

Evolution

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- **Evolutionary Biology** is the branch of science that deals with the study of the history and development of life forms on Earth.
- To truly understand what *evolution* is, we must look beyond just the living organisms.

What is Evolution?

- Evolution refers to the gradual development and diversification of life forms over millions of years.
- It explains the changes in flora and fauna that have occurred on Earth through natural processes.

Understanding Evolution in Context

- To comprehend these biological changes, it is essential to place them within a broader framework, which includes:
 - The origin of life
 - The evolution of Earth
 - The formation of stars
 - The evolution of the universe

The Grand Story of Life

- The study of evolution is not limited to biology alone; it is intertwined with the cosmic narrative.
- The **story of life on Earth** is one of the most intricate and longest ever told—constructed through scientific research, evidence, and reasoned conjecture.
- It encompasses:
 - The origin of life
 - The evolution of diverse life forms
 - The development of biodiversity
- All of this has occurred within the vast **timeline of Earth's history** and against the background of the universe's evolution.

Origin of Life

Looking Back in Time

- When we gaze at stars on a clear night, we are essentially looking into the past.
 - **Stellar distances** are measured in light-years, meaning the light from those stars began its journey millions of years ago from trillions of kilometers away.
 - In contrast, objects in our immediate surroundings are seen instantly, placing them in **present time**.
 - Therefore, observing stars gives us a glimpse into the past.

The Vastness of the Universe

- The universe is unimaginably vast and is estimated to be around **13.8 billion years old**.
- It consists of huge clusters of galaxies, each containing stars, gas, and dust.
- In comparison, Earth is just a speck in the cosmic scale.

The Big Bang Theory: Origin of the Universe

- The Big Bang Theory suggests that the universe originated from a **massive explosion**.
- As the universe expanded, the temperature decreased, allowing the formation of Hydrogen and Helium.
- These gases condensed under gravity to form the galaxies we see today.

Formation of Earth and Early Conditions

- Earth is believed to have formed **about 4.5 billion years ago** within the solar system of the Milky Way Galaxy.
- Initially, Earth lacked an atmosphere.
- **Volcanic activity** released gases like water vapour, methane (CH_4), carbon dioxide (CO_2), and ammonia (NH_3) from the molten mass.
- Ultraviolet rays (UV) from the Sun broke water molecules into Hydrogen and Oxygen:
 - Hydrogen (H_2) escaped due to its lightness.
 - Oxygen reacted with CH_4 and NH_3 to form water and CO_2 .
- An **ozone layer** eventually formed.
- As Earth cooled, water vapor condensed and fell as rain, filling depressions to form **oceans**.

Origin of Life on Earth

- Life appeared approximately **500 million** years after Earth's formation, i.e., about 4 billion years ago.

Theories on the Origin of Life

1. Panspermia Theory

- Some scientists believe life came from outer space.
- Early Greek thinkers proposed that life was transferred through spores from other planets.
- This idea is known as **Panspermia**, still supported by some astronomers.

2. Spontaneous Generation Theory

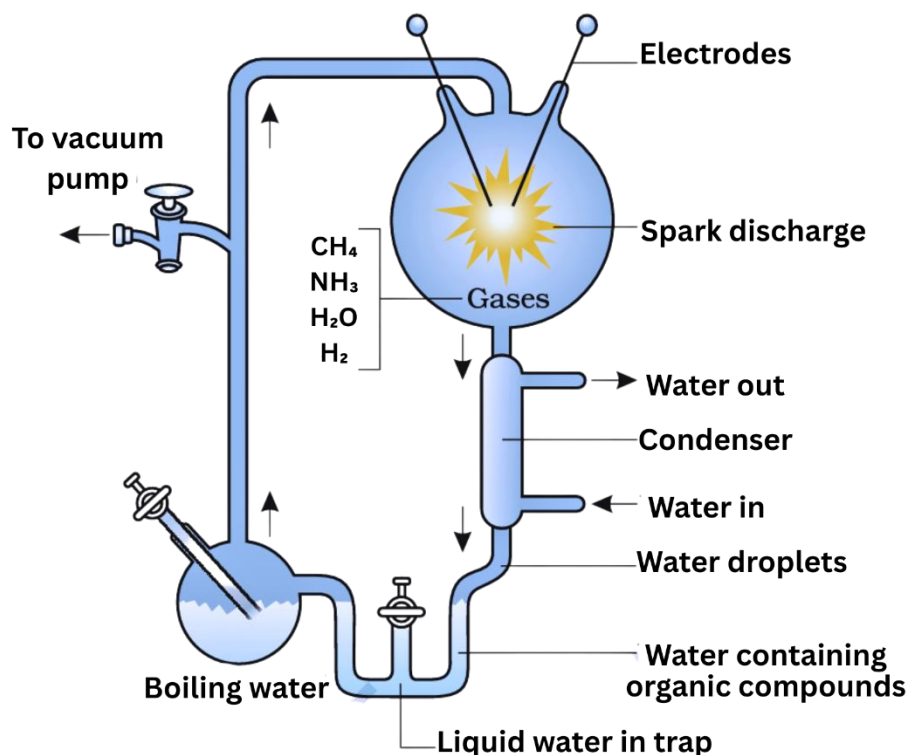
- It was once believed that life originated from decaying organic matter (e.g., straw, mud).
- Known as spontaneous generation, this theory was refuted by **Louis Pasteur**.
- **Pasteur's Experiment:**
 - In pre-sterilized flasks, no life formed from killed yeast.
 - In flasks open to air, new life forms emerged, proving that life arises only from pre-existing life.
- Thus, the theory of spontaneous generation was dismissed.

Chemical Evolution: A Scientific Hypothesis

- The origin of the first life form still remains uncertain.
- **Oparin (Russia)** and **Haldane (England)** proposed that life originated from non-living organic molecules like RNA and proteins through a process called **chemical evolution**.
- Earth's early conditions were:
 - High temperature
 - Volcanic activity
 - Reducing atmosphere (rich in CH₄, NH₃, etc.)

Miller's Experiment (1953)

- **Stanley L. Miller**, an American scientist, recreated early Earth-like conditions in the lab:
 - Used a closed flask containing CH₄, H₂, NH₃, and water vapor.
 - Electric discharge at 800°C simulated lightning.
 - Result: Formation of amino acids.
- Later experiments showed formation of sugars, nitrogen bases, pigments, and fats.
- Meteorite analysis also revealed similar organic molecules, suggesting such processes may occur elsewhere in space.
- Hence, chemical evolution became a widely accepted idea.



Diagrammatic representation of Miller's experiment

From Molecules to Life

- Exact details of how the **first self-replicating** metabolic structures formed remain unknown.
- The first non-cellular life forms (possibly giant molecules like RNA, proteins, polysaccharides) may have appeared ~3 billion years ago.
- These could reproduce themselves to some extent.
- The first cellular life forms likely emerged around 2 billion years ago, probably as **single-celled organisms**.
- All early life forms existed in aquatic environments.

Biogenesis: A Widely Accepted Concept

- The idea that life evolved gradually from non-living molecules through evolutionary forces is known as **biogenesis**.
- While we still lack details about the exact path of origin, biogenesis is accepted by the majority of scientists today.

Evolution Of Life Forms – A Theory

The Theory of Special Creation

- According to conventional religious beliefs, the **Theory of Special Creation** makes three key claims:
 1. All living organisms were created individually and in their present form.
 2. The diversity of life forms has remained unchanged since the time of creation and will remain so in the future.
 3. The age of the Earth is believed to be **about 4000 years**.
- These ideas were widely accepted until the **19th century**, when they were strongly challenged by scientific observations and discoveries.

Darwin's Observations and the Concept of Evolution

- **Charles Darwin**, during his voyage aboard the H.M.S. Beagle, observed a wide variety of life forms and fossils around the world.
- He noted that:
 - Existing organisms shared similarities with one another.
 - Many organisms showed similarities to extinct species that lived **millions of years ago**.
 - **New species** have appeared over time, and many old species have gone extinct.
- From these observations, Darwin proposed the idea of gradual evolution of life forms over time.

Variation and Natural Selection

- Within any **population**, there is inherent variation in characteristics.
- Some traits provide better survival advantages under natural conditions (e.g., climate, food availability, environmental factors).
- Organisms with these advantageous traits are more likely to:
 - Survive
 - Reproduce
 - Pass on their traits to the next generation
- This process was termed natural selection by Darwin.
 - According to Darwin, fitness refers to reproductive fitness, i.e., the ability to leave behind more offspring than others.
- Hence, individuals better adapted to their environment are naturally selected over time.

Alfred Wallace and Parallel Observations

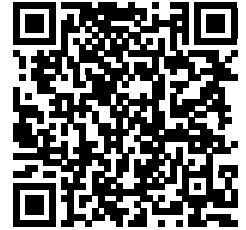


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