- **Structure of the Universe**
  - The universe is space and all of the matter and energy within
  - Our solar system contains many planets which orbit the sun
  - Our sun is one of billions of stars which circle the center of the milky way galaxy
  - The milky way galaxy is one of billions of galaxies within the Universe
    - Three main types of galaxy are: spiral, elliptical, and irregular
  - Distances in the Universe are so vast that light years are used as a unit of measure
    - Light (c) is the fastest thing in the Universe at 300,000,000 meters/ second
    - Light Year (ly) is the distance light travels in one year; it is a measure of distance not time
- **Stars**
  - Stars are large bodies of gas which are held together by gravity. Stars begin in a nebula, which is a large cloud of gas and dust, and turn into a star as nuclear fusion begins near the center of the contracted cloud.
  - Main sequence stars are medium sized stars (our sun is a main sequence star)
  - Main sequence stars turn into Red giant stars near the end of their lifespan
  - Death of stars
    - Low mass stars can collapse into white dwarf stars
    - Large stars die with a super nova; and some eventually collapse into a neutron star or a black hole
  - The luminosity of a star is its brightness. Brightness can be measured by apparent magnitude or absolute magnitude.
  - HR-Diagrams plot stars on a graph by their temperature and luminosity
- **Observing the Universe**
  - Energy travels through the universe in electromagnetic waves. The electromagnetic spectrum includes all wavelengths from large radio waves to microwaves, visible light, and the smallest x-rays and gamma rays
  - Telescopes can be made to detect the different wavelengths of the spectrum
  - The Doppler effect is a change in the apparent wavelengths or frequencies of energy based on the motion of the object producing the energy
  - The Red Shift & Blue Shift of light occurs due to the Doppler Effect; and allows us to determine if galaxies are moving away from us or towards us.
  - Spectroscopes can be used to detect the composition of distant stars and galaxies as each element uniquely absorbs and emits certain wavelengths of light

Theories of the universe

- For much of history, Earth was thought to be at the center of the Universe
- **Flat Earth** – an archaic theory that the Earth is flat and disk shaped.
    - By 250 BC Greek mathematician Eratosthenes, who new that the Earth was round, was able to calculated the circumference of the Earth very accurately
- **Ptolemy theory**: Claudius Ptolemy, a Greek mathematician (140-150 AD) stated that all things circle the Earth: Evidence was the observations of everything which seem to circle the Earth as they move across the sky
- **Copernicus Universe Theory**: Nicolas Copernicus (Polish astronomer & mathematician) (1512). The first theory that did not have the Earth at the Universe's center. In this theory all things circled the sun in circular orbits: Evidence was mathematical and based on observations of the sun and planets
- **Kepler Universe Theory** Johannes Kepler (German astronomer) (1609) stated that the planets orbit the sun in elliptical orbits (The sun was still considered the center of the universe) Evidence was mathematical models and observations of the planets
- **Thomas Wright:** In 1750 Thomas Wright (English astronomer) suggested that our solar system is one of many within the milky way galaxy, and that many faint cloudy spots are incredibly distant galaxies
- **Big Bang Theory** (1927) George Lemaitre (Belgian priest and physicist) Using Albert Einstein's equations, Lemaitre proposed that the universe is expanding outward and most galaxies are moving away from one another. If galaxies are expanding outward then they must have been close together at one time. He proposed that everything in the universe was once contained within a very small area and then suddenly expanded rapidly, creating the universe.
    - Estimates of the age of the universe range from 13 to 15 billion years
    - Edwin Hubble provided the 1st observational evidence of the big bang theory
    - Current evidence includes; redshift from distant galaxies, the abundance of light elements in the universe, and cosmic background radiation.
- Expanding on the Big Bang theory
    - **Freidman Hypothesis**: Alexander Freidman (Russian physicist) suggested the mutual attraction of everything, due to gravity, will slow the expanding universe until it stops, and begins to contract into a Big Crunch: no evidence
    - **Oscillating Universe**: Freidman, Einstein, & Tolman suggested that the universe could go through infinite big bangs and crunches. no evidence
    - **Inflationary Universe**: Alan Guth (American physicist) (1980): Mathematical theory which describes exponential expansion of the early universe
    - Current evidence suggests that the universe is not slowing down; but speeding up. Most galaxies are moving away from us; and the further away they are, the faster they appear to be moving.