



Formation of the Universe and our Solar System

Studying the Stars

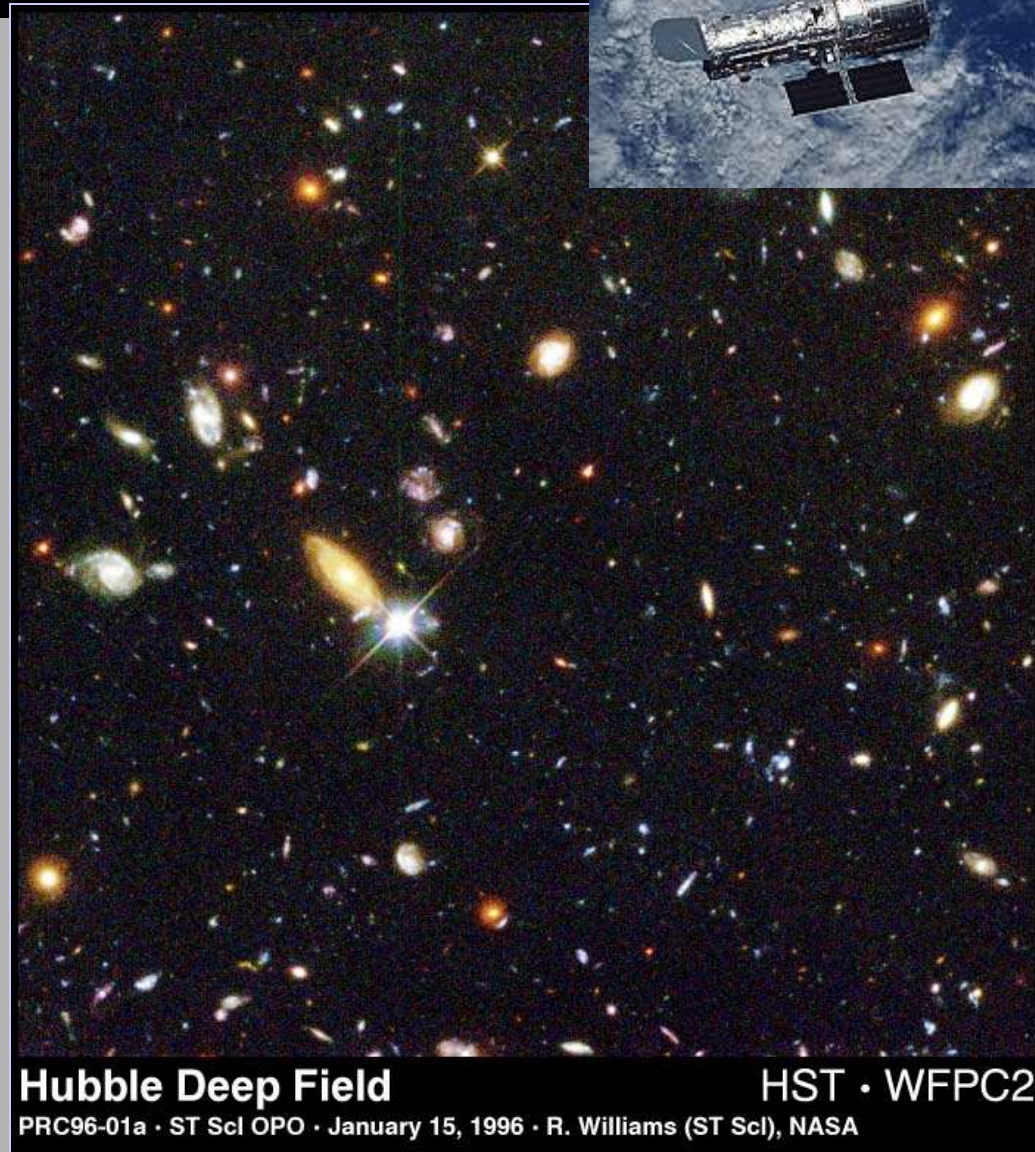
- **Astronomy** = scientific study of the universe
- **Cosmology** = study of the origin, properties, processes, and evolution of the universe

Observing the Universe

- Measuring distance – the average distance between the Earth and the sun is **one Astronomical Unit** = about 150,000,000 km
- **Electromagnetic Spectrum** = all the wavelengths of electromagnetic radiation from the sun.
 - Special instruments detect this radiation in space

Hubble Space Telescope

- Edwin **Hubble** developed a **telescope** that is orbiting 600 km, or 370 miles above Earth. It makes one orbit every **97** minutes.
- This telescope detects electromagnetic radiation being emitted from stars and records the images, as seen here.
- It is a spacecraft, with a power supply, communications equipment and control systems



Hubble Deep Field

HST • WFPC2

PRC96-01a • ST ScI OPO • January 15, 1996 • R. Williams (ST ScI), NASA

Do you remember?

Electromagnetic Spectrum

- **Longer**

- Radio waves
- Microwaves
- Infrared rays
- Visible light

- **Shorter**

- Ultraviolet rays
- X-rays
- Gamma rays

Telescopes

- Telescopes – **collect** and **concentrate** electromagnetic radiation from the sky (from **stars**)
- **Older** telescopes – collected **visible** light

Telescopes

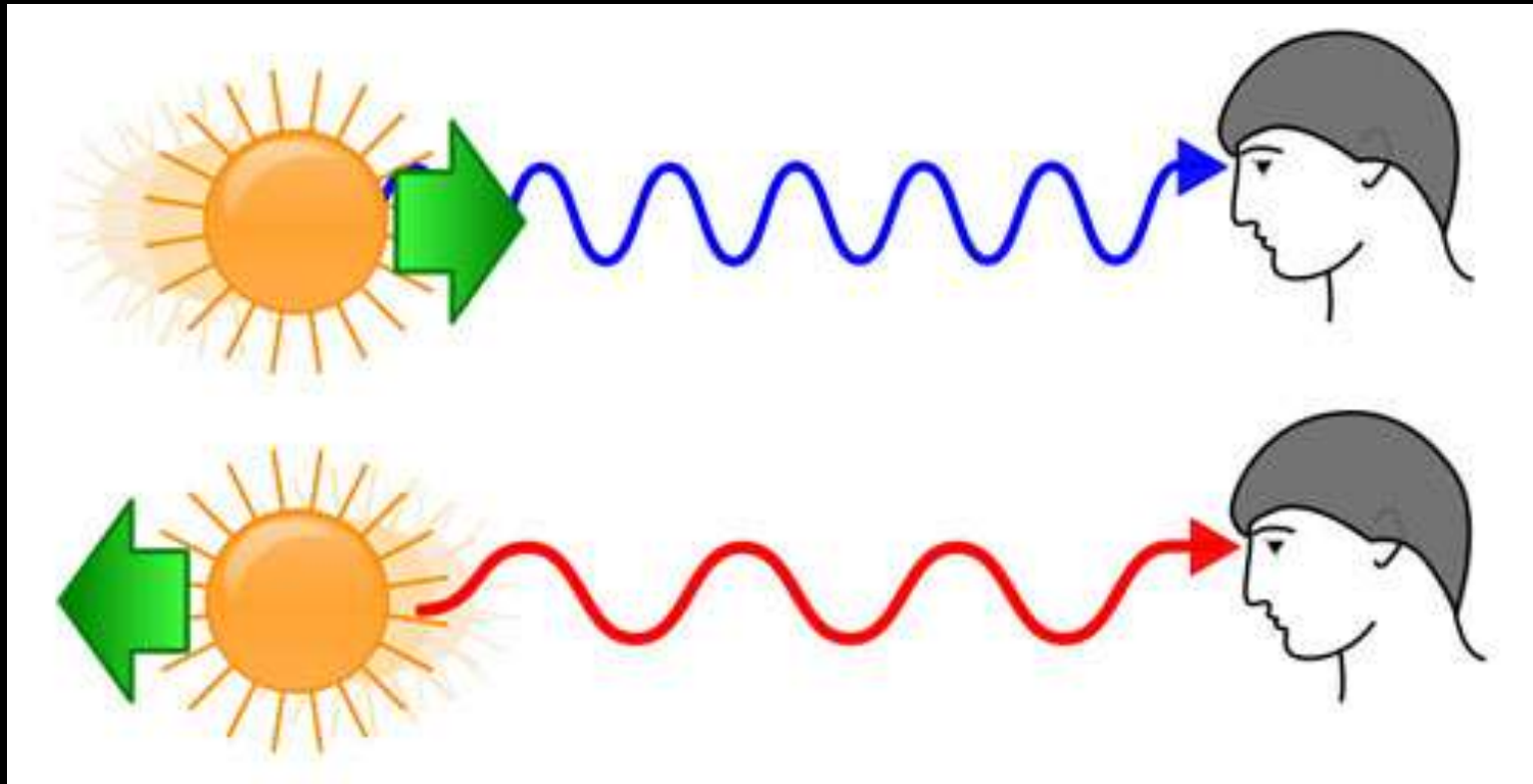
- **Modern** telescopes – collect and use **invisible** electromagnetic radiation
 - Different telescopes are used for different forms of radiation
 - Since much radiation is blocked by the atmosphere, these telescopes are often placed at high altitudes
 - However they work best in outer space

How did the Universe Form?

- **Big Bang Theory:**

- The **universe** began as a **single point** and has been **expanding** ever since. ~ **14 billion years**
- It continues to expand – how do we know?
 - **Red shift** – When a galaxy is moving away from the Earth, the light waves (radiation) from that galaxy are stretched out, making it look red.
 - **Blue shift** – when an object is traveling towards Earth, the waves are compressed, turning them blue

Red Shift



Our Place in Space

- Our **Galaxy** is named the **Milky Way**
- Our **Solar System** resides **within** the Milky Way
 - **One star** (solar *means* star, our sun)
 - **Eight planets** (**m, v, e, m, || j, s, u, n ||**)
 - **Asteroid belt** (|| outside the first 4 planets)
 - **Kuiper belt** (|| outside the last 4 planets)
- All bound together by **gravity**

The Milky Way...

Well, not exactly...



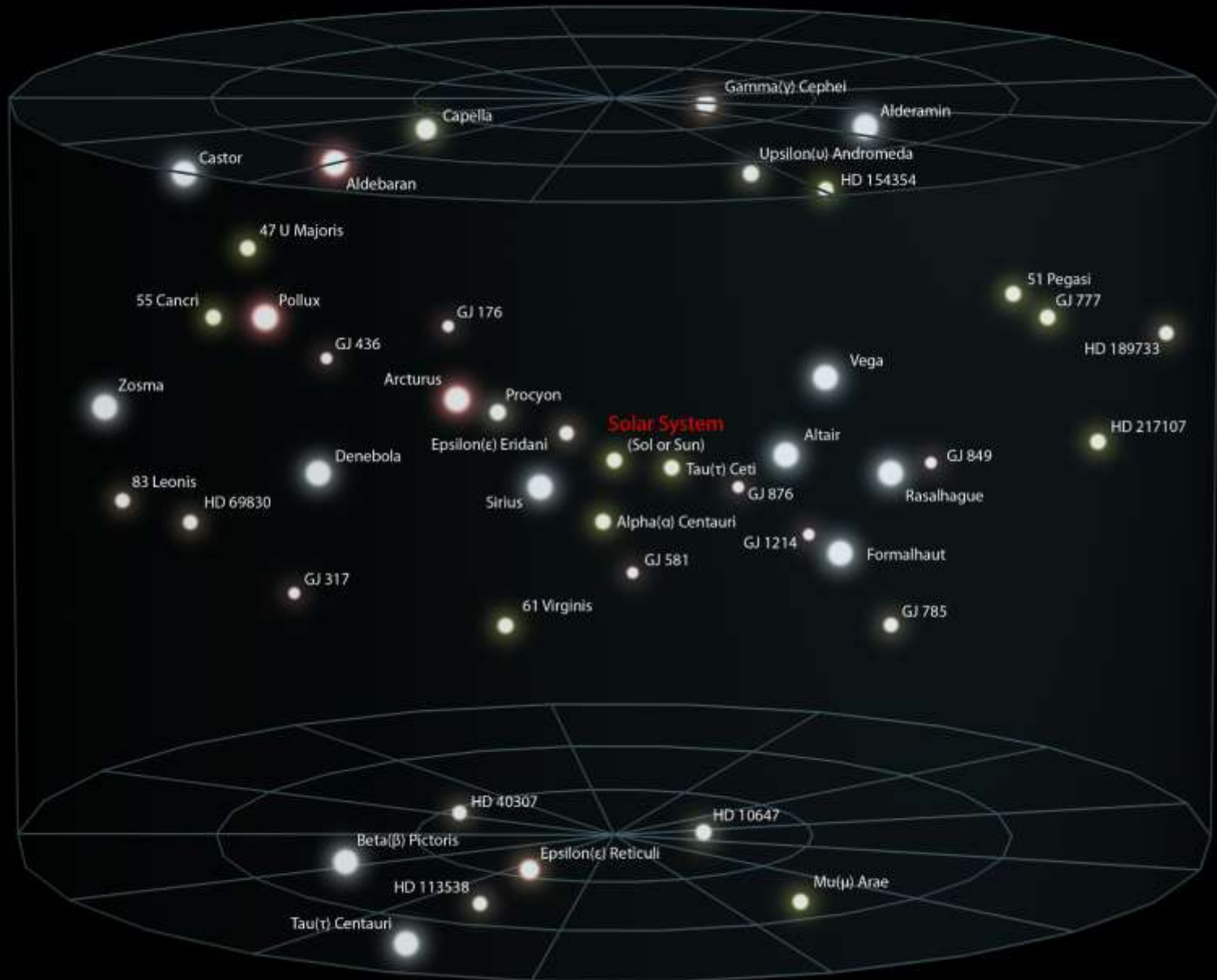
But this does look like
the Milky Way.

- **This is NGC 6744, an intermediate spiral galaxy about 30 million light-years away**
- We do not have pictures of the Milky Way because we cannot send a camera or telescope out beyond the Milky Way

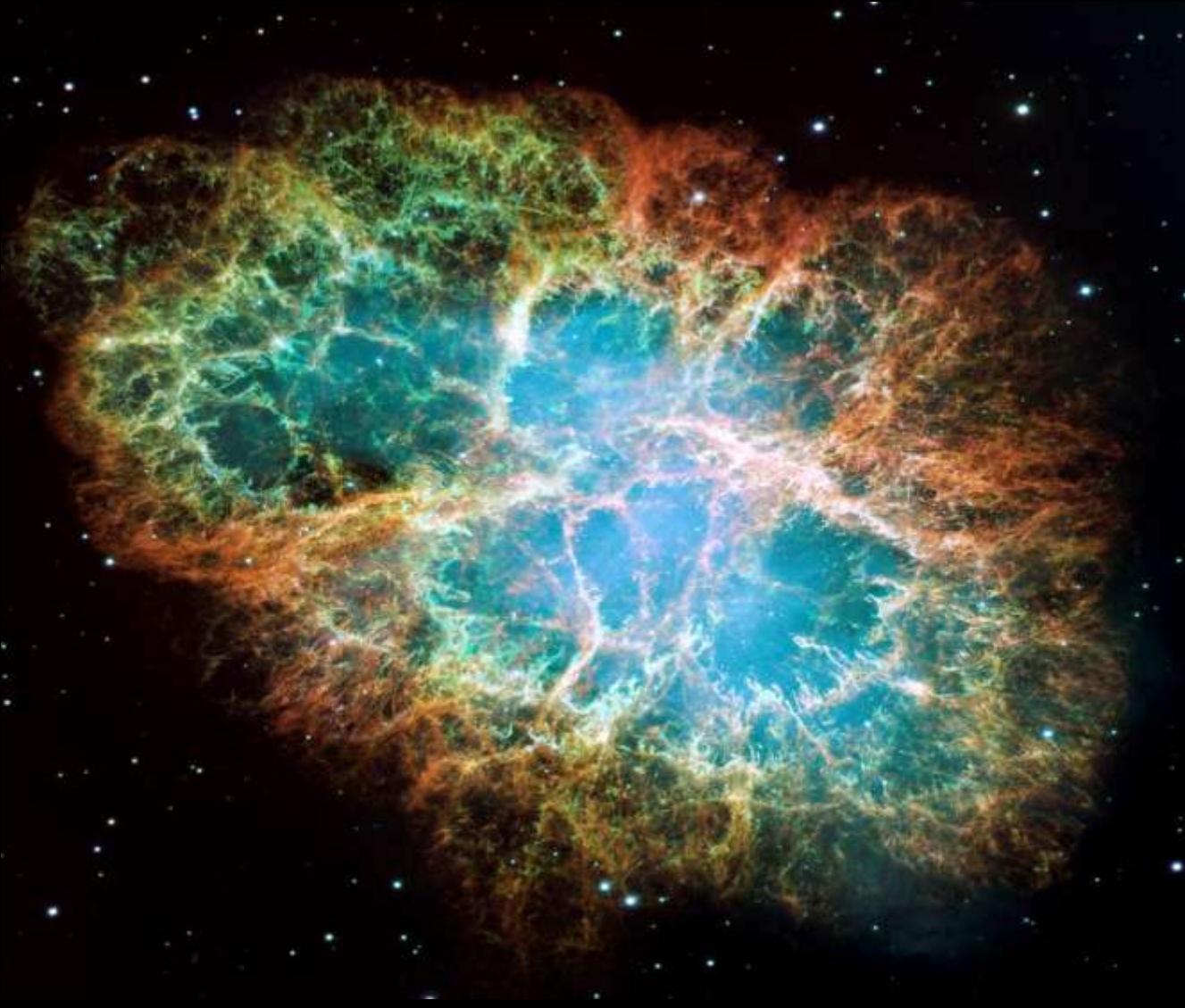
Photos from the Inside



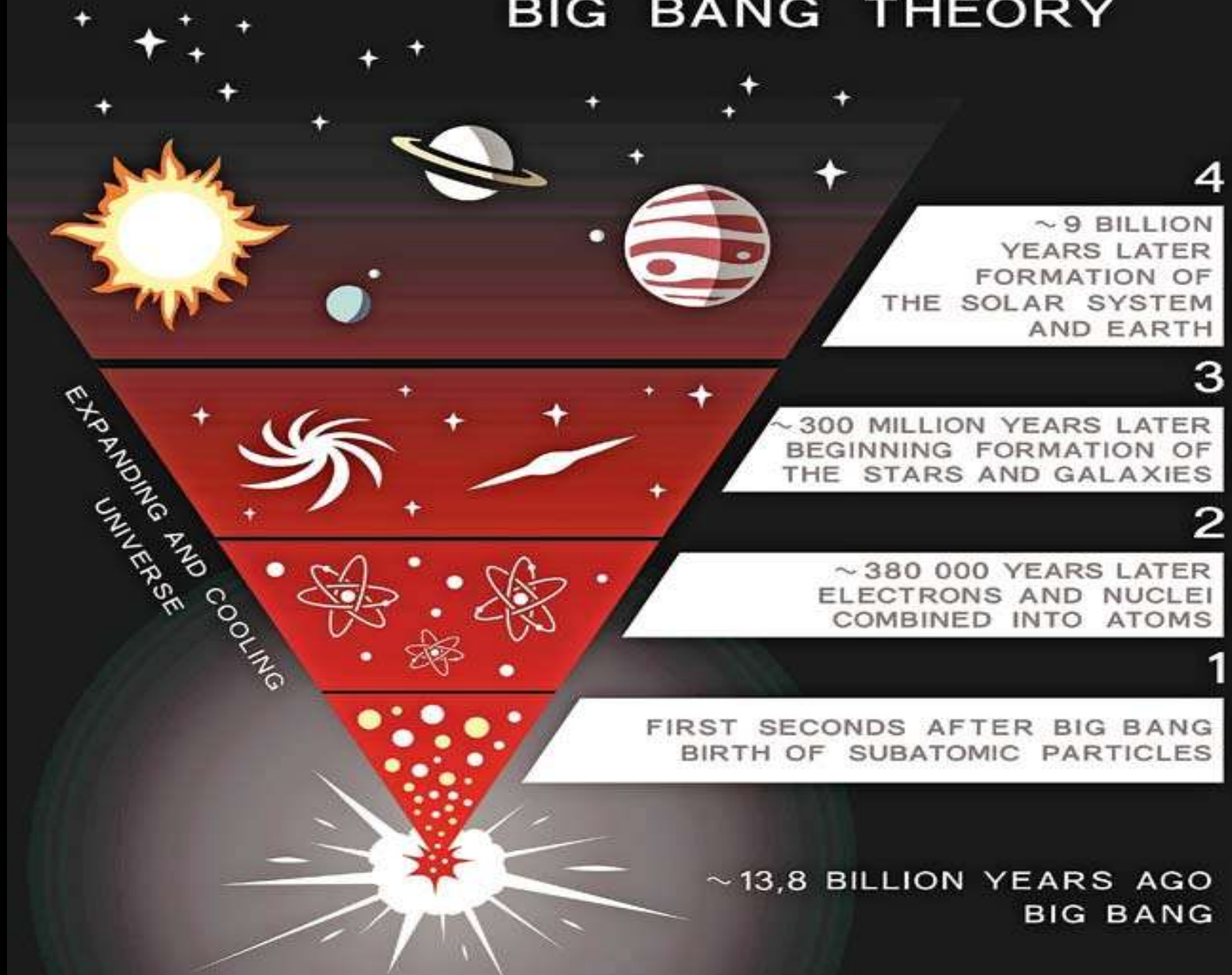
Solar Interstellar Neighborhood



Formation of the Solar System



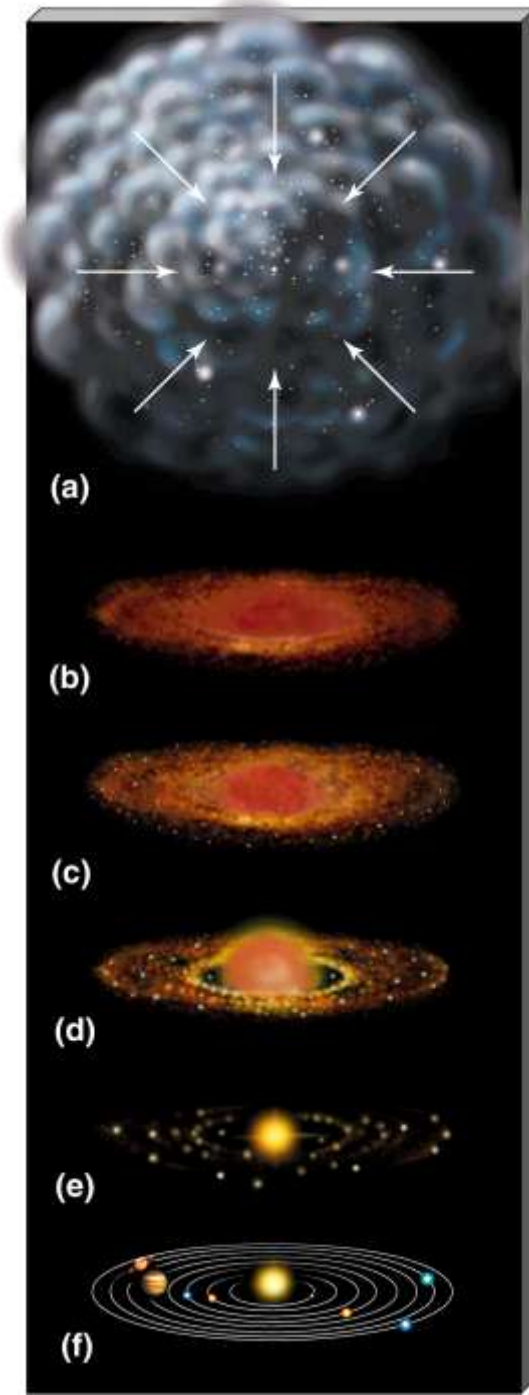
BIG BANG THEORY



Nebular Hypothesis

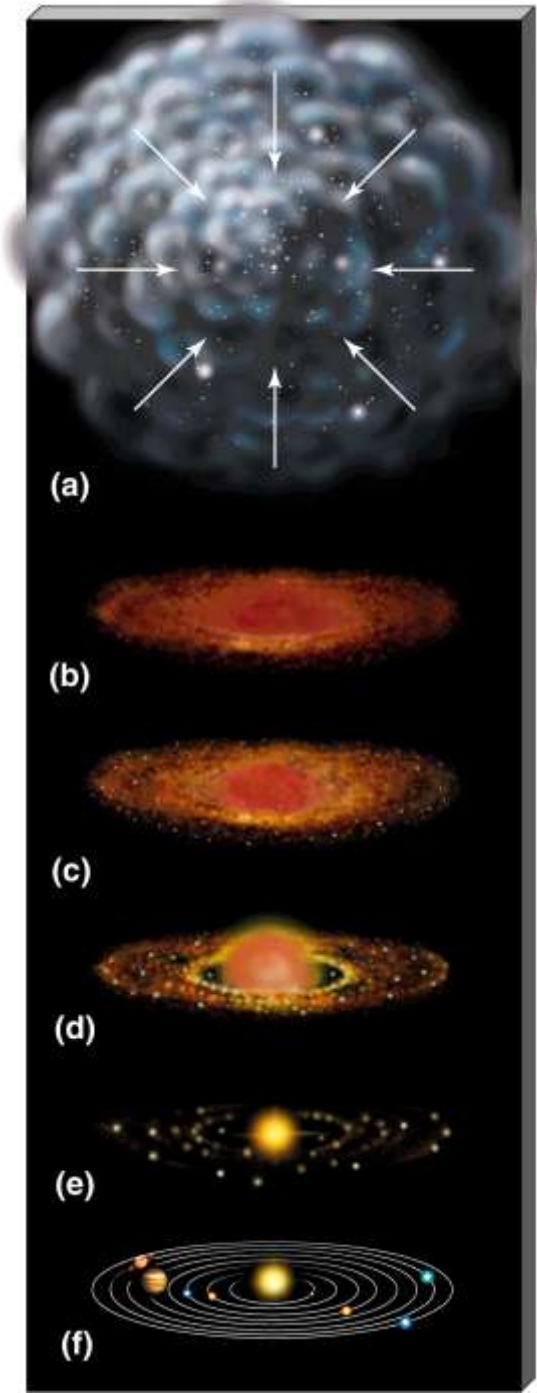
The Solar System was **formed** --

- From a **nebular cloud** of **dust** and **gas**
 - **Gravity** pulled the dust and gases together
 - Nebula was bumped by a nearby **supernova** blast
- 4.6 billion** years ago.
- Supernovae are **exploding stars**

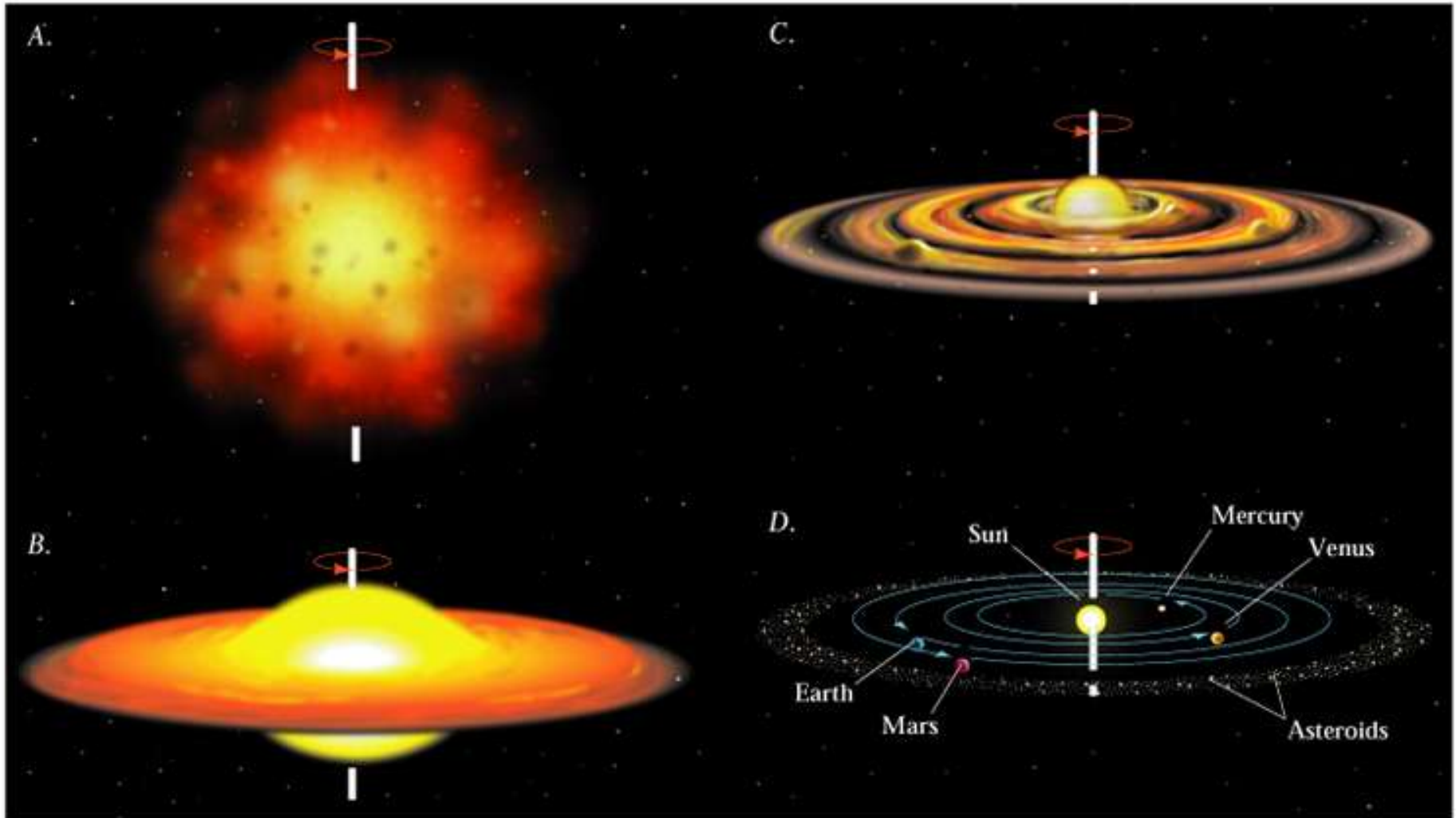


Nebular Hypothesis

- The cloud **collapsed** and began to **spin** because of the **energy** and **force** and **motion** of the material in the cloud.
- The material flattened out into a **spinning disk** with the middle part becoming the **Sun**, and clumps in the disk becoming the **planets**.



Nebular Hypothesis



How old is the Solar System?

- Approximately **4.6 Billion** years old
 - How do we know this?
- Scientists study the **age** of **meteorites** that have fallen to Earth.
 - Scientists use a process called **Radioactive Dating** to measure how long ago the meteorites formed by studying elements in the meteorite.

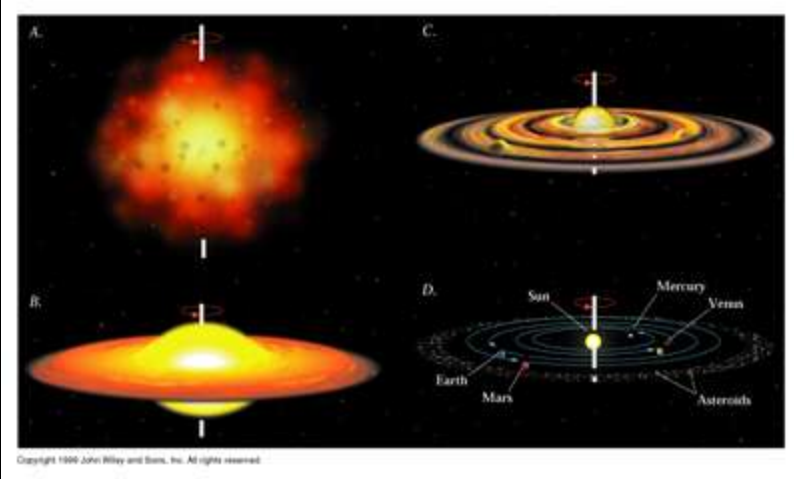
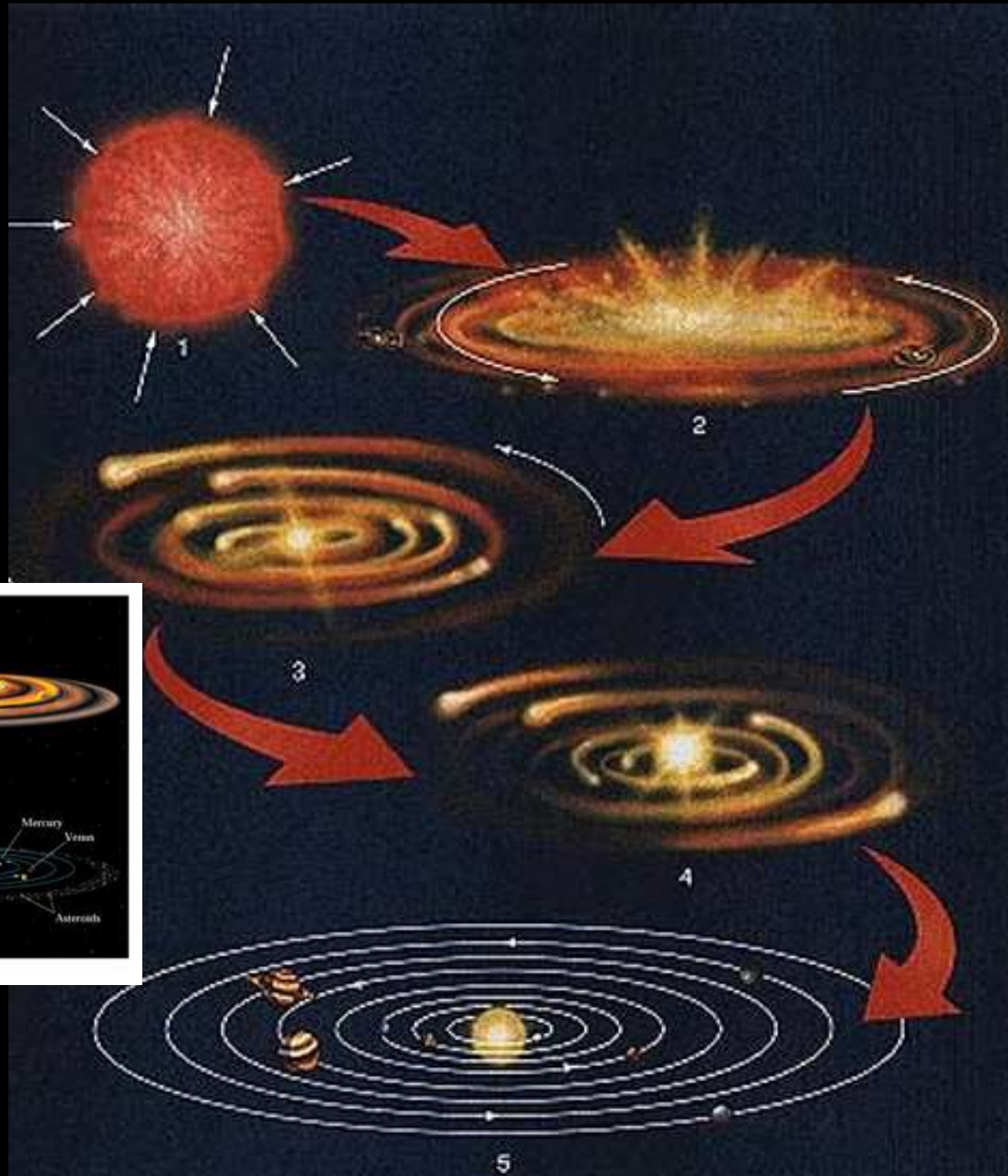
Review of Steps in the Formation of the Solar System

1. Began with a nebula cloud of dust and gas
2. A supernova made the cloud start to collapse.
3. Gravity pulled the gas and dust together, forming a spinning disk.
4. The disk got thinner; particles began to stick together - accretion; clumps formed.
5. The clumps got bigger as particles and other small clumps stuck to them, eventually forming the planets.

Review, cont.

5. The nebula got hotter and denser in the center and cooled at the edges.
6. As the cloud continued to fall in from the force of its mass and gravity, the center became intensely hot and nuclear fusion began, forming a star, the Sun
7. The sun ignited and solar winds swept past the inner planets stopping the clumping process.
8. The left-over clumps are found in the asteroid belt between Mars and Jupiter, and the Kuiper Belt beyond Neptune.

Supernova Explosion



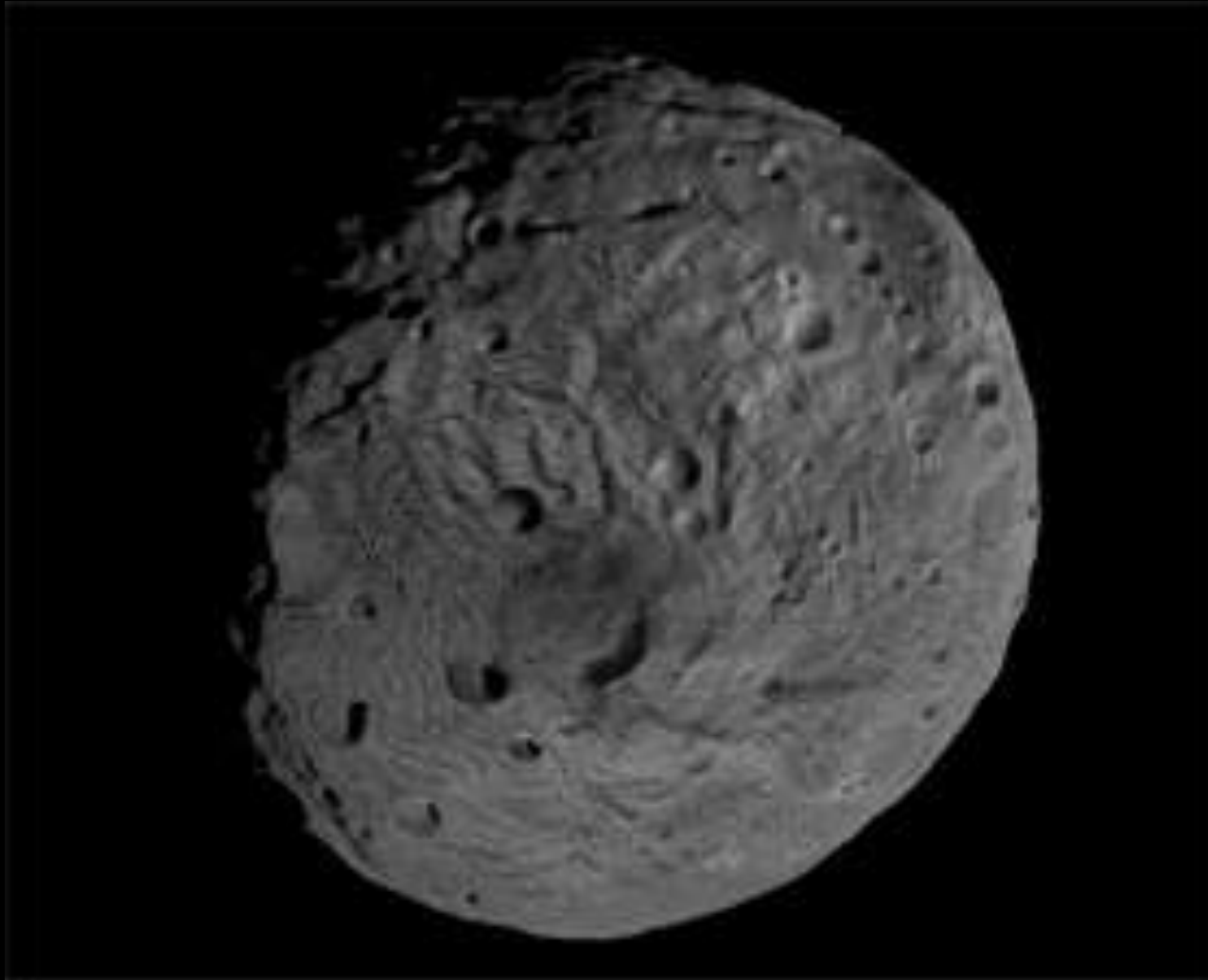
Formation of Solar System ----->

Bill Nye – Outer Space Video

How did Earth Form?

- Earth is 4.6 billion Years old
 - By studying the **age** of **meteorites** and moon rocks
 - Radioactive Dating, aka, radiometric decay
- As the **Solar System** was still **forming**, Earth formed as **planetesimals** (dust and particles) **accreted** (collided and stuck together).
- Next step: **Protoplanet** – a planet embryo that has undergone **internal melting** to **differentiate** it's **interior**

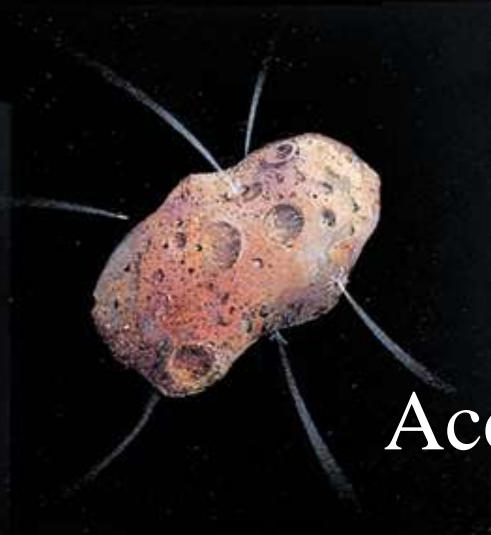
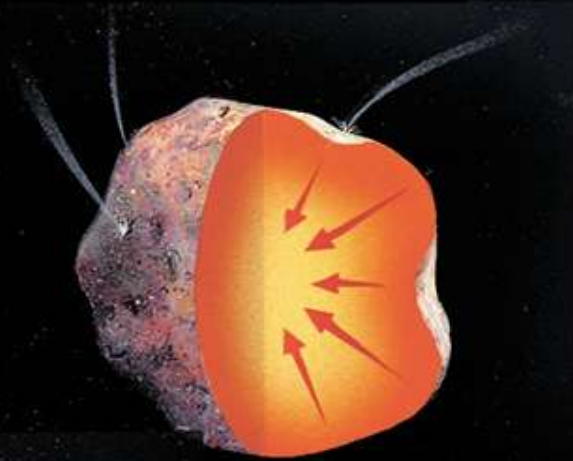
Vesta – Discovered 2012



How Did Earth Form?

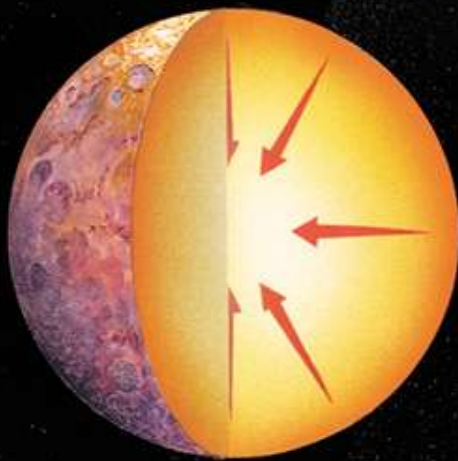
- Eventually the Earth became large enough to be a planet.
- When objects **collide**, **energy** from the collision is converted to **heat**.
- Earth was completely **molten**
- There was **NO OXYGEN** in the **atmosphere** when Earth was young





Accretion

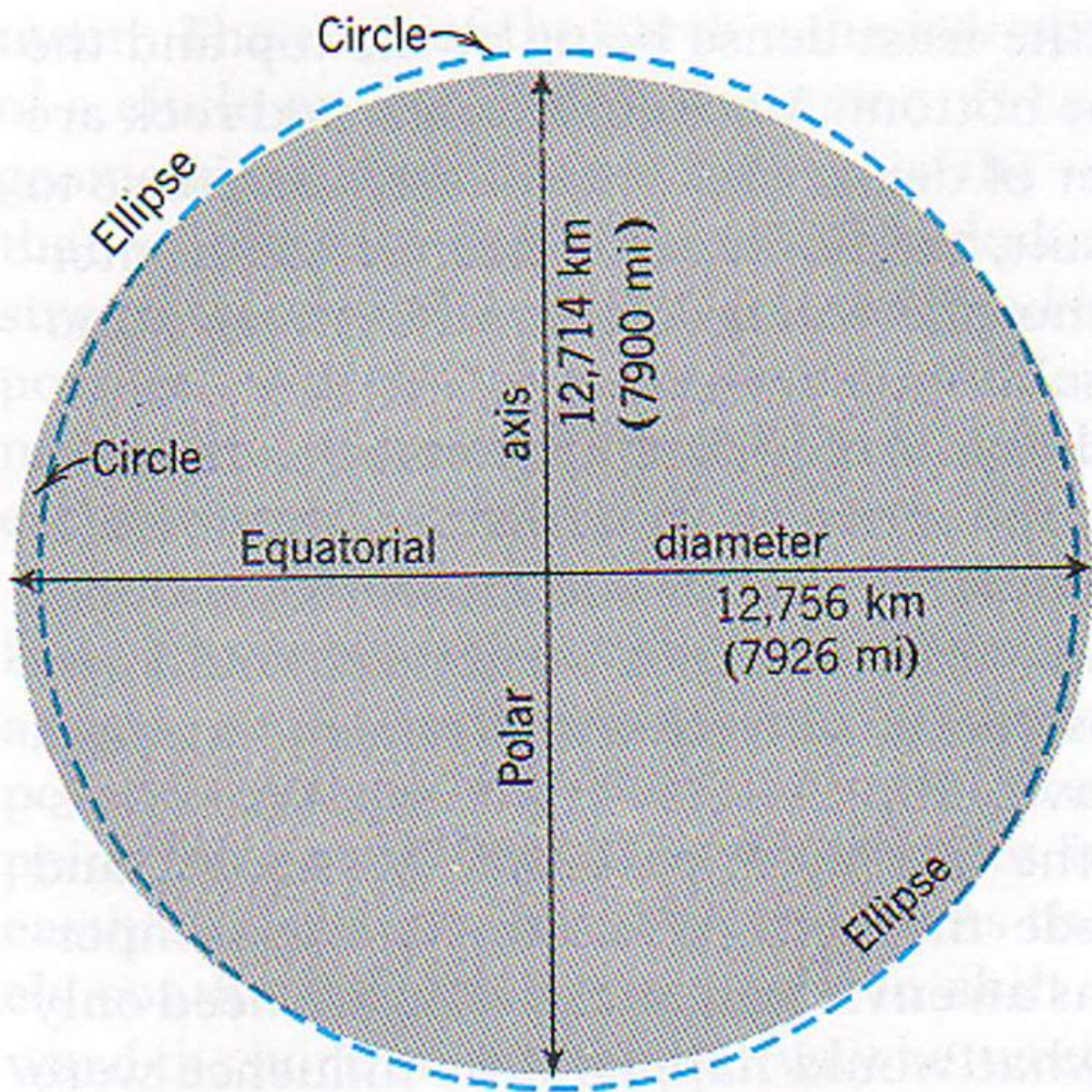
Gravity and spinning motion
reshapes the proto-Earth.



Differentiation

Earth's Shape

- Earth is not a perfect **sphere**
- **Gravity** and the **spinning** motion reshaped the **proto-Earth** and caused it to **bulge** in the center.
- This resulting shape is called an **ellipse**.



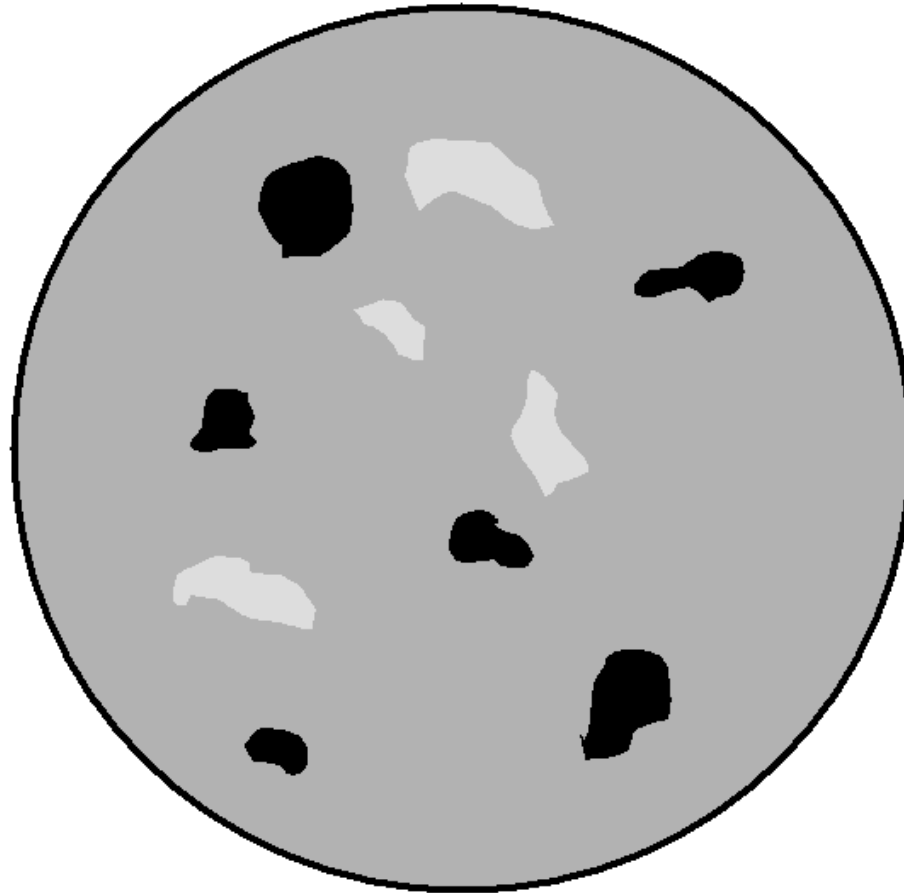
How We Know: Weight / Mass

- **Weight** is the **force** with which **gravity** pulls an object toward Earth's **center**.
- The **farther** an object is from the Earth's center, the **lighter** it is.
- Measure the **weight** of an object at several places on Earth. It **is different**.
- If you want to lose **weight** (not mass), go to the **Equator!**

Differentiation: Density Review

- Differentiation: the **denser** elements and minerals fall toward the **center** of the Earth
- **Lighter** elements and minerals **rise** towards the **surface**.
- **Differentiation** caused the Earth to **separate** into a **core**, **mantle**, and **crust**

Differentiation



Differentiation also gave us...

- **Oceans**

- **formed** from **comets** that hit the Earth
- And from water **stored** in **rock** deep in Earth

- **Atmosphere**

- formed from **outgassing** of gases from **volcanic** eruptions which produced **oxygen**

Earth – the Perfect Planet

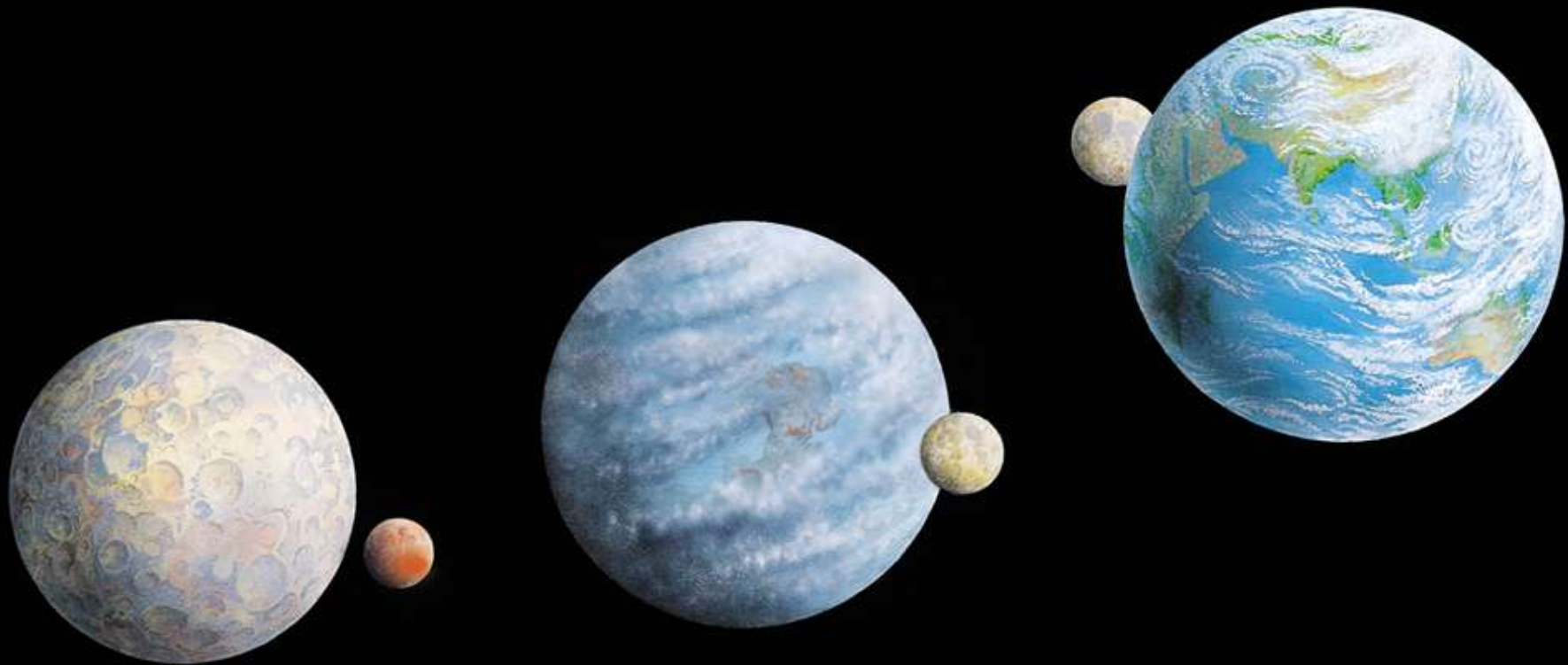
- **Water** - We are the only know planet with **liquid water**, therefore we can support life
- **Warmth** - We are the only planet with the **right distance** from the **sun** to support life
- **Ozone** layer – our atmosphere is conducive to life, with the ozone layer **protecting** us from the **sun's harmful rays**

How Earth's Moon was formed!



The newborn moon orbits within a ring of debris splashed out by the impact that formed it, over a molten earth





Early Earth

- Being hit all the time kept it completely molten.
- When impacts slowed down, Earth cooled, and life began.
- Earliest fossils, bacteria, are 3.5 billion years old.

We love impacts!

- Water and organic molecules (with carbon) came from comets and asteroids!
- Therefore, the very objects that prevented life to begin, were also the cause of life!

Cosmic Collision: Arizona's Impact

- <http://video.search.yahoo.com/video/play?ei=utf-8&fr=sfp&p=cosmic+collision%2C+arizona+impact&vid=216751670107&dt=30094701&l=139&turl=http%3A%2F%2Fts4.mm.bing.net%2Fvideos%2Fthumbnail.aspx%3Fq%3D216751670107%26id%3D91e7ca837729171c71b5b1add24ce59c%26bid%3DJnEzr5%252f6Ckodjg%26bn%3DThumb%26index%3Dch1%26url%3Dhttp%253a%252f%252fdsc.discovery.com%252fvideos%252fcosmic-collisions-arizona-impact.html&rurl=http%3A%2F%2Fdsc.discovery.com%2Fvideos%2Fcosmic-collisions-arizona-impact.html&tit=Cosmic++Collisions%3A++Arizona++Impact+%3A++Video+%3A++Dis...&sigr=12599u2tm&newfp=1>