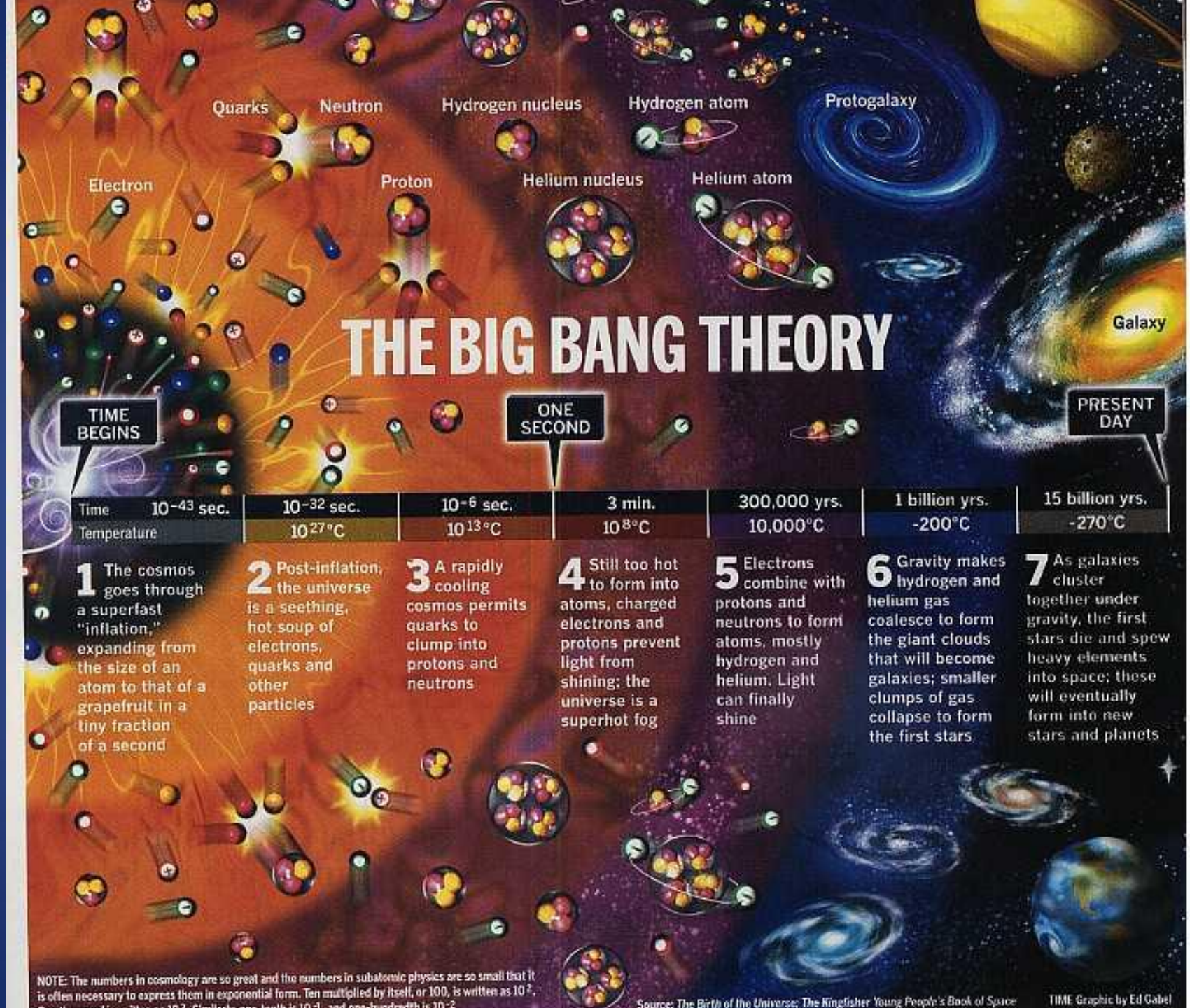
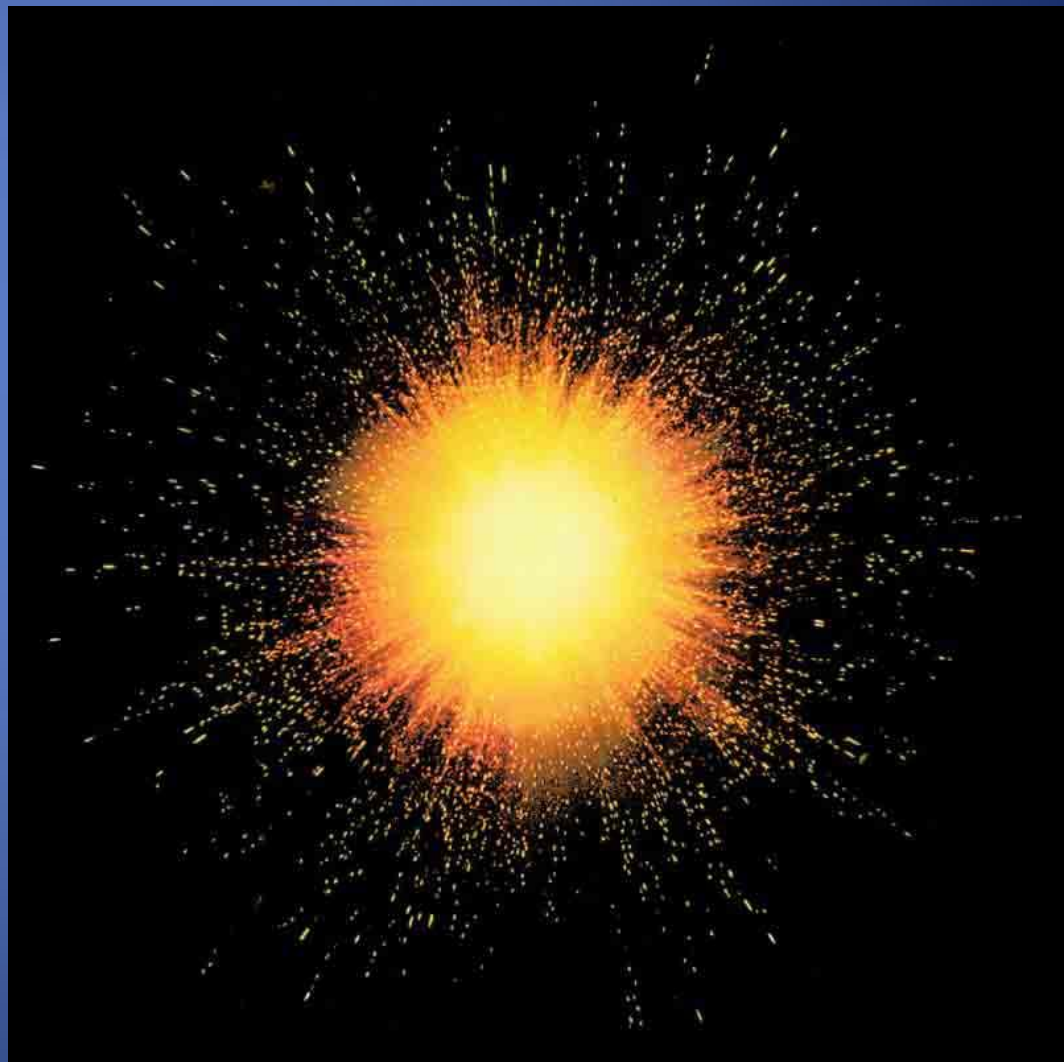

THE BIG BANG THEORY
Quarks
Neutron
Hydrogen nucleus
Hydrogen atom
Protogalaxy
Electron
Proton
Helium nucleus
Helium atom
Galaxy
TIME BEGINS
ONE SECOND
PRESENT DAY
Time 10^{-43} sec. | 10^{-32} sec. | 10^{-6} sec. | 3 min. | 300,000 yrs. | 1 billion yrs. | 15 billion yrs.
Temperature 10^{27}°C | 10^{13}°C | 10^{8}°C | 10,000°C | -200°C | -270°C
1 The cosmos goes through a superfast "inflation," expanding from the size of an atom to that of a grapefruit in a tiny fraction of a second
2 Post-inflation, the universe is a seething, hot soup of electrons, quarks and other particles
3 A rapidly cooling cosmos permits quarks to clump into protons and neutrons
4 Still too hot to form into atoms, charged electrons and protons prevent light from shining; the universe is a superhot fog
5 Electrons combine with protons and neutrons to form atoms, mostly hydrogen and helium. Light can finally shine
6 Gravity makes hydrogen and helium gas coalesce to form the giant clouds that will become galaxies; smaller clumps of gas collapse to form the first stars
7 As galaxies cluster together under gravity, the first stars die and spew heavy elements into space; these will eventually form into new stars and planets
NOTE: The numbers in cosmology are so great and the numbers in subatomic physics are so small that it is often necessary to express them in exponential form. Ten multiplied by itself, or 100, is written as 10^2,
Source: The Birth of the Universe; The Kingfisher Young People's Book of Space
TIME Graphic by Ed Gabel

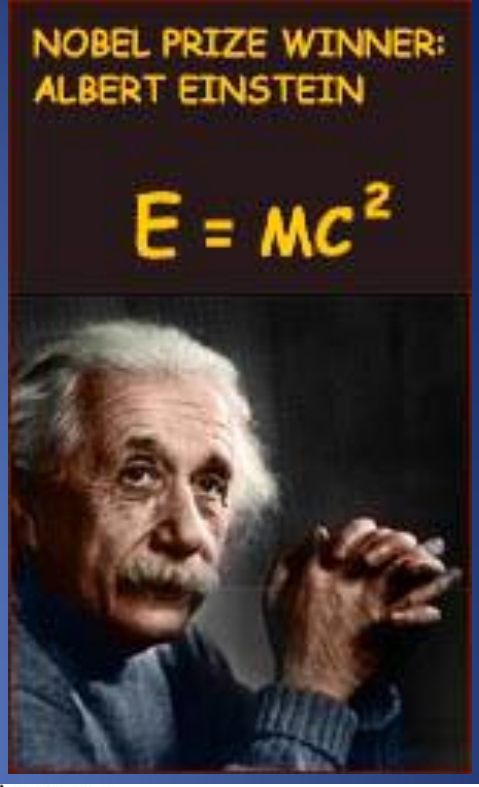
Time begins

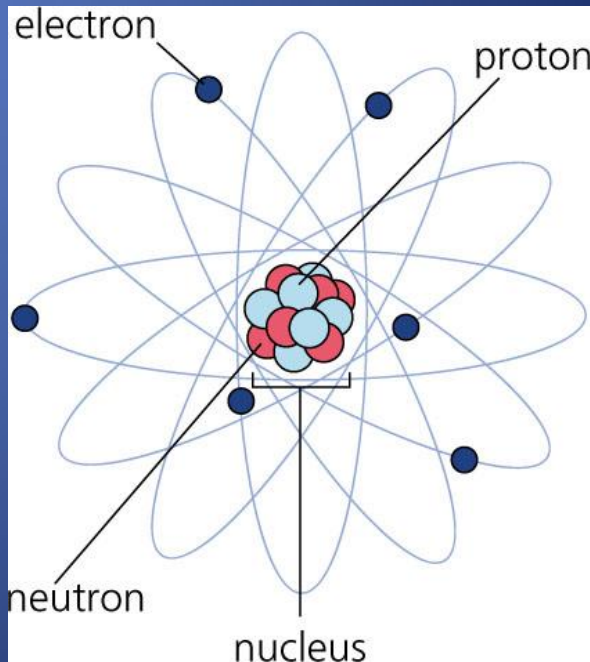
- The universe begins ~13.7 Billion years ago
- The universe begins as the size of a single atom
- The universe began as a violent expansion
  - All matter and space were created from a single point of pure energy in an instant



~ 3 minutes after big bang

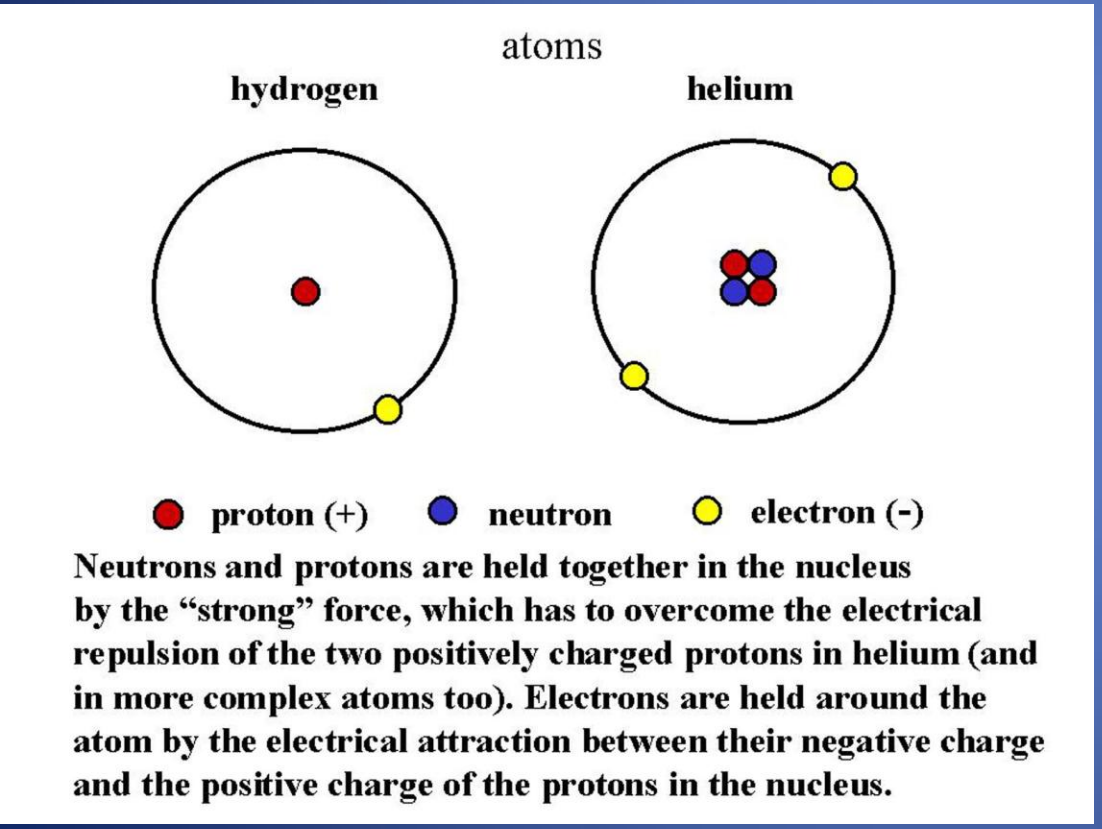
- The universe has grown from the size of an atom to larger than the size a grapefruit
- $E=mc^2$
- energy froze into matter according to Albert Einstein's equation.
- This basically says that like snowflakes freezing, energy forms matter into clumps that today we call protons, neutrons and electrons.
- These parts later form into atoms





~ Several hundred thousand years

after Big Bang



- ATOMS form (specifically Hydrogen and its isotopes with a small amount of Helium.)
- The early Universe was about 75% Hydrogen and 25% Helium. It is still almost the same today.

~200 to 400 million years

after Big Bang

- 1st stars and galaxies form

~ 4.6 billion years ago

- Our Solar system forms

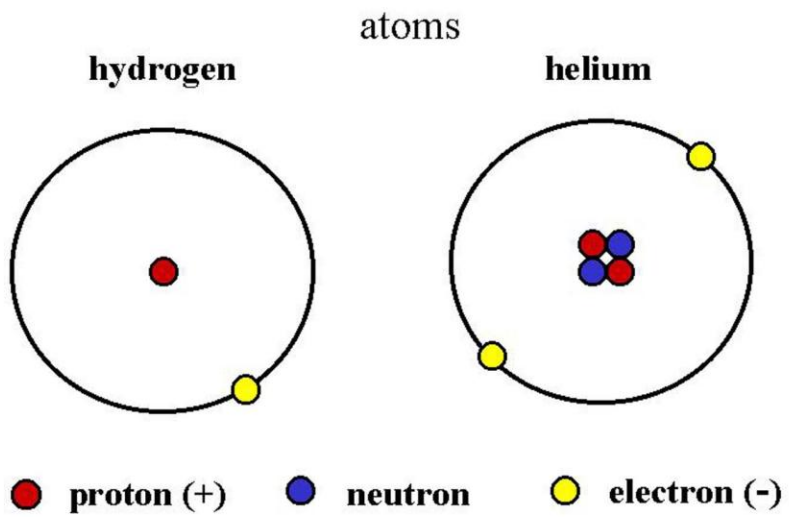
Misconceptions about the Big Bang

- there was no explosion; there was (and continues to be) an expansion
  - Rather than imagining a balloon popping and releasing its contents, imagine a balloon expanding: an infinitesimally small balloon expanding to the size of our current universe
- we tend to image the singularity as a little fireball appearing somewhere in space
  - space began inside of the singularity. Prior to the singularity, *nothing* existed, not space, time, matter, or energy - nothing.

Big Bang Timeline – Include, label and color

1. What happened
2. When each event (thing) happened

- Big Bang – energy
- Matter
  - E=mc2
    - protons
    - Neutrons
    - electrons
- Atoms
  - Hydrogen
  - helium
- Stars and galaxies
- Our solar system
  - Sun and all planets
- Earth (present day)



Neutrons and protons are held together in the nucleus by the "strong" force, which has to overcome the electrical repulsion of the two positively charged protons in helium (and in more complex atoms too). Electrons are held around the atom by the electrical attraction between their negative charge and the positive charge of the protons in the nucleus.

Big Bang evidence

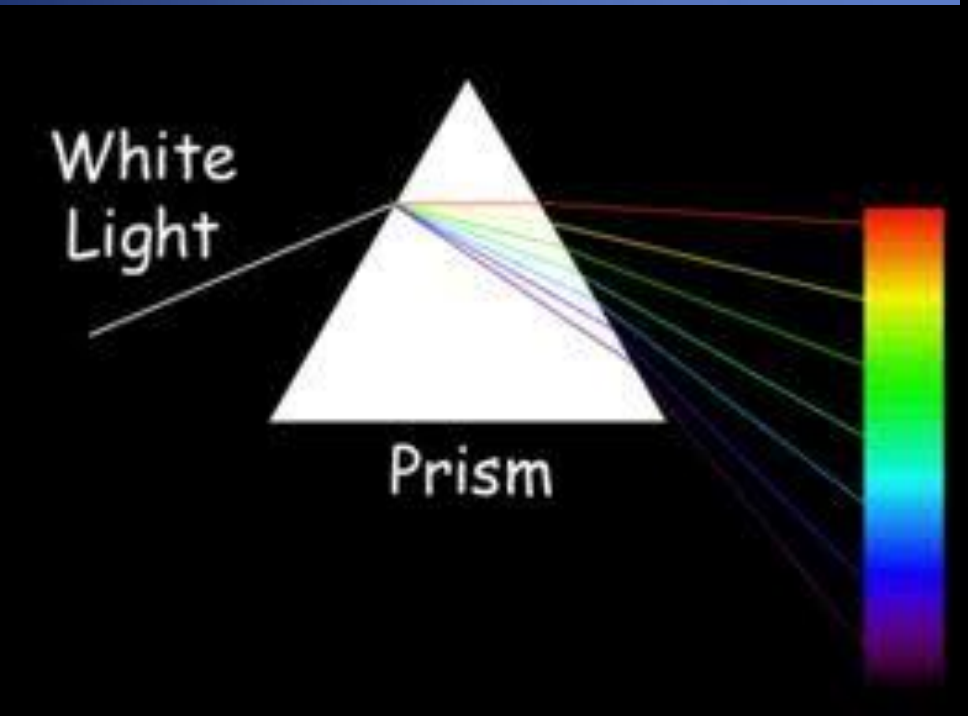
1) Universal expansion and Hubble's Law
2) 3 degree background radiation
3) Quasars
4) Radioactive decay
5) Stellar formation and evolution
6) Speed of light and stellar distances

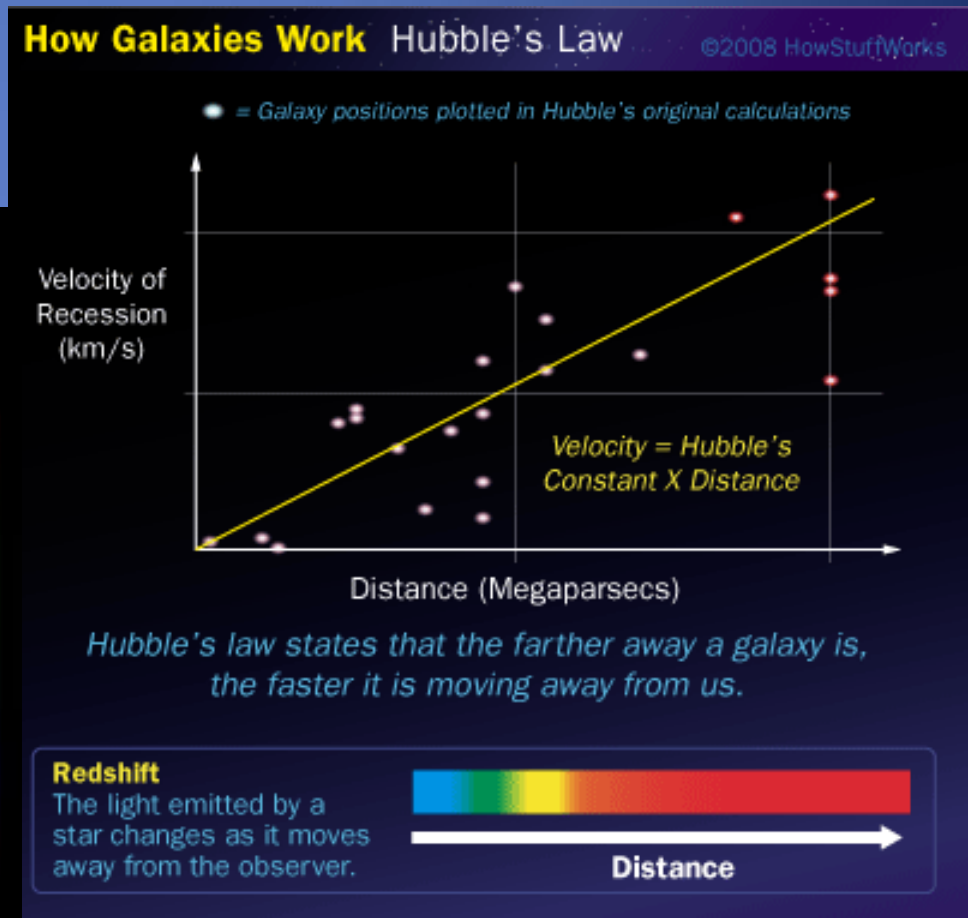
1. Universal expansion and Hubble's Law

a) Hubble observed the majority of galaxies are moving away from us and each other

b) The farther, the faster they move

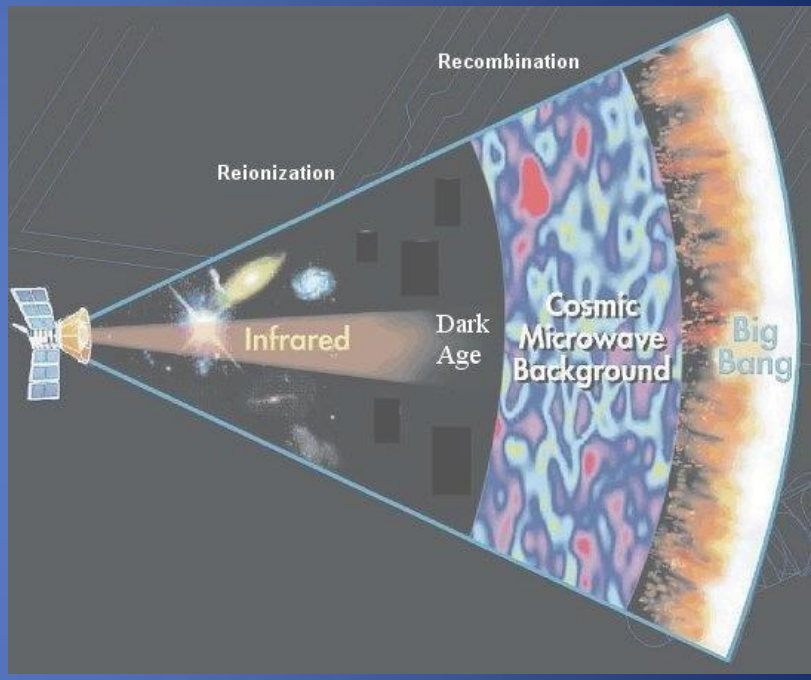
c) Red Shift





2. Back ground radiation

a) Noise radiation (static) is evenly spread across space
b) The amount of radiation matched predictions
c) C.O.B.E satellite confirmed for the entire universe that noise radiation (static) is evenly spread
d) Law of conservation of energy (energy can neither be created or destroyed) – energy remains constant over time

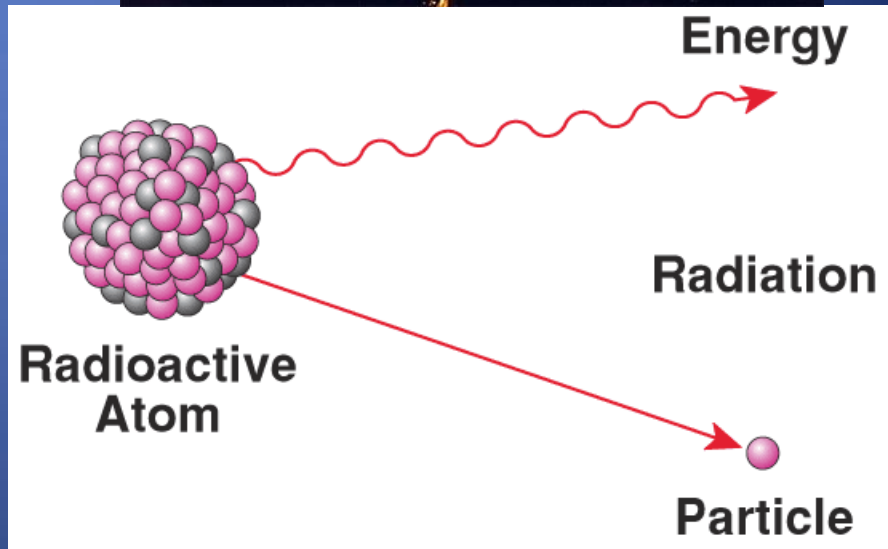


3. Quasars - super large (solar system size) galactic cores that put out more light than whole galaxies

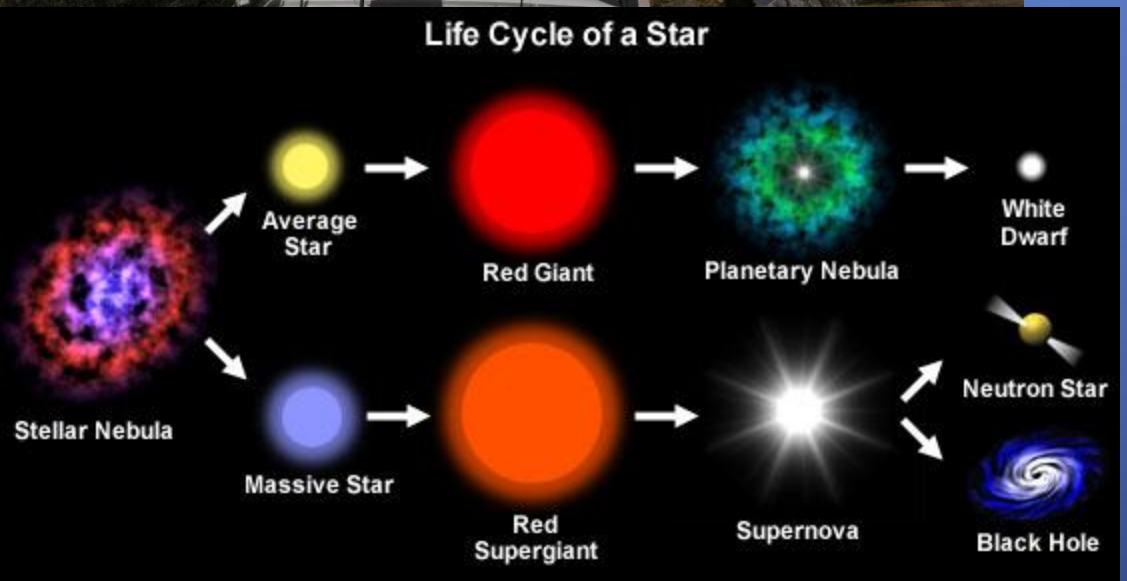
- Only found 10-15 billion light years away
- Found nowhere else
- Nothing exists past them

4. Radioactive decay

- Radiometric dating – gives us the age of items from the decay of radioactive materials found within the object
- Moon rocks have been dated and found to be older than Earth
  - Gives us an estimated time that Earth and the Moon formed

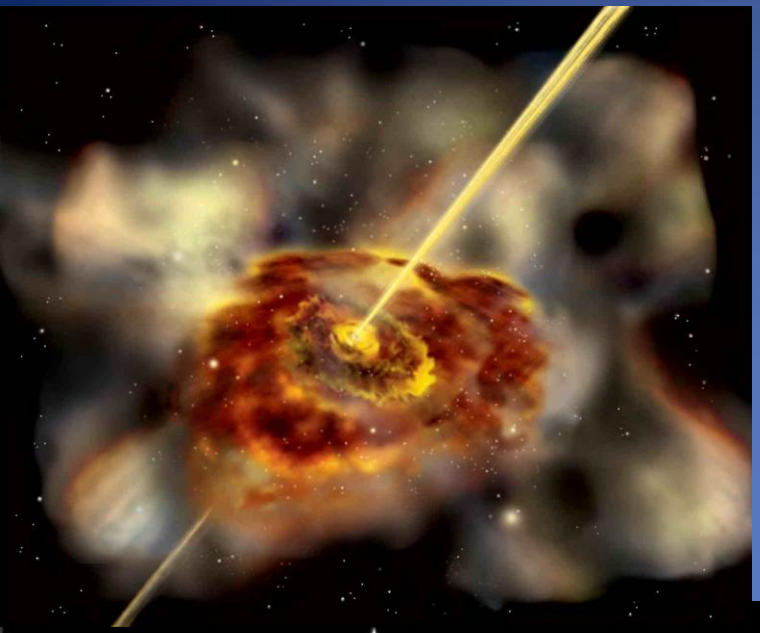


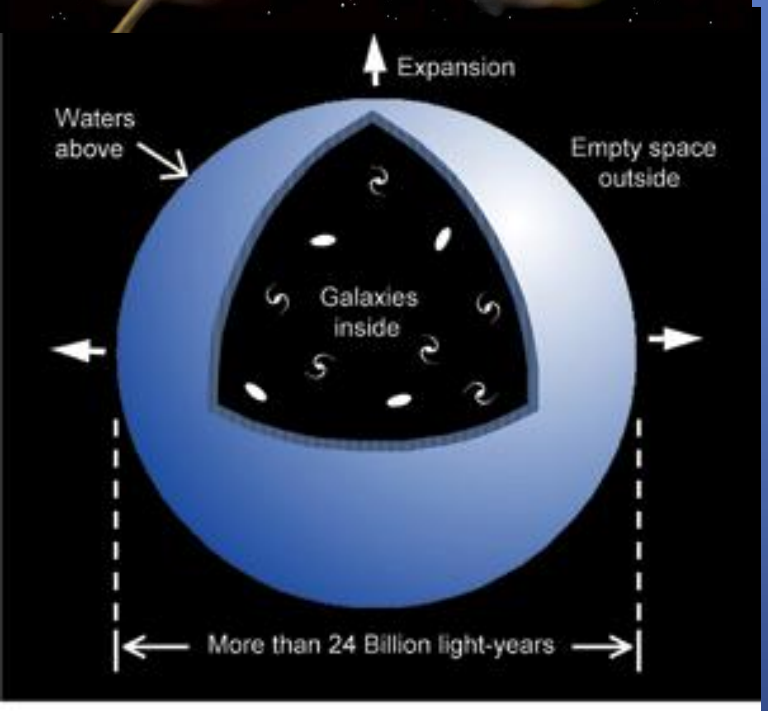
5. Stellar formation and evolution



- We observe the life cycles of stars across the universe using tools such as satellites and telescopes
- we view stars form, burn and explode

6. Speed of light and stellar distances





- The speed of light is a universal constant of 300,000 km/s2
- We observe stars millions/billions of light-years away
- A light-year is the distance that light travels in 1 year – the light we see today from a star 500 light years away is 500 years old
- The furthest stars away are 10-15 billion light years away
- We have telescopes that can see further, but there isn't anything viewable

LASTLY – we are pretty sure everything has a beginning, right?