EVOLUTION

Evolutionary Biology is the study of history of life forms on earth. The evolution of life on earth, different changes in flora and fauna around earth that co-exist along with human beings also forms part of evolution.

Origin of Life

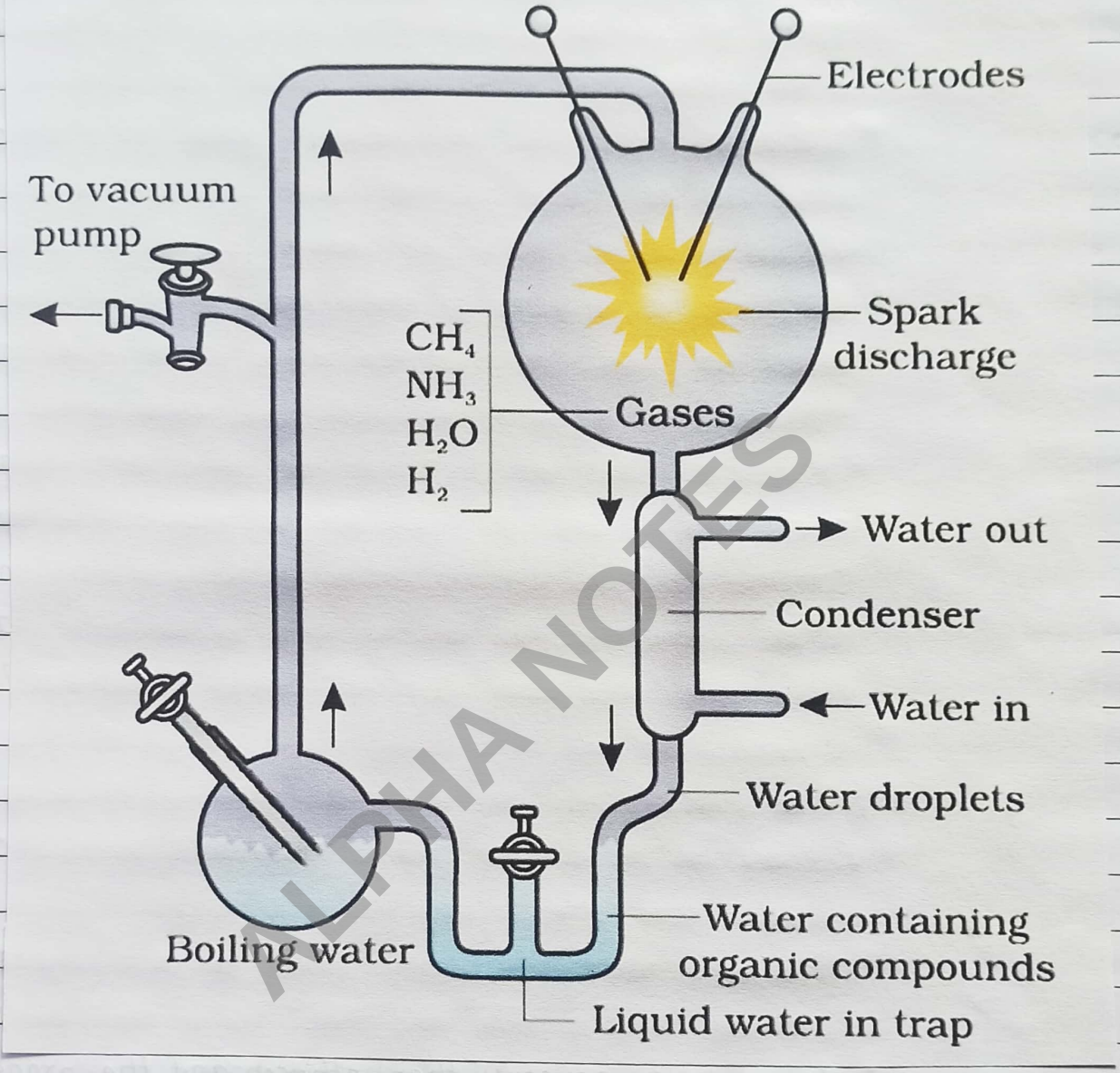
The origin of life is considered unique event in the history of universe. Huge clusters of galaxies comprises the universe. Galaxies contains, stars and clouds of gas and dust. Big Bang Theory attempts to explain the origin of universe. According to this theory, a huge explosion occurs that forms the different galaxies.
In solar system of Milky way galaxy, earth has been supposed to be formed about 4.5 billion years ago.
There was no atmosphere in earlier earth. Water vapour, methane, carbon dioxide and ammonia released from molten mass covered the earth's surface. The ultraviolet rays from sun splits the water into hydrogen and oxygen. Life appeared 500 million years after the formation of earth.

There are different theories regarding the origin of life on earth.

- Some scientists believes that life comes from other planets. Early greek thinkers thought units of life called spores were transferred to earth from other planets. 'Panspermia' is still a favourite idea for some astronomers.

- According to theory of spontaneous generation, life came out of dead, decaying and rotting matter like straw, mud, etc.
- Louis Pasteur experimentally proved that life arises only from pre-existing life. Spontaneous generation theory is dismissed after that.
- Oparin and Haldane proposed that the first form of life could have come from pre-existing non-living organic molecules (e.g. RNA, protein, etc.) and that formation of life was preceded by chemical evolution, i.e., formation of diverse organic molecules from inorganic constituents. The conditions on earth were - high temperature volcanic storms, reducing atmosphere containing CH_4, NH_3, etc.

In 1953, S.L. Miller conducted an experiment to show the origin of life on earth in the physical environment similar to condition prevails at that time. Miller created similar conditions of temperature and pressure in laboratory scale. He created electric discharge in a flask containing CH_4, H_2, NH_3 and water vapour at 800°C. He observed formation of amino acids. In similar experiments others observed, formation of sugars, nitrogen bases, pigments and fats. Analysis of meteorite content also revealed similar compounds indicating that similar processes are occuring elsewhere in space. This experimental evidence about the origin of life is called chemical evolution of life.



The first non-cellular forms of life could have originate 3 billion years back. They would have been giant molecules like RNA, Protein, Polysaccharide, etc. The first cellular forms of life were probably single-celled and originated in water ~~for~~ medium. The theory which states that first form of life arose slowly through evolutionary forces from non-living molecules is called abiogenesis.

Evolution of life forms - A Theory

Conventional religious literature reveals about the theory of special creation based on three connotations:

ⓐ All living organisms were created as such.

ⓑ Diversity in organisms is always same since creation and will be the same in future.

ⓒ Earth is about 4000 years old.

All these ideas were strongly challenged during the nineteenth century.

- Based on observations made during a sea voyage in a sail ship called H.M.S. Beagle round the world, Charles Darwin concluded that existing living forms share similarities to varying degrees not only among themselves but also life forms that existed millions of years ago.
- Many life forms do not exist anymore because of extinctions of different life forms and there has been gradual evolution of life forms.
- Darwin's theory of natural selection is based on the fact that those who are better fit in an environment, leaves more progeny than others and the progenies will survive more hence are selected by the nature which he implied as mechanism of evolution.
- Alfred Wallace stated that all the existing life forms share similarities and shares some common ancestors which are present at different periods in the history of earth.
- The geological history of earth closely correlates with the biological history of earth and a final conclusion is that earth is not thousand years old as was thought, but millions of years old.

Adaptive Radiation

The process of evolution of different species in given geographical area starting from a point and radiating to other areas of geography (habitat) is called adaptive radiation. Darwin's finches represent one of the best examples of adaptive radiation. Australian marsupials, each ~~with~~ different from the other evolved from an ancestral stock, but all within the Australian island continent. When more than one adaptive radiation appeared to have occured in an isolated geographical area (representing different habitats), we can call this convergent evolution, e.g., Placental mammals and Australian marsupials.

Biological Evolution

The nature selects for the fittest. Fitness is based on characteristics which are inherited. Some organisms are better adapted to survive in an otherwise hostile environment. Fitness is the end result of the ability to adapt and get selected by nature.

Lamarck had said that evolution of life forms had occured but driven by use and disuse of organs. Lamarck gave the example of Giraffes who in an attempt to forage leaves on tall trees had to adapt by elongation of their necks and they passed on this acquired characters of elongated neck to succeeding generations.

Branching descent and natural selection are the two keys concepts of Darwinism Theory. Darwin's theory of natural selection was based on certain observations like:

- Limited natural resources
- Struggle for existence
- Overpopulation
- Survival of the fittest
- Competition for resources

Evidences for Evolution

Paleontological Evidence

- Paleontology is the study of fossils.
- Fossils are remains of hard parts of life forms lived in past but found in rocks or sediments.
- Rocks from sediments and a cross section of earth's crust indicates the arrangement of sediments one over the other during the long history of earth.
- Different aged rock sediments contain fossils of different life forms that probably died during the formation of the particular sediment which represent extinct organisms.
- A study of fossils in different sedimentary layers indicates the geological period in which the organisms existed.
- The study showed that life forms varied over time and certain life forms are restricted to certain geological time spans.
- New forms of life have arisen at different times in the history of earth.

Anatomical and Morphological Evidence

- Comparative anatomy and morphology show similarities and differences among organisms of today and those that existed years ago.

Homologous organs

- The organs whose structure or origin is same but functionally different. For example, In plants, the thorns and tendrils of Bougainvillea and Cucurbita.

- Whales, bats, cheetah and humans share similarities in the pattern of bones of forelimbs. All of them have humerus, radius, ulna, carpals, metacarpals and phalanges in their forelimbs. Though the forelimbs have similar anatomical structure but they perform different functions.
- The same structure developed along different directions due to adaptations to different needs.
- Homology is based on divergent evolution.
- Homology indicates common ancestry.

Analogous organs

- The organs whose structure or origin is not similar but functionally active are called analogous organs. Example: wings of bird and butterfly perform similar functions, flippers of penguins and dolphins, eyes of octopus and mammals.
- It is the similar habitat that results in selection of similar adaptive features in different groups of organism but towards the same function.
- Analogy is based on convergent evolution.

Biochemical Evidence

- Similarities in proteins and genes performing a given function among diverse organisms gives clues to common ancestry. These biochemical similarities point to the same shared ancestry as structural similarities among diverse organisms.

Natural Selection

Industrial melanism

- Before industrialization in great britain, it was observed that there were more white winged moths on trees than melanised or dark moths.
- Before industrialization, almost white-coloured lichen covered the tree trunks and in that background the white-winged moths survived and the black moths were eaten by predators.
- During post-industrialization period, the tree trunks became dark due to industrial smoke and under such condition, the white moths did not survive due to predators and the dark ones survived.
- Hence, after industrialization, there were more dark winged moths.
- Hence, Industrial melanism supports evolution by natural selection.

Antibiotic resistant bacteria

- By employing antibiotics to bacterial colonies, the colonies sensitive to penicillin died, whereas the others that were resistant to penicilin survived.
- Probably the bacteria that survived penicillin underwent a chance mutation that thereby possesing a gene that contributed to their resistance to penicillin drug and hence selected by the nature, in some course of time, it was considered as fittest and established as a new species.

Mechanism of Evolution

Evolution needs variation.
Darwin mentioned that natural selection is the reason for evolution.
Hugo de Vries based on his work on evening primrose brought forth the idea of mutation.
He believed that mutation causes evolution.
Evolution for Darwin was gradual, while Hugo de Vries believed that mutation causes speciation and hence, he called it saltation (single step large mutation).

Hardy-Weinberg Principle

- Gene frequency remains constant from generation to generation and is stable, this is called genetic equilibrium.
- Sum total of allelic frequencies is 1 and individual frequencies can be named as p, q. hence, $p + q = 1$, where p and q represents the frequency of allele A and allele a.
- In diploids, the frequency of AA is p^2, aa is q^2 and of Aa is $2pq$.
  Hence, the formula is $p^2 + 2pq + q^2$, which is a binomial expansion of $(p+q)^2$, which can be applied to any population to find out gene frequency.

> When frequency measured differs from expected value, the difference indicates the extent of evolutionary change.

Factors affecting Hardy - Weinberg Principle are -

1. Gene Flow
2. Genetic Drift
3. Mutation
4. Genetic Recombination
5. Natural Selection

Gene Flow

- The transfer of section of population to another place resulting in a change in gene frequencies in both old and new population is called gene Flow.
- New genes and alleles are added to new population which are genetically different but can interbreed.

Genetic Drift

- The random change in gene frequency occurs by chance is called genetic drift.
- Sometimes, the change in allelic frequencies is so different in the new population, that they become a different species and the original drifted population becomes founders and hence the effect is called 'founder effect'.

Mutation

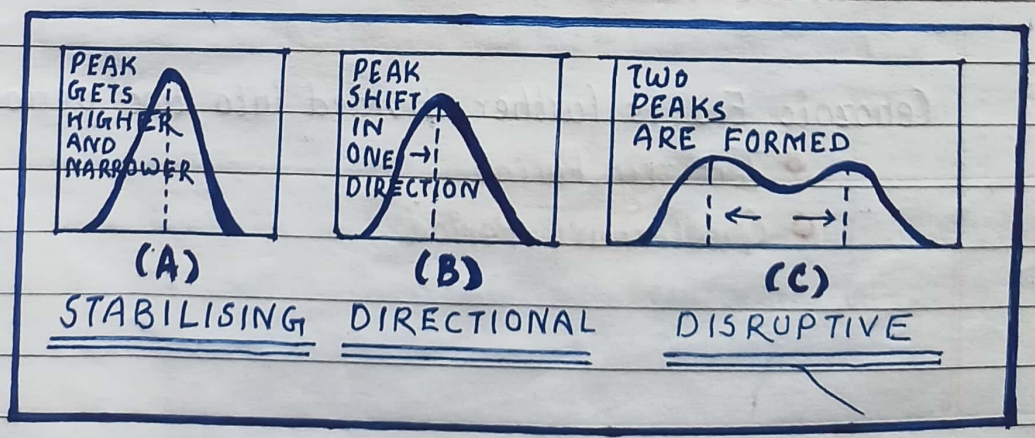
- The spontaneous change in the genetic makeup of an individual is called mutation.
- Pre-existing advantageous mutations when selected will result in observation of new phenotypes and over few generations, this would result in Speciation.

Genetic Recombination

- Exchange of genes between non sister chromatids of homologous chromosomes during gametogenesis is called genetic recombination.
- Variation due to recombination during gametogenesis or due to gene flow or genetic drift results in changed frequency of genes and alleles in future generation.

Natural Selection

- The process by which better adapted individuals with useful variations are selected by nature and leave greater number of progencies is called natural selection.
- Natural selection can lead to -
  - Stabilizing selection - here, more individuals acquire mean character value.
  - Directional change - here, more individuals acquire value other than the mean character value.
  - Disruptive selection - here, more individuals acquire peripheral character value at both ends of the distribution curve.



Geological Timescale

- Azoic Eon
- Archaezoic Eon
- Proterozoic Eon
- Phanerozoic Eon

Phanerozoic Eon are further classified into three Eras:

- Paleozoic Era
- Mesozoic Era
- Cenozoic Era

Paleozoic Era is further classified into six periods:

- Cambrian Period
- Ordovician Period
- Silurian Period
- Devonian Period
- Carboniferous Period
- Permian Period

Mesozoic Era is further divided into three periods:

- Triassic Period
- Jurassic Period
- Cretaceous Period

Cenozoic Era is further divided into two periods:

- Tertiary Period
- Quaternary Period

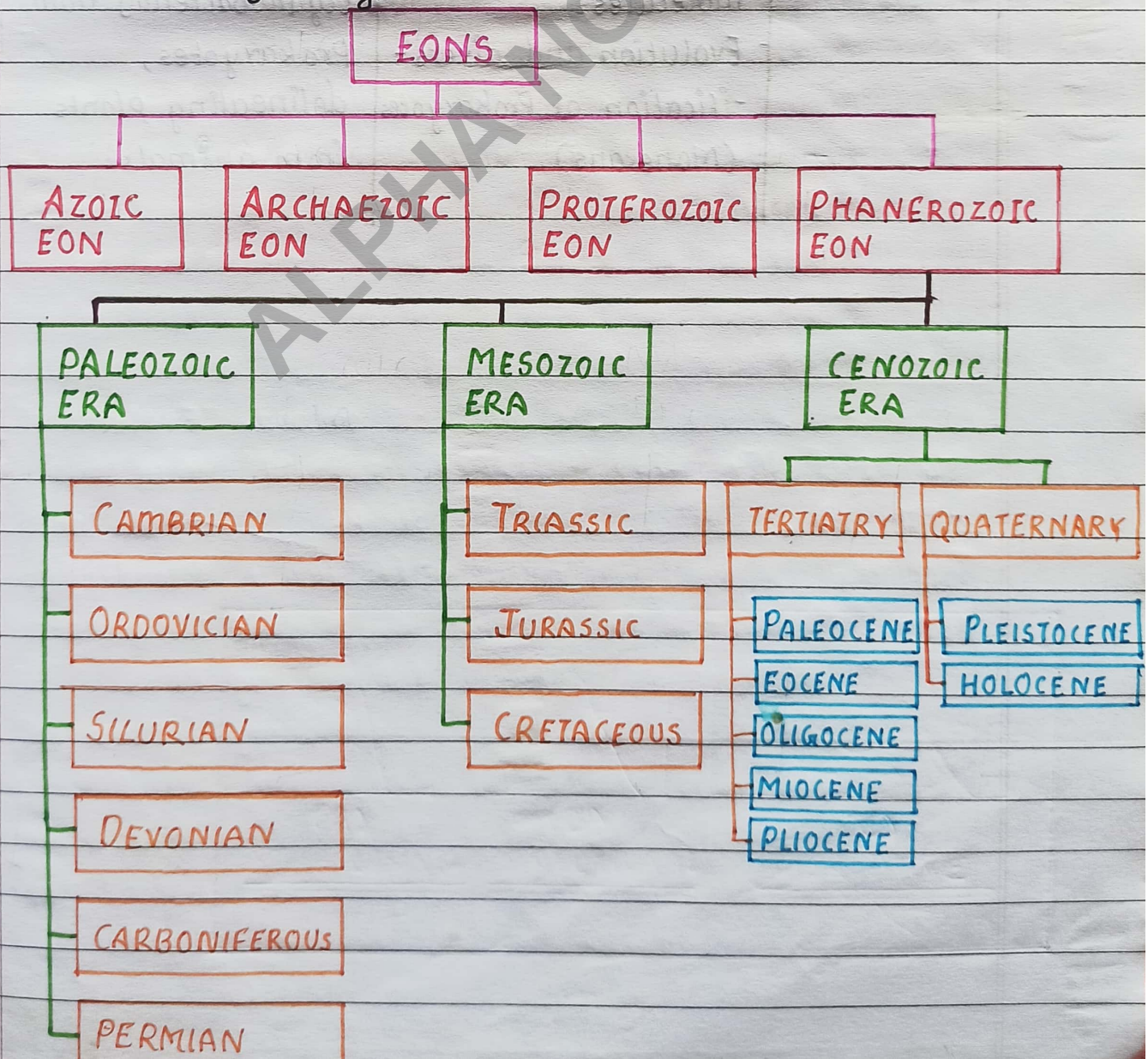
Tertiary period is further divided into five Epochs:

- Paleocene Epoch
- Eocene Epoch
- Oligocene Epoch
- Miocene Epoch
- Pliocene Epoch

Quaternary period is further divided into two Epochs:

- Pleistocene Epoch
- Holocene Epoch

Geological Timescale



Period	Epoch	Significant events
Quaternary (2.5 mya - till now)	Holocene (0.01 mya - till now)	- Supremacy of Homo sapiens - Emergence of agriculture - Domestication of animals - Emergence of civilisations, invention of machines and the rest is history.

A Brief Account of Evolution

- About 2000 million years ago, the first cellular forms of life appeared on earth.
- Some cellular forms had the ability to release O_2 and slowly single cell organisms become multicellular organisms.
- By the time of 500 mya, invertebrates were formed and active.
- Jawless fish probably evolved around 350 mya.
- Sea weeds and few plants existed probably around 320 mya.
- First organisms that invaded land were plants.
- Fish with stout and strong fins could move on land and go back to water was about 350 mya.
- In 1938, a lobe finned fish caught in South Africa happened to be a Coelacanth which evolved into first amphibians that lived on both land and water and these were the ancestors of modern days frog and salamanders.
- The Amphibians evolved into reptiles. They lay thick shelled eggs which do not dry up in sun, unlike those of amphibians.

- The modern day descendants of reptiles are the turtles, tortoises and crocodiles.
- In the next 200 million years or so, reptiles of different shapes and sizes dominated on earth.
- Giant ferns (pteridophytes) were present but they all fell to form coal deposits slowly.
- Some of the reptiles went back into water to evolve into fish like reptiles around 200 mya. (e.g., Ichthyosaurs)
- The land reptiles were the dinosaurs and the biggest of them was Tyrannosaurus rex, which was about 20 feet in height and had some huge fearsome dagger like teeth.
- About 65 mya, the dinosaurs suddenly disappeared from the earth. The reason is still unknown. Some says that they have evolved into birds and some says they might got killed by climatic changes.
- The first mammals were like shrews and their fossils are small sized.
- Mammals were viviparous and protected their unborn young inside the mother's body. Mammals were more intelligent in sensing and avoiding danger.
- Mammals dominated the earth when the population of reptiles came down.
- In South America, there were mammals resembling horse, hippopotamus, bear, rabbit, etc.
- Due to continental drift, when South America joined North America, these animals were overridden by North American fauna.
- Due to same continental drift, pouched animals of Australia survived because of lack of competition from any other mammal.
- Some mammals live wholly in water.

Examples - whales, dolphins, seals and sea cows.

Origin and Evolution of Man

The stages of evolution of man are -

1. Dryopithecus and
2. Ramapithecus
3. Australopithecus
4. Homo habilis
5. Homo erectus
6. Neanderthal man
7. Homo sapiens

Dryopithecus and Ramapithecus :

- About 15 million years ago, primates called Dryopithecus and Ramapithecus were existing.
- They were hairy and walked like gorillas and chimpanzees
- Ramapithecus was more man-like while Dryopithecus was more ape-like.
- Few fossils of man-like bones have been discovered in Ethopia and Tanzania.
- These revealed hominid features leading to the belief that about 3-4 million years ago, man-like primates walked in Eastern Africa.

Australopithecus :

- About two million years ago, Australopithecines probably lived in East African grasslands.
- Evidence showed that they hunted with stone weapons but essentially ate Fruits.
- Some of the bones among the bones discovered were different.

Homo habilis :

- Homo habilis were the first human-like being the homonid creature.
- The brain capacities were between 650 - 800 cc.
- They probably did not eat meat.

Homo erectus :

- Fossils discovered in Java in 1891 revealed that Homo erectus arose 1.5 million years ago.
- They had a large brain around 900 cc.
- They probably ate meat.

Neanderthal man :

- The Neanderthal man with a brain size of 1400 cc lived in near east and central Asia between 1,00,000 to 40,000 years back.
- They used hides to protect their body and buried their dead.

Homo sapiens :

- Homo sapiens arose in Africa and moved across continents and developed into distinct races.
- During ice age between 75,000 - 10,000 years ago, modern Homo sapiens arose.
- Pre-historic cave arts developed about 18,000 years ago.
- Agriculture came around 10,000 years back and human settlements started.
- The rest of what happened is a part of human history of growth and decline of civilisations.

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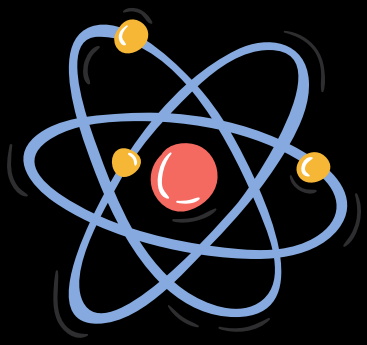

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