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Introduction

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Chapter 4: Heredity and Evolution

Chapter 4: Heredity and Evolution

Heredity and Variation

- Living organisms have certain recognisable heritable features such as height, complexion, colour of hair and eyes, shape of nose and chin etc. These are called characters.
- The alternative forms of a character are called traits. The inheritable characteristics or traits may be morphological, anatomical, physiological or reproductive.
- The transmission or passing of genetically based characters or traits from the parents to their offspring is called heredity.

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Heredity and Variation

- The occurrence of small differences or changes among the individuals of a species is called variation. Hereditary variations are of great importance in the process of evolution of a new species.
- Asexual reproduction results in a small amount of variation as compared to sexual reproduction.
- Genes are the specific parts of chromosomes or deoxyribonucleic acid (DNA) segments which determine hereditary characteristics.

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Heredity and Variation

- Every gene has two alternative forms for a character, each of which produces different effects in an organism. These alternative forms are called alleles. Example: In case of pea plants, the stem height is controlled by two alleles- one for tallness and the other for dwarfness.
- Of the two alleles of a gene, one is dominant, i.e. super ruling and the other is recessive, i.e. subordinate or submissive. A dominant allele is the allele which hides or masks the expression of its corresponding allele, which in turn becomes recessive.

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Heredity and Variation

- A contrasting pair of alleles constitutes an allelomorph.
- The genetic constitution of an organism is called its genotype. It is the description of genes present in an organism. The genotype of a tall plant could be TT or Tt, while that of a dwarf plant is tt.
- Phenotype refers to the observable characteristics or the expressed shown character of an organism. Example: Tall and dwarf are the phenotypes of a plant because these traits are visible to us.

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Heredity and Variation

- When two parents are crossed to produce progeny, their progeny is called the first filial generation or F1 generation.
- When the first generation progeny or F1 progeny is crossed amongst themselves to produce a second generation progeny, this progeny is called the second filial generation or F2 generation.
- A new form of plant resulting from a cross of different varieties of a plant is known as a hybrid.

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Types of Variations

Somatic Variation

- It takes place in the body cell.
- It is neither inherited nor transmitted.
- It is also known as acquired traits.
- Examples: cutting of tails in dogs, boring of pinna etc.

Gametic Variation

- Takes place in the gametes/Reproductive cells.
- Inherited as well as transmitted.
- Also known as inherited traits.
- Example: human height, skin colour.

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Rules for Inheritance of Traits

Mendel's work

Gregor Johann Mendel, known as 'Father of Genetics', was an Austrian Monk who worked on pea plants to understand the concept of heredity.

His work laid the foundation of modern genetics.

He made three basic laws of inheritance - The Law of Dominance, The Law of Segregation and The Law of Independent Assortment.

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Rules for Inheritance of Traits

Mendel's work

Traits	Shape of seeds	Colour of seeds	Colour of pods	Shape of pods	Plant height	Position of flowers	Flower colour
Dominant trait	Round 	Yellow 	Green 	Full 	Tall 	At leaf junction 	Purple 
Recessive trait	Wrinkled 	Green 	Yellow 	Flat, constricted 	Short 	At tips of branches 	White 

Seven pairs of contrasting traits in pea plant

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Monohybrid Inheritance:

- A cross which involves only a single pair of contrasting characters is called a monohybrid cross. Example: A cross between a tall pea plant (TT) and a dwarf pea plant (tt).
- Observations of Monohybrid Cross

(i) All F1 progeny were tall, no medium height plant. (Half way characteristic)

(ii) F2 progeny ¼ were short, ¾ were tall.

(iii) Phenotypic ratio F2 – 3 : 1 (3 tall : 1 short)

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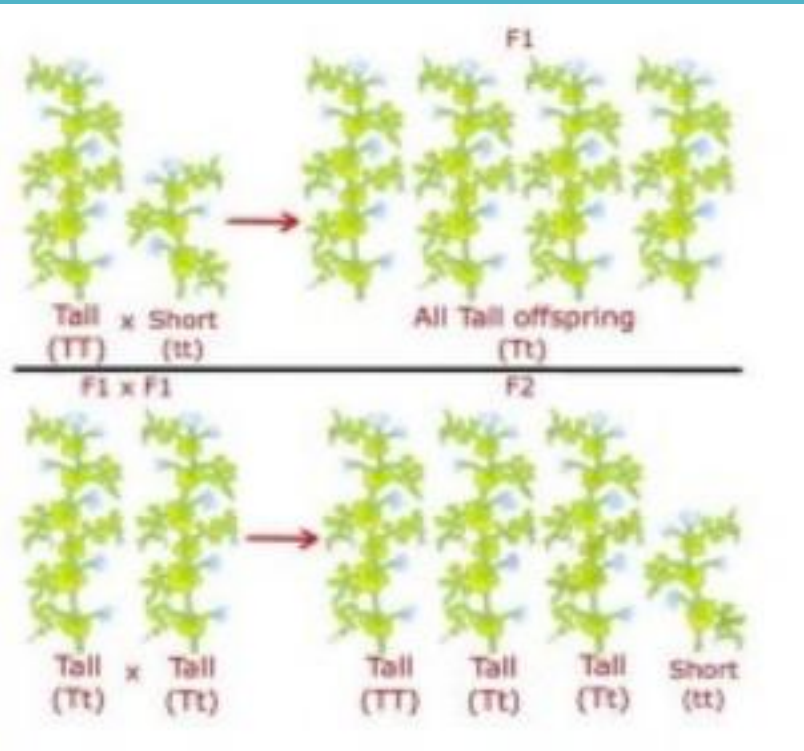

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Monohybrid Inheritance:

Phenotypic ratio: 3 : 1

Genotypic ratio: 1 : 2 : 1

- **The results of the monohybrid cross enabled Mendel to formulate his first law of inheritance, which is called the law of segregation. It states that- 'The characteristics or traits of an organism are determined by internal factors, which occur in pairs. Only one of a pair of such factors can be present in a single gamete'.**

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Dihybrid Inheritance

- A cross which involves plants with two pairs of contrasting characters is called a dihybrid cross. Example: A cross of pea plants having round and yellow seeds (RRYY) and plants with wrinkled and green seeds (rryy).
- Observations

i. When RRyy was crossed with rrYY in F1 generation all were Rr Yy round and yellow seeds.

ii. Self pollination of F1 plants gave parental phenotype and two mixtures (recombinants round yellow and wrinkled green) seeds plants in the ratio of 9 : 3 : 3 : 1.

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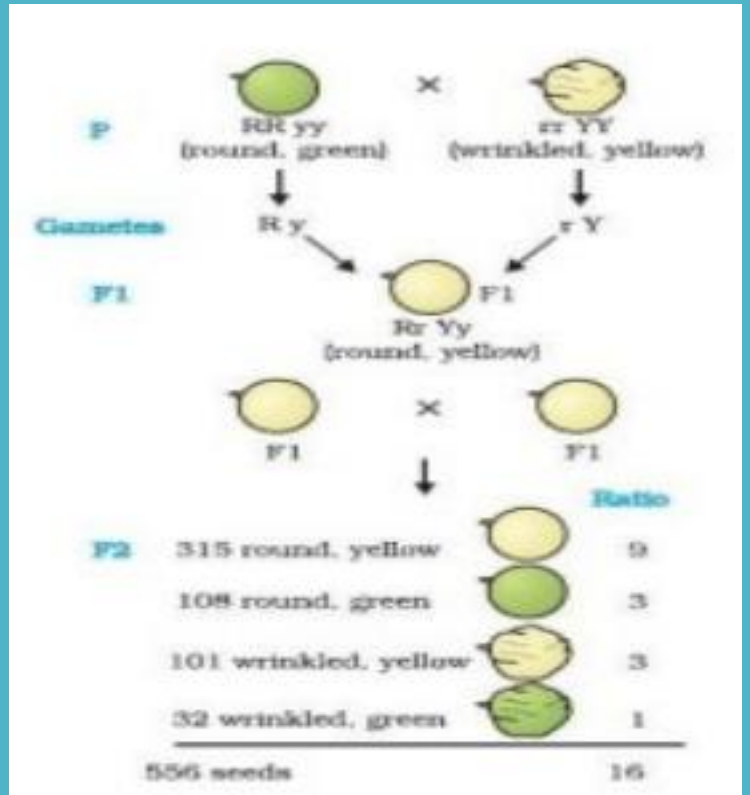
Dihybrid Inheritance

Phenotypic ratio: 9 : 3 : 3 : 1

Genotypic ratio: 1 : 4 : 1 : 1 : 1 :2 : 2 : 2 : 2



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How do These Traits Get Expressed?

- The DNA present in the cell is responsible for making the proteins. A section of this DNA that provides information for one protein is termed the gene for that specific protein.
- The proteins that are thus synthesized are essential in many of the biochemical reactions that are responsible for the expression of a trait and they are controlled by specific enzymes.
- Any alterations in them will lead to a variation in that trait, and hence genes control the traits in such a way. If the traits are to be inherited independently from both the parents, then they need to be present separately.

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How do These Traits Get Expressed?

- Therefore each gene set is present as separate independent pieces that are called as chromosomes, with each cell having two sets, one each from both the parents.
- When these two germ cells combine, they tend to restore the number of chromosomes and hence the DNA. Hence there are two genes for the expression of every trait.

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Sex Determination

- The phenomenon or process which determines whether a developing embryo will be a male or a female is known as sex determination.
- In most organisms, environmental and genetic or chromosomal mechanisms are mainly responsible for the determination of sex of an individual.
- Humans have 22 pairs of autosomes and 1 pair of sex chromosome.

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Sex Determination

- Females have similar sex chromosomes XX, whereas males have a dissimilar pair, i.e. XY. All eggs carry the X chromosome, while sperms may either carry an X or a Y chromosome.
- The sex of a child depends on whether the egg fuses with the sperm carrying an X chromosome (resulting in a female) or with the sperm carrying a Y chromosome (resulting in a male).

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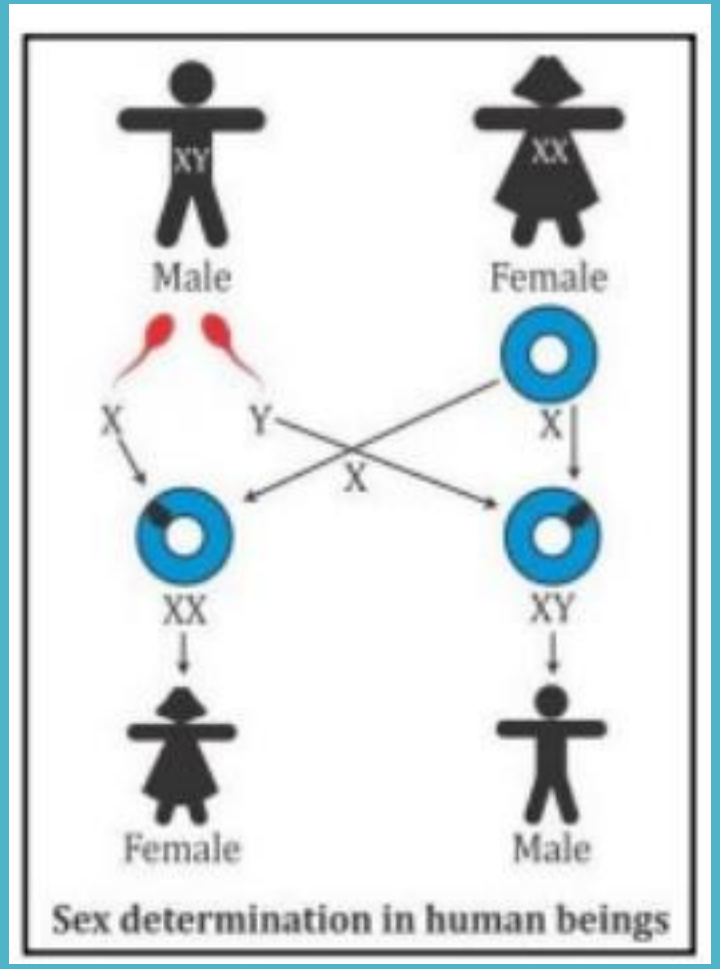
Sex Determination



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Evolution

- Evolution can be defined as the formation of more complex organisms from pre-existing simpler organisms over a certain period. It is a slow, but progressive, natural, sequential development or transformation of animals and plants from ancestors of different forms and functions.
- Variation and heredity are the two basic factors of evolution. The selection of variants by environmental factors forms the basis of evolutionary processes.

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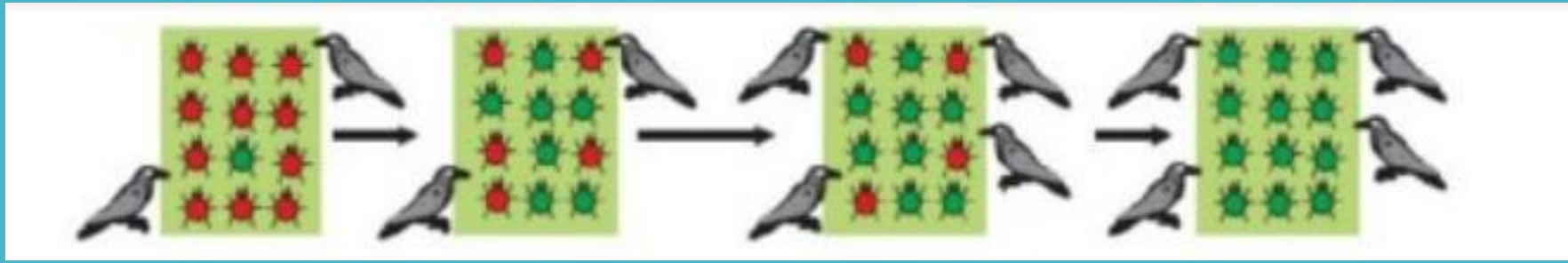
Evolution

An Illustration

Situation I (Group of red and green beetles)(Colour variation arises during reproduction)



All beetles red except one that is green → Crows feed on red beetle → No. of beetles reduces

One beetle green → Progeny beetles green → Crows could not feed on green beetles as they got camouflaged (hide) in green bushes → Number of green beetles increases

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Evolution

An Illustration

Conclusion

- Green beetles got the survival advantage or they were naturally selected as they were not visible in green bushes.
- This natural selection is exerted by crows resulting in adaptations in the beetles to fit better in their environment.

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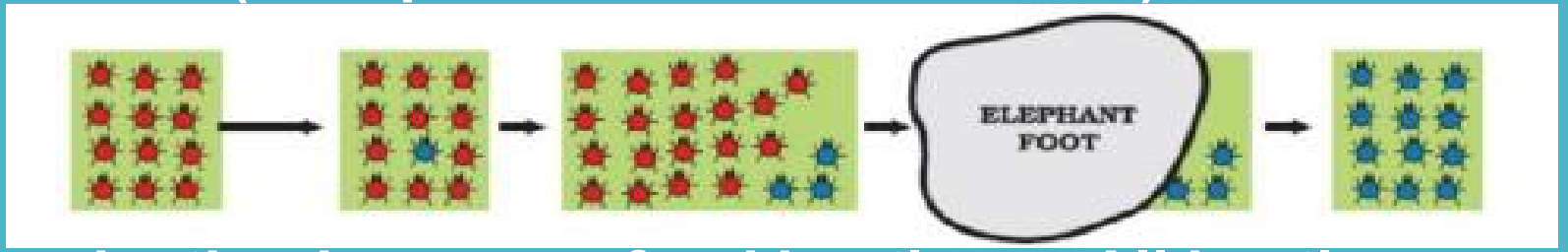
Evolution

An Illustration

Situation II (Group of red and blue beetles)



Reproduction in group of red beetles → All beetles are red except one that is blue →Number of red beetles increases as they reproduces → One blue beetle reproduces and no. of blue beetles also increases → Crows can see both blue and red beetles and can eat them → Number reduces but still red beetles are more and blue ones are few → Suddenly elephant comes and stamps on the bushes → Now beetles left are mostly blue

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Evolution

An Illustration

Conclusion

- Blue beetles did not get survivals advantage. Elephant suddenly caused major havoc in beetles population otherwise their number would have been considerably large.
- From this we can conclude that accidents can change the frequency of some genes even if they do not get survival advantage. This is called genetic drift and it leads to variation.

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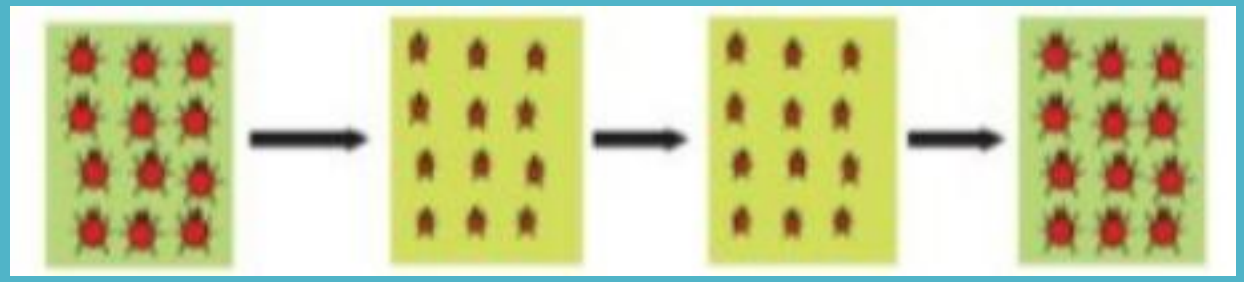
Evolution

An Illustration

Situation III (Group of red beetles and Bushes)



Group of red beetles → Habitat of beetles (bushes) suffer from plant disease → Average weight of beetles decreases due to poor nourishment → Number of beetles kept on reducing → Later plant disease gets eliminated → Number and average weight of beetles increases again

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Evolution

An Illustration

Conclusion

No genetic change has occurred in the population of beetle. The population gets affected for a short duration only due to environmental changes.

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Evidence for Evolution

Morphological Evidence	• Morphological evidence of evolution reflects in the form of external features • or the appearance of an organism.
Anatomical Evidence	• Anatomical evidence of evolution is usually reflected in the form of structures, which appear quite similar in their organisation. • The similarities found in different groups of organisms indicate that these organisms must have had a common ancestor. • Different organisms have organs which perform a similar function. These organs which have a similar function but are different in structure and origin are called analogous organs. For example- tail fin of a lobster and flukes of a whale, wings of a fly and wings of a bird, eyes of arthropods and eyes of vertebrates, are all analogous organs. • There are some organs which are fundamentally similar in structure and origin but are modified to perform different functions in different organisms. They are called homologous organs. For example- forelimbs of man are adapted for handling, while forelimbs of bats and birds are adapted for flying, while those of whales and seals are adapted for swimming.

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Evidence for Evolution

Vestigial Organs	• Organs which are found in a reduced or rudimentary condition and do not perform any function in the possessor are called vestigial organs or non- functional organs. For example- ear muscles, wisdom tooth, coccyx or reduced tail and plica semilunaris in man.
Study of Fossils	• Fossils are the preserved remains or traces of animals, plants and other organisms from the remote past. • The study of fossils is called palaeontology, which provides direct evidences in favour of organic evolution. • It helps us to compare the past with the present so as to establish the changes which have occurred in the course of evolution.
Embryological Evidence	• The study of development of an organism from the embryonic stage is called embryology. • The comparison of embryos states that in the course of development from the embryo to their adult form, animals go through stages which resemble or represent successive stages in the evolution of their remote ancestors.

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Differences between Inherited and Acquired Traits

Inherited Traits	Acquired Traits
1. Characteristics inherited from the previous generation.	1. Characteristics which develop in response to the environment and cannot be inherited.
2. Occur due to a change in genes or DNA.	2. No change in genes or DNA is involved.
3. Pass on from one generation to another.	3. Cannot pass on from one generation to another.
4. Examples: Red curly hair, brown eyes	4. Examples: Cycling, swimming

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Darwin's Theory of Evolution

- According to Darwin’s Theory of Natural Selection, organisms produce more offspring than they need for their existence. They compete among themselves and fight with the environmental factors for their various needs in life. In the struggle for existence, those with favourable variations continue to exist and those with unfavourable variations die out. Thus, a new species is formed by natural selection.
- A species is a population of organisms consisting of similar individuals which can breed together and produce fertile offspring.
- The process by which a new species develops from the existing species is known as speciation.

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Important Factors which Contribute to Speciation

Geographical isolation	•Leads to reproductive isolation due to which there is no flow of genes between separated groups of population.
Genetic drift	•Genetic drift with changes in the gene flow imposed by the isolation mechanism acts as an agent of speciation.
Natural selection	•Genetic variation within a population of organisms may cause some individuals to survive and reproduce more successfully than others.

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Evolution and Classification

- The principles of classification help us trace the evolutionary relationships of the species around us.
- In 1859, Charles Darwin first described this concept of evolution in his book The Origin of Species.

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Evolution and Classification

- Certain groups of organisms have ancient body designs and are referred to as primitive or lower organisms. Some organisms have acquired their body designs relatively recently and are called advanced or higher organisms.
- There is a strong possibility that complexity within organisms increases with an increase in evolutionary time. Hence, we can say that older organisms are relatively simpler, while younger organisms are more complex.

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Tracing Evolutionary Relationships

In the evolutionary relationships, the occurrence of common characteristics are the basis of classifying them into groups. These common characteristics can be identified as being of 2 types, namely:

Homologous characteristics: These are those characteristics that are present in different organism but look similar and they have a have a common ancestor. They may have the similar basic organ structures but with a different function in various organisms. Example - Mammals, birds, reptiles and amphibians have four limbs, but each serves a different purpose and are modified to perform that function.

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Tracing Evolutionary Relationships

Analogous characteristics: These are those characteristics that have the similar function in different organisms and they have evolved independently for different ancestors. Example: the wings of bats and of birds look similar as they serve to perform the same function of flying, but the wings of a bat are actually a fold of skin between the fingers.

Hence these different types of characteristics help in tracing the evolutionary relationships between species to a great extent.

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Fossils

To study the evolutionary relationships, the current species as well as the species that are no longer in existence also needs to be considered.

The body of an organism usually decomposes when it dies, but due to some environmental conditions like hot mud or lava, their bodies may be buried in them, harden and eventually leave an impression of the body parts. This preserved traces of the living organisms that existed in a past geological period are termed as fossils.

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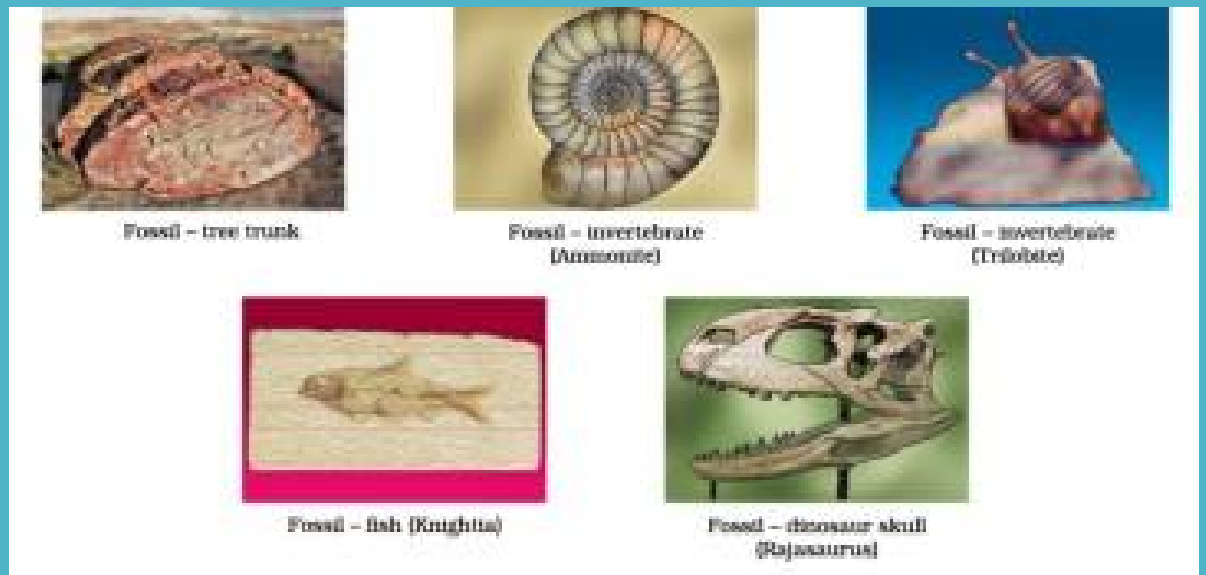
Fossils

The fossils help in determining the various evolutionary stages of the species. The process of conversion of an organism into a fossil is termed as fossilisation and its study is referred to as palaeontology.



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Fossils

There are two ways to determine the age or dating of the fossils.

- Relative dating: This method involves the digging of the earth and excavating the fossils from the rocks. The more recent ones are found closer to the earth's surface.
- Radiometric dating: In this method, the fossils can be dated based on the radioactive elements present in the rocks and detecting the ratios of different isotopes of the same element in the material of the fossil.

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Fossils

Evolution by Stages

- The great variety of organisms existing on the Earth is due to changes which have occurred gradually in stages and have resulted in the evolution of a new species.
- The occurrence of different stages of evolution in a species is not because of a single DNA change.

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Fossils

Evolution by Stages

Evolution of Eyes	• Primitive organisms which existed on the Earth were slow moving and small in size. They did not require a specialised organ for observing any object. • As evolution progressed, comparatively larger and mobile organisms evolved. Most of them were predators and required better vision for predation. • Hence, from the basic design of eyes, more complex forms evolved.
Evolution of Feathers	• Birds make use of their feathers for flying. • However, feathers did not evolve for flight. They evolved as a means of providing insulation to the body in cold weather.
Evolution by Artificial Selection	• Artificial selection is the process in which human preferences have a significant effect on the evolution of a particular species. • Humans cultivate wild cabbage as a source of food and have produced different varieties of it by artificial selection. Common vegetables such as cabbage, kale, broccoli, cauliflower and kohlrabi are descendents of wild cabbage. • Artificial selection has helped in creating diversity in plants and animals.

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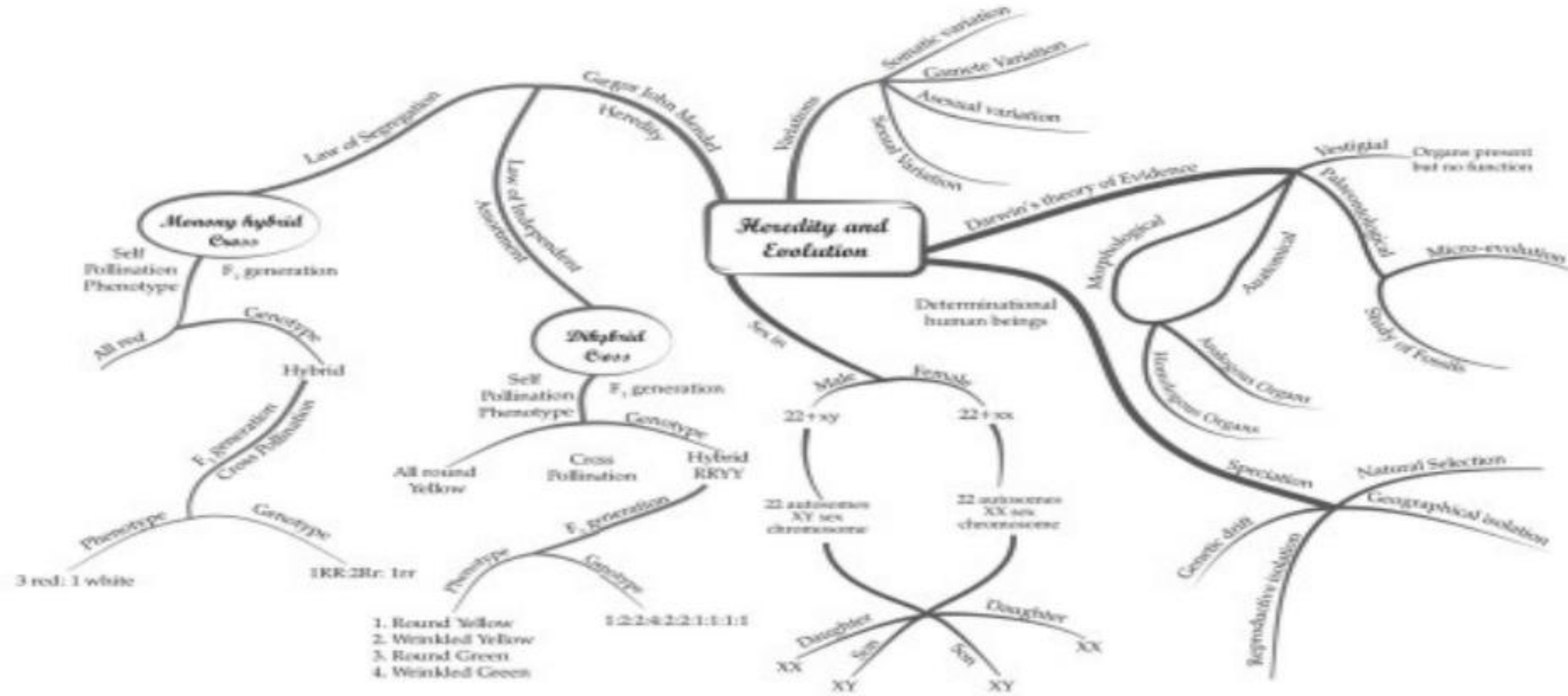
Evolution Should Not Be Equated with Progress

- Evolution has resulted in the generation of new varieties of species. It results in the production of diverse life forms subjected to environmental selection. The only progress which has occurred due to evolution is the emergence of more complex body designs of organisms.
- When we consider the evolutionary history of man, we often say that human beings evolved from chimpanzees. However, this is not the case. In fact, both chimpanzees and human beings had a common ancestor a long time ago. The two offspring of that common ancestor evolved differently to form the modern day chimpanzees and human beings.

MIND MAP : LEARNING MADE SIMPLE

Chapter-9



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