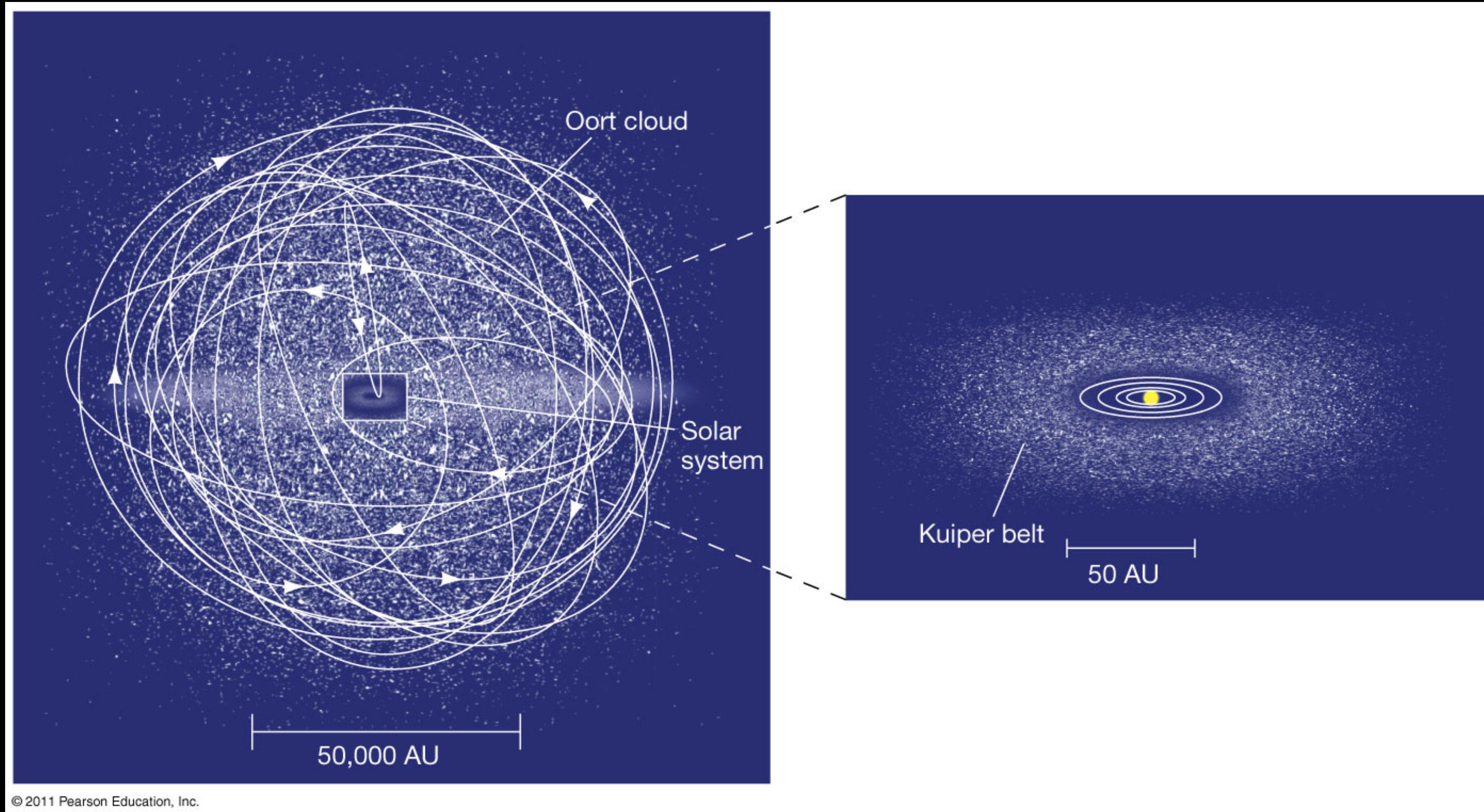


Image: National Observatory of Japan /EOS

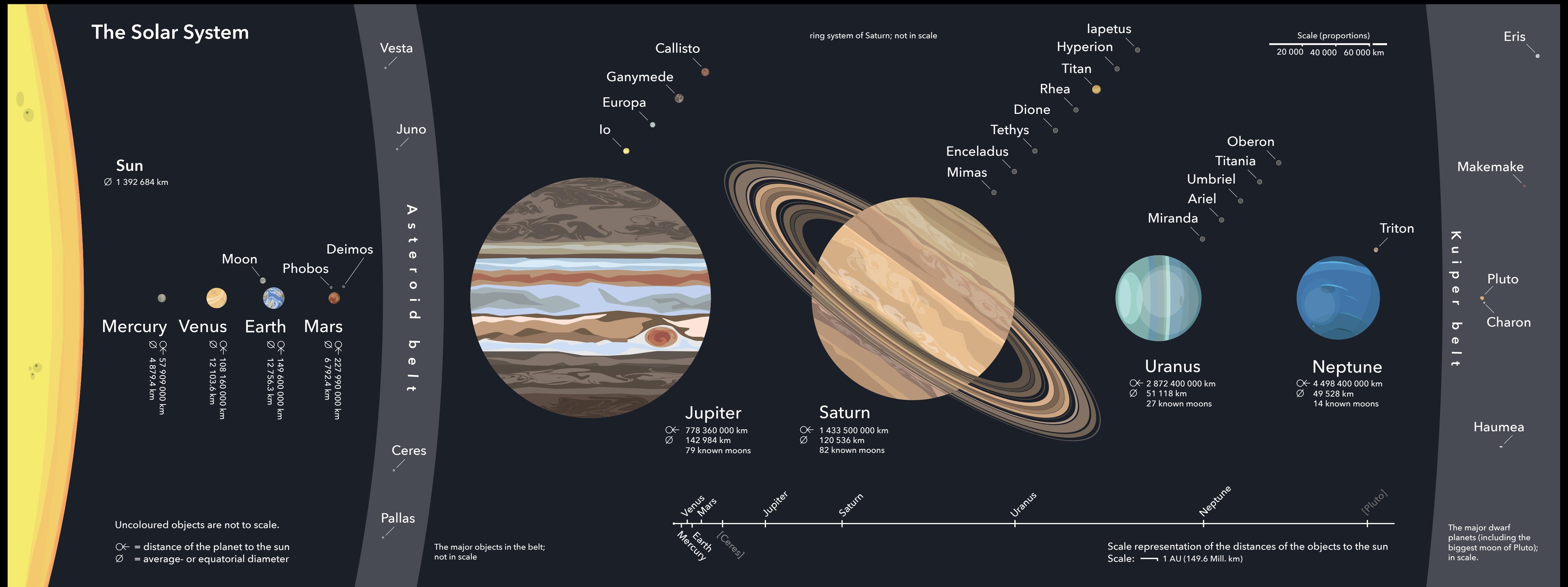
# Our Solar System

# Solar System Structure

Our solar system is surrounded by the Oort Cloud (this is where long period comets come from)



# Solar System Structure



# Solar System Structure

If the Earth was a standard marble size:

- What would be the approximate diameter of the Sun?
- About how much area would we need to accurately model our Solar System?

# Solar System Scale

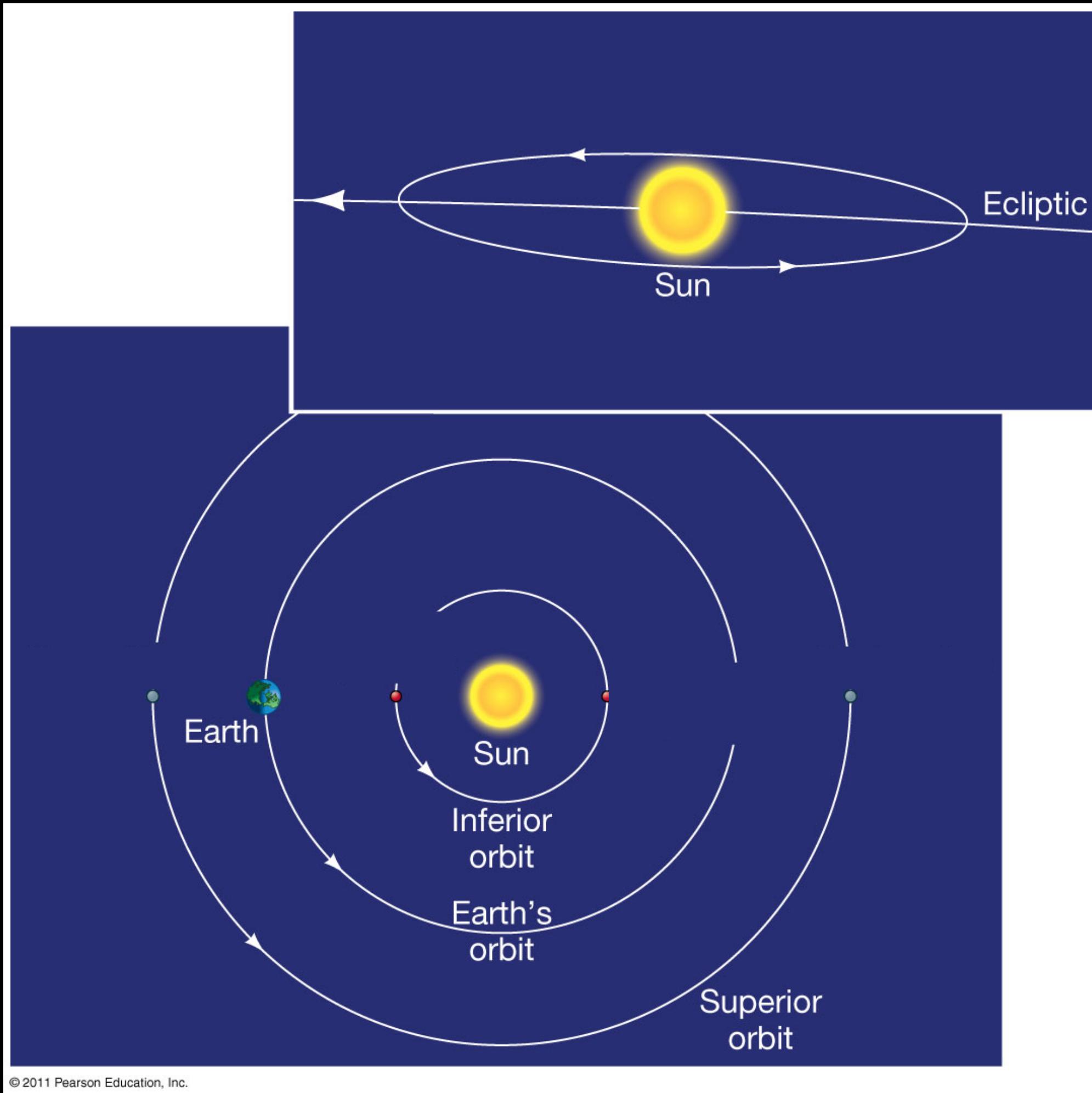


by Wylie Overstreet and Alex Gorosh, 2015, Black Rock Desert, Nevada

# **Very Brief and Abridged Astronomy History**

# Very Brief Astronomy History

Heliocentric model



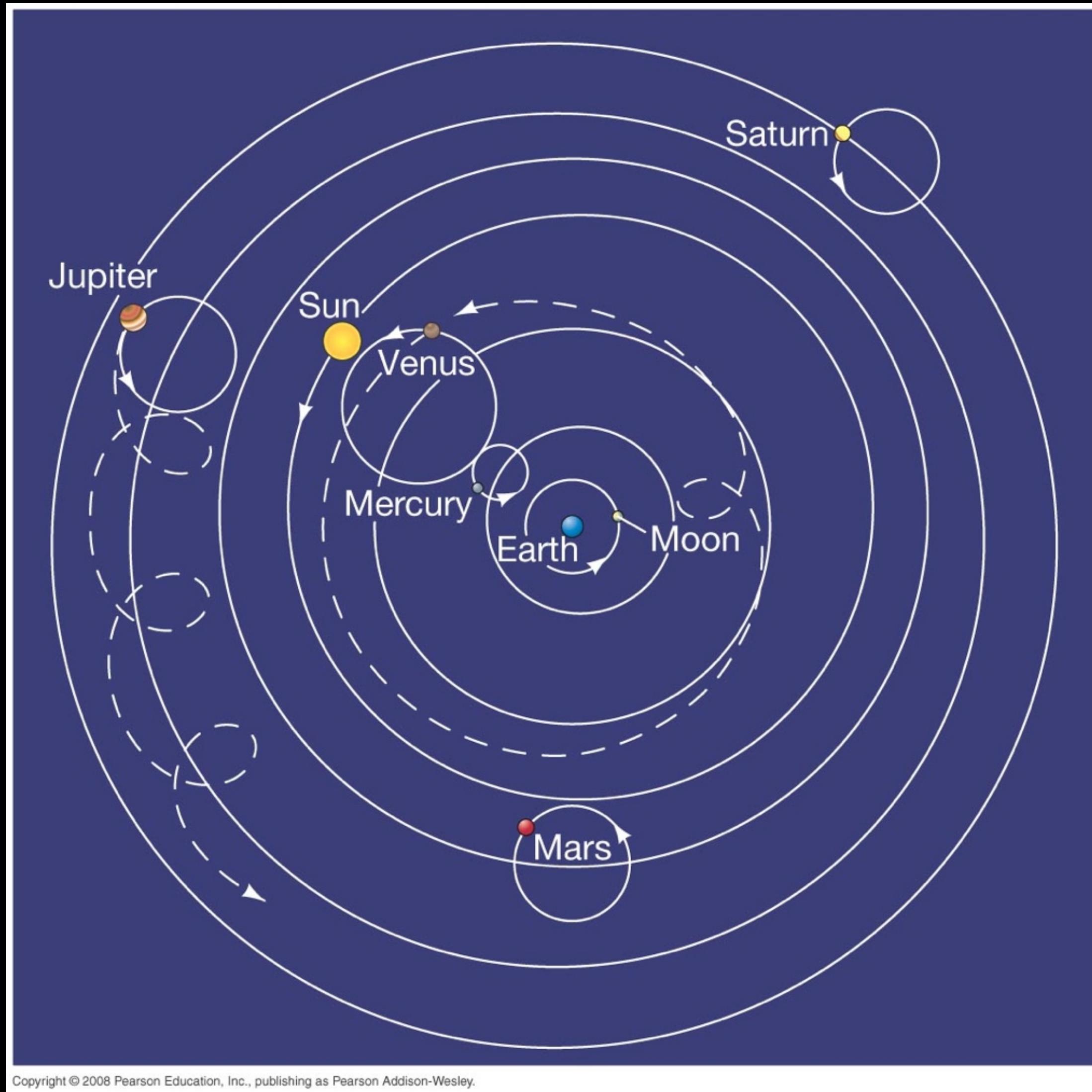
# Very Brief Astronomy History

Geocentric model

Ptolemy's  
Model

~140 C.E.

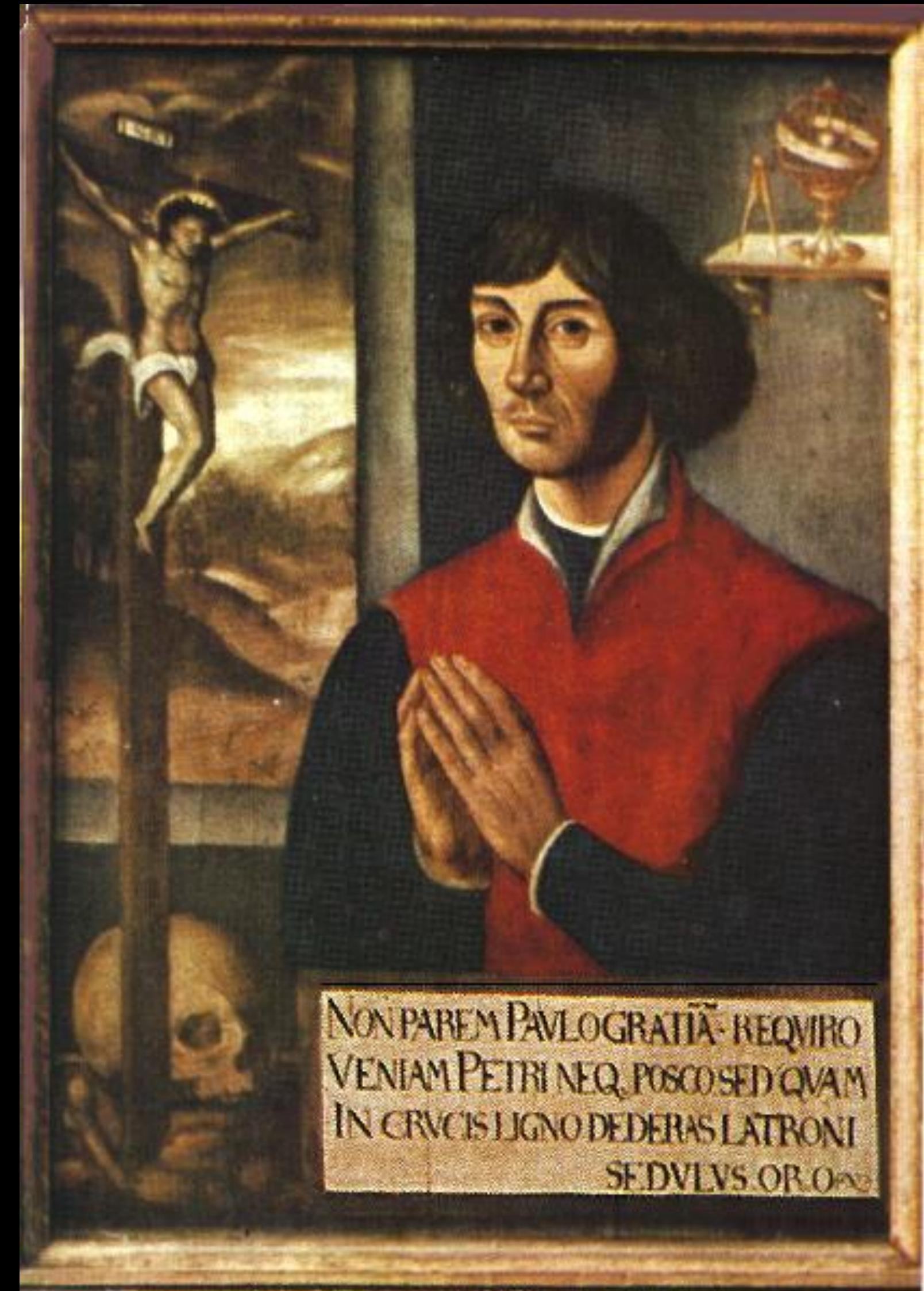
“Epicycles”



# Very Brief Astronomy History

## Copernicus(1473-1543)

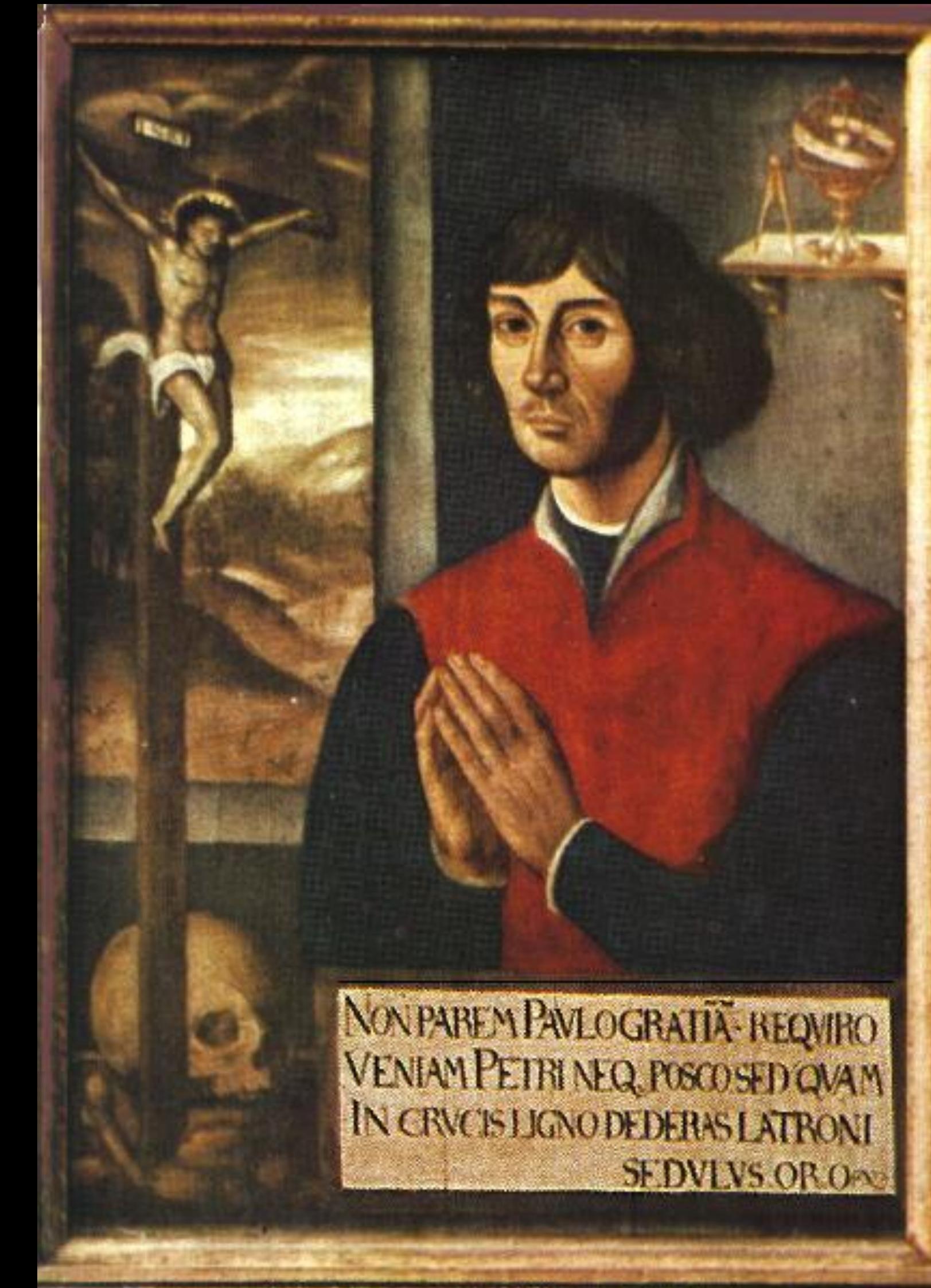
- Rediscovered the heliocentric model with the Sun in the center of the solar system, the Earth rotating and the Moon revolving around the Earth.
- When he published his ideas, 1543, they had little effect on the public. But were very influential for certain scientists.



# Very Brief Astronomy History

## Copernicus(1473-1543)

- 1600 Giordano Bruno was executed for teaching the heliocentric model.
- 1616 Copernicus's work was banned.



# Very Brief Astronomy History



Tycho Brahe  
(1546-1601)

- Made extensive observations of the planets, with greater precision than ever before.
- Hired Johannes Kepler in 1600 to make sense of his data, and then died a year later leaving him all of his observations.

# Very Brief Astronomy History

Galileo Galilei (1564-1642)-  
“the father of experimental science”

Embraced the newest technology:  
**the telescope (1609)**

Made new observations (1610):

- Moon has mountains and valleys
- Sun has sun spots and rotates  
(Don't look at the sun without proper gear!)
- Jupiter has moons
- Saturn has rings
- Venus has phases



# Very Brief Astronomy History

Galileo Galilei (1564-1642)-  
“the father of experimental science”

- 1633 Galileo was forced to retract his claims and sentenced to house arrest until he died (1642).



# Very Brief Astronomy History

Johannes Kepler  
(1571-1630)



Kepler first tried to match Tycho's observations of planets with circular orbits

But an 8-arcminute discrepancy led him eventually to ellipses.

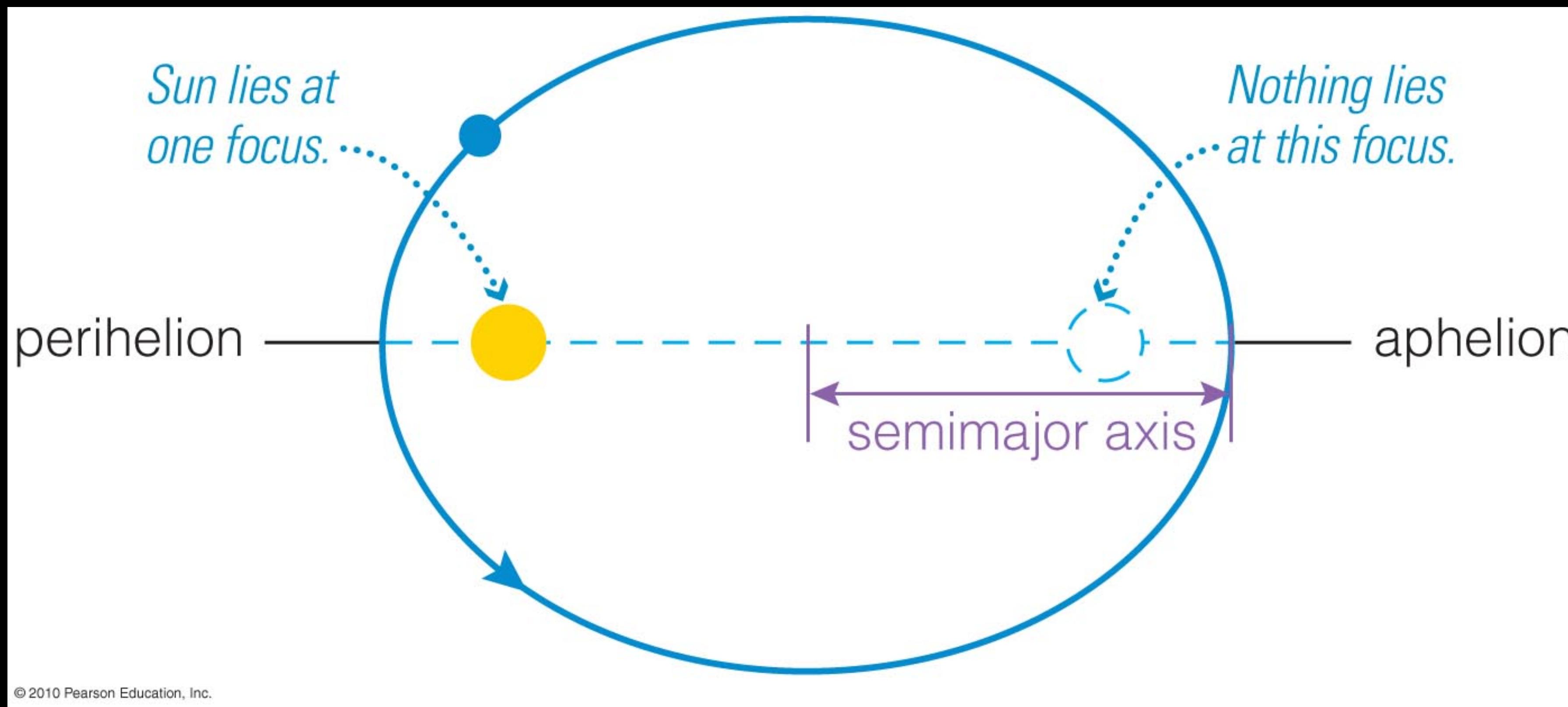
“If I had believed that we could ignore these eight minutes [of arc], I would have patched up my hypothesis accordingly. But, since it was not permissible to ignore, those eight minutes pointed the road to a complete reformation in astronomy.”

# Kepler's Laws of Planetary Motion

Using Tycho Brache's data, Kepler derived 3 laws of planetary motion.

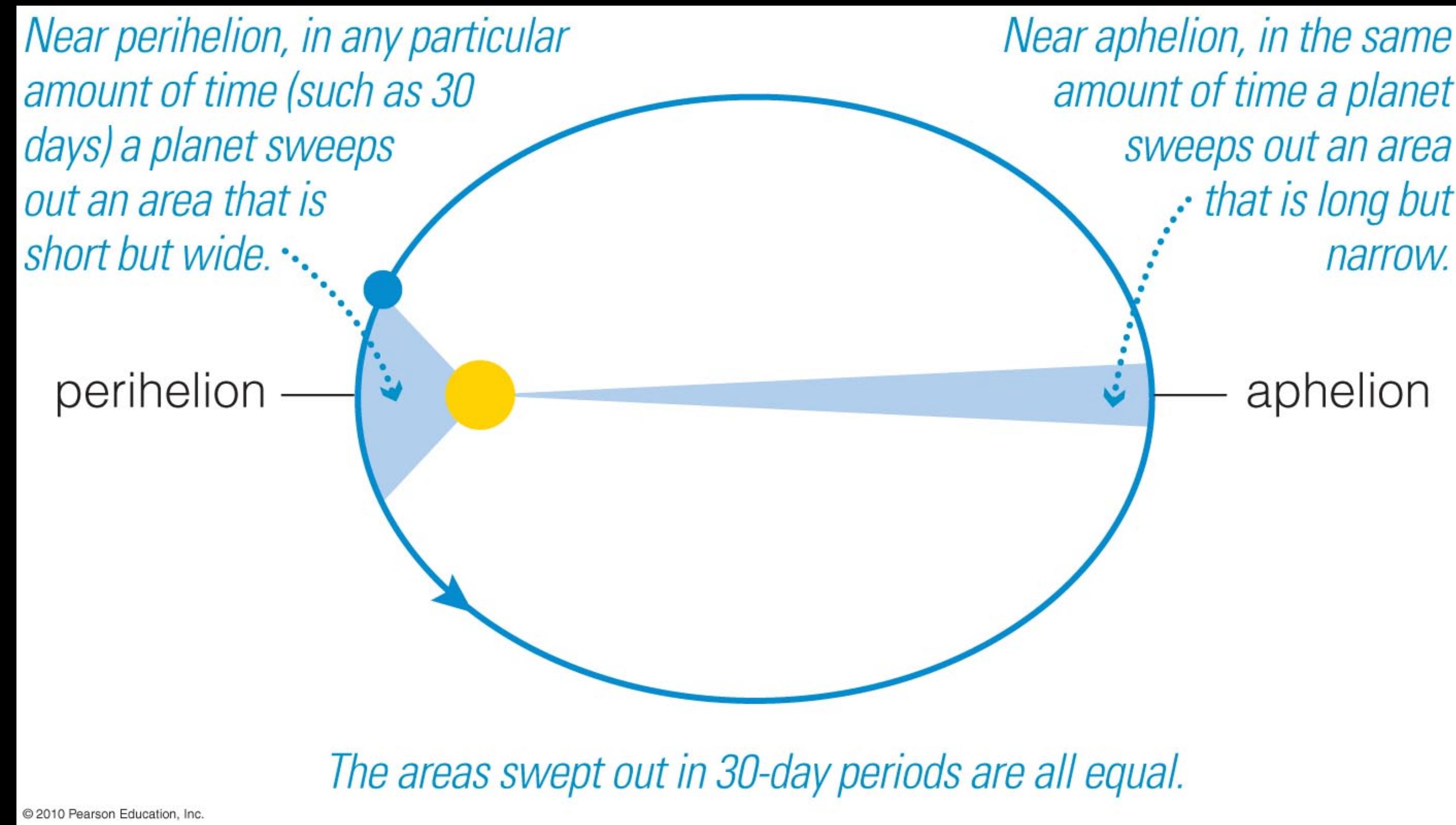
# Kepler's Laws of Planetary Motion

Kepler's First Law: The orbit of each planet around the Sun is an *ellipse* with the Sun at one focus.



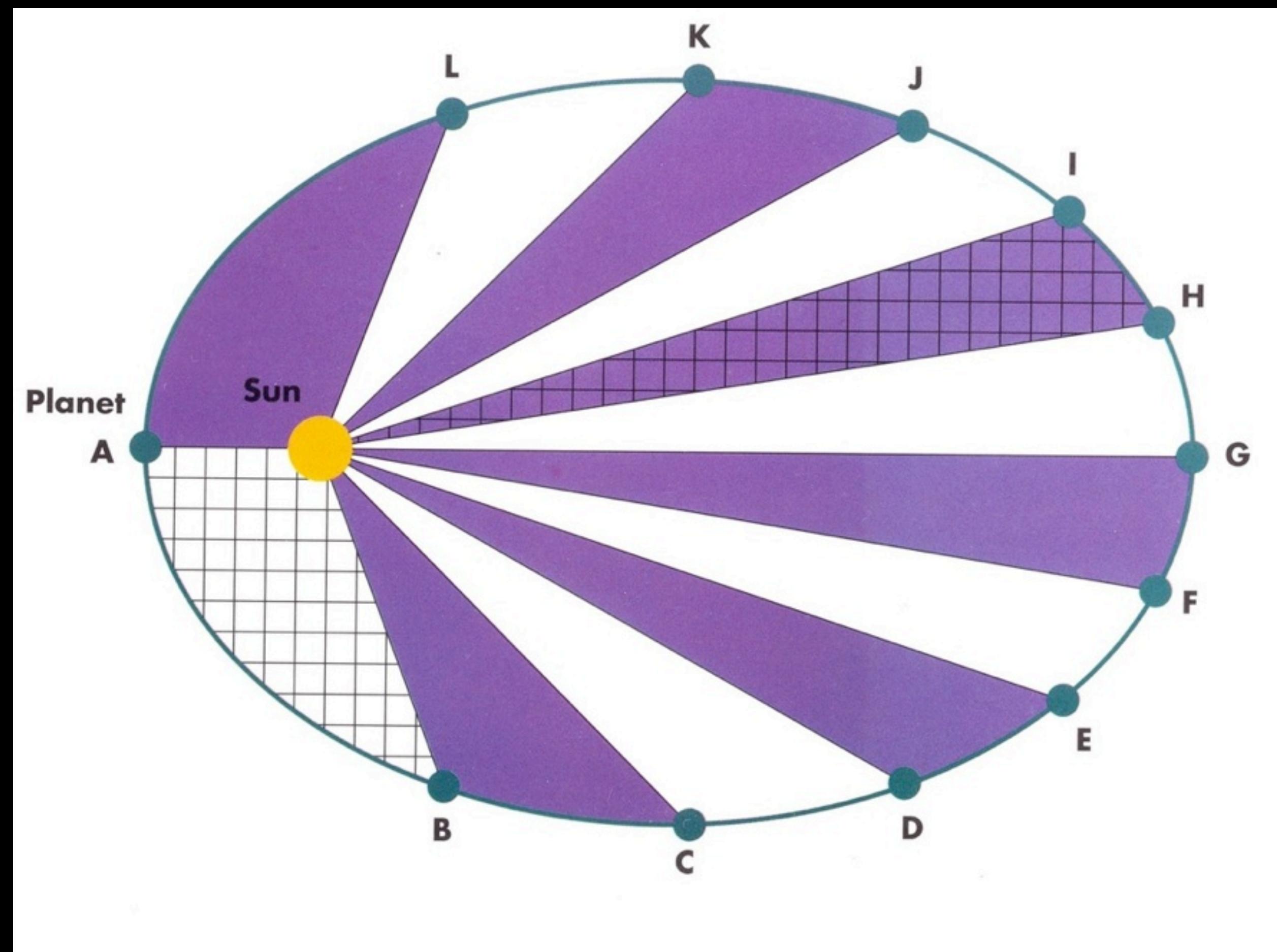
# Kepler's Laws of Planetary Motion

**Kepler's Second Law:** As a planet moves around its orbit, it sweeps out equal areas in equal times.



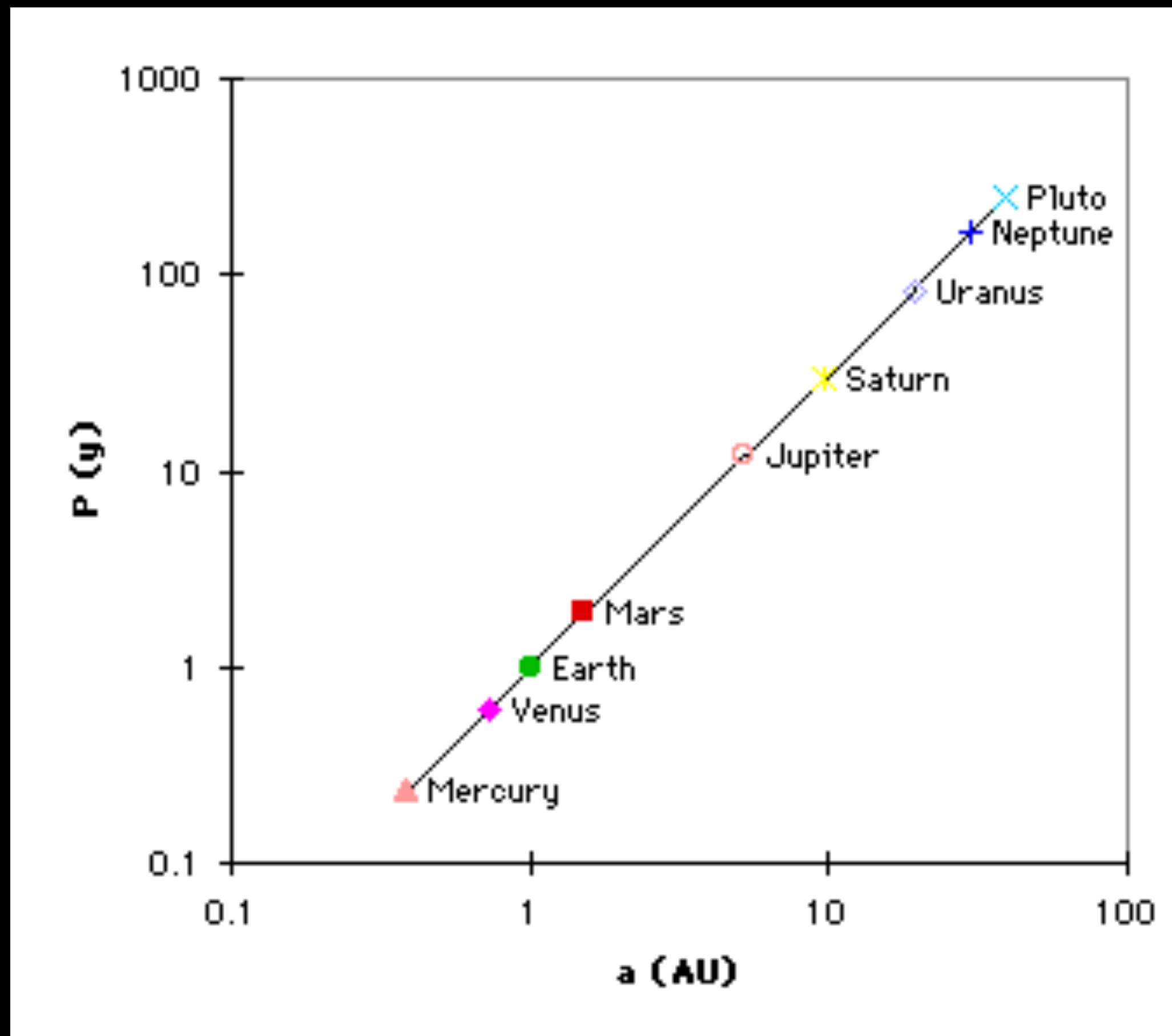
# Kepler's Laws of Planetary Motion

Kepler's Second Law: As a planet moves around its orbit, it sweeps out equal areas in equal times.



# Kepler's Laws of Planetary Motion

Kepler's Third Law: The period of a planet's orbit squared is proportional to the cube of the semi-major axis.



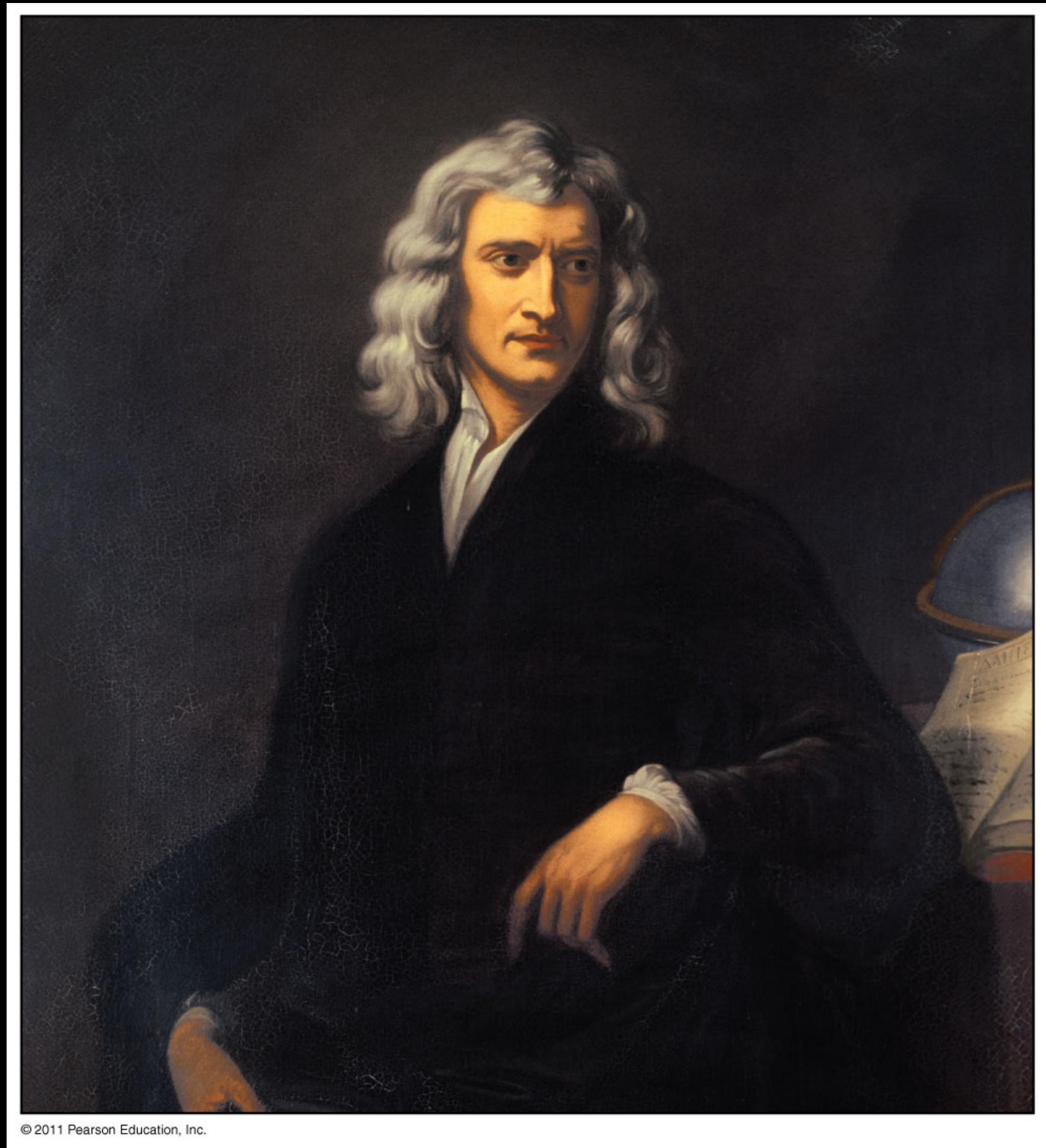
$$P^2 \propto K a^3$$

A planet **2, 3, 4 or 10** times farther away than Earth takes...  
 $(2^3)^{1/2} = 2.8$   
 $(3^3)^{1/2} = 5.2$   
 $(4^3)^{1/2} = 8.0$   
 $(10^3)^{1/2} = 31.6$   
times longer to go around the Sun!

# Brief History of Astronomy

## Isaac Newton (1643-1727)

Newton's Laws of motion explain how objects interact with the world and with each other

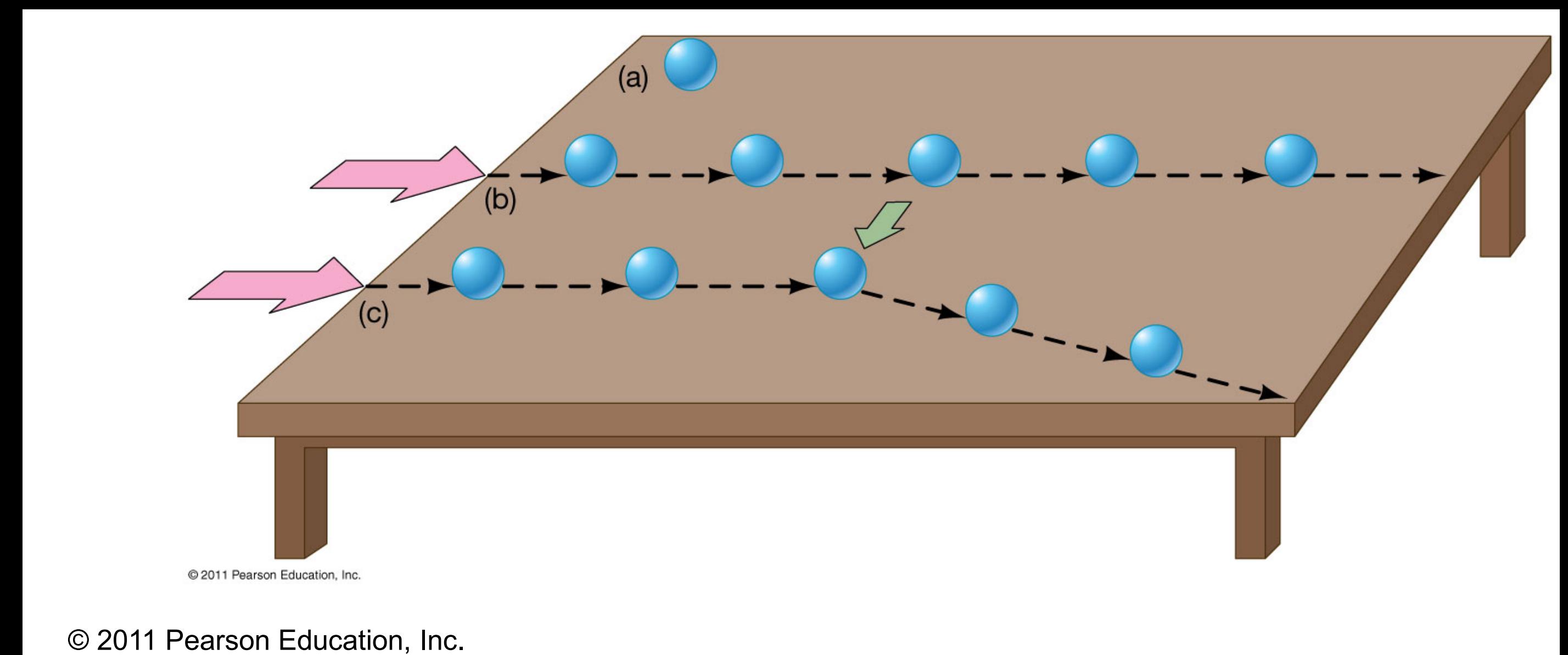


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# Newton's Laws of Motion

## Newton's First Law:

- (a) an object at rest will remain at rest
- (b) An object moving in a straight line at a constant velocity will remain so
- (c) Unless acted upon by an external force



# Newton's Laws of Motion

**Newton's Second Law:** When force is exerted on an object, its acceleration is inversely proportional to its mass

$$a = \frac{F}{m}$$

More commonly seen as:

$$F = ma$$

# Newton's Laws of Motion

**Newton's Third Law:** is commonly understood as

For every action there is an equal and opposite force

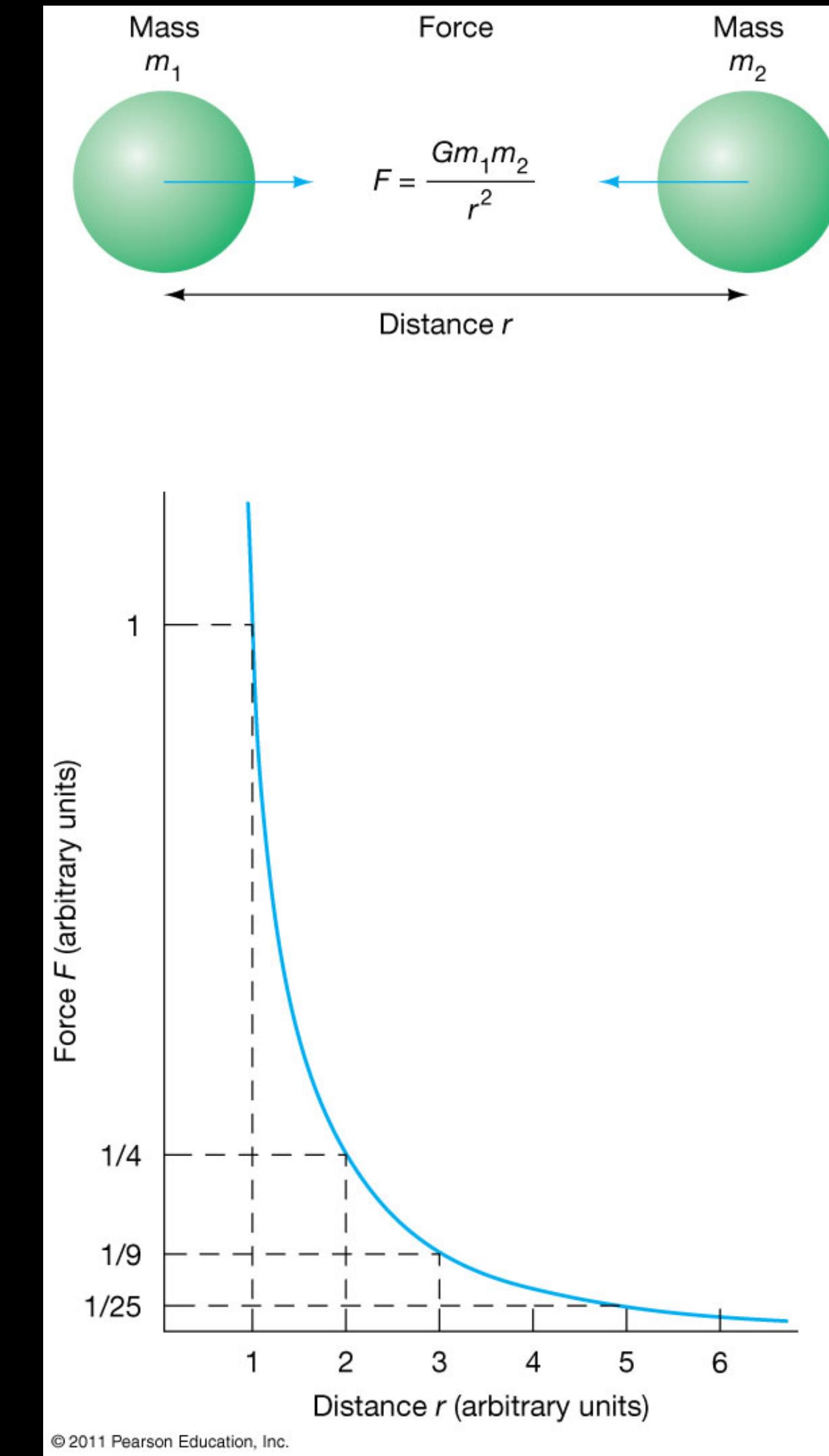
**What did Newton's laws do for us??**

# Newton's Laws of Gravitation

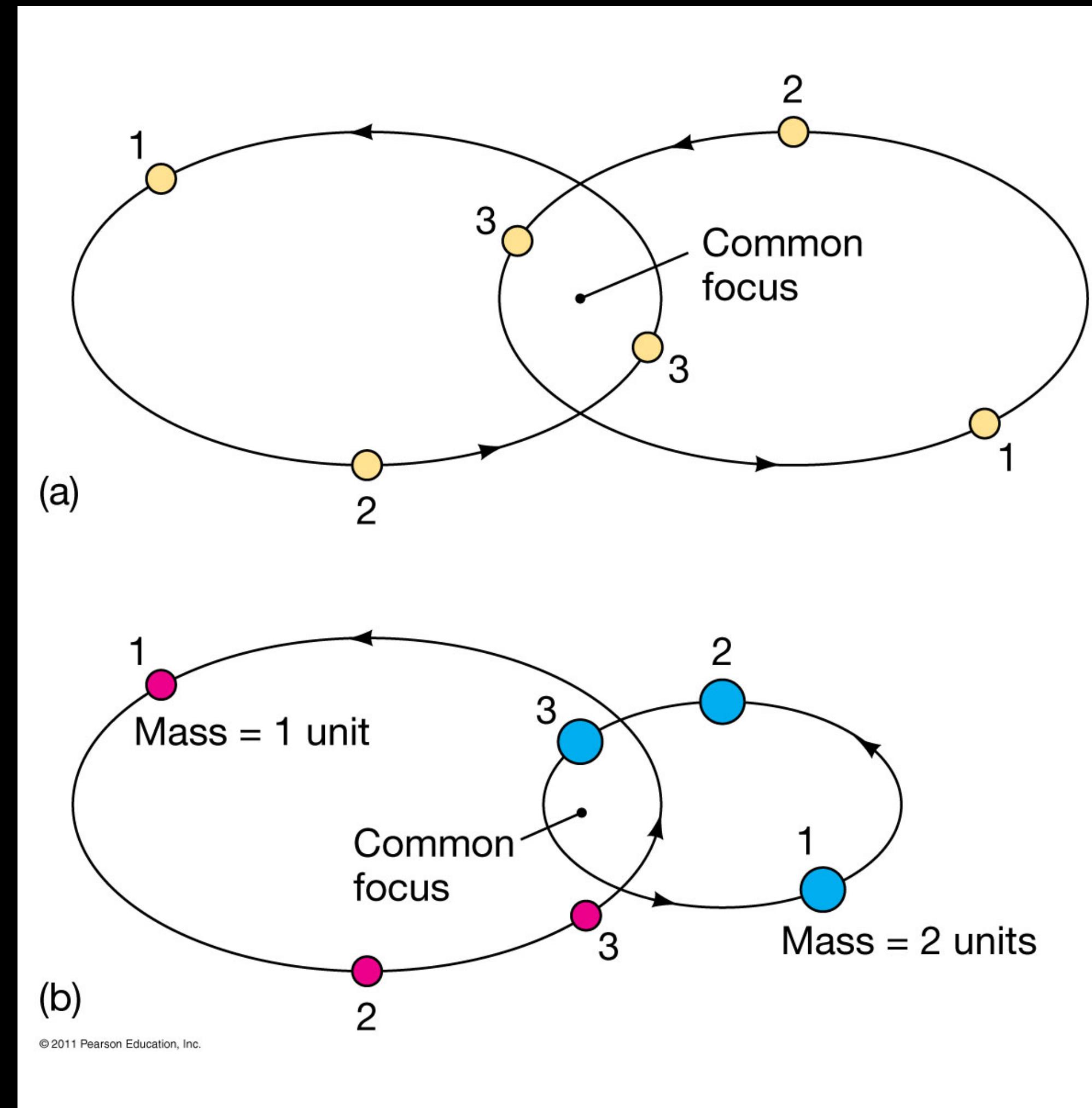
$$F = \frac{GMm}{r^2}$$

The constant G is the gravitational constant. It was experimentally derived.

$$G = 6.67 \times 10^{-11} \frac{m^3}{kg \cdot s^2}$$

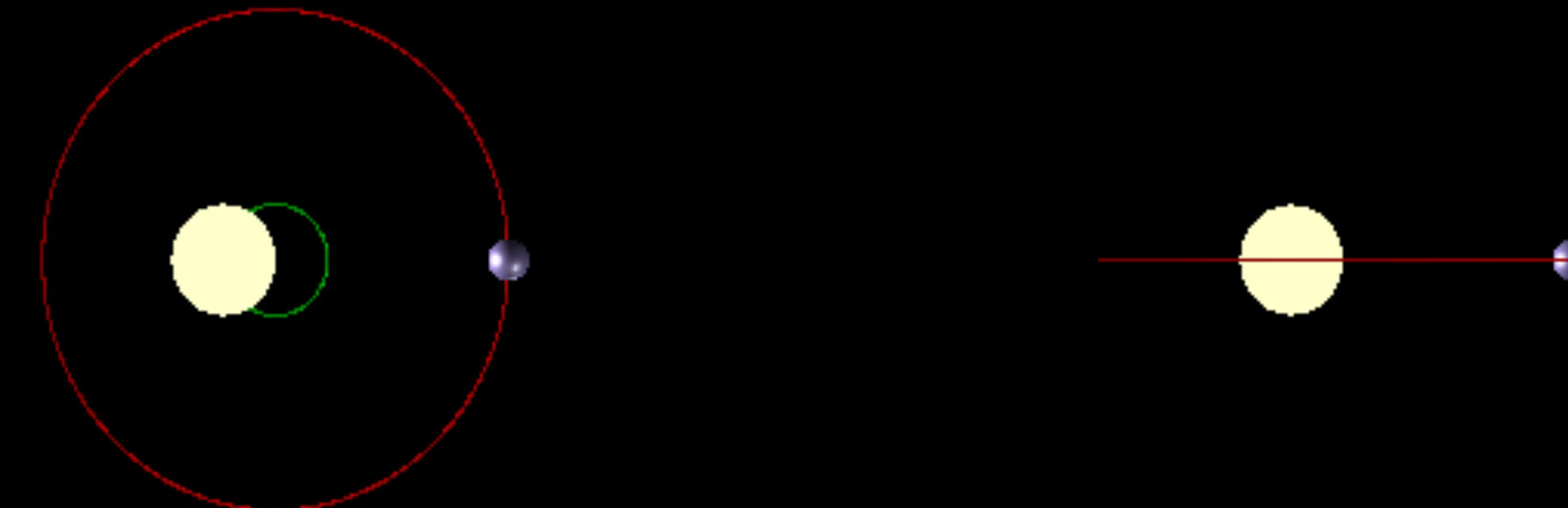


# Newton adjusted Kepler's First Law to include Center of Mass



# Newton adjusted Kepler's First Law to include Center of Mass

When one mass is significantly greater than the other.



But remember, our solar system has many bodies orbiting around one center of mass!!!

From Newton's Laws we can derive a number of useful formulas related to gravity.

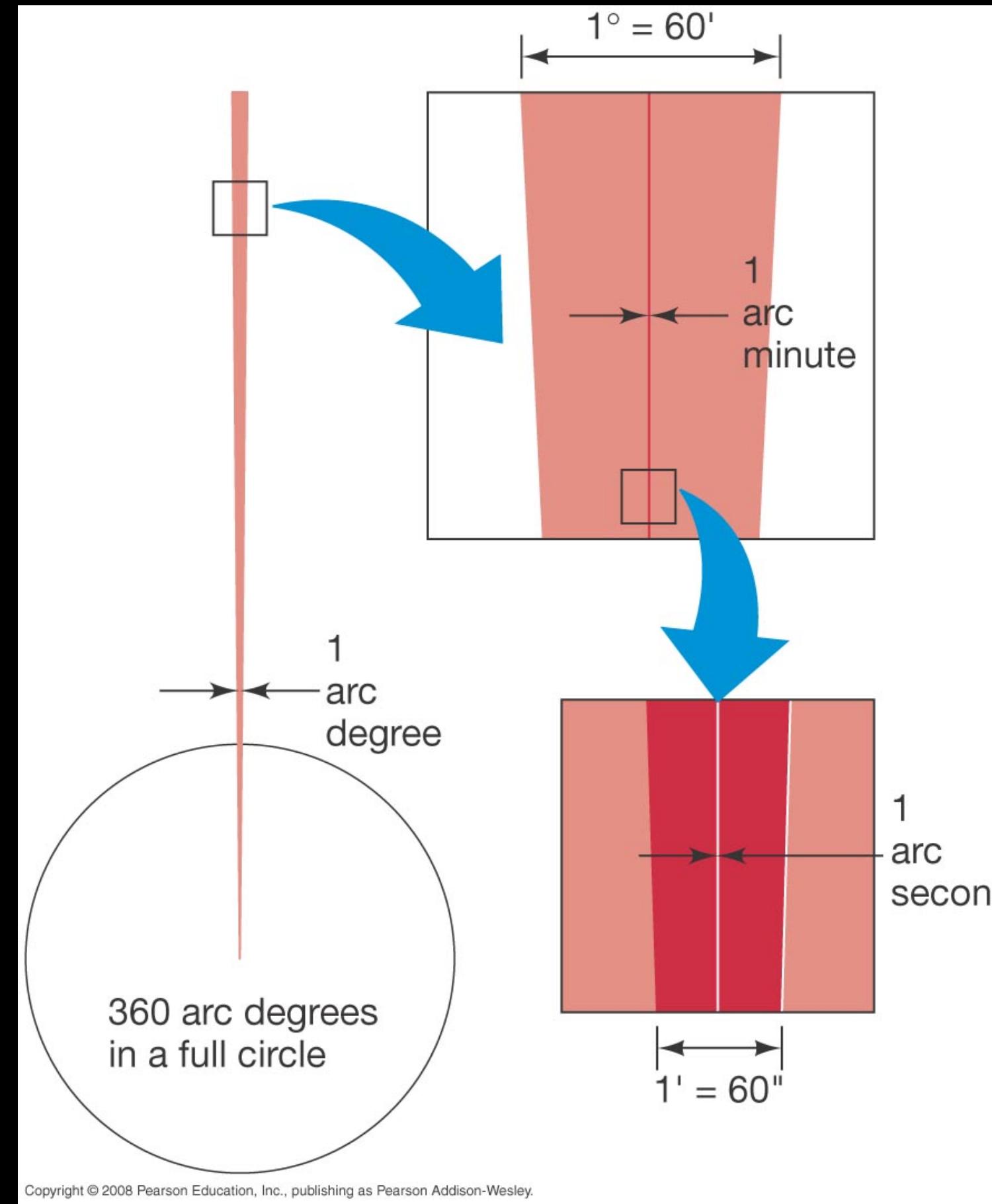
*Let's go to the board...*

# **Size measurements in astronomy**

# Size measurements in astronomy

Measurements *on the sky*:  
degree, arcminute, arcsecond

An arc **degree**, often just referred to as a degree, is about the size of your pinky finger held straight out



One degree equals  $60'$  (arcminutes)

One arc minutes equals  $60''$  (arcseconds)

# Size measurements in astronomy

## Distances *in space*

### Light Distance

Because the speed of light is a constant,  $c = 3 \times 10^8 \text{ m/s}$ , we define distance with respect to the time it takes light to travel:

$$\text{light second} = 3.00 \times 10^8 \text{ m}$$

$$\text{light minute} = 1.80 \times 10^{10} \text{ m}$$

$$\text{light day} = 2.59 \times 10^{13} \text{ m}$$

$$\text{light year} = 9.46 \times 10^{15} \text{ m}$$

### The parsec

Astronomers that work on regions that are very far from us measure distances in parsecs

$$1 \text{ parsec} = 3.26 \text{ light years}$$

$$1 \text{ kpc} = 1,000 \text{ parsecs}$$

$$1 \text{ Gpc} = 1,000,000 \text{ parsecs}$$