CHAPTER – 9
Heredity and Evolution

Genetics : Branch of science that deals with Heredity and variation.

Heredity : It means the transmission of features/ characters/ traits from one generation to the next generation.

Variation : The differences among the individuals of a species/ population are called variations.

MENDEL AND HIS WORK ON INHERITANCE

Gregor Johann Mendel (1822&1884) : Started his experiments on plant breeding and hybridisation

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 PARTS)		
CHARACTER	**DOMINANT TRAIT**	**RECESSIVE TRAIT**
Flower colour	Purple	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

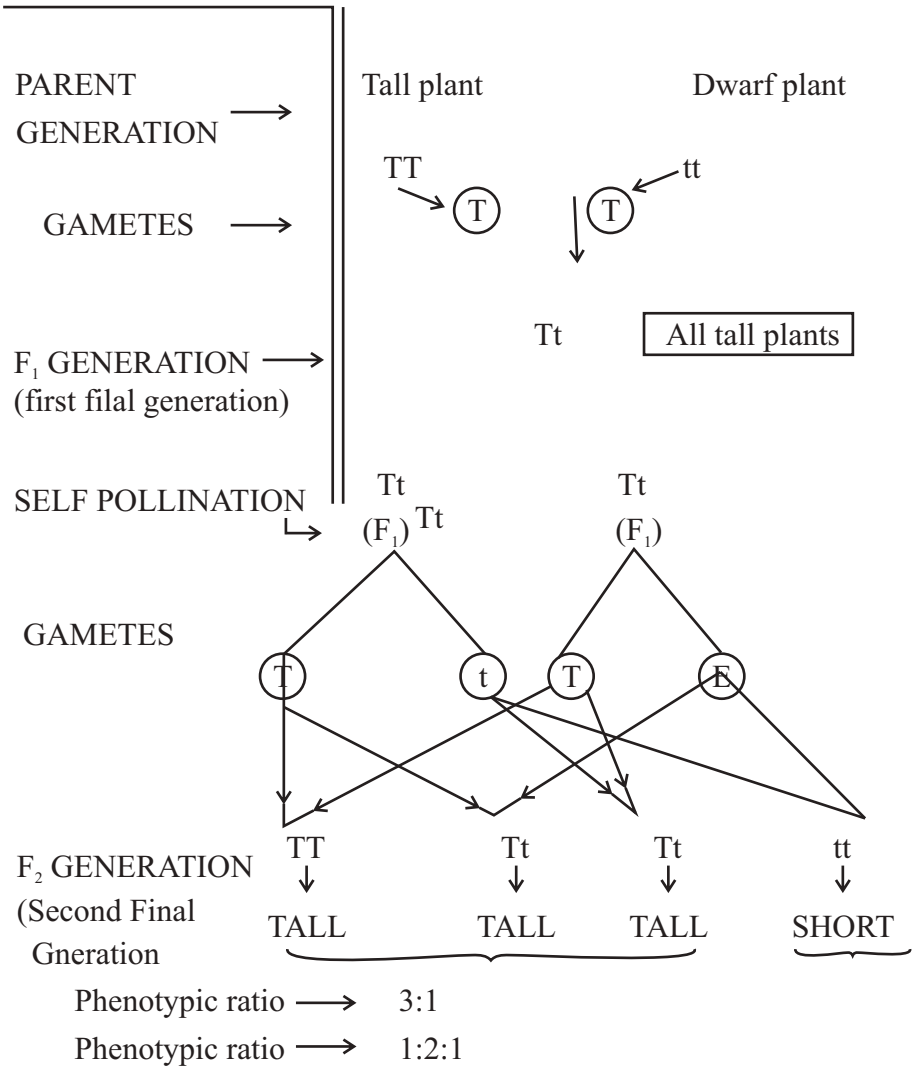
Seven pairs of contrasting characters in $\frac{\text{Garden}}{\text{Pea}}$

Mendels 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 (monohybrid cross) contrasting characters

Example : Tall / Short Plants.


PARENT GENERATION
Tall plant
Dwarf plant
GAMETES
TT
T
tt
T
Tt
All tall plants
F1 GENERATION
(first filal generation)
SELF POLLINATION
Tt
(F1)
Tt
Tt
(F1)
GAMETES
T
t
T
t
F2 GENERATION
(Second Final
Gneration
TT
Tt
Tt
tt
TALL
TALL
TALL
SHORT
Phenotypic ratio
3:1
Phenotypic ratio
1:2:1

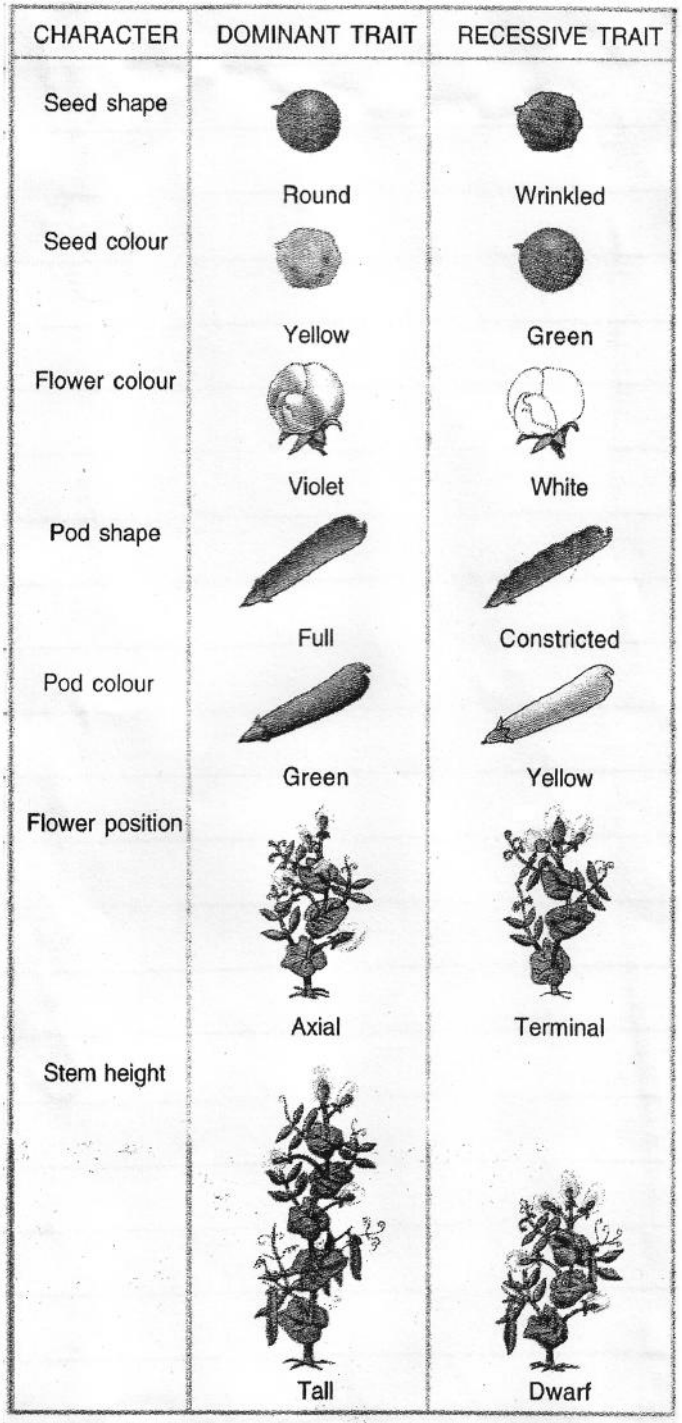


Fig. Mendel's seven different unit characters

TT, tt] Both dominant gene / Both recessive gene] Pure or conditon — homozygous

Tt ⟶ One dominant, one recessive gene — 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 :
1. All F_1 progeny were tall (no medium height plant (half way characteristic)
2. F_2 progeny ¼ were short
3. Phenotypic ratio F_2 – 3:1
   Genotypic ratio F_2 – 1:2:1

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) 't' are recessive trait (because it remains supressed)

Dihybrid Cross : A cross macle 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]

Selfing F_1

F_1 Rr Yy → RY, Ry, rY, ry

F_1 Rr Yy → RY, Ry, rY, ry (GAMETES)

F_2

♂ / ♀	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

GENOTYPIC RATIO :
RRYY ; 1
RRYy : 2
RrYY : 2
RRyy : 1
RrYy : 4
Rryy : 2
rrYY : 1
rrYy : 2
rryy : 1

RATIO : 1 : 2 : 2 : 1 : 4 : 2 : 1 : 2 : 1

Observations :
1. When **RRYY** was crossed with **rryy** in F_1 generation all were Rr Yy round and yellow seeds.
2. Self pollination of F_1 plants gave parental phenotype + two mixtures (recombinants) Round wrinkled, green yellow : seeds plants appeared in the ratio of 9:3:3:1

Conclussions :
1. Round and yellow seeds are **DOMINANT** characters
2. Occurence of new phenotypic combinations show that genes for round and yellow seeds are **inherited independently** of each other.

Sex Determination

Phenomenon of decision or determination of sex of an offspring

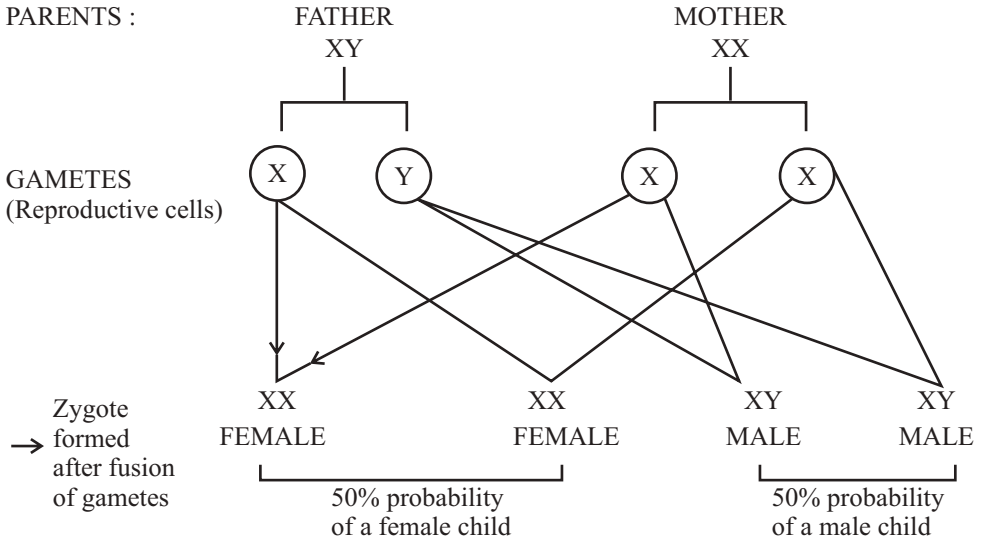
FACTORS
Responsible for Sex Determination

Environmental	**Genetic**
In some animals the temperature at which the fertilised eggs are kept decides the gender.	In some animals like humans gender or individual is determined by a pair of chromosome called sex chromosome
eg. in Turtle	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 chromosomes that help in deciding gender of that individual are called sex chromosome.

XX – female
XY – male

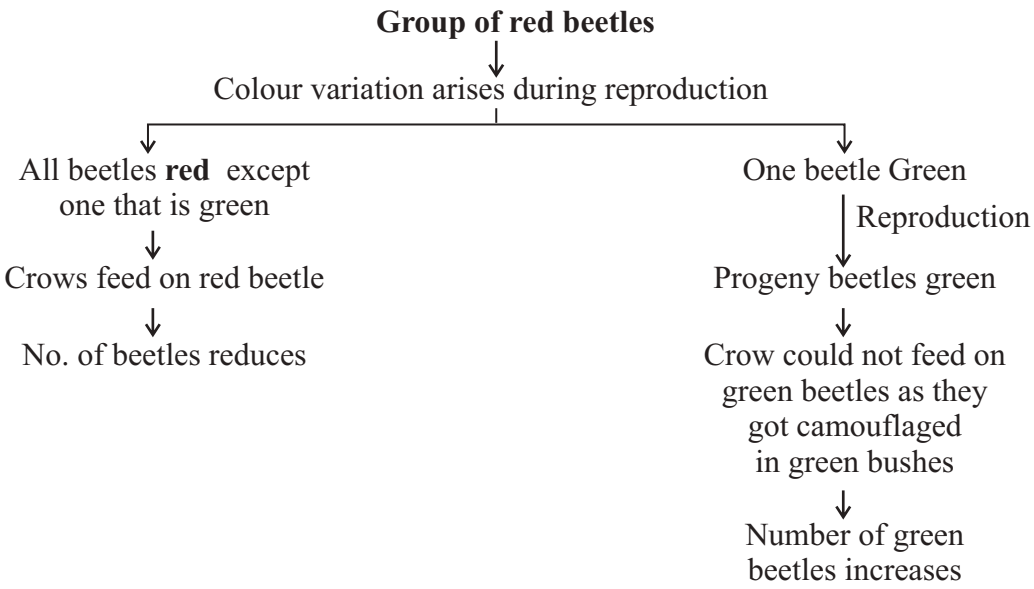
Sex determination in Human beings



This shows that half the children will be boys and half will be girls. All children will in herit 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.

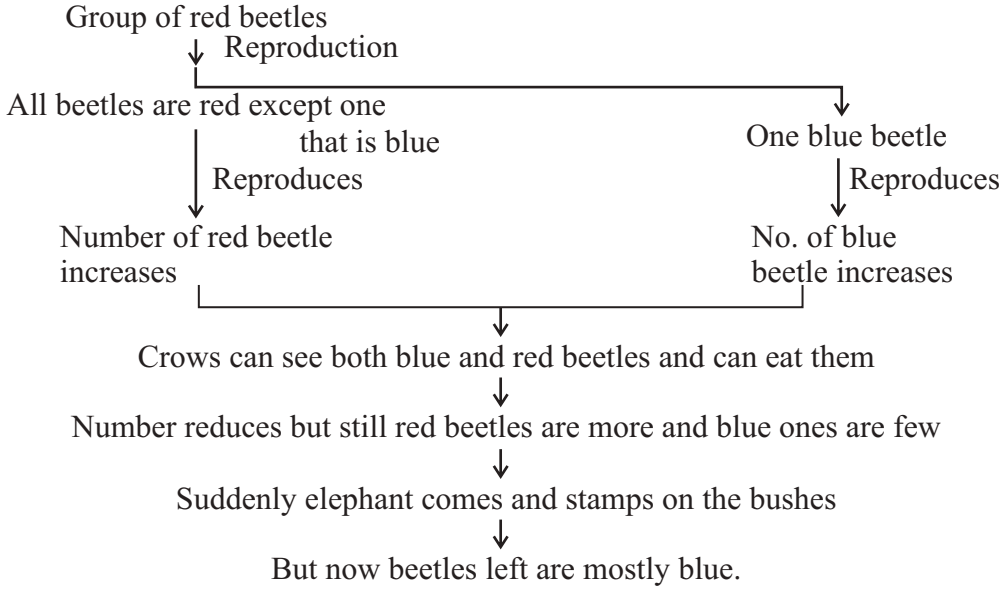
Evolution

SITUATION-I



Situation 1 : 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

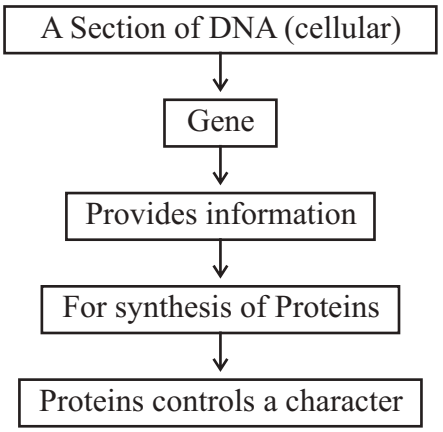


Situation 2 : Blue beetles did not get survivals advantage. Elephant suddenly caused major havoc in beetle population otherwise there number would have been considerably large.

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.

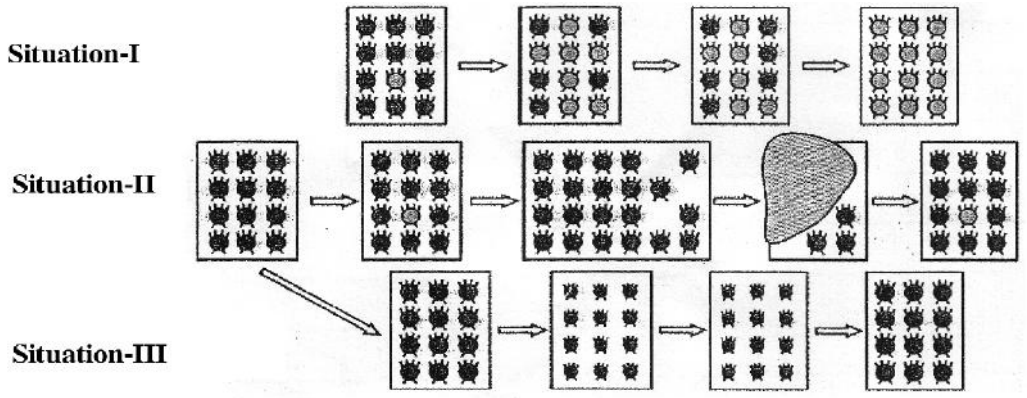
Mechanism of Heredity

Characters or traits of an organism are controlled by the genes



Example :

Gene T	⟶	responsible for synthesis of efficient enzyme (Protein)	⟶	More production of growth hormone	⟶	Results in Tall Plants
Gene t	⟶	responsible for synthesis of less efficient enzyme	⟶	Less production of growth hormone	⟶	Results in short Plants



Genetic drift. It leads to diversity without any adaptation

SITUATION-III

Group of red beetles

↓

Habitat of beetles (bushes)
Suffer from plant disease

↓

Average weight of beetles
decreases due to poor nourishment

↓

No of beetles kept on reducing

↓

Later plant disease gets eliminated

↓

Number and average weight of the beetles
increases again

Situation 3 : No genetic change has occured 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 eg. Low weight of starving beetles.	3. They are helpful in evolution. eg. Colour of eyes and hair

Speciation

Micro evolution : It is the evolution which is on a small scale. eg. change in body colour of beetles.

Speciation : it is the process of formation of new species.

Species : A group of similar individuals that along to a population that can interbreed and produce ferrite off spring.

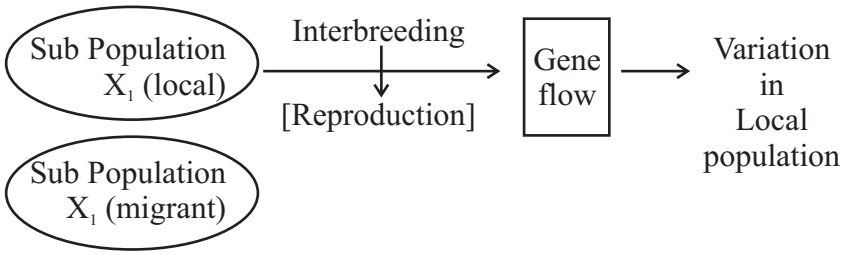
Geneflow : It is exchange of genetic material by interbreeding between populations of same species or individuals

WAYS BY WHICH SPECIATION TAKES PLACE

↓

Speciation takes place when variation is combined with geographical isolation.

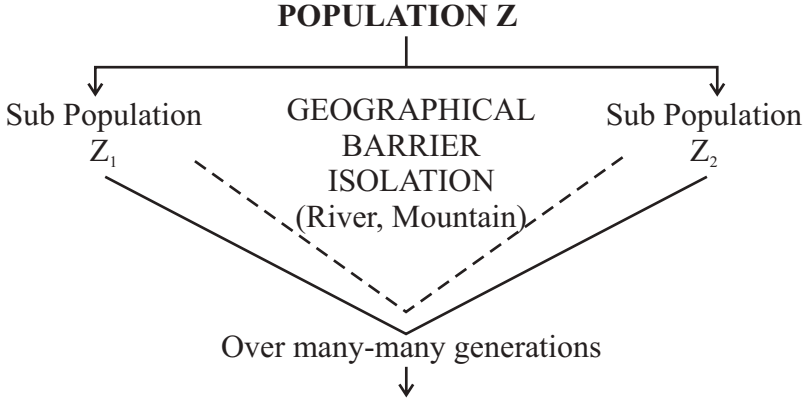
Gene flow : occurs between population that are partly but not completely seperated



Genetic Drift

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

*Natural Selection : The process by which nature selects and consolidate those organisms which are more suitably adapted and posesses favorable variations



Results in Accumulation of different variations in
Sub population Z_1 and Z_2

↓

Genetic drift

↓

Natural selection

↓

Sub population Z_1 and Z_2 incapable
of interbreeding

↓ Reproductive Barrier ↓

Formation of new Species 1 | Formation of new Species 2

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

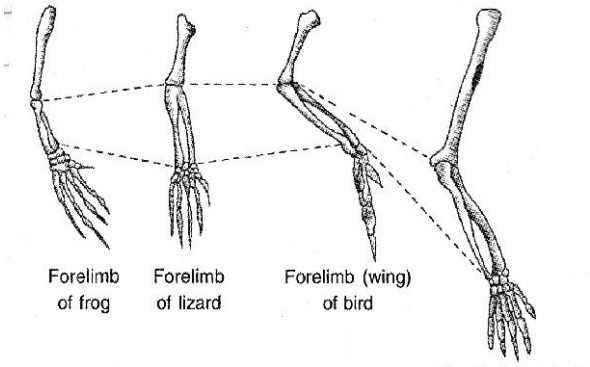


Fig. 5.9 Homologus organs of some vertebrates

Fig. 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.

Example :

Forelimb of Horse	(Running)	Same basic plan, different functions
Winds 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 :

Wings of bat	elongated fingers with skin folds	Design different same function ie. flight
Wings of bird	Feathery covering along the arm	

III. **Fossils :** (Palaeontological evidences)

The remains and relics of dead organisms of the past.

Example :

i) Fossil of wooly mammoth

ii) Archeopteryx (fossil bird)

iii) Dead insect caught in hot mud.

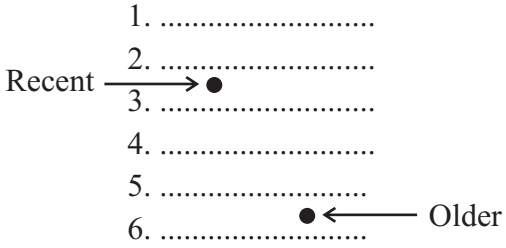
FOSSILS ARE PRESERVED TRACES OF LIVING ORGANISMS

Eg.	AMMONITE	-	Fossil invertebrate
	TRILOBITE	-	Fossil in vertebrate
	KNIGHTIA	-	Fossil fish
	RAJASAURUS	-	Fossil dinosaur skull

AGE OF THE FOSSILS

i. Deeper the fossil, older it is.

II. Detecting the ratios of different of the same element in the fossil material ie **Radio-carbon dating.** [C-(14) dating)



Evolution by stages

Evolution takes place in stages ie bit by bit over 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**

Evolutions of feathers

Feathers provide insulation in cold weather

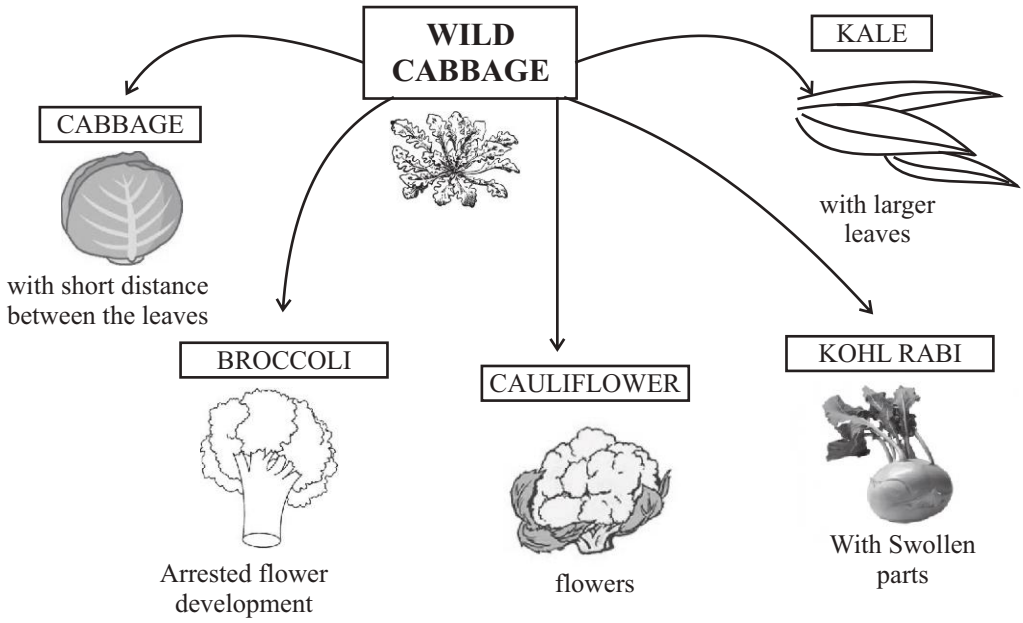
but later they might become useful for flight.

Example :

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

Artificial Selection :

Humans have been a powerful agent in modifying wild species to suit their own requirement through out ages by using artificial selection. eg (i) Wild cabbage the dissimilar looking structures have evolved from a common ancestral design. (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 more distantly related will accumulate greater differences in their DNA

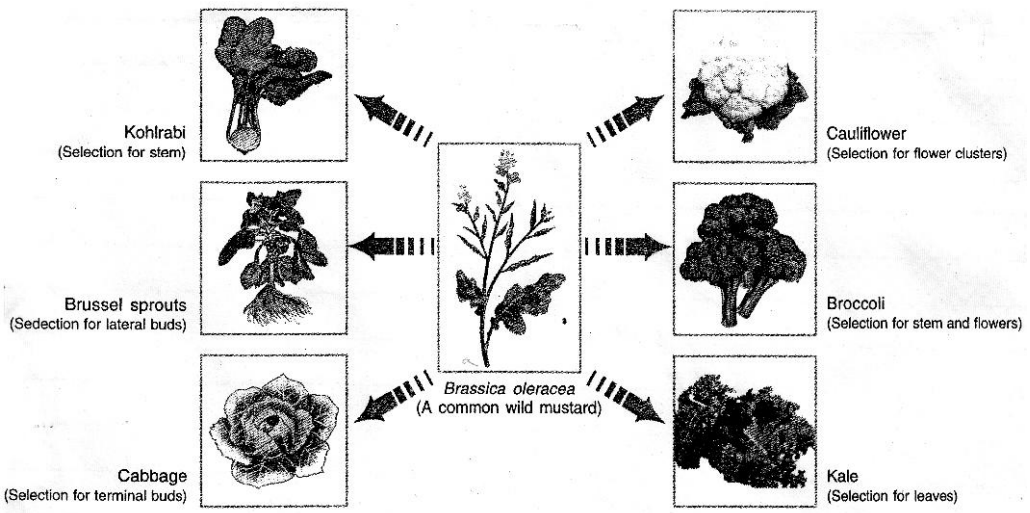
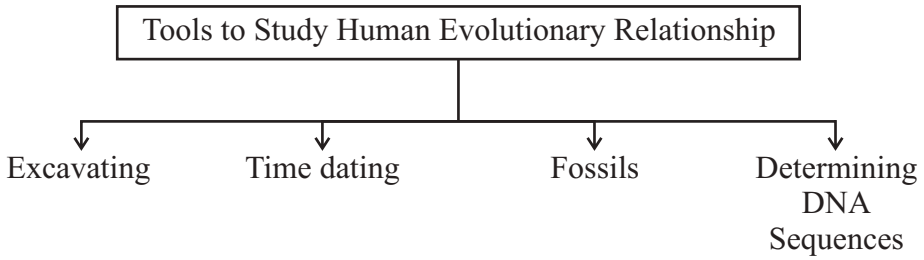


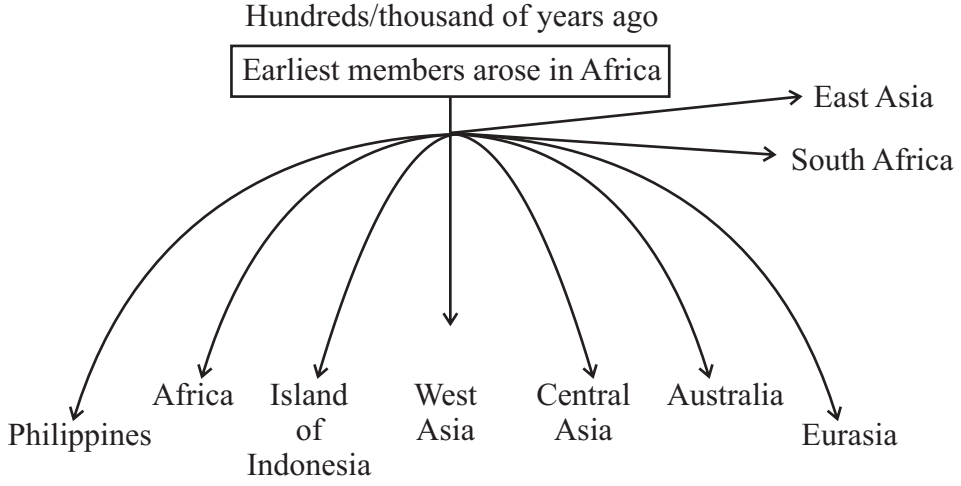
Fig. Some crop plants produced by selective breeding

Human Evolution



Although there is great diversity of human forms all over the world get all **humans are a single species**

GENETIC FOOTPRINTS OF HUMANS



- They did'nt go in a single line
- They went forward and backward
- Moved in and out of Africa
- Sometimes came back to mix with each other.

EXERCISE

(Question Bank)

Very Short Answers (1 Mark)

1. Define variation
2. What is monohybird cross?
3. What is dominant trait.
4. What are genes?
5. Define Homologous organs
6. If an individual has XX chromosome [22+XX] will that individual be male or female.
7. Which plant Mendel had choosen for his experiments.
8. How do Mendel's experiment show that traits may be dominant or recessive?
9. Define analogous organs? Give example.

Short Answers (2 Marks)

1. Differentiate between acquired and Inherited traits? Give example of each.
2. Explain what are fossils? How the age of fossils be determined
3. What is speciation? What factors lead to formation of a new species.
4. Explain the mechanism of sex determination in humans.
5. Differentiate between homologous and analogous organs. by giving examples.
6. Define inheritance. What are the units of inheritance
7. What is genetic drift? How it contributes to the formation of new species
8. Explain monohydrid cross by taking tall and dwarf plants. Mention the phenotypic and genotypic ratio of F_1 and F_2 off springs.

Long Answer (5 Marks each)

1. Explain the process of artificial selection by taking the example of wild cabbage plant.
2. Explain about the human evolution.