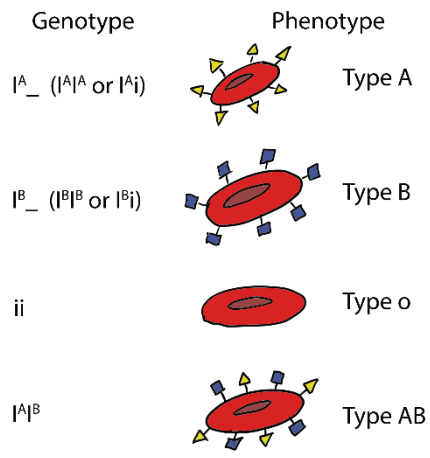
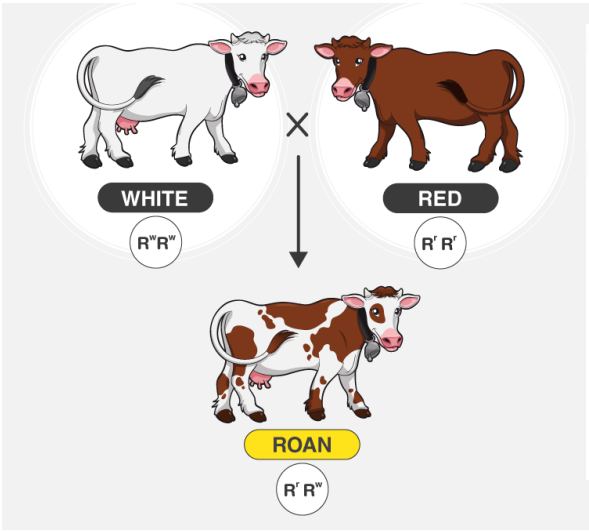
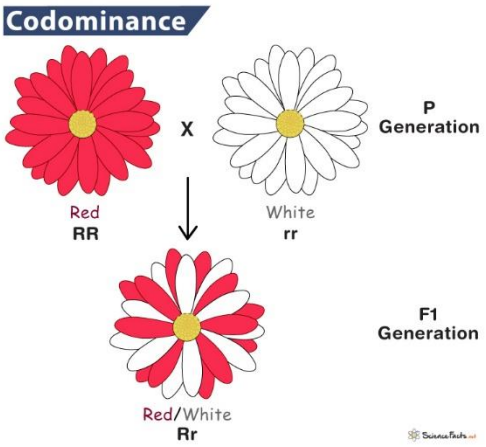


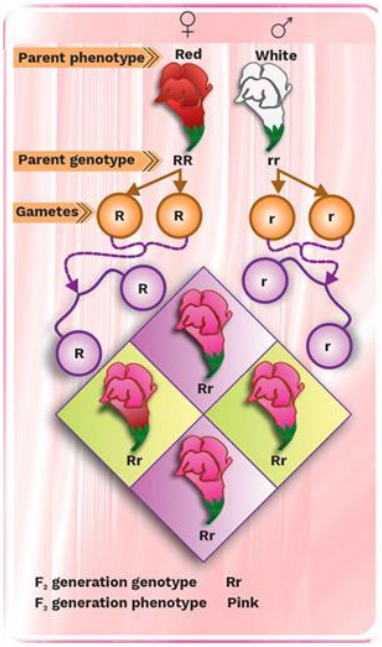


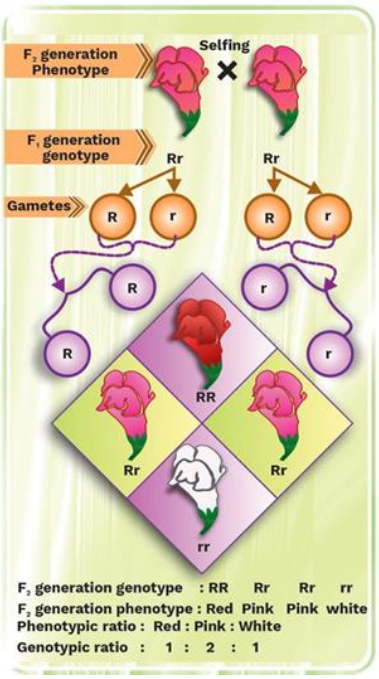


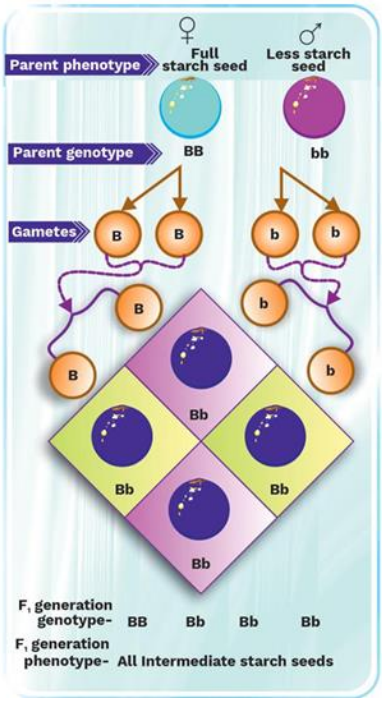
Multiple Alleles

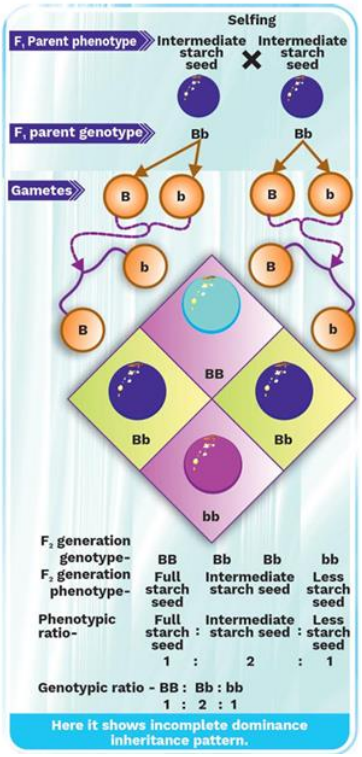
In a set of two or more gene (located on same gene locus) the same character is controlled by more than two different types of allele. We get to know about multiple allele in a population study. Ex: ABO blood group.

Incomplete Dominance









Four'O clock flower **Starch Grain**

Synthesis

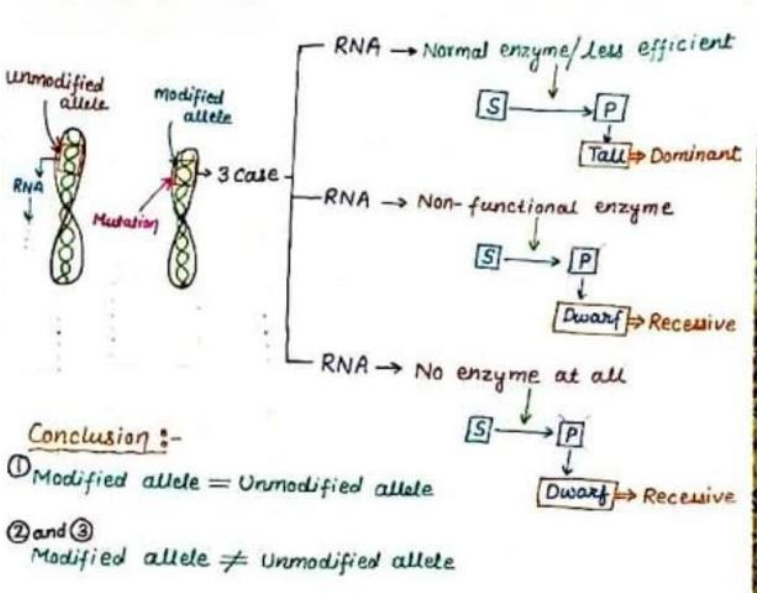
CONCEPT OF DOMINANCE:

The dominant allele is unmodified and produces a normal enzyme.

The recessive allele is modified allele (formed due to mutation).

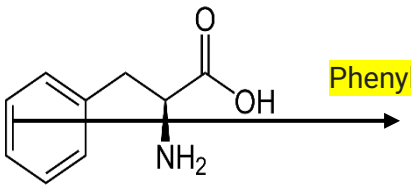
Case 1 Normal/ Less efficient Enzyme	Case 2: Non functional Enzyme	Case 3: No Enzyme at all
Produce same phenotype	Phenotype may be effected.	Phenotype may be effected.

Hence, recessive trait is seen due to non-functional enzyme or because no enzyme is produced.

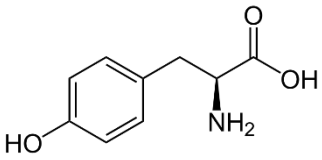


Pleiotropy - Single gene exhibits multiple phenotypic expressions. A single pleiotropic gene may produce more than one effect.
For example,
(i) **Phenylketonuria,** a disorder caused by mutation in the gene coding the enzyme phenylalanine hydroxylase.

In absence of enzyme Phenylalanine Hydroxylase- The affected individuals show hair and skin pigmentation and mental problems.



Phenylalanine Hydroxylase



Act as Precursor for:
- Dopamine
- Adrenaline
- Thyroid Hormone (T3 &t4)
- **Melanine (Skin Pigmentation)**

Phenylalanine (Essential Amino Acid- Taken from diet) **Trysoine**

(Non- Essential Amino Acid)

(In Absence of Hydroxylase Enzyme Extra Phenylalanine)

↓ Deamination by Liver

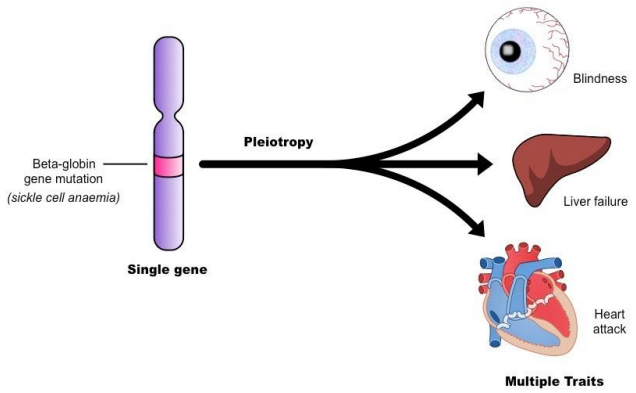
Forming Ketones Bodies (Excreted in Urine) – **if reached brain causes damage to Brain**

(ii) Gene coding for starch synthesis in pea plant- Control Seed Shape and Size of the Grain.

Bb – Intermediate size and Round (show incomplete dominance for seed size)

Genotype	Phenotypes	
	Size of starch grains	Seed shape
BB	Large sized	Round
Bb	Intermediate size	Round
bb	Small size	Wrinkled

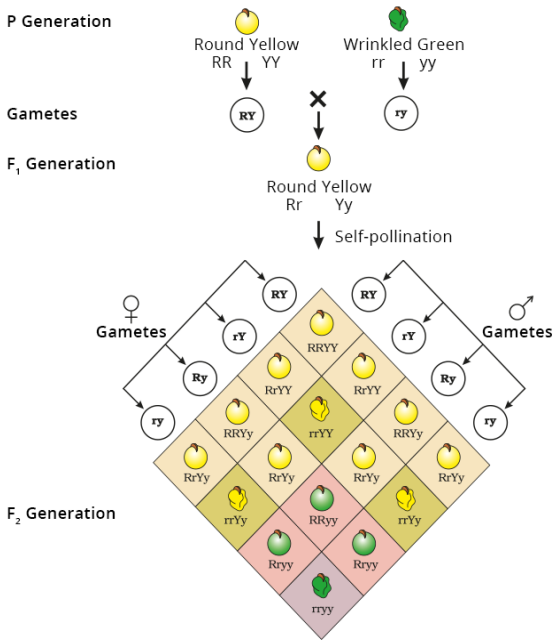
(iii) Sickle Cell Anaemia



The gene mutation results in sickle-shaped red blood cells also leads to other affected traits like anemia, blood clots, pain, Liver Damage, high blood pressure, Heart Attack, ,Blindness.
Homozygous Recessive individual dies early in life due to severe anaemia (premature destruction of RBCs).
Heterozygous survive and have high resistance to malaria as plasmodium can not survive in these cells. **S**everely stricken malarial region (part of Africa) may have 40% population may have sickle cell anemia.

Inheritance of Two genes (Dihybrid Cross)

A cross made to study simultaneous inheritance of two pairs of genes.



Law of independent Assortment – The law states that **'when two pairs of traits are combined in a hybrid, segregation of one pair of characters is independent of the other pair of characters'**.
Genotypic Ratio

RRYY	RrYY	rrYY	RRYy	RrYy	rrYy	RRyy	Rryy	rryy
1	2	1	2	4	2	1	2	1

Phenotypic Ratio

Round Yellow	Round Green	Wrinkled Yellow	Wrinkled Green
9	3	3	1

Polygenic Inheritance- given by Galton in 1833.

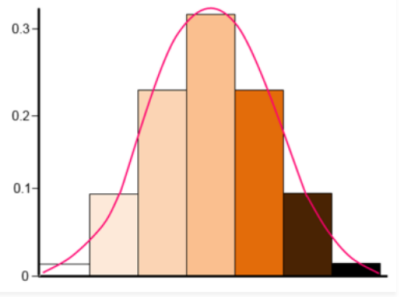
Traits controlled by three or more genes (multiple genes) which can be present on the same or different chromosomes.

The phenotype shows participation of each allele and is also influenced by the environment and is called quantitative inheritance as the character/phenotype can be quantified.

Effect of a single gene is too small , So each allele has a cumulative or additive effect

(i) **Human Skin Colour** which is caused by a pigment melanin. The quantity of melanin is due to three pairs of polygenes (A, B and C).

(AA BB CC) Black or Very Dark, (aa bb cc) white or very light, (Aa Bb Cc / Aa BB Cc…. etc) Intermediate colour often called mulatto A total of eight allele combinations is possible in the gametes forming 27 distinct genotypes.



(ii) Human Height- around 400 genes responsible for the phenotype and environment greatly influences the expression of genes.

(iii) **Eye colour:** At least 9 colours of eye colour are recognised in humans. There are two major eye colour genes and 14 more genes that determine the expression of the phenotype. A different number of alleles contribute to each colour. These are found to be X-linked.

♀ / ♂	ABC	aBC	AbC	ABc	abC	Abc	aBc	abc
ABC	AABBCC Very dark	AaBBCC Dark	AABbCC Dark	AABBCc Dark	AaBbCC Fairly dark	AABbCc Fairly dark	AaBBCc Fairly dark	AaBbCc Intermediate
aBC	AaBBCC Dark	aaBBCC Fairly dark	AaBbCC Fairly dark	AaBBCc Fairly dark	aaBbCC Intermediate	AaBbCc Intermediate	aaBBCc Intermediate	aaBbCc Fairly light
AbC	AABbCC Dark	AaBbCC Fairly dark	AAbbCC Fairly dark	AABbCc Fairly dark	AabbCC Intermediate	AAbbCc Intermediate	AaBbCc Intermediate	AabbCc Fairly light
ABc	AABBCc Dark	AaBBCc Fairly dark	AABbCc Fairly dark	AABBcc Fairly dark	AaBbCc Intermediate	AABbcc Intermediate	AaBBcc Intermediate	AaBbcc Fairly light
abC	AaBbCC Fairly dark	aaBbCC Intermediate	AabbCC Intermediate	AaBbCc Intermediate	aabbCC Fairly light	AabbCc Fairly light	aaBbCc Fairly light	aabbCc Light
Abc	AABbCc Fairly dark	AaBbCc Intermediate	AAbbCc Intermediate	AABbcc Intermediate	AabbCc Fairly light	Aabbcc Fairly light	AaBbcc Fairly light	Aabbcc Light
aBc	AaBBCc Fairly dark	aaBBCc Intermediate	AaBbCc Intermediate	AaBBcc Intermediate	aaBbCc Fairly light	AaBbcc Fairly light	aaBBcc Fairly light	aaBbcc Light
abc	AaBBCc Intermediate	aaBbCc Fairly light	AabbCc Fairly light	AaBbcc Fairly light	aabbCc Light	Aabbcc Light	aaBbcc Light	aabbcc Very light

Phenotypic ratio - Very Dark : Dark : Fairly Dark : Intermediate : Fairly light : Light : Very light

1 : 6 : 15 : 20 : 15 : 6 : 1