INTERACTION OF GENE & FACTOR HYPOTHESIS

A/C Mendel & Bovery (Chromosomal Theory of Inheritance).

- 1. One factor / gene controles one character.
- 2. One character is controlled by one factor/gene.
- 3. There is complete dominance.
- 4. Genes are Non-Interfering i.e. Non-interference of Gene
- 5. Complete seggregation.

Vikas

After rediscovery of Mendel's Law, Many genetical & crossing experiments were done by various scientists. Among them Bateson & Punnet found certain important results which do not fit in Mendelian & Boverian one.

It has been found that —

- 1. One gene is controlling more than one character at a time i.e. Pleotropism.
- 2. One character may be controlled by more than one gene
- 3. Incomplete dominance.
- 4. Linkage.
- 5. Interferance of Gene.

Vikas

GENE INTERACTION:

Phenotypic expression of one gene may be changed due to influence of other genes.

Defn —>

Gene Interaction is a phenomenon of modification of phenotypes of certain genes by the other genes.

CONCEPT OF INTERACTION OF GENES.

Let us consider

Recessive Gene	Dominant Gene	—	Phenotype.
a	A	→	x
b	B	→	Y.

Each dominant gene A & B have there recessive genes a & b correspondingly.
The interaction will be
— i) Presence of A & Absence of B.
ii) Presence of B & Absence of A.
iii) Absence of Both A & B.
iv) Presence of Both dominant A&B
In such case they may give Rise rise to a new character z.

Abbreviated genotypic ratio:

Serial Number	Genotypes	Ratio	Abbreviated Genotypes	Ratio
1.	AABB	1		
2.	AaBB	2	AB	9
3.	AAB	2		
4.	AaBb	4		
5.	AAbb	1.	Ab	3
6.	Aabb	2		
7.	aaBB	1	aB	3.
8.	aaBb	2		
9.	aabb	1	ab	1

Normally Gene interaction is of two types.

i) Allelic / Intragenic Interaction.
ii) Non-allelic / Intergenic Interaction

i) Allelic / Intragenic Interaction:
The interaction takes place between two alleles of the same gene present at same locus.
It is of following types.

- a) Incomplete dominance
- b) Co-dominance
- c) Multiple Alleles.

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ii) Non-Allelic / Intergenic Interaction:
Such interaction took place between alleles of different genes present on same or different chromosomes and influence (change) the phenotype.

It is of following types.

- i) Simple Interaction i.e. Collaboration Factor,
- ii) Complementary Gene.
- iii) Epistasis — a) Recessive Epistasis / Supplementary Gene Effect
  b) Dominant Epistasis.
- iv) Polymorphic Gene.
- v) Duplicate Gene.
- vi) Inhibitory Gene.
- vii) Polygenic Inheritance / Additive Factor.

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SIMPLE INTERACTION:

Here two non-allelic pairs of gene affecting the same character in such a way that when they are present together give a different phenotype [K] when they are alone as A the phenotype is different [L], as B the phenotype [M] and when both are recessive a fourth one i.e. [N] type of phenotype.

e.g. In case of Fowl Comb Type

Phenotype: Rose Comb × Pea Comb — Parents.

Genotype: RR pp × rr PP

Gamete: (Rp) (rP)

Rr Pp — Walnut Comb — F_1

On Selfing

RP	Rp	rP	rp
9	3	3	1
Walnut	Rose	Pea	single

F_2

Here

Inheritance of of Collour of Flowers in Streptocarpus.

Phenotype: Red × Mauve — Parents.

Genotype: RRmm × rrMM

Gamete: (Rm) (rM)

RrMm — Blue coloured — F_1

On Selfing.

RM	Rm	rM	rm
9	3	3	1
Blue.	Red	Mauve	salmon colour.

F_2

COMPLEMENTARY GENE:

1st Studied by Bateson & Punnet.

In such caseses there are two independent pairs of genes which fail to express alone but express themselves in combination i.e. when both are present together. e.g.

Colour of Flower in *Lathyrus odorata*

Phenotype	White	x	White	Parents
Genotype	CCpp		ccPP	
Gamete	Cp		cP	

↓

CcPp — Purple — F_1

On selfing ↓

CP	Cp	cP	cp
9	3	3	1
Purple	White	White	White

Purple 9 : 7 White.

⇒ It has been shown by the Experiment with Extracts of Flowers (white) from two different Homozygous Parents.

Extract of A when mixed with extract of B (Both colourless) show purple colour.

Precursor —Gene C→ Product —Gene E→ Product

X ↓ White | Y ↓ White | Z ↓ Purple

EPISTASIS :

Here a pair of genes at one locus may mask the the expression of gene a pair of gene at different locus.

The gene which masks is known as Epistatic Gene and which has been masked is known as Hypostatic Gene

It is of two types.

i) Recessive Epistasis : Here recessive alleles (Homozygous) masks the effect of other gene pair however homozygous or heterozygous dominant e.g. Colour of grain in Maize.

Phenotype — Red — ~~Purple~~ White — Parents.
Genotype — RR pp. — rr P P.

Gametes — (Rp) — (rP) — Vikil

↓

Purple [Rr Pp] — F_1

On selfing ↓

9	3	3	1
R P	R p	r P	r p
Purple	Red	White	White

White + White = 4

9 : 3 : 4.

Here the colour of grain is governed by two pair of genes R (Red) & P (purple)

The recessive [rr] masks the effect of P & PP

Here R/r is Epistatic &
P is Hypostatic.

Vikil

It is also known as Supplementary Gene

Similar case in coat colour of mice.

Phenotype	Black	×	Albino	Parent.
Genotype	CCaa		ccAA	
Gamete	(Ca)		(cA)	

↓

CcAa — F_1.

Agouti

On Selfing ↓

9	3	3	1
CA	Ca	cA	ca
Agouti	Black	Albino	Albino

(Albino + Albino = 4)

9 : 3 : 4.

(b) Dominant Epistasis:

Here the dominant gene of one pair masks the effect of other dominant gene. e.g. Colour of fruit in Summer Squash.

Phenotype: White × Green — Parent

Genotype: WWYY × wwyy

Gamete: WY, wy

F_1: WwYy — All White

On selfing ↓

9	3	3	1
WY	Wy	wY	wy
White	White	Yellow	Green

White 12 : 3 Yellow : 1 Green

POLY MORPHIC GENE:

There are two pairs of non-allelic gene controlling the same character.

- When they are alone they produce identical phenotype but when come together they show additive (Quantitative) enhanced effect in phenotype. e.g.

Length of Awn in Barley.

Phenotype: Long Awn × Awnless — Parents

Genotype: AABB × aabb

Gametes: AB, ab

AaBb — F_1

Long Awn

On selfing ↓

9	3	3	1
AB Long Awn	Medium Awn	Med Awn	Awnless

Long Awn 9 : 6 Medium Awn : 1 Awnless.

DUPLICATE GENE

In this case two pairs of genes of different ~~genes~~ locus controles the character resulting in same phenotype in either single (alone) or double (together) condition. e.g

shape of Capsule of Shepherd's purse. i.e. *Capsella bursa-pastoris*.

Phenotype → Triangular × Oval. Parents.

Genotype → AABB aabb

Gamete → (AB) (ab)

AaBb — F_1

Triangular

On Selfing

9 AB : 3 Ab : 3 aB : 1 ab — F_2

15 Triangular : 1 Oval.

Other examples are

a) Shape of seeds of *Lathyrus sps.*

b) Colour of endosperm of Maize.

c) Awned variety of Rice, etc.

Duplicate Gene with dominance Modification:

In such cases when two dominant genes pairs come together they i.e. the dominant phenotype which will be seen only if two non-allelic or two allelic dominant alleles are there. e.g.

Pigment glands of cotton.

Phenotype: Glandular × Glandless — Parents.

Genotype: $G_1G_1G_2G_2$ × $g_1g_1g_2g_2$

Gamete: G_1G_2 — g_1g_2

$G_1g_1G_2g_2$ — F_1

Glandular

On selfing

~~Genotype~~ → ~~$G_1G_2g_1g_2$~~ (9) $G_1G_1g_2g_2$ (1) $G_2G_2g_1g_1$ (1) $G_1g_1g_2g_2$ (2) $G_2g_2g_1g_1$ (2) $g_1g_1g_2g_2$ (1)

Genotype → $G_1g_1G_2g_2$ (9) $G_1G_1g_2g_2$ (1) $g_1g_1G_2G_2$ (1) = 11 Glandular

Genotype: $G_1g_1g_2g_2$ (2) $g_1g_1G_2g_2$ (2) $g_1g_1g_2g_2$ (1) = 05 Glandless

INHIBITORY GENE :

These genes have non of their phenotypes but they inhibits the expression of another non-allelic gene. e.g. In case of Rice, leaf colour

Phenotype	Purple	X	Green	Parents
Genotype	PPii.		pp II	
Gamete	Pi		pI	

↓

Pp Ii — Green — F_1

On Selfing ↓

9	3	3	1	
PI	Pi	pI	pi	F_2
Green	Green	Purple	Green.	

13 Green : 1 Purple.

e.g. Feather coll colour of Fowl.

INHIBITORY FACTOR WITH PARTIAL DOMINANCE

In such cases there is incomplete or partial dominance is shown by Inhibitory gene i.e. They show inhibitory effect in Homozygous (II) condition and partial inhibition in Heterozygous (Ii or iI) condition. e.g. Nature of Hair in Guinea pig.

Phenotype: Rough × Smooth — Parents

Genotype: RRii × rrII

Gamete: (Ri) (rI)

RrIi — F_1

Partially Rough

On Selfing ↓

Genotype	R I I	rrII	R – Ii	Rii	rrii
Number	3	3	6	3	1
Phenotype	Smooth	Smooth	Partially Rough	Rough	Smooth.

~~7 Smooth.~~

7 Smooth : 6 Partially Rough : 3 Rough.

RRII	RrII	RRIi	RrIi	RRii	Rrii	rrII	rrIi	rrii
1	2	2	4	1	2	1	2	1
Smooth	Smooth	Partially Rough	Partially Rough	Rough	Rough	Smooth	Smooth	Smooth

7 Smooth : 6 Partially Rough : 3 Rough

MULTIPLE GENE:

For certain character/trait there may be several genes. These are independent in their ~~segg~~ segregation, but cumulative/additive/quantitative effect on their phenotype e.g. kernel colour of wheat.

Phenotype: Dark Red × White — Parents.

Genotype: $R_1R_1R_2R_2$ × $r_1r_1r_2r_2$

Gametes: R_1R_2 and r_1r_2

~~R_1R~~ $R_1r_1R_2r_2$ — F_1

Medium Red

On Selfing ↓

Genotype	Dominant Allele	Frequency	Phenotype	Ratio
$R_1R_1R_2R_2$	4	1	Dark Red	1
$R_1r_1R_2R_2$	3	2	Medium Dark Red	4
$R_1R_1R_2R_1$	3	2	" " "	
$R_1R_1r_2r_2$	2	1	Medium Red	6
$r_1r_1R_2R_2$	2	1	" "	
$R_1r_1R_2r_2$	2	4	" "	
$R_1r_1r_2r_2$	1	2	Light Red	4
$r_1r_1R_2r_2$	1	2	" "	
$r_1r_1r_2r_2$	0 (None)	1	White	1

Some other examples are

— Length of corolla in Nicotiana longiflora

— Skin colour of human being.

This effect is not only in two of different pairs of gene, but may be also due to more ~~than~~ than two i.e. 03, 04, 05 ...... n.

Hence a simple formula is applied i.e.

$\left(\frac{1}{4}\right)^n$ Here n is the no. of different Alleles.

& the types are $\left(\frac{1}{2}+\frac{1}{2}\right)^n$

It has been expanded with the help of Pascal's Triangle

Number of different Pairs of Gene involved (n)	Expansion of ~~Expants~~ Binomial i.e $\left(\frac{1}{2}+\frac{1}{2}\right)^n$.
1	1 : 1
2	1 : 2 : 1
3	1 : 3 : 3 : 1
4	1 : 4 : 6 : 4 : 1
5	1 : 5 : 10 : 10 : 5 : 1
6	1 : 6 : 15 : 20 : 15 : 6 : 1
7	1 : 7 : 21 : 35 : 35 : 21 : 7 : 1
8	1 : 8 : 28 : 56 : 70 : 56 : 28 : 8 : 1
9	1 : 9 : 36 : 84 : 126 : 126 : 84 : 36 : 9 : 1
10	1 : 10 : 45 : 120 : 210 : 256 : 210 : 120 : 45 : 10 : 1

Pleiotropy: In such cases genes are controlling more than one character at a time.

e.g. Genes for bristle, eye and wing, bar eyed in case of *Drosophilla* ~~melag~~ *melanogaster* are not different but only one.

Here ~~Hence~~ One gene is controlling so many characters

- In case of *Lathyrus odoratus* same gene controles
  - colour of flower, seed coat, Red spot in axil of leaves.
- In case of Cotton
  - size of plant, boll & number of seeds.

etc.

Modifiers: Such genes may modify the phenotypic effect of a major gene.

~~It is~~ They may enhance ~~of~~ or reduce the quantitative effect.

e.g. Skin/Body colour of human beings

Supressors: Such genes inhibit the effect of mutant genes over wild one

e.g. Su-s gene in *Drosophilla melanogaster* supresses the expression of dominant mutant Star eye (S).

Genes for Supressors for wings.

PENETRANCE:

It is ability of a gene to be expressed to any degree.
In case of Most of genes it is complete, Pea characters.
But in some cases it is incomplete.
e.g. Red colour of Snapdragon.
e.g. Polydactyly in human being (P).
Expressed in Homozygous (PP) but some times fail to be expressed in Heterozygous (Pp) condition.

Expressivity:

The gene may penetrate but their of phentypic expression may be effected by some other gene.
e.g. Polydactyly is mainly in ~~right~~ Left hand and hardly in the Right one.

Atavism:

Genes responsible for appearance of characters of remote past (ancesstors).
e.g. Appearance of tail in some human baby