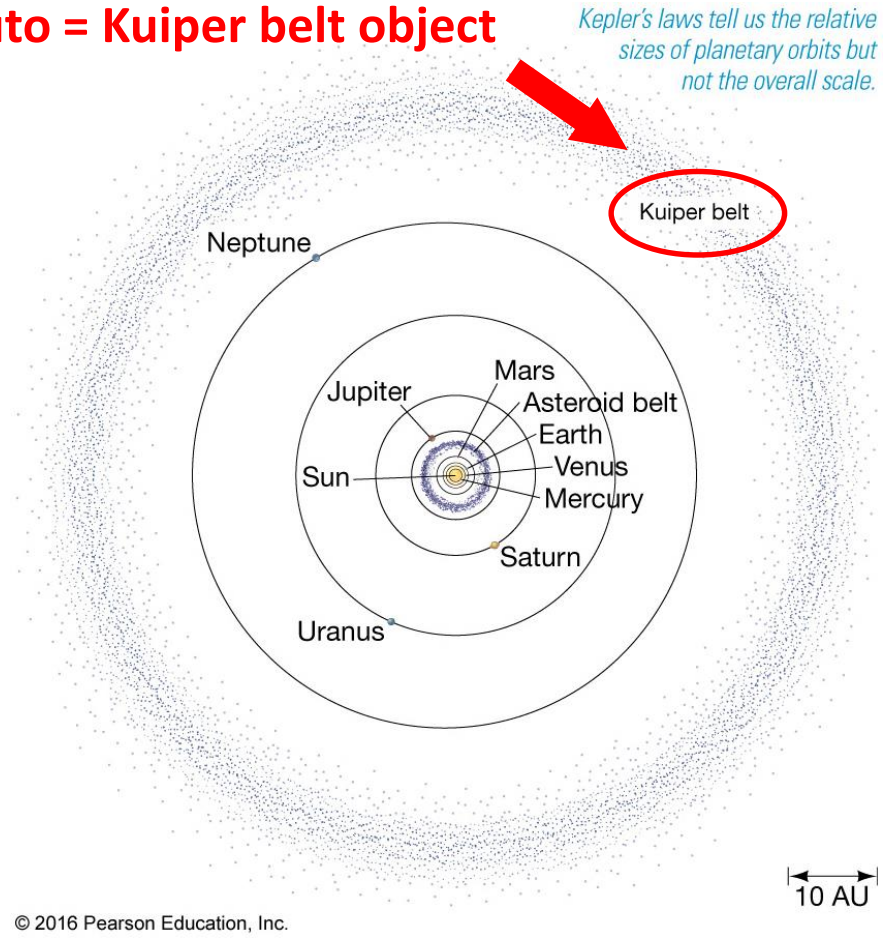
AST 1002

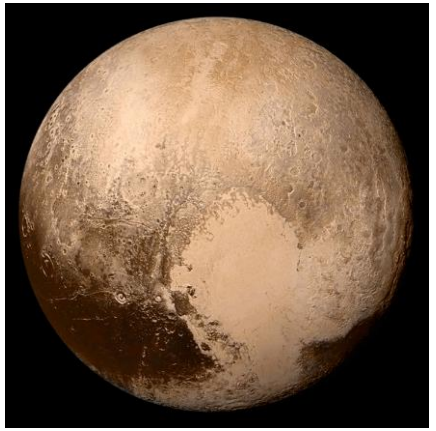
The Planets

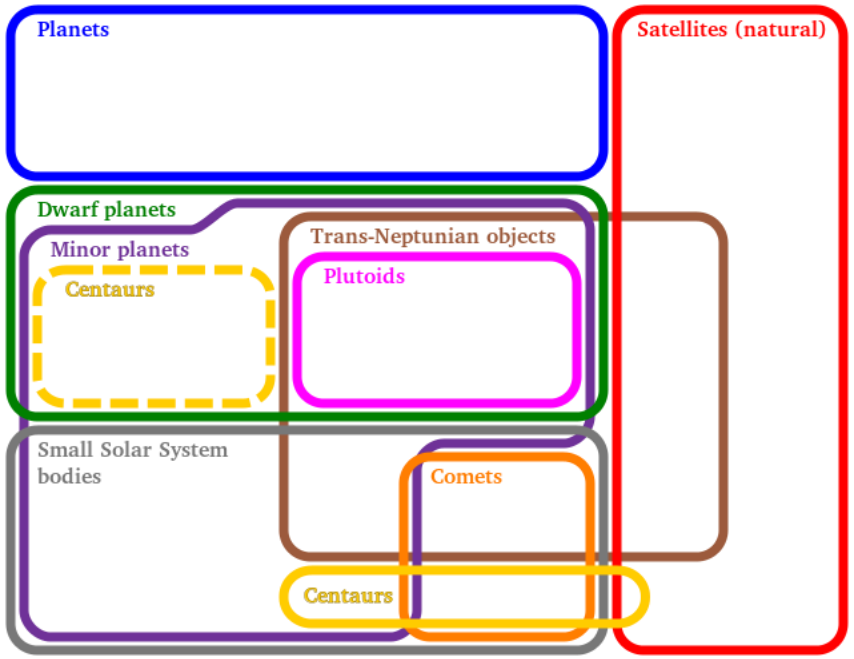


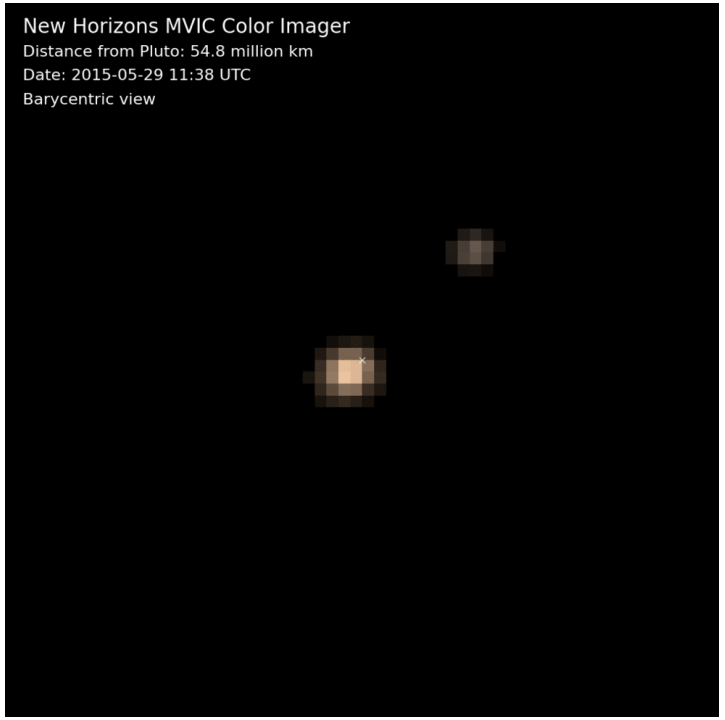
Pluto = Kuiper belt object



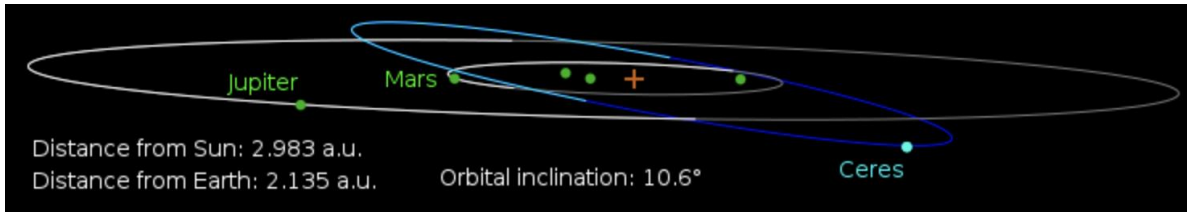
Pluto: Not a Planet (Unfortunately)

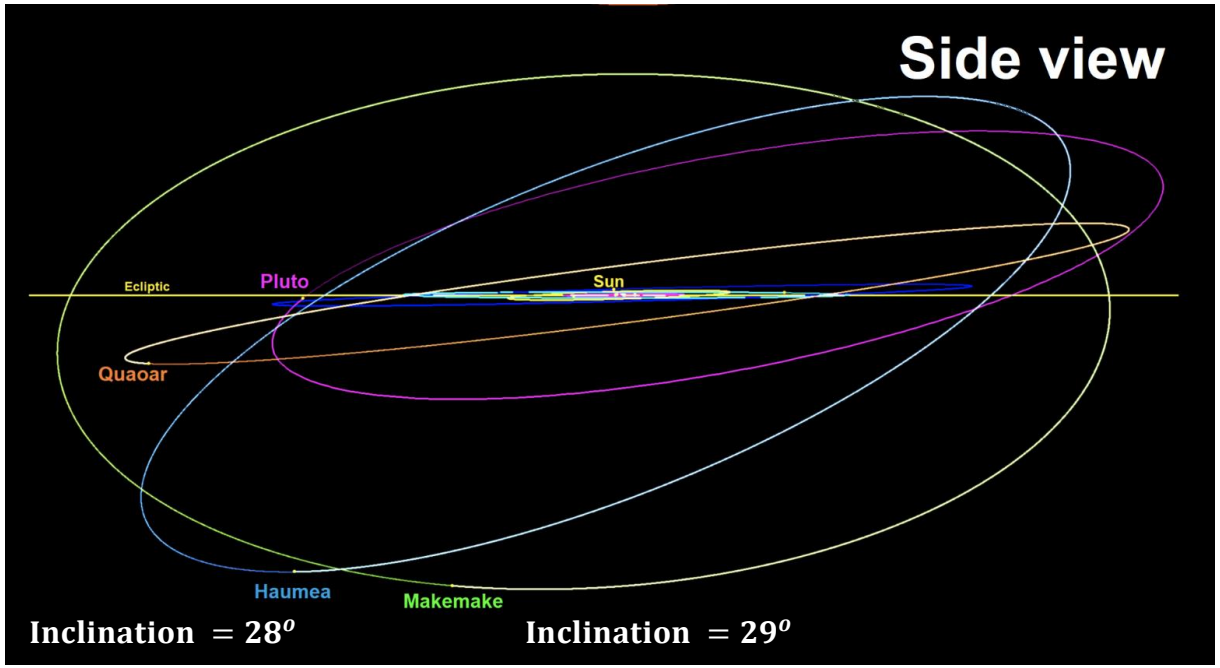


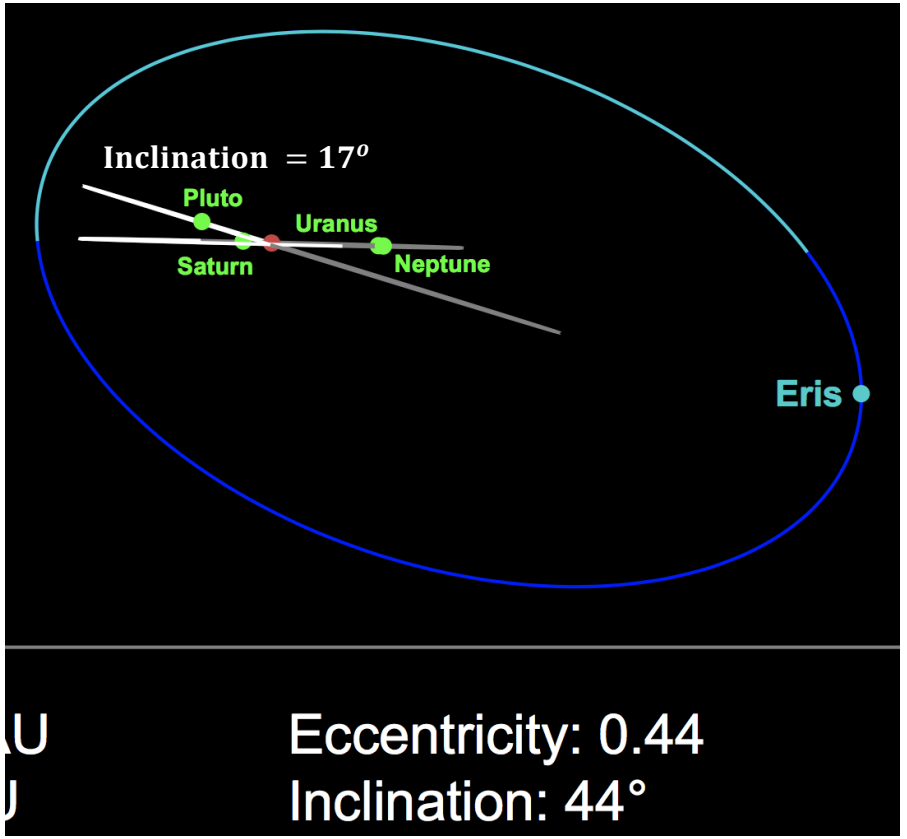




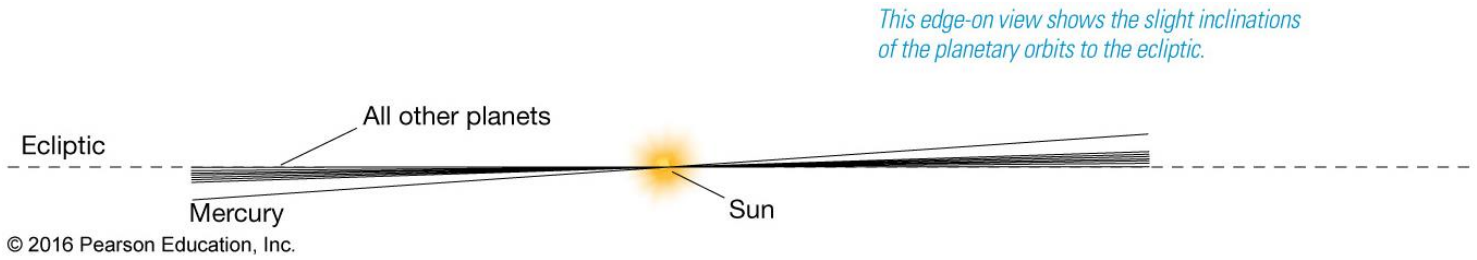
Dwarf Planet Orbits

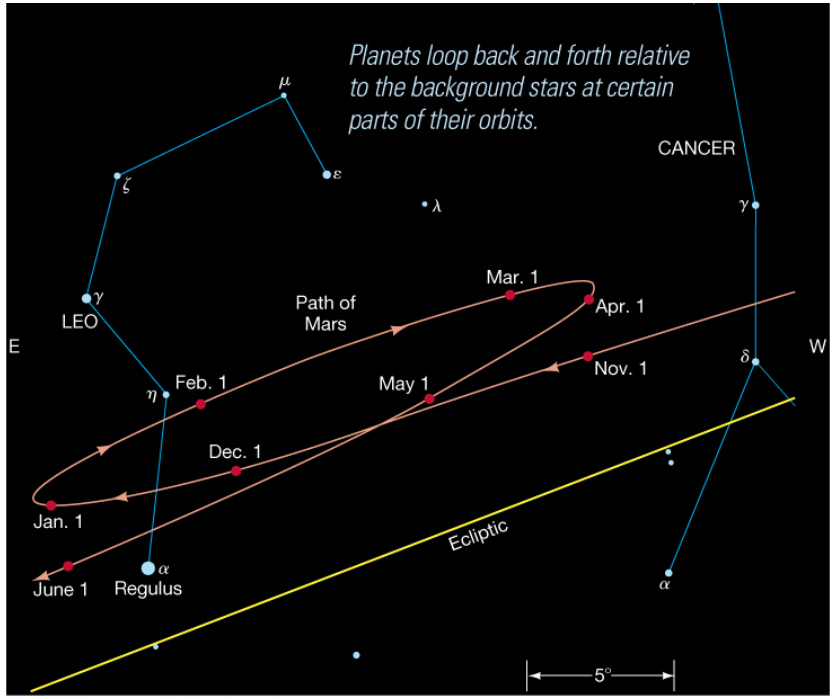






Features of Planets





Elliptical Orbits

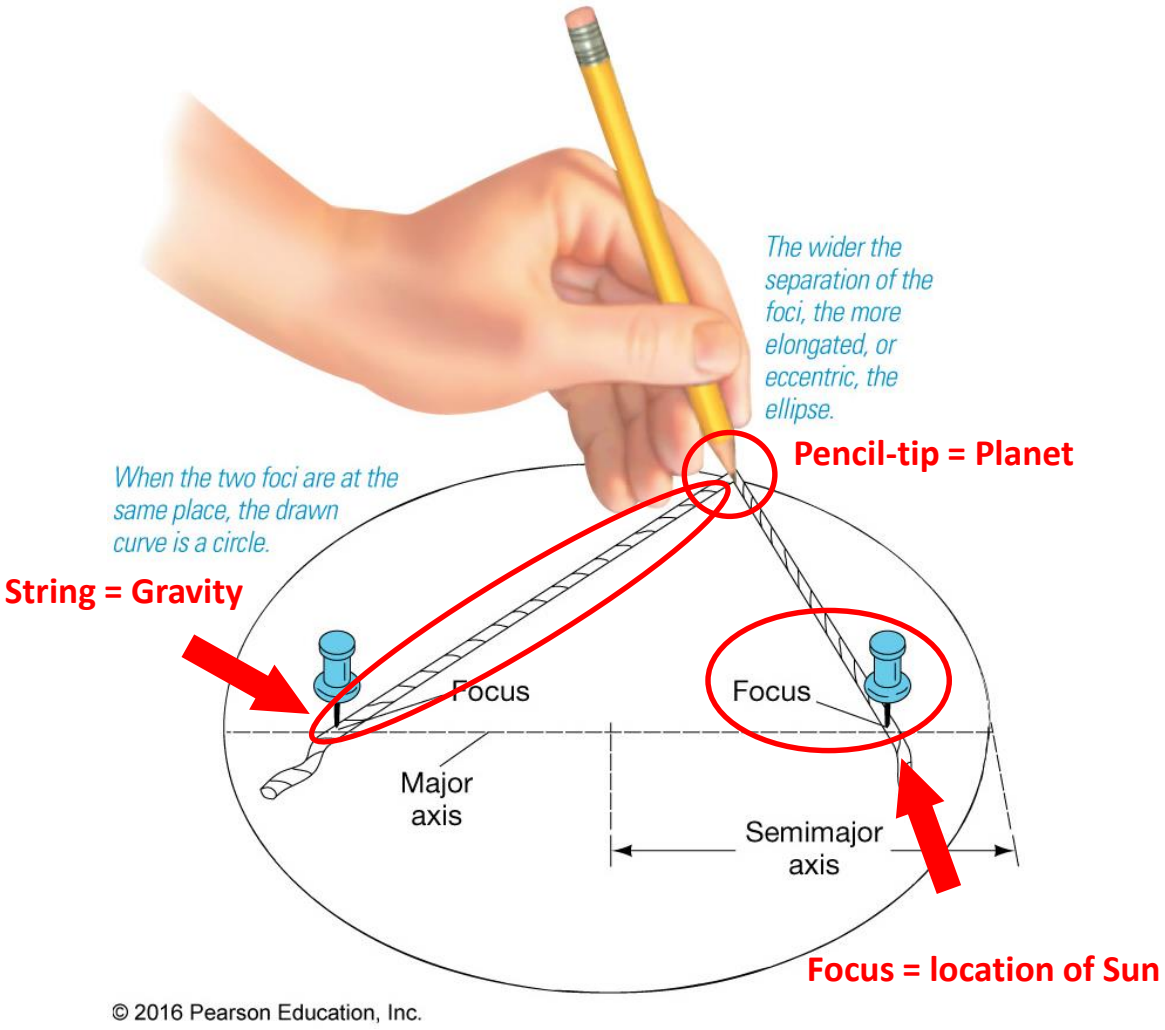
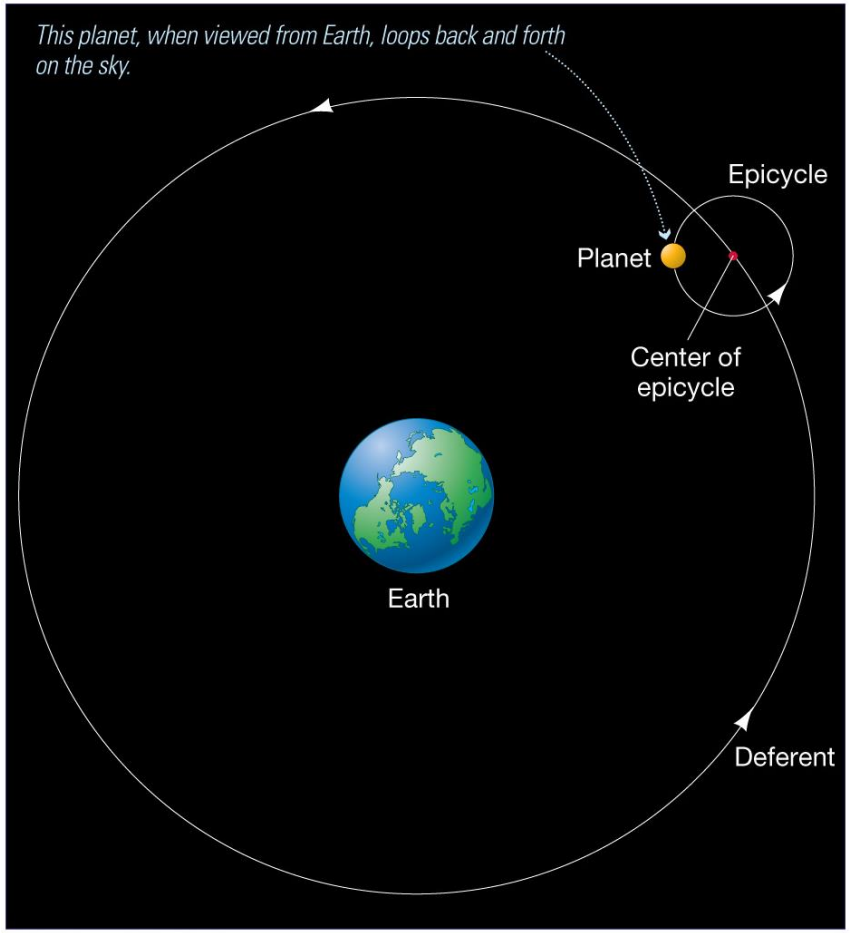


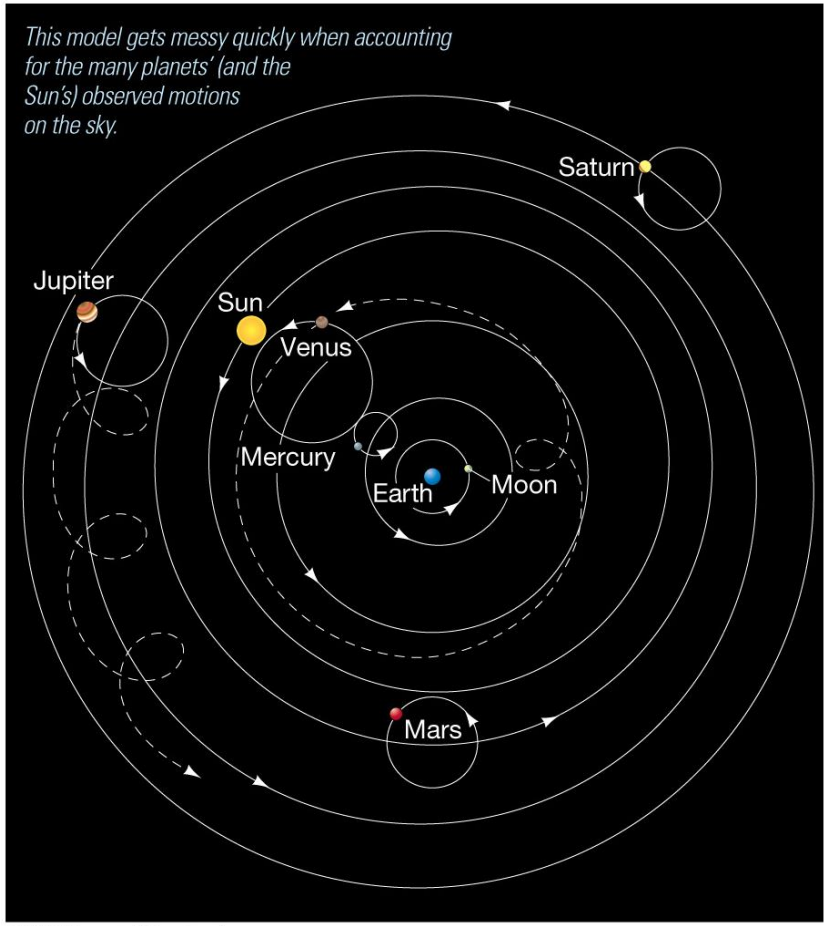
Table 3.1 Properties of Some Solar System Objects

Object	Orbital semimajor axis (AU)	Orbital period (Earth years)	Orbital eccentricity
Mercury	0.39	0.24	0.206
Venus	0.72	0.62	0.007
Earth	1.00	1.0	0.017
Mars	1.52	1.9	0.093
Jupiter	5.2	11.9	0.048
Saturn	9.5	29.4	0.054
Uranus	19.2	84	0.047
Neptune	30.1	164	0.009
Sun	—	—	—

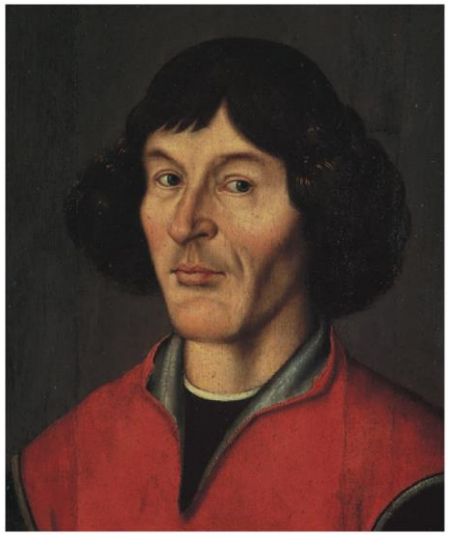
$$e = \sqrt{1 - \frac{b^2}{a^2}}$$

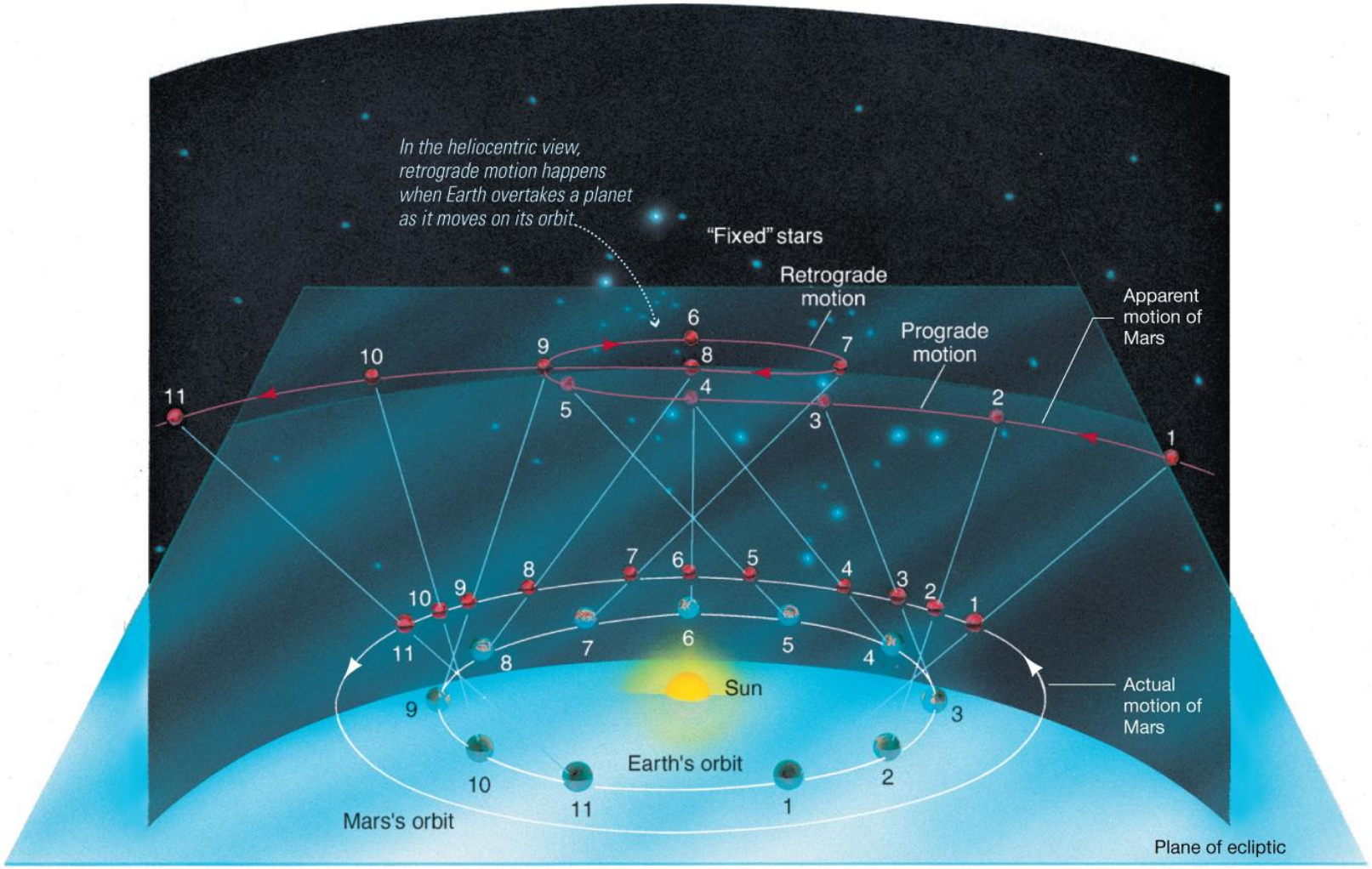
Ptolemaic Geocentrism



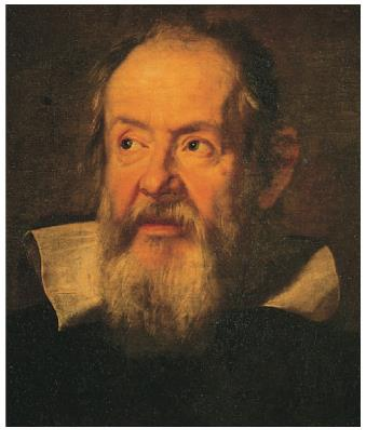


Heliocentrism (Copernicus)

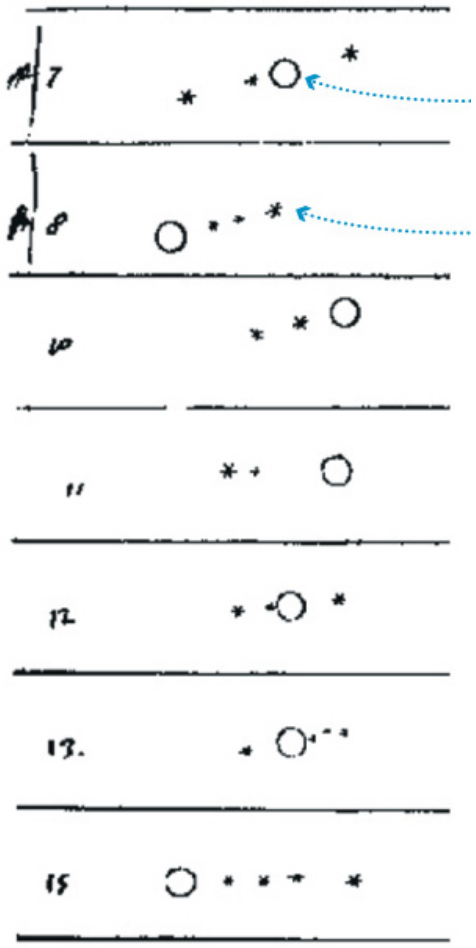




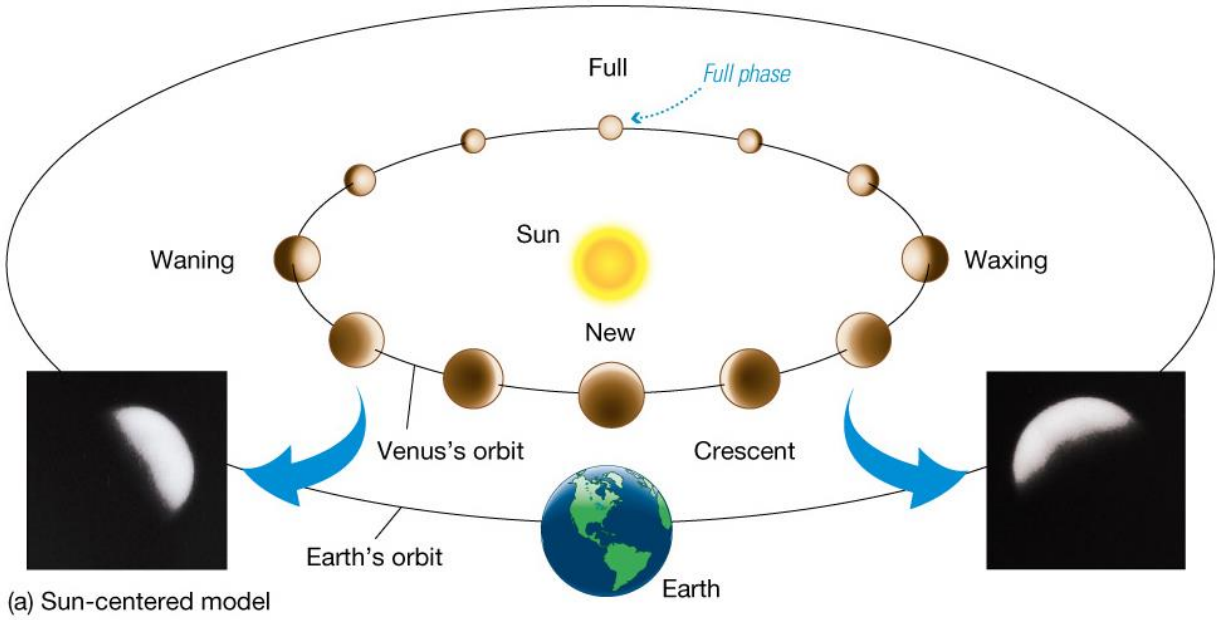
Heliocentrism (Galileo)



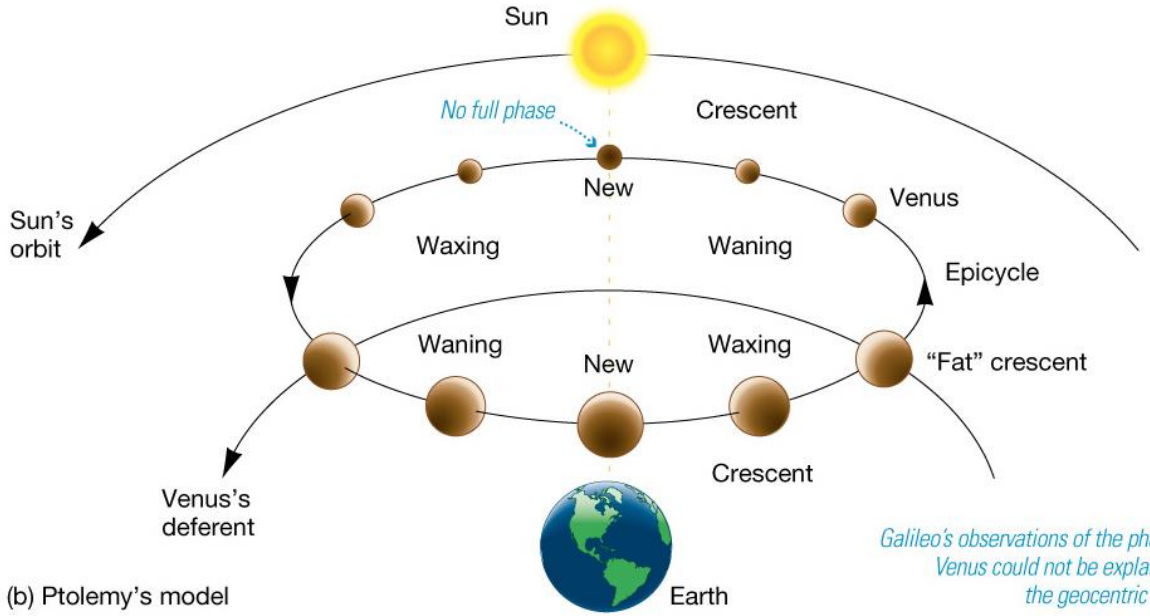
(a)



(c)



(a) Sun-centered model



(b) Ptolemy's model

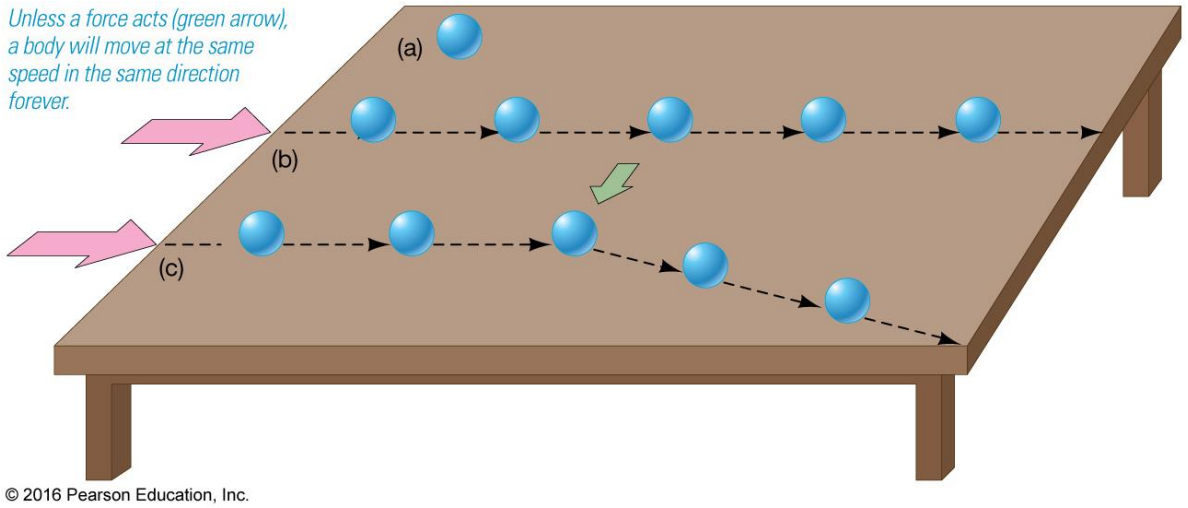
Galileo's observations of the phases of Venus could not be explained by the geocentric model.

Newton's Laws of Motion

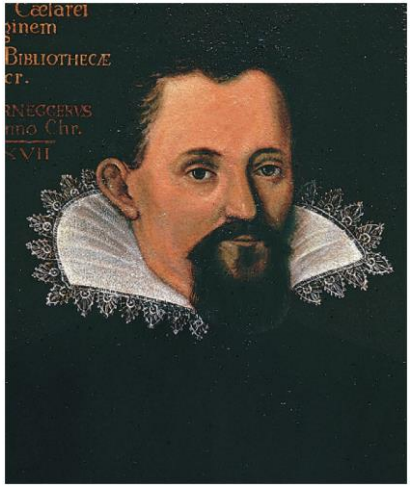
I. An object at rest will remain at rest, and an object in motion will remain in motion, unless acted upon by a force.

II. $F = ma$

III. For every action, there is an equal and opposite reaction.



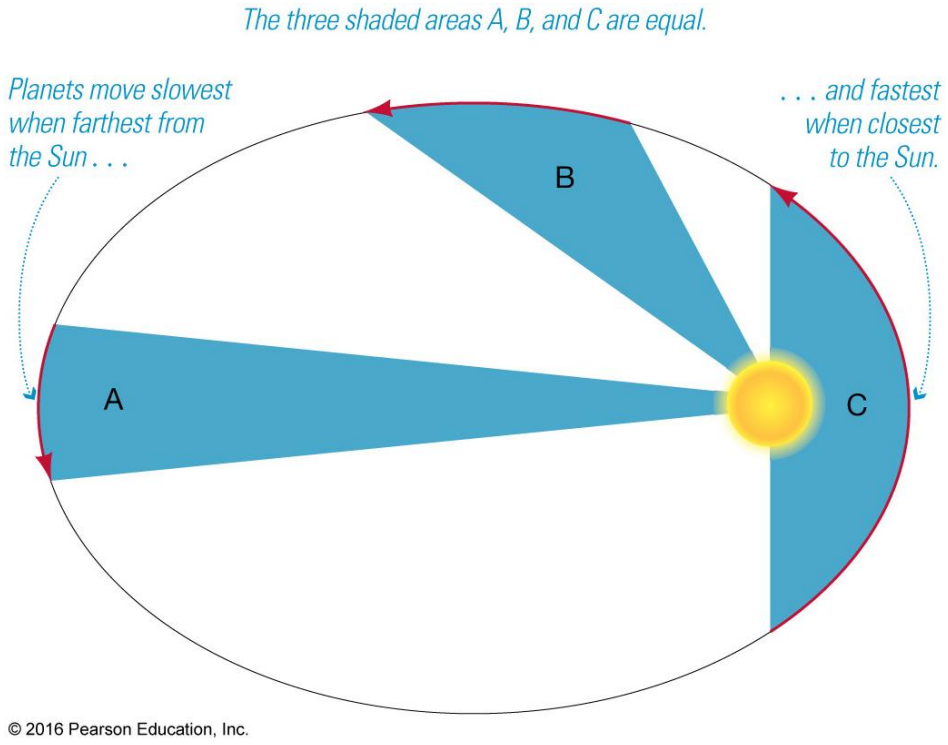
Kepler's Laws of Planetary Motion



I. Planetary orbits are ellipses

II. A planet covers equal areas in equal times around the ellipse

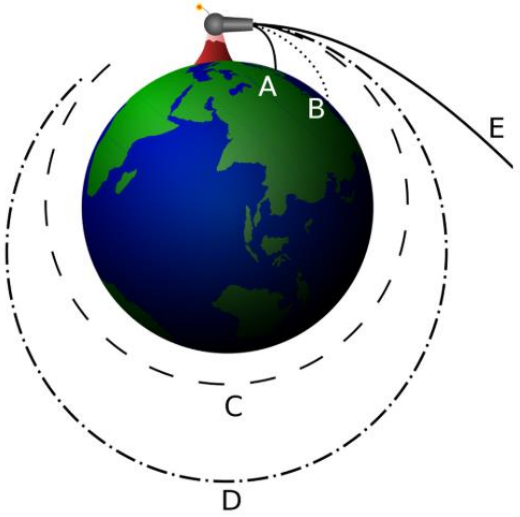
III. $P^2\ (\text{years}) = \dfrac{a^3\ (\text{AU})}{M\ (\text{solar masses})}$

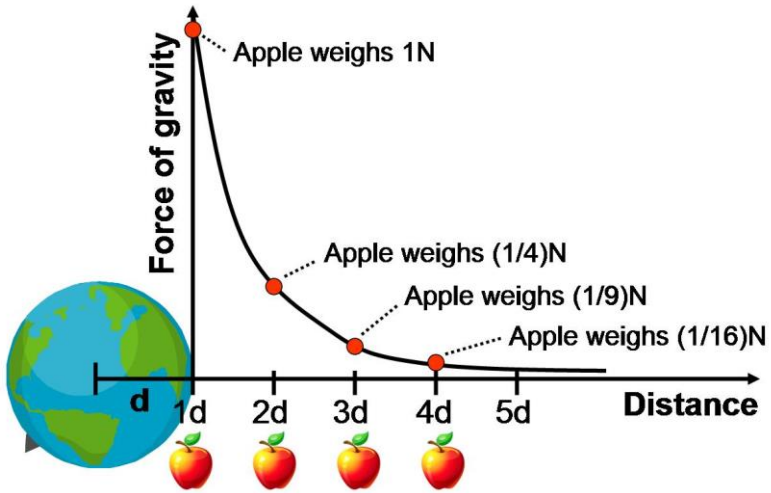


https://en.wikipedia.org/wiki/Newton%27s_cannonball

Newton's Law of Universal Gravitation

- Newton explained Kepler's laws by postulating that the force responsible for apples dropping on Earth and the force responsible for the motion of heavenly bodies are the same force: gravity.
- This is the concept of **universal gravitation**.
- Newton justified his postulate with his famous Cannonball Thought Experiment.
- To properly account for Kepler's laws, the force of gravity must decrease with distance.





Using Kepler's Third Law