B. Sc. II Sem V Zoology Paper II Genetics

Modification of Mendelian Ratios

There are two types of gene interactions, intra-allelic and inter-allelic gene interactions.

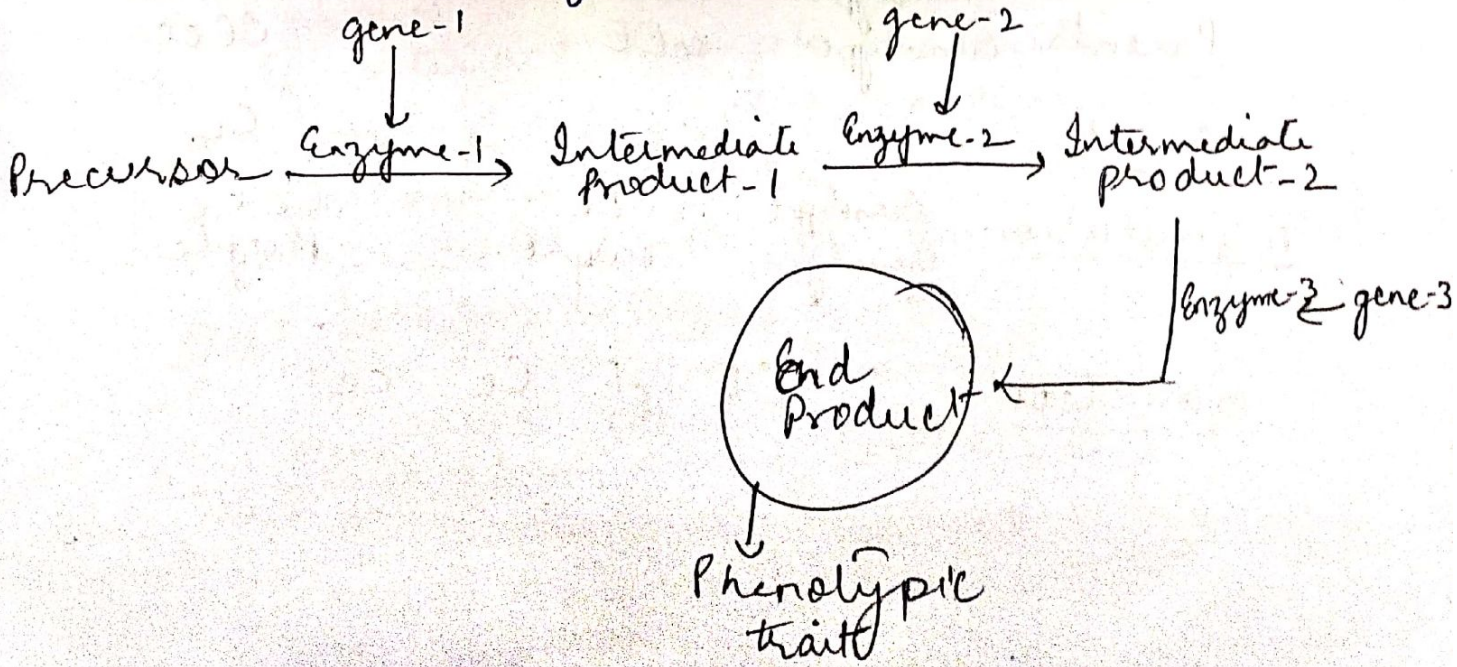
- **Intra-allelic or allelic gene interactions:**

These are interactions between 2 allelic genes (gene alleles of a single gene) for the determination of a single phenotypic trait of an organism.
Such interactions are characteristic of Mendel's monohybrid & dihybrid cross.

- **Inter-allelic or non allelic gene interactions:**

- The interactions between 2 or more independent (non homologous) gene pairs located on the same or different chromosomes for the expression of a single phenotypic trait of an organism.

→ **Mechanism of gene interaction:**



Modified F2 ratios

→ **Complementary genes**

Two independent pairs of genes which interact to produce a trait together, but each dominant gene alone does not show its effect, are called complementary genes.

In this type of gene interactions the production of one of the phenotypes of a trait requires the presence of dominant alleles of both the genes controlling the concerned trait.

When any one of the two or both the genes are present in homozygous recessive state, the contrasting phenotype is produced.

eg A cross between 2 white-flowered sweet peas, Lathyrus odoratus, varieties produced plants with purple flowers. F1 plants on inbreeding gives F2 generation in a ratio of 9 purple flowered to 7 white flowered plants.

Parents	Phenotype	white	×	white
	Genotype	ccEE		CCee
Gametes		cE		Ce
F1 generation	Genotype	CcEe		CcEe
	Phenotype	Purple		Purple

Gametes CE cE Ce ce

2 Generation

gametes → / ↓	CE	Ce	cE	ce
CE	CCEE Purple	CCEe Purple	CcEE Purple	CcEe Purple
Ce	CCEe Purple	CCee white	CcEe Purple	Ccee white
cE	CcEE Purple	CcEe Purple	ccEE white	ccEe white
ce	CcEe Purple	Ccee white	ccEe white	ccee white

Phenotypic Ratio = Purple : white
9 : 7

The extracts of white flowers of the two parents having different dominant genes appear colorless when kept separately but when mixed together purple color develops.
This shows that products of gene C & E are able to interact complementarily
The genes C & E produce anthocyanin in two biochemical reactions.
End product of 1st rxn forms the substrate for 2nd rxn.

$$A \xrightarrow[\text{Raw material}]{\text{Gene C}} B \xrightarrow[\text{Enzyme}]{\text{Gene E}} \text{Anthocyanin}$$

→ Duplicate Genes or factors

Two pairs of genes which lie in different chromosomes & produce a single trait with or without a cumulative effect are known as the duplicate genes (factors). It is of 2 types:

a) Duplicate genes with cumulative effect:

The dominant allele of two genes located at different loci in homozygous or heterozygous condition together produce one phenotype, which is the same for both the genes.

eg. A cross b/w sandy male & female pig

Parents	Phenotype	Sandy male pig	Sandy female pig
	Genotype	$SSrr$	$ssRR$
	Gametes	Sr, Sr	sR, sR
F_1 Gen.	Genotype	$SsRr$	$SsRr$
	Phenotype	Red	Red
	Gametes	SR, sR, Sr, sr	SR, sR, Sr, sr

F_2 Gen.

Gametes	SR	Sr	sR	sr
SR	$SSRR$ Red	$SSRr$ Red	$SsRR$ Red	$SsRr$ Red
Sr	$SSRr$ Red	$SSrr$ Sandy	$SsRr$ Red	$Ssrr$ Sandy
sR	$SsRR$ Red	$SsRr$ Red	$ssRR$ Sandy	$ssRr$ Sandy
sr	$SsRr$ Red	$Ssrr$ Sandy	$ssRr$ Sandy	$ssrr$ ~~Sandy~~ White

F_2 Phenotypic Ratio — Red : Sandy : White

9 : 6 : 1

Explanation:
The coat colour in Duroc-jersy breed of pigs depends of 2 pairs of genes (SSRR & ssRR) which interact in a peculiar manner. The dominant genes S & R together produce red coat & separately produce sandy coat colour.
Homozygous recessive genotypes ss & rr produce white coat colour.

b) Duplicate genes without cumulative effect:
All the genotypes with one or more dominant alleles produce the same phenotype & recessive alleles produce a different phenotype.

eg. The plant named shepherd's purse, Capsella bursa bears 2 types of seed capsules: triangular and top-shaped. Their cross:

Parents	Phenotype	Triangular capsule	×	Top-shaped capsule
	Genotype	AABB		aabb
	Gametes	AB, AB	×	ab, ab
F1 generation	Genotype	AaBb		AaBb
	Phenotype	Triangular capsule		Triangular capsule
	Gametes	Ab, Ab, aB, ab		AB, Ab, aB, ab

F2 generation

Gametes → / ↓	AB	Ab	aB	ab
AB	AABB Triangular	AABb Triangular	AaBB Triangular	AaBb Triangular
Ab	AABb Triangular	AAbb Triangular	AaBb Triangular	Aabb Triangular
aB	AaBB Triangular	AaBb Triangular	aaBB Triangular	aaBb Triangular
ab	AaBb Triangular	Aabb Triangular	aaBb Triangular	aabb Top-shaped

F2 Phenotypic Ratio: Triangular : Top shaped
15 : 1

Explanation:
Two pairs of independently segregating dominant genes are responsible for the triangular shape of the seed capsules.
All genotypes having one or more dominant genes, produce plants with triangular seed capsules. Only the genotypes comprising recessive alleles produce plants with top-shaped seed capsules.

→ Epistatic Genes or Inhibiting Genes:

A pair of genes at one locus may prevent the expression of a pair of genes at another locus. Such genes are called inhibiting genes.
The prevention of the expression of one pair of genes by another pair of genes is known as epistasis. in contrast to dominance in which the expression of one allele is prevented by the other allele of the same gene.
Epistasis is the inter-allelic gene suppression & dominance is the intra-allelic gene suppression

Epistatic genes: The genes which inhibit the action of basic genes

Hypostatic genes: The basic genes, the expression of which is prevented by epistatic genes.

(4)

A cross showing interaction of inhibiting & basic genes in two varieties of white fowl: White Leghorn & White Plymouth Rock.

Parents Phenotypes: Homozygous Dominant White Leghorn fowl × Homozygous Recessive White Plymouth Rock

Genotypes: CCII × ccii

Gametes: CI, CI × ci, ci

F_1 Generation Genotypes: CcIi × CcIi

Phenotypes: Heterozygous White × Heterozygous White

Gametes: CI, Ci, cI, ci × CI, Ci, cI, ci

F_2 Progeny

Gametes → / ↓	CI	Ci	cI	ci
CI	CCII White	CCIi White	CcII White	CcIi White
Ci	CCIi White	CCii Coloured	CcIi White	Ccii Coloured
cI	CcII White	CcIi White	ccII White	ccIi White
ci	CcIi White	Ccii Coloured	ccIi White	ccii White

F_2 Phenotypic Ratio: White : Coloured

13 : 3

Explanation: The basic gene C produces colour in the feathers but the inhibiting gene I prevents the development of colour. The gene I interacts with gene C so as to suppress its expression.

In F_2 generation, the genotypes having inhibiting gene I along with basic colour producing gene C produce white fowls. The genotypes which do not have I gene, give rise to coloured fowls

Example 2 : Recessive Epistasis

Gray colour in mice is dominant over the black colour. Gene A is necessary to produce any pigment. In homozygous recessive condition (aa), no pigment is formed & an albino mouse is produced.

Parents

Phenotype — BBAA: Homozygous Gray; bbaa: Albino

Genotype

Gametes — BA, BA; ba, ba

F1 progeny

Genotype — BbAa

Phenotype — Heterozygous Gray

Gametes — BA, Ba, bA, ba

F2 progeny

Gametes → / ↓	BA	Ba	bA	ba
BA	BBAA Gray	BBAa Gray	BbAA Gray	BbAa Gray
Ba	BBAa Gray	BBaa Albino	BbAa Gray	Bbaa Albino
bA	BbAA Gray	BbAa ~~Gray~~	bbAA Black	bbAa Black
ba	BbAa Gray	Bbaa Albino	bbAa Black	bbaa Albino

F2 Phenotypic Ratio

Gray : Black : Albino

9 : 3 : 4

Since the recessive alleles suppress the expression of a trait in this cross, i.e. it is called Recessive Epistasis

Example 3: Dominant Epistasis

Coat colour in dogs depends on the interaction of 2 genes: one epistatic & one hypostatic. Black coat colour is dominant over brown coat colour. Here, the dominant gene I (Epistatic) inhibit the expression of hypostatic gene B or b, thereby producing white coat colour. The alleles of hypostatic genes BB, Bb, bb express only if both the alleles of epistatic gene are recessive ii.

Parents Phenotypes: White male dog × White female dog

Genotypes: BbIi × BbIi

Gametes: BI, Bi, bI, bi × BI, Bi, bI, bi

~~F1 Progeny~~ ~~Genotype~~ ~~Phenotype~~ ~~Gametes~~

F2 Progeny

Gametes → / ↓	BI	Bi	bI	bi
BI	BBII White	BBIi White	BbII White	BbIi White
Bi	BBIi White	BBii Black	BbIi White	Bbii Black
bI	BbII White	BbIi White	bbII White	bbIi White
bi	BbIi White	Bbii Black	bbIi White	bbii Brown

F2 Phenotypic Ratio: White : Black : Brown

12 : 3 : 1

Since, the dominant alleles of epistatic gene inhibits the expression of trait i.e the coat colour (hypostatic gene) in the cross i.e why is called as Dominant Epistasis