THE RADIANT EDUCATION POINT
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Heredity and evolution

Heredity- Heredity is the phenomena of inheritance of traits/features from the parents to their offspring/progeny.
Trait is any characteristic that is transferred from parent to offspring. E.g. height and colour.
Evolution- Evolution is the process of development of new type of living organism from an old one by gradual changes.
Variation- is the minor differences which exist between individuals belonging to the same species.
→ The differences in the characters/traits between the parent and offspring is called Variation.

Types of Variations

→ Variation are of two types:
(i) Somatic Variation
(ii) Gametic Variation

• **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.

Importance of variations

- It is the basis of the heredity.
- It is the basis of the evolution also.
- It increases the chances of the survival of the organism according to the changing environment.
- Depending upon the nature of variations different individuals would have different kinds of advantage.
  Example, Bacteria that can withstand heat will survive better in a heat wave.

Causes of variation

The most common causes of variations are mutation, recombination and random mating. Recombination or crossing over is one of the important reason for variation. It is a exchange of chromosome segment at the time of gamete formation.

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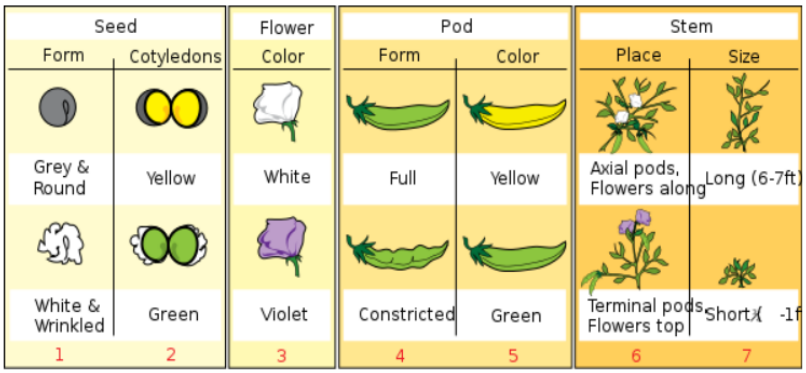
Mendel and His Work on Inheritance

→ Gregor Johann Mendel (1822 & 1884) started his experiments on plant breeding and hybridisation. He proposed the laws of inheritance in living organisms.

→ Mendel was known as Father of Genetics.

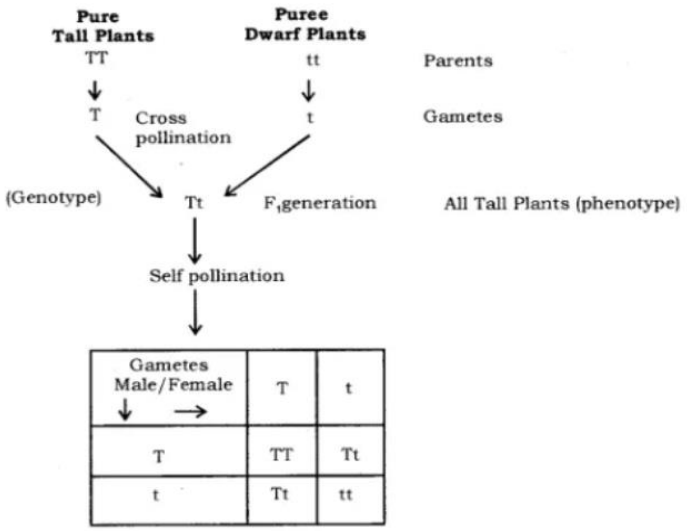
→ Plant selected by Mendel: Pisum sativum (garden pea). He used a number of contrasting characters for garden pea. Seven pairs of contrasting characters in Garden Pea

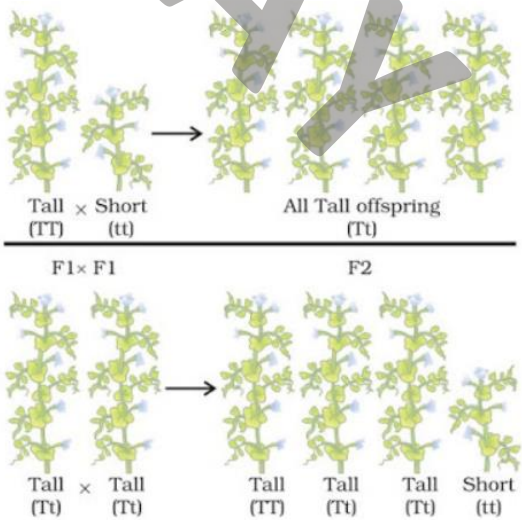
Character Trait	Dominant Trait	Recessive Trait
Flower colour	Violet	White
Flower position	Axial	Terminal
Seed colour	Yellow	Green
Seed shape	Round	Wrinkled
Pod shape	Inflated	Constricted
Pod colour	Green	Yellow
Height of plant	Tall	Dwarf/Short



Monohybrid Cross: The cross in which Mendel showed inheritance of dominant and recessive characters is monohybrid cross. To observe inheritance of single pair of contrasting characters

He took pure tall (genotype TT) and pure dwarf (genotype tt) pea plants and cross pollinated them to obtain first generation or first filial generation. In this figuration (F1 generation) he obtained only tall plants. This meant that only one of the parental traits was seen, not the mixture of the two. The plants of F generation or progeny are then self pollinated to obtain F2 generation or progeny. Now all plants were not tall. He obtained 75% tall plants and 25% dwarf plants i.e. the phenotypic ratio was 3:1. This indicates that in the F1, generation both tall and dwarf traits were inherited but tallness expressed it self. Tallness is a dominant trait and dwarfness is a recessive trait. F2 generation has a genotypic ratio of 1 : 2 : 1 of three types of plants represented by TT, Tt and tt as shown in the cross.





Pure or homozygous condition
(TT, tt) : Both are dominant traits, Both are recessive alleles
Hetrozygous condition (Hybrid)
Tt : One is dominant, one recessive trait

Phenotype means Physical appearance either they are Tall or Short.
Genotype means Genetic make up that are TT, Tt or 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)

Conclusions
→ TT and Tt both are tall plants while tt is a short plant.
→A single copy of T is enough to make the plant tall, while both copies have to be 't' for the plant to be short.
→ Characters/traits like 'T' are called dominant trait (because it express itself) and 't' are recessive trait (because it remains suppressed).
Conclusion: Phenotypic ratio—Tall : Dwarf 3 : 1
Genotype ratio—Pure Tall : Hybrid Tall : Pure Dwarf 1 : 2 : 1

Mendel's Laws of Inheritance
Law of Dominance, Law of Independent Assortment and Law of Segregation and are the three Mendel's laws of inheritance.

♦ Law of Dominance
This is also called as Mendel's first law of inheritance. According to the law of dominance, hybrid offsprings will only inherit the dominant trait in the phenotype. The alleles that are suppressed are called as the recessive traits while the alleles that determine the trait are known as the dormant traits.

♦ Law of Independent Assortment
Also known as Mendel's second law of inheritance, the law of independent assortment states that a pair of trait segregates independently from another pair during gamete formation. As the individual heredity factors assort independently, different traits get equal opportunity to occur together.

♦ Law of Segregation
The law of segregation states that during the production of gametes, two copies of each hereditary factor segregate so that offspring acquire one factor from each parent. In other words, allele (alternative form of the gene) pairs segregate during the formation of gamete and re-unite randomly during fertilization. This is also known as Mendel's third law of inheritance.

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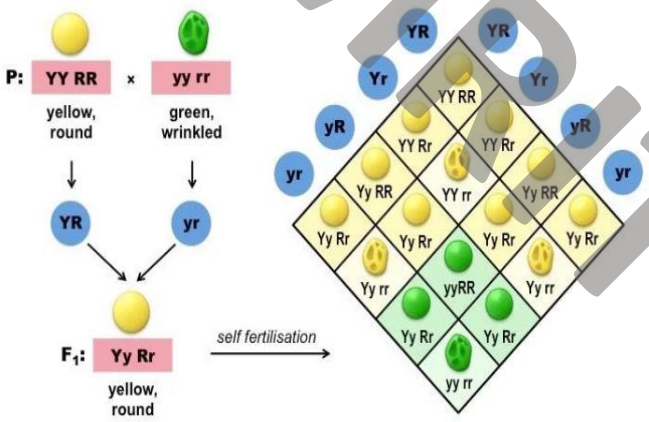
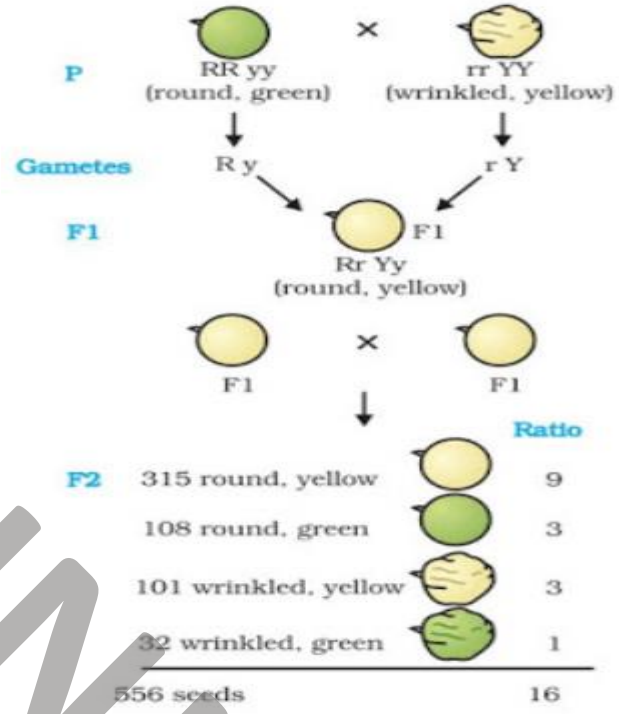
Dihybrid Cross:

Mendel also carried out experiments to observe inheritance of two pairs of contrasting characters, which is called dihybrid cross. He cross breed pea plants bearing round green seed with plants bearing wrinkled and yellow seeds. In the Fx generation he obtained all round and yellow seeds it means round and yellow traits of seeds are dominant features while wrinkled and green are recessive. He self-pollinated the plants of F: generation to obtain F2 generation, he obtained four different types of seeds round yellow, round green, wrinkled yellow and wrinkled green in the ratio of 9 : 3 : 3 : 1. He concluded that traits are independently inherited

Conclusion

- Round and yellow seeds-9.
- Round and green seeds-3.
- Wrinkled and yellow seeds-3.
- Wrinkled and green seeds-1.





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.

Conclusions

→ Round and yellow seeds are Dominant characters.

→ Occurrence of new phenotype combinations show that genes for round and yellow seeds are inherited independently of each other.

Transfer of characters

The nucleus of cell contains chromosomes that carry genetic information. Chromosomes are made from long, coiled molecules of DNA. DNA contains genes and they are units of heredity and are responsible for inheritance. Genes control the expression of characteristics. Different genes are responsible for different traits. In other words, a gene carries the genetic code for a particular characteristic. For example, height of an organism, complexion, and shape of nose are all controlled by different genes.

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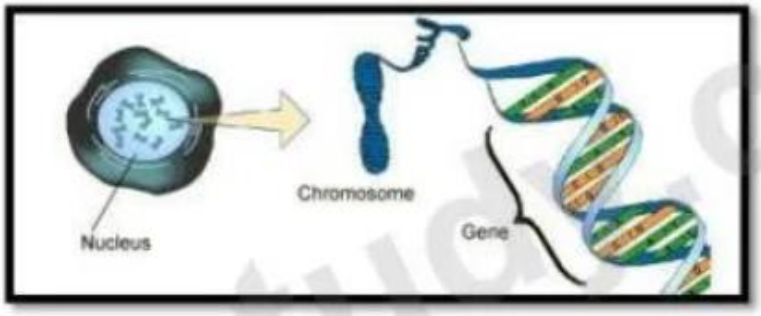

Characters are transferred through genes present in the DNA molecules in the chromosomes present in the nucleus of the cell.

The inheritance of characters is due to the fact that both the father and mother contributes equal amount of genetic material to the child. So for each trait there are two factors one from the father and one from the mother.

Most genes have two or more variations, called alleles. For example. The gene for height has two alleles — tall or short. An individual may inherit two identical or two different alleles from their parents. When two different alleles are present they interact in specific ways.

Dominant trait- The gene which decides the trait in the presence of other different gene. In other words, the trait that is expressed is called dominant and is denoted using the capital letter.

Recessive trait- The gene which decides the trait in the presence of other identical gene. In other words, the trait that is not expressed is called recessive trait and is denoted using small letter. Tall (TT) and short (Tt).

The traits due to dominant alleles are always expressed even when a recessive allele is present. Traits due to recessive alleles are only observed when two recessive alleles are present. For example, the allele for tallness is dominant and the allele for shortness is recessive.

If an individual inherits:
Two tall alleles (both dominant-TT), the person will be tall
One tall allele (dominant- T) and one short allele (recessive-t), the person will be tall
Two short alleles (recessive), the person will be short (tt).

How do traits get expressed?

Cellular DNA is the information source for making proteins in the cell.
A part of DNA that provides information for one particular protein is called a gene for that protein for example; the height of a plant depends upon the growth hormone which is in turn controlled by the gene. If the gene is efficient and more growth hormone is secreted the plant will grow tall. If the gene for that particular protein gets altered and less of it is secreted when the plant will remain short. Both the parents contribute equally to the DNA of next generation during sexual reproduction. They actually contribute a copy of the same gene for example; when tall plant is crossed with short plant the gametes will have single gene either for tallness or for shortness. F1 generation will get one gene for tallness and other for shortness also.

Some important terms

1. **Chromosomes** are long thread-like structures present in the nucleus of a cell which contain hereditary information of the cell in the form of genes.
2. **DNA** is a chemical in the chromosome which carries the traits in a coded form.
3. **Gene** is the part of a chromosome which controls a specific biological function.

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4. **Contrasting characters:** A pair of visible characters such as tall and dwarf, white and violet flowers, round and wrinkled seeds, green and yellow seeds etc.
5. **Dominant trait**: The character which expresses itself in a (Ft) generation is dominant trait. Example: Tallness is a dominant character in pea plant.
6. **Recessive trait:** The character which does not express itself but is present in a generation is recessive trait. Ex. dwarfism in the pea plant.
7. **Homozygous:** A condition in which both the genes of same type are present for ex; an organism has both the genes for tallness it is expressed as TT and genes for dwarfness are written as tt.
8. **Heterozygous:** A condition in which both the genes are of different types for example; an organism has genes Tt it means it has a gene for tallness and the other for dwarfness only tall character is expressed.
9. **Genotype:** It is genetic make-up of an individual for example; A pure tall plant is expressed as TT and hybrid tall as Tt.
10. **Phenotype**: It is external appearance of the organism for example; a plant having Tt composition will appear tall although it has gene for dwarfness.
11. **Homologous pair** of characters are those in which one member is contributed by the father and the other member by the mother and both have genes for the same character at the same position.

Sex Determination

Determination of sex of an offspring is known as Sex Determination.

Factors responsible for Sex Determination

→ Environmental and Genetic factors are responsible for sex determination.

• Environmental

→ In some animals, the temperature at which the fertilized eggs are kept decides the gender. Example: Turtle

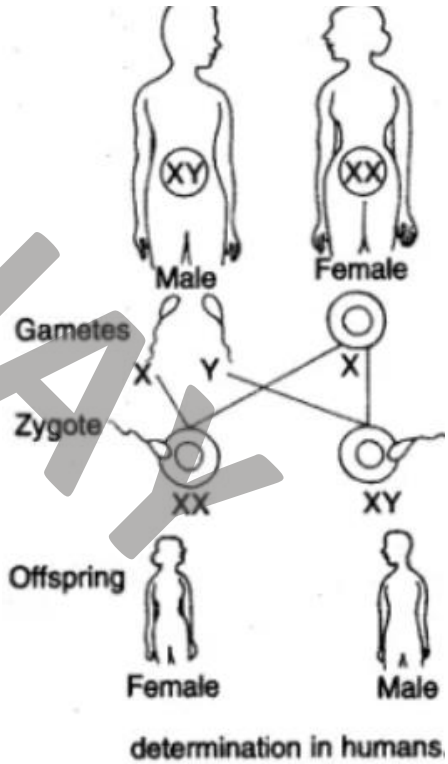
• Genetic

In some animals like humans gender or individual is determined by a pair of chromosomes called sexchromosome.

Sex Chromosomes: In human beings, there are 23 pairs of chromosomes. Out of these 22 chromosome pairs are called autosomes and the last pair of chromosomes that help in deciding the gender of that individual are called sex chromosome.

XX – female; XY – male

The cross done shows that half the children will be boys and half will be girls. All children will inherit an X chromosome from their mother regardless of whether they are boys or girls. Thus sex of children will be determined by what they inherit from their father, and not from their mother.



determination in humans.

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Determining sex of a new-born individual genetically:

- In human beings the sex of the individual is " determined genetically.
- There are 23 pairs of chromosomes of which 22 are similar in male and female and are known as autosomes.
- The remaining one is sex chromosome which is XY in males and XX in females.
- Males produce two types of sperms X and Y, while female produces one type of egg X.
- If a X type of sperm fertilizers the egg then the sex of baby will be female (XX).
- If Y type of sperm fertilizers the egg then the sex of the baby will be male (XY).

Human Blood Groups: There are four types of blood groups A, B, AB or O. These are controlled by a gene which is denoted by symbols I^A, I^B and I^O (sometimes also denoted as i). The genes I^A and I^B show no dominance over each other (they are codominant, i.e., both expresses themselves independently). But these both genes are dominant over the gene I^O. Therefore, blood group of a person depends on the type of genes present, e.g., (i) Blood group A has the following gene types :

I^AI^A (Homozygous) and I^AI^O (Heterozygous)

(*ii*) Blood group B → I^BI^B and I^BI^O

(*iii*) Blood group AB → I^AI^B

(*iv*) Blood group O → I^OI^O

Acquired Traits:

- These are the traits which are developed in an individual due to special conditions.
- They cannot be transferred to the progeny.
- They cannot direct evolution, for example, the low weight of starving beetles.

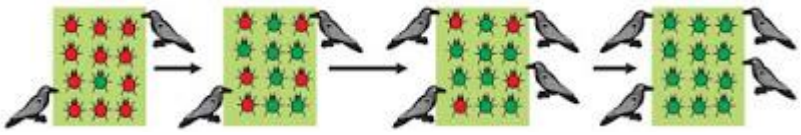
Inherited Traits:

- These are the traits which are passed from one generation to the next.
- They get transferred to the progeny.
- They are helpful in evolution, for example, the colour of eyes and hair.

Evolution

- Evolution is the sequence of gradual changes which takes place in the primitive organisms, over millions of years, in which new species are produced.

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 bettles increases

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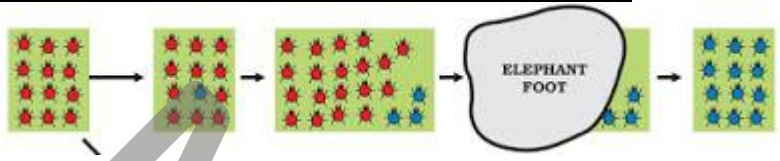
- **Conclusion**
- → Green beetles got the survival advantage or they were naturally selected as they were not visible in green bushes.
- → This natural selection is exerted by crows resulting in adaptations in the beetles to fit better in their environment.

Situation II (Group of red and blue beetles)

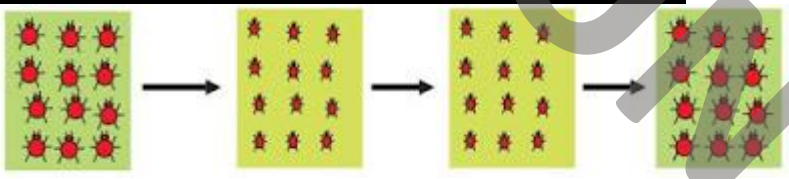


- Reproduction in group of red beetles → All beetles are red except one that is blue → Number of red beetles increases as they reproduces → One blue beetle reproduces and no. of blue beetles also increases → Crows can see both blue and red beetles and can eat them → Number reduces but still red beetles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

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.

- **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

Conclusion

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

Ways by which Speciation takes place

- Speciation takes place when variation is combined with geographical isolation.
- **(i) Gene flow**: Occurs between population that are partly but not completely separated.
- **(ii) Genetic drift**: It is the random change in the frequency of alleles (gene pair) in a population over successive generations.
- **Genetic drift takes place due to:**
- → Severe changes in the DNA
- → Change in number of chromosomes

- **(iii) Natural selection**: Natural selection is one of the basic mechanisms of evolution, along with mutation, migration and genetic drift. Natural selection means the environmental conditions prevailing around an organism against which organism adapts itself, grows – and reproduces further. This leads to a change in the composition of genes within a population further causing evolution. Thus, it can be said that,
  Natural selection results in adaptation in population to fit their environment better. Thus, natural selection direct evolution in the population of a particular species.
- **(iv) Geographical isolation**: It is caused by mountain ranges, rivers etc. Geographical isolation leads to reproductive isolation due to which there is no flow of genes between separated groups of population.

Speciation : It means the origin of new species from the existing ones. It happens when different populations of the same species evolve along different lines.

How speciation occurs ?

- It occurs when two populations are isolated (both geographically and reproductively) leading to almost no gene flow between the two populations.
- Over generations, genetic drift will accumulate different changes in each sub-population.
- Natural selection may also operate differently in these different locations.
- Together natural selection and genetic drift will cause such changes (severe changes in the DNA) that these two groups will not be able to reproduce with each other even if they happen to meet.
- When DNA changes occur to larger extent, it may lead to change in the number of chromosomes or gene expression, eventually the germ cells of the two groups cannot fuse with each other. This leads to emergence of new species.

The various ways in which individuals with a particular trait may increase in a population : Differences in population are responsible for the diversity such as, colour of eyes, hair, shape of ear lobes. This occurs due to : (i) Sexual reproduction (ii) Inaccuracies during DNA replication (iii) Due to environmental changes. This diversity will increase with time as these variations can be passed on only through DNA/genes during reproduction through reproductive tissue (germ cells or gametes).

- If these variations give survival advantage, then such traits are selected in nature and such traits increase in a population.
- Due to genetic drift. This occurs due to geographical or reproductive isolation. It results in the change in gene frequency in a particular: population.
- Migration which leads to gene flow in and out of the population.
- The mutation caused due to particular type of environment. ,
- Acquired traits due to particular type of environment.

Evidence of evolution: Errors in DNA copying (mutation) and sexual reproduction lead to variations which form the basis of evolution. Characteristics that
are common in different kinds of living organisms provide evidence in favour of evolution.

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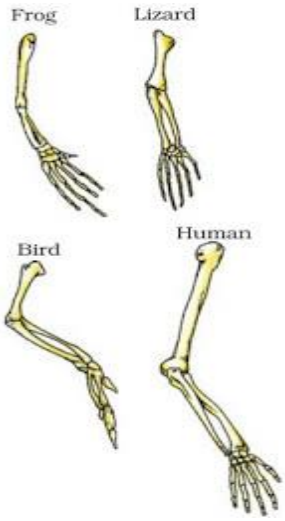
- **Evolution and Classification**
- Both evolution and classification are interlinked.
- → Classification of species is reflection of their evolutionary relationship.
- → The more characteristic two species have in common the more closely they are related.
- → The more closely they are related, the more recently they have a common ancestor.
- → Similarities among organisms allow us to group them together and to study their characteristic.

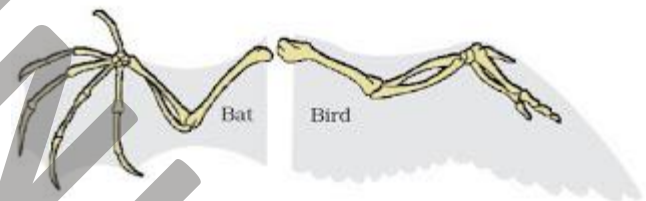
Evidences of Evolution

(i) Homologous Organs (Morphological and anatomical evidences).
→ These are the organs that have same basic structural plan and origin but different functions.
→ Homologous organs provides evidence for evolution by telling us that they are derived from the same ancestor.



- ***Example:***
- Forelimb of horse (Running)
- Winds of bat (Flying)
- Paw of a cat (Walk/scratch/attack)
- Same basic structural plan, but different functions perform.

(ii) Analogous Organs: These are the organs that have different origin and structural plan but same function.
→ Analogous organs provide mechanism for evolution.



Example:
Wings of bat → Elongated fingers with skin folds
Wings of bird → Feathery covering along the arm
→ Different basic structure, but perform similar function i.e., flight

Fossils of the information which they provide regarding evolution: Fossils are the remains of ancient life forms, which got preserved somehow in the layers of earth, snow or oil.
Information given by fossils:

- They reveal that the life forms which existed earlier do not exist today which indicate that the living forms are ever changing (evolving).
- They are used to guess the time when a particular organism existed on earth. It is done through carbon dating.

- ***Study of Fossils***: Fossils are preserved remains of living organisms that lived in the past. When living organisms die their bodies decompose but some parts of their body may be in such an environment that they do not decompose for example; if a dead insect gets caught in hot mud it will not decompose quickly but the mud will harden and retain impressions of the body parts of the insects. These impressions are also called fossils
  → Fossil Archaeopteryx possess features of reptiles as well as birds. This suggests that birds have evolved from reptiles.

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Estimating Age of Fossil: There are 2 methods :

- **Relative method :** On digging, the fossils which are closer to the surface are more recent than the fossils found in deeper layers.
- **Dating fossils (carbon dating method):** It is done by detecting the ratios of different isotopes of the same element (i.e., isotope of C-14 which is radioactive) in the fossil material.

Evolution by Stages

Evolution takes place in stages i.e. bit by bit generations.

(i) Fitness Advantage

***Evolution of Eyes*:** Evolution of complex organs is not sudden. It occurs due to minor changes in DNA, however takes place bit by bit over generations.

Flat worm has rudimentary eyes. (Enough to give fitness advantage)

•Insects have compound eyes.

• Humans have binocular eyes.

(ii) Functional Advantage

- ***Evolution of Feathers*:** Feathers provide insulation in cold weather but later they might become useful for flight.

  Example:

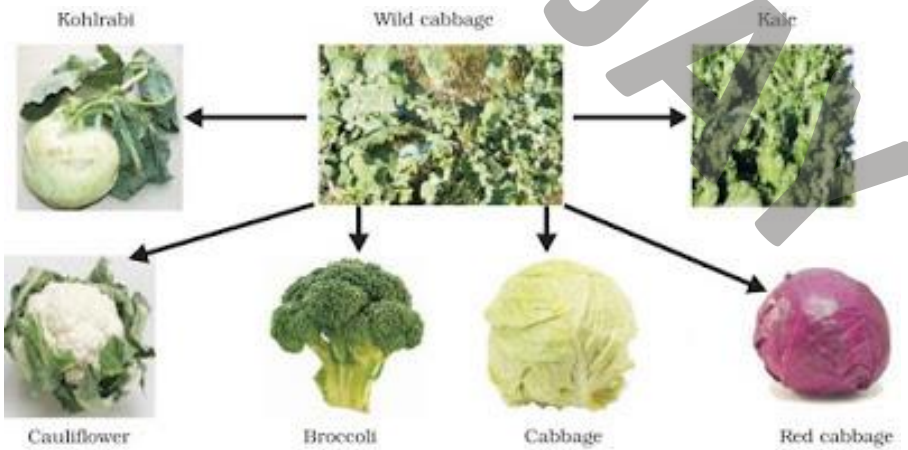
  (i) Dinosaurs had feathers, but could not fly using feathers.

  (ii) Birds seem to have later adapted the feathers to flight.

Evolution by Artificial Selection

Humans have been a powerful agent in modifying wild species to suit their own requirement throughout ages by using artificial selection.

Example:



(i) From wild cabbage many varieties like broccoli, cauliflower, red cabbage, kale, cabbage and kohlrabi were obtained by artificial selection.

(ii) Wheat (many varieties obtained due to artificial selection).

Molecular Phylogeny

→ It is based on the idea that changes in DNA during reproduction are the basic events in evolution.

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→ Organisms which are most distantly related will accumulate greater differences in their DNA.

Human Evolution

Excavating, Time dating, Fossils and Determination of DNA sequences are the tools to study Human evolutionary relationship.

→ Although there is great diversity of human forms all over the world, yet all humans are a single species.

→ All humans come from Africa. The earliest members of the human species, Homo sapiens, can be traced there. Our genetic footprints can be traced back to our African roots.

→ The residents spread across Africa, the migrants slowly spread across the planet from Africa to West Asia, then to Central Asia, Eurasia, South Asia, East Asia. They travelled down the islands of Indonesia and the Philippines to Australia, and they crossed the Bering land bridge to the Americas.

→ They did not go in a single line.

→ Sometimes came back to mix with each other.