GENE INTERACTION

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INTRODUCTION

- Phenomenon of two or more genes affecting the expression of each other in the various way in the development of a single character of an organism, it is known as gene interaction. In other word, change in the expression of one gene developing on the presence or absence of another gene.
- However, mostly character in all the species is controlled by two or more gene which affects the expression of concerned characters in various ways. In this ways, typical dihybrid ratio 9:3:3:1 and trihybrid ratio 27:9:9:9:3:3:3:1 are modified.

CAUSES OF MODIFICATION OF DIHYBRID RATIO: The modification of dihybrid ratio may be due to incomplete dominance, lethal gene action or gene interactions:
Suppose:

Examples	**Seed shape in pea**	**Flower colour in pea**
Dominancy	**Complete dominance**	**Incomplete dominance***
Phenotypic ratio in F2	**3 round : 1 wrinkled**	**1 red : 2 pink : 1 white**
Genotypic ratio in F2	**1 WW : 2 Ww : 1 ww**	**1 RR : 2 Rr : 1 rr**

*This is only for example, not fact, because the character of flower colour in pea is a complete dominance.

If a parent with WWRR gene is cross to another parent with wwrr gene, it will produce phenotypic ratio 6:3:3:2:1:1 in F2 generation, because this is product of 3:1 X 1:2:1.
6:3:3:2:2:1 = 6 (3X2) : 3 (3X1) : 3 (3X1) : 2 (1X2) : 1 (1X1) : 1 (1X1)

Continue..

Parents: Round red WW RR X Wrinkled white ww rr

Gametes: W R | W r

F1: Ww Rr Round pink

F2

♀	W R	W r	w R	w r
W R	WW RR	WW Rr	Ww RR	Ww Rr
W r	WW Rr	WW rr	Ww Rr	Ww rr
w R	Ww RR	Ww Rr	ww RR	ww Rr
w r	Ww Rr	Ww rr	ww Rr	ww rr

Ratio	Genotype	Phenotype
6	2 WW Rr	Round Pink
	1 Ww Rr	
3	1 WW RR	Round Red
	2 Ww RR	
3	1 WW rr	Round White
	2 Ww rr	
2	2 ww Rr	Wrinkled Pink
1	1 ww RR	Wrinkled Red
1	1 ww rr	Wrinkled White

WW/Ww : ww 12 + 4 = 16 Round wrinkled Frequency of WW/Ww =12/16 Frequency of ww=4/16	RR : Rr : rr 4 + 8 + 4 = 16 Red Pink White Frequency of RR = 4/16 Frequency of Rr = 8/16 Frequency of rr = 4/16

Genotypic frequency in F2 of monohybrid	Product	Product of frequency in F2 generation	Phenotypic ratio
1 WW + 2 Ww X 2 Rr	3 X 2	12/16 X 8/16 12X8 /16 = 96/16	6
1 WW + 2 Ww X 1 RR	3 X 1	12/16 X 4/16 = 12X4/16 = 48/16	3
1 WW + 2 Ww X 1 rr	3 X 1	12/16 X 4/16 = 12X4/16 = 48/16	3
1 ww X 2 Rr	1 X 2	4/16 X 8/16 = 4 X 8 / 16 = 32 / 16	2
1 ww X 1 RR	1 X 1	4 / 16 X 4 / 16 = 4 X 4 /16 = 16 / 16	1
1 ww X 1 rr	1 X 1	4 / 16 X 4 / 16 = 4 X4 / 16 = 16 / 16	1

1. TYPICAL DIHYBRID RATIO (9:3:3:1)

- When dominant alleles of each of the two genes appear separate phenotypes if they are alone in the particular zygote, because dominant allele of one gene is present with the homozygous recessive allele of other gene in a zygote.
- The dominant allele of both the genes are present together in any zygote, they produce distinct phenotype.
- The homozygous recessive alleles of both the gene in a zygote produce another phenotype.
- The dominant allele(s) PP or Pp along with rr produces pea comb, while dominant allele RR or Rr along with pp produces rose comb. But dominant alleles PP and RR present together to produce walnut comb, recessive forms of both the genes produces single comb.
- For example: comb shape in poultry

Parents: Pea comb PPrr X Rose comb ppRR

Gametes: Pr | p R

F1: PpRr Walnut comb

F2:

♂	P R	P r	p R	p r
P R	PP RR	PP Rr	Pp RR	Pp Rr
P r	PP Rr	PP rr	Pp Rr	Pp rr
p R	Pp RR	Pp Rr	pp RR	pp Rr
p r	Pp Rr	Pp rr	pp Rr	pp rr

Phenotypic ratio : 9 walnut : 3 pea : 3 rose : 1 single
Genotypic ratio : 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

2.DUPLICATE GENE ACTION (DUPLICATE DOMINANT EPISTASIS)- 15:1

- Any one of both dominant genes produce the same phenotype whether they are alone or together with recessive allele of other gene. But both the genes are present together in homozygous recessive condition, they are produce contrasting phenotype. As a result, the 9 : 3 : 3 : 1 ratio is modified into 15 : 1 in F2 generation.
- For example: Floating habit in rice

Parents

Non floating
Dw1 Dw1 Dw2 Dw2

X

Floating
dw1 dw1 dw2 dw2

Gametes

Dw1
Dw2

Dw1
dw2

F1

Dw1 dw1 Dw2 dw2
Non floating

F2

♂	Dw1 Dw2	Dw1 dw2	dw1 Dw2	dw1 dw2
Dw1 Dw2	Dw1 Dw1 Dw2 Dw2	Dw1 Dw1 Dw2 dw2	Dw1 dw1 Dw2 Dw2	Dw1 dw1 Dw2 dw2
Dw1 dw2	Dw1 Dw1 Dw2 dw2	Dw1 Dw1 dw2 dw2	Dw1 dw1 Dw2 dw2	Dw1 dw1 dw2 dw2
dw1 Dw2	Dw1 dw1 Dw2 Dw2	Dw1 dw1 Dw2 dw2	Dw1 dw1 Dw2 Dw2	Dw1 dw1 Dw2 dw2
dw1 dw2	Dw1 dw1 Dw2 dw2	Dw1 dw1 dw2 dw2	Dw1 dw1 Dw2 dw2	Dw1 dw1 dw2 dw2

Phenotypic ratio: 15 : 1
Genotypic ratio : 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

- Another examples: Fruit shape in bursa, and Nodulation in groundnut

3. COMPLIMENTARY GENE ACTION (Duplicate Recessive Epistasis) : 9 : 7

- In such gene interaction, the homozygous recessive allele either of two gene in any zygote can mask the expression of dominant alleles of another gene, and they are produce white phenotype.
- While dominant allele of both the genes are present together, they produce contrasting phenotype.
- As a result, complimentary gene action modified the typical ratio 9 : 3 : 3 : 1 into a 9 : 7 ratio in F2 generation.
- For example: flower colour in sweet pea

Parents: Purple CC RR X White cc rr

Gametes: C R and c r

F1: CcRr Purple

F2:

♂	C R	C r	c R	c r
C R	CC RR	CC Rr	Cc RR	Cc Rr
C r	CC Rr	CC rr	Cc Rr	Cc rr
c R	Cc RR	Cc Rr	cc RR	cc Rr
c r	Cc Rr	Cc rr	cc Rr	cc rr

Phenotypic ratio: 9 : 7
Genotypic ratio : 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

*Gene rr has masking effect on CC or Cc gene, similarly gene cc has also masking effect on Rr or Rr, and they are produce white phenotype

- Another example: Aleurone grain colour in maize, and HCN (hydrocyanic acid) production in clovers.

4. SUPLIMENTARY GENE ACTION (RECESSIVE EPISTASIS)- 9 : 3 : 4

- In this type of gene interaction, the dominant allele of first of the two genes controlling a character, and it has a phenotypic effect. The dominant allele of the other gene does not have any phenotypic effect itself, but it is modifies the phenotypic effect of first dominant gene.
- In other word, the allele RR governing the red phenotype. While the allele PrPr have no phenotypic effect itself, but it modifies to phenotypic expression of allele RR which produce purple phenotype.
- For example: Grain aleurone colour in maize.

Parents: Purple RR PrPr X White rr prpr

Gametes: R Pr | r pr

F1: Rr Prpr Purple

F2

♂	R Pr	R pr	r Pr	r pr
R Pr	RR PrPr	RR Prpr	Rr PrPr	Rr Prpr
R pr	RR Prpr	RR prpr	Rr Prpr	Rr prpr
r Pr	Rr PrPr	Rr Prpr	rr PrPr	rr Prpr
r pr	Rr Prpr	Rr prpr	rr Prpr	rr prpr

Phenotypic ratio: 9 purple : 3 red : 4 white
Genotypic ratio : 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

- Another example: Agouti (gray) coat colour in mice.

5.INHIBITORY GENE ACTION (DOMINANT INHIBITORY EPISTASIS)- 13 : 3

- In such gene interaction, the dominant allele of first of the two genes governing a character, and it has a phenotypic effect. The dominant allele of the other gene does not have any phenotypic effect itself, but it has the ability to stop expression of dominant allele of the first dominant gene.
- So the dominant allele of both the gene present together, they produce the same phenotype as that produce by the recessive homozygotes of both the gene.
- In other word, allele R produce red phenotype, while allele II does not have any phenotypic effect but it stop to expression of RR and produce white phenotype as that produce by the gene rrii.
- For example: seed colour in maize.

Parents — Red Rr ii X White rr II

Gametes — R i, r i

F1 — Rr Ii White

F2

♂	R I	R i	r I	r i
R I	RR II	RR Ii	Rr II	Rr Ii
R i	RR Ii	RR ii	Rr Ii	Rrii
r I	Rr II	Rr Ii	rr II	rr Ii
r i	Rr Ii	Rr ii	rr Ii	rr ii

Phenotypic ratio: 13 white : 3 red

Genotypic ratio : 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

Another example: Plumose feather colour in poultry, and production of anthocyanin pigment in rice.

6. MOSKING GENE ACTION (DOMINANT EPISTASIS)- 12 :3 : 1

- In masking gene action, when dominant alleles of each of the two genes produce distinct phenotypes if they are alone in the particular zygote.
- But both the dominant genes are present together, the expression of first gene mask the expression of the other gene
- While both the genes are present in the homozygous recessive condition, it produce different phenotype.
- In other word, gene BB produce black colour, while gene YY express yellow colour. The gene BB have masking effect on the YY gene and produce black colour. The genotype bb yy produce white phenotype.
- For example: seed coat colour in barley.

Parents — Black Bb yy X Yellow bb YY

Gametes — B y, b Y

F1 — Bb Yy Black

F

♂	B Y	B y	b Y	B y
B Y	BB YY	BB Yy	Bb YY	Bb Yy
B y	BB Yy	BB yy	Bb Yy	BB yy
b Y	Bb YY	Bb Yy	bb YY	bb Yy
b y	Bb Yy	Bb YY	bb Yy	bb yy

Phenotypic ration: 12 black : 3 yellow : 1 white
Genotypic ration : 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

- Another example: seed colour in jowar, and fruit colour in summer squash

7. POLYMERIC GENE ACTION- 9 : 6 : 1

- In such gene interaction, the dominant allele of each of the two gene governing a character which produce identical phenotype when they are alone.
- But if both the genes are present together, their phenotypic effect enhance, because both the dominant genes have cumulative or additive effects.
- If both the genes are present in homozygous recessive condition, it produce distinct phenotype.
- So polymeric gene action modified the 9 : 3 : 3 : 1 ratio into 9 : 6 : 1 ratio in F2 generation.
- In other word, dominant allele A or B give rise to medium awn length, while dominant allele A and B present together produce long awn length due to additive effect. But alleles a and b present together, give rise to awnless.
- Foe example: Awns length in barley

Parents — Long awn AA BB × Awnless aa bb

Gametes — A B | a b

F1 — Aa Bb Long awn

F2

♂	A B	A b	a B	a b
A B	AA BB	AA Bb	Aa BB	aa bb
A b	AA Bb	AA bb	Aa Bb	Aa BB
a B	Aa BB	Aa Bb	aa BB	aa Bb
a b	Aa Bb	Aa bb	aa Bb	aa bb

Phenotypic ratio: 9 long awn : 6 medium awn : 1 awnless

Genotypic ratio : 1 : 2 : 2 : 4 : 1 : 2 : 1 : 2 : 1

Another example: Fruit shape in summer squash

HAVE A NICE DAY