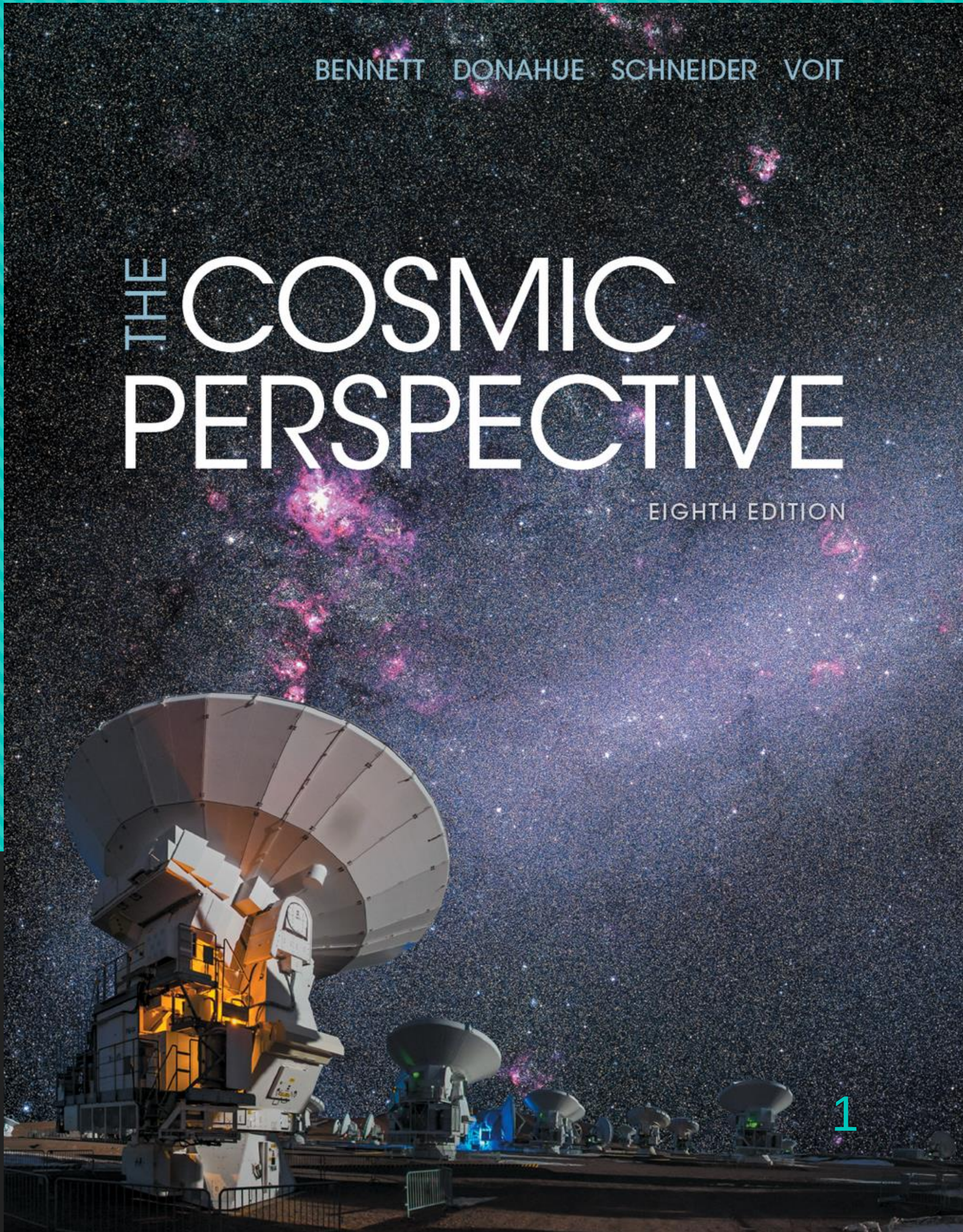
Chapter 1: A Modern View of the Universe



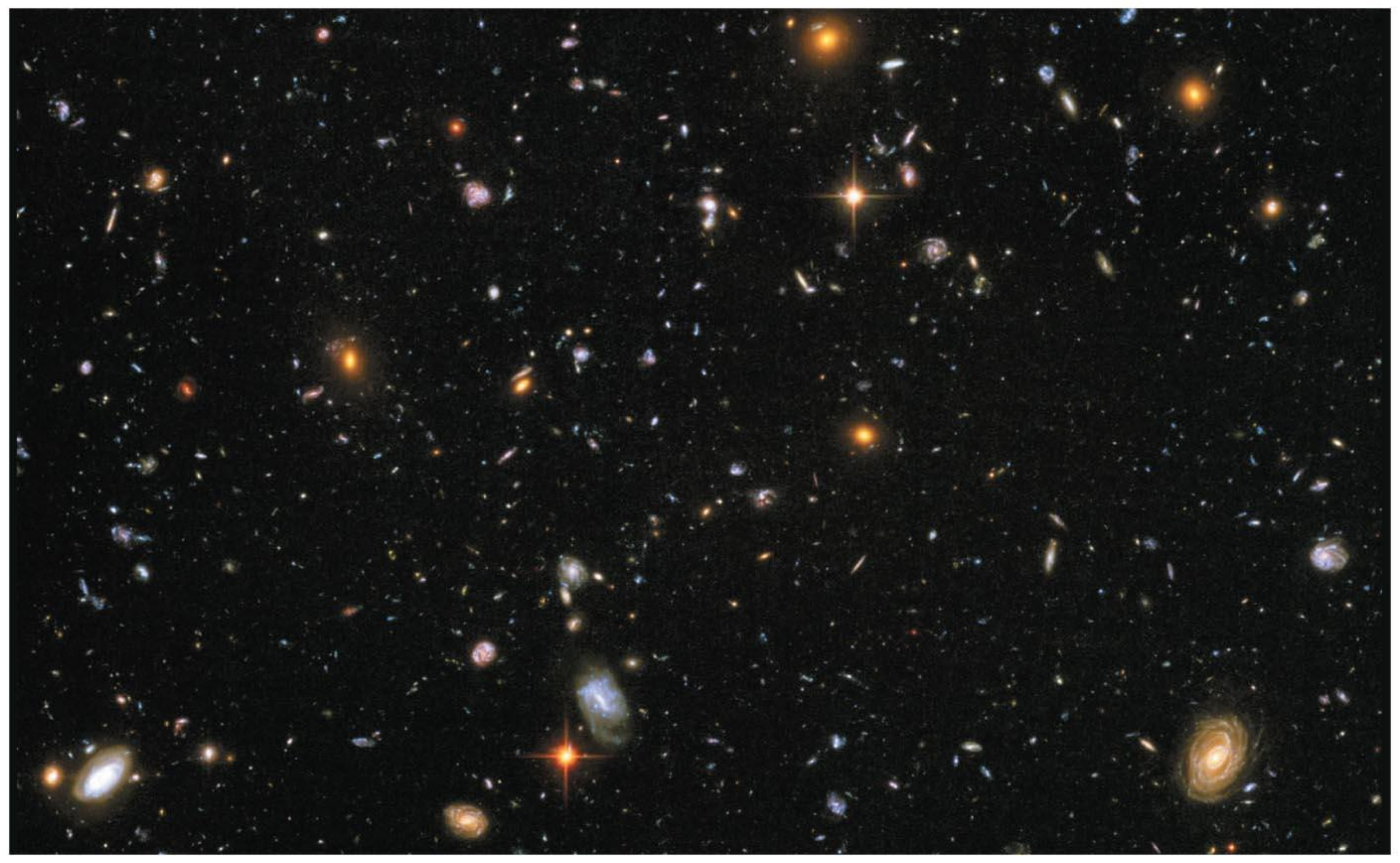
Mastering Astronomy Instructions

- Need to purchase immediately.
  - This is a required material for the course. No excuses will be accepted.

To register for Astronomy 1033:

- Go to www.pearsonmylabandmastering.com.
- Under Register, select **Student**.
- Confirm you have the information needed, then select **OK! Register now**.
- Enter your instructor's course ID: **drozdov67723**, and **Continue**.
- Enter your existing Pearson account **username** and **password** to **Sign In**.
  - You have an account if you have ever used a Pearson MyLab & Mastering product, such as MyMathLab, MyITLab, MySpanishLab, MasteringBiology or MasteringPhysics.
- If you don't have an account, select **Create** and complete the required fields.
  - Enter your name exactly as it appears in University records (i.e. Dina Drozdov)
- Select an access option.
- Enter the access code that came with your textbook or was purchased separately from the bookstore. Buy access using a credit card or PayPal account.
  Get temporary access by selecting the link near the bottom of the page.
  - This expires after 2 weeks automatically.

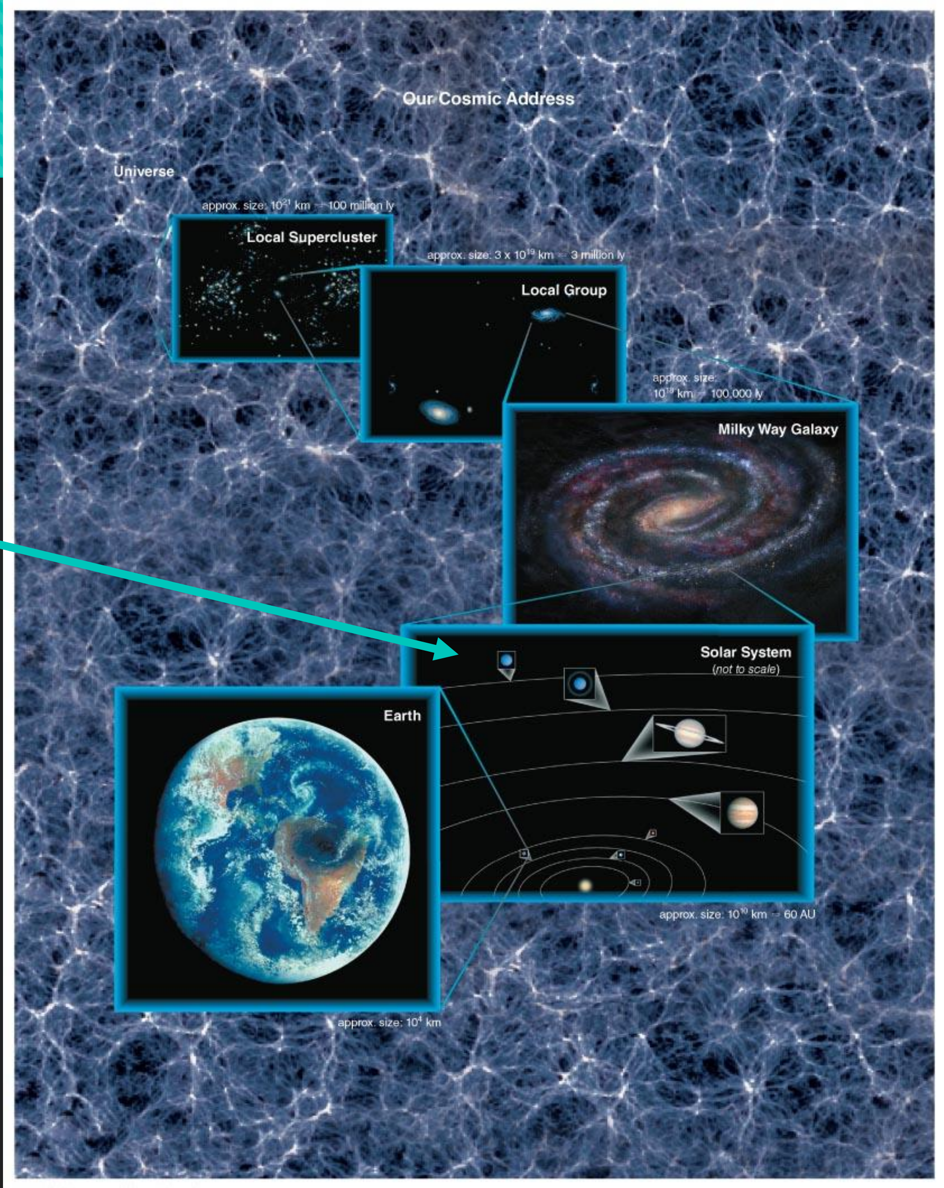
A Modern View of the Universe



Hubble Deep Field

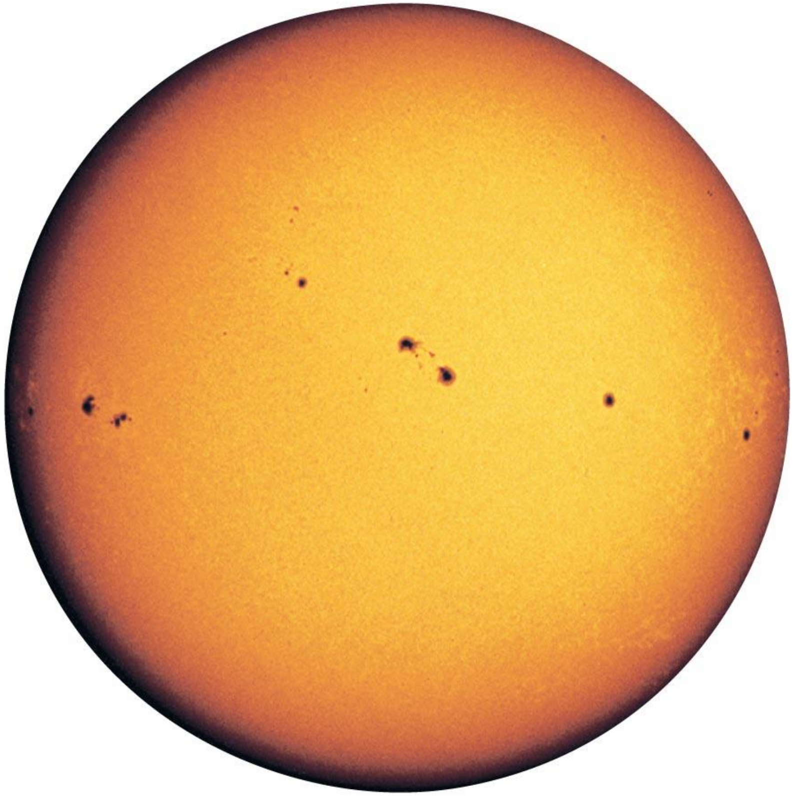
What is our place in the universe?

Our focus in this class



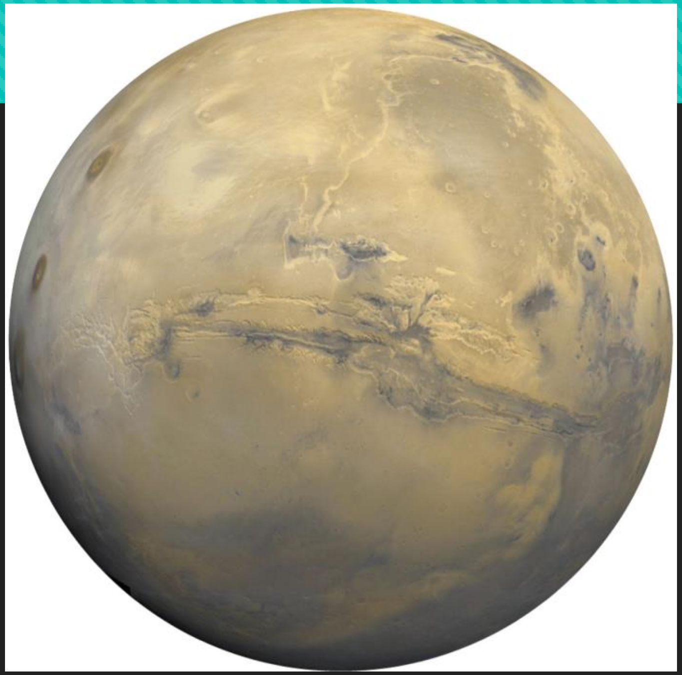
Star

- A large, glowing ball of gas that generates heat and light through nuclear fusion

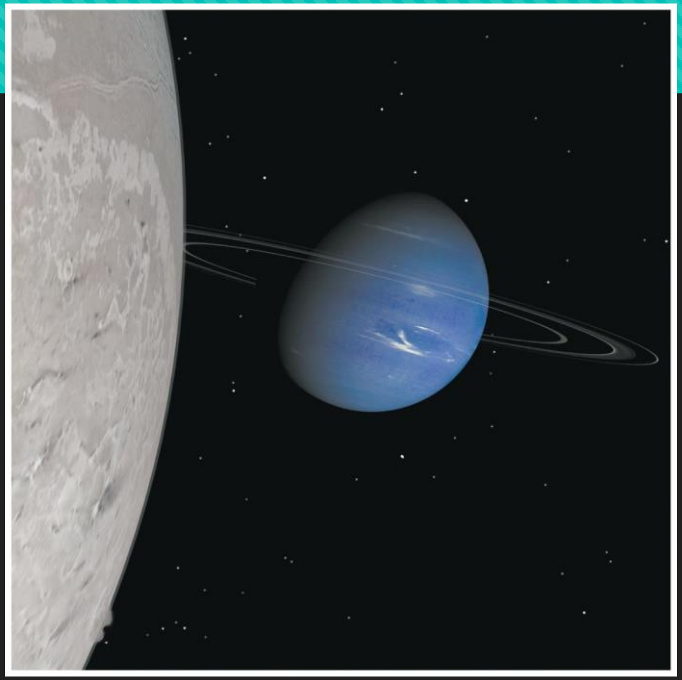


a A visible-light photograph of the Sun's surface. The dark splotches are sunspots—each large enough to swallow several Earths.

Planet



Mars



Neptune

- A moderately large object that orbits a star; it shines by reflected light. Planets may be rocky, icy, or gaseous in composition.

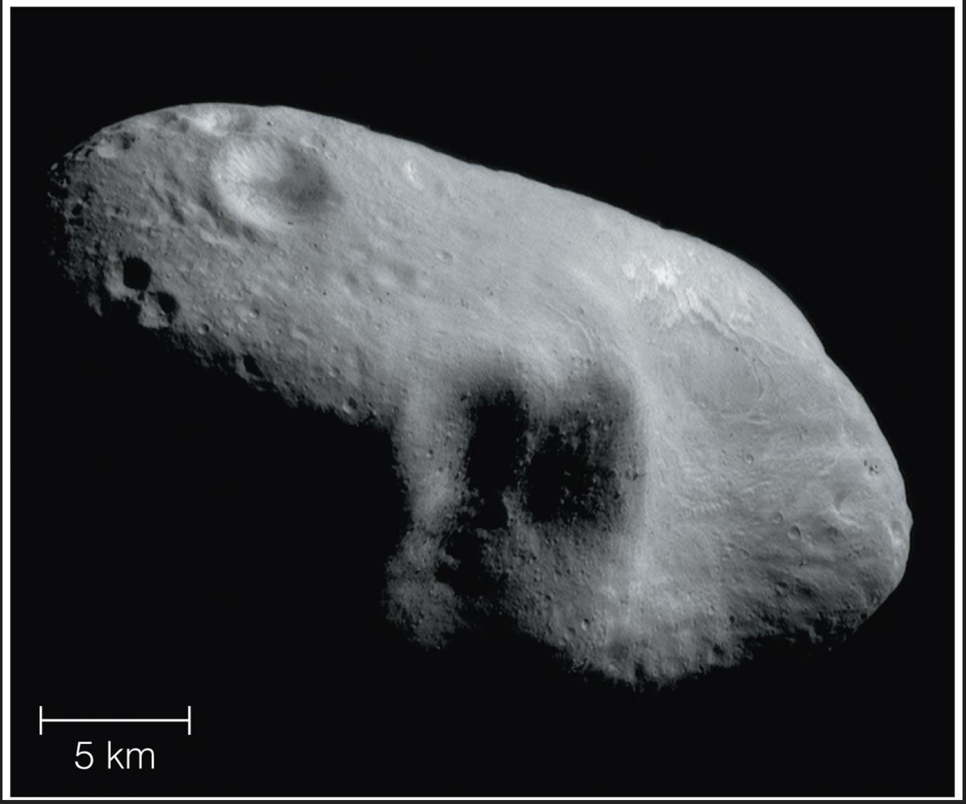
Moon (or Satellite)

- An object that orbits a planet

Ganymede (orbits Jupiter)

Asteroid

- A relatively small and rocky object that orbits a star



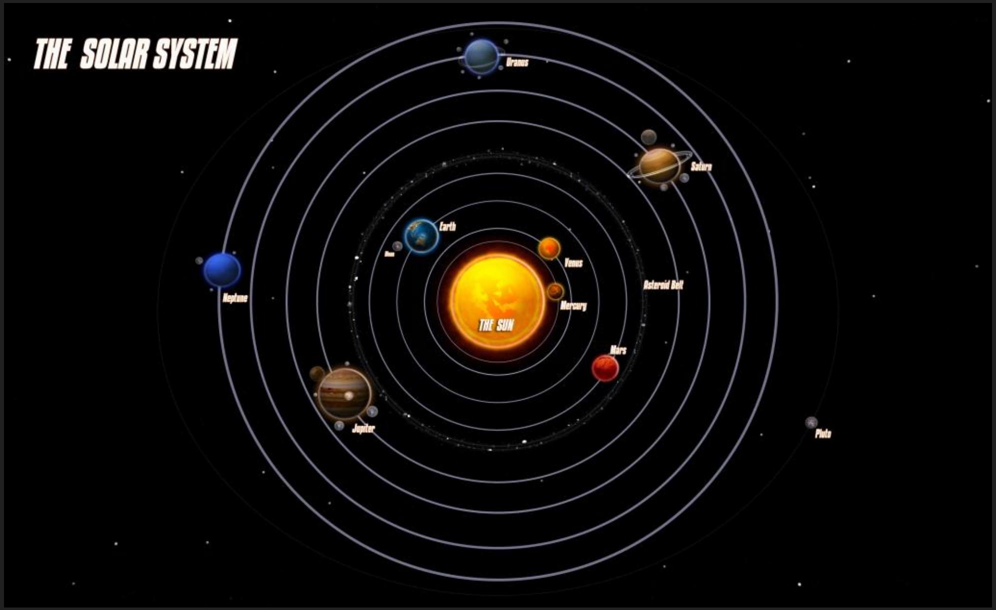
Eros, an asteroid

Comet

- A relatively small and icy object that orbits a star

Solar (Star) System

- A star and all the material that orbits it, including its planets and moons

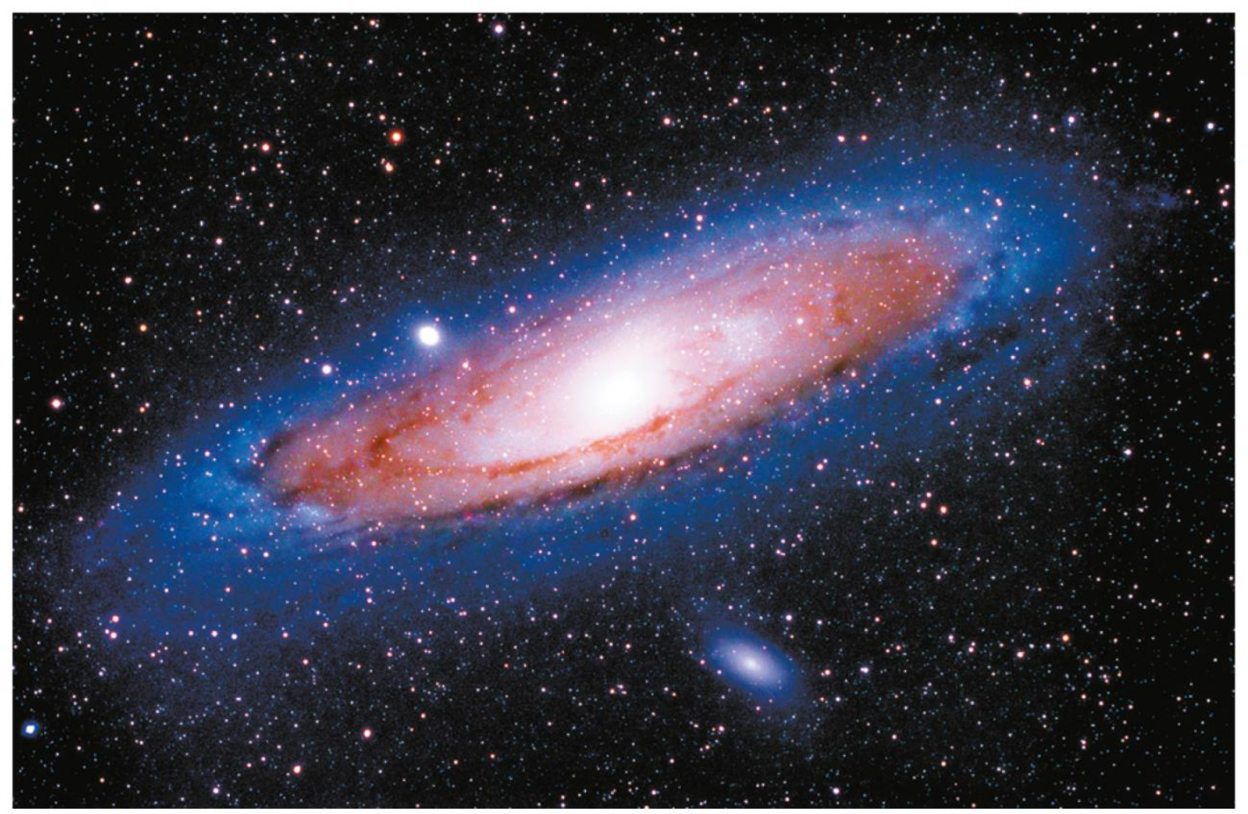


Nebula

- An interstellar cloud of gas and/or dust

Galaxy

- A great island of stars in space, all held together by gravity and orbiting a common center



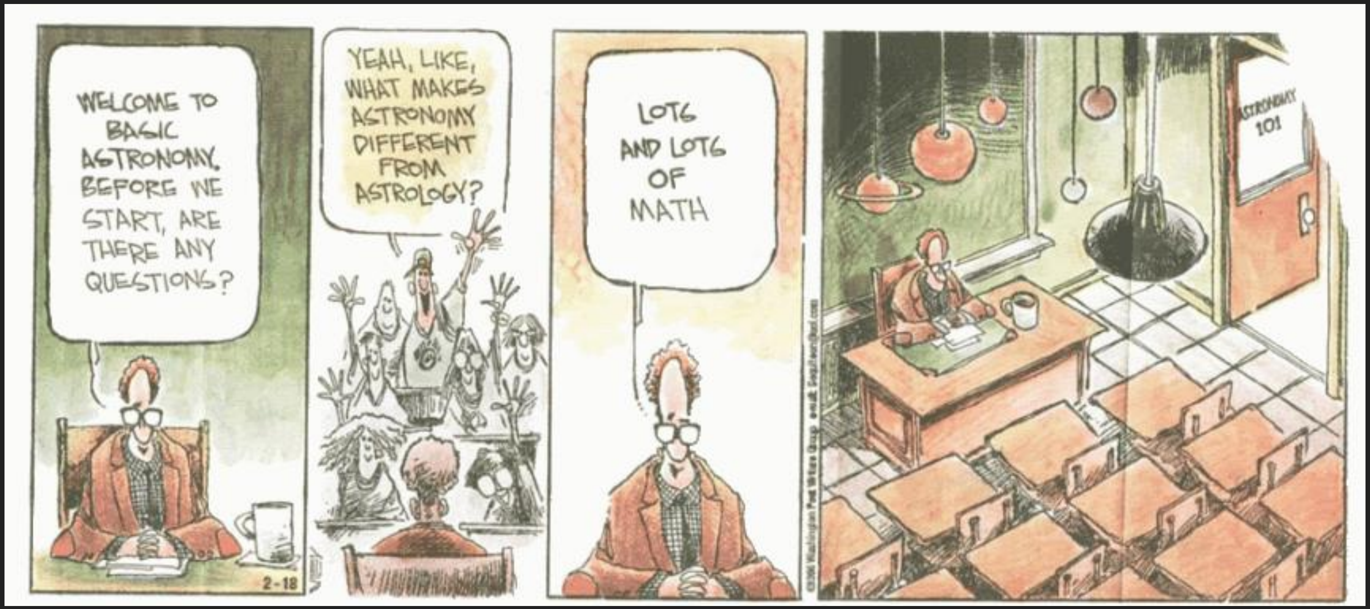
M31, the great galaxy in Andromeda

Universe

- The sum total of all matter and energy; that is, everything within and between all galaxies

Light-year

- The **distance** light can travel in 1 year
- About 10 trillion kilometers (6 trillion miles)
- This is a <u>really</u> important concept in Astronomy.



Math Review - Scientific Notation

Large Numbers

- To convert a large number using scientific notation, move the decimal point to the **LEFT** until it reaches the second to last position. Count the number of moves. This is the exponent (will be positive because you are moving left).
- **Example**: Earth is located at an average distance of 149598000000m from the Sun = 1.496×10^{11} m

Small Numbers

- To convert a small number using scientific notation, move the decimal point to the **Right** until it reaches the second to last place in number. Count the number of moves. This is the exponent (since you went right, it is negative).
- **Example**: The wavelength of green light is 0.00000051m = 5.1×10^{-7} m

#15 is a Mathematical Review on Powers and Roots

Math Review – Metric System

- Useful prefixes to know:

Prefix	Symbol	Power	Multiply by	Example Unit
giga	G	10^{9}	1,000,000,000	gigameter (Gm)
mega	M	10^{6}	1,000,000	megameter (Mm)
kilo	k	10^{3}	1000	kilometer (km)
centi	c	10^{-2}	0.01	centimeter (cm)
milli	m	10^{-3}	0.001	millimeter (mm)
micro	μ	10^{-6}	0.000001	micrometer (μm)
nano	n	10^{-9}	0.000000001	nanometer (nm)

Will be provided on an exam. Know how to use forwards and backwards.

$$\boxed{distance = velocity\ x\ time}$$

- Really important equation.
- Be always mindful of units, and show them in all of your work. However, unless specified, do not include in Mastering Astronomy.

How far is a light-year?

$$\boxed{distance = velocity\ x\ time}$$

$$1\ \text{light-year} = (\text{speed of light}) \times (1\ \text{year})$$

$$= \left(300{,}000\,\frac{\text{km}}{\text{s}}\right)\times\left(\frac{365\ \text{days}}{1\ \text{yr}}\times\frac{24\ \text{hr}}{1\ \text{day}}\times\frac{60\ \text{min}}{1\ \text{hr}}\times\frac{60\ \text{s}}{1\ \text{min}}\right)$$

- velocity = c (speed of light) = $3x10^8$ m/s
- time = 1 year
- Units don’t match! Dimensional analysis is necessary.
  - ✓ You <u>must</u> know how to convert units in this class!

How far is a light-year?

M.I. 1.1

$$1\ \text{light-year} = (\text{speed of light}) \times (1\ \text{year})$$

$$= \left(300{,}000\,\frac{\text{km}}{\cancel{\text{s}}}\right) \times \left(\frac{365\ \cancel{\text{days}}}{1\ \cancel{\text{yr}}} \times \frac{24\ \cancel{\text{hr}}}{1\ \cancel{\text{day}}} \times \frac{60\ \cancel{\text{min}}}{1\ \cancel{\text{hr}}} \times \frac{60\ \cancel{\text{s}}}{1\ \cancel{\text{min}}}\right)$$

$$= 9{,}460{,}000{,}000{,}000\ \text{km} = 9.46\ x\ 10^{12}\,km$$

~10 trillion km

#3

Question

- As we just discovered, 1ly = 9.46×10^{12} km. How many meters are in 1 ly?

A. 9.46×10^{12} m

B. 9.46×10^{15} m

C. 9.46×10^{10} m

D. 9.46×10^{9} m

Far away means looking back in time?

Destination	Light travel time
Moon	1 second
Sun	8 minutes
Sirius	8 years
Andromeda Galaxy	2.5 million years

- Light travels at a finite speed (300,000 km/s).
- Thus, we see objects as they were in the past:

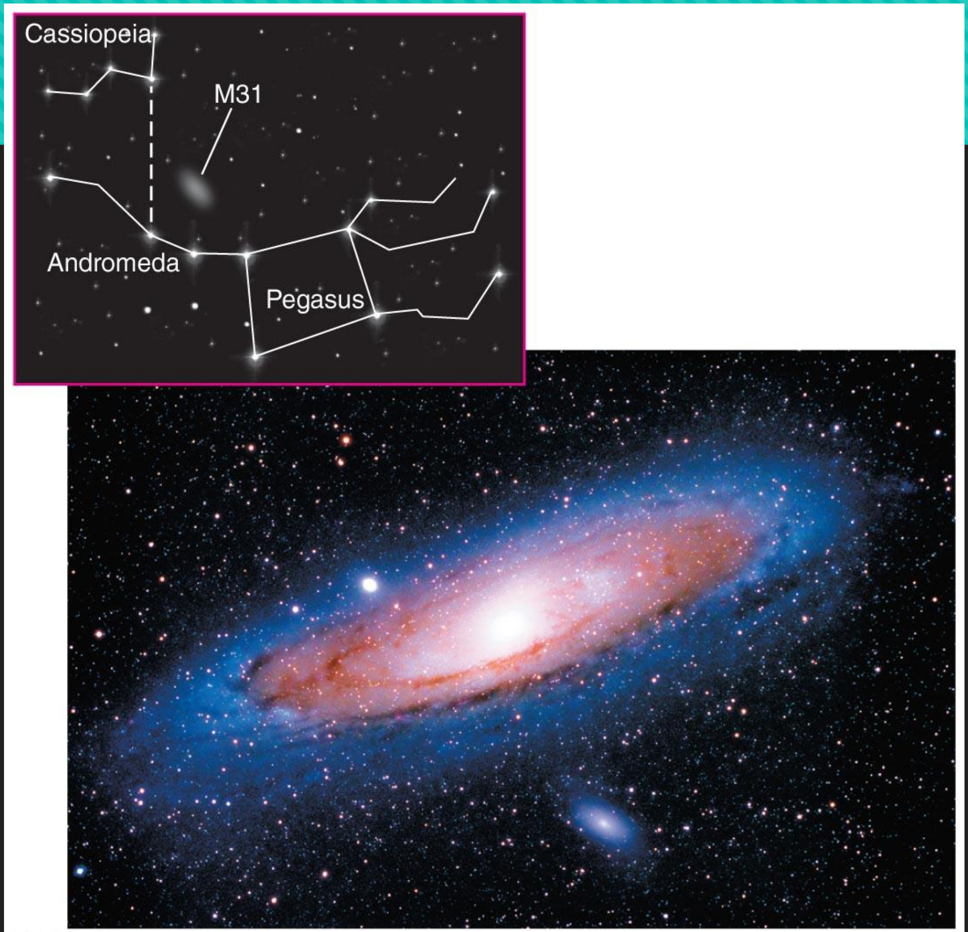
The farther away we look in distance, the further back we look in time.

Far away means back in time?

Example:

- The Orion Nebula is 1500 ly away.
- We see the Orion Nebula as it actually looked 1500 years ago!
- The light has taken 1500 years to reach us.

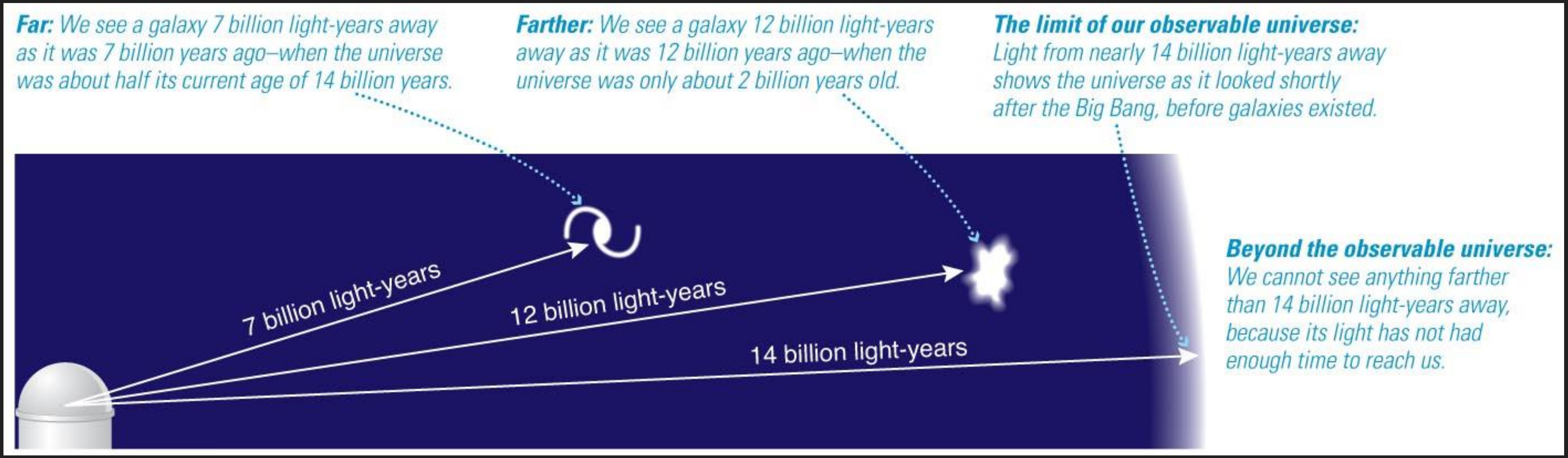
Far away means back in time?



Example:

- This photo shows the Andromeda Galaxy as it looked about 2 1/2 million years ago.
- **Question: When will we be able to see what it looks like now?**

Can we see the entire universe?



Thought Question

Why can't we see a galaxy 15 billion light-years away?
(Assume the universe is 14 billion years old.)

A. Because no galaxies exist at such a great distance.
B. Galaxies may exist at that distance, but their light would be too faint for our telescopes to see.
C. Because looking 15 billion light-years away means looking to a time before the universe existed.

Math examples

$$\boxed{distance = velocity\ x\ time}$$

- Suppose you are driving on the highway at 60mph. If you drive for 10 hours, how far did you drive?
- A radar pulse is sent from Earth to an asteroid, bounces off, and returns to Earth. The round trip takes 150s. How far away is the asteroid?
  - What if we knew the distance and were looking for the time it would take?

#12

Which of the following has the various objects listed in order from smallest to largest?

A. the solar system; the Milky Way; the Local Group
B. the solar system; the Local Group; the Milky Way
C. the Milky Way; the Local Group; the solar system
D. the Local Group; the solar system; the Milky Way

What have we learned?

- **What is our place in the universe?**
  - Earth is part of the solar system, which is the Milky Way Galaxy, which is a member of the Local Group of galaxies in the Local Supercluster.

Thought Question

Suppose you tried to count the more than
100 billion stars in our galaxy, at a rate of one per second.

How long would it take you?

A. a few weeks
B. a few months
C. a few years
D. a few thousand years

How big is the universe?

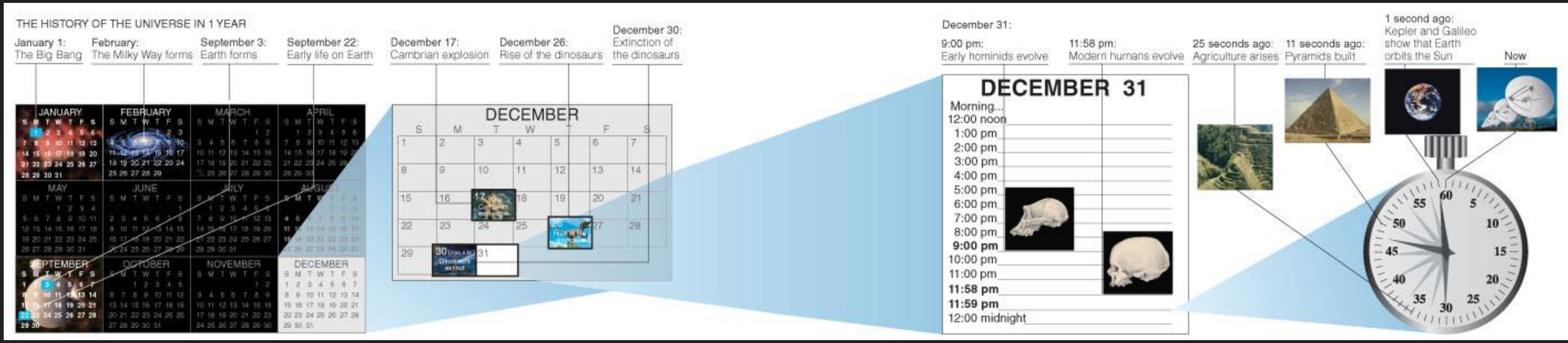
- The Milky Way is one of about 100 billion galaxies.
- 10^{11} stars/galaxy x 10^{11} galaxies = 10^{22} stars
- There are as many stars as grains of (dry) sand on *all* Earth's beaches.

What does the universe look like from Earth?

- With the naked eye, we can see more than 2000 stars as well as the Milky Way.

How do our lifetimes compare to the age of the universe?

- The cosmic calendar: a scale on which we compress the history of the universe into 1 year.
- On a cosmic calendar that compresses the history of the universe into 1 year, human civilization is just a few seconds old, and a human lifetime is a fraction of a second.

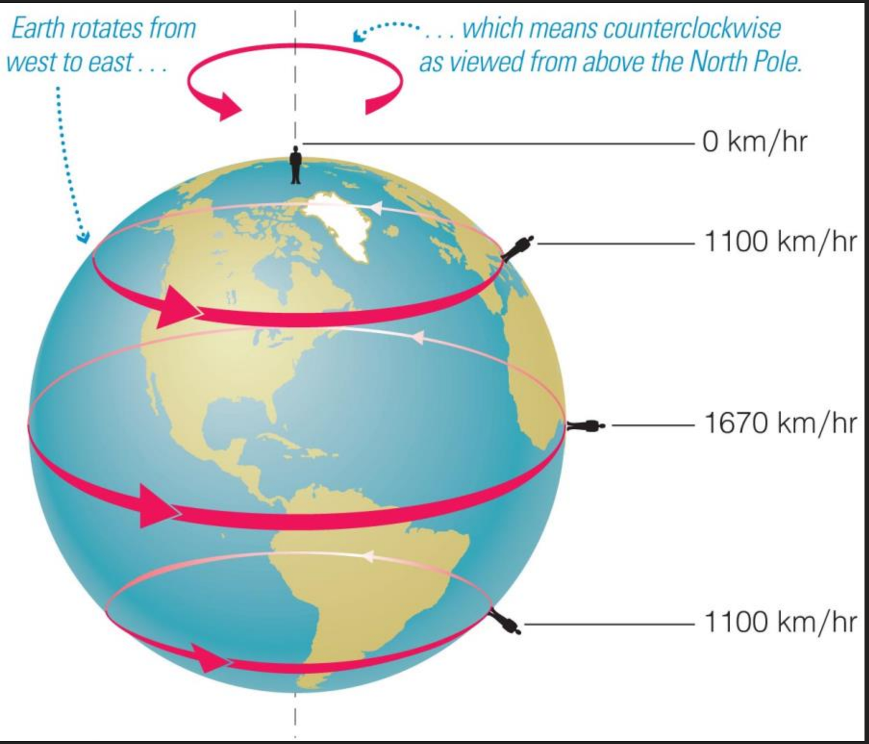


Which of the following ranks your different astronomical motions from slowest to fastest?

A. rotation of Earth; motion of the Sun around the center of the Milky Way; motion of Earth around the Sun
B. motion of the Sun around the center of the Milky Way; motion of Earth around the Sun; rotation of Earth
C. motion of Earth around the Sun; rotation of Earth; motion of the Sun around the center of the Milky Way
D. rotation of Earth; motion of Earth around the Sun; motion of the Sun around the center of the Milky Way

How is Earth moving through space?

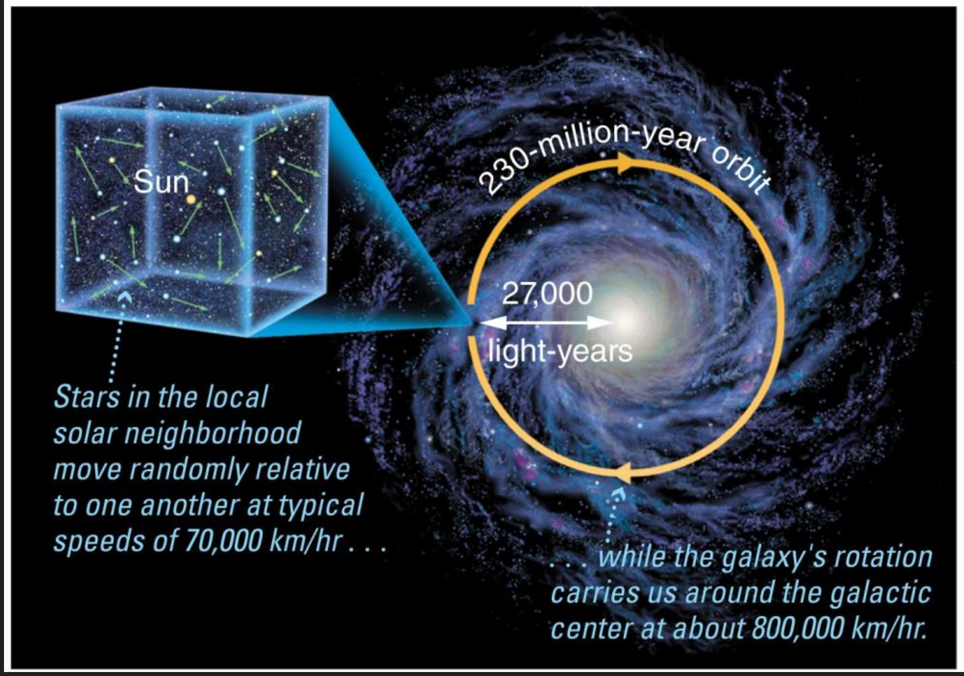
- Contrary to our perception, we are not "sitting still."
- Earth **orbits** the Sun (revolves) once every year:
  - at an average distance of 1 AU ≈ 150 million kilometers.
  - with Earth's axis tilted by 23.5° (pointing to Polaris)
- It rotates in the same direction it orbits, **counterclockwise** as viewed from above the North Pole.



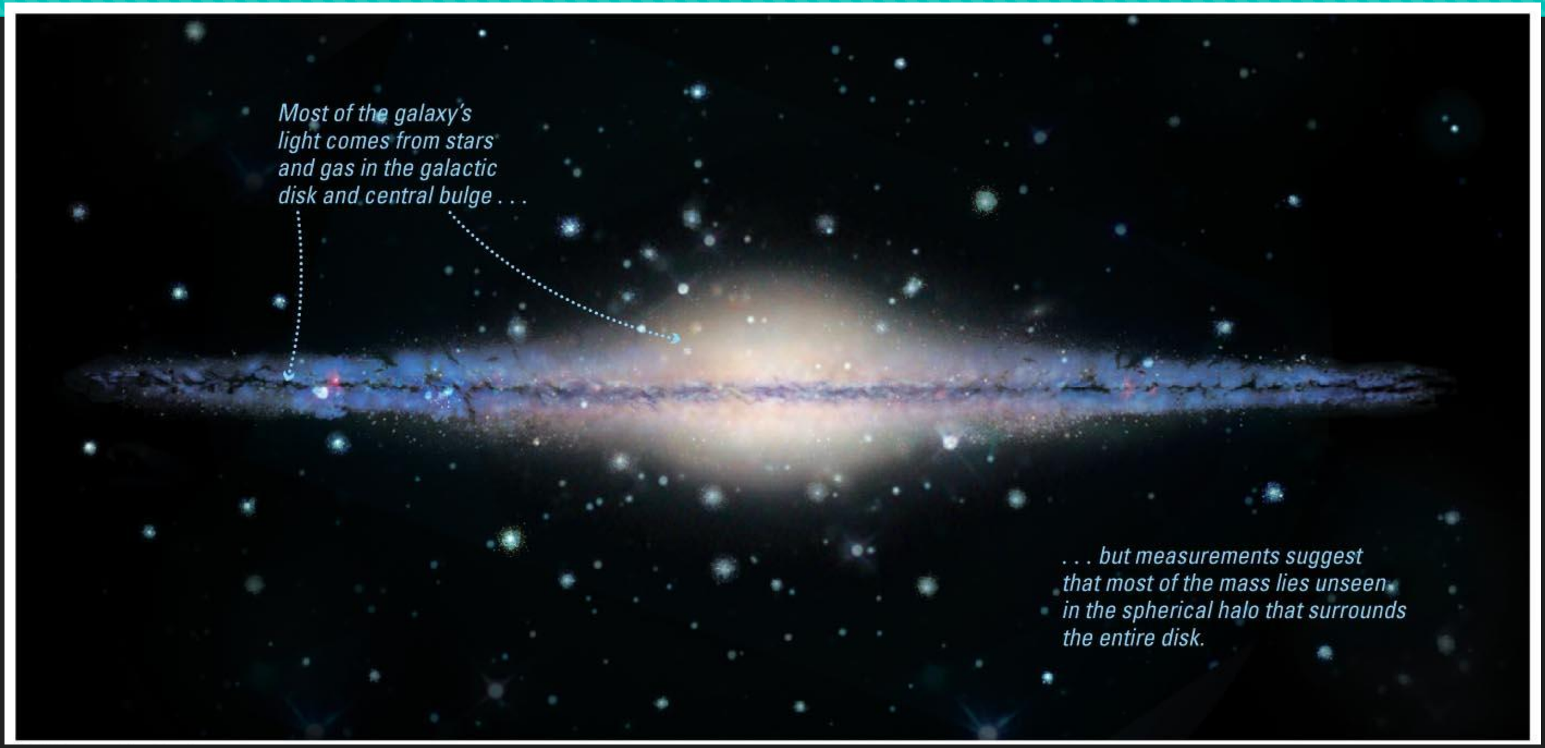
The Earth **rotates** around its axis once every day.

How is our Sun moving in the Milky Way Galaxy?

- Our Sun moves randomly relative to the other stars in the local solar neighborhood…
  - typical relative speeds of more than 70,000 km/hr
  - but stars are so far away that we cannot easily notice their motion
- … and orbits the galaxy every 230 million years.



How is our Sun moving in in the Milky Way Galaxy?



- More detailed study of the Milky Way's rotation reveals one of the greatest mysteries in astronomy:

Astronomical Units We Will Use in This Course

Astronomical Unit (AU)

- Is the Earth's average distance away from the Sun.
- 1AU = 150 million km = 93 million miles.
- Used to describe distances to objects within our solar system.

Light Year (ly)

- Is the *distance* light travels in one year.
- 1 ly = 9.46 trillion km = 5.88 trillion miles.
- Used to describe distances to stars and galaxies.

$$\boxed{1mi = 1.609\ km}$$

#7 Use your textbook appendix

Which of the following has astronomical distances listed in order from smallest to largest?

A. 1 AU, 1 light-year, the size of the solar system
B. 1 AU, the size of the solar system, 1 light-year
C. 1 light-year, 1 AU, the size of the solar system
D. the size of the solar system, 1 AU, 1 light-year

How has the study of astronomy affected human history?

- The Copernican revolution showed that Earth was not the center of the universe (Chapter 3).
- Study of planetary motion led to Newton's laws of motion and gravity (Chapter 4).
- Newton's laws laid the foundation of the industrial revolution.
- Modern discoveries are continuing to expand our "cosmic perspective."

Reading Quiz #1 topic