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Top 6 Types of Epistasis Gene Interaction

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The following points highlight the top six types of epistasis gene interaction. The types are: 1. Recessive Epistasis 2. Dominant Epistasis 3. Dominant [Inhibitory] Epistasis 4. Duplicate Recessive Epistasis 5. Duplicate Dominant Epistasis 6. Polymeric Gene Interaction.

Epistasis Gene Interaction: Type # 1.

Recessive Epistasis [9:3:4 Ratio]:

When recessive alleles at one locus mask the expression of both (dominant and recessive) alleles at another locus, it is known as recessive epistasis. This type of gene interaction is also known as supplementary

epistasis. A good example of such gene interaction is found for grain colour in maize.

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There are three colours of grain in maize, viz., purple, red and white. The purple colour develops in the presence of two dominant genes (R and P), red colour in the presence of a dominant gene R, and white in homozygous recessive condition (rrpp).

A cross between purple (RRPP) and white (rrpp) grain colour strains of maize produced plants with purple colour in F_1 . Inter-mating of these F_1 plants produced progeny with purple, red and white grains in F_2 in the ratio of 9 : 3 : 4 (Fig. 8.2).

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Parents		Purple Grains PPRR		x	White Grains pprr	
F ₁		PpRr			Purple Grains	
		PR	Pr	pR	pr	
F ₂	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

Fig. 8.2. Recessive epistasis for grain colour in maize. The normal dihybrid segregation ratio of 9 : 3 : 3 : 1 is modified to 9 : 3 : 4 in F₂.

Here allele r is recessive to R, but epistatic to alleles P and p. In F₂, all plants with R-P- (9/16) will have purple grains and those with R-pp genotypes (3/16) have red grain colour. The epistatic allele r in homozygous condition will produce plants with white grains from rrP- (3/16) and rrpp (1/16) genotypes.

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Thus the normal segregation ratio of 9 : 3 : 3 : 1 is modified to 9 : 3 : 4 in F₂ generation. Such type of gene interaction is also seen in coat colour in mice, bulb colour in certain characters in many other

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Epistasis Gene Interaction: Type # 2.

Dominant Epistasis [12 : 3 : 1 Ratio]:

When a dominant allele at one locus can mask the expression of both alleles (dominant and recessive) at another locus, it is known as dominant epistasis. In other words, the expression of one dominant or recessive allele is masked by another dominant gene. This is also referred to as simple epistasis.

An example of dominant epistasis is found for fruit colour in summer squash. There are three types of fruit colours in this cucumber, viz., white, yellow and green. White colour is controlled by dominant gene W and yellow colour by dominant gene G. White is dominant over both yellow and green.

The green fruits are produced in recessive condition (wwgg). A cross between plants having white and yellow fruits produced F_1 with white fruits. Inter-mating of F_1 plants produced plants with white, yellow and green coloured fruits in F_2 in 12 : 3 : 1 ratio (Fig. 8.3). This can be explained as follows.

Parents	White Fruit WWgg		Yellow Fruit wwGG	
		x		
F_1		WwGg	White Fruit	
	WG	Wg	wG	wg
	WG	WWGG [W]	WWGg [W]	WwGG [W]
	Wg	WWGg [W]	WWgg [W]	WwGg [W]
	wG	WwGG [W]	WwGg [W]	Wwgg [W]
	wg	WwGg [W]	Wwgg [W]	wwgg [w]

W = White Fruit, Y = Yellow fruit, G = Green fruit

Fig. 8.3. Dominant epistasis for fruit colour in Summer squash. 12 : 3 : 1 in F_2 generation.

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Here W is dominant to w and epistatic to alleles G and g. Hence it will mask the expression of G/g alleles. Hence in F_2 , plants with W-G-(9/16) and W-gg (3/16) genotypes will produce white fruits; plants with wwG- (3/16) will produce yellow fruits and those with wwgg (1/16) genotype will produce green fruits.

Thus the normal dihybrid ratio 9 : 3 : 3 : 1 is modified to 12:3: 1 ratio in F_2 generation. Similar type of gene interaction has been reported for skin colour in mice and seed coat colour in barley.

Epistasis Gene Interaction: Type # 3.

Dominant [Inhibitory] Epistasis [13 : 3 Ratio]:

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In this type of epistasis, a dominant allele at one locus can mask the expression of both (dominant and recessive) alleles at another locus. This is also known as dominant epistasis. An example of this type of gene

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interaction is found for anthocyanin pigmentation in rice.

The green colour of plants is governed by the gene I which is dominant over purple colour. The purple colour is controlled by a dominant gene P. When a cross was made between green (IIpp) and purple (iiPP) colour plants, the F₁ was green. Inter-mating of F₁ plants produced green and purple plants in 13 : 3 ratio in F₂ (Fig. 8.4). This can be explained as follows.

Parents		Green Plant IIpp		x	Purple Plant iiPP	
F ₁		IIpp		↓	iiPP	
		Green Plant			Green Plant	
		IP	Ip		iP	ip
F ₂	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 F₂ generation.

Here the allele I is epistatic to alleles P and p. Hence in F₂, plants with I-P-(9/16), I-pp (3/16) and iipp (1/16) genotypes will be green because I will mask the effect of P or p. Plants with iiP-(3/16) will be purple, because I is absent.

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In this way the normal dihybrid segregation ratio $9 : 3 : 3 : 1$ is modified to $13 : 3$ ratio. Similar gene interaction is found for grain colour in maize, plumage colour in poultry and certain characters in other crop species.

Epistasis Gene Interaction: Type # 4.

Duplicate Recessive Epistasis [$9 : 7$ Ratio]:

When recessive alleles at either of the two loci can mask the expression of dominant alleles at the two loci, it is called duplicate recessive epistasis. This is also known as complementary epistasis. The best example of duplicate recessive epistasis is found for flower colour in sweet pea.

The purple colour of flower in sweet pea is governed by two dominant genes say A and B. When these genes are in separate individuals (AAbb or aaBB) or recessive (aabb) produce white flower.

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A cross between purple flower (AABB) and white flower (aabb) strains produced purple colour in F_1 . Inter-mating of F_1 plants produced purple and white flower plants in 9 : 7 ratio in F_2 generation (Fig. 8.5). This can be explained as follows.

Here recessive allele a is epistatic to B/b alleles and mask the expression of these alleles. Another recessive allele b is epistatic to A/a alleles and mask their expression.

Hence in F_2 , plants with A-B- (9/16) genotypes will have purple flowers, and plants with aaB- (3/16), A-bb- (3/16) and aabb (1/16) genotypes produce white flowers. Thus only two phenotypic classes, viz., purple and white are produced and the normal dihybrid segregation ratio 9 : 3 : 3 : 1 is changed to 9 : 7 ratio in F_2 generation.

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Parents	Purple Flower AABB		White Flower aabb		
		x			
		↓			
F ₁		AaBb	Purple Flower		
	AB	Ab	aB	ab	
F ₂	AB	AABB [P]	AABb [P]	AaBb [P]	AaBb [P]
	Ab	AABb [P]	AAbb [W]	AaBb [P]	Aabb [W]
	aB	AaBb [P]	AaBb [P]	aaBB [W]	aaBb [W]
	ab	AaBb [P]	Aabb [W]	aaBb [W]	aabb [W]

P = Purple Flower, W = White Flower

P = Purple Flower, W = White Flower

Fig. 8.5. Duplicate recessive epistasis for flower colour in sweet pea. The normal dihybrid segregation ratio 9 : 3 : 3 : 1 is changed to 9 : 7 in F₂.

Epistasis Gene Interaction: Type # 5.

Duplicate Dominant Epistasis [15 : 1 Ratio]:

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When a dominant allele at either of two loci can mask the expression of recessive alleles at the two loci, it is known as duplicate dominant epistasis. This is also called duplicate gene action. A good example of duplicate dominant epistasis is awn character in rice. Development of awn in rice is controlled by two dominant duplicate genes (A and B).

Presence of any of these two produce awn. The awnless common develops only when both these genes are in homozygous

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recessive state (aabb). A cross between awned and awnless strains produced awned plants in F_1 . Inter-mating of F_1 plants produced awned and awnless plants in 15 : 1 ratio in F_2 generation (Fig. 8.6). This can be explained as follows.

Parents		Awed Rice AABB		x	Awnless Rice aabb	
F_1		AaBb			Awed Rice	
		AB	Ab	aB	ab	
F_2	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 = Awed Rice, a = Awnless Rice

Fig. 8.6. Duplicate dominant epistasis for awn character in rice. The normal dihybrid segregation ratio 9 : 3 : 3 : 1 is changed to 15 : 1 ratio in F_2 generation.

The allele A is epistatic to B/b alleles and all plants having allele A will develop awn. Another dominant allele B is epistatic to alleles A/a. Individuals with this allele also will develop awn character. Hence in F_2 , plants with A-B-(9/16), A-bb-(3/16) and aaB-(3/16) genotypes will develop awn.

The awnless condition will develop only in double recessive (aabb) genotype (1/16). In this way only two classes of plants are developed and the normal dihybrid segregation ratio 9 : 3 : 3 : 1 is modified to 15 : 1 ratio in F_2 . Similar gene action is found for modulation in peanut and non-floating chickpea.

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Polymeric Gene Interaction [9:6:1 Ratio]:

Two dominant alleles have similar effect when they are separate, but produce enhanced effect when they come together. Such gene interaction is known as polymeric gene interaction. The joint effect of two alleles appears to be additive or cumulative, but each of the two genes show complete dominance, hence they cannot be considered as additive genes. In case of additive effect, genes show lack of dominance.

A well-known example of polymeric gene interaction is fruit shape in summer squash. There are three types of fruit shape in this plant, viz., disc, spherical and long. The disc shape is controlled by two dominant genes (A and B), the spherical shape is produced by either dominant allele (A or B) and long shaped fruits develop in double recessive (aabb) plants.

A cross between disc shape (AABB) and long shape (aabb) strains produced disc shape fruits in F_1 . Inter-mating of F_1 plants produced plants with disc, spherical and long shape fruits in 9 : 6 : 1 ratio in F_2 (Fig. 8.7). This can be explained as follow.

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Parents	Disc Shape Fruit AABB			Long Shape Fruit aabb	
			×		
F ₁		AaBb		Disc Shape Fruit	
	AABB	Ab	aB	ab	
F ₂	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

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

Fig. 8.7. Polymeric gene interaction for fruit shape in summer squash. The normal dihybrid segregation ratio 9 : 3 : 3 : 1 is modified to 9 : 6 : 1 ratio in F₂.

Here plants with A—B—(9/16) genotypes produce disc shape fruits, those with A-bb-(3/16) and aaB-(3/16) genotypes produce spherical fruits, and plants with aabb (1/16) genotype produce long fruits. Thus in F₂, normal dihybrid segregation ratio 9:3:3: 1 is modified to 9 : 6 : 1 ratio. Similar gene action is also found in barley for awn length.

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Which organelle is known as "power house" of the cell?

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