KSQUARE CAREER INSTITUTE

EVOLUTION

Class 12 Biology • Origin of Life • NEET Notes

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Lecture at a Glance

1. What is evolution & evolutionary biology
2. Origin of the universe — Big Bang theory
3. Formation of earth & early atmosphere
4. Theories of origin of life — abiogenesis, biogenesis, panspermia, special creation, chemical evolution
5. Experiments — Redi, Spallanzani, Pasteur (swan-neck flask), Urey–Miller
6. Added: protobionts (coacervates & microspheres), nature of first life, practice MCQs

INTRODUCTION

- **Evolutionary Biology** is the study of the **history of life forms on earth**.
- To understand changes in **flora and fauna** over millions of years, we must understand the **origin of life** — i.e. the evolution of the **earth**, of **stars** and of the **universe** itself.
- This is "the longest of all the construed and conjectured stories" — the story of the origin of life and evolution of biodiversity on earth, against the background of the evolution of the universe.

Evolution

The word **evolution** means **"to unfold hidden potentials"**.

Evolution is an **orderly change from one form to another**.

The term 'evolution' was introduced by **Herbert Spencer**.

ORIGIN OF THE UNIVERSE — BIG BANG THEORY

Big Bang Theory

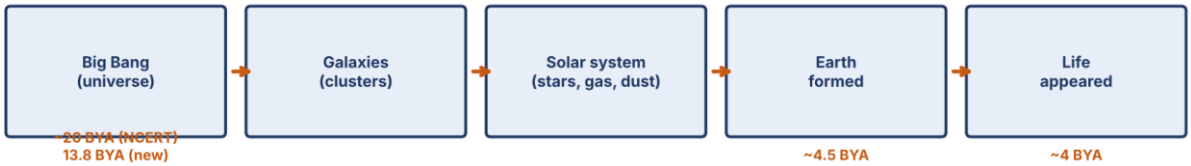
The Big Bang theory explains the **origin of the universe**.

It states that the universe originated about **20 billion years ago** (NCERT) by a **single huge explosion** (thermonuclear explosion) — unimaginable in physical terms.

Proposed by **Abbé (Georges) Lemaître**.

- The universe **expanded** and the **temperature came down**; hydrogen and helium formed later.
- Gases condensed under gravitation and formed the **galaxies** of the present-day universe.
- In the solar system of the **Milky Way galaxy**, the **earth** was supposed to have been formed.

Universe → Galaxies (huge clusters) → Solar system (stars, clouds of gas & dust) → Earth



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NCERT age of the universe: **20 billion years**. Modern estimate (new NCERT / current science): **13.8 billion years**. In NEET, follow the NCERT figure unless the options say otherwise.

FORMATION OF EARTH & EARLY ATMOSPHERE

- The **earth was formed about 4.5 billion years ago**.
- There was **no atmosphere** on early earth.
- **Water vapour, methane (CH_4), carbon dioxide (CO_2) and ammonia (NH_3)** released from the **molten mass** covered the surface.
- **UV rays** from the sun broke up water into **hydrogen (H_2) and oxygen (O_2)**; the lighter H_2 escaped.
- Oxygen combined with **NH_3 and CH_4** to form **water, CO_2** and others.
- The **ozone layer** was formed.
- As the earth **cooled**, the water vapour fell as **rain** and filled the depressions to form **oceans**.
- **Life appeared about 500 million years after the formation of earth, i.e. almost 4 billion years ago**.

Faculty note — formation of simple molecules

Early earth had **free atoms** of elements like C, H, O, N — **maximum was hydrogen**.

Due to high temperature, **hydrogen reacted with oxygen → water** (inorganic).

Hydrogen reacted with nitrogen → ammonia (inorganic).

The **first organic compound** formed was **methane (CH_4)**.

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The early atmosphere was **reducing** (no free O_2). Free O_2 was absent — an important MCQ point.

THEORIES OF ORIGIN OF LIFE

#	Theory	Main idea	Supported / proposed by
1	**Abiogenesis** (Spontaneous generation)	Life came out of decaying & rotting matter (straw, mud)	Ancient Greek philosophers
2	**Biogenesis**	Life originates only from pre-existing life	Francesco Redi, Spallanzani, Louis Pasteur (term by Huxley; idea by Harvey)

#	Theory	Main idea	Supported / proposed by
3	**Panspermia** (Cosmic theory)	Units of life (spores) transferred to different planets incl. earth	Early Greek thinkers
4	**Special Creation**	Living & non-living created by a supernatural power (God)	Father Suarez (mythology / religion based)
5	**Chemical Evolution** (Chemogeny)	First life arose from non-living inorganic & organic molecules	Oparin & Haldane; proved by Urey & Miller

1. Theory of Spontaneous Generation (Abiogenesis)

- States that **life came out of decaying and rotting matter** like **straw, mud** etc.
- Supported by **ancient Greek philosophers**.
- E.g. they believed that the **mud of the river Nile** could give rise to organisms when **warmed by sunlight**; maggots from rotting meat; frogs/worms from mud.

2. Theory of Biogenesis

- Proposed / supported by **Francesco Redi, Lazzaro Spallanzani and Louis Pasteur** through experiments (faculty note: idea proposed by **Harvey & Huxley**).
- States that **new life originates only from pre-existing life** ("omne vivum ex vivo").
- **Limitation:** it does **not explain the origin of the first life**.

Experiments supporting biogenesis (Added detail)

Scientist	Experiment	Conclusion
Francesco Redi (1668)	Kept meat in open jars, jars covered with gauze and sealed jars — maggots appeared only in open jars	Maggots come from eggs laid by flies, not from meat
Lazzaro Spallanzani	Boiled broth in sealed flasks — no microbes grew	Microbes come from the air, not from broth
Louis Pasteur	Swan-neck flask experiment (below)	Life comes only from pre-existing life

Louis Pasteur's Swan-Neck Flask Experiment

- Louis Pasteur **disproved the theory of abiogenesis**.
- He demonstrated that **life comes only from pre-existing life**.
- He showed that **life did not come from killed yeast** (sugar + yeast broth) in a **closed, pre-sterilised flask**.
- But in an **opened flask** (neck broken), **life (microbes) appeared**.

Flask	Treatment	Result
Swan-neck intact	Broth boiled; curved neck traps dust & microbes	**No growth**
Neck broken	Broth exposed to air	**Microbial growth**

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Pasteur's experiment finally **disproved spontaneous generation** — but it did **not** explain how the **first** life arose on earth.

3. Cosmic Theory (Theory of Panspermia)

- States that the **units of life (spores)** were **transferred to different planets including earth** from outer space.
- Supported by **early Greek thinkers**; still a favourite idea of some astronomers.

4. Theory of Special Creation

- States that **living and non-living** things were created by some **supernatural power (God)**.
- Supported by **Father Suarez**; it is **mythology-based** (e.g. the Bible's story of **Adam and Eve**).
- Ideas: all living organisms were created as such; diversity was always the same since creation; earth is about 4000 years old — all **challenged** in the 19th century.

5. Theory of Chemical Evolution (Chemogeny)

Oparin – Haldane Theory

Proposed by **A.I. Oparin** (Russia) and **J.B.S. Haldane** (England).

The **first form of life** originated from **non-living inorganic and organic molecules** such as **CH_4, NH_3, H_2O, sugars, proteins, nucleic acids** (biomolecules) etc.

i.e. **"Abiogenesis first, but biogenesis ever since."**

Formation of diverse organic molecules from inorganic constituents = **chemical evolution**.



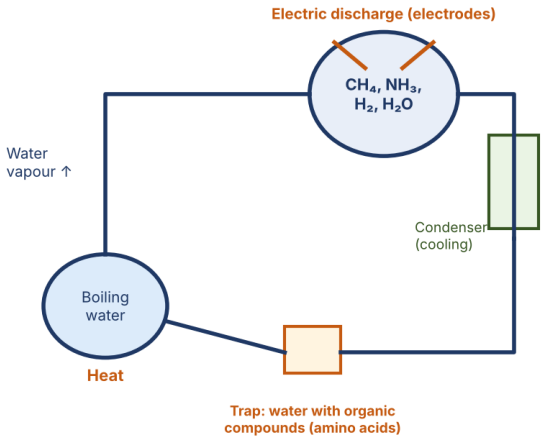
Conditions on early earth

High temperature, **volcanic storms**, **reducing atmosphere** containing **CH_4, NH_3, H_2O vapour, H_2** etc.

Energy sources: **UV radiation, lightning (electric discharge), heat**.

UREY – MILLER EXPERIMENT

Experimental proof of the theory of chemical evolution (1953).



- **Harold Urey and Stanley Miller** experimentally proved the theory of chemical evolution.
- They created conditions like those of **primitive earth** — high temperature, volcanic storms, **reducing atmosphere** with **CH_4, NH_3, H_2O, H_2**.
- They made an **electric discharge** in a **closed flask** containing **CH_4, NH_3, H_2 and water vapour at 800 °C**.
- As a result, some **amino acids** were formed.
- In similar experiments, others observed formation of **sugars, nitrogen bases, pigments and fats**.

Component	Role in the apparatus
Boiling water flask	Supplies water vapour (primitive ocean)
Gas chamber (CH_4, NH_3, H_2, H_2O)	Primitive reducing atmosphere
Electrodes / spark	Electric discharge = lightning (energy source)
Condenser	Cools vapours = rain
Trap / U-tube	Collects water with organic compounds (amino acids)

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O_2 was NOT used in Miller's experiment — the atmosphere was reducing. Favourite NEET question!

Gases ratio commonly quoted: **$CH_4 : NH_3 : H_2 = 2 : 1 : 2$**.

Analysis of **meteorite** content also revealed similar compounds — suggesting similar processes occur elsewhere in space.

PROTOBIONTS & THE FIRST LIFE (ADDITIONAL TOPIC)

- Complex organic molecules aggregated to form **protobionts** — non-living, cell-like structures with a membrane-like boundary.
- **Coacervates** — proposed by **Oparin**; colloidal droplets of proteins/carbohydrates in water.
- **Microspheres** — produced by **Sidney Fox** by heating amino acids (proteinoids) and cooling in water.

- The **first non-cellular forms of life** could have originated about **3 billion years ago** — giant molecules (RNA, proteins, polysaccharides etc.).
- These capsules **reproduced their molecules**; the first **cellular** forms did not appear until about **2000 million years ago**, probably **single-celled**, in **water**.
- The first organisms were **anaerobic** and **chemoheterotrophic** (took ready-made organic food).
- **RNA** was probably the **first genetic material** (RNA world hypothesis) — it can act both as genetic material and as a catalyst (ribozyme).

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NCERT: this version of abiogenesis — the **first form of life arose slowly through evolutionary forces from non-living molecules** — is accepted by the majority.

PRACTICE MCQS

Q1. Which of the following gases was NOT used by Miller in his experiment?

(a) CH_4
(b) NH_3
(c) H_2
(d) O_2

Answer: (d) — The primitive atmosphere was reducing.

Q2. According to NCERT, the universe originated about

(a) 4.5 billion years ago
(b) 20 billion years ago
(c) 4 billion years ago
(d) 2 billion years ago

Answer: (b) — Earth: 4.5 BYA; life: ~4 BYA.

Q3. Louis Pasteur's swan-neck flask experiment disproved

(a) Theory of biogenesis
(b) Theory of special creation
(c) Theory of spontaneous generation
(d) Theory of chemical evolution

Answer: (c)

Q4. The theory of chemical evolution was proposed by

(a) Urey and Miller
(b) Oparin and Haldane
(c) Redi and Spallanzani
(d) Darwin and Wallace

Answer: (b) — Urey & Miller gave the experimental proof.

Q5. In Miller's experiment, which of the following was formed?

(a) Nucleic acids
(b) Amino acids
(c) Proteins
(d) Living cells

Answer: (b)

Q6. The theory stating that units of life (spores) were transferred from other planets to earth is

(a) Special creation
(b) Panspermia
(c) Abiogenesis
(d) Chemogeny

Answer: (b)

Q7. "Abiogenesis first, but biogenesis ever since" is the concept of

(a) Theory of special creation
(b) Oparin–Haldane theory
(c) Theory of panspermia
(d) Spontaneous generation

Answer: (b)

Q8. Which of the following was absent in the primitive atmosphere of earth?

(a) Water vapour
(b) Methane
(c) Ammonia
(d) Free oxygen

Answer: (d)

Q9. Microspheres were produced experimentally by

(a) Oparin
(b) Sidney Fox
(c) Stanley Miller
(d) Haldane

Answer: (b) — Coacervates — Oparin.

QUICK REVISION

- Evolution = orderly change from one form to another; word means 'to unfold hidden potentials'; term by **Herbert Spencer**.
- Big Bang (Abbé Lemaître): universe ~**20 BYA** (NCERT) / 13.8 BYA (modern).
- Earth formed ~**4.5 BYA**; life appeared ~**4 BYA** (500 million years after earth formed).
- Early atmosphere: water vapour, CH_4, CO_2, NH_3 — **reducing**, no free O_2; UV split water; ozone formed; rain formed oceans.
- Abiogenesis — Greek philosophers; Biogenesis — Redi, Spallanzani, Pasteur; Panspermia — spores from space; Special creation — Father Suarez; Chemical evolution — Oparin & Haldane.
- Pasteur: swan-neck flask, killed yeast — disproved spontaneous generation.
- Urey–Miller (1953): CH_4, NH_3, H_2, H_2O at **800 °C** + electric discharge → **amino acids**; others got sugars, N-bases, pigments, fats.
- Coacervates — Oparin; Microspheres — Sidney Fox; first life anaerobic chemoheterotroph; RNA = first genetic material.