GENE INTERACTION

Mendelin principles says that the trait is determined by a single pair of genes of factors it is not always true because some traits are determined by the two or more pairs of alleles are genes located in different chromosomal loci by the interaction for e.g. Eye colour in Drosophila is determined by the 20 different types of genes. Similarly skin colour in man is the combined action of several genes the inter action of genes involves the combined effect on single trait or some genes modify the expression of other genes. Thus genes are inherited as combined unit this hypothesis is a deviation from the Mendel's fundamental laws. The interaction may be between the genes located on the same chromosome or in different chromosomes. This kind of inter action is called inter allelic or non-allelic interaction. Sometimes it may be between the alleles of a same trait, and then it is called intra allelic interaction. The following are some of the gene interactions.

1. Supplementary factors
2. Complementary factors
3. Dominant epistasis
4. Recessive epistasis
5. Polygenic traits
6. Lethal genes.

I. Supplementary factors:

When the two independent dominant genes interacting to produce a phenotypic trait which is different from that is produced by either of the dominant gene alone, such genes are called supplementary genes or factors. Bateson and Punnett have explained it by taking example of inheritance of comb types in fowls. **Example**: Inheritance of comb pattern in fowls In poultry the dominant gene 'R' determine the Rose comb its recessive gene 'r', another dominant gene 'P' determine the pea comb its recessive gene is 'p'

The genotypes of the above three homozygous forms will be as follows:

Pea = PP rr Rose = ppRR Single = PP rr

Both rose comb (RR) and Pea comb is dominant over single comb hence its genotype is rrpp When a homozygous rose comb (RR rr) hen is crossed with homozygous pea comb rooster (PPpp) all F 1 individuals RrPp show an entirely new comb viz, Walnut comb, Wall nut comb is thus produced by the inter action of two different dominant genes. Hence these two genes are called supplementary genes. When f_1 walnuts offsprings are interbreed four types of comb patterns are appeared in the ratio of 9: 3:3:1.

The above cross is illustrated using the following checker board

P- gen Rose comb hen Pea comb Cock

RRpp X PPrr

Gametes Rp X Pr

F_1Generatio RrPp - Walnut comb

F_1 interbreeding RrPp XRrPp

Gametes produced by F $_1$ Progeny are RP, Rp, rP ,rp

The result of F_2 progeny are 9- Walnut: 3- Rose: 3- Pea: 1- Single

Gametes	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

Fig. 15.4 Inheritance of comb types in fowls.

:cker board the following ratio of different phenotypes is obtained:

Phenotype	Walnut	Rose	Pear	Single
Number	9	3	3	1

Thus ratio of F_2 progeny is 9:3:3:1

II. Complimentary factors

Bateson and Punnet and have demonstrated that sometimes two or more dominant genes occurring in separate chromosomes interact to produce a trait, one complementing the other one pair is alone is not sufficient to produce that trait. Such genes are said to be complementary genes.

Example: Expression of flower colour in *Lathyrusodoratus.*

A gene C having recessive allele is responsible for a colourless pigment chromogen, another gene P having recessive allele p is responsible for an activating enzyme which converts chromogen to coloured pigment anthocianin. When these two genes interact leads to production of flower colour.

One of the white flowered plant has chromogen factor with the genotype CCpp and the other has the enzyme factor with the genotype ccPP . On crossing these two plants produces colour flower plant with genotype CcPp . This plant produces four types of gametes namely CP,Cp,Cp,cp. F1 on selfing produces 16 plants representing 9 purpleand 7 white which is deviation from Mendel's Dihybrid cross ratio.

The above cross can be illustrated as follows:

P- Generation White flower CCpp X White flower ccPP

Gametes Cp X cP

F_1 Generation Cc Pp - Purple colour flower plant

F_1 on selfing Cc Pp X Cc Pp

The gametes produced by F_1 Progeny are CP, Cp, cP ,cp

The result of F_2 progeny are 9 - Colured : 7: White

Gametes	CP	Cp	cP	cp
CP	CCPP Colured	CCPpColured	CcPPColured	CcPpColured
Cp	CCPpColured	CCpp White	CcPpColured	Ccpp White

cP	CcPPColured	CcPpColured	ccPP White	ccPp White
cp	CcPpColured	Ccpp White	ccPp White	ccpp White

Thus ratio of F_2 progeny is 9:7

III. Epistasis: (Inhibiting factors)

Sometimes two different genes which are not alleles and present on different chromosomes or same chromosomes both influences the same trait of organism, in this one gene expression is masked by the other gene are called epistasis. The gene that prevent the expression is of the other is called epistatic gene, and the gene which is masked is called hypostatic gene. If the Epistatic gene is dominant for its another allele is called dominant epistasis . If epistatic allele is recessive for another allele is called recessive epistasis.

1. A) Dominant Epistasis: 13:3 ratio.

Example 1: Plumage colour in poultry birds White leghorn and Wyandotte or Plymouth Rock . In poultry white leghorn birds are white but they have a gene for colour plumage ‘C’ which has recessive allele ‘c’. But ‘I’ is inhibiting factor it inhibits the allele for colour ‘C’ is present as epistatic allele, hence they are genetically coloured but phenotypically white. So the gene for colour is hypostatic in white leghorn. Whereas the white plumage gene ‘c’ of white Wyandotte or Plymouth Rock is recessive over the coloured varieties.

When a white leghorn hen IICC is crossed with white Wyandotte rooster iicc, produces only progeny with white plumage ‘IiCc’, since, inhibitor allele not allow the allele C to produce colour. When F1 individuals are interbreeding they produce white and colour birds in the ratio of 13: 3. In F 2 generation genotypes with allele ‘I’ are all white and with recessive allele ‘i’ are coloured. Whereas genotype iicc also white because c is recessive allele for colour allele ‘C. ultimately total number of white birds are 12+1=13 and coloured birds are 3.

Above cross can be illustrated as follows using checker board.

P- Generation Whiteplumage white leghorn X White plumage Plymouth Rock

Genotype IICC iicc

Gametes IC X ic

F_1 Generation IiCc- White plumage

F_1 on selfingIiCc X IiCc

The gametes produced by F_1 Progeny are IC,Ic,iC,ic

The result of F_2 progeny are 13-White 3- Coloured

Gametes	IC	Ic	iC	ic
IC	IICC White	IICc White	IiCC White	IiCc White
Ic	IICc White	IIcc White	IiCc White	Iicc White
iC	IiCC White	IiCc White	iiCC Colour	iiCc Colour
Ic	IiCc White	Iicc White	iiCc Colour	iicc White

Thus ratio of F_2 progeny is 13:3 (12:3:1)

1. B) Dominant epistasis in dog:

In dogs black 'B" is dominant over brown 'b' and both dominant and recessive alleles are influenced by a dominant epistatic gene 'I' which will prevent the expression of both alleles and gives white colour to the coat without pigment. Hence, both B and b Alleles are able to express only in the absence of dominant allele 'I'.

When a white female dog BBII is crossed with brown male dog bbii produces F1 progeny which are all white. On interbreeding of F 1 individuals they produce F 2 Progeny in the ratio of white, black and brown in the ratio of 12: 3:1.

Above cross is illustrated as follows.

P- Generation   white coat female dog   X   brown coat male dog
BBII   bbii

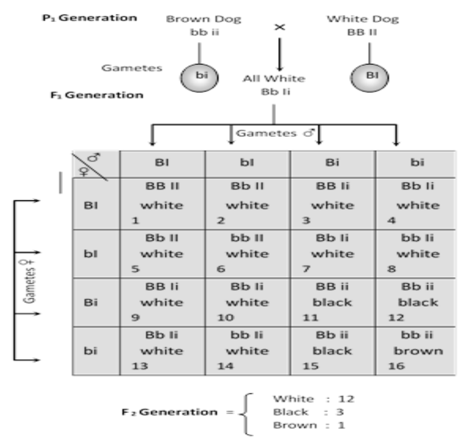
Gametes   BI   bi

F 1 generation   BbIi   White coat

F1 Inter breeding   Bb Ii   X   BbIi

Gametes produced are BI, Bi, bI, bi

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***



Interaction of inhibiting genes in dog for coat colour showing dominant epistasis

In the above cross phenotypic Ratio of F2 generation is 12: 3:1.
It is a deviation from MendalianDihybrid cross.

2 a) Recessive epistasis: Epistasis due to recessive allele is called recessive epistasis. In mice alleles B and A interact to produce agouti here the coat colour is more or less grey the hair are black at the base and tip , with an yellow band in between Which is a protective colour of natural wild variety. Allele B produce Black colour and its recessive allele b inhibit the expression of allele A. The allele ‘a’ determine the albinism (white coat). The presence of the dominant allele (BB) of the epistatic gene allows expression of Allele A so that agouti (AA and Aa) and black (BB) coat colours can be produced.

The recessive epistatic allele ‘ bb’ do not allows expression of Allele A so that give raise albino

P- Generation Agouti X albino
Genotype BBAA bbaa
Gametes BA ba

F 1 generation BbAa Agouti

F1 Inter breeding Bb Aa X BbAa

Gametes produced are BA, Ba, bA. ba

Gametes	BA	Ba	bA	ba
BA	BBAA Agouti	BBAa Agouti	BbAA Agouti	BbAa Agouti
Ba	BBAa Agouti	BBaa **Black**	BbAa Agouti	Bbaa **Black**

bA	BbAA Agouti	BbAa Agouti	bbAA **Albino**	bbAa **Albino**
ba	BbAa Agouti	Bbaa **Black**	bbAa **Albino**	bbaa **Albino**

in the above cross it is found that recessive epistatic allele in homozygous condition bb condition mask the expression of AA, Aa, But in dominant homozygous condition and heterozygous condition fails to suppress the activity of AA or Aa alleles.
The result obtained is Agouti 9: black 3: Albino 4
In the above cross phenotypic ratio of F2 generation is 9: 3: 4.

V. LETHAL GENES

Lethal factors or lethal genes cause savior defects in the possessor leading death when they are homozygous condition. They affect the possessor before attaining the full form.Lethal genes can also alter the basic 9:3:3:1 ratio .The lethal genes may be dominant or recessive. The dominant lethal genes are known to cause their effect either in homo condition or in heterozygous condition. But recessive genes are known to cause defect only homozygous condition, hence their appearance is rare to see.

Dominant Lethal genes : Example: Yellow Mice.

The yellow body color in mice is dominant over brown, but the yellow mice are never true breeding. When yellow mice are inbred, (Cross – 1) the progeny consists of yellow and brown mice in the ratio 2:1 which does not fit any of the Mendelian expectations. Moreover, the litter size after inbreeding is smaller by one fourth as compared to litter size resulting from a cross between yellow and brown. When yellow mice were backcrossed to true breeding brown mice (Cross 2), only heterozygous yellow mice were obtained. The reason for not finding homozygous mice was explained by a French geneticist L.Cuenot. He sacrificed Yy pregnant females after inbreeding and examined the embryos to determine if death occurred in embryonic stages or not. Indeed, one-fourth of the embryos were observed to die in late stages of development. Thus only heterozygous yellow and brown mice in the ration 2:1 were being born. The ratio 1:2:1 expected when a cross between two heterozygous is made was never obtained proving the lethal expression of the homozygous yellow gene.

On crossing yellow mice with non-yellow mice production of yellow and non yellowoffsprings in the ratio of 1: 1 resulted. (Cross-2)From this it is clear that yellow colour is dominant over non yellow and that yellow mice are always heterozygous. According to Mendalian ratio 1 pure yellow YY : 2 hybrid yellow Yy : 1 pure non yellow , where as in the above cross we find two yellow heterozygous Yy and one pure non yellow yy . This is because the fact that the homozygous condition produce a lethal effect in the embryo.

Cross 1:

P- generation Yellow heterozygous X Yellow heterozygous

Genotype Yy Yy

Gametes Y y Yy

F1 progeny YY Yy Yy yy

Homozyugous Yellow Heterozygous yellownon yellow

1 2 1

Dies Survives Survives

Cross -2:

P- Generation Yellow heterozygous X NonYellow(Brown)

Genotype Yy yy

Gametes Y y y

F1 progeny Yy yy

Heterozygous non yellow

Yellow

1 1

Survives survives

Cross: 3.

P- Generation Non Yellow X NonYellow(Brown)

Genotype yy yy

Gametes y y

F1 progeny yy

Non yellow

Survives

.