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Understanding the Process of Biological Evolution

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Opinion Article

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DESCRIPTION

Evolution is the change in heritable characteristics of biological populations over successive generations. These characteristics are the expressions of genes, which are passed on from parent to offspring during reproduction. Variation tends to exist within any given population as a result of genetic mutation and recombination. Evolution occurs when evolutionary processes such as natural selection (including sexual selection) and genetic drift act on this variation, resulting in certain characteristics becoming more common or more rare within a population. The evolutionary pressures that determine whether a characteristic is common or rare within a population constantly change, resulting in a change in heritable characteristics arising over successive generations. It is this process of evolution that has given rise to biodiversity at every level of biological organisation. The theory of evolution by natural selection was conceived independently by Charles Darwin and Alfred Russel Wallace in the mid-19th century and was set out in detail in Darwin's book On the Origin of Species.

Evolution by natural selection is established by observable facts about living organisms: (1) more offspring are often produced than can possibly survive; (2) traits vary among individuals with respect to their morphology, physiology, and behaviour (phenotypic variation); (3) different traits confer different rates of survival and reproduction (differential fitness); and (4) traits can be passed from generation to generation (heritability of fitness). In successive generations, members of a population are therefore more likely to be replaced by the offspring of parents with favourable characteristics. In the early 20th century, other competing ideas of evolution such as mutationism and orthogenesis were refuted as the modern synthesis concluded Darwinian evolution acts on Mendelian genetic variation. All life on Earth—including humanity—shares a last universal common ancestor (LUCA) which lived approximately 3.5–3.8 billion years ago.

The fossil record includes a progression from early biogenic graphite to microbial mat fossils to fossilised multicellular organisms. Existing patterns of biodiversity have been shaped by repeated formations of new species (speciation), changes within species (anagenesis), and loss of species (extinction) throughout the evolutionary history of life on Earth. Morphological and biochemical traits are more similar among species that share a more recent common ancestor, and these traits can be used to reconstruct phylogenetic trees.

The complete set of observable traits that make up the structure and behaviour of an organism is called its phenotype. These traits come from the interaction of its genotype with the environment. As a result, many aspects of an organism's phenotype are not inherited. For example, suntanned skin comes from the interaction between a person's genotype and sunlight; thus, suntans are not passed on to people's children. However, some people tan more easily than others, due to differences in genotypic variation; a striking example are people with the inherited trait of albinism, who do not tan at all and are very sensitive to sunburn. Heritable traits are passed from one generation to the next via DNA, a molecule that encodes genetic information. DNA is a long biopolymer composed of four types of bases. The sequence of bases along a particular DNA molecule specifies the genetic information, in a manner similar to a sequence of letters spelling out a sentence. Before a cell divides, the DNA is copied, so that each of the resulting two cells will inherit the DNA sequence. Portions of a DNA molecule that specify a single functional unit are called genes; different genes have different sequences of bases. Within cells, the long strands of DNA form condensed structures called chromosomes. The specific location of a DNA sequence within a chromosome is known as a locus. If the DNA sequence at a locus varies between individuals, the different forms of this sequence are called alleles. DNA sequences can change through mutations, producing new alleles. If a mutation occurs within a gene, the new allele may affect the trait that the gene controls, altering the phenotype of the organism. However, while this simple correspondence between an allele and a trait works in some cases, most traits are more complex and are controlled by quantitative trait loci (multiple interacting genes)