Unit 1: Cosmology and Earth's Place in Space

Objectives:

E5.1b - Describe how the Big Bang theory accounts for the formation of the universe.

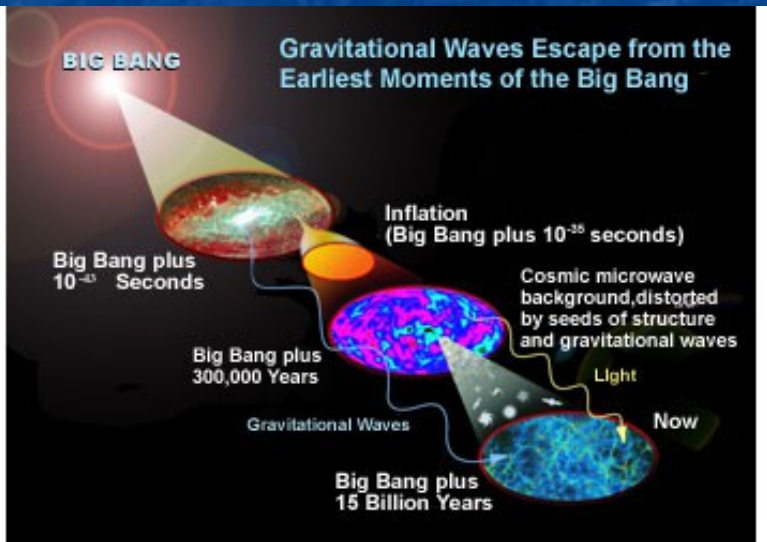
E5.1c - Explain how observations of the cosmic background radiation have helped determine the age of the universe.

E5.3A - Explain how the solar system formed from a nebula of dust and gas in a spiral arm of the Milky Way Galaxy about 4.6 Ga.

The Big Bang*

The foundation of modern cosmology is the ***theory*** know as the ***Big Bang***.

The universe formed around 14 billion years ago from one colossal explosion. This single event is where all the matter and energy that make up our universe today is believed to have come from.



The Big Bang

As the energy created from the ***Big Bang*** began to spread wider, it began to cool and create clumps of matter. This was in the form of elements such as hydrogen and helium. Eventually as energy and matter continued to spread apart and the universe grew larger, it began to form random clumps of dust and gas called giant molecular clouds.

These clouds of matter eventually created stars and the galaxies that comprise them.

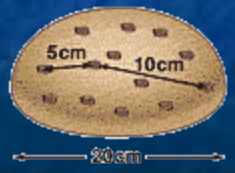
Eagle Nebula – 7000 light years away from us

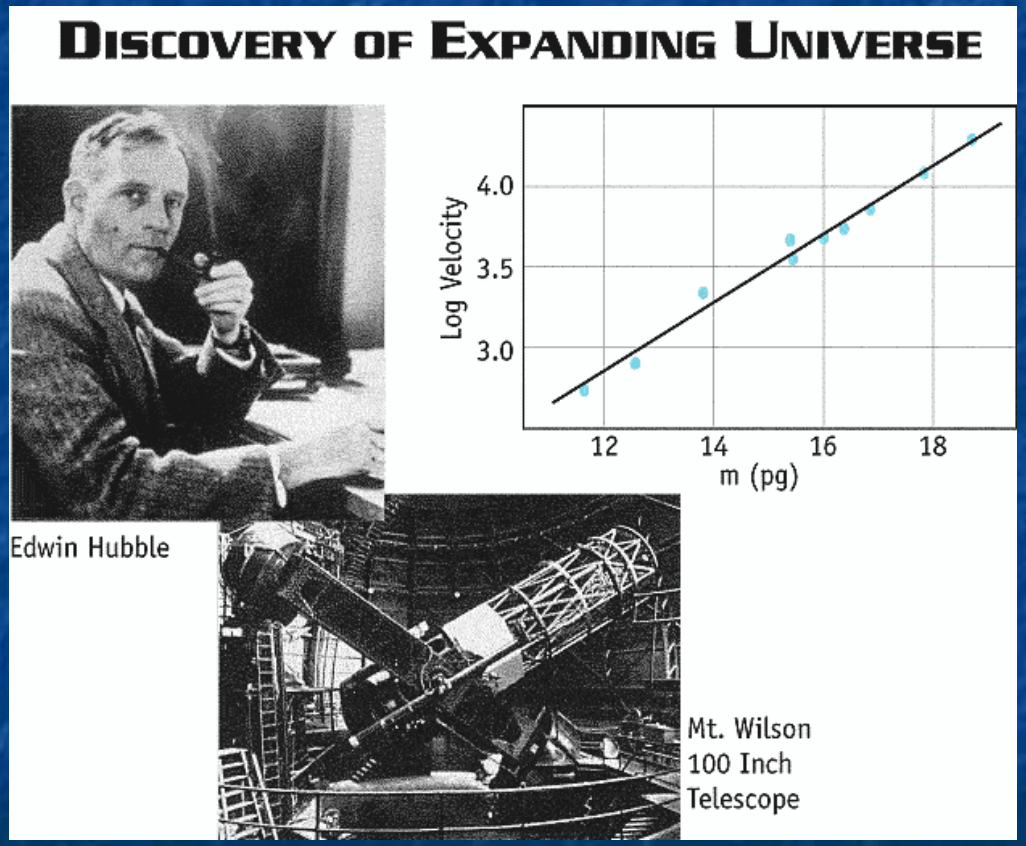
Support for the Big Bang

- The expansion of the universe.
- The abundance of light elements (H, He, Li).
- The cosmic background microwave radiation.

Support for the Big Bang

In 1929, Edwin Hubble announced that his observations of galaxies outside our own Milky Way showed that they were moving away from Earth with a speed that was proportional to their distance from us.

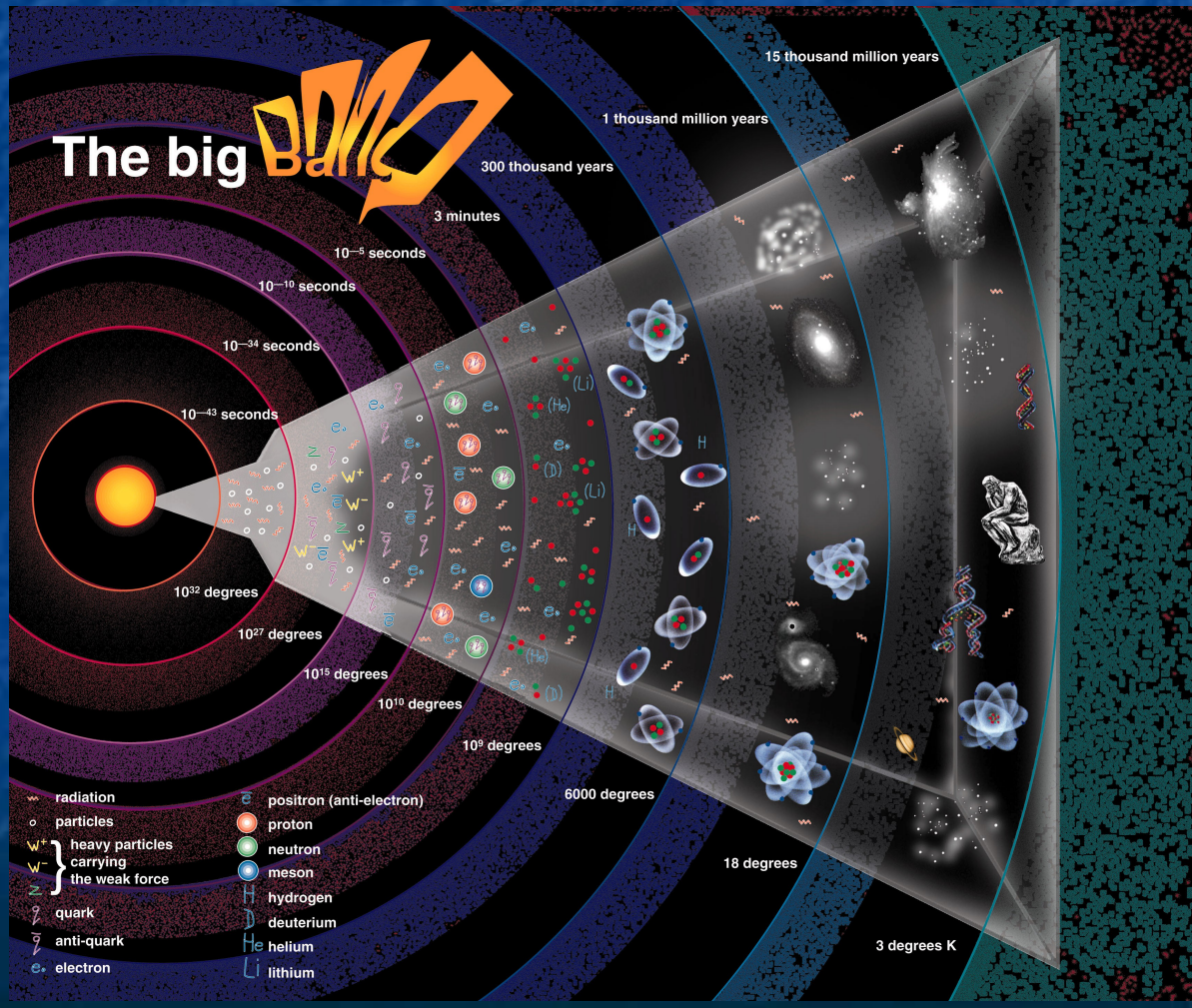




Support for the Big Bang

The Big Bang theory believes that the original particles began to cool and within three minutes formed the lightest of all the elements found in our universe: hydrogen, helium, and lithium.

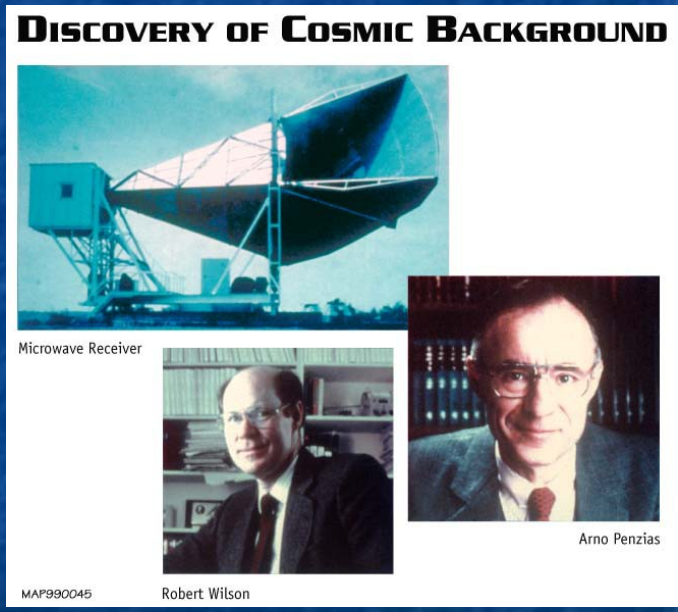
Elements larger than lithium are all created in stars.



Support for the Big Bang*

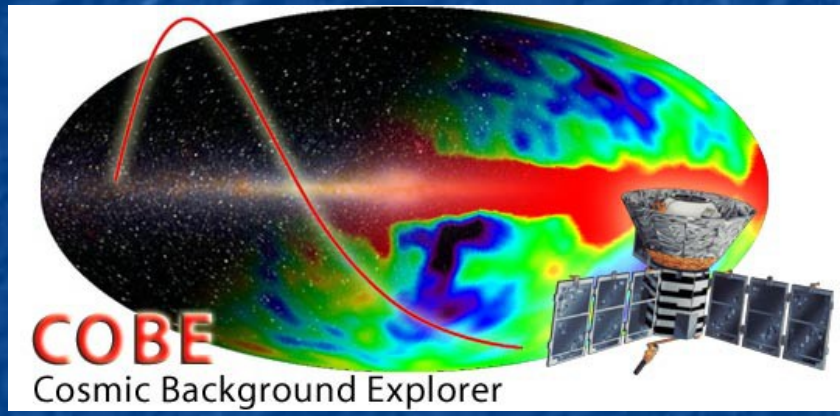
The ***Big Bang*** theory predicts that the early universe was a very hot place, and that as it expands, the gas within it cools. Thus, the universe should be filled with radiation that is literally the remnant heat left over from the Big Bang. This is called the "***cosmic microwave background radiation***" (or CMB).

The radiation was acting as a source of excess noise in a radio receiver they were building.

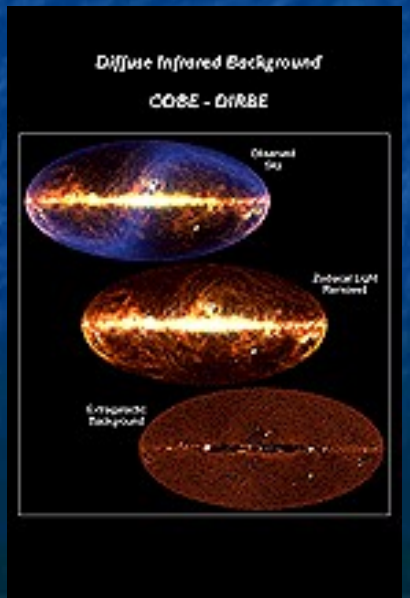


Support for the Big Bang

Today, the CMB is very cold, only 2.725° above absolute zero, thus the radiation shines primarily in the microwave portion of the electromagnetic spectrum. It may be invisible to our eyes, but it fills the universe and can be detected everywhere we look.



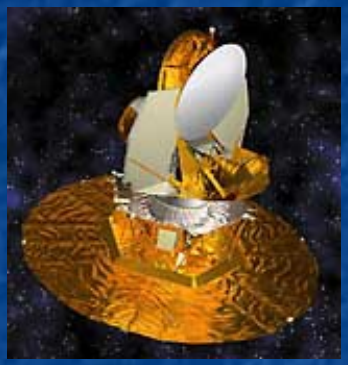
The ***Cosmic Background Explorer*** (COBE) satellite was launched in 1989. Images from COBE show different presentations of the background radiation that exists throughout our universe.

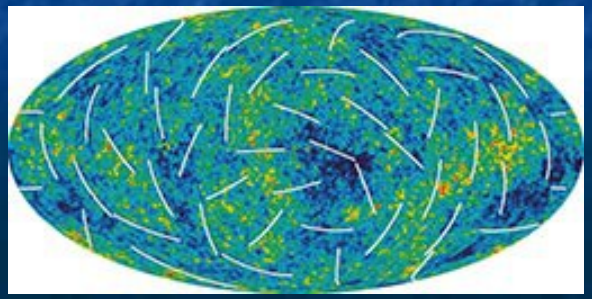


Support for the Big Bang

The ***Microwave Anisotropy Probe*** (MWAP) was launched in 2001. Colors indicate warmer (red) and cooler (blue) spots. The white bars show the "polarization" direction of the oldest light.

This new information helps to pinpoint when the first stars formed and provides new clues about events that transpired in the first trillionth of a second of the universe.





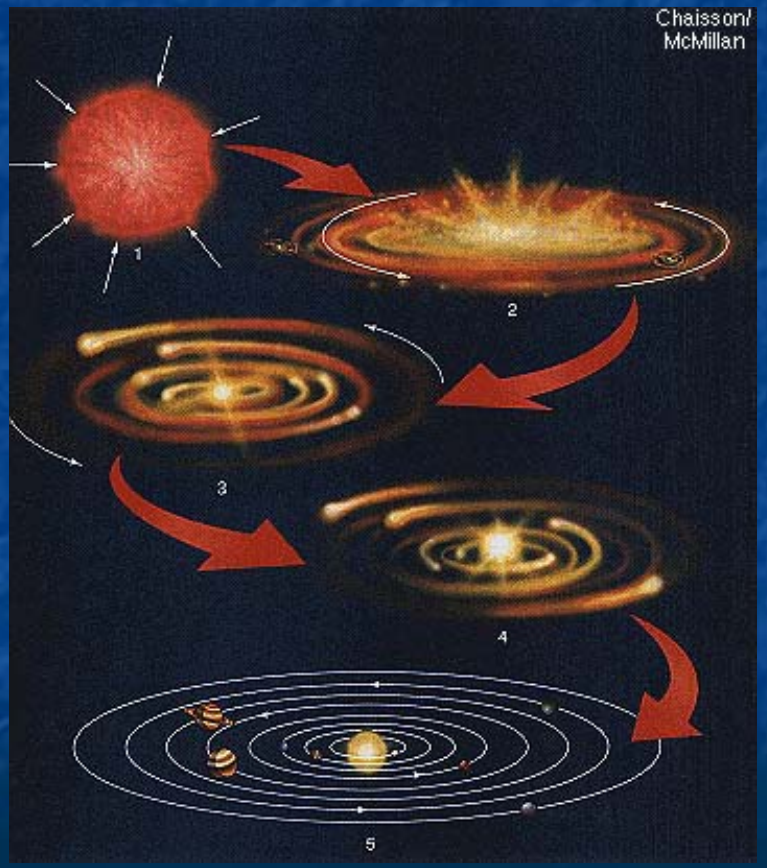
Origin of the Solar System*

The most widely accepted model of the formation of our solar system is called the nebular hypothesis.

It suggests that about 4.6 billion years ago a great cloud of gas and dust was rotating slowly in space.

The cloud was at least 10 billion kilometers in diameter.

As time passed, the cloud shrank under the pull of its own gravity. As it shrank, its rate of rotation increased.

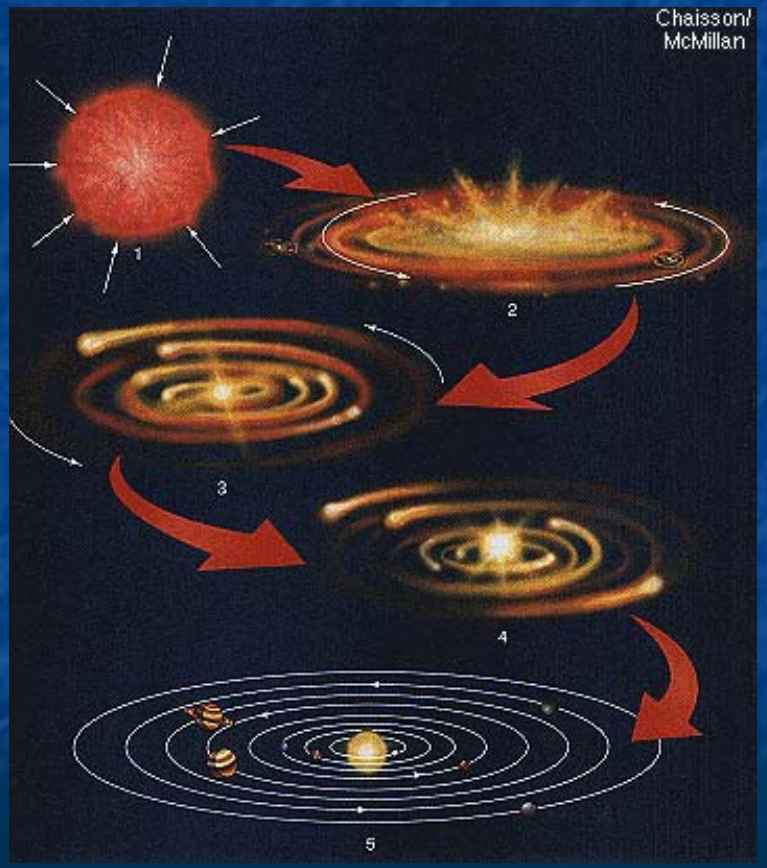


Origin of the Solar System

Most of the material in the rotating cloud gathered around its center.

Compression of this material made its interior so hot that a powerful reaction called hydrogen fusion occurred. At this time, the star we now know as our sun was born.

About 10% of the material in the cloud formed a great plane-like disk surrounding the sun and extending far into space.



Origin of the Solar System*

Frictional, electromagnetic, and gravitational forces within the disk caused most of its mass to condense, forming solid particles of ice and rock.

The condensed particles in the spinning cloud eventually combined into larger bodies called planetesimals.

The planetesimals continued to compress and spin, sometimes colliding with each other and other objects in space. Eventually these planetesimals developed into planets and moons.