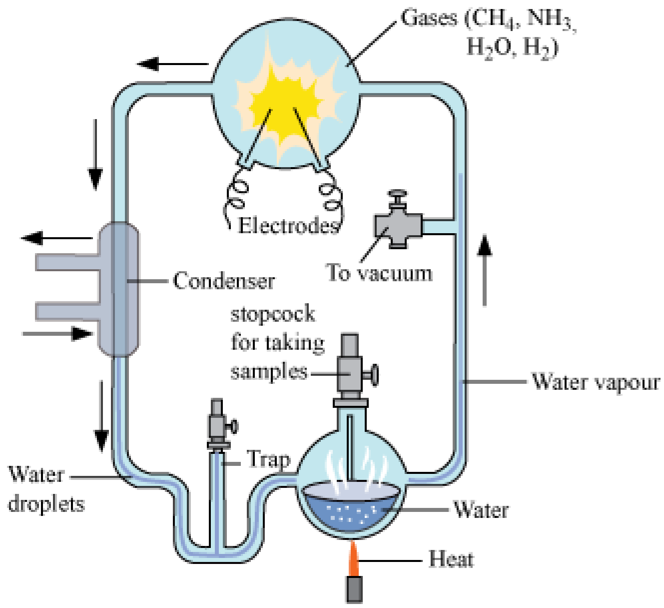
Evolution

Origin of Life and Evolution

Origin of Life

Year	Scientist	Theory/Experiment	Conclusion
1927	Lemaitre	Big Bang theory	The universe expanded from explosion of a primordial, hot substance.
1924 – 1929	Oparin and Haldane	Chemical evolution preceded organic evolution	Simple organic molecules originated from inorganic precursors.
1952	Stanley Miller and Urey	Synthesis of biomolecules by creation of similar conditions as primitive atmosphere on laboratory scale	Amino acids were synthesised from ammonia, oxygen, and carbon dioxide inside specialised apparatus.

Urey and Miller experiment



- Primitive atmosphere had high temperature, volcanic storms, and reducing atmosphere, containing CH_4, NH_3, H_2, etc.

- Urey and Miller took the same compounds in a closed flask along with water vapour at 800°C and created an electric discharge.

- Formation of biomolecules such as amino acids, simple sugars, fats, etc. was observed in the flask.

Theories of Evolution

- The theory of special creation or divine intervention was challenged by Charles Darwin.

- He made observations on his sea-trip around the world aboard H.M.S.

  Beagle and concluded that all existing living forms share similarities among themselves and also with other life forms, which existed millions of years ago of which many are extinct.

- The evolution of life forms has been gradual and those life forms better fit in environments that leave more progeny. This is called natural selection and is a mechanism of evolution.

- Alfred Wallace working in the Malay Archepelago also came to the same conclusion.

  Today, the most accepted theory of evolution is the Synthetic theory of evolution in which the origin of species is based on the interaction of genetic variation and natural selection.

Evidences of Evolution

- **Fossils –** They represent plants and animals that lived millions of years ago and are now extinct. Different aged rock sediments contain fossils of different life-forms, which probably died during the formation of the particular sediment.

- **Comparative anatomy and morphology –** It shows evidences of the similarities and differences between living forms of today and that of the prehistoric times. Some of the examples of comparative anatomy and morphology are:

- **Homologous organs –** All mammals share the same pattern of forelimbs. Though they perform different functions, they are anatomically similar. This is called **divergent evolution** and the structures are called homologous structures (common ancestors).

- **Analogous organs –** The pair of organs is not anatomically similar, but performs the same function (e.g., the wings of butterflies and birds). This is called **convergent evolution**.

- **Vestigial organs** - Organs which are non-functional in the existing individuals but were functional in the distant ancestors are known as vestigial organs. For example, nictitating membrane in the human eye, appendix, wisdom teeth etc.

- **Adaptive melanism –** In England, it was noted that before industrial revolution, the number of white-winged moths was more than that of dark melanised moth. However, after industrialisation, there were more of dark melanised moths. The explanation was that after industrialization, the tree trunks became darker with deposits of soot and smoke and hence, the number of dark moths increased in order to protect themselves from predators while the white-winged ones were easily picked up by the predators.

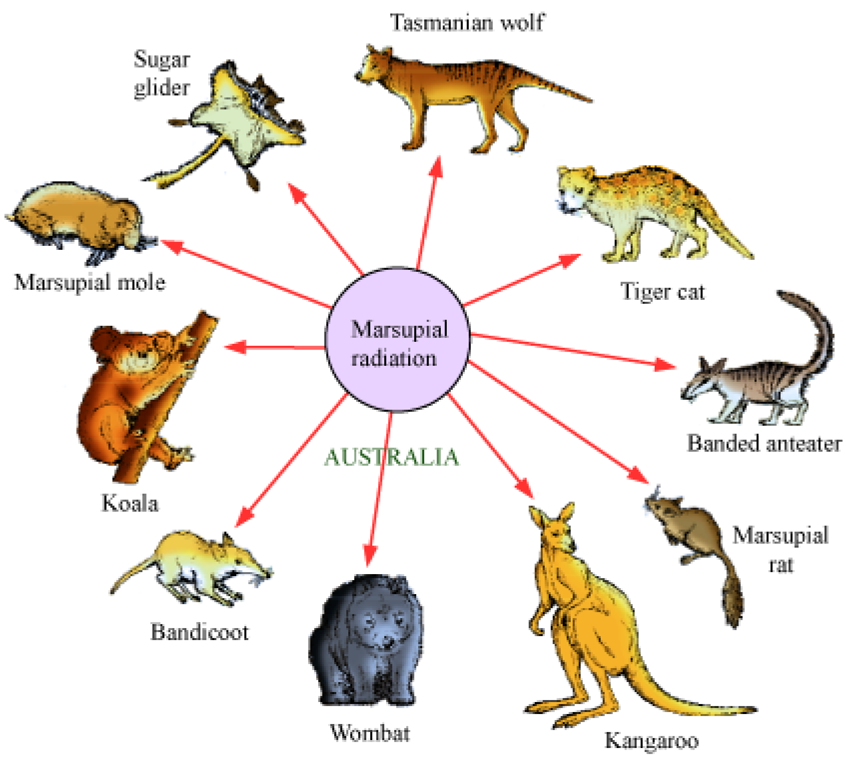
- Similarly, the herbicide and pesticide resistant plants and animals and antibiotic resistant bacteria are some of the evidences that point towards evolution.

- **Embryological evidences** - Embryos also provide an important evidence of evolution. Embryos of vertebrates exhibit many features which are not seen in adults. For example, all embryos of vertebrates develop a pair of gill slits behind the head. But these gill slits are present in fishes and are of no use to land vertebrates. It could mean that land vertebrates descended from fishes that had gill slits to help in aquatic respiration.
- Examples of embryological evidences include -
- Protonema, which is an early stage in the development of moss or fern gametophyte, resembles the filamentous green algae in structure, physiology and growth pattern. This suggests an algal ancestry of bryophytes and pteridophytes.
- The seedlings of acacia tree initially develop simple leaves, but the leaves that develop later are compound.

- **Molecular evidences** - Similarity can be observed even at the molecular level and this similarity indicates phylogenetic relationship. The degree of similarity is indicated in the base sequence of their nucleic acids, and amino acid sequence in proteins. For example, human DNA differs in only 1.8% of its base pairs from chimpanzee DNA.

Adaptive Radiation

- During his exploration of the Galapagos Islands, Darwin noticed that there were many varieties of finches in the same island.
- They varied from normal seed eating varieties to those that ate insects.
- This process of evolution starting from a single point and radiating in different directions is called adaptive radiation.
- The other example for this is the evolution of the Australian marsupials from a single ancestor. Placental mammals also exhibit similarities to their corresponding marsupial. Example: placental wolf and the Tasmanian wolf
- When more than one adaptive radiation occurs in an isolated geographical area, the phenomenon is called convergent evolution.



Biological Evolution & Mechanism of Evolution

- The slow and gradual process of change of one organism into another is known as **Organic Evolution**.
- The occurrence of evolution has been supported by various theories put forth by biologists.

Lamarck's Theory of Evolution

- In 1809, Jean Baptiste Lamarck a French zoologist put forth the theory of inheritance of acquired characters; also known as **Lamarckism**.
- According to Lamarck, the evolution occurs based on three main bases; new needs, use and disuse of organs and inheritance of acquired characters.
- Lamarck believed that new needs force the organimsls to put in additional efforts to fulfill them. This brought about changes in their morphology and physiology and led to evolution.
- He also stated that according to their need, organisms put some organs in their bodies to maximum use while some of the organs were not used. The part of the body put to maximum use will have the tendency to grow larger and stronger while the part less used will become less prominent and ultimately disappear altogether. Thus, the organisms acquired new characters. For example, giraffe have developed long necks as a result of attempts to eat leaves high up on trees.

Weismamm's Experiment

- Mutiliation experiment on rats was conducted by August Weismann to disprove Lamarck's theory of inheritance of acquired characters.
- In this experiment, the tail of male and female rats was cut off and these rats were allowed to breed.
- According to Lamarck, taillessness is an acquired character which needs to be herited but surpisingly, the offsprings had normal tail.
- Weismann repeated this procedure for 21 generations and each time, the offsprings were normal tailed. This experiment proved Lamarck's theory was wrong.

Darwin's theory of Evolution

- According to Darwin, evolution took place by natural selection.

- The number of life forms depends upon their ability to multiply and their life span.

- Another aspect of natural selection is the survival of the fittest, where nature selects the individuals, which are most fit, to adapt to their environment.

- **Branching descent** and **natural selection** are the two important concepts of Darwin’s theory of evolution.

- Darwin also observed that variations are inheritable and the species fit to survive the most, leaves more offsprings. Hence, the population’s characteristics change, giving rise to the evolution of new life forms.

Mechanism of Evolution

- Darwin did not quite explain how evolution gave rise to different species of the same organism.

- Mendel mentioned about inheritable factors, which influenced the phenotype of an organism.

- Hugo de Vries based on his work on evening primrose suggested that variations occurred due to mutations.
- Mutations are random and directionless while the variations that Darwin talked about were small and directional. Hugo de Vries gave the name **saltation** (single step large mutation) to the mutations which brought about speciation.

Hardy-Weinberg Principle

- The frequency of occurrence of alleles of a gene in a population remains constant through generations unless disturbances such as mutations, non-random mating, etc. are introduced.
- Genetic equilibrium (gene pool remains constant) is a state which provides a baseline to measure genetic change.
- Sum total of all allelic frequencies is 1.
- Individual frequencies are represented as p and q such as in a diploid, where p and q represent the frequency of allele *A* and *a*.

  The frequency of *AA* is p^2, that of *aa* is q^2, and that of *Aa* is 2pq.
- Hence, $p^2 + 2pq + q^2 = 1$, which is the expansion of $(p + q)^2$.
- When the frequency measured is different from that expected, it is indicative of evolutionary change.
- Hardy-Weinberg equilibrium is affected by
  - gene flow or gene migration
  - genetic drift (changes occurring by chance)
  - mutation
  - genetic recombination
  - natural selection
- Sometimes, the change in allele frequency is so prominent in the new sample of population that they become a different species and the original drifted population becomes the founder. This effect is called founder effect.
- The advantageous mutations that help in natural selection over the generations give rise to new phenotypes and result in speciation.

  Natural selection causes allele frequencies of a population to change. Depending upon which traits are favoured in a population it can produce three different results.

(1) Stabilizing selection - If both the smallest and largest individuals contribute relatively fewer offspring to the next generation than those closer to average size do, then stabilizing selection is operating. It reduces the variation but does not change mean value.

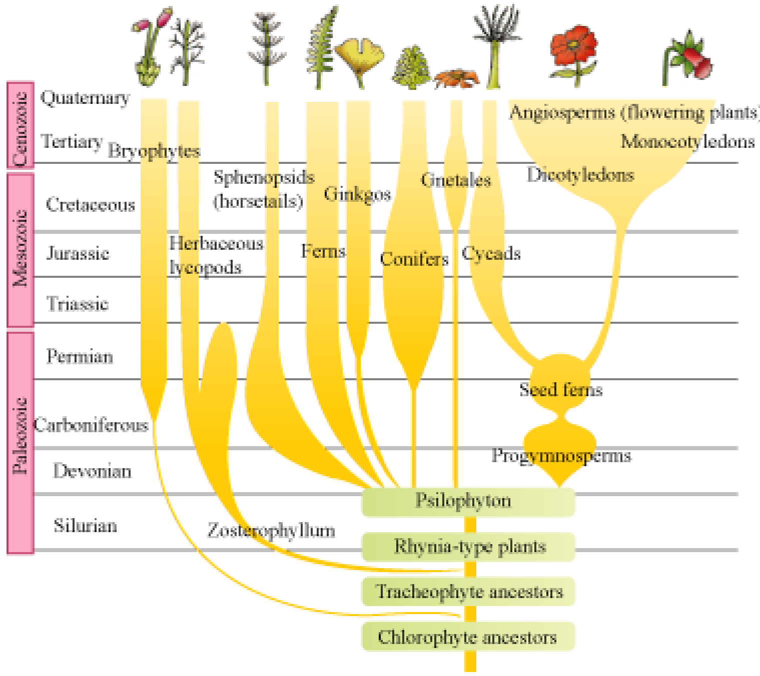
(2) Directional selection – If individuals at one extreme of the size distribution e.g. (the larger ones) contribute more offspring to the next generation then the other individuals do, then the mean size of individuals in the population will increase. In this case directional population is operating. If directional selection operates for many generations, an evolutionary trend within the population results.

(3) Disruptive selection- When natural selection simultaneously favours individuals at both extremes of the distribution, disruptive selection is operating. As a result we can see two peaks in the distribution of a trait.

Evolution of Plants and Animals

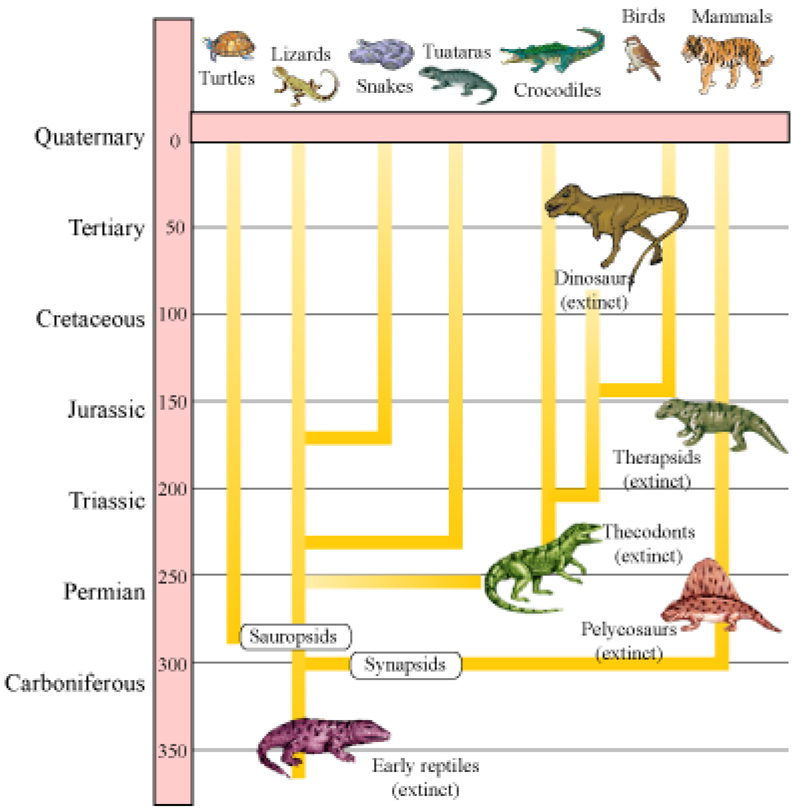
Evolution of Plants

- Cellular life forms occurred on earth about 2000 million years ago.
- Some of these cells had the ability to produce oxygen through reactions similar to photosynthesis.
- Slowly, single-celled organisms became multicellular.
- Seaweeds and some plants probably existed around 320 million years ago.



Evolution of Animals

- Animals evolved about 500 million years ago. The first of them to evolve were invertebrates.
- Jawless fishes evolved around 350 million years ago.
- Some of the fishes could go on land, and then come back to water. These were the first amphibians. In 1938, a fish Coelacanth, which was thought to be extinct, was caught in South Africa. This variety of fish, called lobefins, is believed to have evolved into the first amphibians.
- Amphibians evolved into reptiles. In the next 200 million years, reptiles of different sizes dominated the earth. However, about 65 million years ago, some of them such as dinosaurs disappeared.
- The first among the mammals were small shrew-like mammals.
- During continental drift when North America joined South America, primitive mammals suffered, but pouched mammals of Australia survived the same drift because of lack of competition from other mammals.

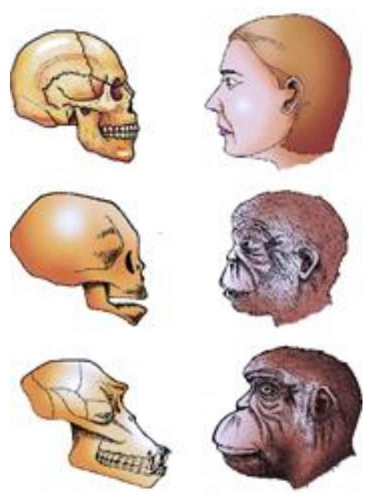


Origin and Evolution of Man

Year	Evolution	Characteristics
15 million years ago	*Dryopithecus* (ape-like) and *Ramapithecus* (man-like)	Hairy and walked similar to chimpanzees
3 – 4 million years ago	Man-like primates	Not tall, but walked straight
2 million years ago	*Australopithecines*, also called *Homo habilis*,lived in East Africa	Used stone weapons and ate fruits; human-like with brain capacity of 650 – 800 cc; not meat eaters

1.5 million years ago	*Homo erectus*	Brain capacity of about 900 cc; were meat eaters
1,000 – 40, 000 years ago	Neanderthal man	Brain capacity of 1400 cc; used hides
75, 000 – 10, 000 years ago	*Homo sapiens*	

When we compare the skulls of an adult human being, baby chimpanzee, and adult chimpanzee, we observe that skull of baby chimpanzee resembles human being more as compared to adult chimpanzee.



Human Races:

There are various kind of differences in charateristics of humans of different groups. Anthropologists have divided humans into given sub-classes or races based on the differences in their charateristics.

Race	Characteristics	Areas of Inhabitation
Caucasoids	Light skin, black or brown eyes, high ridged	Europe, India and parts of America

	nose with narrow nostrils and straight or wavy hair	
Mongoloids	Yellowish or reddish skin, thick lips, wider nose and straight hair	China, Japan, Mongolia, Malaysia and American Indians
Congoids	Black skin, thick lips, broad nose and woolly hair	Central and South Africa
Capoids	Black or brown skin	Africa
Australoids	Brown skin, deep eye sockets and curly hair	Australia