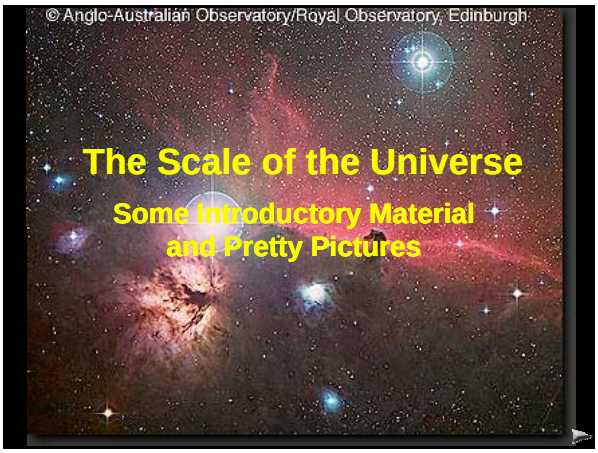


The facts we know today will be the same tomorrow but today's theories may tomorrow be obsolete.

A scientific theory is regarded simply as the best model available consistent with the facts.

Because the universe is such a big place, we need a really long measuring stick:

Introducing…

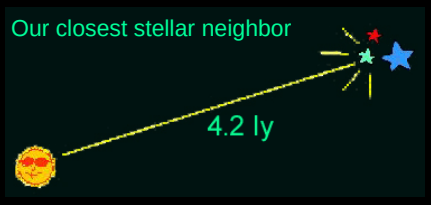
The Astronomical Unit

- The Earth is 1.496 x 10^8 km from Sun
- So… 1 AU = 1.496 x 10^8 km (93 million miles)
- That was easy.

The Light Year

- Cosmic speed limit: 3.00 x 10^8 m/s
  (That's 186,000 miles per second to you and me)
- Distance can be measured by the length of time the light traveled from an object.
- 1 ly is 5,879,000,000,000 miles or 9,461,000,000,000 km
- 1 pc = 3.26 ly

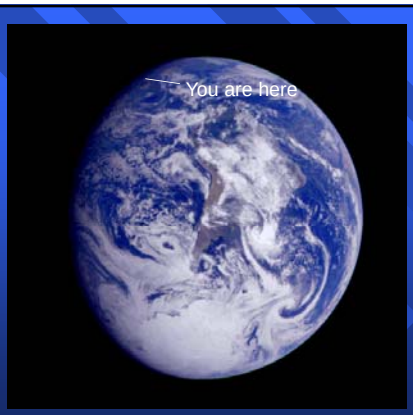
Proxima Centauri (α-Centauri)



When we look outside of our safe and cozy domain, what do we see in our universe?

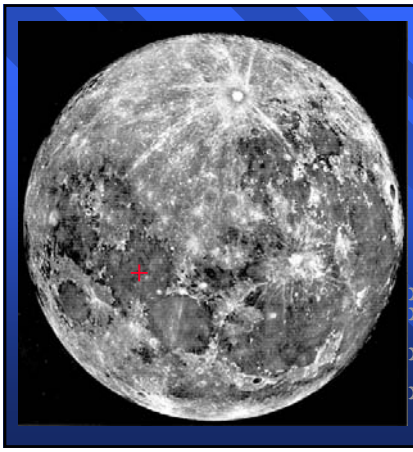
Let's take a short ramble through the night sky…

starting with…



Home

Once thought the center of the universe, we're not even the center of our solar system.



Moon

6 manned visits between 1969 and 1972. Recently revisited by the unmanned *Clementine* and *Galileo* missions. Permafrost found in a crater near the south polar impact basin.

- $^1/_6$ mass of Earth.
- Nearly same age as Earth.
- 256,000 mi away (384,000 km).
- A mere 1.4 light-seconds away

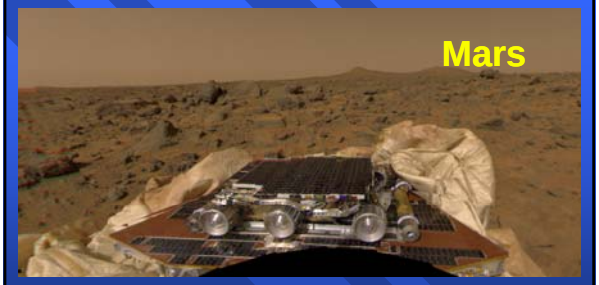
Moon

As much as we know about the moon, we still don't know where it came from!

Mars

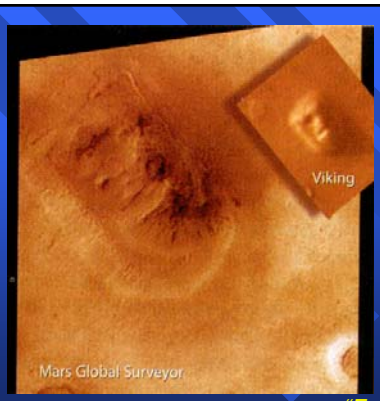
- ♂ 46.5 million miles (74.8 million km) from Earth at opposition.
- ♂ 4 light minutes away
- ♂ Recently visited by *Pathfinder.* (1997)
- ♂ Mars Global Surveyor (1998)
- ♂ Mars Climate Orbiter (lost 1999)
- ♂ Mars Polar Lander (lost 1999)

Mars



- About ½ the size of Earth.
- Evidence exists of an earlier hospitable atmosphere - now gone - mostly CO_2 remains.
- Liquid water once persisted which is also now gone.
- Mars' climate punctuated by seasons and dust storms.

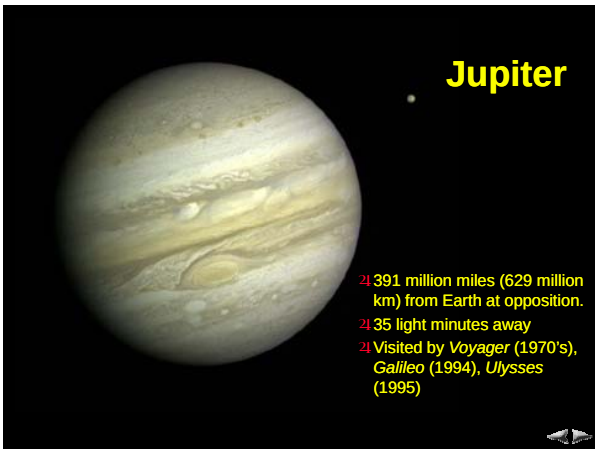
Mars



Cydonia
"Face on Mars"

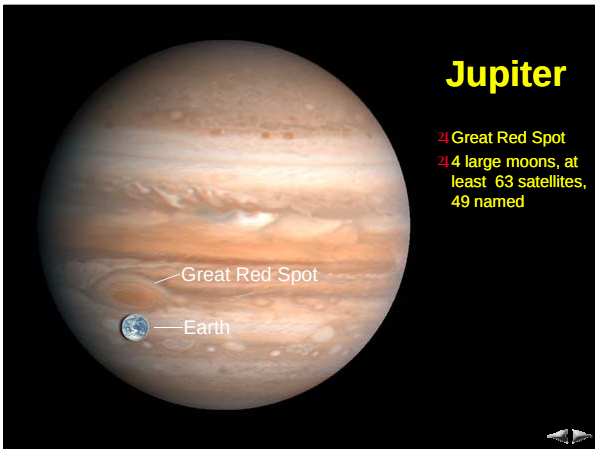
As we leave the inner solar system we encounter the

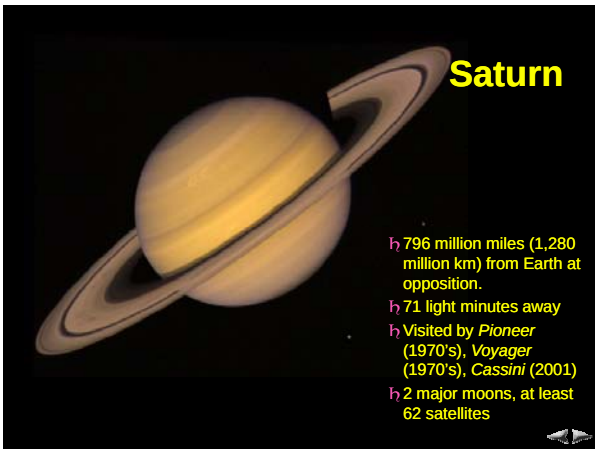
Gas Giant Planets

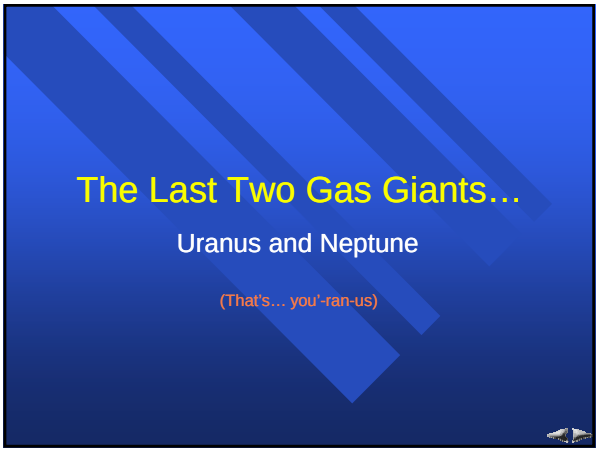


I have observed four planets, neither known or observed by any astronomers before me, that orbit around Jupiter like Venus or Mercury around the sun.

Galileo Galilei, 1617




Saturn
♄ 796 million miles (1,280 million km) from Earth at opposition.
♄ 71 light minutes away
♄ Visited by *Pioneer* (1970's), *Voyager* (1970's), *Cassini* (2001)
♄ 2 major moons, at least 62 satellites


The Last Two Gas Giants…
Uranus and Neptune
(That's… you'-ran-us)


Uranus and Neptune

We finally leave our solar system

Next stop…
THE STARS

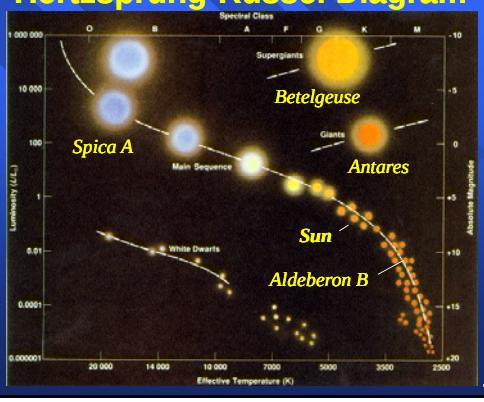
Well, perhaps not *our* next stop!

- α-Centauri only 4.2 ly away
- Nearly 10,000 years to get there even at 100,000 mph!
- Sirius (8.7 ly) is brightest and blue
- Betelgeuse (500 ly) 10th brightest and red
- Most stars we see are at most a few 1000 ly

The Orion Nebula

A Stellar Nursery
A few thousand ly away

Hertzsprung-Russel Diagram



What about our star?

- Not at all unique
- ~4.6 billion years old
- Only ~5-7 billion years left
- Red giant stage
- White dwarf and planetary nebula

Are there planets around other stars?

Probably!

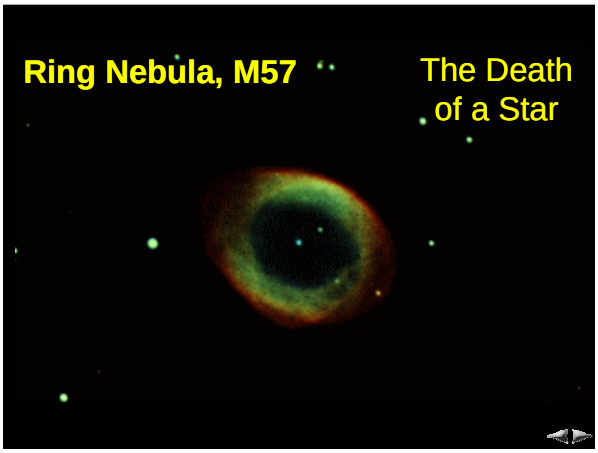
Protoplanetary disks in Orion

What happens to old stars?

- White dwarfs and planetary nebula (<1.5 ⊙)
- Neutron stars and pulsars (~3-5 ⊙)
- Black holes (>5 ⊙)

Ring Nebula, M57

The Death of a Star



The Crab Nebula, M1

The Death of a Star

Globular Clusters

Is our place in the universe unique?

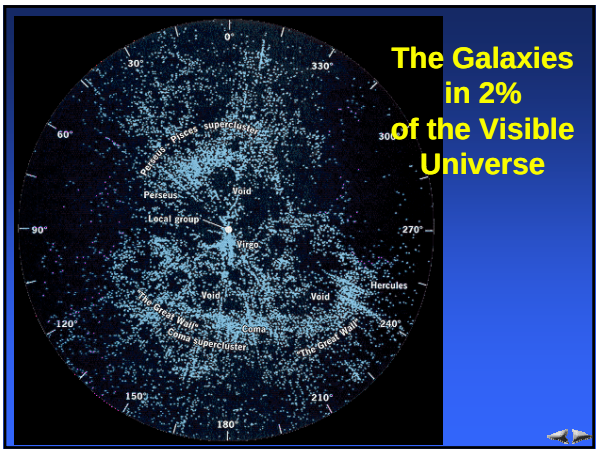
Galileo showed that we were not at the center of the solar system.

Since then, observations show...


Our place in the galaxy
You are here


Galaxy M83
A galaxy similar to Milky Way 10-20 million ly away


Dwingeloo 1
A galaxy in the ZOA 15 million ly



Just how big *is* the universe?

The Universe, as has been observed before, is an unsettlingly big place, a fact which for the sake of a quiet life most people tend to ignore.

Douglas Adams,
The Restaurant at the End of the Universe

No... honest…

It's ***REALLY*** big!

HST
WFPC2
Deep Sky

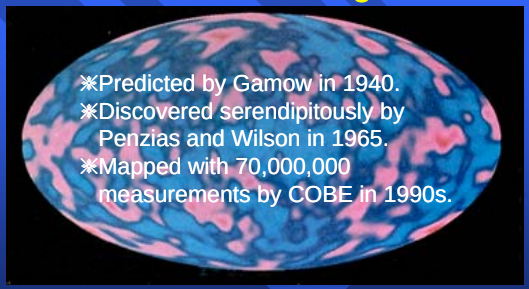
So... how did it all start?

We think it started from the expansion of a small point of extreme energy (the primordial singularity).

This is the way the world began, not with a whimper but with a bang.

What is the scientific evidence of the Big Bang?

2.7 K Cosmic Background



- Predicted by Gamow in 1940.
- Discovered serendipitously by Penzias and Wilson in 1965.
- Mapped with 70,000,000 measurements by COBE in 1990s.

Doppler Shift and Receding Galaxies

- Doppler shift is like the sound of a siren as it approaches and passes.
- Discovered by Edwin Hubble in 1929 and verified on 1000s of galaxies since.
- Red-shifted spectral lines from galaxies show that the celestial object is moving away from us. (Space-time is expanding)
- Recession velocity is calculable.
- Red-shift is determined by the distance the object is away (and *vice versa*).

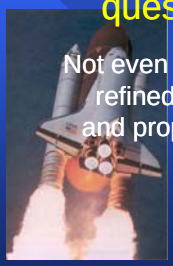
Other Evidence of the Big Bang

- Quasars (billions ly away) with look-back times of 95+% the age of the universe.
- Newly discovered gravitational lensing (predicted by Einstein).
- Dark matter (matter too cool to emit energy)
- Atom ratio of H to He

Cosmology points to and we conclude that...

- The universe is extraordinarily big.
- The universe is expanding.
- The universe is very old.
- The universe had a beginning.

So, are all the questions answered?



Not even close. As the models are refined, the size, age, contents, and properties of the universe are also refined.

The mystery is not that we do not fully understand, but that we understand anything at all.

The important thing is not to stop questioning.

Albert Einstein