Chapter 2
Origins
➢ Formation of Universe, Solar System and Earth
➢ Creation of Oceans

Formation of the Universe
➢ Big Bang, 13*10^9 years ago
➢ Formation of elementary particles
➢ Gravitational formation of dense regions
➢ 1*10^9 yrs later ➞ first stars

Origin of the Solar System
➢ Rotating cloud of gas from which sun and planets formed
➢ Initiated by "supernova" ➞ exploding star

Nuclear Fusion: The joining of atoms under tremendous temperatures and pressures to create atoms of a heavier element. In the Sun, four hydrogen atoms are fused to create each helium atom. Two of the hydrogen’s protons become neutrons in the process.

Supporting Evidence for the Big Bang
- Edwin Hubble discovered spreading of galaxies.
- Cosmic background radiation (the glow left over from the explosion itself) discovered in 1964.
Moderate Size Stars (Our Sun): C & O

Large Stars (more, H & He): Fe

Supernova: Heavier Elements Formed

A nebula (a large, diffuse gas cloud of gas and dust) contracts under gravity. As it contracts, the nebula heats, flattens, and spins faster, becoming a spinning disk of dust and gas. Star will be born in center. Planets will form in disk. Warm temperatures allow only metal/rock “seeds” to condense in the inner solar system. Hydrogen and helium remain gaseous, but other materials can condense into solid “seeds” for building planets. Cold temperatures allow “seeds” to contain abundant ice in outer solar system. Terrestrial planets are built from metal and rock. Solid “seeds” collide and stick together. Larger ones attract others with their gravity, growing bigger still.

Earth, Ocean and Atmosphere accumulated in layers sorted by density.

The planet grew by the aggregation of particles. Meteors and asteroids bombarded the surface, heating the new planet and adding to its growing mass. At the time, Earth was composed of a homogeneous mixture of materials. Earth lost volume because of gravitational compression. High temperatures in the interior turned the inner Earth into a semisolid mass; dense iron (red drops) fell toward the center to form the core, while less dense silicates move outward. Friction generated by this movement heated Earth even more. The result of density stratification: an inner and outer core, a mantle, and the crust.

How did water and water vapor form on early Earth?

- The Sun stripped away Earth’s first atmosphere.
- Gases, including water vapor, released by the process of outgassing, replaced the first atmosphere.
- Water vapor in the atmosphere condensed into clouds.
- After millions of years, the clouds cooled enough for water droplets to form.
- Hot rain fell and boiled back into the clouds.
- Eventually, the surface cooled enough for water to collect in basins.

Sources of Water

* Mantle rocks
  - Evidence from meteorites
  - Release through volcanic activity

* Outer space
  - Evidence from Dynamics Explorer
Billions of years ago

Life probably originated in the ocean

The evolution of our atmosphere

Age and Time

Radioactive Decay Series

The future of Earth

How long can Earth exist?

1 billion = 1,000,000,000 or 10^9
Earth is 4.6 * 10^9 years old
Oceans are 4.2 * 10^9 years old
Oldest rocks date from 3.8 * 10^9 years ago
First evidence of life dates from 3.6 * 10^9 years ago

1 million = 1,000,000 or 10^6
Ocean and atmosphere reach the state we know today 800 * 10^6 years ago

Past and Future

Millions of years in the future

704 million years

At that time, Earth will probably be recycled into component atoms.
Summary

Most of the atoms that make up Earth, its ocean, and its inhabitants were formed within stars billions of years ago. Stars spend their lives changing hydrogen and helium into heavier elements. As they die, some stars eject the elements into space during cataclysmic explosions. The sun and planets, including Earth, condensed from a cloud of dust and gas enriched by the recycled remnants of exploded stars.

Earth formed by accretion—the clumping of small particles into a large mass. The mass heated as it grew and eventually melted. The heavy iron and nickel crashed toward Earth’s center to become its core; the lighter silicates and aluminum compounds rose to the surface to form a crust. Earth became density stratified—that is layered by density.

The ocean formed as soon as Earth was cool enough for water to remain liquid. Life followed soon thereafter.

Thinking Analytically

1. A light-year is the distance light can travel in one year. Light travels at 300,000 kilometers per second. Commercial television broadcasting began in 1939. Television signals travel at the speed of light. How far away would a space probe have to be before it could no longer detect those signals?

2. Can you think of any way an astronomer could detect a large planet orbiting a star without actually seeing the planet? (Hint: how would a star move as the planet orbits it?)