Dominance and Epistasis

INTRODUCTION

- Mendel always observed dominance i.e. masking effect of one allele of a gene over other allele. In other words, he observed intragenic masking effect or intra locus masking effect. The main features of dominance are listed as follows:
- 1. Locus Involved: Dominance involves single locus. It involves two alleles of the same locus.
- 2. Type of Interaction: Dominance involves intragenic or intra locus interaction. In other words, it is the interaction between two alleles of the same gene. The gene which expresses in F, is called dominant gene and the gene whose effect is suppressed in F, is known as recessive gene.
- 3. Types: Dominance is of three types viz. complete dominance, incomplete dominance and co-dominance.
- 4. Phenotypic Ratio in F_2: The phenotypic ratio in F, is modified in case of incomplete dominance.
- 5. Evolution of new Phenotype: In case of intra allelic interaction evolution of new phenotype is not possible.

EPISTASIS

- Later on cases of inter locus or inter genic masking effects were observed which were called as gene interaction or epistasis. The masking of the phenotypic effect of alleles at one gene alleles of another gene is termed as epistasis. Thus epistasis is the interaction between the genes at two or more loci. In plants, the first case of epistasis was observed by Bateson (1909) for flower color in garden pea. Later on epistasis was reported in several plant species

Main features of epistasis are presented as follows:

- 1. Locus Involved Epistasis involves two different loci. It involves alleles of two different genes.
- 2. Type of Interaction: Epistasis involves inter-genic or inter locus interaction. In other words, it is the interaction between alleles of two different genes. The gene which has masking effect is called epistatic gene and the gene whose effect is masked is known as hypostatic gene. The masking effect can be exhibited by both dominant allele and recessive allele.
- 3. Types: Epistasis is of various types viz. complementary, supplementary, duplicate.etc.
- 4. Phenotypic Ratio in F_2: In case of epistasis, the phenotypic ratio is modified in F_2 generation.
- 5. Evolution of new Phenotype: Inter allelic interaction sometimes leads to evolution of new phenotype.

DOMINANCE AND EPISTASIS

- Epistasis differs from dominance in several ways. Important differences between dominance and epistasis are presented below

TABLE 4.1 : Differences between Dominance and Epistasis

S.No.	Particulars	Dominance	Epistasis
1.	Locus involved	Single	Two or more
2.	Types	Three, *viz.* complete, incomplete and over-dominance	Several types
3.	Known as	Intragenic interaction	Intergenic interaction
4.	Effect of recessive gene	Suppressed	Can exhibit masking effect
5.	Fixation	Not possible	Possible in homozygotes
6.	Phenotypic ratio in F_2	Modified in case of incomplete dominance.	Modified
7.	Development of new phenotype	Not possible	Possible due to gene interaction.

TYPES OF EPISTASIS

Epistasis can be classified into two types, viz., dominant epistasis and recessive epistasis

Dominant Epistasis

(i)Dominant Epistasis [12:3: 1 Ratio]
(ii) Dominant Inhibitory Epistasis [13:3 Ratio]
(iii) Duplicate Dominant Epistasis [15: 1 Ratio]
(iv) Dominant [Polymeric] Epistasis [9: 6:1 Ratio]

Recessive Epistasis

(i)Recessive Epistasis [9: 3: 4 Ratio]
(ii) Duplicate Recessive Epistasis [9: 7 Ratio}

DOMINANT EPISTASIS [12: 3:1 RATIO]

Example: Fruit colour in summer squash and seed coat colour in barley.
The fruit colour in summer squash is of three types, viz. **white, yellow and green**.
A cross between white and yellow fruit colour plants produced F with white fruit.
Intermating of F, plants produced plants with white, yellow and green coloured fruits in 12:3:1 ratio in F_2 generation.سو

Explanation: Suppose the genotype of white fruit is WWgg and that of yellow fruit as wwGG. A cross between them will have WwGg genotype with white fruit colour in F_1

(1) Allele W is dominant over w and epistatic to alleles G and g. Hence, wherever allele is present plants will produce white fruit [12/16].

(ii) Plants with ww G will produce yellow fruit colour [3/16].

(iii) Plants with wwgg-genotype will produce green fruits [1/16].

Parent generation

White fruit
WW gg

Yellow fruit
ww GG

Gametes

Wg

wG

F_1 (selfed)

White fruit
WwGg

F_2	WG	Wg	wG	wg
WG	WWGG White	WWGg White	WwGG White	WwGg White
Wg	WWGg White	WWgg White	WwGg White	Wwgg White
wG	WwGG White	WwGg White	wwGG Yellow	wwGg Yellow
wg	WwGg White	Wwgg White	wwGg Yellow	wwgg Green

Phenotypes

White fruit

Yellow fruit

Green fruit

Phenotypic ratio 12 : 3 : 1

2. DOMINANT INHIBITORY EPISTASIS [13: 3 RATIO}

Example: The well known examples of dominant inhibitory epistasis is found for anthocyanin pigmentation in rice and grain colour in maize. The green colour of plant is controlled by the gene I which is dominant over purple colour. The purple colour is controlled by a dominant gene P. A cross between green and purple colour plants produced green plants in F. Intermating of F, plants produced green and purple colour plants in 13:3 ration in F_2 generation.

Explanation: Suppose the genotype of green plant is II*pp* and that of purple plant as *ii*PP. A cross between them will have l*i*P*p* genotype with green plant colour in F_1. This can be explained as follows.

(i) Here, allele I is epistatic to P and *p*. Hence plants with I alleles [12/16] will have green plants and plant with both recessive alleles [*iipp*] will also have green plant colour.

(ii) Plants with i¡P-genotypes [3/16] will produce purple plant colour.

(iii) Thus in F_2 a phenotypic ratio of 13: 3 is obtained.

Parents: Green Plant IIpp × Purple Plant iiPP

F_1: IiPp — Green Plant

F_2	IP	Ip	iP	ip
IP	IIPP [G]	IIPp [G]	IiPP [G]	IiPp [G]
Ip	IIPp [G]	IIpp [G]	IiPp [G]	Iipp [G]
iP	IiPP [G]	IiPp [G]	iiPP [P]	iiPp [P]
ip	IiPp [G]	Iipp [G]	iiPp [P]	iipp [G]

G = Green Plant, P = Purple Plant

Fig. 8.4. Inhibitory epistasis for anthocyanin pigmentation in rice. The normal dihybrid ratio is modified to 13 : 3 ratio in F_2 generation.

3. DUPLICATE DOMINANT EPISTASIS [15: 1 RATIO]

Example: This type of epistasis has been reported for awn character in rice. A cross between awned and awnless strains produced awned plants in F1. Intermating oflants produced awned and awnless plants in 15:1 ratio in F_2 generation.

Explanation: Suppose the genotype of awned strains is AABB and that of awnlesa aabb. A cross between them will have AaBb genotype with awn character.

(i) Here, A and B alleles are epistatic to *aa* and *bb* alleles.

(ii) The awnless plants develop only in the genotypes having double recessive (aabb) genes.

(iii) Thus plants with two dominant alleles [A-B-] as well as single dominant allele [either A or B] will produce plants having awns and double recessive genotype [*aabb*] will produce awnless plants. Thus, a 15: 1 phenotypic ratio is observed in F_2 generation.

Parents: Awned Rice AABB × Awnless Rice aabb

F_1: AaBb — Awned Rice

F_2	AB	Ab	aB	ab
AB	AABB [A]	AABb [A]	AaBB [A]	AaBb [A]
Ab	AABb [A]	AAbb [A]	AaBb [A]	Aabb [A]
aB	AaBB [A]	AaBb [A]	aaBB [A]	aaBb [A]
ab	AaBb [A]	Aabb [A]	aaBb [A]	aabb [a]

A = Awned Rice, a = Awnless Rice

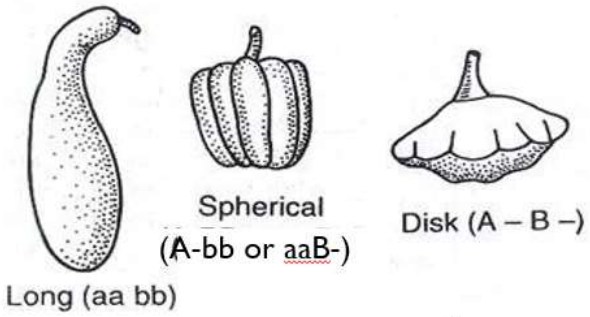


Fig. Shape of summer squash

4. DOMINANT POLYMERIC EPISTASIS [9:6: 1 RATIO]

Example: Fruit shape in summer squash
Three types: disc shape, spherical and long
Disc shape: two dominant gene [A and B]
Spherical shape: either dominant allele [A or B]
Long fruits: double recessive [*aabb*]

(i) Presence of both dominant genes [AB] together produce enhance effect i.e. disc shape
(ii) Plants with single dominant gene [either A or B] produce spherical shape
(iii) Double recessive genes [*aabb*] produce long fruits.

Parents: Disc Shape Fruit AABB × Long Shape Fruit aabb

F_1: AaBb Disc Shape Fruit

F_2:

	AABB	Ab	aB	ab
AB	AABB [D]	AABb [D]	AaBB [D]	AaBb [D]
Ab	AABb [D]	AAbb [S]	AaBb [D]	Aabb [S]
aB	AaBb [D]	AaBb [D]	aaBB [S]	aaBb [S]
ab	AaBb [D]	Aabb [S]	aaBb [S]	aabb [L]

D = Disc shape fruit, S = Spherical fruit, L = Long fruit

RECESSIVE EPISTASIS [9:3:4 RATIO]

Example: Grain colour in maize
Bulb colour in onion
Purple grains RRPP
White grains rrpp
Cross: RrPp purple grain colour
(i)Presence of two dominant alleles together {R-P} produces purple grains
(ii)Presence of one dominant gene R produces red colour of grain
(iii) Allele r is epistatic to alleles P and P. The r allele in homozygous condition produces white grains in rrP- and rrpp genotypes.

Parents — Purple Grains PPRR × White Grains pprr

F_1 — PpRr — Purple Grains

F_2

	PR	Pr	pR	pr
PR	PPRR [P]	PPRr [P]	PpRr [P]	PpRr [P]
Pr	PPRr [P]	PPrr [W]	PpRr [P]	Pprr [W]
pR	PpRR [P]	PpRr [P]	ppRR [R]	ppRr [R]
pr	PpRr [P]	Pprr [W]	ppRr [R]	pprr [W]

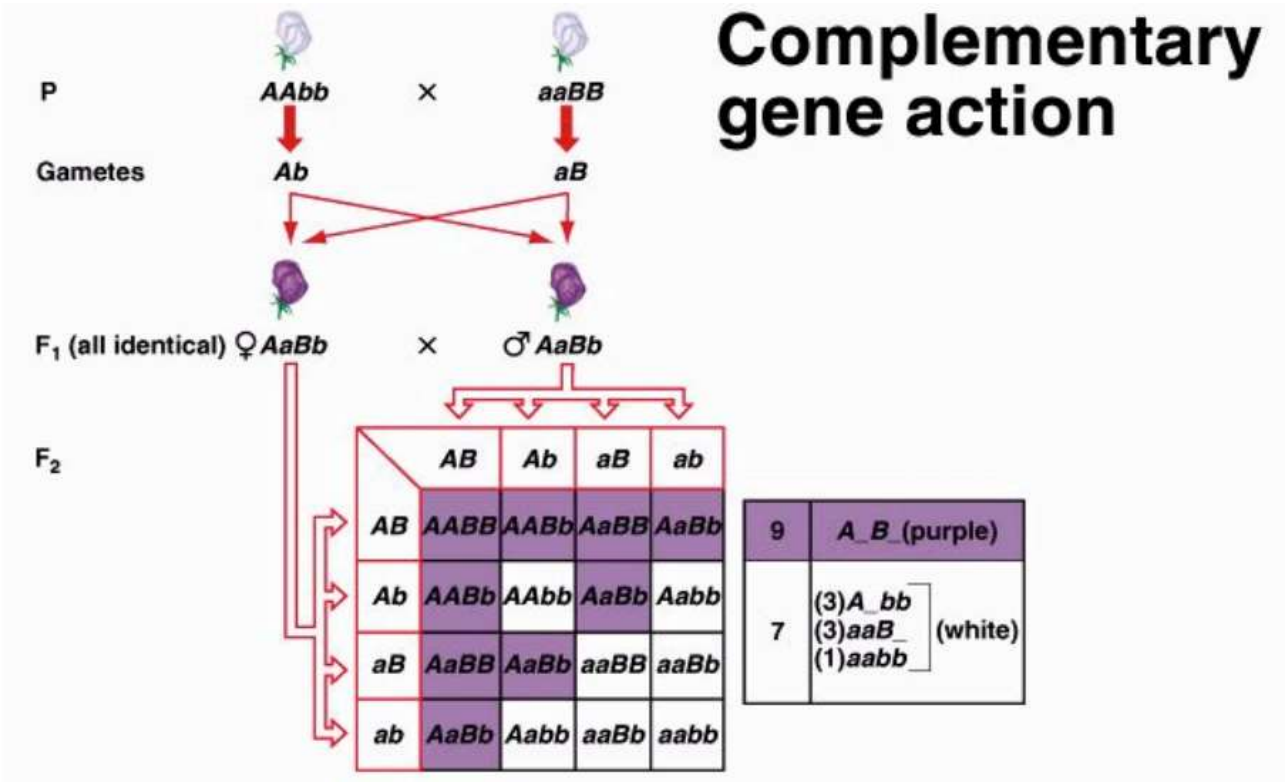
P = Purple, R = Red, and W = White grains

DUPLICATE RECESSIVE EPISTASIS [9:7 RATIO]

Example: Flower colour in garden pea
Cross between two white coloured flower gave purple flower in F1. Intermating produced purple and white flowers in 9:7 ratio in F2

Explanation:
White flower : Aabb and aaBB
Cross: Aa Bb will give purple flower

(i) Two dominant gene together produce purple flower
(ii) Homozygous allele masks 'a' masks dominant allele B and homozygous recessive 'b' masks the dominant allele
(iii) Plants with two dominant: purple
(iv) aaB, Abb and aabb will produce whit flower
(v) 9:7 ratio in F2



Summary of gene interaction

	A-B-	A-bb	aaB-	aabb
Simple interaction	9	3	3	1
Dominant epistasis	12		3	1
Recessive epistasis	9	3	4	
Complementary factor	9	7		
Duplicate gene	15			1
Polymorphic gene	9	6		1
Inhibitory factor	13		3	

THANK YOU