Unit | 11

Evolution and behavior

Unit Map

11.A Emergence of evolutionary thoughts

Evolution is the change over time of inherited traits found in a population of individuals. Inherited traits are distinguishing characteristics comprising a phenotype that comprises of factors like physiology, anatomy, biochemistry and behavior that are passed on from one generation to the next. Evolution acts on existing variation of inherited traits encoded within genes of the population (gene pool). New variants of inherited traits can enter a population from outside populations, a process called as gene flow.

Variation can enter a population's gene pool in at least three ways
i. Mutation of DNA
ii. Epimutation (a change inherited in some way other than through the sequence of nucleotides in DNA)
iii. Genetic recombination.

11.A.1 Lamarckism-Theory of inheritance of acquired characters

The theory of inheritance of acquired characters was given by French naturalist Lamrack and it states that modifications which the organism acquires in adaptation to the environments during its lifetime are passed on to the next generation and becomes a part of heredity.
Lamarck in his book, Philosophie Zoologique, included his theory explaining the changes that occur in the formation of new types. Although, his views on evolutionary mechanism are outmoded now, he still has a very important place in the history of evolutionary thought. He was the first evolutionist to conclude that evolution is a general fact covering all forms of life. His evolutionary ideas can be discussed in brief as follows.

- Internal forces of life tend to increase the size of the organism. New structures appear because of an inner want of the organism.
- The organs of an animal became modified in direct response to a changing environment.
- Use and disuse of organs. The various organs became greatly improved through use or reduced to vestiges through disuse.
- Inheritance of acquired characteristics. Such bodily modifications, in some manner, could be transferred and impressed on the germ cells to affect future generation. Thus, inheritance was viewed by Lamarck simply as the direct transmission of those superficial bodily changes that arose within the lifetime of the individual owing to use or disuse.

  Thus, Lamarck believed that organic changes seen in animals were resulted by the influence of environment on the gradual changes of species due to their tendency to become more and more perfect. According to him, when an animal's environment changes, its needs change and this leads to special demands on certain organs. Organs used more extensively would enlarge and become more efficient. Conversely, an organ or organs, no longer used, would degenerate and atrophy. He postulated that such changed characteristics (acquired traits) would be transmitted to the offspring.

  Examples of Lamarckism

  - If a giraffe stretched its neck for leaves, for example, a nervous fluid would flow into its neck and make it longer. Its offspring would inherit the longer neck and continued stretching would make it longer still over several generations. Meanwhile organs that organisms stopped using would shrink.
  - Ducks and other aquatic birds invaded waters from land in search of enough food, because food was scarce on land and these birds did not have power to fly. In water, the duck would stretch its toes apart to give more push during swimming. This new characteristic would be inherited and the subsequent generation of duck would upon stretching their toes form a more defined web. Each generation would do the same until the webbed foot seen on ducks today was fully formed. This would then be passed on from generation to generation, essentially unchanged once the perfected state was attained.
  - The whales lost their hindlimbs as the consequence of the inherited effect of disuse.
  - Eyes are reduced in moles since they live underground. In cave animals also, eyes might become functionless and might even disappear.

  Criticism of Lamarckism

  - Civier (1769-1832) who believed in theory of special creation, disapproved lamarkian theory demonstrating order changes in fossil.
  - Weisman (1904) defines lamark's view and rejected lamarkism by introducing germ plasma theory and he totally rejected use and dis-use of organ has any effect on evolution of species.
  - Darwin did not considered Lamarckism but put emphasis on Mendelism and variation.
  - German scientist August Weismann was the first person who for the first time made a definite distinction between heritable changes and those, which cannot be inherited. In 1890, he performed some experiments to test if characters

may disappear due to disuse. This he did by cutting the tails of white mice for more than 20 generations to see if this has any effect on tail length. The measuring of tail length of the off springs of 20 successive generations revealed that on average, the tails were not shorter. It means that, acquired character, which in this case was the cut tail, was not inherited.

- Castle and Phillips performed transplantation experiments to show that environment has no effect on heredity. In one of the experiments they transplanted the ovary of a black female guinea pig into the body of white female guinea pig and the recipient female was mated with a white male guinea pig. They found that all the individuals from this pair were black. This shows that the environment does not affect the heredity as has been suggested by Lamarck.
- Boaring of ears and nostrils in Indian women has been continued as the tradition from centuries but their off springs do not show any trace of holes in ears and nostrils.

Neo-Lamarckism Taking to the views of the opponents of Lamarckism professor Giard and Cope (1840-1897), put Lamarckian theory into a new form called neo-Lamarckism. According to neo Lamarckism

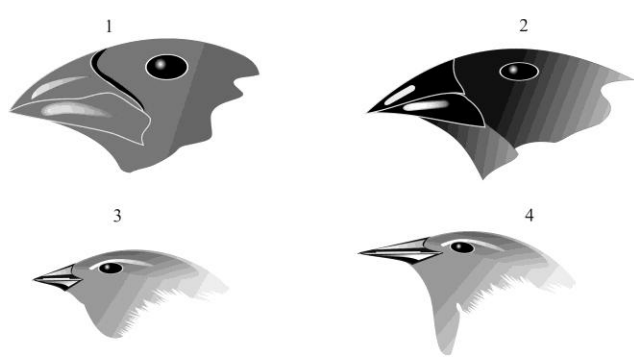
- New needs create a new habit and the new environments create a new need, which play as the key point of evolution.
- Evolutionary changes involves the inter play of environmental factors, activity of organisms and inherited determiners.
- Evolution is the direct results of action of environment or the structure of organs and their relevant functions.

11.A.2 Darwin–Concepts of variation, adaptation, struggle, fitness and natural selection

Darwin sailed at age 22 in 1831 on the ship H.M.S. Beagle, a trip that proved critical in leading Darwin to his understanding of evolution. Paramount was his visit to the many Galápagos Islands 600 miles off the west coast of South America. Darwin identified 13 species of Finches among the Galapagos Islands that were primarily differentiated by beak size. In contrast, only one species of this bird existed on the mainland South America to the east. Darwin correctly concluded that the different beaks were adaptations to different diets available among the islands.

Darwin ultimately generalized the observation from the finches that any population consists of individuals that are all slightly different from one another. Furthermore, individual organisms having a phenotype characteristic providing an advantage in Darwin's Finches will pass their phenotype traits more frequently to the next generation. Over time and generations the traits providing reproductive advantage become more common within the population. Darwin called this process descent with modification. Adaptive radiation, as observed by Charles Darwin in Galapagos finches, is a consequence of allopatric speciation among island populations.

Darwin also correctly understood that the variability allowing adaptation already existed in the finch population, though its genetic (genotype) reason was not yet known by science at the time. Nature was not producing the variation within the finch population sit already existed. Rather, nature selected from among the population variation the traits that better fostered survival and reproduction, a process known as natural selection.



1. Geospiza magnirostris 2. Geospiza fortis
3. Geospiza parvula 4. Certhidea olivacea

Darwin's Observations and Conceptualizations

Darwin's observations during his travels ultimately led him to four fundamental concepts that he elegantly put forth on his 1859 book, Origin of Species.

i. **Adaptation** all organisms adapt to their environments.
ii. **Variation (or diversity)** organisms exhibit variability in their traits (in modern terms, genotype variability determines the phenotype variability).
iii. **Over-reproduction** organism populations tend to reproduce beyond the environment's ability to support them ultimately encountering a limit on population size.
iv. **Reproductive success** Organisms exhibit variability in adaptation to environment; hence some will survive and reproduce better than others, a process known as natural selection. This is often referred to as survival of the fittest. In reality, such attributes as speed, size or strength is only more fit for survival if it endows the organism with a reproductive advantage in the existing environment. Those organisms best adapted to the environment will have a greater chance of surviving and passing their genes on to the next generation. Darwin called the process by which favorable variations are passed from

generation to generation natural selection. He made many important observations on the relationship of individual variation to survival. During his stay in the Galapagos Islands, Darwin noted that the populations of tortoises on each island had physical features so distinctive that people could often tell from which island an animal came simply by looking at it.

Natural selection is commonly referred to as survival of the fittest means that organisms must not only survive to adulthood, they must actually reproduce. If they do not reproduce, their genes are not passed on to the next generation. Evolution occurs only when advantageous genetic variations are passed along and become represented with increasing frequency in succeeding generations.

Darwin's natural selection could not incorporate gene inheritance or random gene mutation because genes had not yet been discovered. Modern evolutionary theory describes decent with modification at the level of genes, phenotypes and populations whereas Darwin described evolution at the level of organisms, speciation and individuals.

Demerits of theory of natural selection

- Darwinism or natural selection theory does not account for the beginning of organs. It remains concerned with the survival of the fittest, but not for the arrival of the fittest.
- Over-specialization in certain cases like extinct Irish deer in which huge antlers outweigh the entire skeleton, or the immense spiral tusks of the Jefferson mammoth, or the minute fidelity of certain mimicking insects such as Kallima, or huge dinosaurs of Mesozoic–all cannot be explained on the basis of continuous variations and natural selection. These organs or body structures should not have reached such a harmful stage, if natural selection was operating. However, such cases of over specializations have been explained by Darwin on the basis of discontinuous variations which, according to him, do not play any role in evolution.
- Natural selection cannot account for degeneracy of an organ.

Certain Neo-Darwinians, such as Weismann and his followers rejected Darwin’s theory except its principal element of natural selection. These Neo-Darwinians, though distinguished between germplasm and somatoplasm of living organisms in their germplasm theory, yet they could not appreciate the role of mutations in evolution. While Darwin believed that the adaptations result mainly by a single source, i.e., natural selection, Neo-Darwinians thought that adaptations result from multiple forces and natural selections is only one of these many forces. Neo-Darwinians also believed that characters are not inherited as such but there are character determiners, the determinants or biophores, which control only the development. The ultimate character would result out due to the interaction of the determiners, activity of the organism and the environment during development.

11.A.3 Mendelism and spontaneity of mutations

Topic covered in Unit 8.I

11.A.4 Evolutionary synthesis

The modern synthetic theory of evolution involves five basic processes-mutations, variations, heredity, natural selection and isolation. Migration of individuals from one population to another and hybridization increase the amount of genetic variability in a population.

i. Mutation Sudden heritable changes in the DNA sequence are known as mutations. Mutation can produce drastic changes or can remain insignificant. There are equal chances of a gene to mutate back to normal. Most of the mutations are harmful or deleterious and lethal but not all. Most of the mutant genes are recessive to normal gene and these are able to express phenotypically only in homozygous condition.

ii. Variation The process of recombination was very little known at the time of Darwin. Recombination is of several kinds: meiosis, sexual reproduction, crossing over produce new gene combinations. Chromosomal mutations such aspolyploidy, deletion, duplication, inversion and translocation also result in variation.

iii. Heredity The transmission of characteristics or variations from parent to offspring is an important mechanism of evolution.

iv. Natural selection brings about evolutionary change by favouring differential reproduction of genes. Differential reproduction of genes produces change in gene frequency from one generation to the next. Natural selection creates new adaptive relations between population and environment, by favouring some gene combinations, rejecting others and constantly moulding and modifying the gene pool.

v. Isolation Isolation of organisms of a species into several populations or groups under physiological or geographical factors is supposed to be one of the most significant factors responsible for evolution. Geographical isolation includes physical barriers such as high mountains, rivers, oceans and long distances preventing interbreeding between related organisms. Physiological barriers help in maintaining the individuality of the species, since these isolations do not allow the interbreeding amongst the organisms of different species. This is called reproductive isolation.

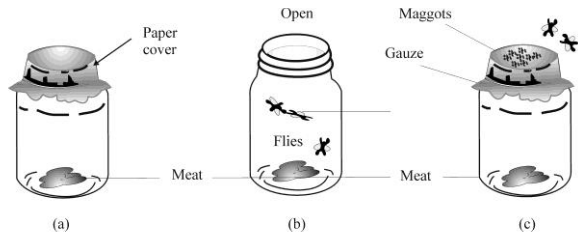
Speciation (Origin of new species) It occurs when the populations of a species are segregated by geographical and physiological barriers due to which different genetic differences occurs because of factors mutations, recombination, hybridization, genetic drifts and natural selection. The populations become different from each other morphologically and genetically and they become reproductively isolated, forming new species.

11.B Origin of cells and unicellular evolution

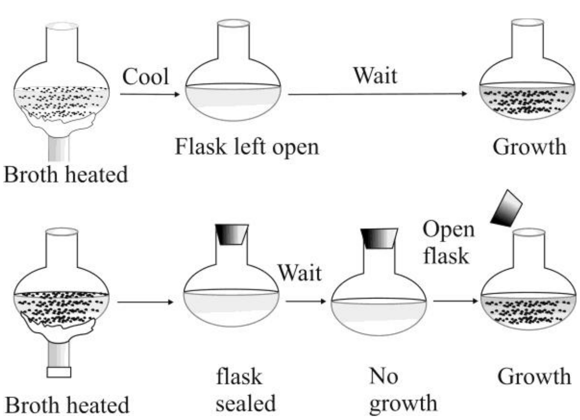
11.B.1 Abiotic synthesis of organic monomers and polymers

- **Abiogenesis**

Abiogenesis means generation of life from non-living things. It states that life can arise spontaneously from non living things under proper conditions. It is also known as spontaneous generation. Earlier people believed that mice appearing in stored grain and maggot in meat are examples of abiogenesis. During the late seventeenth century, an Italian doctor Francesco Redi performed an experiment to check the validity of the theory of spontaneous generation. In his paper Esperienze intorno alla generazione degli netti (1668), he described a series of experiments in which he placed meat in three jars, one open, one closed with gauze and the third closed with paper. Flies laid their eggs on the meat in the open jar. The eggs hatched to maggots, then young flies. Unable to reach the meat, flies laid their eggs on the gauze of the second jar and the maggots hatched on the gauze, not on the meat. No eggs were laid on the paper or the meat of the third jar, so it remained free of maggots. With this repeatable experiment, Redi proved scientifically that life, the maggots, comes from life, the flies, and not from non life, the dead meat.



An Italian scholar Abbe Spallanzani in 1765 tested the theory of spontaneous generation of microbes. He prepared flasks of meat broth, which were boiled for several hours and then one flask was left open and the other flask was sealed. In the sealed flask, the broth remained clear for months, and when the seals were broken and the broth tested, it was shown to be free of microbes. The microorganisms developed only in the opened flask. He concluded that the microorganisms did not come from broth but from the air that entered the flask. Spallanzani's experiments were neither conclusive nor satisfying to many of his contemporary scientists. Some claimed that by boiling he had driven out a vital force necessary for spontaneous generation.



Louis Pasteur (1822–1895) in the nineteenth century, some two hundred years after the initial experiments of Spallanzani, devised several experiments by which the spontaneous generation of microbes was disproved. The simplest and most sophisticated one was with the use of a swan-neck flask. He prepared a meat broth in this flask and boiled it for several hours. He then left the flask unsealed on a laboratory bench. The flask was not sealed and there was a free exchange of air with environment, so the system did not lack oxygen. Still, the swan-neck remained free of microbial contamination