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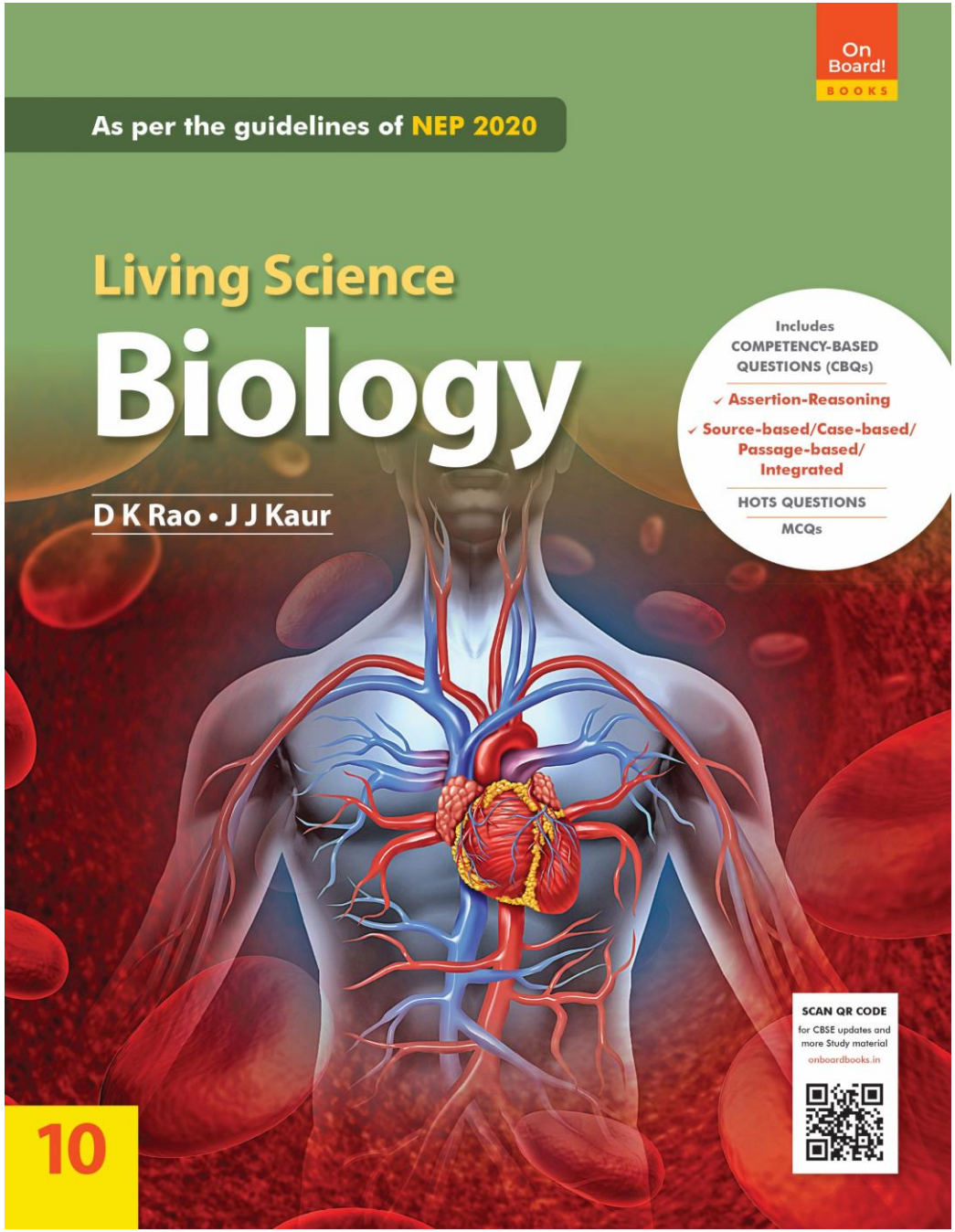
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CBSE
Living Science
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Class 10

Chapter 4 Heredity and Evolution

LEARNING OBJECTIVES

Heredity, Genetics And Variations

- Important Terms Used in Genetics

Inheritance of Traits – Mendel's Contributions

- Mendel's Experiments

Monohybrid Cross

- Interpretation of Mendel's Observations

Mendel's Laws of Inheritance

Transmission of Traits

- What are genes?

Sex Determination in Human Beings

Evolution

Acquired and Inherited Traits

Speciation

- How does new species come into existence?

Evolution and Classification

- Characteristics of evolutionary significance of classification

Tracing Evolutionary Relationships

- Morphological and anatomical evidences
- Vestigial organs
- Embryological evidences
- Fossils (Palaeontological evidences)
- Biochemical evidences

Evolution by Stages

Evolution of Man

Heredity, Genetics and Variations

Continuity or transmission of characters or traits from one generation to another is termed as heredity. In other words, the phenomenon by which living organisms transmit parental characteristics to the successive generation is called **heredity** or **inheritance**.

Some other important terms used in genetics

Inherited traits: The characteristics or traits which are transmitted from parents to their offsprings are known as inherited traits. For example, eye colour, tongue rolling and right or left handedness.

Chromosomes: Filamentous thread-like bodies present in the nucleus of a cell, composed of chromatin material (DNA-protein complex).

Variation: Different characteristics or traits among individuals of a species.

Gene: A unit of inheritance forming part of a chromosome. It is a section of DNA found on chromosomes. Genes are passed from parents to the offsprings.

Gametes: Male or female sex cells.

Alleles: Alleles are alternate forms of a gene or a pair of matching genes.

Dominant allele: The allele which decides the appearance of an organism even in the presence of an alternative allele is called a dominant allele.

Recessive allele: The allele which cannot express itself in the presence of the dominant allele is called a recessive allele. It can decide the appearance of an organism only in the presence of another identical gene.

Genotype: The genetic constitution of an organism. For example, FF, Ff or ff.

Phenotype: Outward visible expression of genes, which is an inherited feature in an individual's appearance.

Homozygous: Both alleles of a gene are identical. For example, FF.

Heterozygous: The two alleles of a gene are dissimilar, i.e. one dominant and one recessive allele for a particular characteristic. For example

Accumulation of Variation During Reproduction

The information to be inherited is present in the sex cells (or gametes) of the parents. These gametes are the link for passage of characters or traits from parents to offsprings.

Any variations that have been acquired by individuals through reproduction and passed on to succeeding generations are called **heritable variations** or **germinal variations**. However, any variation that remains limited to only one generation and does not pass onto next generation is called **somatic** or **non-heritable variation**. The branch of biology that deals with the changes and its causes in the diversity of living organisms over the period of time is called **evolution**.

Mendel's Experiments

Mendel designed his cross-breeding experiments taking various characteristics:

- The crosses where only one trait was focused were termed as monohybrid crosses and the offspring was called a hybrid.
- The crosses in which two traits were taken into consideration were designated as dihybrid crosses. The crosses in which three traits or four traits were taken into consideration were termed as **tri-hybrid and tetra-hybrid crosses**, respectively.
- Mendel removed the anthers of the flowers, selected to be the seed parents, well before the female part of the flower, gynoecium became mature. This process is called as **emasculation**.
- He crossed true-breeding tall stem variety plant (which he called tall plant) with a true-breeding short stem variety plant (dwarf plant). The offsprings were termed as hybrid. He performed the experiment by transferring pollen grains from the anther of the dwarf plant to the stigma of the tall plant. Self-pollination was prevented by removing all the stamens from the tall plant. **The plants of parental generation were designated as P.** The seeds from the tall plant were then collected and sown.

- He found that all plants which grew from these seeds were tall plants. The plants in this generation were called **F1 generation (F1 progeny) or first filial generation plants**.
- In order to completely analyze his results, Mendel allowed F1 plants to self-fertilize and used the seeds of F1 generation to raise the F2 generation. These plants were called **F2 generation (F2 progeny) or second filial generation plants**.
- He used the seeds of F2 generation to raise the F3 generation (by self-pollination of F2 plants). The analysis of traits or features in a particular generation was very carefully done by observing them and keeping their records.

Monohybrid Cross

A cross between two parents representing contrasting forms of a single trait or feature is called monohybrid cross.

Note: Refer to the book p137-139 for Monohybrid cross between tall and short plant

Interpretation of Mendel's Observations

On the basis of the analysis of the results of the monohybrid and dihybrid crosses, following conclusions can be drawn:

- In a monohybrid cross, when a cross is made between the contrasting pair of a trait, only one of the traits appears, in the F1 generation.
- The trait, which was not present in the offspring of a particular cross in F1 generation, again reappears in the F2 generation.
- In a dihybrid cross, when combination of contrasting pairs of two traits were taken together, only one variety of each trait appears in the F1 generation.
- The other variety of each trait reappears in the F2 generation on the same lines of the dihybrid cross.
- However, the presence of two new combinations of the two contrasting pairs of traits in the F2 generation also occurs.

Mendel's Laws of Inheritance

Mendel postulated three laws of inheritance on the basis of his monohybrid and dihybrid experiments.

Law I: Law of dominance

When two homozygous individuals with one or more sets of contrasting characteristics are crossed, the characteristics which appear in the F1 hybrids are dominant and those which do not appear in F1 generation are recessive.

Law II: Law of segregation

When a pair of allele is brought together in a hybrid, the members of the allelic pair remain together without mixing and separate or segregate from each other when the hybrid forms gametes. Since each gamete is pure for a characteristic, the law is also known as **law of purity of gametes**.

Law III: Law of independent assortment

It states that, when a dihybrid organism forms gametes,

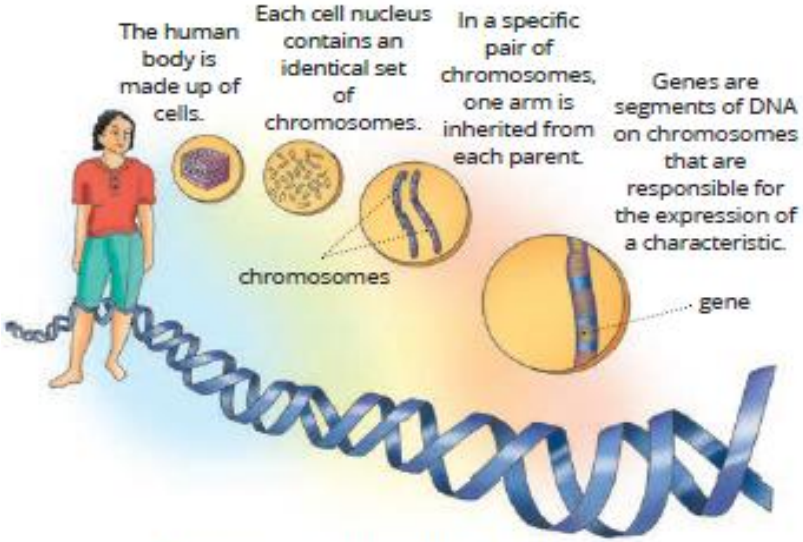
- each gamete receives one allele from each allelic pair (or each characteristic), and
- the assortment of alleles of different characteristics during gamete formation is independent of their parental combinations.

Transmission of Traits

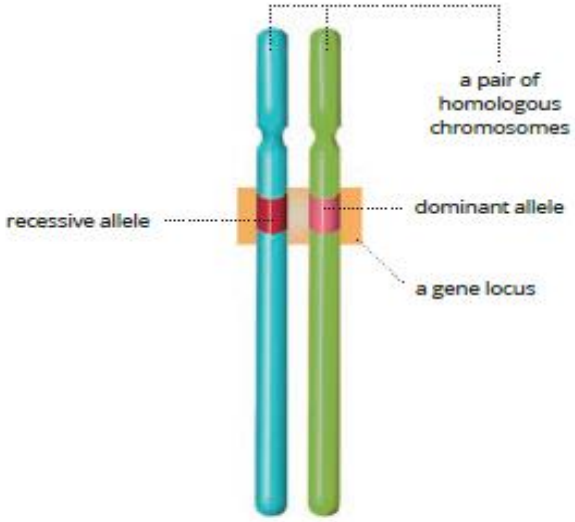
All living organisms produce their own kind. So, there must be some common thing that makes an offspring similar to its parents. In scientific terms, we call it trait or characteristic that are passed from parents to the offspring during sexual reproduction. These traits are transferred through genes located on their chromosomes.

What are genes?

Cellular DNA is the information source for making protein in the cell. A section of DNA on a chromosome which provides information for protein is called gene. **Genes are the units of heredity** . They are located in a linear fashion on chromosomes. Thus, **chromosomes are the carriers of genes.** These are located within the cell nucleus.



a. Gene is the basic unit of heredity found on chromosomes



b. Alternative forms of the gene occupying the same position on a pair homologous chromosomes.

Sex Determination in Lower Animals

In most of the sexually reproducing organisms male and female reproductive organs are present separately. Different animals have different methods of sex determination.

- In some animals like turtles, *Chrysemys picta*, the temperature during the time of fertilization of eggs determines the sex. If eggs are incubated at lower than 28 ° C, males are produced and at over 33 ° C, females are developed.
- In honeybees, males are haploid while females are diploid.
- In *Bonellia*, if larvae grows alone, it develops into a female, while if it enters the body of female it develops into a male.

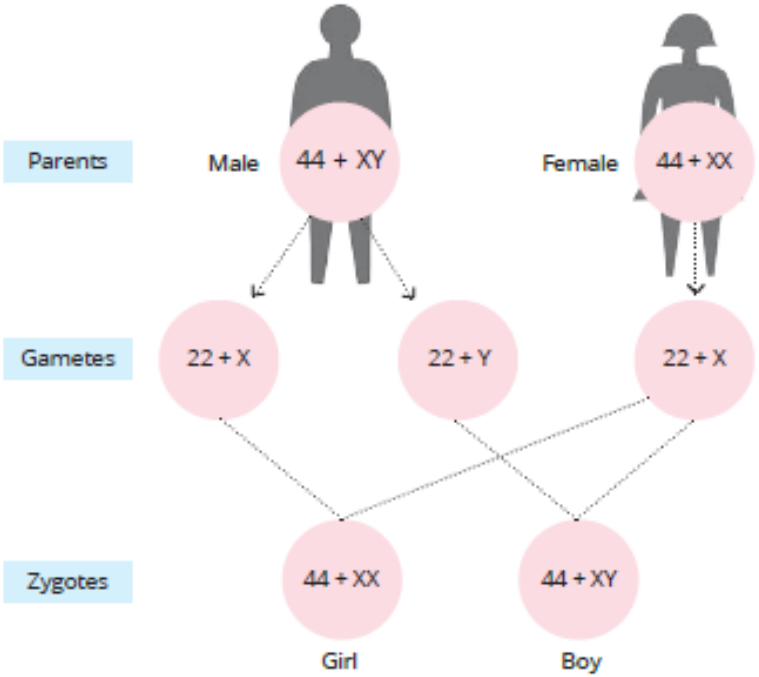
Sex Determination in Human Beings – Son or Daughter?

In human beings, there are 23 pairs of chromosomes, out of which one pair is sex chromosome. There are two types of sex chromosomes – X and Y. A female contains two X-chromosomes (i.e. homomorphic), while a male contains one each, i.e. X and Y-chromosome (i.e. heteromorphic). Rest of the 22 pairs of chromosomes are exactly similar and are called the **autosomes**.

How is it determined if the child would be male or female?

- The sex of the offspring will be determined by the type of chromosome (X or Y) inherited from father.
- At the time of fertilization, when the sperm and the egg unite to form a zygote, each individual inherits one of the two possible combinations of sex chromosomes.

- A zygote (XX) with two X-chromosomes (one from father and one from mother) develops into a girl while a zygote, (XY) with one X-chromosome (from mother) and one Y-chromosome (from father) develops into a boy.



Sex determination in human beings

Evolution

Evolution is defined as a naturally occurring slow, continuous and irreversible process of change. The following processes are responsible for evolution:

1. Variations in the gene pool of members of a population

2. Natural selection favouring accumulation of advantageous variations

3. Genetic drift or chance selection

Variation during reproduction occurs due to two reasons

- because of errors in DNA copying, and
- as a result of sexual reproduction.

Acquired and Inherited Traits

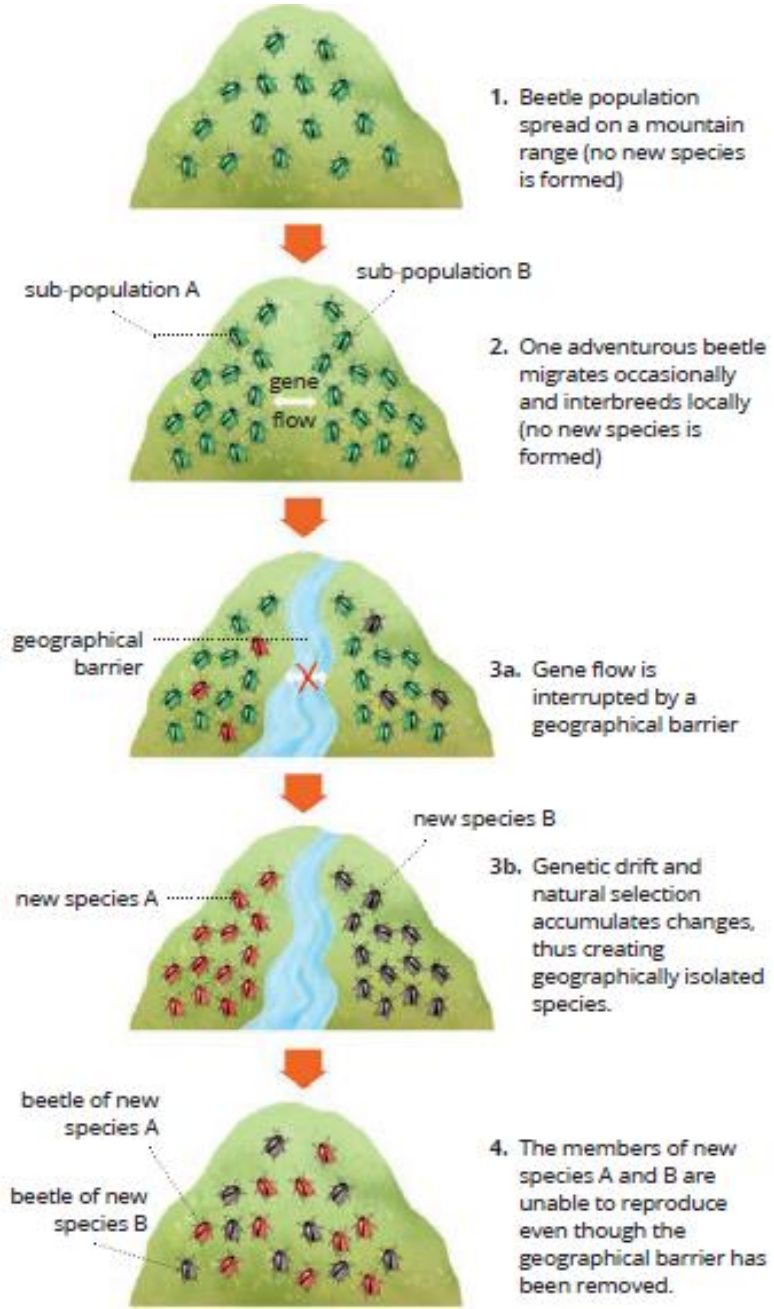
A characteristic or trait of an organism which is developed in response to the change in external environment and is not inherited is called an **acquired trait.** **Inherited traits** mean the characteristics which we receive from our parents. In other words all those traits that pass from one generation to next generation through DNA in germ cells are known as inherited traits.

Speciation

A **species** is a population of organisms consisting of similar individuals which can interbreed amongst each other and produce fertile offsprings. The process by which new species is developed from the existing species is known as **speciation**.

How does new species come into existence?

If a population splits into two populations, which cannot reproduce among each other (cannot interbreed), then new species are formed and these two non-interbreeding populations can be called two independent species.



Conclusion

The factors leading to the formation of a new species are:

- **Geographical isolation** of a population due to any physical barriers.
- **Reproductive isolation** due to which there is no gene flow between separated population groups.
- **Genetic drift** leading to accumulation of changes in genetic make-up.
- Variation caused due to **natural selection**

Evolution and Classification

1. There are some characteristics which are broader and widely found. These characteristics are dominant and they decide more fundamental differences among organisms.

2. On the other hand, there are some characteristics that are at microscopic level.

3. The broader characteristic is followed by limiting characteristic or small characteristic.
4. The characteristic in each next level would be dependent on the previous characteristic and would decide the variety in the next level.

Levels of classification

- Some basic characteristics are shared by most organisms. For example, **cell is the basic unit of life** is a characteristic common to all organisms.
- At the next level of classification will be a characteristic shared by most, but not all organisms. For example, that cell has a membrane bound nucleus (**eukaryotes**) or not (**prokaryotes**).
- Which organisms are **unicellular**, and which ones are **multicellular**, is another characteristic which marks a basic difference in body design, because of specialization of cell types and tissues.
- Among multicellular organisms, whether they can carry out photosynthesis (**autotrophs**) or not (**heterotrophs**) provides next level of classification.
- Among the multicellular organisms, which do not carry out photosynthesis, whether the skeleton is inside (**endoskeleton**) or outside the body (**exoskeleton**), provides another fundamental difference in design.

Tracing Evolutionary Relationships

The evolutionary relationship can be traced by identifying common characteristics. These characteristics will be similar in different organisms, because they are inherited from a common ancestor. There are many evidences which prove that evolution has taken place. These are:

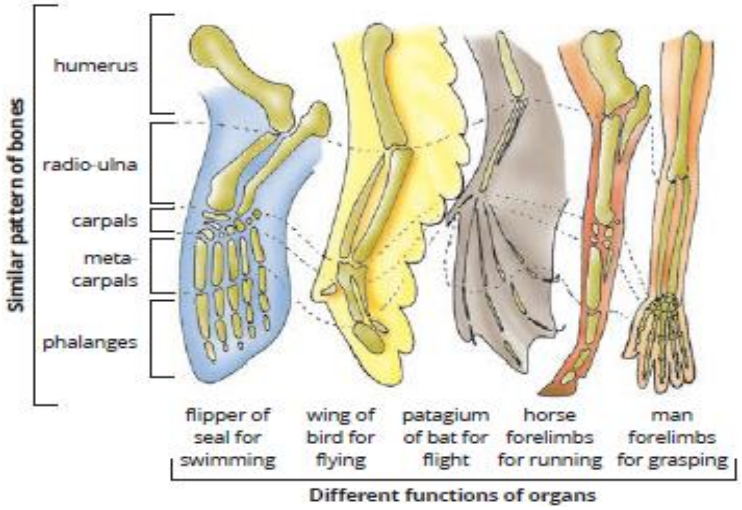
1. Morphological and anatomical evidences **2.** Vestigial organs
3. Embryological evidences **4.** Fossils (Palaeontological evidences)
5. Biochemical evidences

Morphological and anatomical evidences

A comparative morphological and anatomical study of organisms reveals similarities which point to their common ancestry.

Homologous organs

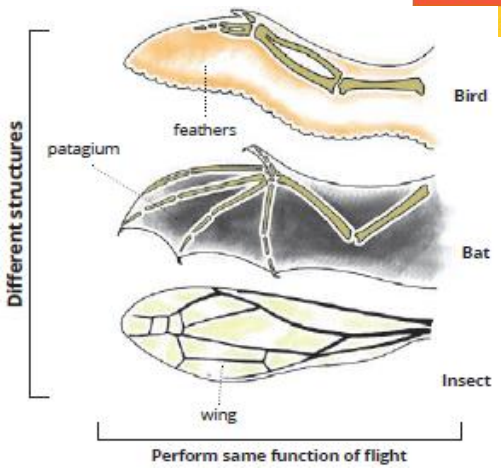
Organs similar in structure and origin but different in function are called homologous organs. Homology shows modification of some organs for special functions in the course of evolution.



Homology in the forelimbs of some organisms

Analogous organs

Organs similar in function but different in structure and origin are termed **analogous organs**, such as wings of an insect, bat and bird.



Analogy in the wings of some organisms

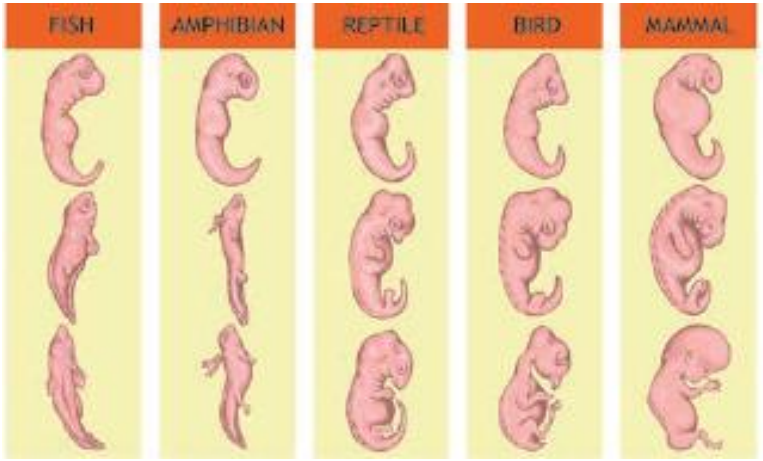
Vestigial organs

Rudimentary and non-functional organs are called **vestigial organs.** These organs are the remains of organs that were fully developed and functional in the ancestral forms in the past and have disappeared due to change in the mode of life of organisms.

Embryological evidences

Developmental stages of vertebrates show certain features that support the concept of organic evolution.

- Similarity in the early development from zygote to gastrula in all multicellular animals suggests a common ancestry.



Embryonic stages of some organisms showing common

- Temporary non-functional teeth in embryos of birds indicate that birds have evolved from toothed reptiles as their embryos recapitulate the toothed ancestral stage.
- Resemblance among vertebrate embryos indicates that all vertebrates have evolved from a common ancestor.

Fossils (Palaeontological evidences)

Fossils are the remains or impressions of dead organisms preserved in sedimentary rocks or other substances that lived in the remote past. **Palaeontology** is the study of fossils. Fossils provide direct and most reliable evidences for evolution.

A few fossils – **a.** Invertebrate (Trilobite), **b.** Invertebrate (Ammonite), **c.** Fish (*Knightia*), **d.** Dinosaur skull (*Rajasaurus*)

How to calculate the age of fossils?

There are two ways to calculate the age of fossils.

1. Relative method: In first method, if we dig into the earth and find fossils, it can be assumed that those fossils which are found close to the surface are more recent than those found in deeper layers.

2. Radioactive method: In the second method, isotopes of carbon are used for dating the fossils. This is done by detecting the ratios of different isotopes of the same element in the fossil material.

Biochemical evidences

Organisms which support common ancestry show similar biochemical reactions.

- Similar chemical nature and similar functions of enzymes and hormones of different vertebrates
- Similar composition of blood and lymph
- Similarities between blood proteins
- Biochemical recapitulation

Evolution by Stages

Evolution of eyes: When any structural change occurs in the organs, such as eyes, even an intermediate stage such as a rudimentary eye can be useful to some extent.

Evolution of feathers: An organ may adapt for one function initially but later on, it can become useful for an entirely different function.

Evolution by artificial selection: Many a times, very different looking structures evolve from a common ancestral design. Evolution of wild cabbage is a recent example. As a result, we have

1. **cabbage:** artificial selection for very short distance between leaves
2. **broccoli:** artificial selection for arrested flower development
3. **cauliflower:** artificial selection for sterile flowers
4. **kohlrabi:** artificial selection for swollen parts and
5. **kale:** artificial selection for slightly larger leaves

Evolution of Man

In order to study evolution of man, the various tools such as time dating, excavation and studying fossils as well as determining DNA sequences have been used. All humans belong to a single species, *Homo sapiens*.

Place of origin of man

The family of humans (Hominidae), evolved about 20 million years ago.
At the same time, its close relatives, the family of chimpanzees, gorillas and orangutans (Pongidae) diverged from it.

The fossils of prehuman and ancestral human forms are found in East Africa, Asia and Europe, indicating that man's centre of origin was probably in Africa. Man, *Homo sapiens*, evolved about 5,00,000– 7,50,000 years ago.

Ancestors of human beings

The *Lemur* and *Loris* are said to be the early ancestors of human beings. *Lemur* is a small monkey like animal with a long tail.

Evolutionary changes in humans

1. Erect posture (to stand and walk straight) **2.** Bipedal locomotion (to free forelimbs) **3.** Forelimbs adapted to hold objects **4.** Increase in brain size and its complexity (to think intelligently and logically) **5.** Articulation of speech for better interaction and communication.

How did they migrate?

The genetic footprints of humans can be traced back to the African roots. About two-three hundred thousand years ago, some of human ancestors migrated from Africa to West Asia, then to Central Asia, Eurasia, South Asia and East Asia. Then, these ancestors travelled down the islands of Indonesia and the Philippines to Australia. From Australia, they crossed the Bering land bridge to America. They went forward and backward, even moving in and out of Africa.

SUMMARY...

- The phenomenon by which living organisms transmit parental characteristics to their offsprings/successive generation is called heredity.
- Inheritance is the transmission of genetically controlled characteristics or traits from one generation to the next.
- The science which deals with the mechanisms responsible for similarities and differences among closely-related species is called genetics.
- The difference in characteristics or traits produced among individuals of a species is known as variation.
- Gregor Johann Mendel is considered the father of genetics. He was the first to explain the mechanism of transmission of characteristics from parents to the offspring, generation after generation.
- He conducted a series of hybridization experiments for over a period of eight years on the common garden pea plant, *Pisum sativum*.
- A cross between two parents representing contrasting forms of a single trait or feature is called monohybrid cross.
- A dihybrid cross is one in which contrasting or alternating forms of two traits or features (i.e. heterozygous for two pairs of alleles) are simultaneously considered in the hybridization experiment.

❖ Mendel postulated three laws of inheritance on the basis of his experiments: law of dominance, law of segregation, and law of independent assortment.

❖ Genes are the units of heredity. They are unit of DNA located in a linear fashion on chromosomes.

❖ In human beings, a zygote with two X-chromosomes (one from father and one from mother) develops into a girl while a zygote with one X-chromosome (from mother) and one Y-chromosome (from father) develops into a boy.

❖ Evolution is defined as a naturally occurring, slow, continuous and irreversible process of change.

❖ There are many evidences which prove that evolution has taken place.

❖ Organs similar in structure and origin but different in function are called homologous organs.

❖ Organs similar in function but different in structure and origin are termed as analogous organs.

❖ Rudimentary and non-functional organs are called vestigial organs.

❖ Fossils are the remains or impressions of dead organisms preserved in sedimentary rocks or other substance media that lived in the remote past.

THANK YOU