Chapter - 9

Heredity and Evolution

Genetics

Deals with | the study of

Heredity

The transmission of characters/traits from one generation to the next generation.

Variation

The differences in the characters/traits between the parent and offspring.

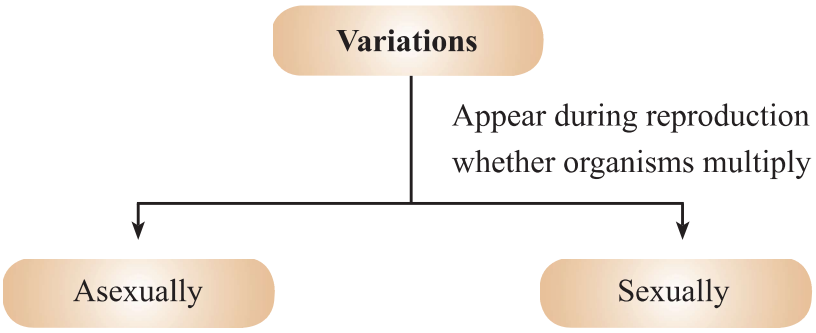
Somatic variation

- Takes place in the body cells.
- Neither inherited nor transmitted.
- Also known as acquired traits.
- Example, boring of pinna, cutting of tails in dogs.

Gametic variation

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

Accumulation of Variation during Reproduction



- Variations are fewer.
- Occurs due to small inaccuracies in DNA copying. **(Mutation)**

- Variations are large.
- Occurs due to crossing over, separation of chromosomes, mutation.

Importance of Variation :

(i) 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.

(ii) Main advantage of variation to species is that it increases the chances of its survival in a changing environment.

Free ear lobes and **attached ear lobes** are two variants found in human populations.

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). Mendel used a number of contrasting characters for garden pea.

(TABLE OF CONTRASTING CHARACTERS. SEVEN PAIRS)

CHARACTER	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

Seven pairs of contrasting characters in Garden Pea.

Medel's Experimental Material : He chose Garden Pea *(Pisum sativum)* as his experiment material because of :

(i) Availability of detectable contrasting traits of several characters.

(ii) Short life span of the plant.

(iii) Normally allows self-fertilisation but cross-fertilisation can also be carried out.

(iv) Large no. of seeds produced.

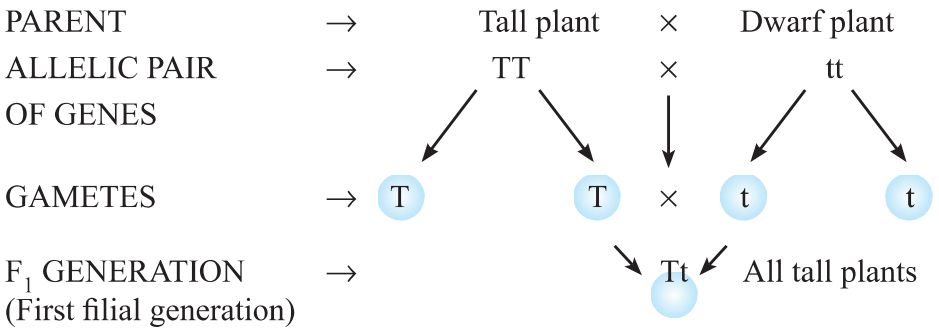
- **Mendel's Experiments :** Mendel conducted a series of experiments in which he crossed the pollinated plants to study one character (at a time).

Monohybrid Cross

Cross between two pea plants with one pair of contrasting characters is called a monohybrid cross.

Example : Cross between a tall and a dwarf plant (short).

MONOHYBRID CROSS



SELF POLLINATION → Tt × Tt

of F_1 gametes

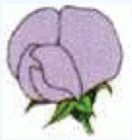
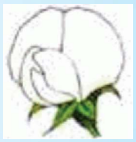
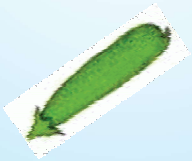
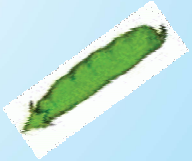
GAMETES → T, t × T, t

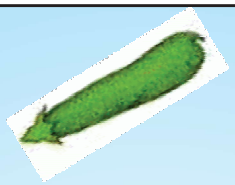
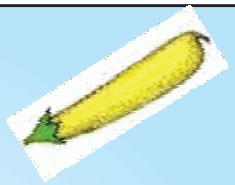
F_2 GENERATION →

Gametes →	T	t
T	TT tall	Tt tall
t	Tt tall	tt dwarf

Phenotypic ratio → 3 : 1 — Tall : Dwarf 3 : 1

Genotypic ratio → 1 : 2 : 1 — TT : Tt : tt 1 : 2 : 1

CHARACTER	DOMINANT TRAIT	RECESSIVE TRAIT
Seed shape	 Round	 Wrinkled
Seed colour	 Yellow	 Green
Flower colour	 Violet	 White
Pod shape	 Inflated/full	 Constricted

Pod Colour	 Green	 Yellow
Flower position	 Axial	 Terminal
Stem height	 Tall	 Dwarf

TT, tt] Both dominant traits / Both recessive alleles] — Pure or homozygous condition

Tt] One dominant, one recessive trait] — Hetrozygous condition – Hybrid

Phenotypic ratio → 3 : 1

Genotypic ratio → 1 : 2 : 1

Phenotype → Physical appearance [Tall or Short]

Genotype → Genetic make up [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)

Genotypic ratio F2 – 1 : 2 : 1 $\begin{pmatrix} TT & : & Tt & : & tt \\ 1 & : & 2 & : & 1 \end{pmatrix}$

Conclusions

1. TT and Tt both are tall plants while tt is a short plant.
2. 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.
3. Characters/traits like 'T' are called dominant trait (because it express itself) and 't' are recessive trait (because it remains suppressed).

Dihybrid Cross

A cross between two plants having two pairs of contrasting characters is called dihybrid cross.

PARENT GENERATION → Round green seeds × Wrinkled yellow seeds

RRyy ↓ × rrYY ↓

GAMETES → Ry × rY

F_1 → RrYy [Round, yellow]

F_1 × F_1

Selfing F_1 gametes → Rr Yy (RY, Ry, rY, ry) × Rr Yy (RY, Ry, rY, ry)

F_2 gametes →

	RY	Ry	rY	ry
RY	RRYY	RRYy	RryY	RrYy
Ry	RRYy	RRyy	RrYy	Rryy
rY	RrYY	RrYy	rrYY	rrYy
ry	RrYy	Rryy	rrYy	rryy

Phenotypic Ratio

Round, yellow : 9

Round, green : 3

Wrinkled, yellow : 3

Wrinkled, green : 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.

9	:	3	:	3	:	1
(Round yellow)		(Round green)		(Wrinkled yellow)		(wrinkled green)

Conclusions

1. Round and yellow seeds are Dominant characters.

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

How do these traits get expressed

Cellular DNA (Information source)

↓ For synthesis of

Proteins (Enzyme)

↓ Works efficiently

More Hormone

↓ produced

Tallness of plant

Therefore, genes control characteristics/traits.

SEX DETERMINATION

Determination of sex of an offspring.

FACTORS

Responsible for Sex Determination

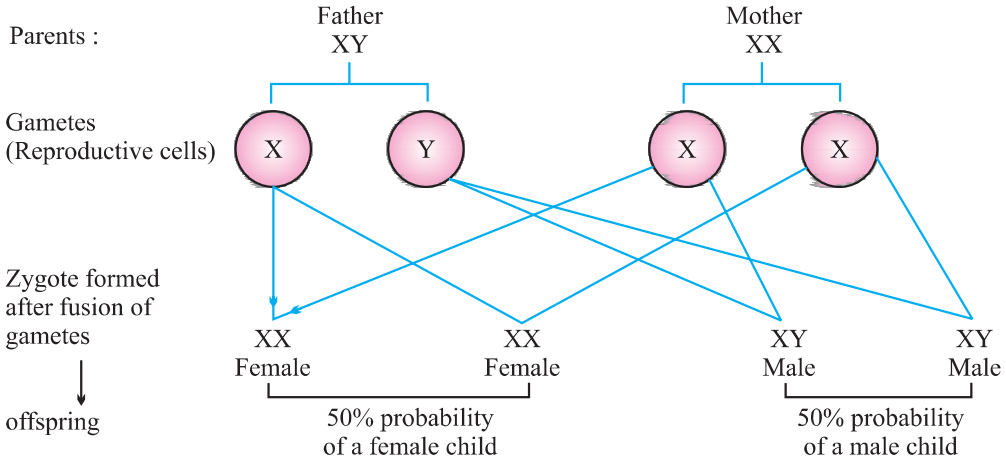
Environmental	**Genetic**
In some animals, the temperature at which the fertilized eggs are kept decides the gender. E.g., in turtle	In some animals like humans gender or individual is determined by a pair of chromosomes called sex chromosome. XX – Female XY – Male

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

XX – Female

XY – Male

Sex determination in Human Beings



This shows that half the children will be boys and half will be girls. All children will inherit an X chromosome from their mother regardless 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.

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 beetles

↓

Colour variation arises during reproduction

All beetles red except one that is green	One beetle green
↓	↓ Reproduction
Crows feed on red beetle	Progeny beetles green
↓	↓
No. of red beetles reduces	Crows could not feed on green beetles as they got camouflaged in green bushes
	↓
	Number of green beetles increases

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 beetles

↓ Reproduction

All beetles are red except one that is blue — One blue beetle

↓ Reproduces — ↓ Reproduces

Number of red beetles increases — No. of blue beetles 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

↓

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.

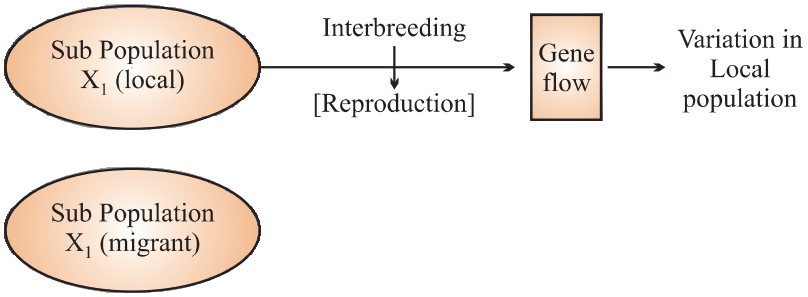
ACQUIRED AND INHERITED TRAITS

Acquired Traits	Inherited Traits
1. These are the traits which are developed in an individual due to special conditions.	1. These are the traits which are passed from one generation to the next.
2. They cannot be transferred to the progeny.	2. They get transferred to the progeny.
3. They cannot direct evolution. *E.g.,* Low weight of starving beetles.	3. They are helpful in evolution. *E.g.,* Colour of eyes and hair.

WAYS BY WHICH SPECIATION TAKES PLACE

Speciation takes place when variation is combined with geographical isolation.

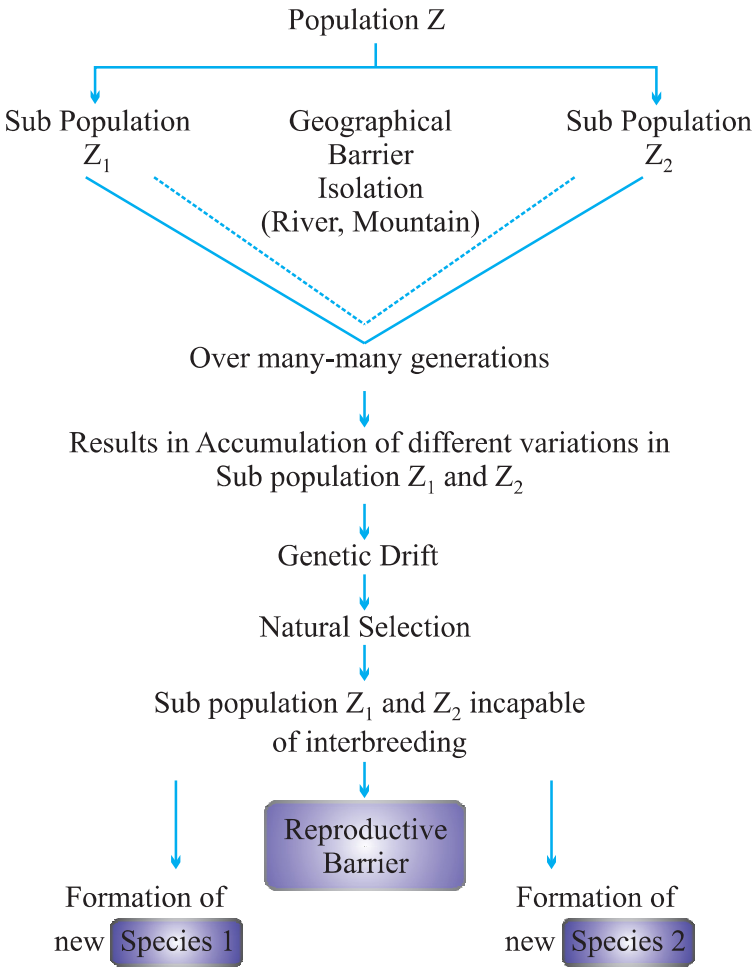
1. Gene flow : Occurs between population that are partly but not completely separated.



2. Genetic drift : It is the random change in the frequency of alleles (gene pair) in a population over successive generations.

3. Natural selection : The process by which nature selects and consolidate those organisms which are more suitable adapted and possesses favourable variations.

4. 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.



Genetic drift takes place due to :

(a) Severe changes in the DNA

(b) Change in number of chromosomes

Evolution and Classification

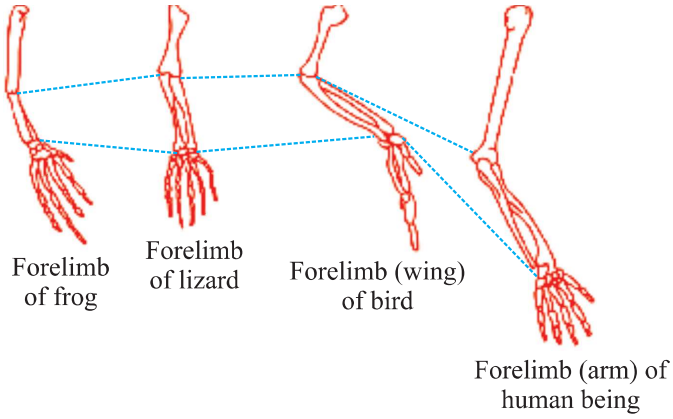
Both evolution and classification are interlinked.

1. Classification of species is reflection of their evolutionary relationship.

2. The more characteristic two species have in common the more closely they are related.

3. The more closely they are related, the more recently they have a common ancestor.

4. Similarities among organisms allow us to group them together and to study their characteristic.



Homologous organs of some vertebrates

(a) Wing of bird (b) Wing of insect

Analogous organ of flying birds

TRACING EVOLUTIONARY RELATIONSHIPS

(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)	Same basic structural plan, but different functions perform.
Wings of bat	(Flying)	
Paw of a cat	(Walk/scratch/attack)	

II. Analogous Organs : These are the organs that have different origin and structural plan but same function.

Example : Analogous organs provide mechanism for evolution.

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

III. Fossils : (Paleontological evidences)

The remains and relics of dead organisms of the past.

FOSSILS ARE PRESERVED TRACES OF LIVING ORGANISMS

Fossil Archaeopteryx possess features of reptiles as well as birds. This suggests that birds have evolved from reptiles.

Examples of Fossils

AMMONITE	-	Fossil-invertebrate
TRILOBITE	-	Fossil-invertebrate
KNIGHTIA	-	Fossil-fish
RAJASAURUS	-	Fossil-dinosaur skull

AGE OF THE FOSSILS

I. Deeper the fossil, older it is.

II. Detecting the ratios of difference of the same element in the fossil material *i.e.,* **Radio-carbon dating** [C-(14) dating]

Recent ⟶

1. (Top layer of the earth surface)
2. .....
3. .....
4. .....
5. .....

• ⟵ Older

6. .....

Evolution by Stages

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

I. Fitness Advantage

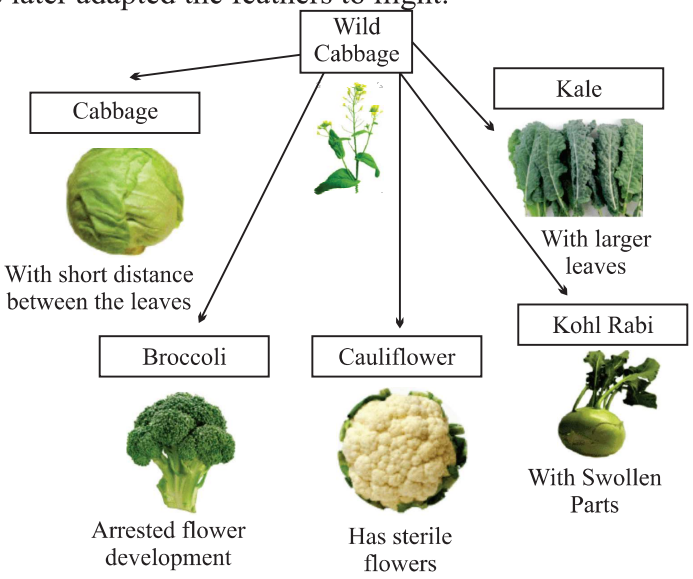
Evolution of Eyes : Evolution of complex organs is not sudden. It occurs due to minor changes in DNA, however takes place bit by bit over generations.

- 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, Dinosaurs had feathers, but could not fly using feathers. Birds seem to have later adapted the feathers to flight.



Evolution by artificial selection

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. *E.g.,*

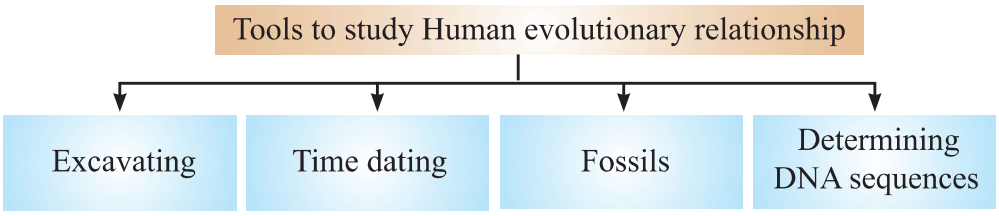
(i) From wild cabbage many varieties like broccoli, cauliflower, red cab bage, kale, cabbage and kohlrabi were obtained by artificial selection.

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

Molecular Phylogeny

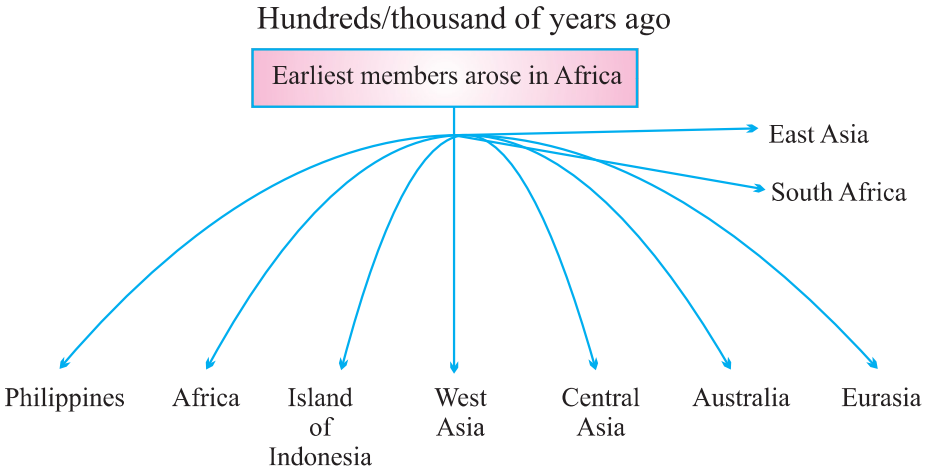
- It is based on the idea that changes in DNA during reproduction are the basic events in evolution.
- Organisms which are most distantly related will accumulate greater differences in their DNA.

HUMAN EVOLUTION



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

GENETIC FOOTPRINTS OF HUMANS



- They did not go in a single line.
- They went forward and backward.
- Moved in and out of Africa.
- Sometimes came back to mix with each other.

Genetic Terminology

1. Gene : Mendel used the term factor for a gene. A gene is the unit of DNA responsible for the inheritance of character.

2. Allele : A pair of genes that control the two alternatives of the same character *e.g.,* TT/tt.

3. Heterozygous : The organism in which both the genes of a character are unlike *e.g.,* Tt.

4. Homozygous : The organism in which both the genes of a character are similar *e.g.,* TT, tt.

5. Dominant : The gene which expresses itself in F_1 generation is known as dominant gene.

6. Recessive : The gene which is unable to express itself in presence of the dominant gene.

7. Genotype : It is the genetic constitution of an organism which determines the characters.

8. Phenotype : It is the appearance of an individual.

9. Micro-evolution : It is the evolution which is on a small scale.

10. Species : A group of similar individuals within a population that can interbreed and produce fertile offspring.

11. Chromosome : Thread like structures present in the nucleus of a cell, containing hereditary information of the cell.

12. DNA : Deoxyribose Nucleic Acid.

It is present in chromosomes which carries traits in a coded form, from one generation to the next.

QUESTIONS

VERY SHORT ANSWER TYPE QUESTIONS (1 Mark)

1. Write the scientific name of men and garden pea.
2. Where are genes located ?
3. No two individuals are absolutely alike in a population. Why ?
4. What are the chromosomes XY and XX known as ?
5. Name five varieties of vegetables which have been produced from 'wild cabbage' by the process of artificial selection.

SHORT ANSWER TYPE QUESTIONS (2 Marks)

1. Differentiate between homologous and analogous organs, with examples.
2. What are fossils ? How can the age of fossils be determined ?

SHORT ANSWER TYPE QUESTIONS (3 Marks)

1. Variation is beneficial to the species but not necessarily for the individual. Give three reasons to justify it.
2. The human hand, cat paw and horse foot, when studied in detail show the same structure of bones and point towards a common origin.
   (a) What do you conclude from this ?
   (b) What is the term given to such structures ?

LONG ANSWER TYPE QUESTIONS (5 Marks)

1. Which one is the edible part in kale, kohlrabi, broccoli, cabbage and cauliflower ?
2. Name a recessive trait which is quiet common in human beings.

Hints to Long Answer Type Questions

1. Kale - Large leaves
   Kohl rabi - Swollen part
   Broccoli - Arrested flower
   Cauliflower - Sterile flower
   Cabbage - Leaves with short distance between them
2. (a) Human height
   (b) Skin colour
   (c) Attachment of ear lobes
   (d) Eye colour