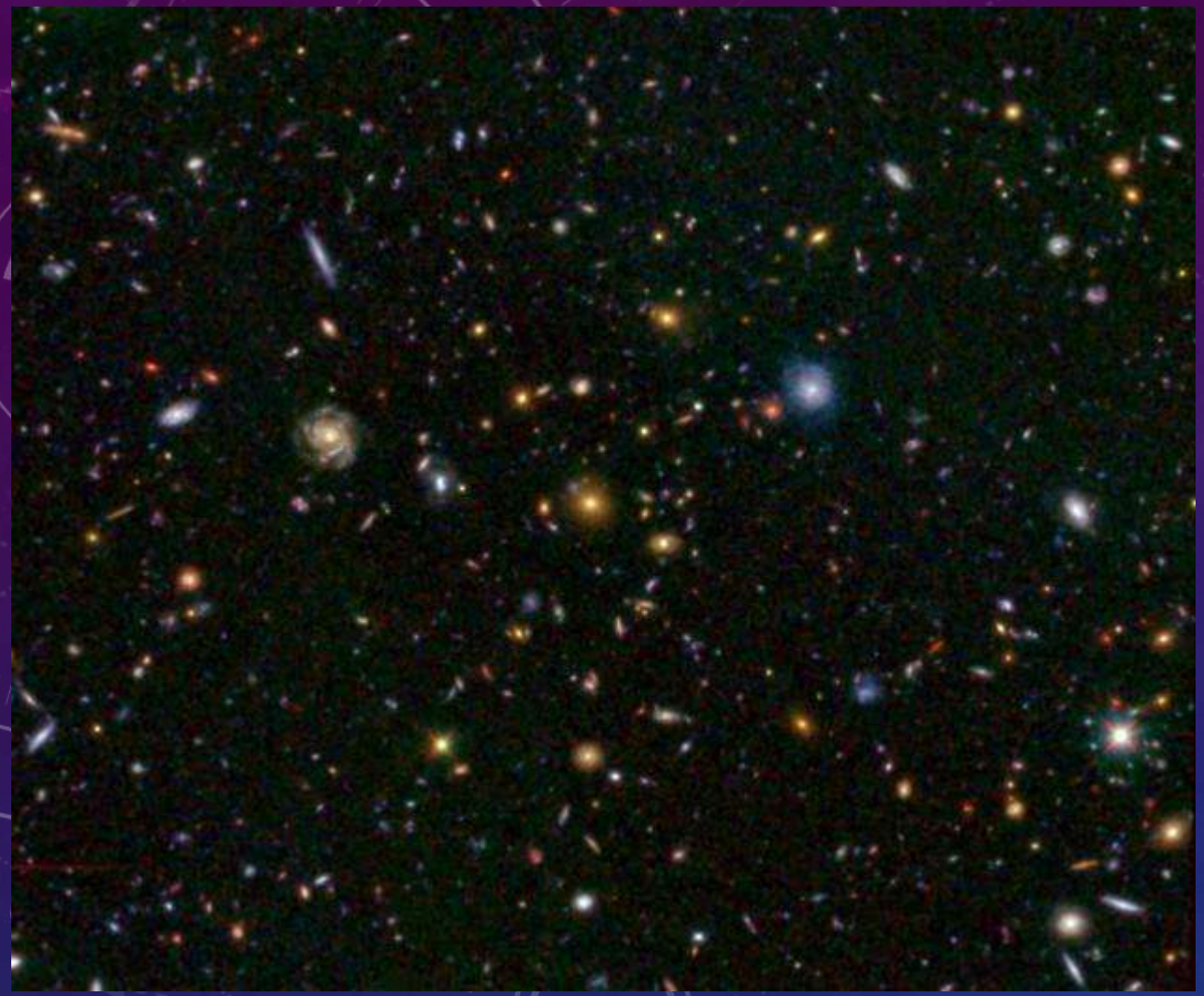
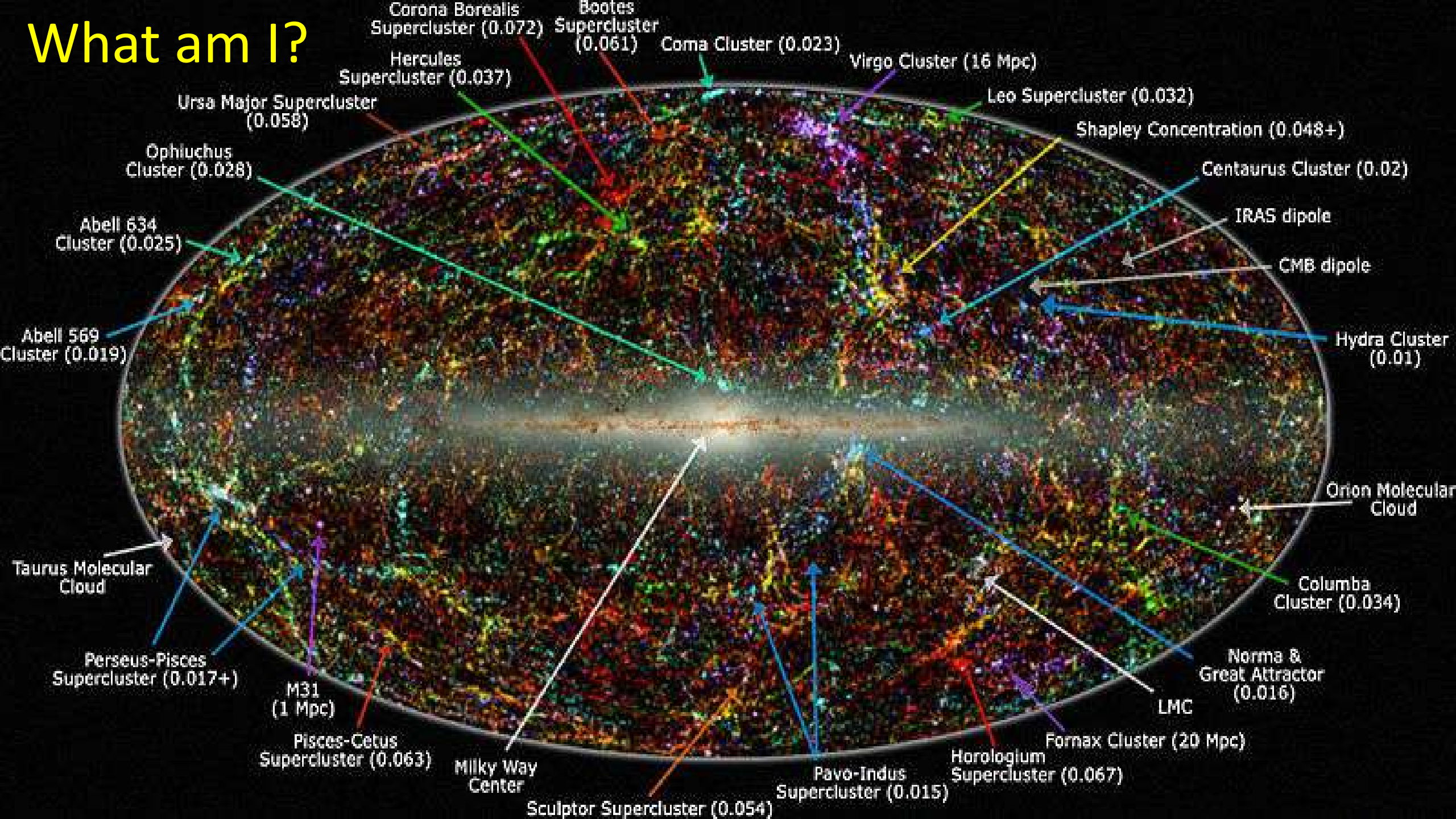


THE UNIVERSE

25.3 NOTES

What am I?


Corona Borealis Supercluster (0.072)
Bootes Supercluster (0.061)
Coma Cluster (0.023)
Hercules Supercluster (0.037)
Virgo Cluster (16 Mpc)
Ursa Major Supercluster (0.058)
Leo Supercluster (0.032)
Shapley Concentration (0.048+)
Ophiuchus Cluster (0.028)
Centaurus Cluster (0.02)
Abell 634 Cluster (0.025)
IRAS dipole
CMB dipole
Abell 569 Cluster (0.019)
Hydra Cluster (0.01)
Orion Molecular Cloud
Taurus Molecular Cloud
Columba Cluster (0.034)
Perseus-Pisces Supercluster (0.017+)
Norma & Great Attractor (0.016)
M31 (1 Mpc)
LMC
Pisces-Cetus Supercluster (0.063)
Fornax Cluster (20 Mpc)
Milky Way Center
Horologium Supercluster (0.067)
Pavo-Indus Supercluster (0.015)
Sculptor Supercluster (0.054)

Do you think it's likely that there is life elsewhere? What about intelligent life?

Take every pebble, every stone, and every grain of sand on Earth, and you still don't have the number of stars in the sky. So with that many stars, what are the chances of another planet like ours?

Right now we are concentrating our search within about seventy-five light-years, to collect enough light to find planets that are tiny in comparison to their stars. Intelligent life is an interesting question. The answer depends on a lot of different assumptions. How long does life need to become intelligent? How long does intelligent life survive?

Planet Hunter Lisa Kaltenegger

It is hard to know when we only have a sample of one, our own Earth.

I'm assuming we want to define ourselves as intelligent! We are just starting to find planets that are small enough to have rocky surfaces and liquid water, and thus could be habitats. But if you think of Earth's history of about 4.5 billion years and draw this time on a 24-hour clock, humans come on the scene about 38 seconds before midnight. If you want humans with technology, it is only a fraction of a second on the clock.

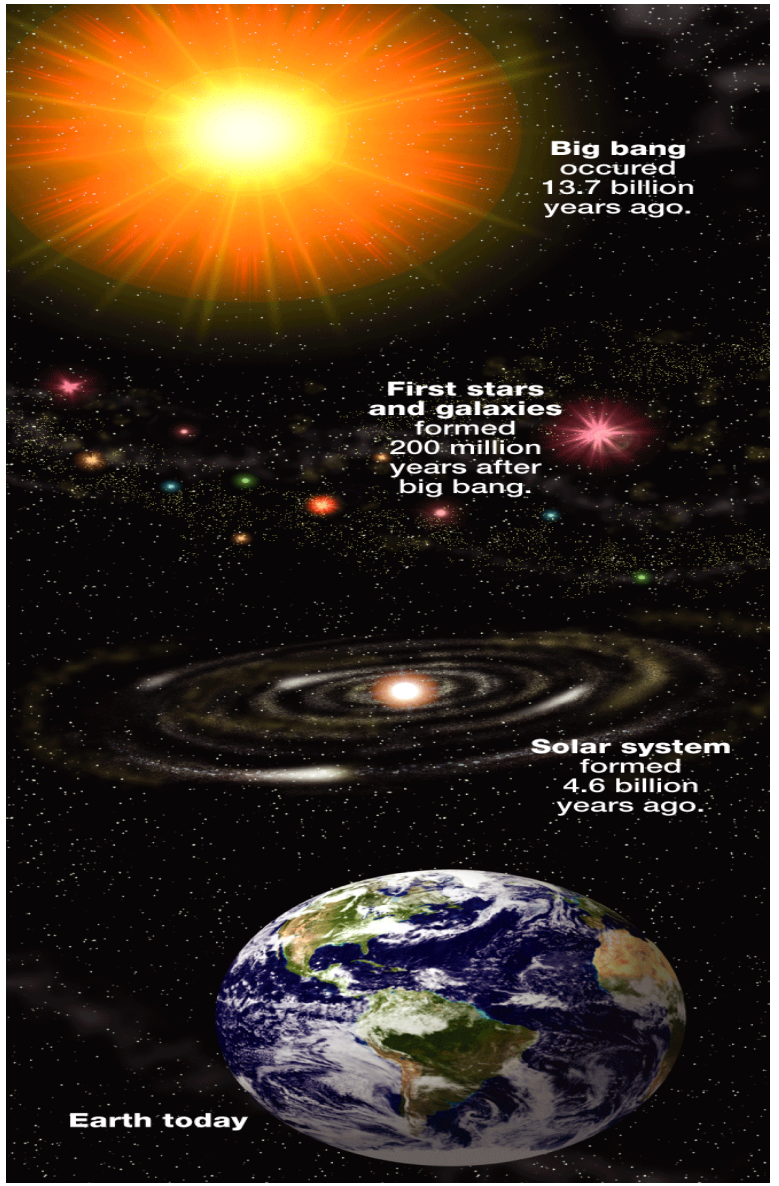
So finding a planet that is a) nearby, b) like ours, and c) in the same evolutionary stadium? It will be tricky. But who knows, maybe we will get lucky. It is a big open question. What do you think?

STEPHEN HAWKING - THE EXPANDING UNIVERSE

HTTPS://YOUTU.BE/DCLEXO0PCZ4 (4:13)

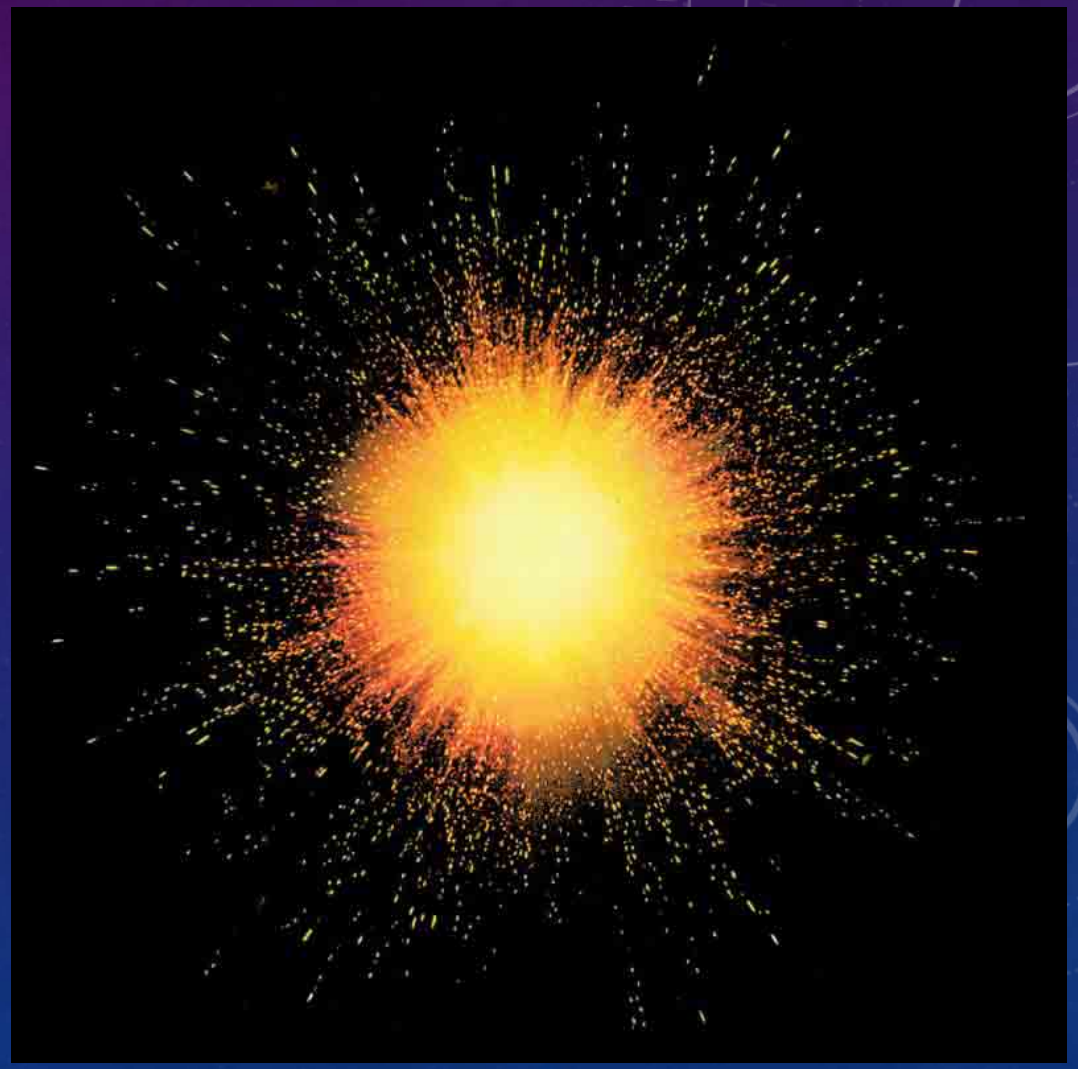
THE BIG BANG

- The **big bang theory** states that at one time, the entire universe was confined to a dense, hot, supermassive ball. Then, about 13.7 billion years ago, a violent explosion occurred, hurling this material in all directions.

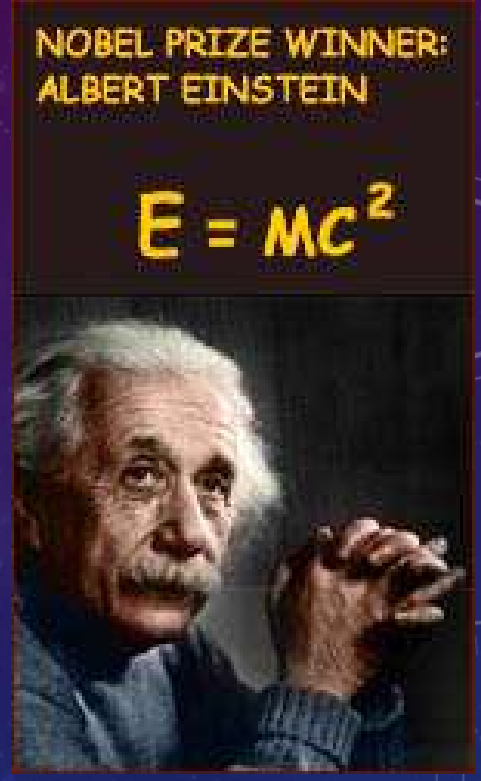


TIME BEGINS

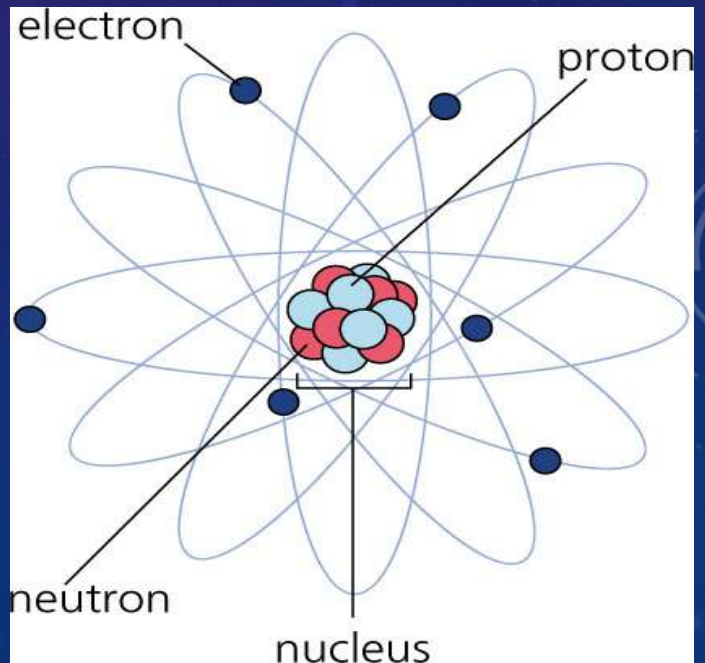
- The universe begins ~13.7 Billion years ago
- The universe begins as the size of a single atom
- The universe began as a violent expansion
  - All matter and space were created from a single point of pure energy in an instant



~ 3 MINUTES AFTER BIG BANG

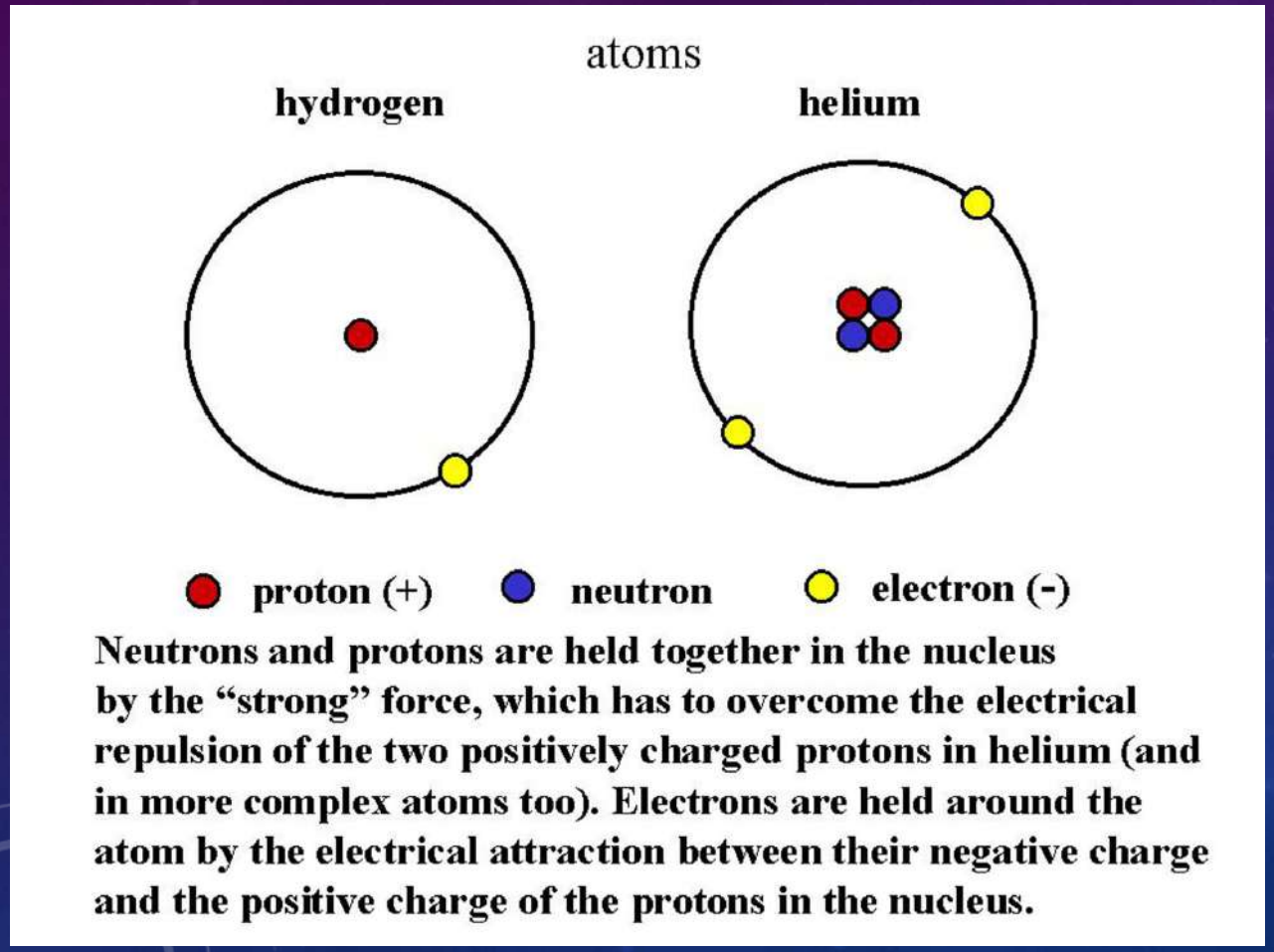


- The universe has grown from the size of an atom to larger than the size a grapefruit
- $E=mc^2$
- energy froze into matter according to Albert Einstein's equation.
- This basically says that like snowflakes freezing, energy forms matter into clumps that today we call protons, neutrons and electrons.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



~ SEVERAL HUNDRED THOUSAND YEARS

AFTER BIG BANG



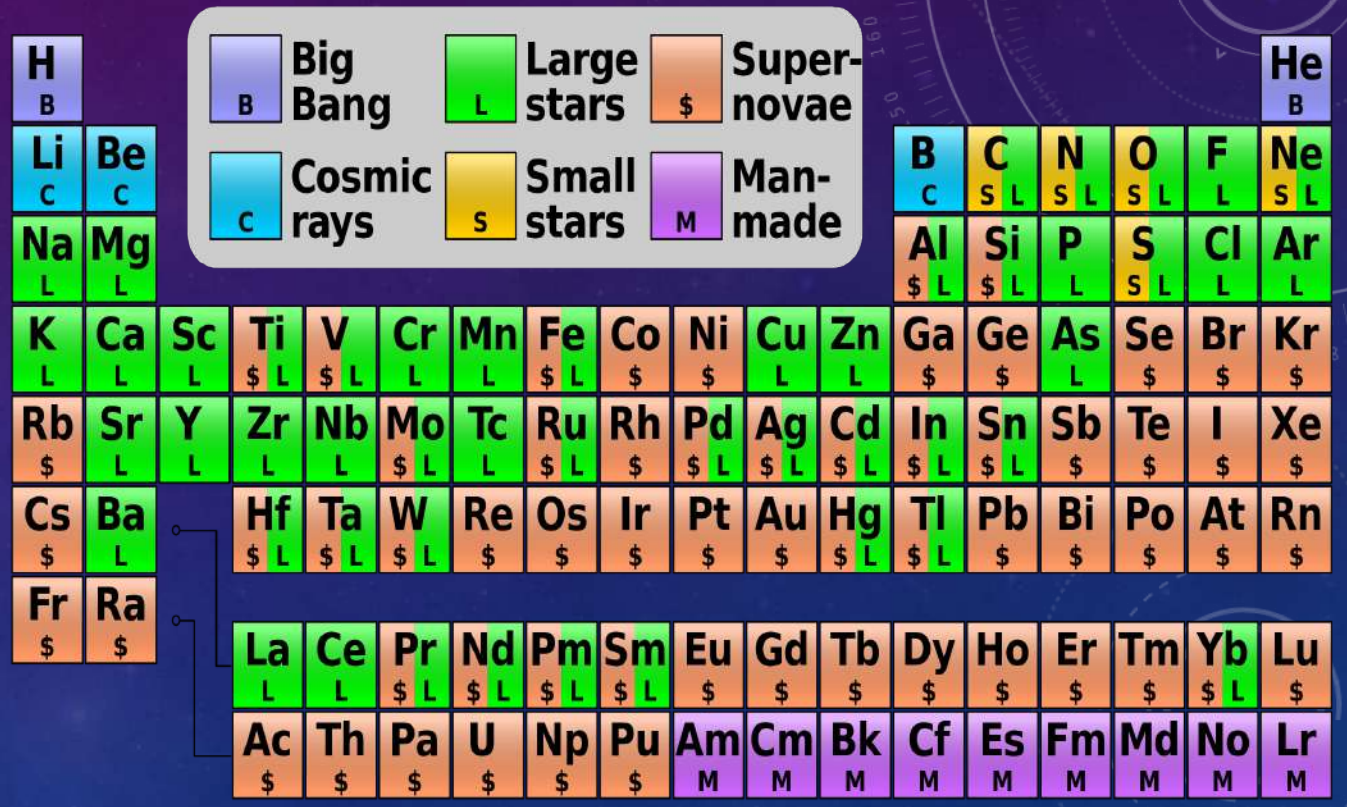
- ATOMS form (specifically Hydrogen and its isotopes with a small amount of Helium.)
- The early Universe was about **75% Hydrogen** and **25% Helium**. It is still almost the same today.

CREATION OF THE ELEMENTS IN THE UNIVERSE

- Helium and a small amount of other Nuceli (up to Lithium) were formed from High energy collisions starting from protons and neutrons in the early universe before any stars existed

- More massive elements, up to iron, are produced in the cores of stars by NUCLEAR FUSION which releases energy

- Supernova explosions of massive stars are the mechanism by which elements more massive than iron are produced



~200 TO 400 MILLION YEARS

AFTER BIG BANG

- 1st stars and galaxies form

~ 4.6 BILLION YEARS AGO

- Our Solar system forms

THE BIG BANG - SCIENCE FOR SCHOOLS

HTTPS://YOUTU.BE/JJ3NQYOO8SG (1:31)

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

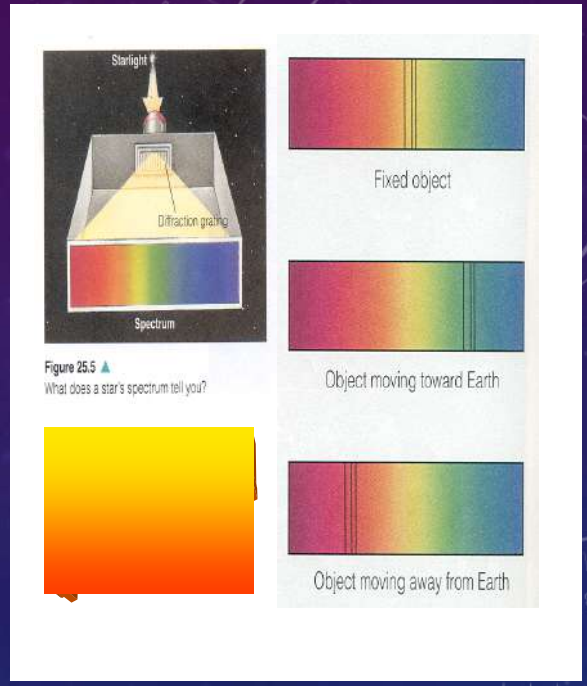
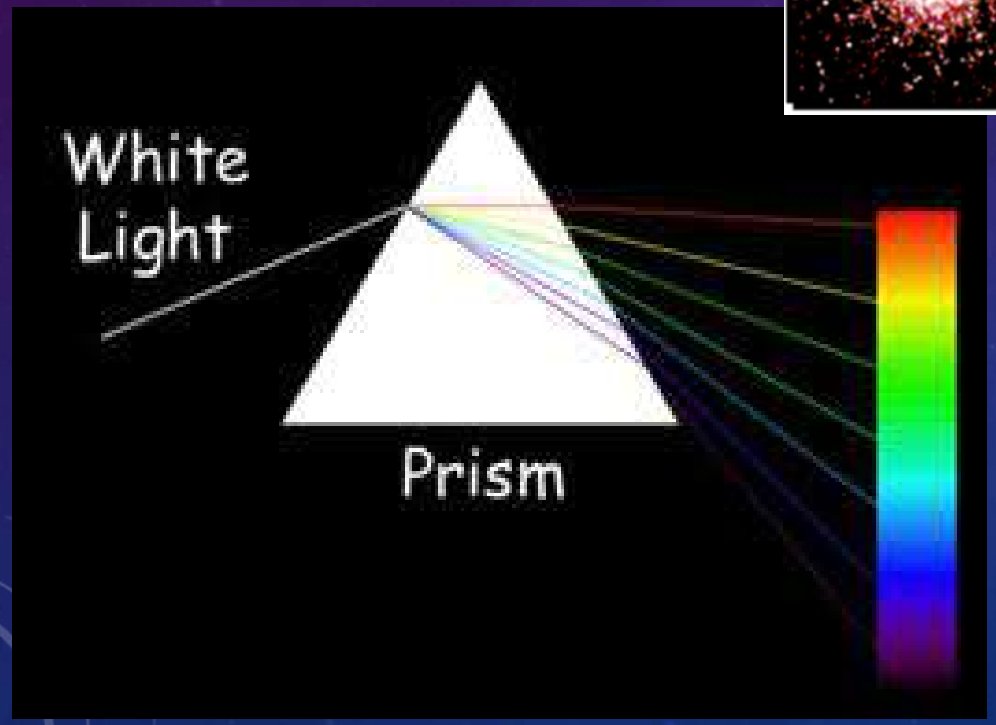
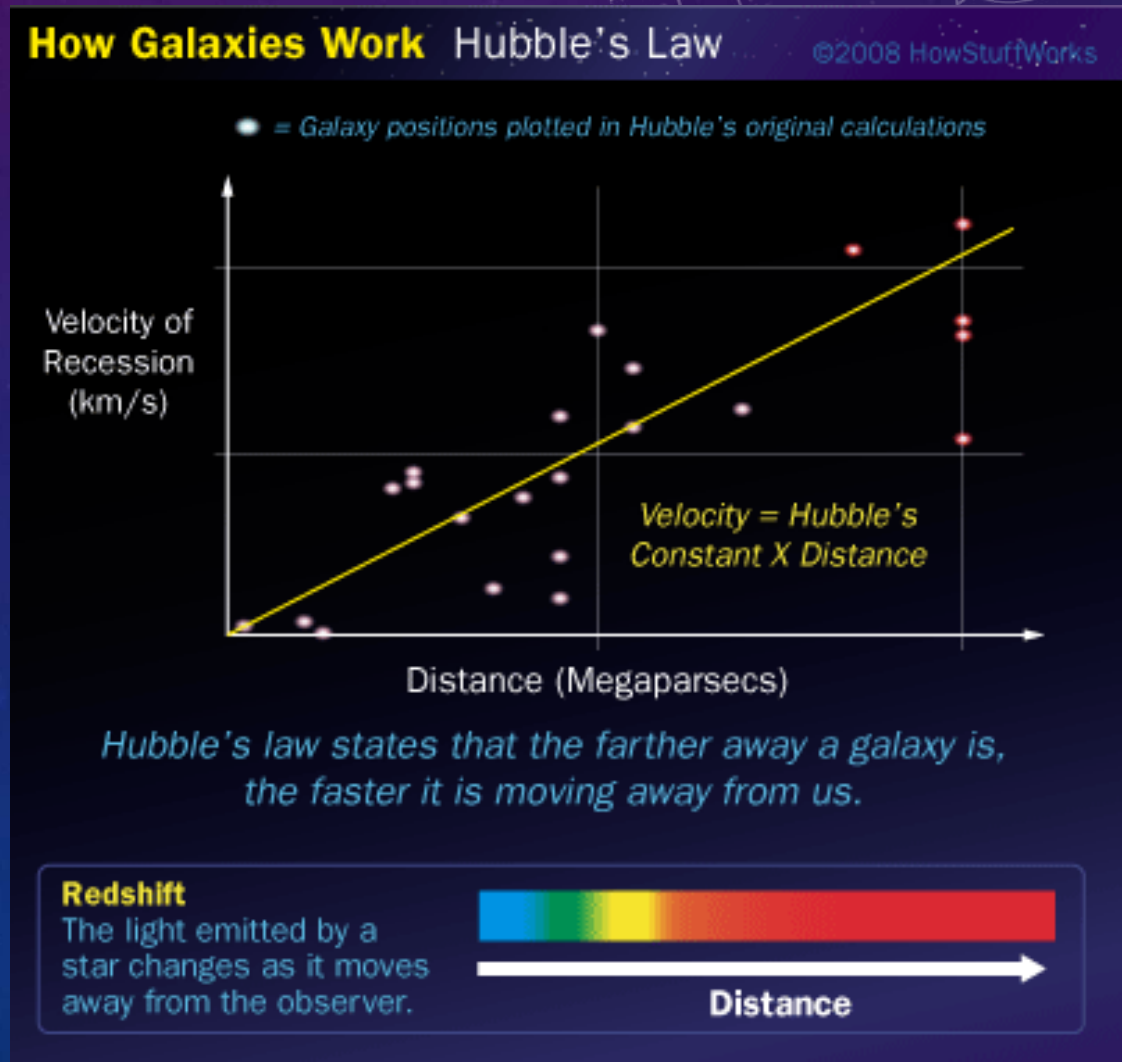


Figure 25.5 ▲
What does a star's spectrum tell you?

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

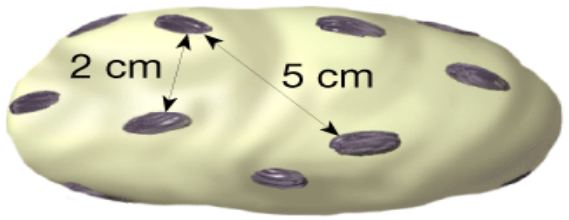




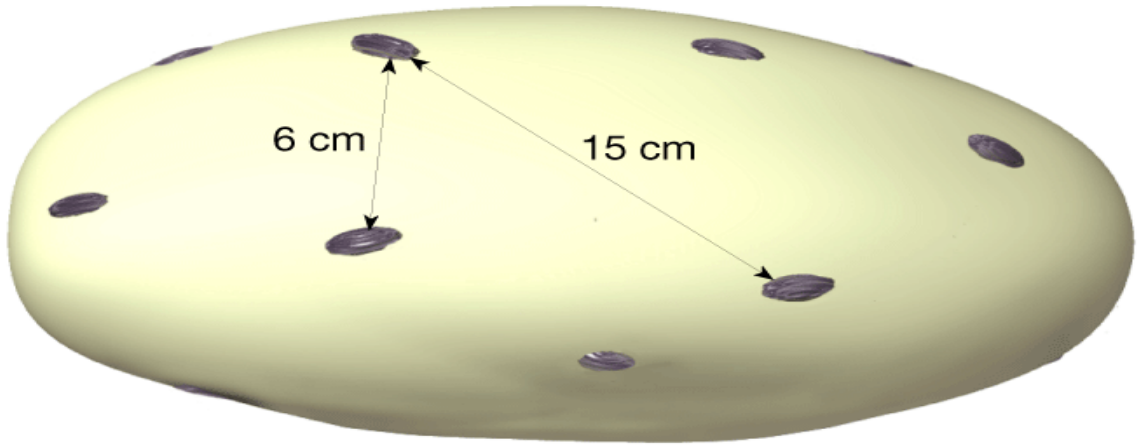
A/B – HUBBLE'S LAW

- To help visualize the nature of the universe, imagine a loaf of raisin bread dough that has been set out to rise for a few hours. As the dough doubles in size, so does the distance between all the raisins. Objects located farther apart move away from each other more rapidly.

- **Hubble's law** - galaxies are retreating from the Milky Way at a speed that is proportional to their distance.



Raisin bread dough before it rises.



Raisin bread dough a few hours later.

C - RED SHIFTS

Red-shift

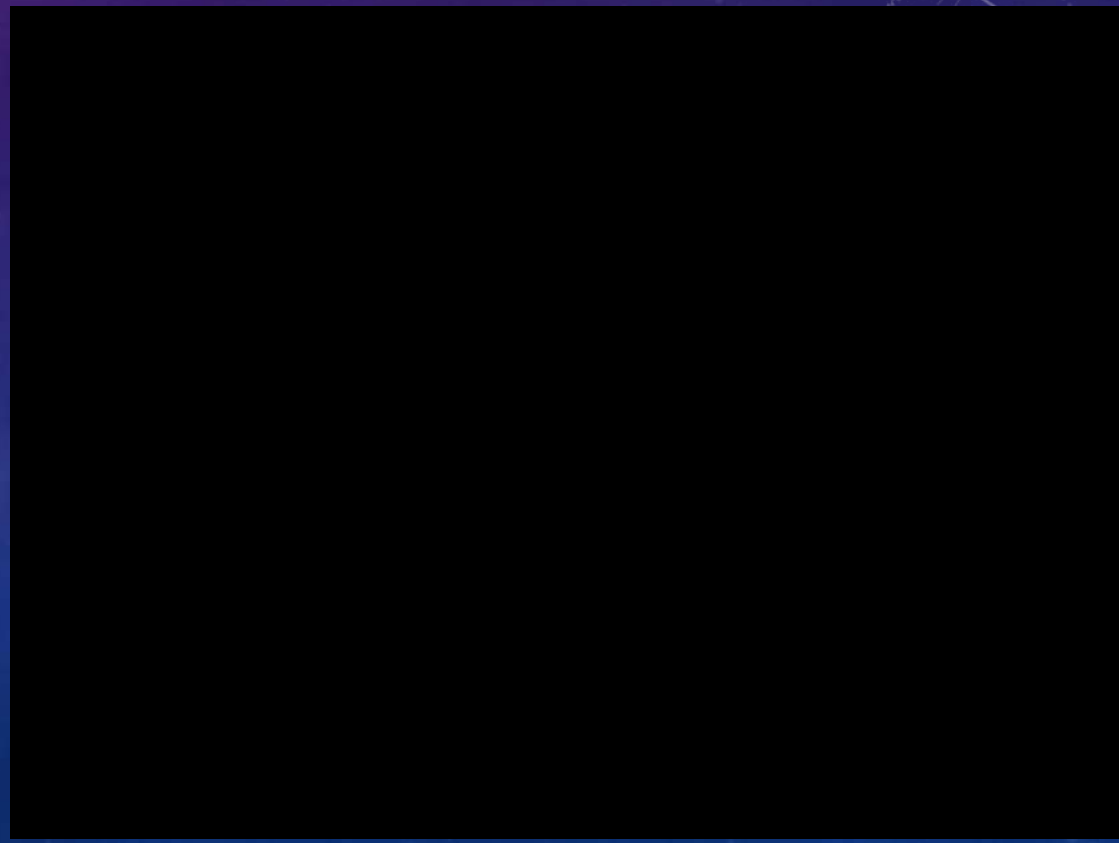
Receding

Advancing

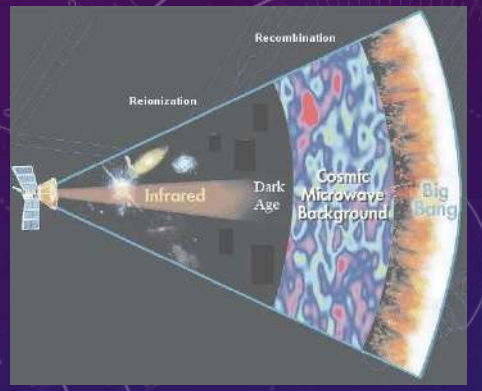
- **Red shift** - the light waves are "stretched," which shows that Earth and the source are moving away from each other.

*Less common is the **Blue shift** – moving toward

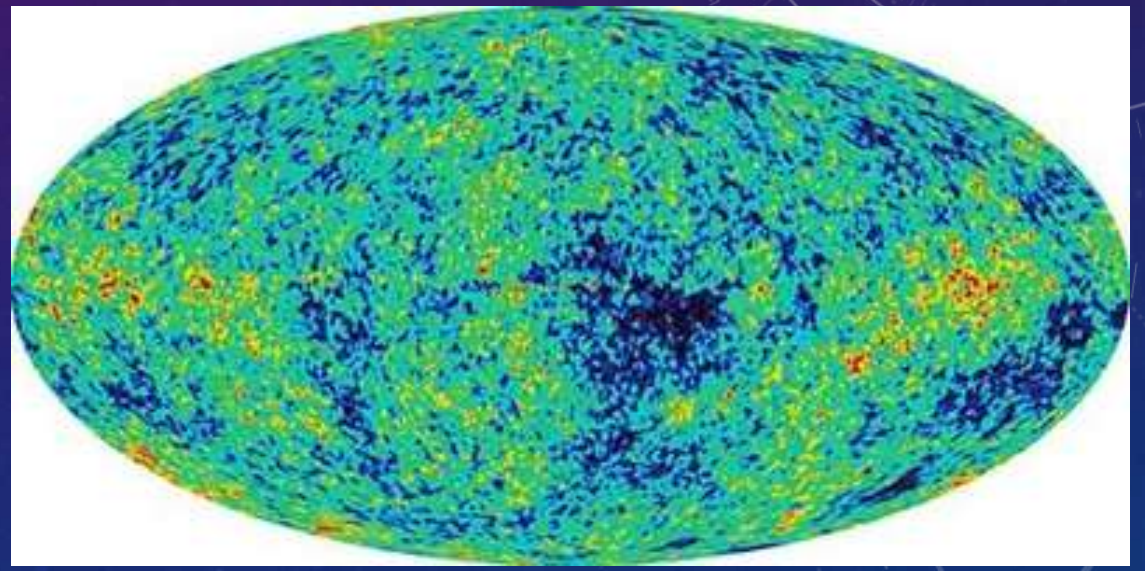
- The red shifts of distant galaxies indicate that **the universe is expanding**.



2. BACK GROUND RADIATION



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



The Universe's "baby picture". WMAP's map of the temperature of the microwave background radiation shows tiny variations (of few microdegrees) in The 3K background. Hot spots show as red, cold spots as dark blue.

NASA MISSIONS STUDY COSMIC BACKGROUND RADIATION

- NASA has launched two missions to study the cosmic background radiation, taking "baby pictures" of the Universe only 400,000 years after it was born.
  - The first of these was the Cosmic Background Explorer (COBE). In 1992, the COBE team announced that they had mapped the primordial hot and cold spots in cosmic background radiation. These spots are related to the gravitational field in the early Universe and form the seeds of the giant clusters of galaxies that stretch hundreds of millions of light years across the Universe. This work earned NASA's Dr. John C. Mather and George F. Smoot of the University of California the 2006 Nobel Prize for Physics.
  - The second mission to examine the cosmic background radiation was the Wilkinson Microware Anisotropy Probe(WMAP). With greatly improved resolution compared to COBE, WMAP surveyed the entire sky, measuring temperature differences of the microwave radiation that is nearly uniformly distributed across the Universe. The picture shows a map of the sky, with hot regions in red and cooler regions in blue. By combining this evidence with theoretical models of the Universe, scientists have concluded that the Universe is "flat,"meaning that, on cosmological scales, the geometry of space satisfies the rules of Euclidean geometry (e.g., parallel lines never meet, the ratio of circle circumference to diameter is pi, etc).
- A third mission, Planck, led by the European Space Agency with significant participation from NASA, was. launched in 2009. Planck is making the most accurate maps of the microwave background radiation yet. With instruments sensitive to temperature variations of a few millionths of a degree, and mapping the full sky over 9 wavelength bands, it measures the fluctuations of the temperature of the CMB with an accuracy set by fundamental astrophysical limits.

3. QUASARS

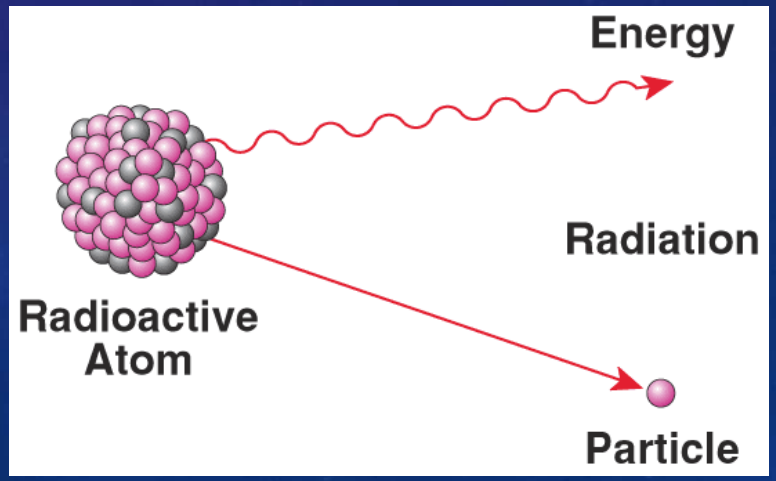
SUPER LARGE (SOLAR SYSTEM SIZE) GALACTIC CORES THAT PUT OUT MORE LIGHT THAN WHOLE GALAXIES

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

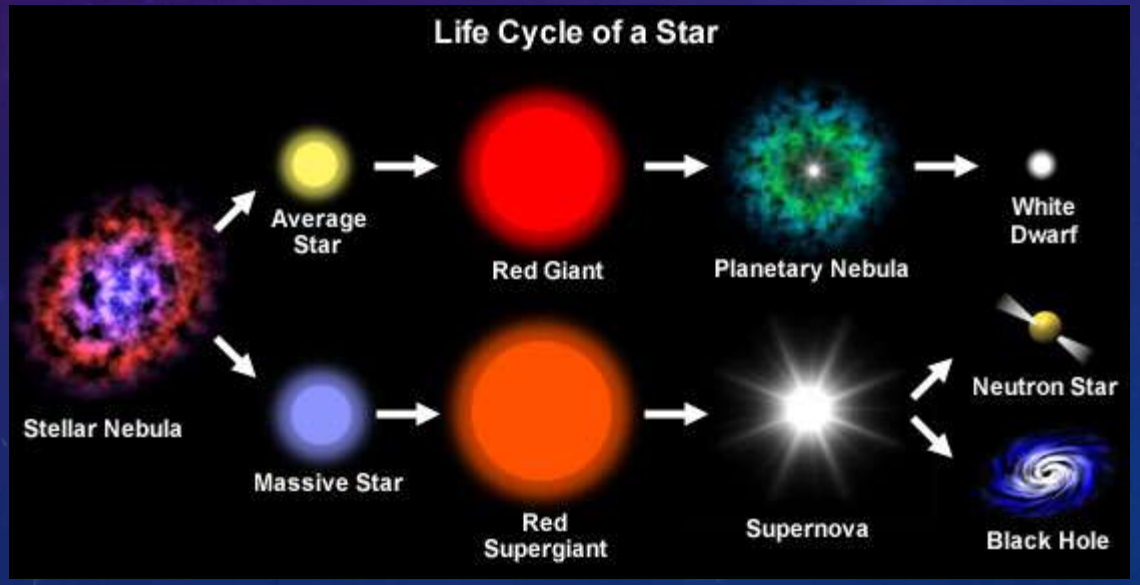
4. RADIOACTIVE DECAY

- 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


Learn more about a radioactive material's half-life using coins.

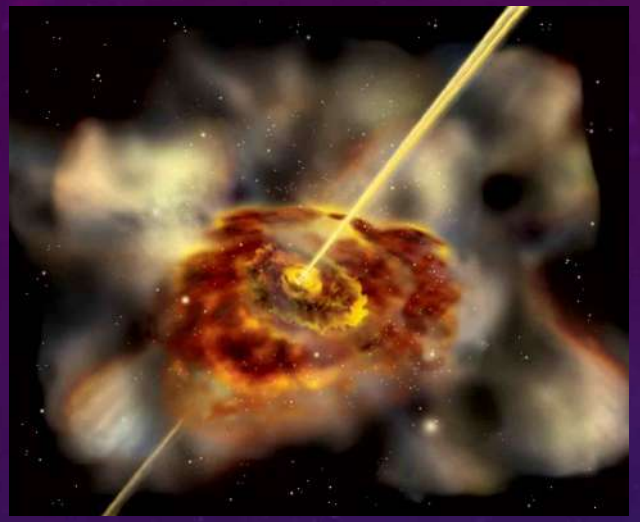


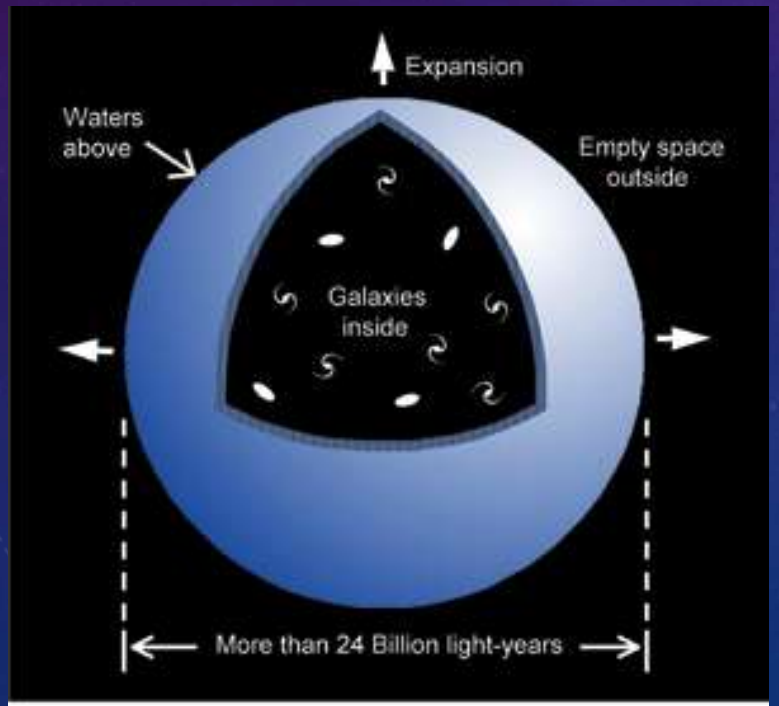
5. STELLAR FORMATION AND EVOLUTION



- We observe the life cycles of stars across the universe using tools such as satellites and telescopes
- Stars primary composition are H (75%) & He (25%)
- Stars are powered by Nuclear Fusion (H -> HE)
- We view stars form, burn and explode

6. SPEED OF LIGHT AND STELLAR DISTANCES

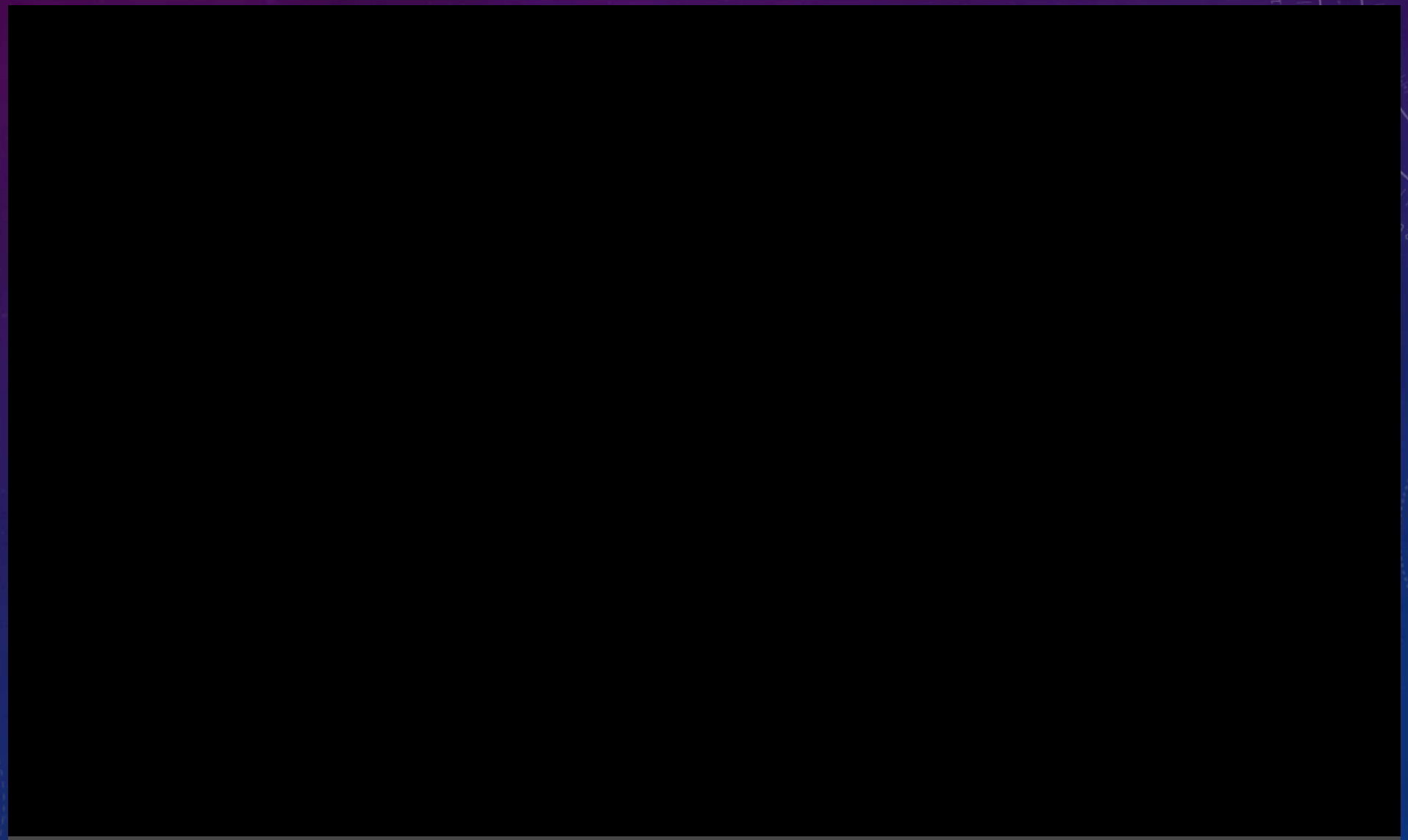




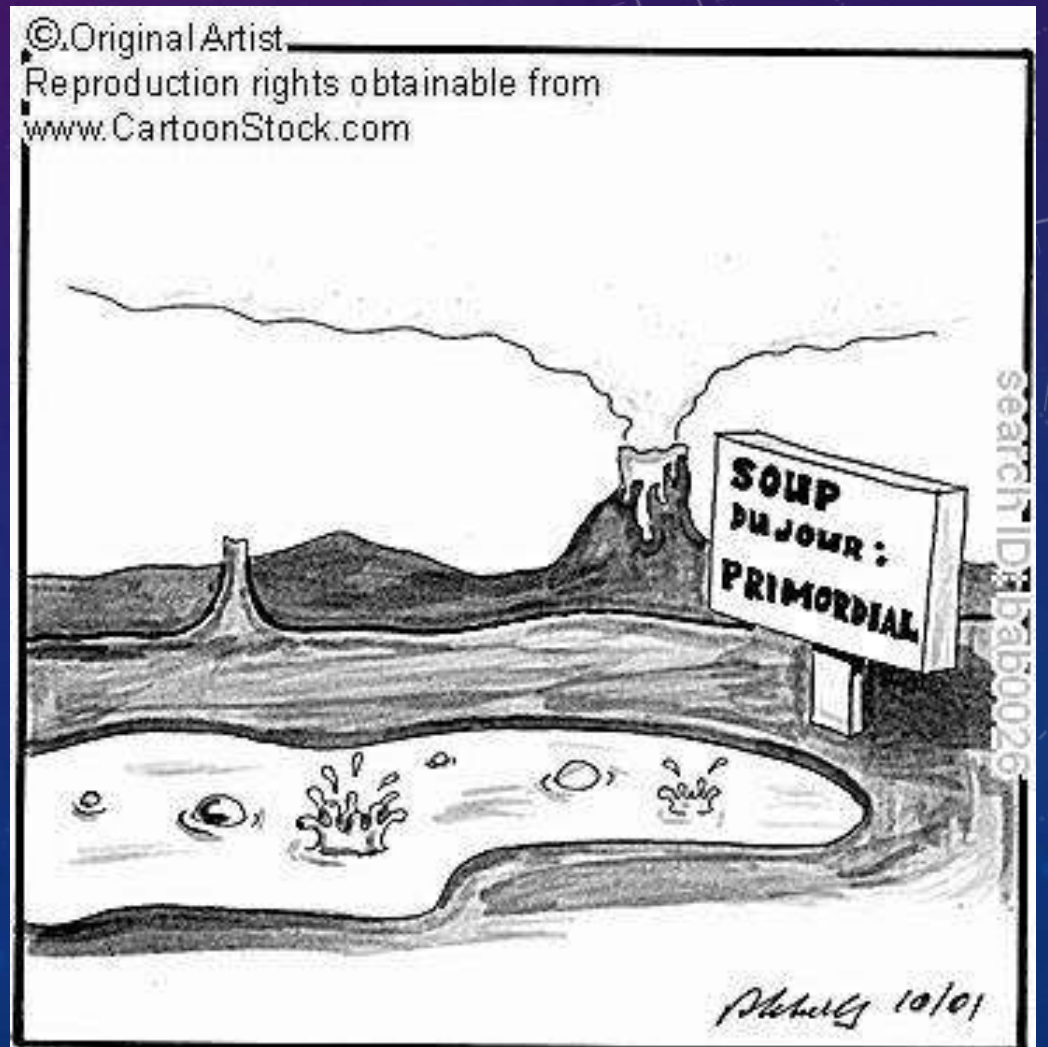
- The speed of light is a universal constant of 300,000 km/s2
- We observe stars millions/billions of light-years away
- A light-year is the distance that light travels in 1 year – the light we see today from a star 500 light years away is 500 years old
- The furthest stars away are 10-15 billion light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

BIG BANG EVIDENCE

HTTPS://WWW.STEM.ORG.UK/RXUAE (2:50)



LASTLY – WE ARE PRETTY SURE EVERYTHING HAS A BEGINNING, RIGHT?



REVIEW...

1. Based on RED shifts, astronomers conclude that…
A. Earth is the center of the universe
B. the Universe is contracting
C. the Universe is expanding

2. Greater RED shifts in the spectra of galaxies indicate…
A. faster speedsC. higher temperatures
B. slower speedsD. lower temperatures

3. According to the Big Bang Theory, the Universe began about..
A. 4.5 billion years ago C. 49.6 billion years ago
B. 13.7 billion years ago D. 130 billion years ago

REVIEW…

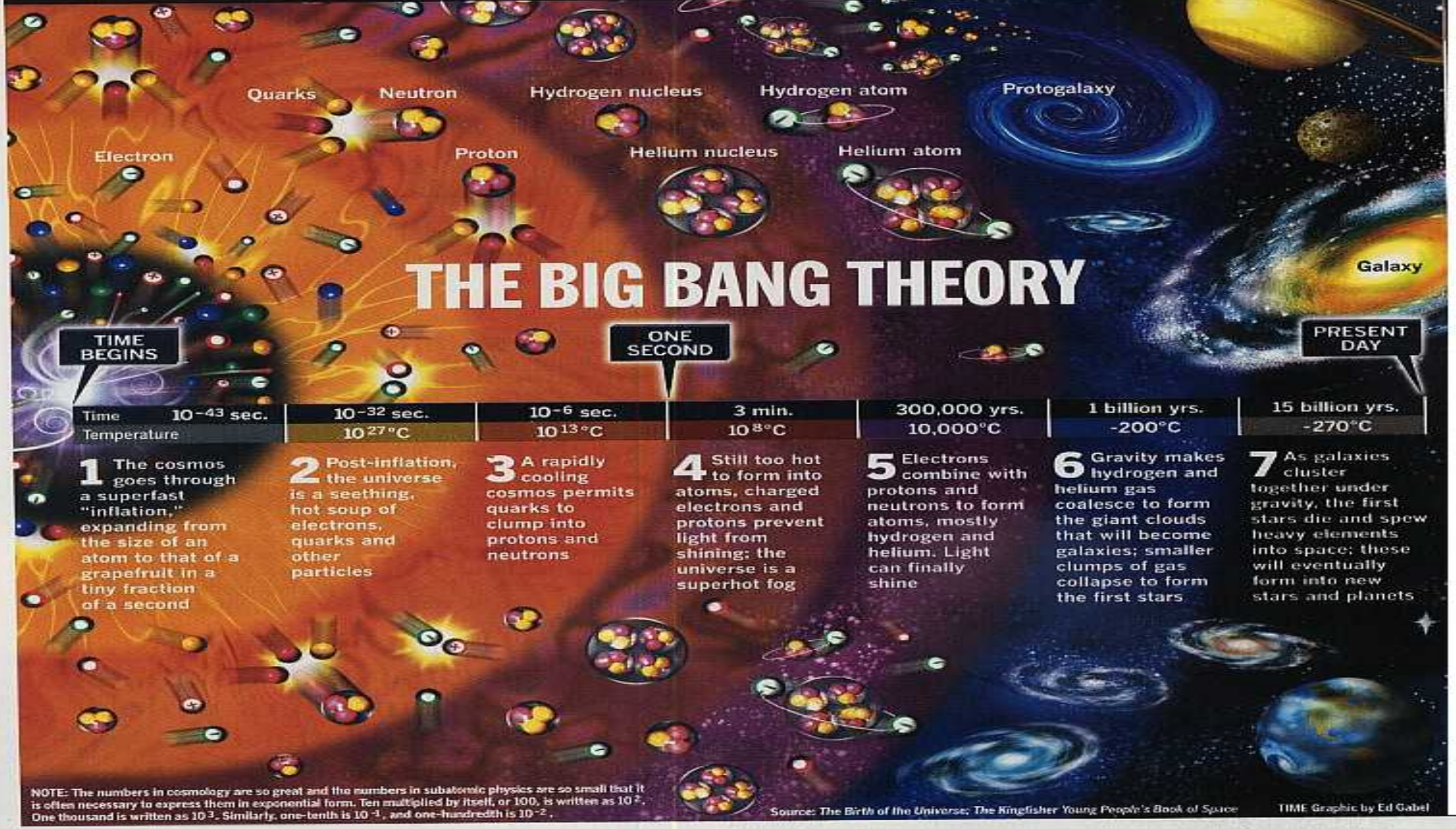
4. Which of the following supports the big bang theory?

A. pulsarsC. irregular galaxies

B. cosmic background radiation D. galactic clusters

5. According to Hubble's Law, galaxies are retreating at a speed that is proportional to their _____.A. orientation C. galactic position

B. distanceD. mass



THE BIG BANG THEORY

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}. One thousand is written as 10^{3}. Similarly, one-tenth is 10^{-1}, and one-hundredth is 10^{-2}.

Source: *The Birth of the Universe*; The Kingfisher Young People's Book of Space

TIME Graphic by Ed Gabel

THE BIG CRUNCH?

- The future of the universe follows two possible paths:

1. The universe will expand forever.

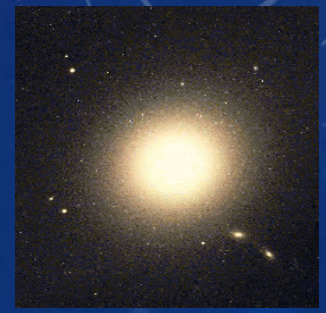
2. The outward expansion will stop and gravitational contraction will follow.

Most scientists think the universe will continue to expand with no ending point.
No one knows for sure!

What am I?

MILKY WAY GALAXY

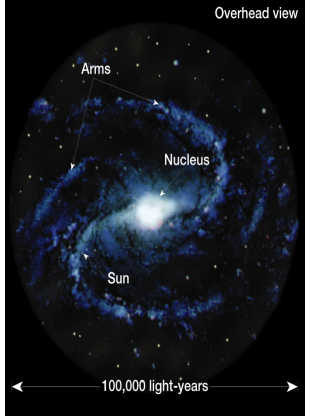
- **Galaxy** = group of stars, dust, and gases held together by gravity.
  - Our galaxy, the Milky Way is a large spiral galaxy whose disk is about 100,000 light-years wide and about 10,000 light-years thick at the center (nucleus)
- Structure of the Milky Way
  - Radio telescopes reveal that the Milky Way has at least three distinct spiral arms, with some splintering. Our solar system (including the Sun) is located on a spiral arm.

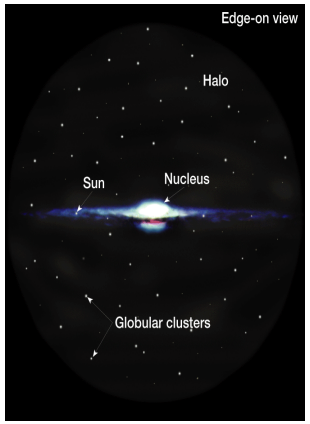


TYPES OF GALAXIES

- Spiral Galaxies (disk shaped)
  - 30% of all galaxies
  - All sizes, Usually large diameters of up to 225,000 light-years and contain both young and old stars.

Ex. Milky Way

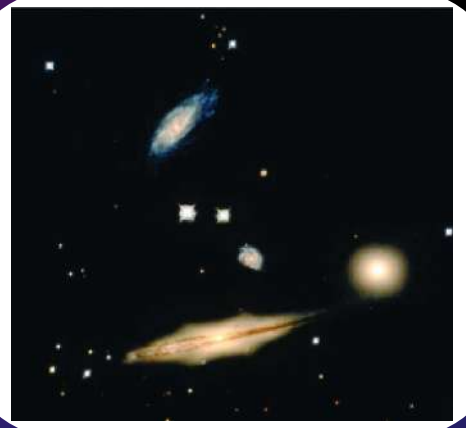


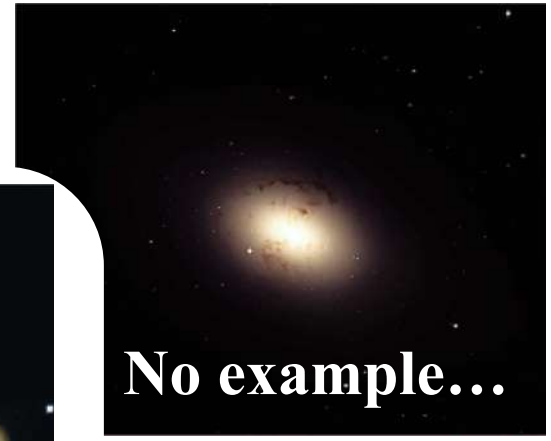


TYPES OF GALAXIES

Elliptical Galaxies

- 60% of all galaxies.
- Range in shape from round to oval.
  Most are small in size
* Mostly old stars.





Irregular Galaxies

- 10% of all galaxies
- All sizes
- Made of young stars!

REVIEW...

1. Our galaxy is called the _____.

A. Local group C. Andromeda

B. Orion D. Milky Way

2. Where is our Sun located in our galaxy?

A. in a spiral arm C. at the tip of a spiral arm

B. in the nucleus center D. in Andromeda

3. About 60% of all known galaxies are classified as _____.

A. spiral B. elliptical C. irregular

4. The Milky Way Galaxy is classified as _____.

A. spiral B. elliptical C. irregular