Lecture 43

Evolution

The Tree of Life

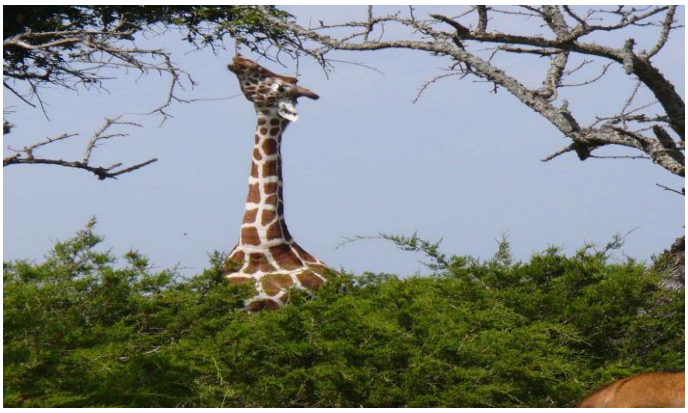
The Tree of Life is an ever-evolving depiction of life's common ancestry. Scientists design the Tree of Life from careful observations and comparisons of living things. The tree shows that all organisms are related through their descent (the branches) from a common ancestor (the root). The more structural and genetic similarities that organisms share, the more closely related they are and the closer they are on the Tree of Life. We can draw a Tree of Life to show how every species is related. Evolution is the process by which one species gives rise to another and the Tree of Life grows.

Theory and Fact

A scientific theory is a well-substantiated explanation of such facts. The facts of evolution come from observational evidence of current processes, from imperfections in organisms recording historical common descent, and from transitions in the fossil record. Theories of evolution provide a provisional explanation for these facts. Evolution means change over time, as in stellar evolution. In biology it refers to observed changes in organisms, to their descent from a common ancestor, and at a technical level to a change in gene frequency over time; it can also refer to explanatory theories (such as Charles Darwin's theory of natural selection) which explain the mechanisms of evolution. To a scientist, fact can describe a repeatable observation that all can agree on; it can refer to something that is so well established that nobody in a community disagrees with it; and it can also refer to the truth or falsity of a proposition.

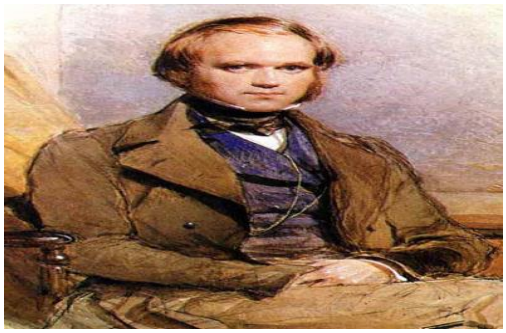
Transmutation

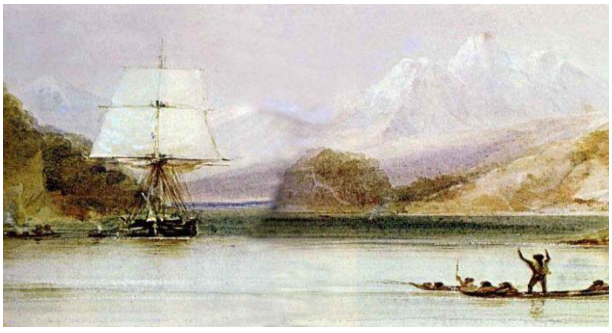
Jean-Baptiste Lamarck proposed a theory on the transmutation of species in Philosophie Zoologies (1809). Lamarck did not believe that all living things shared a common ancestor. Rather he believed that simple forms of life were created continuously by spontaneous generation. He also believed that an innate life force, which he sometimes described as a nervous fluid, drove species to become more complex over time, advancing up a linear ladder of complexity that was related to the great chain of being. Lamarck also recognized that species were adapted to their environment. He explained this observation by saying that the same nervous fluid driving increasing complexity, also caused the organs of an animal (or a plant) to change based on the use or disuse of that organ, just as muscles are affected by exercise. He argued that these changes would be inherited by the next generation and produce slow adaptation to the environment. Hence giraffes got their long necks to reach high branches.



Darwin's Voyage

The voyage of the *Beagle* (1831-1836) was one of the most important scientific expeditions in history. On board was the young naturalist Charles Darwin. His investigations would change science and the world forever. There was no sudden discovery on the Galapagos sparked by the finches as popular legend has it. Instead he intensively studied the geology, animals, plants and peoples of the lands visited. Along the way he made a number of striking discoveries, particularly in South America, which eventually led him to realize that living things must evolve over time. After his return home he formulated what he called "natural selection" to explain how living things adapt to a changing world.





Genetics

Gregor Mendel discovered some of the "rules" of diploid inheritance. Mendel's work was not widely known until it was rediscovered in the 1900s. Mendel demonstrated particulate inheritance, dispensing with the problems of blending inheritance. This mode of inheritance was initially used to argue against natural selection being a strong force: Since variants or mutants observed by early geneticists had discrete effects, and species differed discretely, species could have arisen by discrete, perhaps systemic changes (perhaps with a direction determined by orthogenesis or other mechanisms).

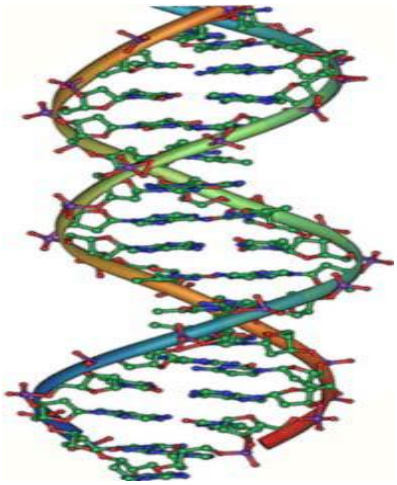
Evolutionary Principles

Charles Darwin proposed the idea of evolution in his book 'On the Origin of Species' in 1859. He called evolution 'descent with modification'. It is the process by which all life on earth has diversified from bacterial mats that existed over 3.6 billion ago. Evolution has had a long time. For a long time it was mistakenly thought that evolution was a simple linear progression, with humankind at the top of the ladder. This old view was replaced long ago as new evidence came to light. We now understand that evolution proceeds in a kind of branching pattern, with species on one branch giving rise to other branches and so on.

Genetics and Phenotype

Genotype

The genotype is the genetic makeup of a cell, an organism, or an individual usually with reference to a specific characteristic under consideration.

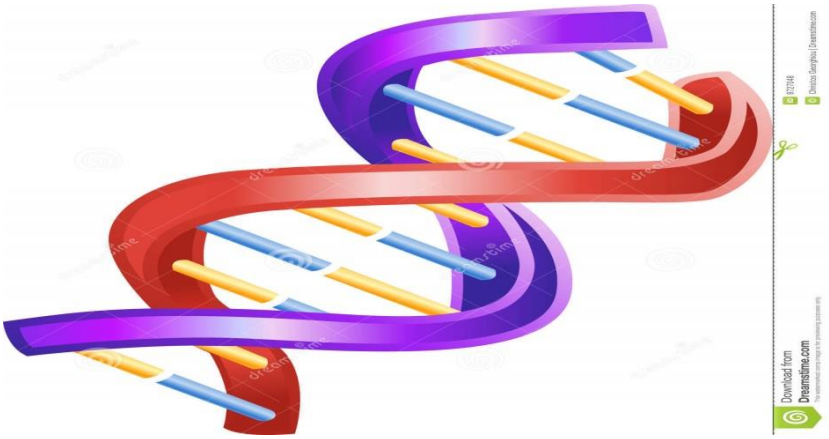


Phenotype

The observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences. The expression of a specific trait, such as stature or blood type, based on genetic and environmental influences.

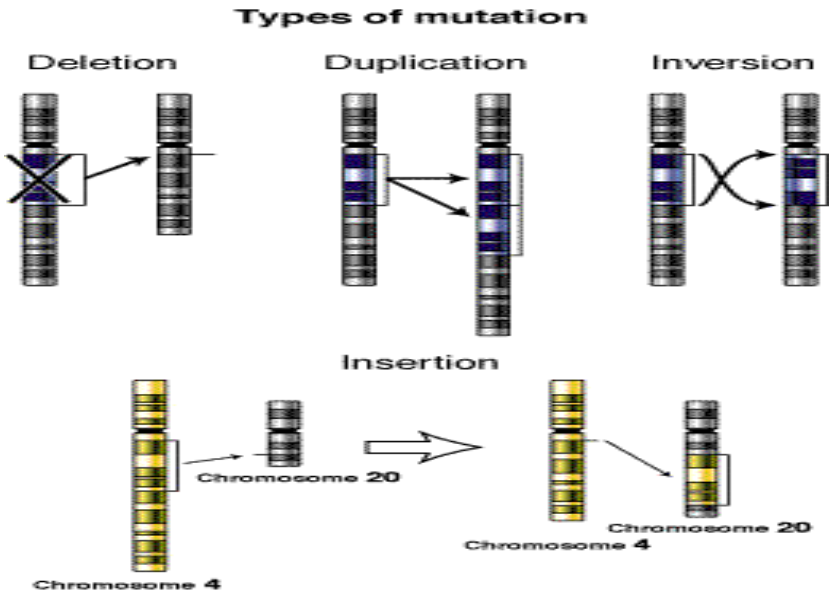
DNA

The double-helix structure of DNA was discovered in1953. DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. Nearly every cell in a person's body has the same DNA. Most DNA is located in the cell nucleus (where it is called nuclear DNA), but a small amount of DNA can also be found in the mitochondria (where it is called mitochondrial DNA or mtDNA).



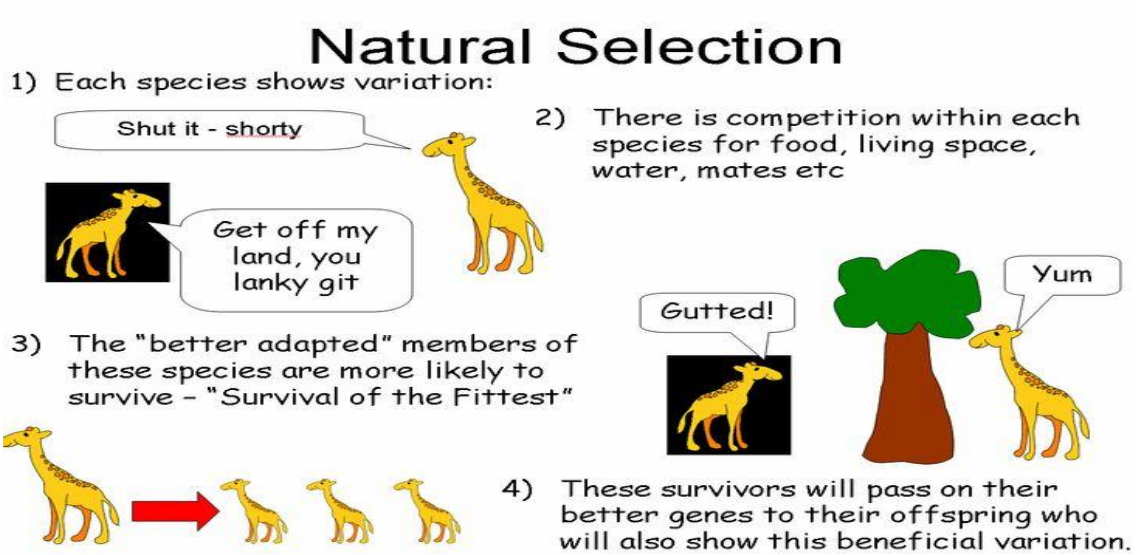
Mutation

Mutation is a natural process that changes a DNA sequence. Mutations result from damage to DNA which is not repaired, errors in the process of replication, or from the insertion or deletion of segments of DNA by mobile genetic elements. Mutations may or may not produce discernible changes in the observable characteristics (phenotype) of an organism. Mutations play a part in both normal and abnormal biological processes including: evolution, cancer, and the development of the immune system, including junctional diversity.



Natural Selection

Natural selection is the differential survival and reproduction of individuals due to differences in phenotype. It is a key mechanism of evolution, the change in heritable traits of a population over time. Variation exists within all populations of organisms. This occurs partly because random mutations arise in the genome of an individual organism, and offspring can inherit such mutations. Throughout the lives of the individuals, their genomes interact with their environments to cause variations in traits. (The environment of a genome includes the molecular biology in the cell, other cells, other individuals, populations, species, as well as the abiotic environment.) Individuals with certain variants of the trait may survive and reproduce more than individuals with other, less successful, variants. Therefore, the population evolves.

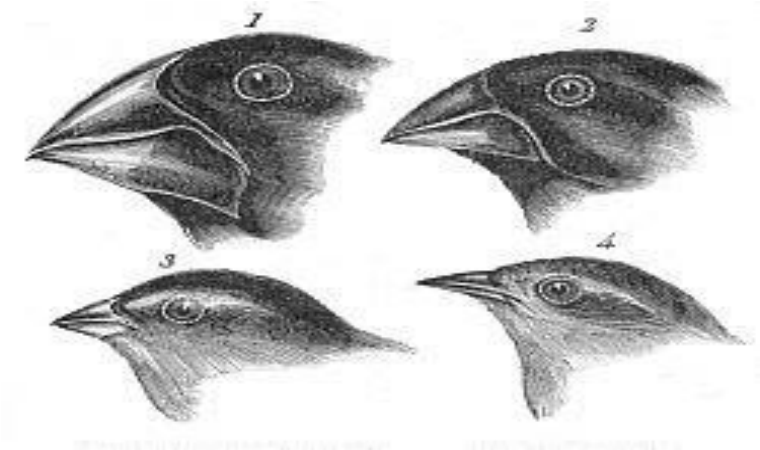


Microevolution

Microevolution is the change in allele frequencies that occurs over time within a population.[1]This change is due to four different processes: mutation, selection (natural and artificial), gene flow, and genetic drift. This change happens over a relatively short (in evolutionary terms) amount of time compared to the changes termed 'macroevolution' which is where greater differences in the population occur. Dogs have been artificially selected for certain characteristics for many years. Because their different breeds have different alleles. All breeds of dog belong to the same species, Canis lupus (the wolf). That is an example of Microevolution as no new species has resulted.

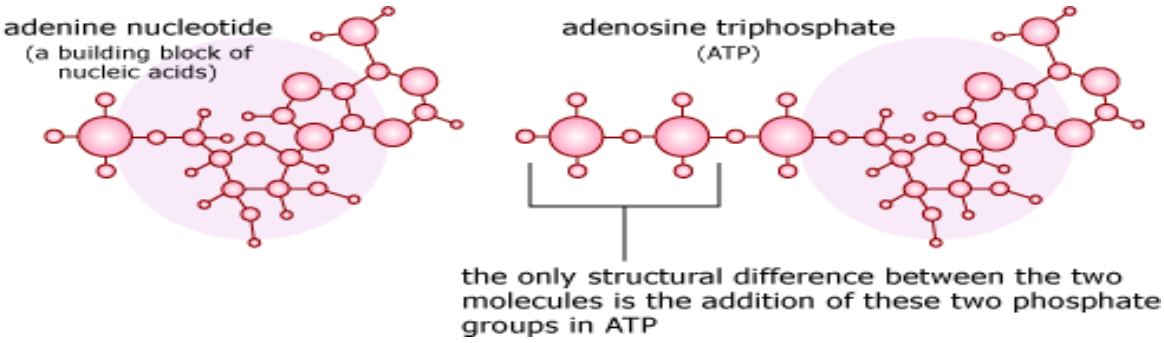
Macroevolution

Macroevolution is evolution on a scale of separated gene pools.Macroevolutionary studies focus on change that occurs at or above the level of species, in contrast with microevolution,which refers to smaller evolutionary changes (typically described as changes in allele frequencies) within a species or population. If the two populations can no longer interbreed, new species are born. This is called Macroevolution. Darwin's Galapagos finches are an example of this process in action.



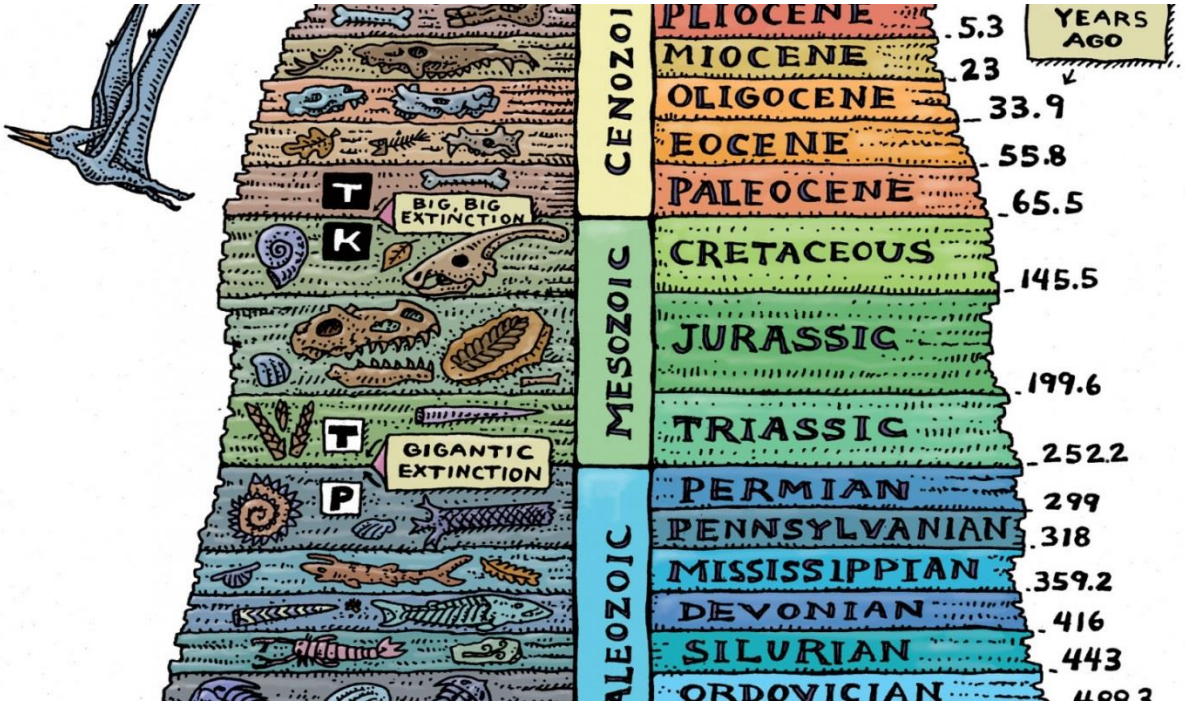
Evidence using Biochemistry

We can begin to piece together how biochemical systems evolved near the root of the tree of life. However, up until the early 1980s, biologists were stumped by a "chicken and egg" problem: in all modern organisms, nucleic acids (DNA and RNA) are necessary to build proteins, and proteins are necessary to build nucleic acids - so which came first, the nucleic acid or the protein. This problem was solved when a new property of RNA was discovered: some kinds of RNA can catalyze chemical reactions and that means that RNA can both store genetic information and cause the chemical reactions necessary to copy it. This breakthrough tentatively solved the chicken and egg problem: nucleic acids (and specifically, RNA) came first and later on, life switched to DNA-based inheritance.



Fossil Record

The fossil record is life's evolutionary epic that unfolded over four billion years as environmental conditions and genetic potential interacted in accordance with natural selection. It could be likened to a movie recording the history of life across nearly four billion years of geological time. Fossils provide a unique view into the history of life by showing the forms and features of life in the past. Fossils tell us how species have changed across long periods of the Earth's history. For instance, in 1998, scientists found a fossil showing an animal at the transition from sea creature to land creature. This tetrapod had a hand-like fin, confirming a prediction of evolutionary biology. The fossil record is a remarkable gift for the study of nature.



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