Gene interactions

Two or more than two genes may interact and specify one character phenomenon is called gene interactions.

To give example, if gene A is responsible for phenotype A and gene B is responsible for phenotype B but when both A and B are present together may give rise to phenotype 'C'

gene (A) ⟩ → Phenotype C
gene (B) ⟩

Types of gene interactions -

1. **Supplementary gene interaction** → (9:3:3:1)

Bateson and Punnett discovered many different type of size and shape of comb in fowl. There are many different kind of breed in domestic chicken. Each breed possess many different kind of comb.

The Wyandotte breed has a comb called rose and Brahma breed has a comb called pea and the leghorn breed has a comb called single. When a rose comb chicken crossed with that of pea comb, in F_1 progeny different type of comb was obtained i.e walnut type.

⇒ When F_1 walnut comb chicken were breed together, then in F_2 progeny four types of comb occur i.e 9/16 walnut, 3/16 pea. 3/16 rose and 1/16 single.

R gene determine shape of rose comb and P gene determine shape of pea comb but when both gene come togethere in a single individual due to cross between rose and pea comb chicken they interact and produce walnut type of comb in F_1. In the cross of two walnut chicken two gene interact variously and produce four types of offspring in F_2.

Thus, two gene interact to produce comb size and shape in fowl. During the inheritance of comb in fowl the gene themselves do not determine the development of character (ence, or absence of comb) but simply changed a character determined by a basic gene and therefore known as supplementary gene interaction.

RRpp (Rose) × rrPP (Pea) — Parents

↓ ↓

Rp — rP — gametes

↓

RrPp (walnut) —— (F1)

↓ Selfing.

	RP	Rp	rP	rp
RP	RRPP walnut	RRPp walnut	RrPP walnut	RrPp walnut
Rp	RRPp walnut	RRpp Rose	RrPp walnut	Rrpp Rose
rP	RrPP walnut	RrPp walnut	rrPP Pea	rrPp Pea
rp	RrPp walnut	Rrpp Rose	rrPp Pea	rrpp single

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Walnut → 9
Rose → 3
Pea → 3
Single → 1

9:3:3:1

Complementary gene interaction → (9:7)

The meaning of complementation is both genes are necessary for the production of a particular phenotype. W. Bateson and R.C. Punnett observed that when two white flower varieties of sweet pea, Lathyrus odoratus were crossed F_1 progeny has purple flowers. When F_2 Progeny obtained from F_1, then both purple and white flowers obtained in 9:7 ratio. This is again a modification of 9:3:3:1 ratio. when only one character i.e flower colour and two gene C and P are involved.

It is clear from the above example that both dominant allele C and P are necessary for the production of pigment in the flowers. Each of the two parents lacks one of the two dominant allele and therefore both bear only white flowers. The two dominant gene are brought together in F_1 generation and therfare coloured flowers are produced.

Precursor → Intermediate → Anthocyanin pigment
↑ Enzyme 1 ↑ Enzyme 2
↑ gene C ↑ gene P

Each dominant allele produce an enzyme that control a step in the synthesis of anthocyanin from a biochemical precursor. If a dominant allele is not present, its step in the biosynthetic pathway is blocked and anthocyanin is not produced.

CCpp × ccPP
White White

Cp cP

~~CcPP~~ CcPp — F1
Purple

↓ Selfing

	CP	cP	Cp	cp
CP	CCPP Purple	CcPP Purple	CCPp Purple	CcPp Purple
cP	CcPP Purple	ccPP white	CcPp Purple	ccPp White
Cp	CCPp Purple	CcPp Purple	CCpp White	Ccpp ~~Pu~~ White
cp	CcPp Purple	ccPp white	Ccpp white	ccpp White

Purple : white
9 : 7

3 **Duplicate gene interaction →** (15:1)

If a dominant allele of both gene loci produce the same phenotype, 9:3:3:1 ratio is modified into a ratio of 15:1.

A modified ratio 15:1 was observed by G.H. Shull from his studies on the plant known as Shepherd's purse belonging to genus Capsella. Two kinds of phenotypes with respect to fruit shape were known,

1. Triangular capsules
2. Top shaped capsules.

when triangular and top shaped phenotypes were crossed, in F_1 generation only triangular capsule were observed. When such F_1 individual with triangular capsule were intercrossed among themselves, in F_2 progeny plant with triangular capsule and top shape capsule were obtained in 15:1 ratio.

Thus, it shows that even a single dominant allele is enough to give rise to dominant phenotype.

AABB × aabb

Triangular — Top shaped

↓ — ↓

AB — ab — gametes

↓

AaBb — (F_1)

Triangular

↓ Selfing

	AB	aB	Ab	ab
AB	AA BB 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

Triangular : Top shaped
15 : 1

4. Epistasis → Epistasis means one gene mask the effect of another gene. In other words, it does not allow the other gene to express itself fully. The gene which mask the effect of another gene known as epistatic gene. Epistasis works at intergenic level while dominance works at interallelic level. (intragenic)
Epistasis is of two type
1. Dominant epistasis (12:3:1)
2. Recessive epistasis (9:3:4)

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1. Recessive epistasis (9:3:4) → Recessive epistasis is due to recessive allele.
In mice the wild body colour is known as Agouti. In Agouti body colour, banding of individual hairs occurs. Agouti colour is controlled by gene A and coloured condition is controlled by gene C. cc allele is epistatic to gene A. Dominant allele 'C' in the absence of A gene give rise to coloured condition.

When both the dominant allele A and C are present then give rise to Agouti.

Thus CCaa → Coloured

ccAA → albino

The albino mouse lack totally in pigments and has white hair and pink eyes.

→ When a homozygous coloured black (CCaa) is crossed with a homozygous albino (ccAA), in F_1, all Agouti appear (CcAa). When the F_1 agouti are crossed among themselves in F_2 Agouti, coloured and albino offspring appear in the ratio of 9:3:4.

CCaa × ccAA

colowred albino

↓ ↓

Ca cA

↓

CcAa Agouti —— (F1)

↓ selfing

	CA	cA	Ca	ca
CA	CCAA Agouti	CcAA Agouti	CCAa Agouti	CcAa Agouti
cA	CcAA Agouti	ccAA albino	CcAa Agouti	ccAa albino
Ca	CCAa Agouti	CcAa Agouti	CCaa Coloured	Ccaa Coloured
ca	CcAa Agouti	ccAa albino	Ccaa Coloured	ccaa albino

Agouti = 9 Colored = 3 albino = 4

(12:3:1)

Dominant epistasis → When out of two genes, the dominant allele (eg. A) of one gene masked the activity of alleles to the B gene. Such type of epistasis known as dominant epistasis. The allele of hypostatic gene B will be able to express themselves phenotypically only when gene A contain two recessive allele (aa). Thus the genotype AABB, AaBb, AAbb, Aabb produce the same phenotype whereas the genotype aaBB or aaBb and aabb produce two additional phenotypes.

In fruit colour of summer squash, gene A is epistatic to B and b

AABB (white) × aabb (green)

↓

AaBb (white) — F1

↓ Selfing

	AB	aB	Ab	ab
AB	AABB white	AaBB white	AABb white	AaBb white
aB	AaBB white	aaBB yellow	AaBb white	aaBb yellow
Ab	AABb white	AaBb white	AAbb white	Aabb white
ab	AaBb white	aaBb yellow	Aabb white	aabb green.
		white = 12 yellow = 3 green = 1	12 : 3 : 1	