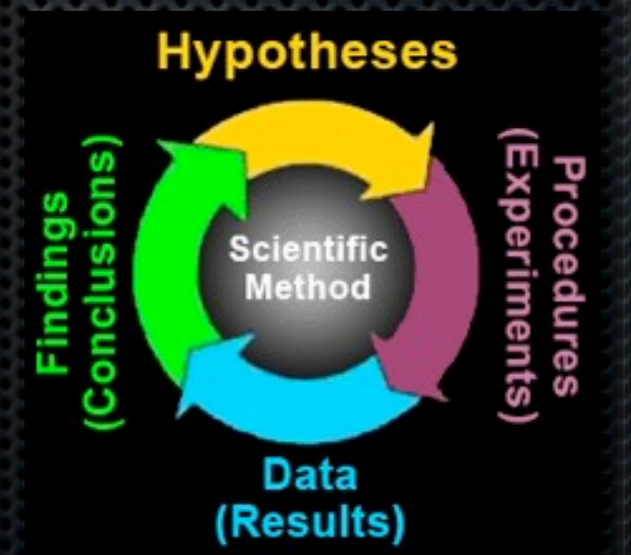
ESC102

Earth in Context

Scientific Method

- The scientific method is an orderly and logical approach that relies on data to inform our understanding of a problem or process.
- assumes that nature is consistent and predictable
  - tentative explanations, called a hypotheses, are produced to explain observed data
- Multiple hypotheses are tested to see if what they predict actually occurs in nature

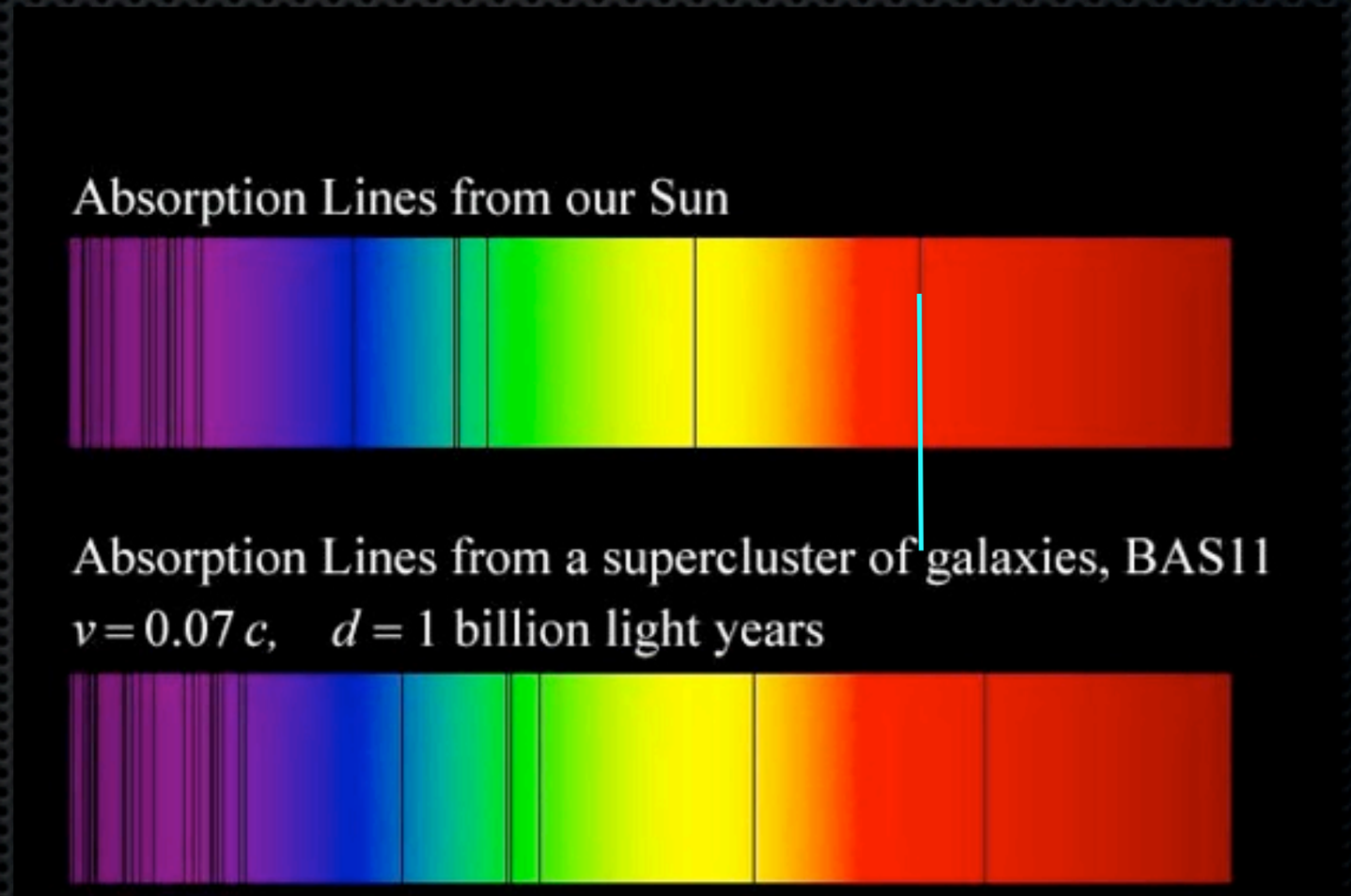


Stars and Galaxies

- Stars are immense balls of incandescent gas.
  - Light and heat derives from nuclear fusion reactions where atoms combine to make new elements
  - Gravity binds stars together into vast galaxies.
- The solar system is on an arm of the Milky Way galaxy.
  - Our sun is one of 300 billion stars in the Milky Way.

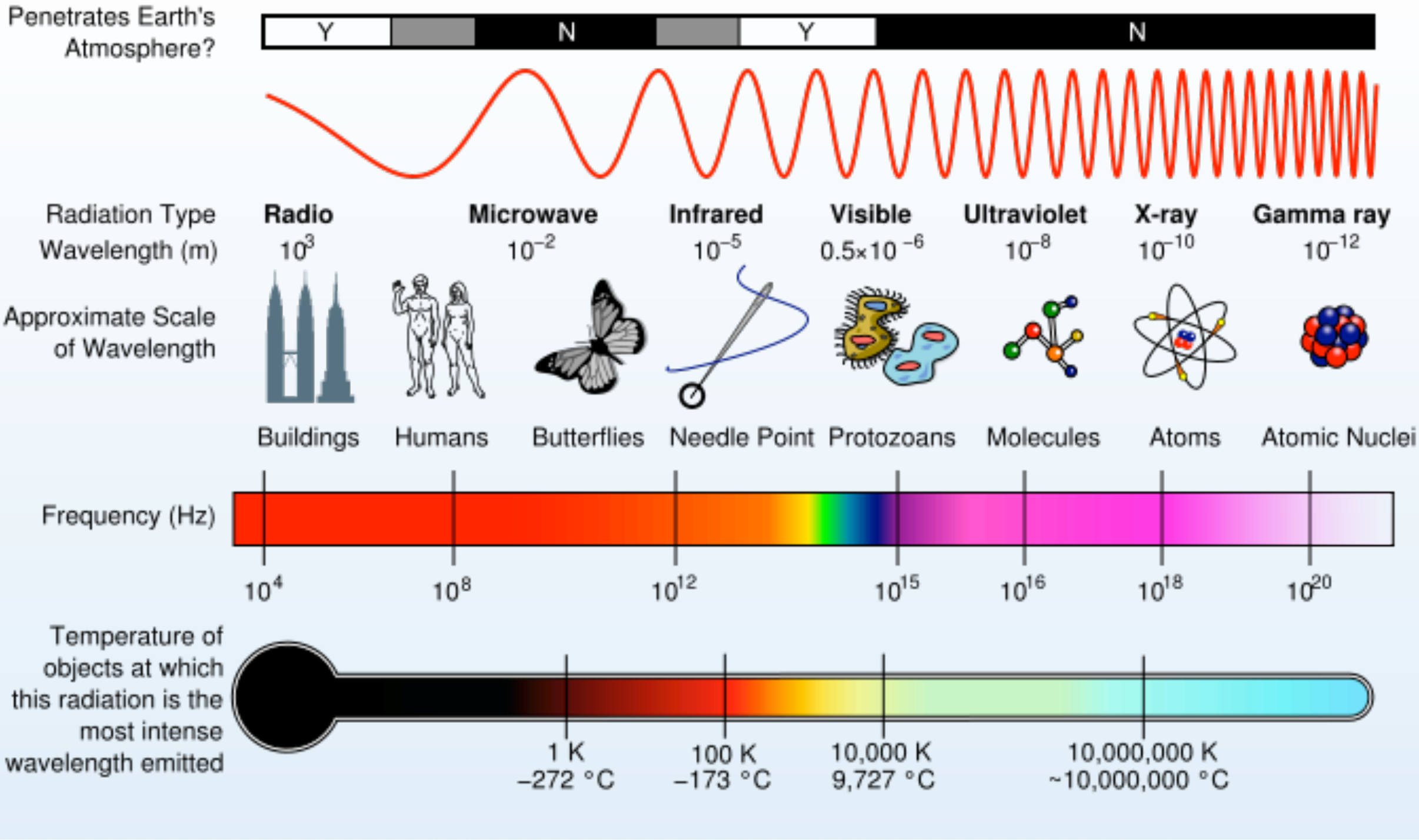
The Beginning

For years scientist observed an apparent red-shift in the light from distant galaxies



Edwin Hubble suggested the observed shift was due to the **doppler effect**

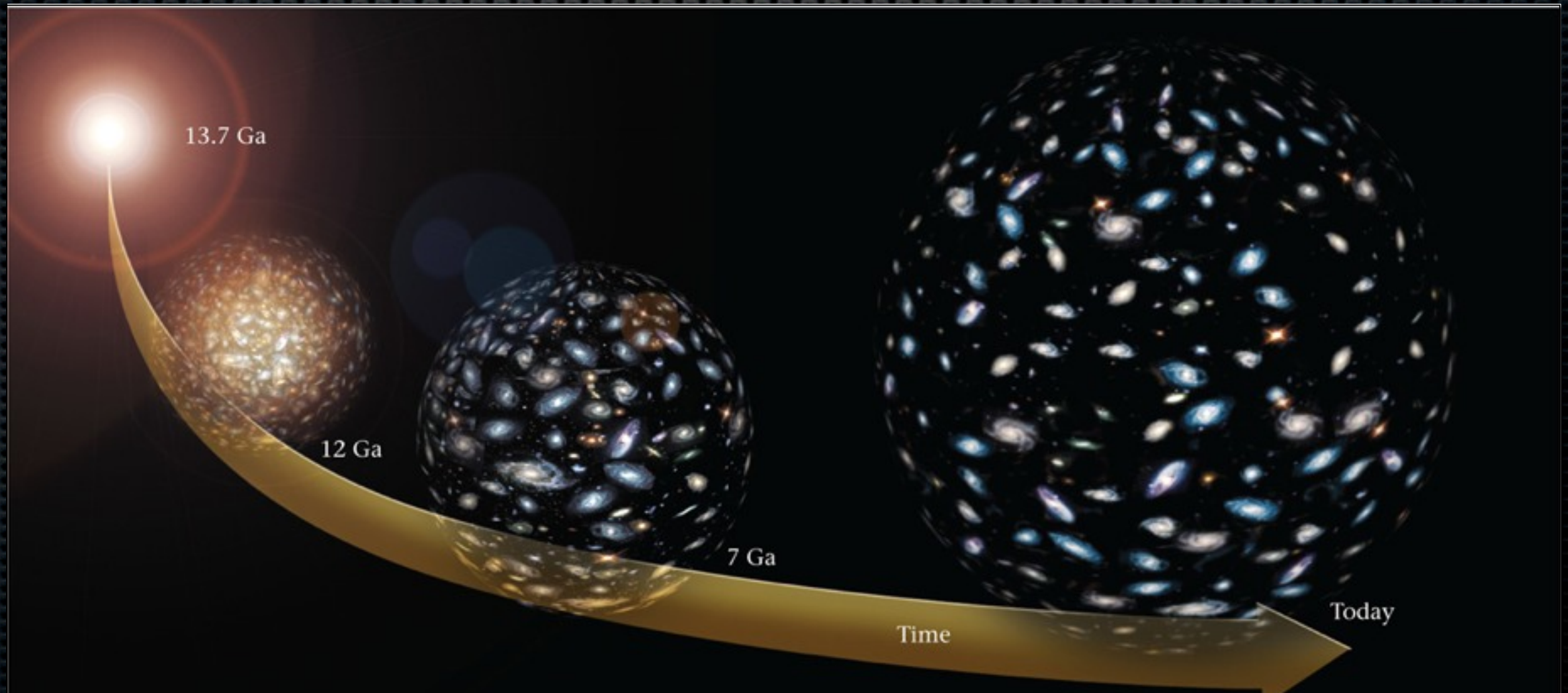
The Doppler Effect



An expanding Universe?

When did it all begin?

- The Big Bang: All mass and energy in a single point.
- Began expanding 13.7 Ga



The Big Bang

- With expansion and cooling, atoms began to bond.
  - Hydrogen formed H_2 molecules - The fuel of stars.
- Gravity caused formation of gaseous nebulae.
  - Resulted in increases in…
    - Increased temperature.
    - Density.
    - Rate of rotation.

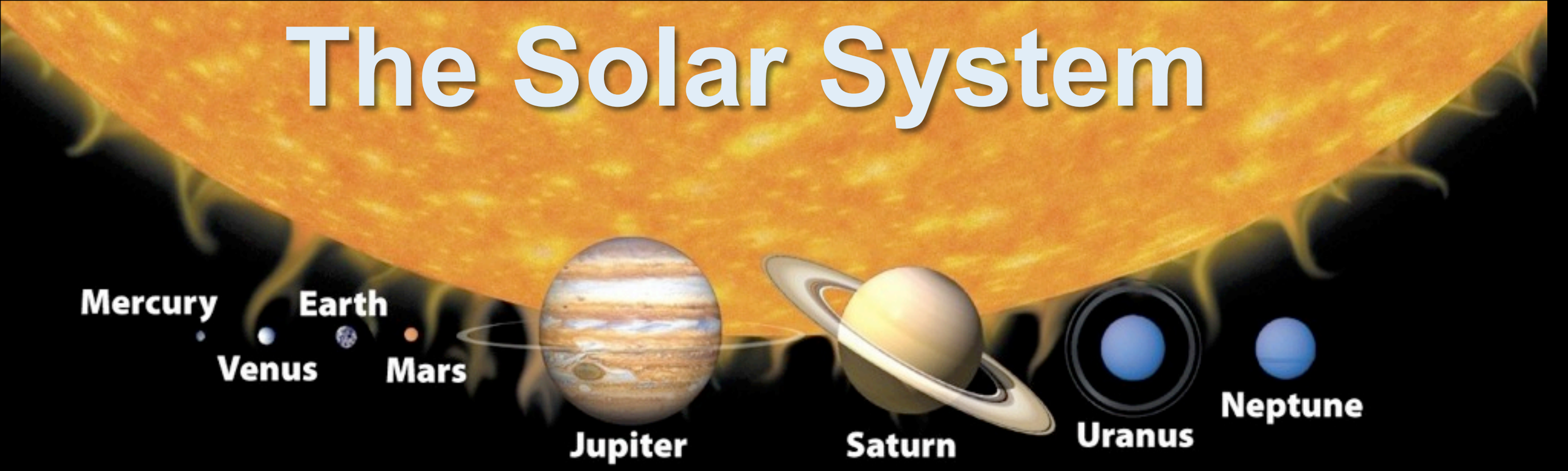
After the Big Bang

- Condensed nebula formed flattened accretion discs.
- Heat and mass from collapse “ignited” nuclear fusion.
- These 1st generation stars consumed H_2 fuel rapidly.
- As the stars became H_2 starved:
  - Collapse and heating.
  - Heavy element production.
  - Catastrophic explosion (supernova).

Nucleosynthesis

- Stars are truly "element factories."
- Big Bang Nucleosynthesis formed lighter elements.
  - Atomic #s 1, 2, 3, 4, and 5 (H, He, Li, Be, and B).
- Heavier elements are from Stellar Nucleosynthesis.
  - Atomic #s 6 – 26 (C to Fe).
- Elements with atomic #s > 26 form during supernovae.

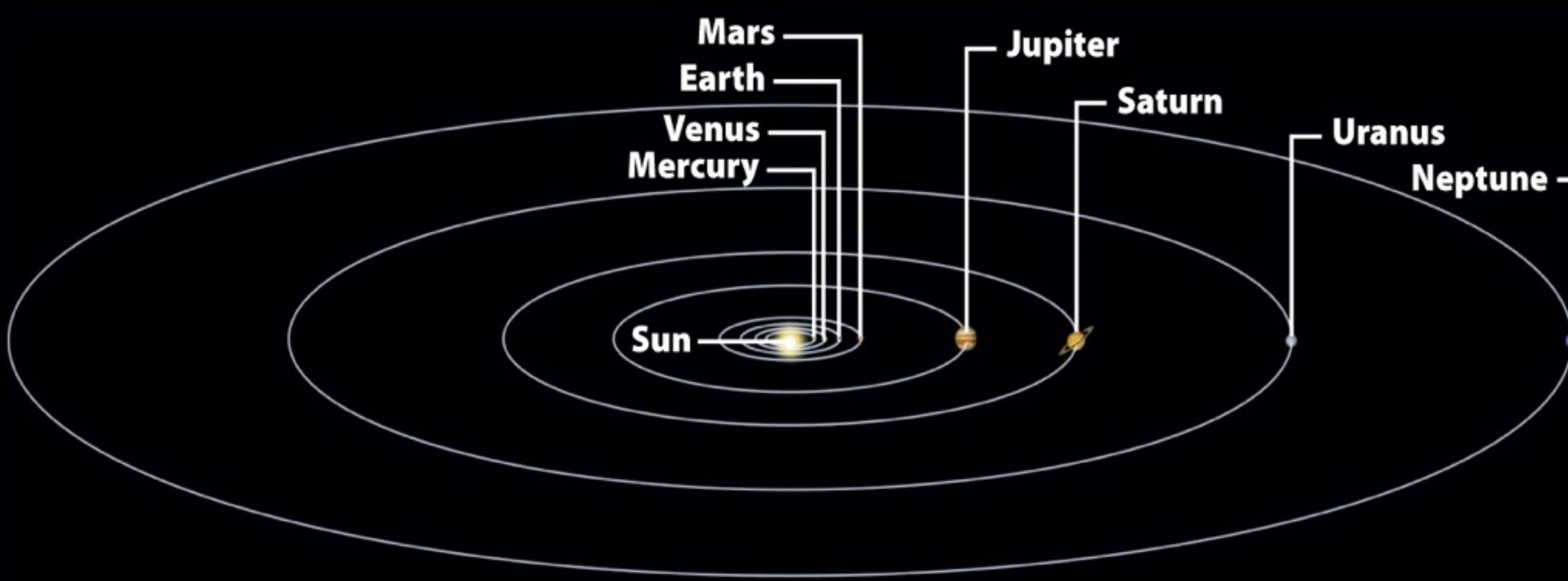
The Solar System



- Solar system: A sun, planets, moons and other objects.
- Earth shares the solar system with 7 planets. A planet…
  - Is a large body orbiting a star (the Sun).
  - Has a nearly spherical shape.
  - Has cleared it's neighborhood of other objects.
- Moon – A solid body locked in orbit around a planet.
- The solar system also includes asteroids and comets.

The Solar System

- The Terrestrial planets are the 4 most interior.
- The Jovian planets occupy the 4 outermost orbits.
- The asteroid belt lies between Mars and Jupiter.

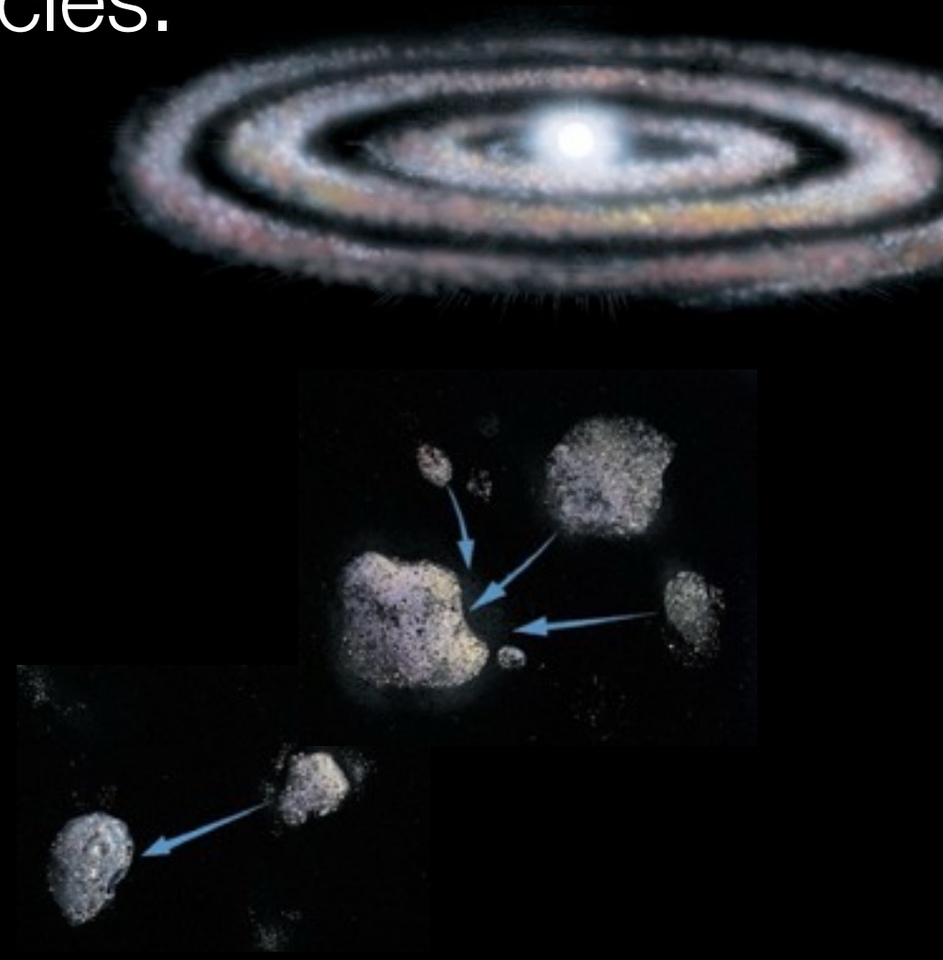


Solar System Formation

- The Nebular Theory.
  - A 3rd, 4th or nth generation nebula forms ~4.56 Ga.
    - Hydrogen and Helium left over from the big bang.
    - Heavier elements produced by stellar nucleosynthesis.
  - This material coalesces into an accretion disc with a protostar at the center.

Solar System Formation

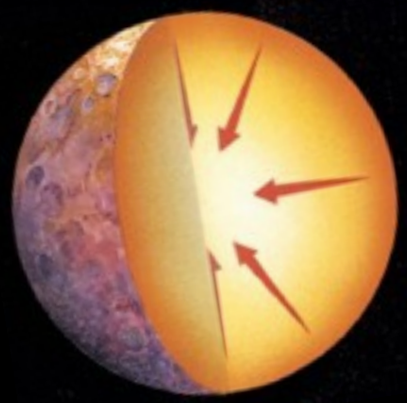
- The ball at the center grows dense and hot.
- Dust in the rings condenses into particles.



- **Planetesimals accumulate into a larger mass.**
- **An irregularly-shaped proto-Earth develops.**

- **The interior heats up and becomes soft.**

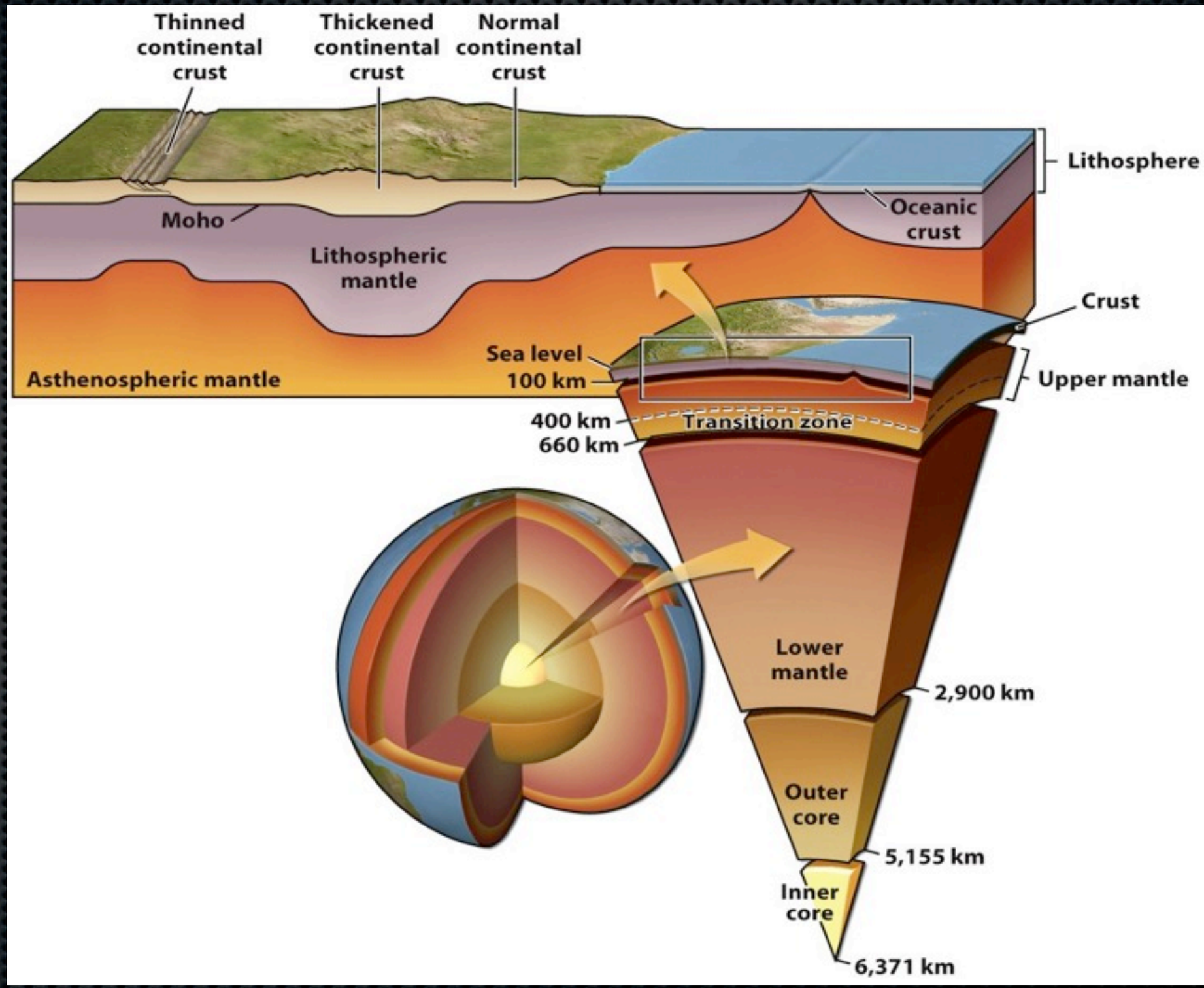
- **Gravity shapes the Earth into a sphere.**



- **The interior differentiates into a-Fe core and stony mantle.**

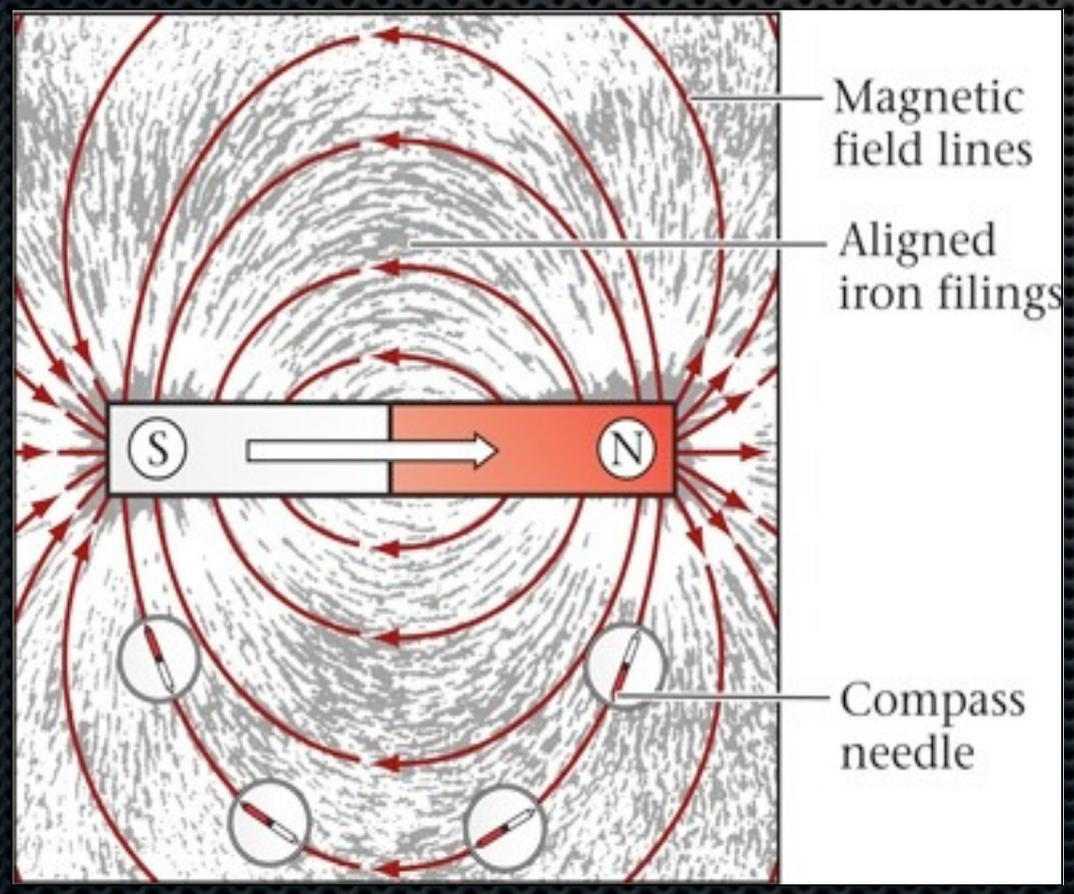
Earth's Interior Layers

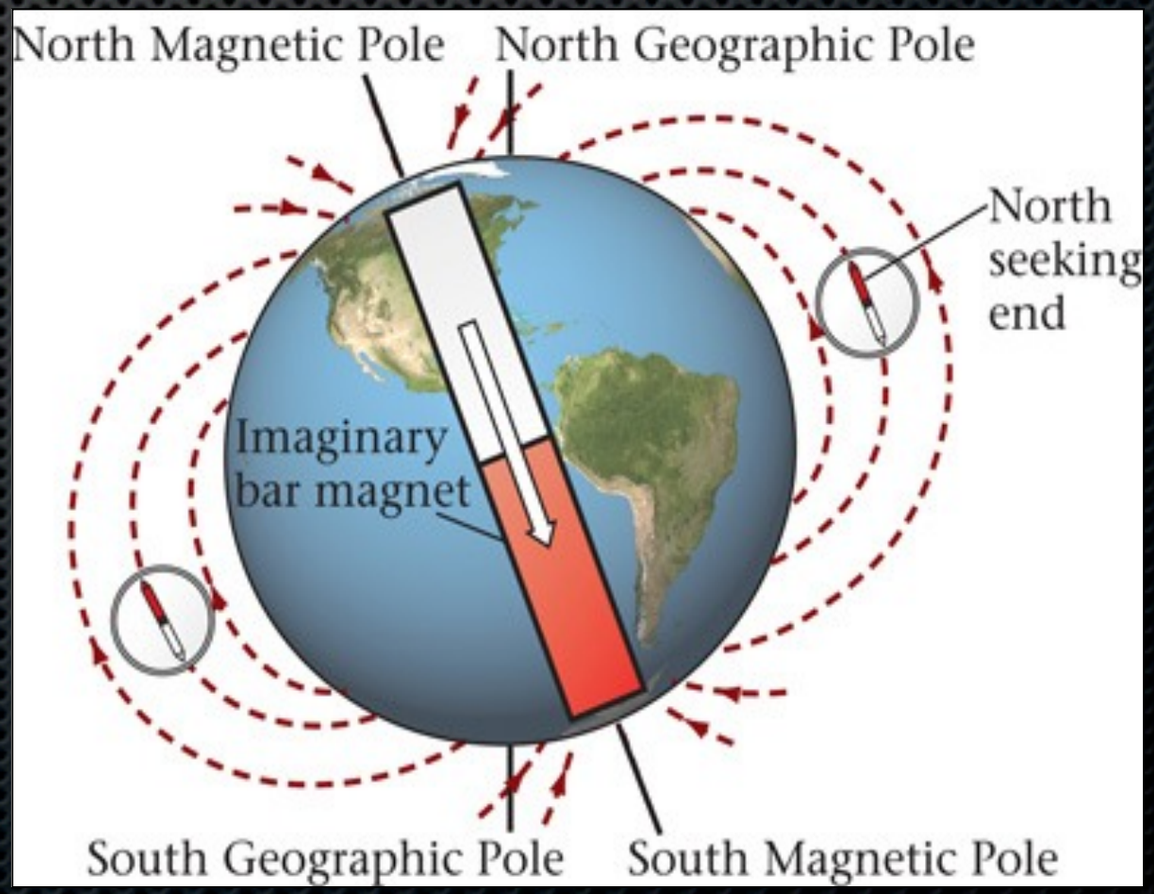
- Crust
  - Continental
  - Oceanic
- Mantle
  - Upper
  - Lower
- Core
  - Outer - Liquid
  - Inner – Solid



Magnetic Field

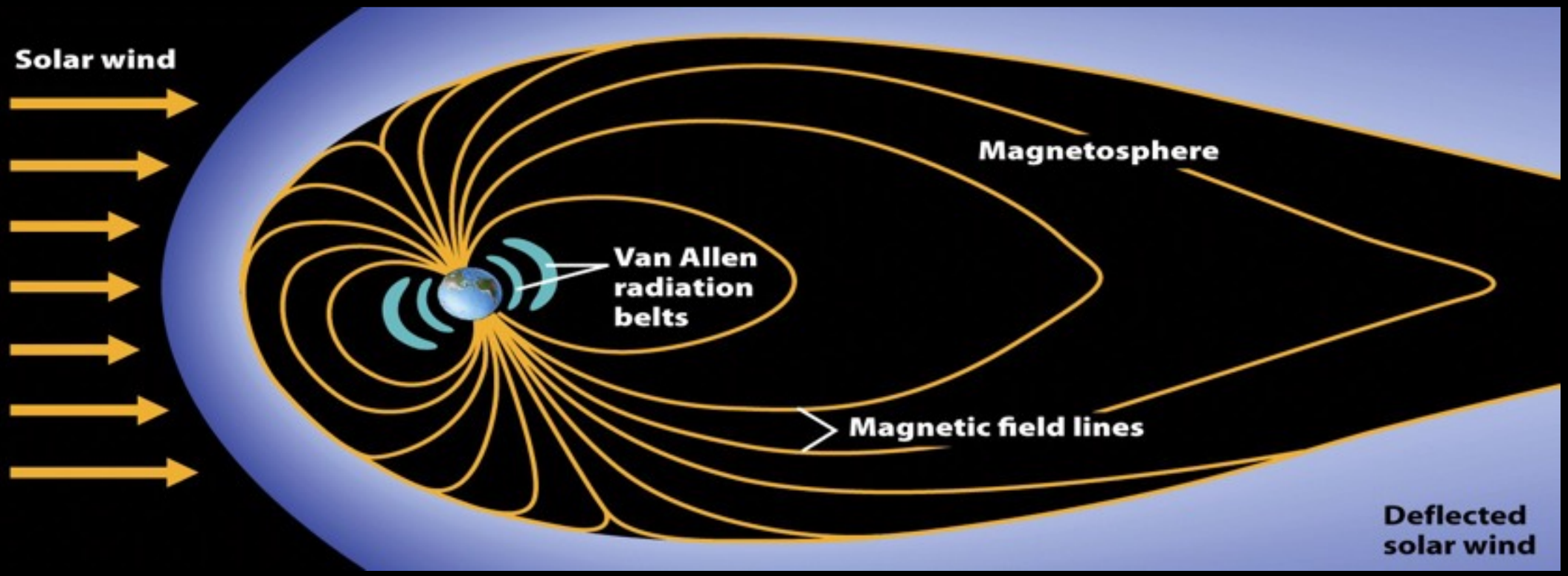
- Like a bar magnet, Earth has a **dipolar** magnetic field.
- Magnetic field lines flow from N to S and…
  - Extend into space and weaken with distance from Earth.
  - Create a shield around Earth (the magnetosphere).





The Van Allen Belts

- The solar wind is deflected by the magnetosphere.
- Near Earth, the stronger magnetic field forms the Van Allen belts, which arrest deadly cosmic radiation.

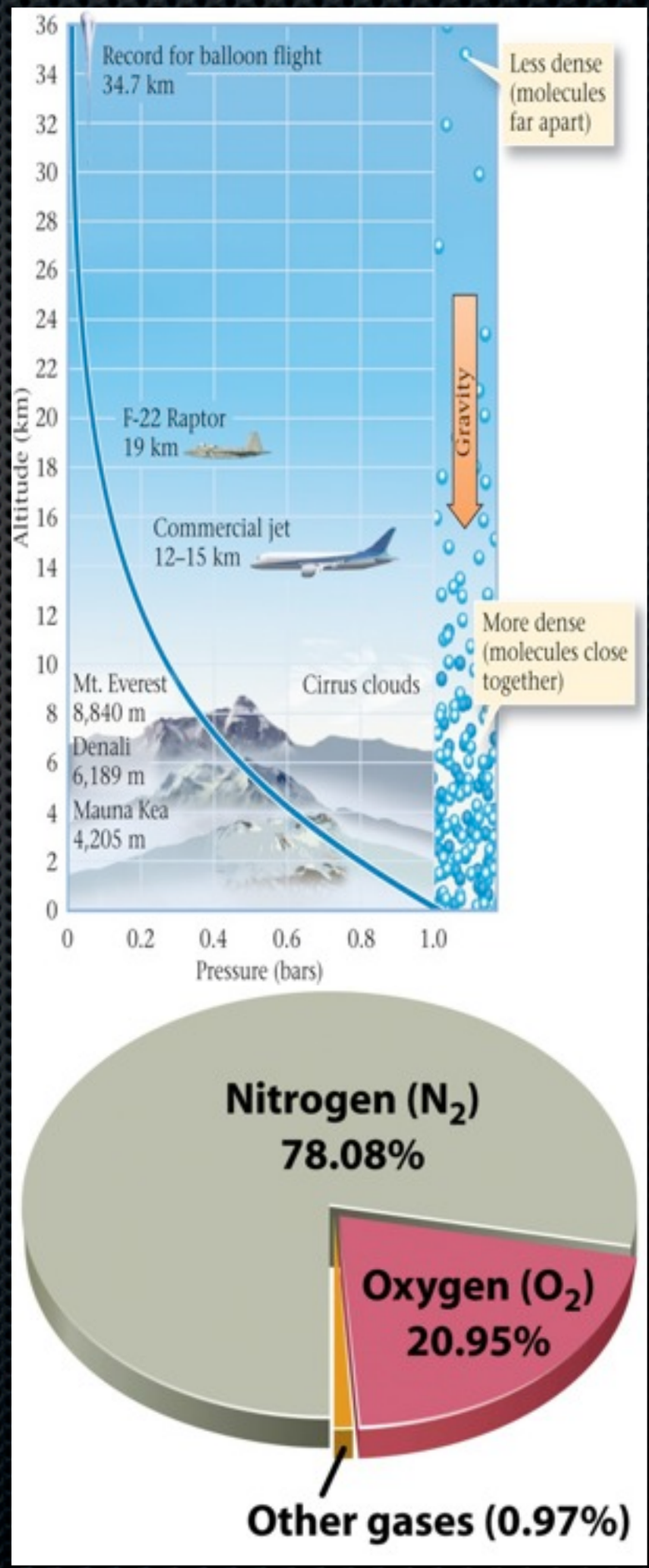


Aurorae

- Some ions escape Van Allen belts.
  - Pulled to the magnetic poles, the ions generate light.
- Spectacular aurora follow solar flares.
  - Aurora borealis – Northern lights.
  - Aurora australis – Southern lights.

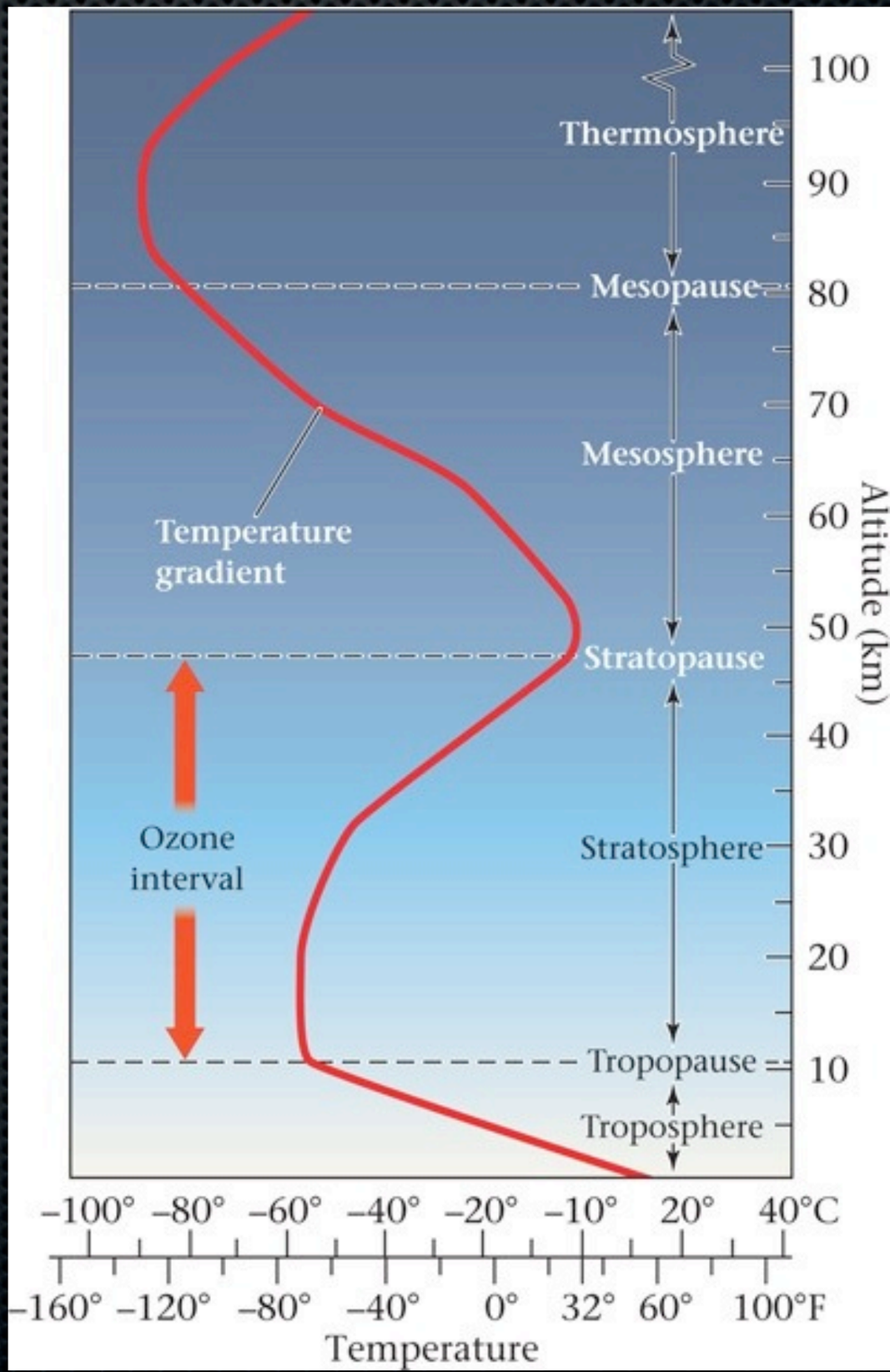
The Atmosphere

- Earth atmosphere is unique among the planets
- Densest at sea-level, the atmosphere thins upward.
- The atmosphere is mostly nitrogen (N_2).
- Oxygen was absent from the atmosphere before 2.5 Ga.



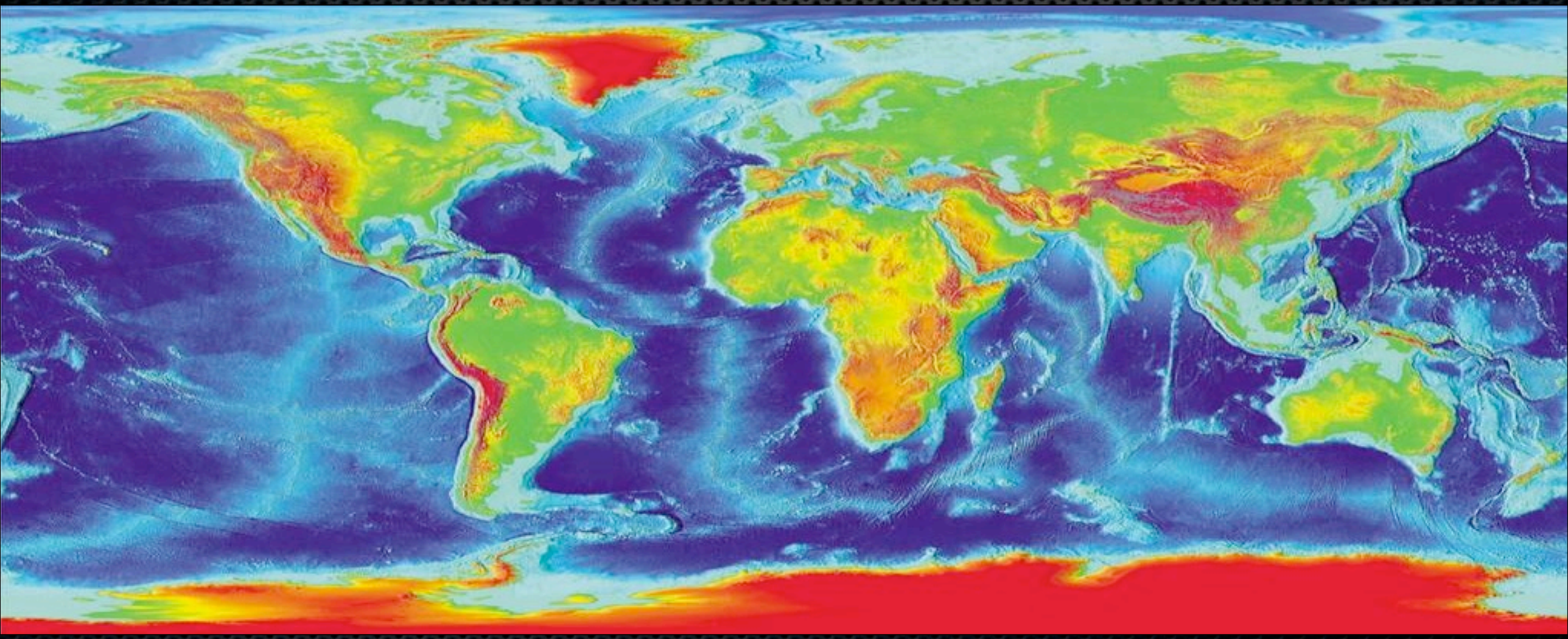
The Atmosphere

- Troposphere (0–11 km).
  - Mixing layer.
  - Weather is limited to this layer.
- Tropopause (11–12 km).
- Stratosphere (12–47 km).
- Mesosphere (47– 81 km).
- Thermosphere (> 81 km).
- Boundaries between layers are termed “pauses.”



Surface Features

- Earth's surface: continents are high; oceans are low. Due to the differing buoyancy of each type of crust.



Earth Materials

- **Organic chemicals** – Carbon containing compounds.
  - Biological remains (wood, peat, lignite, coal, and oil).
  - Geologically rare (decompose in contact with oxygen).
- **Minerals** – Inorganic crystalline solids.
  - Comprise rocks and, hence, most of the earth.
  - Most minerals on Earth are silicates (based on Si and O).