BIOLOGICAL EVOLUTION

Biological evolution is characterized by any genetic alteration occurring within a population that is inherited across successive generations.

Previously, we explored the concept of evolution and its various supporting evidence, such as fossils, homologous structures, artificial and natural selection, among others. Now, we turn our attention to the theories of evolution proposed by different biologists.

Basic Concepts of Evolution

Jean Baptiste de Lamarck (1744-1829) presented the Theory of Inheritance of Acquired Characters, also known as the Theory of Use and Disuse of Organs. This theory represents the initial endeavor to elucidate the origin of species and their adaptation to the environment.

According to Lamarck's theory, organisms undergo modifications to better suit their surroundings. These acquired changes during an organism's lifetime are inherited by subsequent generations. For instance, Lamarck illustrated this concept using the example of giraffes with elongated necks, suggesting that their continuous stretching to reach foliage on tall trees resulted in the inheritance of longer necks by their offspring.

Additionally, Lamarck introduced the principle of Use and Disuse, positing that the utilization of an organ leads to its reinforcement, while disuse results in its deterioration.

Lamarck structured his theory around four fundamental postulates:

(i) Internal forces promote the enlargement of the body.

(ii) The formation of new organs arises from the continuous needs or desires experienced by organisms, termed as the Doctrine of Appetency or Desires.

(iii) The development and efficacy of an organ are directly proportional to its usage.

(iv) All alterations acquired by an organism during its lifetime are transmitted to its offspring through the process of inheritance.

It's worth noting that Lamarck's theory faced criticism from A. Weismann, who proposed the Theory of Germplasm. Weismann conducted an experiment where he sequentially removed the tails of newborn mice over 22 generations. Surprisingly, despite this continual tail removal, Weismann did not observe the emergence of tailless mice or any significant reduction in tail length.

In contemporary times, there has been a resurgence of interest in Lamarck's theory, with some suggesting that environmental influences can affect an organism's genes, leading to acquired changes being passed on to subsequent generations.

Lamarck postulated that the evolution of life forms occurred through the use and disuse of organs. According to him, the utilization of an organ results in its reinforcement, while its disuse leads to its weakening. He illustrated this concept using the example of giraffes, suggesting that their ancestors possessed shorter necks and forelimbs.

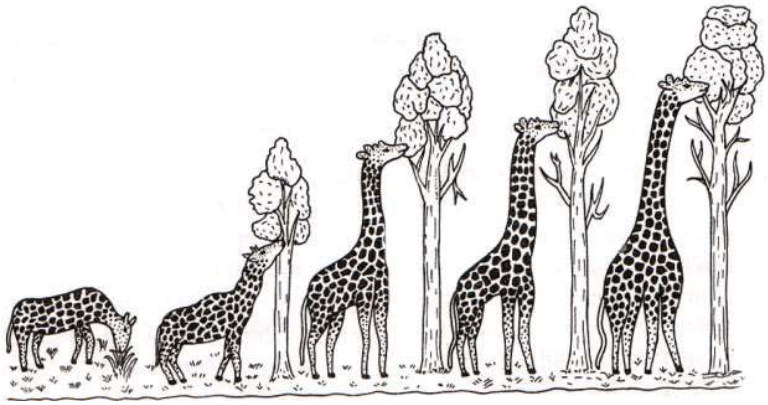

Fig.: Diagram showing elongation of neck in giraffe according to Lamarck

However, in their efforts to reach leaves on tall trees for foraging, they were compelled to elongate their necks. Lamarck hypothesized that this acquired trait, namely the elongation of the neck, was inherited by subsequent generations, eventually leading to the development of the long necks observed in present-day giraffes. Nonetheless, this speculation is no longer accepted by the scientific community.

Basic Concepts of Darwinism

- The Darwinian Theory of evolution revolves around two fundamental concepts: Branching Descent and Natural Selection.
- Natural selection is grounded in several factual observations.

(i) Overproduction

Every organism possesses the capacity to produce a vast number of offspring or organisms, resulting in exponential population growth theoretically. This phenomenon is evident in rapidly multiplying bacterial populations. However, in reality, population sizes are constrained.

(ii) Struggle for existence

- Natural resources are finite, and populations typically maintain stability in size, except for seasonal fluctuations, indicating a perennial competition for resources.
- Only a fraction of the population manages to survive and thrive, often at the expense of others that fail to flourish—a phenomenon known as the struggle for existence.

There are three types of struggles

(a) Intraspecific struggle: This type of struggle involves competition among individuals of the same species for resources such as food, shelter, and breeding opportunities. It is considered the most intense form of struggle.

(b) Interspecific struggle: This involves competition among individuals of different species for resources like food and shelter. It is regarded as the most influential force driving organic evolution.

(c) Environmental struggle: This struggle occurs between organisms and their environment. All organisms contend with environmental challenges such as cold, heat, wind, rain, drought, floods, and so on.

(iii) Variations and Heredity

Within a population, individuals exhibit variations in their characteristics, despite superficial similarities. This inherent variability in traits is a fundamental aspect of populations.
Characteristics that confer advantages for survival in natural conditions, such as climate, food availability, and physical factors, are termed adaptive or useful variations. Conversely, those traits that offer no advantage or are detrimental are labeled as non-adaptive or harmful variations.
Darwin's groundbreaking insight was that heritable variations that enhance an individual's ability to utilize resources effectively in its habitat enable those individuals to reproduce and produce more offspring.

(iv) Natural Selection/Survival of the Fittest

Individuals possessing more adaptive variations are considered "better fit" than those with fewer adaptive traits. Consequently, individuals better suited to their environment are favored by natural selection, leading to their increased reproductive success. Darwin termed this process natural selection and viewed it as a mechanism driving evolution.
Fitness, as defined by Darwin, primarily pertains to reproductive fitness—the ability to produce viable offspring.
It is observed that not all adult individuals within a population have equal opportunities to mate; some males with favorable phenotypic traits are preferred by females. This phenomenon is known as sexual selection.

(v) Origin of New Species

Through the accumulation of heritable variations and the process of natural selection, changes occur in population characteristics, giving rise to new forms.
The Theory of Pangenesis posits that all organs within an individual produce minute particles known as Pangenes, which carry information about the organs. These Pangenes travel through the bloodstream and ultimately reach the gametes, ensuring that each gamete carries information from all the body's organs. After fertilization, these Pangenes guide the development of organs in the offspring, resulting in the inheritance of traits.

Criticism of Darwinism

(a) One of the primary limitations of Darwin's theory is his lack of understanding of genetics. He lacked a satisfactory explanation for the origin, cause, and inheritance of variations.
(b) While Darwin's theory elucidated the concept of survival of the fittest, it fell short in explaining how the fittest individuals emerged in the first place.
(c) Darwin failed to account for why only a select few individuals within a population develop beneficial variations while others exhibit detrimental ones.
(d) Criticism of Darwinism extended to the concept of sexual selection, questioning why only females possess the right to choose their mates.
(e) Darwin's theory struggled to justify the presence of vestigial organs within organisms.
(f) Darwin did not delineate between somatic and germinal variations, leaving a gap in his understanding of the mechanisms underlying evolutionary change.

Example: Provide two instances of adaptive radiation.
Solution: (i) Darwin's Finches
(ii) Australian Marsupials

Basic Concepts of Mutation

The Mutation Theory, introduced by Hugo de Vries and based on his research on evening primrose (Oenothera Lamarckian), posits that significant and abrupt changes occurring suddenly within a population are termed mutations. These mutations involve sudden alterations in the genetic material (DNA) and are inheritable, contributing to the variability within a population's DNA structure.
In addition to recombination, mutation serves as another mechanism driving variation in DNA, thus serving as a discontinuous source of variation and providing the raw material for evolutionary processes.
Hugo de Vries proposed that evolution is primarily driven by mutation rather than the minor variations discussed by Darwin. Unlike Darwinian variations, which are small and directional, mutations are random and lack a specific direction. While Darwin advocated for gradual evolution, de Vries believed that mutations could cause speciation, referring to it as "saltation," signifying a single-step large mutation.

Criticism of Mutation

(i) Natural mutations are not as prevalent as de Vries initially suggested.
(ii) Mutations are typically recessive and often detrimental, whereas the characteristics involved in evolution tend to be dominant.