Chapter 9 - Heredity and Evolution

1. Accumulation of variation during Reproduction.

Variations in an individual may be an advantage or disadvantage for it. It may enable or disable it to cope with changes in the environment. Advantageous variations are selected by environmental factors. For example bacteria that can withstand heat will survive better in a heat wave. Such heritable variations lead to the evolution and formation of new species.

An advantage of sexual reproduction is that the variations accumulated in the gametes of each sex are combined when they fuse to form the zygote. Hence an offspring produced from the zygote receives and carries the variations of both the parents. On the other hand, in asexual reproduction there are minor differences among the offspring. These are due to small errors in DNA copying. As gametes and zygote formation are not involves the asexually produced offspring are quite similar. They have fewer variations accumulated over generations.

2. Heredity:

The process of passing traits from parent to offspring is called **heredity**. **Trait** is any characteristic that is transferred from parent to offspring. e.g. height and colour.

2.1 inherited traits.

In humans, eye color is an example of an inherited characteristic: an individual might inherit the brown-eye trait from one of the parents. Inherited traits are controlled by genes and the complete set of genes within an organism's genome is called its genotype.

2.2 Rules for the Inheritance of traits- Mendel's contributions:

Gregor Johann Mendel was a pioneer among geneticists who put forward the concept of inheritance of characteristics or traits from parent to offspring. Mendel proposed the principle of inheritance and is known as the "Father of Genetics". Mendel has chosen pea plants for his experimentation and found variations among them. Gene is a structural and functional unit of heredity and variations. Gene is a DNA segment on the chromosome. Genes control the expression of characteristics. Mendel called the genes to be factors.

Traits can be either dominant or recessive. Tallness in a plant is a dominant trait, controlled by a dominant allele and is represented by "T" (capital). Shortness in a plant is a recessive trait, controlled by a recessive allele and is represented by "t" (small).

- Homozygous is a condition in which a gene possesses a pair of the same alleles (TT or tt) for a single characteristic.
- Heterozygous is a condition in which a gene possesses a pair of different alleles (Tt) for a single characteristic.

Phenotype is a morphological expression of a single character. For example, tallness or shortness represents the phenotype of the plant. Genotype is the genetic make-up of a cell, an organism, or an individual (i.e. the specific allele make-up of the individual), usually with

reference to a specific characteristic under consideration. Alleles combine to make a genotype, such as TT or Tt or tt.
Punnett square is a statistical method that was used by Mendel to predict the possible genotypes and phenotypes of the offspring.

Monohybrid inheritance
It is the inheritance of a single characteristic controlled by different alleles of the same gene.

- F_1 generation is the first filial generation offspring produced by crossing two parental strains. All the progeny of F_1 generation were tall i.e. the traits of only one parent were visible.
- F_2 generation is the second filial generation offspring produced by crossing F_1's. The F_2 progeny were not all tall. Instead, one quarter of them was short indicating both the traits – that of tallness and shortness were inherited in the F_2 plants.
- Genotypic ratio – 1:2:1, Phenotypic ratio – 3:1.

Dihybrid inheritance
It is the simultaneous inheritance of two characters.
- Dihybrid inheritance is the experimentation of two characteristics with their four contrasting traits.
- For instance, dihybrid inheritance involves a plant producing round and yellow seeds (RR and YY) crossing with a plant producing wrinkled green seeds (rr and yy).
- F_1 progeny produces round and yellow seeds (R and r, and Y and y) in which round and yellow are dominant traits.
- F_2 progeny were similar to their parents and produced round yellow seeds, while some of them produced wrinkled green seeds. However, some plants of the F_2 progeny even showed new combinations, like round-green seeds and wrinkled-yellow seeds.
  Thus the tall/ short trait and the round seed/wrinkled seed trait are independently inherited.

2.3 How do these traits get expressed?
A section of DNA that provides information for one protein is called the gene for that protein. The proteins synthesized according to this information may be enzymes that catalyse biochemical reactions. Each trait is the outcome of several such biochemical reactions each of this is controlled by a specific enzyme.
Each parent contributes one copy of the gene for a particular character. Thus there are two genes for every character. In the gamete, however, only one copy is present because of reduction division and these may be either maternal or paternal origin. When two germ cells combine they will restore the normal number of gene copies in the progeny ensuring the stability of the DNA of the species.

2.4 Sex determination
It is a mechanism which determines the individual to be a male or a female based on the sex chromosomes present in it. In human beings, sex is determined by genetic inheritance. Genes inherited from the parents determine whether an offspring will be a boy or a girl. Gene for all

the characters are linearly arrange on the chromosomes. The chromosomes that carry genes for sexual characters are called **autosomes or sex chromosomes** while those that carry genes for the vegetative characters are called **autosomes or non sex chromosomes.**
Women have XX chromosomes while men have XY.
All the children will inherit an X chromosome from their mother regardless of whether they are boys or girls. Thus the sex of the children will be determined by what they inherit from their father.

3. Evolution:
All the life on Earth has descended from a common ancestor. **Evolution** is the sequence of gradual changes over millions of years in which new species are produced. Charles Robert Darwin was an English naturalist who observed various species of life on the earth and put forward the idea of "evolution of species by natural selection." He said that a species inherits its characters from its ancestors.
Acquired and inherited traits:
An acquired trait is not transmitted to the off spring. In sexually reproducing organisms germ cells are produced in the reproductive organs, while the rest of the body has somatic cells. Changes in somatic cells due to environmental factors are not transmitted to the offspring. This is because a change in a somatic organ caused by a physiological response by the body does not bring about a corresponding change in reproduction organs.
A trait or character that is genetically inherited or passed down from generation to generation is known as inherited trait. Hugo de Vries explained the mechanism of heritable variations. According to him heritable variations arise when there is a change in the genes of the germplasm. He called it mutation. If a particular trait spreads in the population, it means that is favuored by natural selection.

4. Speciation:
Species can be defined as a group of individuals of the same kind that can interbreed and produce fertile progeny.

Speciation: It is an event that splits a population into two independent species which cannot reproduce among them.

- **Process of speciation-Genetic drift**: It occurs due to changes in the frequencies of particular genes by chance alone. e.g. If a hurricane strikes the mainland, and bananas with beetle eggs on them are washed away to an island. This is called a genetic drift.
- **Process of speciation - natural selection**: These are the variations caused in individuals due to natural selection which lead to the formation of a new species. e.g. If the ecological conditions are slightly different on the island as compared to the mainland, it leads to a change in the morphology and food preferences in the organisms over the course of generations.

Process of speciation - splitting of population: A population splits into different sub-populations due to geographical isolation that leads to the formation of a new species.

Natural selection: It explains that organisms that are physiologically or behaviourally better adapted for the environment are selected. Selected organisms can survive and reproduce.

Genetic drift: It is the genetic variation in small populations caused by a specific environmental factor.

Gene flow: It is the transfer of genes from one population to another due to migration. Breeding between the brown and green beetles introduces new gene combinations into the population.
Over generations, genetic drift will accumulate different changes in each sub population. Also, natural selection may also operate differently in the different geographic locations. Speciation due to inbreeding, genetic drift and natural selection will be applicable to all sexually reproducing organism.

5. Evolution and Classification:
Characteristics are the hereditary traits transmitted from parent organisms to their offspring. These are details of appearance or behavior in other words a particular form or a particular function. It shows how closely organisms are related with respect to evolution. The more characteristics two species will have in common, the more closely they are related. And the more closely they are related, the more recently they will have had a common ancestor. For example, a brother and a sister are closely related. They have common ancestors in the first generation before them, namely their parents. A girl and her first cousin are also related, but less than the girl and her brother. This is because cousins have common ancestors, their grandparents in the second generation before them, not in the first one.

5.1 Tracing Evolutionary relationships:
Characteristics are of two types namely, homologous characteristics or analogous characteristics.

- Homologous characteristics are organs that have the same basic structure and origin, but different functions. For example, mammals, birds, reptiles and amphibians have four limbs with the same basic limb layout because they have inherited the limbs from a common ancestor. These limbs have been modified to perform different functions.
- Analogous characteristics are organs that have different structures and are of different origin, but perform same functions. For example, the design of the wings of bats and the wings of birds look similar because they have a common purpose – to fly.

5.2 Fossils:
Usually, when organisms die, their bodies will decompose and be lost. But sometime some body parts may not decompose completely and they will eventually harden and retain the impression of the body parts. All such preserved traces of living organisms are called fossils. Fossils are the remains or traces of a plant or animal that existed in a past geological age, and that has been excavated from the soil. Fossilisation is the process in which an organism is converted into a fossil. Paleontology is the study of fossils.

There are two ways to determine the age of fossils. One way is to dig the earth and start finding fossils. The second way of dating fossils is by detecting the ratios of different isotopes of the same element in the fossil material.

5.3 Evolution by Stages:

Evolution is a gradual process- no organism evolved suddenly. Complex organs evolved in organisms gradually. The eyes of the octopus and the eyes of vertebrates have evolved independently. These similarities of structure, despite of different origins provide a classic example of biological convergence.

Biological convergence is a phenomenon by which two unrelated organisms become quite alike after a period of time through few generations, if it is assumed that they have a common ancestor.

A change that is useful for one property to start with can become useful for quite a different function. For example, long feathers were considered to provide insulation in cold weather. Some reptiles like the dinosaur had feathers but very few were adapted for flying. In the present day, birds use feathers for flight, which is an example of adaptation. It is a characteristic of a particular animal may, post-evolution be useful for performing a totally different function.

It is all very well to say that very dissimilar looking structures evolve from a common ancestral design. It is true that analysis of the organ structure in fossils allow us to make estimates of how far back evolutionary relationships go. The wild cabbage plant is a good example. Broccoli, kohlrabi and kale are produced from its ancestor wild cabbage by artificial selection.

Another way of tracing evolutionary relationships depends on the changes in DNA during reproduction. Comparing the DNA of different species should give us a direct estimate of how much the DNA has changed during the formation of new species. This method is now extensively used to define evolutionary relationships.

6. Evolution should not be equated with progress.

Evolution is simply generation of diversity and the shaping of the diversity by environmental selection. It is not as if the newly generated species are in any way better than the older one. It is just natural selection and genetic drift have together led to the formation of a population that cannot reproduce with the original one, as in case of the evolution of humans and chimpanzees from a common ancestor.

In evolution the new forms evolved are more complex than their ancestors. It is the adaptability of a species to the environment that supports its survival not the complexity of the species. Each species, whether complex or simple is subjected to natural selection. Each species has to go through the process of natural selection to survive and reproduce. In evolutionary terms, we cannot say that a particular species has a better design than another. Each species is well suited and adapted to its environment and hence is good enough to live and reproduce.

6.1 Human Evolution:

The tools used to trace evolutionary relationships are excavation, time-dating, studying fossils, and determining DNA sequences have been used for studying human evolution.

All the human beings in the world, whether they are African or American, share the same gene pool and hence all modern humans belong to the same species- *Homo sapiens*. There are, however, a large number of genes in the gene pool that serve as the source of individual variations. It is for this reason that no two individuals are identical in looks, abilities, behavior, etc. therefore, there is great diversity in human features such as skin colour, height, hair colour, and so on. But there is no biological basis for assuming that humans with different features belong to different races.