NEET Revision Notes
Biology
Evolution

Introduction

- Evolutionary biology is the science of the evolution of life on Earth.
- To understand the evolution of flora and fauna over millions of years on Earth, we must first understand the origin of life, which starts with the evolution of the earth, stars, and the entire cosmos.
- The origin of life is assumed to be yet another event in the history of the universe.
- The Big Bang Theory attempts to explain to humans the origins of the universe.

Modes of evolution:

The Big Bang Theory

- The Big Bang Theory outlines how the universe came to be.
- A **massive explosion** of very dense matter erupts from a singularity point.
- As a result, the **universe expanded** and the **temperature dropped** dramatically.
- After a while, **hydrogen** and **helium** were created.
- Gravitational forces caused the **gases to condense**. They eventually created the universe's **galaxies**. The **Earth** is thought to have formed approximately **4.5 billion years ago** in the **Milky Way galaxy**'s solar system.

Early Earth Situation:

- The Earth formed 4.5 billion years ago.
- There was also **no atmosphere** on the early Earth.
- **Water vapour, carbon dioxide, methane,** and **ammonia** emitted by the molten mass enveloped the surface.
- The **UV radiation** from the sun caused **water to disintegrate** into hydrogen and oxygen.
- Because **hydrogen** gas is **lighter** in comparison to air, it was able to escape into space.

- When oxygen got mixed with ammonia and methane, water, CO_2, and other chemical products were created.
- The **ozone** layer began to form.
- Water vapour condensed and sprinkled like rain as it cooled, filling up all of the depressions as a result forming **oceans**.
- Life appeared approximately 500 million years after the world formed.

The theories related to the origin of life includes:

- The ancient Greeks thought that spores (living entities) were transported to various planets, including Earth. This idea, known as **panspermia**, is still believed by many astronomers today.
- For a long time, it was assumed that life could emerge from **decaying and rotting materials** such as straw and muck. This was the **theory of spontaneous generation.** Using his swan-neck flask experiment, Louis Pasteur dismissed it.

Louis Pasteur's Experiment:

- Experiments have demonstrated that life can only arise from pre-existing life.
- He illustrated that life did not arise from killed yeast in sterile flasks before the experiment.
- Simultaneously, when a similar flask was exposed to air, new living beings emerged from the "dead yeast."
- As an outcome, the theory of spontaneous genesis was rejected.

Chemical Evolution

Oparin-Haldane’s Theory of Life’s Origin:

- Oparin from Russia and Haldane from England postulated that the first forms of life evolved from pre-existing non-living organic molecules (e.g. RNA, protein, etc.).
- **Chemical evolution**, or the formation of various organic molecules from inorganic components, traces the emergence of life.
- In 1953, S.L. Miller, an American physicist, demonstrated the same in a laboratory setting.
- The Earth's environment had deteriorated.

- The weather was extremely hot.
- Volcanic storms were natural disasters that happened when a volcano erupts decreasing the amount of CH_4 and NH_3 in the atmosphere,
- In 1953, S.L. Miller, an American scientist, created the same conditions in a laboratory setting.
- He created an electric discharge in an enclosed flask to mimic the conditions of the early Earth. As a result, the temperature rose to 800°C.
- Gases like CH_4, H_2, NH_3, and water vapour were used inside the flask.
- He observed the formation of amino acids.

Validation of the assumption of chemical evolution:

- Miller observed the synthesis of amino acids from simple inorganic compounds. He recreated the conditions that were assumed to exist on early Earth in the laboratory.
- In identical tests, other scientists observed the formation of sugars, nitrogen bases, pigments, and lipids.
- Comparable chemicals have been discovered in meteorite samples. This implies that similar processes are occurring in other regions of space.

Theory of Natural Selection and Origin of Species

Natural Selection:

- Based on observations created during a round-the-world voyage in a sailing ship called H.M.S. Charles Darwin evaluated that currently, existing life forms share different levels of similarity not only between themselves but also with life forms that occurred millions of years ago.
- Most of these life forms have become extinct. Numerous life forms have perished in the past for a range of reasons. New forms of life have emerged at various times throughout Earth's history.
- Life forms' evolution has been gradual.

Survival of the Fittest:

- Darwin defined fitness as the ability to respond to change. As a result, only the most powerful creatures survive and produce more offspring than others.
- As a consequence, they have a higher chance of survival and are thus

selected by nature. He referred to it as **natural selection**.

- Alfred Wallace, a naturalist working in the Malay Archipelago at the time, reached similar conclusions.
- The planet's geological as well as biological histories are intimately connected.

Paleontological Evidence

- The hard remnants of living things discovered in rocks are known as **fossils**.
- Numerous aged rock sediments contain fossils of a wide range of life forms that most likely died during sediment formation.
- They are the skeletal remains of extinct animals (e.g. Dinosaurs).
- Investigating distinct sedimentary levels wherein fossils were discovered can help determine the geological period in which they were discovered.
- The study discovered that life forms evolved but certain life forms are restricted to specific geological epochs.
- As a result, new forms of life are thought to have originated at various times throughout Earth's history. Paleontological evidence refers to all of this.

Evidence from Comparative Anatomy and Morphology

- Comparative anatomy and morphology demonstrate the similarities and differences between living creatures today and those that existed many years ago.

Divergent Evolution:

- The architecture of the bones of the forelimbs of various warm-blooded organisms including bats, cheetahs, whales, and humans is similar.
- These creatures' forelimbs have unique skills, but they have similar anatomy: their forelimbs include the humerus, ulna, carpal, palm, metacarpal, and phalanx.
- This can be seen, the same framework has been developed across different titles due to alterations to different needs.
- Divergent evolution is the name given to this progression or evolution, and these frameworks are homologous to each other.

- Homology demonstrates common ancestry/ parentage.
- The vertebrate brain and heart are also examples of homologous organs.
- Cucurbita ringlets and Bougainvillaea thorns are homologous.

Differences between Analogous and Homologous organs:

Homologous organs	Analogous organs
Anatomy is similar in these organs.	Anatomy differences occur in these organs.
Functions of these organs are dissimilar.	These organs perform different functions.
Inherited from a common ancestor, thus, similar anatomy.	Not inherited from ancestors
These organs develop in closely related species.	Develops in species that are unrelated.
They emerge because of divergent evolution.	They emerge because of convergent evolution.
Formed as a result of adaptation to a new environment.	These organs resulted from the adaptation to a similar environment
A human arm, a forelimb of a bird, a forelimb of a lizard and a forelimb of a frog are all homologous structures.	Wings in birds, bats, and insects are all analogous structures.

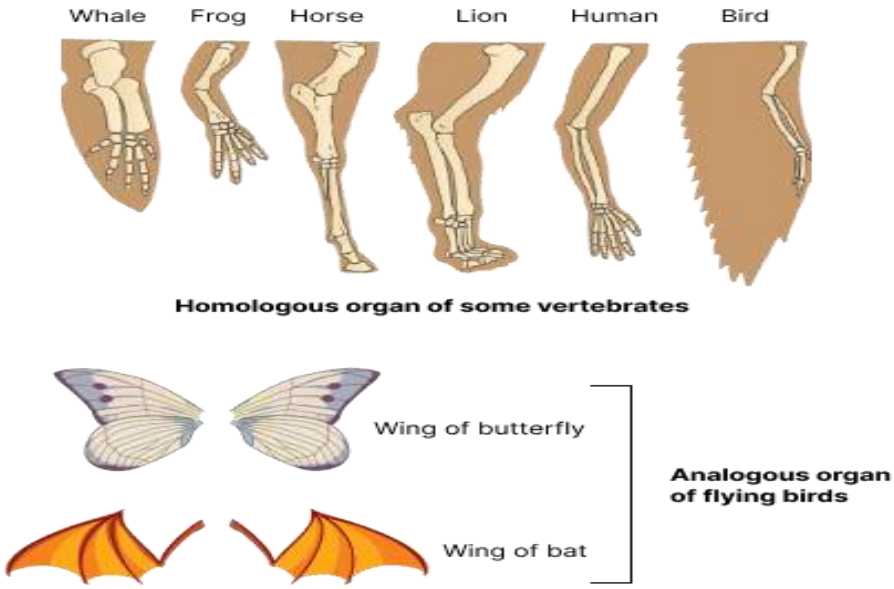

Image: Examples of Homologous and Analogous organs

Convergent Evolution:

- Bird and butterfly wings look very similar. They do not have a similar structure anatomically, but they perform a similar function.
- Thus, analogous organs are the result of convergent evolution.
- Many animals, such as octopuses and mammals, have eyes.
- Penguins and dolphins have flippers.
- For the capacity of nourishment, sweet potato is a root adaptation and potato is a stem adaptation.

Biochemical Evidence:

- Relationships in proteins and genes that perform a specific function in different animals provide information about common parentage/ancestry.

Embryological Support for Evolution:

- Ernst Heckel postulated this evidence as an evolution based on the analysis of some similar features in all animals during their embryonic period that is absent in adulthood.
- All vertebrate embryos, which include human embryos, develop a line of vestigial gill slits directly beneath the head. It is only seen as a highly functional organ in fish. The Gills do not exist in any of the other adult vertebrates.
- Karl Ernst von Baer ignored and disproved the embryological evidence after a thorough investigation. He discovered that the links formed in embryos are never preserved in the adult stages of other beings.

Evolution by Natural Selection

- A typical scenario is a variation in moth population frequency in England in 1850.
- Before industrialization, white-winged moths were more common on branches than dark-winged moths.
- The ratio was changed after industrialisation, in 1920, because there are more dark-winged moths in the very same area.

Evolution by Anthropogenic Action

- The overuse of herbicides, pesticides, and other chemicals has resulted in

a selection of resistant variants on a much smaller time scale.

- This has also been observed for microorganisms for which antibiotics or drugs are used.
- As a result, resistance in organisms emerged over months or years rather than centuries.
- These are the instances of anthropogenic evolution.
- Evolution is a dynamic system. Because it is based on random chance or events in nature, as well as a random mutation in organisms.

Adaptive Radiation

- **Adaptive radiation** refers to the process of evolution of new species in a particular terrestrial area that begins at a point and spreads to different areas of geography.

Darwin's Finches:

- Darwin's theory was based on his observations of birds in the Galapagos Islands.
- Darwin's Finches are named after the small blackbirds he observed.
- He noticed a few species of finches on that island. All of the species he saw had evolved on the island.
- They were essentially modified with seed-eating characteristics. Many other types evolved from these, with different beaks based on the food habit.
- This enabled them to evolve into insect-eating and vegetarian finches.

Australian Marsupial:

- An Australian marsupial was discovered in Australia that a count of marsupials had evolved from a genealogical stock. These marsupials were all distinct from one another.
- Concurrent evolution occurs when more than one versatile radiation appears to have occurred in a distinct topographical range (reflecting various environments).
- Aplacental well-evolved creatures were too visible in Australia to exhibit versatile radiation. They appear to have evolved from marsupials into various placental well-evolved creatures. Placental warm-blooded life forms have resembled the ancestral marsupial (For example, Tasmanian

wolf-marsupial and placental wolf).

Biological Evolution

- Natural selection is the foundation of Darwin's Theory of Evolution.
- The rate of emergence of new species is related to the life cycle.
- There must be a genetic basis for variations to be chosen and developed.
- Animals with advantageous modifications are better adapted to survive in hostile environments.
- Variations result in adjustability. Variations are inherited and have a genetic basis.
- Fitness is an organism's ability to adapt to changing environmental conditions and to be selected by nature.
- Darwinism's central ideas are as follows:
  - ➢ Natural selection: The survival of the fittest by nature in the face of changing environmental conditions.
  - ➢ Theory of Common Descent: Living beings evolve from common ancestors as a result of several varieties.

Evolutionary Theory of Lamarck

- The Evolutionary Theory of Lamarck is also known as the theory of Inheritance of Acquired Characters.
- Lamarck, a French naturalist, mentioned that the evolution of life forms takes place as a result of organ use and exemption.
- He used giraffes as an example to demonstrate this technique.
- He asserted that giraffes evolved long necks to forage for leaves on tall trees. As a result, this character was created out of a desire to adapt and survive.
- This acquired personality was passed down through the generations.
- Giraffes gradually grow long necks over several years.

Mutation

Hugo de Vries was successful in planting evening primrose. Hugo de Vries proposed various mutation theories.

- The mutation is the sudden appearance of a difference in a group.

Hugo De Vries' Mutation Theory Differs From Darwin's Theory of Natural Selection:

- Hugo de Vries proclaimed that mutations, not minor variations, cause evolution, as Darwin suggested.
- Mutations are unanticipated, unplanned, and aimless. The Darwinian changes are minute and directional.
- Darwin believed that evolution was gradual, whereas Hugo de Vries assumed that mutation caused massive changes that gave rise to speciation. As a result, he dubbed it saltation (single-step large mutation).
- Salinization: Salinization is a sudden, long-term evolutionary change caused by large-scale mutations.

Hardy-Weinberg's Principle

The probability of occurrence of alleles of a specific gene existing on a specific locus can be determined for a given population.

- This frequency is generally fixed and remains constant across different generations.
- The Hardy-Weinberg principle is demonstrated using algebraic equations. This is referred to as the **Hardy-Weinberg Principle**.
- According to the Hardy-Weinberg principle, allele frequencies are stable in a population and remain constant from generation to generation.
- The gene pool does not change, this is referred to as **genetic equilibrium**.
- The following is a mathematical representation of the principle:
  $(p+q)^2 = p^2 + 2pq + q^2 = 1$
  Where p and q represent the frequency of individual alleles.
- As a result, p^2 represents the frequency of the homozygous condition, q^2 represents the frequency of the homozygous alleles, and pq represents the frequency of the heterozygous condition.
- Changes in the genetic equilibrium (Hardy Weinberg equilibrium) cause evolution.
- Hardy-Weinberg equilibrium is known to be affected by five factors:
  1. Gene flow or migration.
  2. Genetic recombination.
  3. Natural selection.
  4. Genetic recombination.
  5. Mutation.

1. **Gene Migration:**

- When a portion of a population moves to another location, gene frequencies in both the original and new populations change.
- New genes/alleles will be added to the existing population, while the same will be lost from the old.

2. **Gene Flow:**

- When genes migrate, it is commonly referred to as gene flow.

3. **Genetic Drift:**

- A change in quality occurs as a result of an arbitrary event or by chance.

4. **Founder's Effect:**

- The Founder Effect occurs when the change in allelic frequency is so drastic that the new population species and variants develop a different species.
- The founder species is the first resettled population from which the variability emerged, and this impact is known as the **founder effect.**

5. **Natural Selection:**

- Natural selection can result in:
  - ➢ **Stabilisation:** The process by which more people acquire average character value.
  - ➢ Directional changes occur when a large number of people acquire characteristics that differ from the average character value.
  - ➢ Disruption occurs when a greater number of people obtain peripheral character values at both ends of the distribution curve.

Evolution:

The first forms of life on Earth appeared around 2000 million years ago (mya). They were cellular.

- Certain cellular shapes developed the ability to photosynthesize and thus release oxygen. The climate gradually became more oxygen-rich. This, in turn, aided in the development and progression of more high-impact forms of living beings.
- Single-celled organisms gradually evolved into multicellular life forms.
- Invertebrates first appeared around 500 million years ago.
- Around 350 million years ago, the first fish evolved from invertebrates. They were most likely jawless fish.
- Around 320 million years ago, seaweeds and a few plants managed to evolve and existed.

- The coelacanth is a lobe-finned fish found in South Africa. The coelacanth is thought to have evolved into the first amphibious animals that could live on both land and water.
- The amphibians were the forefathers of frogs and salamanders.
- Amphibians gradually transformed into reptiles.
- Reptile eggs, unlike amphibian eggs, do not dry out in the sun.
- On land, giant ferns like Pteridophytes fell and were buried in the soil.
- Some of the reptiles retreated into aquatic environments to evolve into fish-like reptiles, probably 200 million years ago.
- Dinosaurs were the most well-known land reptiles.
- Tyrannosaurus rex was the largest dinosaur, standing about 20 feet tall and sporting significant dangerous teeth like knives.
- Around 65 million years ago, the dinosaurs went extinct on Earth. A few of these dinosaurs became birds.
- The first mammals were small and shrew-like. They had small fossils.
- Mammals evolved to become viviparous. This kept their developing embryos inside their mother's body.
- Pouched mammals in Australia survived due to a lack of competition from other mammals. Continental Drift is to blame for the lack of competition.

Origin and Evolution of Human

- **Dryopithecus** and other primates existed around 15 million years ago. In appearance and movement, these animals appeared to be similar to chimps and gorillas.
- **Ramapithecus** was more similar to humans, whereas Dryopithecus was more similar to gorillas.
- Some human-like bone fossils have been discovered in Ethiopia and Tanzania.
- **Australopithecines** existed two million years ago. Most likely encountered in the East African grasslands.
    - ➢ They used hunting weapons that they had made up.
    - ➢ They were originally vegetarians.
- The hominid, also known as ***Homo habilis***, was the first human-like organism.
- The hominid's brain capacity ranged between 650 and 800 cubic centimetres.
- Hominids continued to eat only plants.

- Fossils discovered in Java in 1891 appeared to be of the successive level,
- ***Homo erectus*** appeared around 1.5 million years ago. They had a bigger brain with a capacity of 900 cubic centimetres. They were most likely non-vegetarians who ate meat.
- A **Neanderthal man**'s brain was approximately 1400 cc in size. They lived in eastern and central Asia between 100,000 and 40,000 years ago.
- To protect their bodies, Neanderthals developed the use of animal hides. The Neanderthals buried their dead.
- ***Homo Sapiens:*** They originated in Africa, spread to other continents, and evolved into various races.
- Modern *Homo sapiens* appeared during the ice age 75,000-10,000 years ago.
- Around 18,000 years ago, ancient cave art was created.
- Agriculture emerged around 10,000 years ago, followed by human settlement.

Key points to remember:

- The emergence of life on Earth can only be analysed in the light of the origin of the universe, particularly Earth.
- The formation of biomolecules, according to most scientists, initiated the existence of the first cellular life forms.
- What happened to the first form of life after that is a prediction based on Darwinian concepts of organic evolution and natural selection.
- Over millions of years, the diversity of living things on Earth has changed.
- Variations in a population are thought to result in variable fitness.
- Other phenomena such as habitat destruction and genetic drift may amplify these variations, resulting in the emergence of new species and, thus, evolution.
- The concept of branching descent accounts for homology.
- Comparative anatomy, fossils, and comparative biochemistry research even provide evidence for evolution.
- Among the stories of individual species' evolution, the story of modern man's evolution seems to parallel the evolution of the human brain and language.