Bell Ringer

1. What is the first step in the scientific process?
2. What would you want to do after you perform an experiment, but before you make your conclusions?
3. What is the difference between a theory and a hypothesis?
4. (To get started on todays topic) – How did the universe begin?

Bees

Science Matters

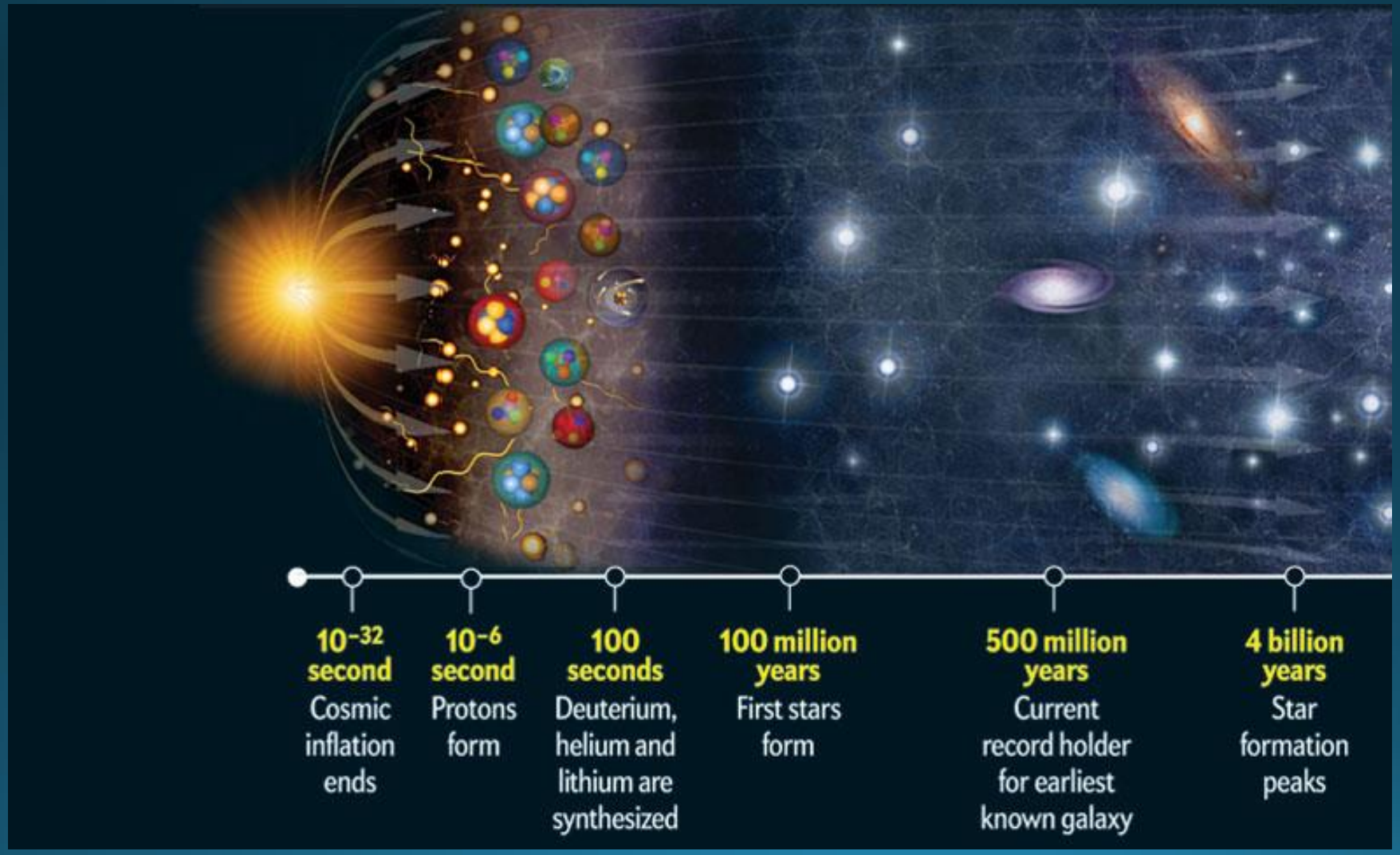
Bees never poop in their hives

- Bees stay in their hives during the winter.
- And they hold it…
- It's a natural instinct to keep their hives clean.
- Openings in the hive are coated by worker bees with an anti-bacterial and anti-fungal glue like fluid.
- Once spring arrives, they all exit and participate in a 'Cleansing Flight'.

Why this matters?

- Bees don't have an immune system like we do.
- But they have natural fluids that act as an antibacterial and an antifungal.
- They also use behavioral traits to protect themselves.
- By studying the bee, we are able to find a good antibacterial and develop good habits.

The Big Bang Theory



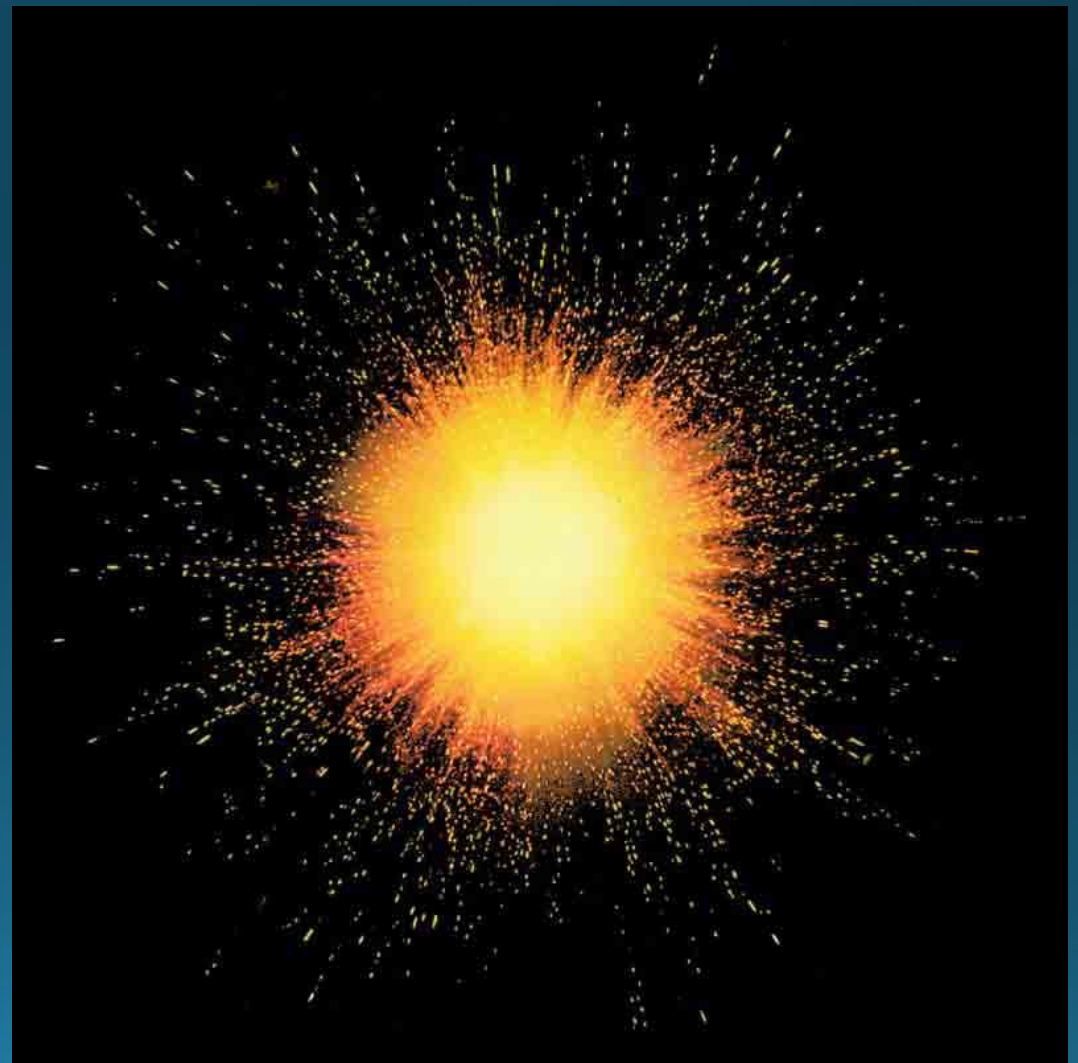
Review:

- What's a theory?
- Our best guess that's been repeatedly tested.

Time begins

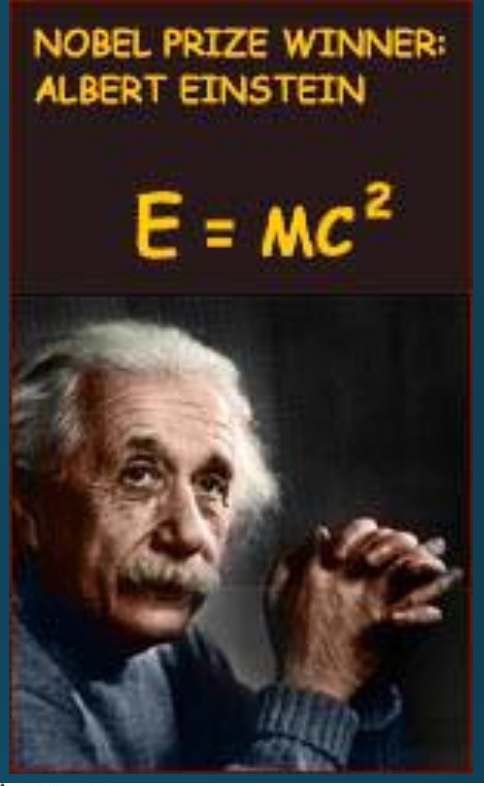
- The universe begins ~13.7 Billion years ago
- The universe begins as the size of a single atom

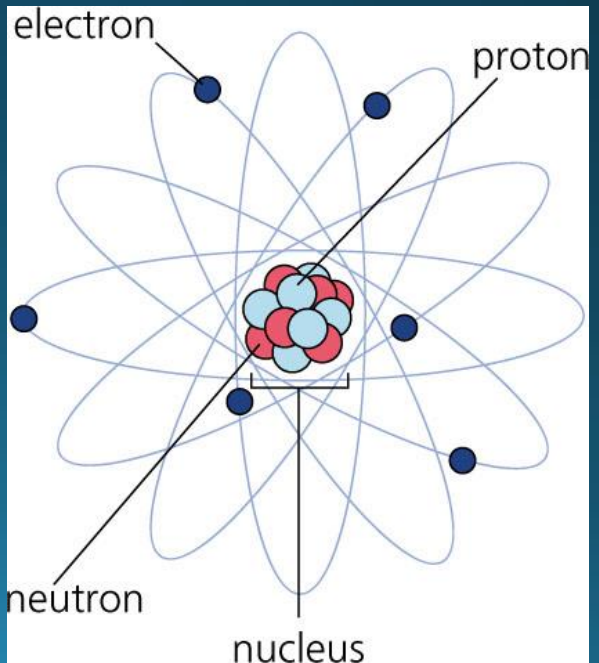
- The universe began as…
- a violent expansion
  - All matter and space were created from a single point of pure energy in an instant



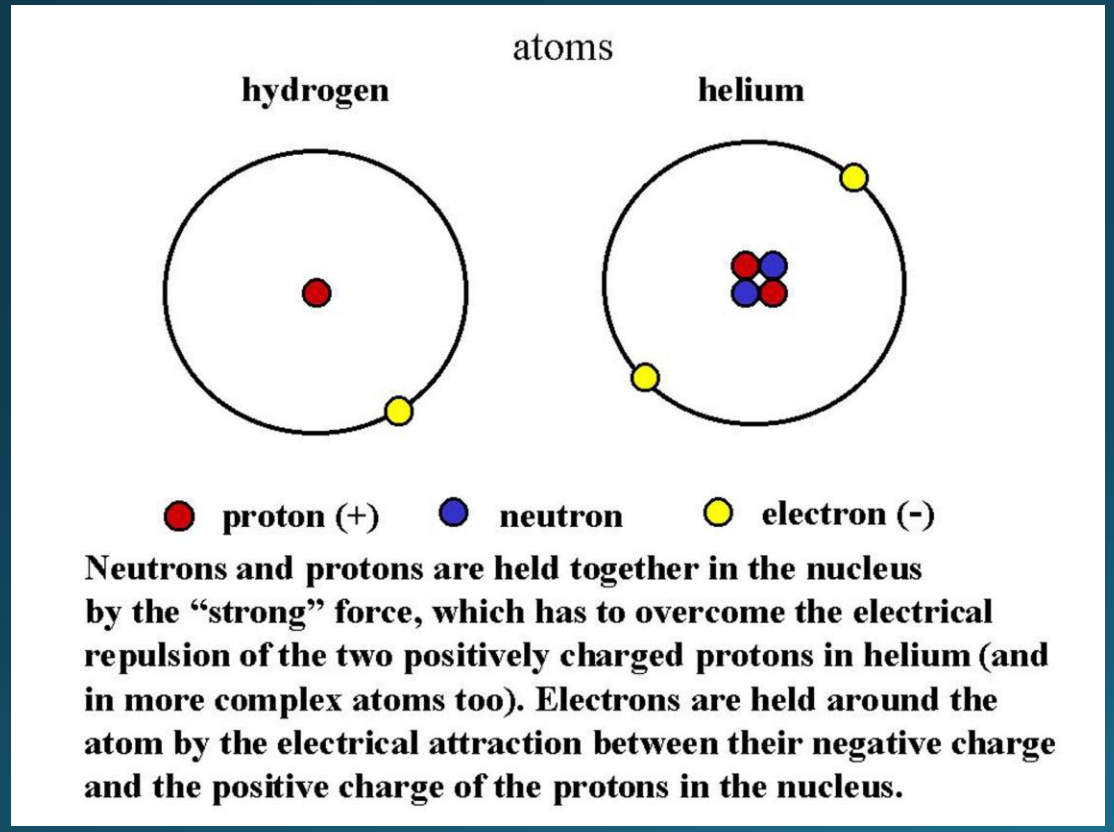
3 minutes after big bang

- The universe has grown from the size of an atom to larger than the size a grapefruit
- $E=mc^2$
- Energy converts into matter according to Albert Einstein's equation. Protons, neutrons, electrons
- Examples of matter to energy?
- Nuclear reactions.
- Burning wood to ash.
- Opposite happened at beginning of universe





Several hundred thousand years after Big Bang



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.

- ATOMS form (specifically Hydrogen 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

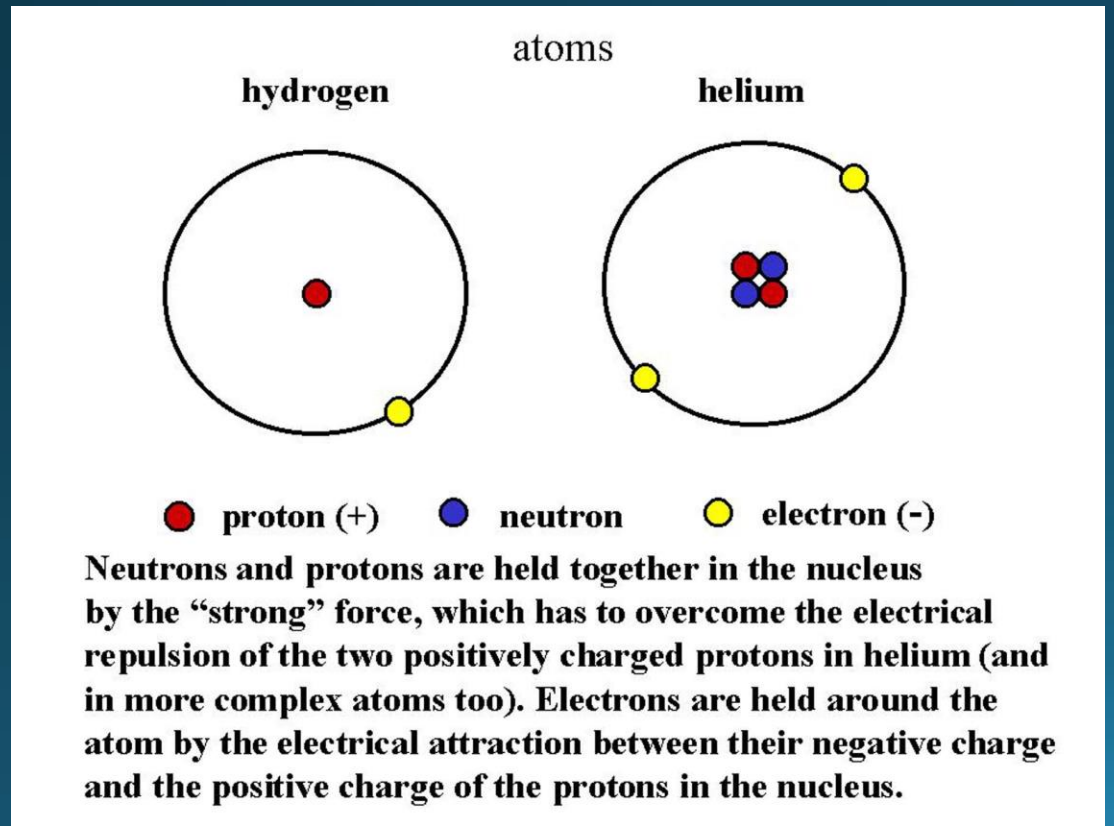
Misconceptions about the Big Bang

- 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.
- I don't like thinking of this so lets move on…

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)

Remember: Theory = a hypothesis that's been tested over and over.

We have evidence.

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 (the person) observed that the majority of galaxies are moving away from us and from each other

b) The farther they are from us, the faster they are moving

c) Red Shift

Balloon Activity

- What You Need:
- 12-inch (30-cm) round latex balloon
- A permanent felt-tip marking pen
- 24-inch (60-cm) piece of string
- Metric ruler

Balloon Activity

What to Do:

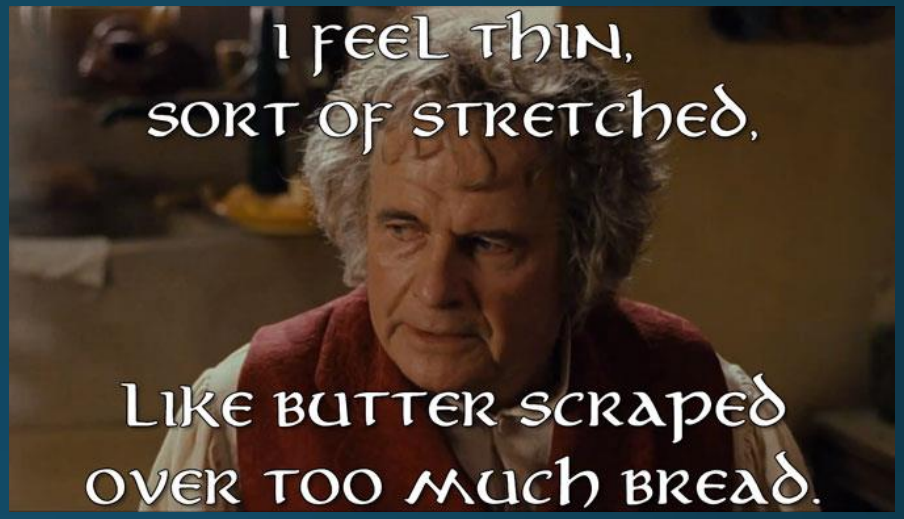
- 1. Inflate your balloon until it is about 4 inches (10 cm) in diameter, but do not tie the end.
- 2. Using the felt-tip marker, make six dots on the balloon in widely scattered locations. Label one dot "home" and the others A-E. The home dot represents the Milky Way galaxy, and the others represent galaxies formed in the early universe.
- 3. Without letting air out of the balloon, use the string and ruler to measure the distance from home to each dot. Record the distances in the worksheet table under the heading "Time 1."
- 4. Inflate the balloon so that its diameter is about 2 inches (5 cm) bigger. Again measure the distances to each of the dots, and record the distances under "Time 2" on the worksheet.
- 5. Inflate the balloon in 2-inch (5-cm) increments **three more times**. After each inflation, measure and record the distances on the worksheet.

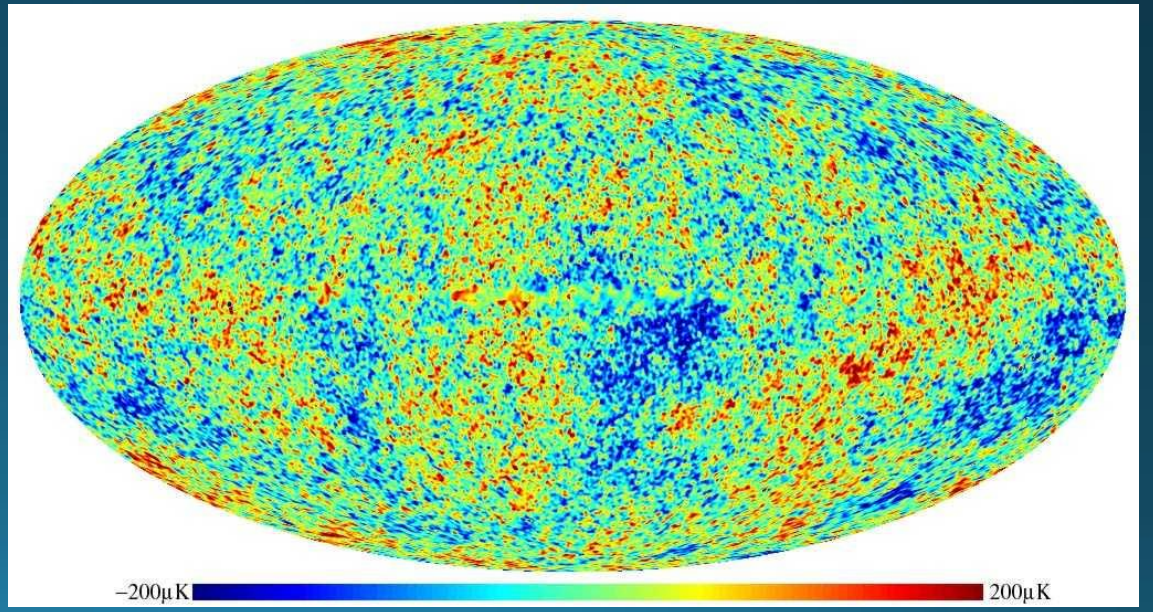
Post-lab questions:

1. How did the distance from the home dot to each of the galaxies change each time you inflated the balloon?
2. Did the galaxies near 'home' or those farther away appear to move the greatest distance?
3. Some scientists predict a 'Big Crunch' in the future, a possibility where all of space collapses back in. What would this look like using this same balloon model?

2. Back ground radiation

a) Noise radiation (static) is evenly spread across space
b) The amount of radiation matched predictions
c) Law of conservation of energy (energy can neither be created or destroyed) – energy remains constant over time



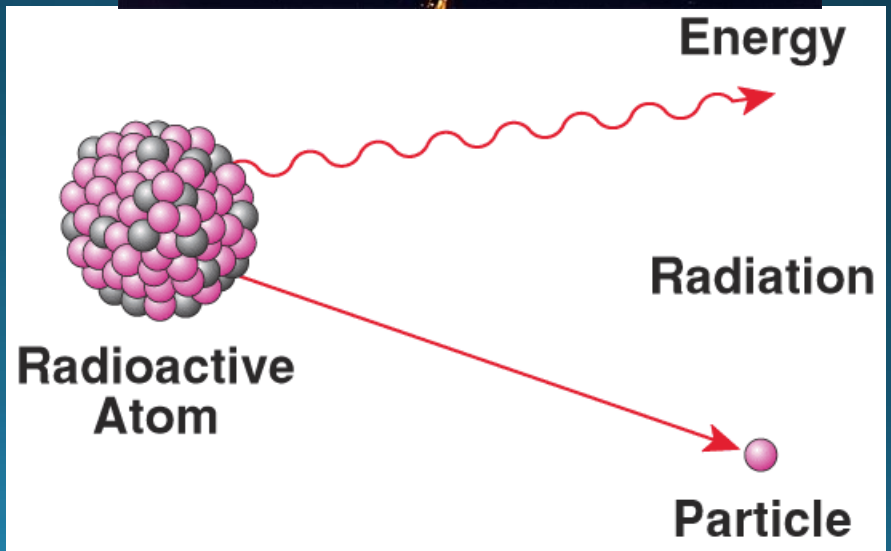


3. Quasars - super large (solar system size) galactic cores that put out more light than whole galaxies

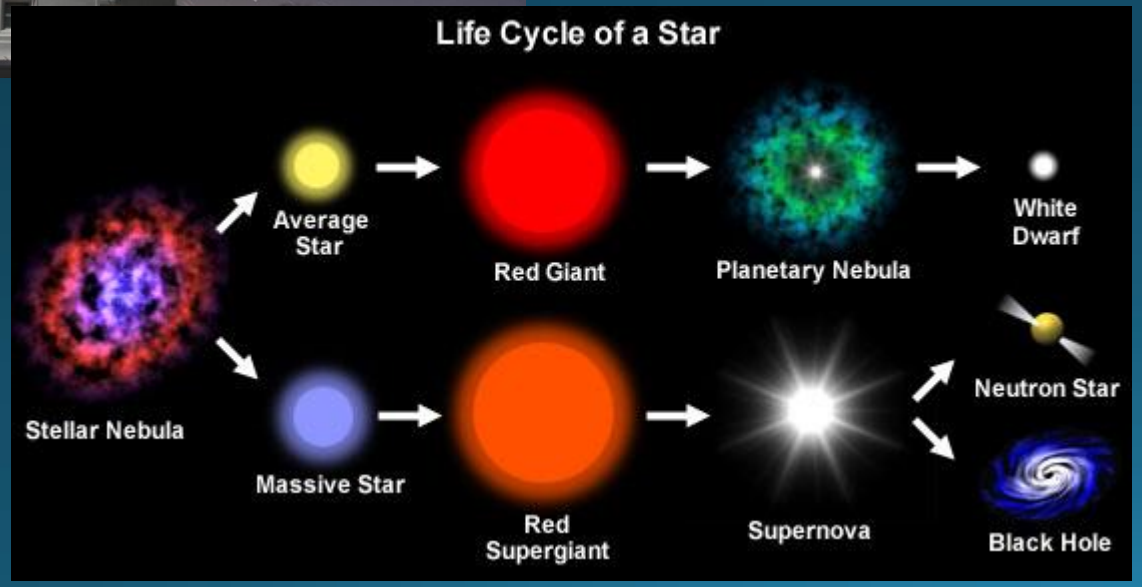
- Only found 10-15 billion light years away (Why is this significant?)
- Found nowhere else
- Nothing exists past them
- These are the first galaxies to have existed.

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 rocks on Earth.
  - Gives us an estimated time that Earth and the Moon formed

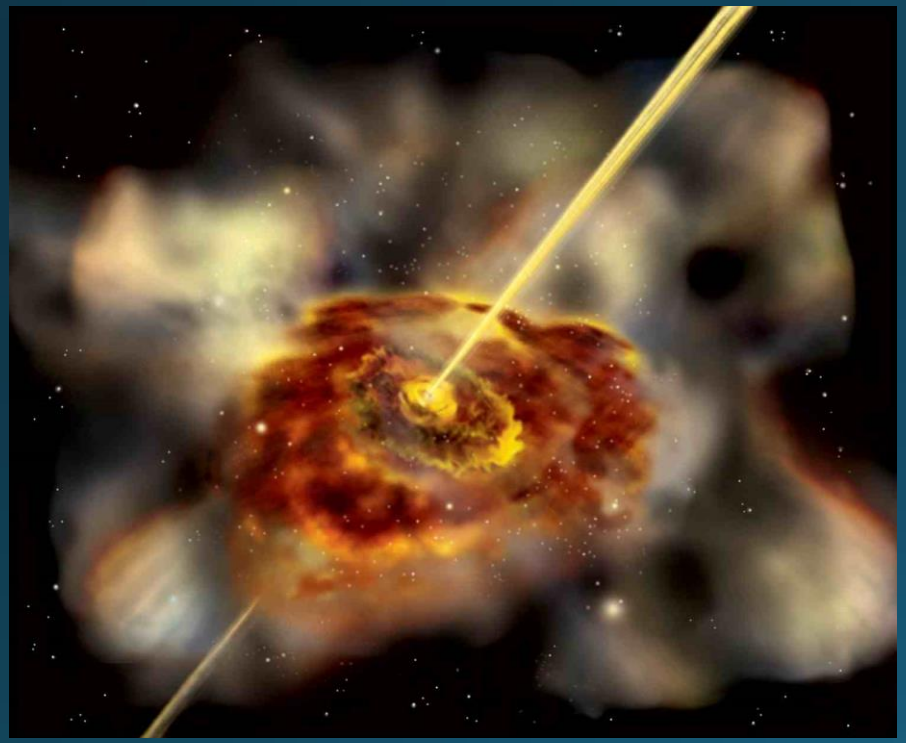


5. Stellar formation and evolution



- We observe the life cycles of stars across the universe using tools such as satellites and telescopes
- We view stars form, burn and explode
- Remember: Far away = back in time.
- Galaxies closer to us have older stars. Galaxies far from us have newer stars just being formed.

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?