Evolution: Evolution refers to the process by which early organisms of the earth diversified into various new forms through slow but continuous variations. Ever since the appearance of the first living beings on the earth some 3.5 billion years ago, new forms have continuously originated. And, the different forms have undergone modifications and given rise to new forms. The newer forms are sufficiently different to be recognized as new species. They breed amongst their own members and not with the ancestral forms or any other forms. The newly formed species may give rise to still newer species over a period of time. According to Darwin, elvolution is 'descent with modification.'

Sources of Genetic Variation: You know that there are two main types of variations—somatic and germinal (genetic). Genetic variation arises due to mutation and it can account for the creation of a new species. Mutation is any change in the structure of a gene. Mutation may lead to a change in the expression of a gene. Such a change may even produce harmful effects in the organism. Another source of variation is genetic recombination. It is a natural process due to which the arrangement of genes in the progeny is in a combination that differs from that of the parents. This is because the offspring receive genes from both the parents, and this ensures the transmission of some genetic variability from the parents to the offspring. Mutation and genetic recombination may give rise to new characters due to change in genes. These new characters may help the individuals to adapt to their environment. Sometimes the new characters may not help individuals to adapt. Disease, competition, etc., can eliminate those less well-adapted individuals. The survivors pass on their advantageous characters to their offspring. This enables the offspring to adapt well to their environment. Thus nature selects new characters by favouring some of them and eliminating others. In this way natural selection may lead to the evolution of a new species with new characters. Let us see how variations in a population lead to evolution.

Variations in a Population: Varia refers to the changes observed in phenotype, and genotype, the individuals in a population or between parents and their offspring. Suppose twelve red beetles live in bushes with green leaves, their population grows by sexual reproduction and generates variations. In a population of beetles, variation may occur through the following means:

Case 1: During reproduction, a colour variation may arise, which may lead to the production of a green beetle. It passes the green colour to its progeny. Crows cannot see green coloured beetles on green leaves, so they cannot eat them. Hence, the grey ones continues to be eaten and number of green beetles increases in the population. In this case, variation gives a survival advantage. The natural selection exerted by the crows will lead to the survival of green beetles.

Case II: In another situation, a colour variation arising during reproduction may result in a blue beetle instead of grey and all its progeny will be blue. Crows can see both blue and grey coloured beetles and therefore, can eat them. At the outset, there are a few blue beetles and more of grey beetles. Suddenly, an elephant stumps on the bushes and kills most of the beetles. By chance, the few beetles that survived were mostly blue, which gradually increase in number. This change in the frequency of some genes in a population which provides diversity without any survival disadvantage is called genetic drift.

Case III: The bushes catch a plant disease and the amount of leaf material for the beetles has reduced due to expansion in population of beetles. As a result, the beetles are poorly nourished and an average weight of an adult beetle has decreased. After a few years, the plant disease may get eliminated and there will be a lot of food for the beetles. Then, they will regain their normal weight. In this case, there is no genetic change occurring. Hence, only a phenotypic variation between the organisms with identical genotypes may arise.

Acquired and Inherited Traits: The characteristics developed during the lifetime of an individual, that cannot be passed on to its progeny are termed as acquired traits (characters). The lifetime experiences of an individual cannot be passed to

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their offprings and are not controlled genetically. For example, if we breed a group of mice and remove the tails of these mice by surgery, the progeny would not be tailless because removal of the tail cannot change the genes of germ cells of the mice and cannot direct the evolution. Thus, it proves that change in non-reproductive tissues cannot be passed on to the DNA of the germ cells.

Inherited traits are those characteristics which are received by offsprings from their parents (i.e. from one generation to another because they are controlled by genes) like colour of hair and eyes, shape of nose, earlobes, etc. There is also reshuffling of gene/chromosome by chance during separation of chromosomes at the time of gametogenesis and fertilisation, which might also lead to variation.

Charles Robert Darwin (1809-1882): He was a British naturalist who formulated his hypothesis that evolution took place due to natural selection and proposed the theory of natural selection, also known as Darwinism. He was an accomplished naturalist and he also conducted studies on the role of earthworms in soil fertility.

Darwin's theory was based on inherited traits and their variations. The four observations are:

1. Individuals within a species differ from each other, there is variation.
2. Offsprings resemble their parents; their characteristics are inherited.
3. The number of offsprings produced are more than the number survived to reach maturity. They suffer from predation, disease and competition.
4. Populations remain fairly constant in size.

Origin of Life on Earth: When a species cannot evolve fast enough to compete in a changing environment, it may become extinct. This might happen, if the environment changes very quickly. e.g. extinction of tigers, etc.

JBS Haldane a British biologist, biochemist and geneticist, proposed in 1929 that life must have originated from the simple inorganic molecules which might have originated on the Earth through a long series of physiochemical changes, to more complex organic molecules that were brought about first by chemical evolution. This gradual change or development of complex forms from simpler forms is known as organic evolution.

Stanley L Miller and Harold C Urey in 1953 gave an experimental supportto Haldane's theory of origin of life. They created an atmosphere similar to that which existed on early Earth (containing hydrogen, ammonia, methane, hydrogen sulphide and water vapour, but no oxygen) over water in an airtight apparatus. This was maintained at a temperature just below 100°C and sparks were passed through the mixture of gases to stimulate lightening. At the end of a week, 1 5% of the carbon from CH_4 had been converted to simple carbon compounds, including amino acids (which make up protein molecule).

Spectiation: A species is defined as a group of interbreeding organisms that produce fertile offspring and are reproductively isolated from other groups. Reproductive isolation means that sexual reproduction between different species is impossible because of the physical, ecological, behavioural, temporal or developmental reasons.

- Physical There may be a sea, mountain or desert between them.
- Behavioural Populations may have different courtship patterns.
- Temporal (time based) Plants may be flowering at different times.
- Ecological Species inhabit different places and never meet up.

Speciation is the development of one or more species from an existing species. The geographical isolation (allopatric speciation) of two groups of population leads to their reproductive isolation (sympatric speciation) due to which no genes are exchanged between them.

Geographical isolation is the major factor for reprodu isolation in sexually reproducing animals only, it cannot be in case of asexually reproducing organisms. However, inbreeding continues within the isolated populations producing more and more generations. Eventually, the members of these two groups will be incapable of reproducing with each other even if they happen to meet. Over generations,

genetic drift accumulates different changes in a sub-population. Also, natural selection may also operate variably in these different geographic locations. e.g. in the territory of one sub-population, crows may get eliminated by eagles.
But this may not be the case in the other sub-population, whereas a result the crow numbers will become very high. As an outcome of this, the green variation will not be selected at the first site, while it will be strongly selected at the second. Together, the processes of genetic drift and natural selection may make two isolated sub-populations more and more different from each other. This will lead to generation of new species. These new species may have developed
1. if the DNA changes are severe enough, such as a change in the number of chromosomes, eventually the germ cells of the two groups cannot fuse each other.
2. if a new variation emerges in which females are able to mate with few males due to their specific trait. This allows very strong natural selection for trait.
Note Allopatric speciation is the formation of new species from populations occurring in different areas due to some physical barrier. Sympatric speciation is the development of new species within that area due to reproductive isolation, mutation, etc.

Evolution and Classification: Evolution is the process by which newer types of organisms are developed from the pre-existing ones through modification. Characteristics are the details of appearance or behaviour; in other words, a particular form or a particular function, e.g. the forelimbs of human beings is a characteristic and that the plants can perform photosynthesis is also a characteristic. Classification is the arrangement of organisms into a series of group based on physiological, biochemical, anatomical or other relationships. All systems of classification are hierarchial. Hierarchy is a type of social organisation in which individuals are ranked according to their status or dominance relative to the members of their groups.

Basic Characteristics of an Organism:

- Cell is the basic unit of life in all organisms.
- Cells of some organisms do not have organised nucleus, .g. bacterial cell, while the cells of some other organisms have a well-organised nucleus.
- Amongst organisms with nucleated cells, some are unicellular and others are multicellular.
- Among multicellular organisms also, some organisms can nanufacture their own food (photosynthesis) while others cannot.
- Other difference between unicellular and multicellular organisms is that some multicellular organisms have skeleton inside the body, while others have skeleton around the body.

Evolution Relationships with Classification: The more closely two species are related, the more characteristics they will have in common and the more recently they will have had their common ancestors. Let us understand this concept with the help of an example as follows. A bother and a sister are closely related and they have a common ancestor in the first generation before them, i.e. their parents. A girl and her first cousin are closely related, but less related than her brother. The cousins have a common ancestor, i.e. their grandparents in the second generation. Thus, evolutionary relationships are traced in the classification of organisms.

Tracing Evolutionary Relationships: In order to find out the evolutionary relationships among organisms, their common features have to be looked upon.

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These common features in different organisms point out towards common ancestry. Evidences have been provided by various fields as given below.

Homologous Organs: According to Darwin, more closely related species have evolved from a common ancestor. The characteristics and fundamentally similar structures suggest the possibility of a common ancestor, e.g. the forelimbs of vertebrates. Such phenomenon of similarity of structure due to common ancestry is known as homology. Characteristics of homologous organs are given below:

1. Similar in basic structure and have the same developmental origin.
2. Have different functions in different organisms.
3. Their similarity is due to common ancestry.

e.g. the forelimbs of vertebrates (lizard, man, frog and bird) have a similar structure, but perform different functions.

Analogous Organs: The organs, which have different origin and basic structure (plan), but show similar appearance and perform similar functions too, e.g. wings of birds and wings of bat. Characteristics of analogous organs areas listed below:

1. Differ in basic structure.
2. Resemble each other in functions.
3. Their similarity is a superficial resemblance.

e.g. the wings of bats and birds are different in their structure and origin but have same function of flying.

Vestigial Organs: These are organs that have been reduced or diminished in size during evolution. There are about 180 vestigial parts in humans. Some of them are vermiform appendix, body hair, nictitating membrane, coccyx or tail bone, wisdom teeth, ear pinna muscles, canines, etc.

Fossils: These are the dead and decayed remains of organisms from the geological past, i.e. preserved traces of living organisms that lived millions of years ago. It is not always necessary that every part of a dead organism decomposes, e.g. a dead insect caught in a hot mud. The mud does not allow the insect to decompose quickly. On the contrary, the mud will eventually harden and retain the impression of the body parts of the insect. This provides us evidence about the presence of insect and also tells us about the structure of the insect. Imprints of leaves, stems, footprints, skin impressions and other traces provide indirect evidences of past life. In other words, fossils record helps us to analyse the connections between the Earth's and life's evolution. By this, we can reconstruct the patterns and trends that existed in the history of life. Science of fossils is known as paleontology.

Kinds of Fossils: Fossils are of various kinds like tree trunk fossils, invertebrate fossils (Ammonite), fish fossils (Knightia) and dinosaur skull fossils (Rajasaurus recently found in Narmada valley) depending upon their differences in appearance and detail and mode of preservation. A fossil Archaeopteryx is the connecting link between birds and reptiles. This is because; it has feathered wings and beak like those of birds, but teeth and tail like those of reptiles. So, it is considered that birds have evolved from reptiles. Thus, fossils provide evidence that living beings (plants and animals) that exist today have originated from primitive organisms through the process of organic evolution.

Dating of Fossils: There are two ways by which we can determine the age of fossils:

1. If we start digging the earth and find fossils, the deepest layers generally contain the oldest fossils, as compared to the surface layers.

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Relative position of the rock and the rate of its erosion can also indicate the same.

2. Carbon dating can also be used. In this, the age of the fossil can be determined by measuring the ratio of the different isotopes of carbon element in the fossil material.

Uses of Fossils

- To determine the history of plants and animals.
- These give us an idea about evolution.
- These give us an idea about climatic conditions of Earth in the past.
- It helps us to analyse the geological time scale.

Note- Geological time scale is a system of chronologic measurement that relates stratigraphy to time and is used by palaeontologists, geologists and other Earth scientists to describe the timing and relationship between events that have occurred throughout Earth's history.

Fossil Formation (Fossilisation): Fossils are formed layer by layer in a sequence. It is a slow process that is totally dependent on where the organisation dies. Generally, fossils are formed from the hard the organism, such as tree trunks or skull.

Evolution is a gradual process: Complicated organs, such as the eyes are selected of an advantage that they are not generated by a single DNA change. Such complex organs are created bit by bit over generations and seem to be a very popular adaptation. The structure is different in different organisms and is sufficient enough to suggest separate evolutionary origins. Feathers, e.g. evolved to provide insulation in cold weather, but later were adapted to be used for flight in animals like birds. In fact, some dinosaurs had feathers too, although they could not fly using them. Thus, we can infer that birds are very closely related to reptiles, since dinosaurs were reptiles. Sometimes, dissimilar appearing structures also evolved from common ancestors. Thus, evolutionary relationship can be established by studying fossils. To study such evolutionary relationship, one current example is of wild cabbage plant. Humans have cultivated wild cabbage for more than two thousand years as food plant and generated different vegetables from it by selection. This is artificial selection (i.e. Modification of species by selective breeding by man) rather than natural selection. Varieties like cauliflower, broccoli, cabbage, red cabbage, kohlrabi and kale have evolved from a common ancestor, i.e. wild cabbage. The tracing of evolutionary relationships depends on the original idea that changes in DNA during reproduction are basic events of evolution. This method is extensively used these days to define evolutionary relationship as comparing the DNA of different species gives us a direct estimate of how much the DNA has changed during the formation of different species.

Molecular Phylogeny: Phylogeny is the evolutionary history of related group of organisms. Molecular phylogeny traces the evolutionary relationships on the concept that organisms that are more distantly related will have a greater number of differences in their DNA. DNA similarity is greatest among the most closely related species and least among the most distant.

Evolution is not necessarily Progressive: Evolution should not be equated with progress. There is no real progress in the concept of evolution. It is simply the generation of diversity by natural selection and its shaping by environmental

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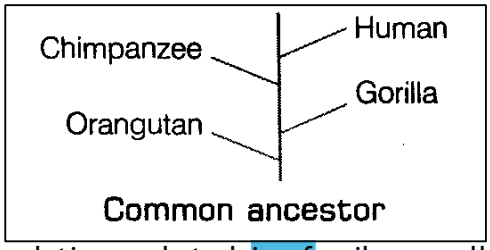
selection. The concept of evolution is not that the animals and the plants, we see around us have evolved from each other or that after the evolution of one species the other got eliminated. It will all depend on the environment. It is just that natural selection and genetic drift have together led to the formation of a population that cannot reproduce with the original one. In fact, some species share similar features as they evolved from a common ancestor. Take for example, the case of human beings and chimpanzees. It is not true that human beings have evolved from chimpanzees. Rather, humans and chimpanzees share more similarities than the other types of apes, which mean that they probably share a more recent ancestor or common ancestor than the others.

The diagram shown below illustrates how humans and apes may have evolved from a common ancestor.

More and more complex body designs have emerged over the time during evolution, but that does not mean older and simpler life forms were inefficient. Many of these life forms still survive, e.g. bacteria, the simplest life form can survive even in critical environmental conditions (like hot springs, deep-sea thermal vents and the ice in Antarctica).



Human Evolution: There is a great diversity of human forms and features across the planet. The tools used to trace evolutionary relationships have also been used for studying human evolution, i.e. excavating, time dating and studying fossils as well as, determining DNA sequences. Skin colour used to be the commonest way for identifying the races due to the diversified forms of human and their features. However, there is no biological basis to the notion of human races. All humans are of a single species. The earliest member of the human species, Homo sapiens can be traced to Africa.

- A couple of hundred thousand years ago, some of our ancestors left Africa, while others stayed back.
- The residents spread across Africa and the migrants spread across planet from Africa to West Asia, Central Asia, Eurasia, South Asia, East Asia, Indonesia, Philippines, Australia and America.
- They did not go in a straight line, so they were not visiting different places just for the purpose of travelling.
- They instead went forward and backward with group separating from each other or sometimes coming back together.
- Like, all other species on the planet, they had come into existence as an accident of evolution and were also trying to live their lives to the best of their abilities.

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