Chapter Twenty-Two: Stars and Galaxies
Lesson 4: Galaxies and the Universe

Galaxies: huge collections of stars

- The universe contains hundreds of billions of galaxies
    - Each galaxy contains hundreds of billions of stars

Gravity holds stars and galaxies together.

Dark matter: matter that emits no light at any wavelength

- Scientists hypothesize that 90% of the universe's mass is dark matter
- Scientists do not understand dark matter or what material makes it up.

<u>3 types of Galaxies:</u>

1. **Spiral Galaxies:**
    a. All stars, gas, and dust exist in spiral arms that begin at a central disk.
    b. Spiral galaxies are thicker near the center, a region called the central bulge.
    c. The spiral arms can be long and symmetrical or short and stubby.
    d. The Milky Way Galaxy is an example.
2. **Elliptical Galaxies:**
    a. Some galaxies are shaped like spheres (like a basketball) or can be more elliptical (like a football).
    b. Have a higher percentages of old, red stars.
    c. Scientists suggest that elliptical galaxies form by the gravitational merging of 2 or more spiral galaxies.
3. **Irregular Galaxies:**
    a. Oddly shaped
    b. Form from gravitational pull of neighboring galaxies.
    c. Contain many young stars and have areas of intense star formations

Gravity holds galaxies together in groups called clusters. Some clusters are enormous.

- Between superclusters are voids, which are regions of nearly empty space.

The Milky Way:

- Our solar system is part of the Milky Way Galaxy
- Member of the Local Group: a cluster of about 30 galaxies
- Scientists expect the Milky Way will merge with the Andromeda Galaxy (the largest galaxy in the Local Group) in about 3 billion years.

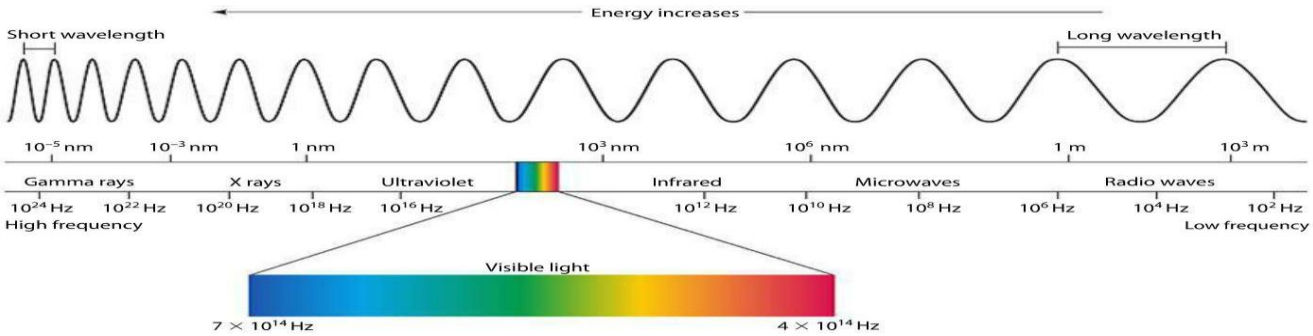
Big Bang Theory: the universe began from one point billions of years ago and has been expanding ever since

- Most scientists agree that the universe is 13-14 billion years old.
- At the beginning, the universe was dense and hot.
- As it cooled, stars formed and gravity pulled them into galaxies.
- As the universe expands, space stretches and galaxies move away from one another.

Doppler Shift: the shift to a different wavelength

- Think about a police car or ambulance
    - Coming towards you:
        - Shorter wavelength, higher frequency, and high sound
    - Going away from you:
        - Longer wavelength, low frequency, and low sound
- As the universe expands, galaxies more away from us making the light from the galaxy red-shifted.
    - Light is moving toward an object, the wavelength is shorter (violet light)
    - Light is moving away from an object, the wavelength is longer (red light)
- Thinking about the spectrum: band of the various colors of light
    - Red, Orange, Yellow, Green, Blue, and Violet
    - Red light: low frequency, long wavelength, and low energy
    - Violet light: high frequency, short wavelength, and higher energy

Electromagnetic Spectrum:



Dark Energy: scientists suggest a force called dark energy to be pushing the galaxies apart.

- Just like dark matter, dark energy is an active area of research.