

INTERACTION OF GENE FACTOR HYPOTHESIS

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

- 1. One factor / gene controls 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 segregation.

~~Vidur~~

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

It has been found that

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

~~Vidur~~

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 $\rightarrow x$
 b B $\rightarrow y$.

Each dominant gene A & B have their 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 to a new character z .

Abbreviated genotypic ratio:

Serial Number	Genotypes	Ratio	Abbreviated Genotypes	Ratio
1.	$AA BB$	1		
2.	$Aa BB$	2	AB	9
3.	$AA B$	2		
4.	$Aa Bb$	4		
5.	AA $AA bb$	1.	Ab	3
6.	$Aa bb$	2		
7.	$aa BB$	1	aB	3.
8.	$aa Bb$	2		
9.	$aa bb$	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.

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.

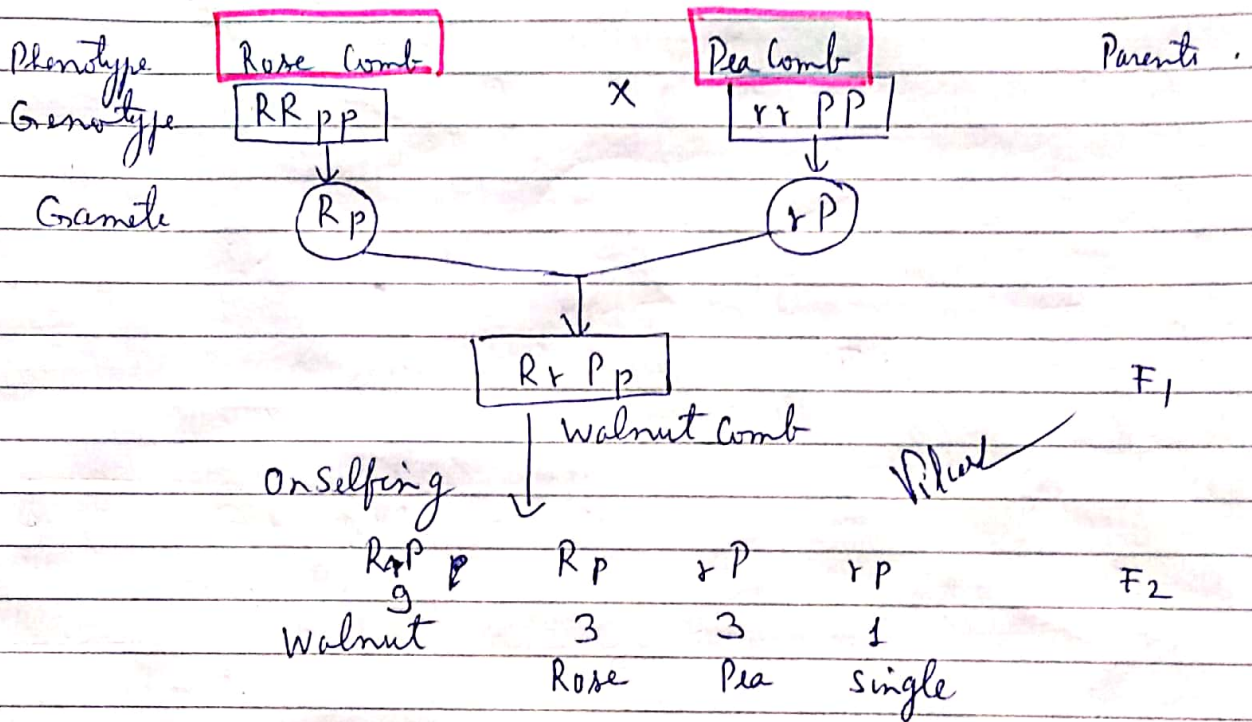
- v) Duplicate Gene.

- vi) Inhibitory Gene.

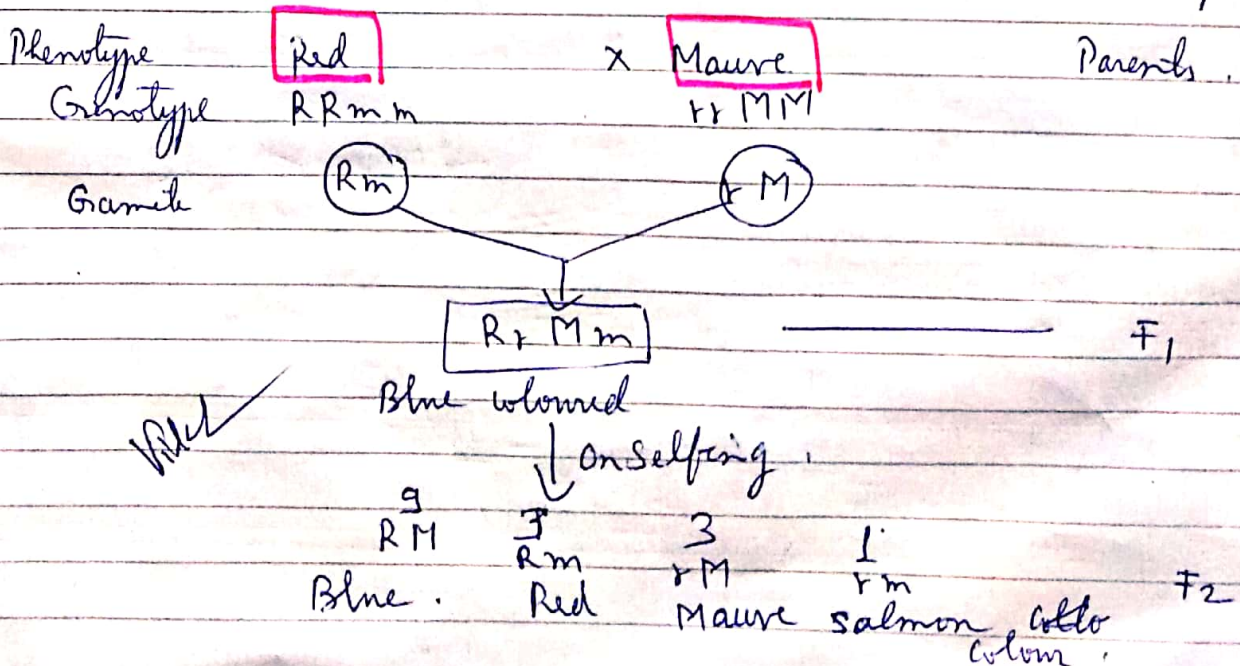
- vii) Polygenic Inheritance / Additive Factor.

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



Here Inheritance of of Colours of Flowers in Streptocarpus

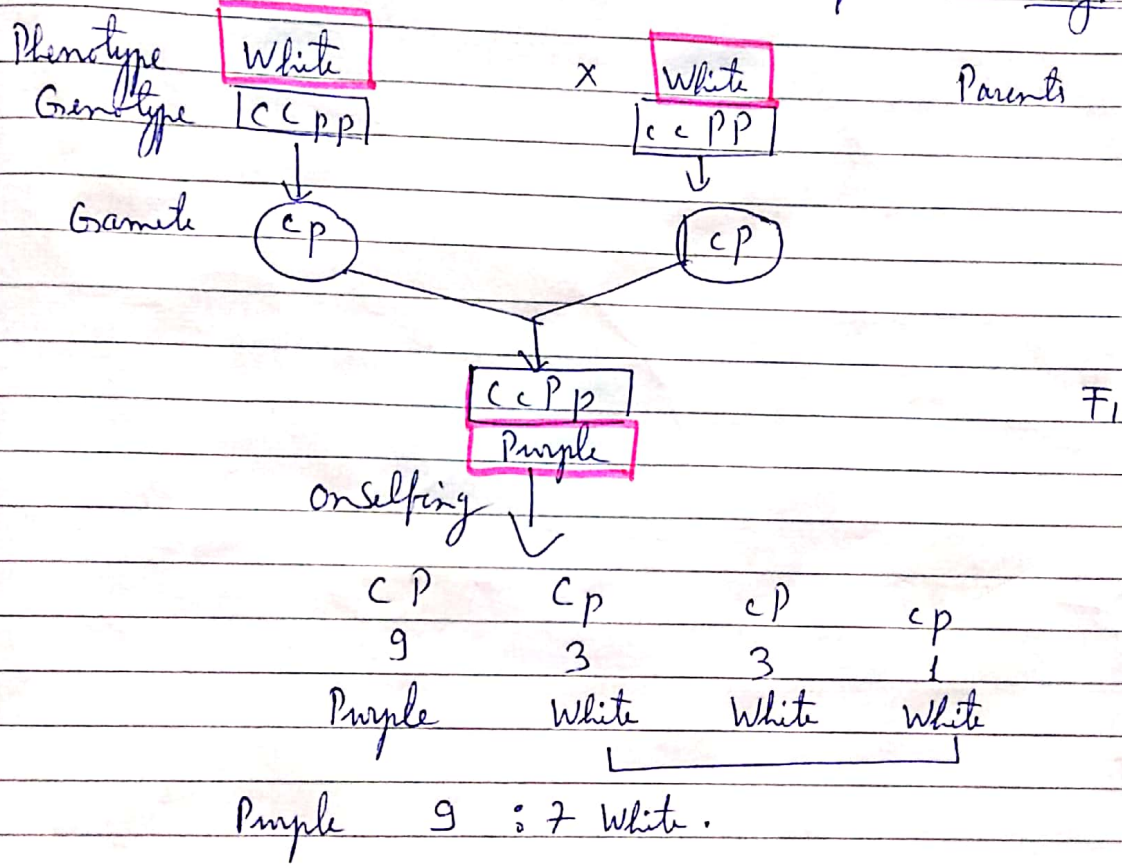


COMPLEMENTARY GENE

1st studied by Bateson & Punnett.

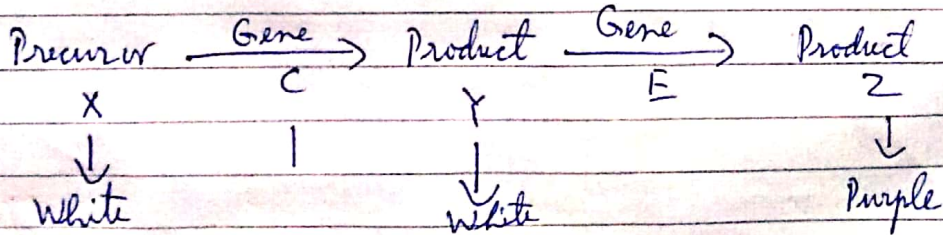
In such cases there are two independent pairs of genes which fail to express alone but express themselves in combination i.e. when both are present together. e.g.

Colour of Flower in *Lathyrus odorata*



⇒ 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.



EPISTASIS :

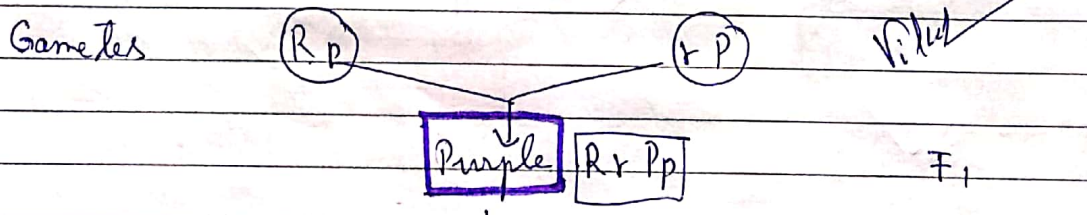
Here a pair of genes at one locus may mask the the expression of gene a pair of gene at different locus.

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

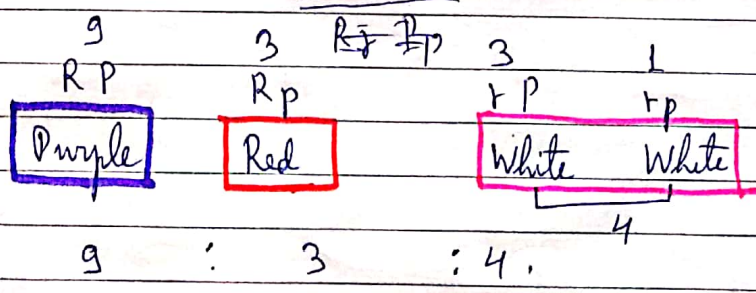
It is of two types .

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 PP.	



On Selfing ↓



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 .

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

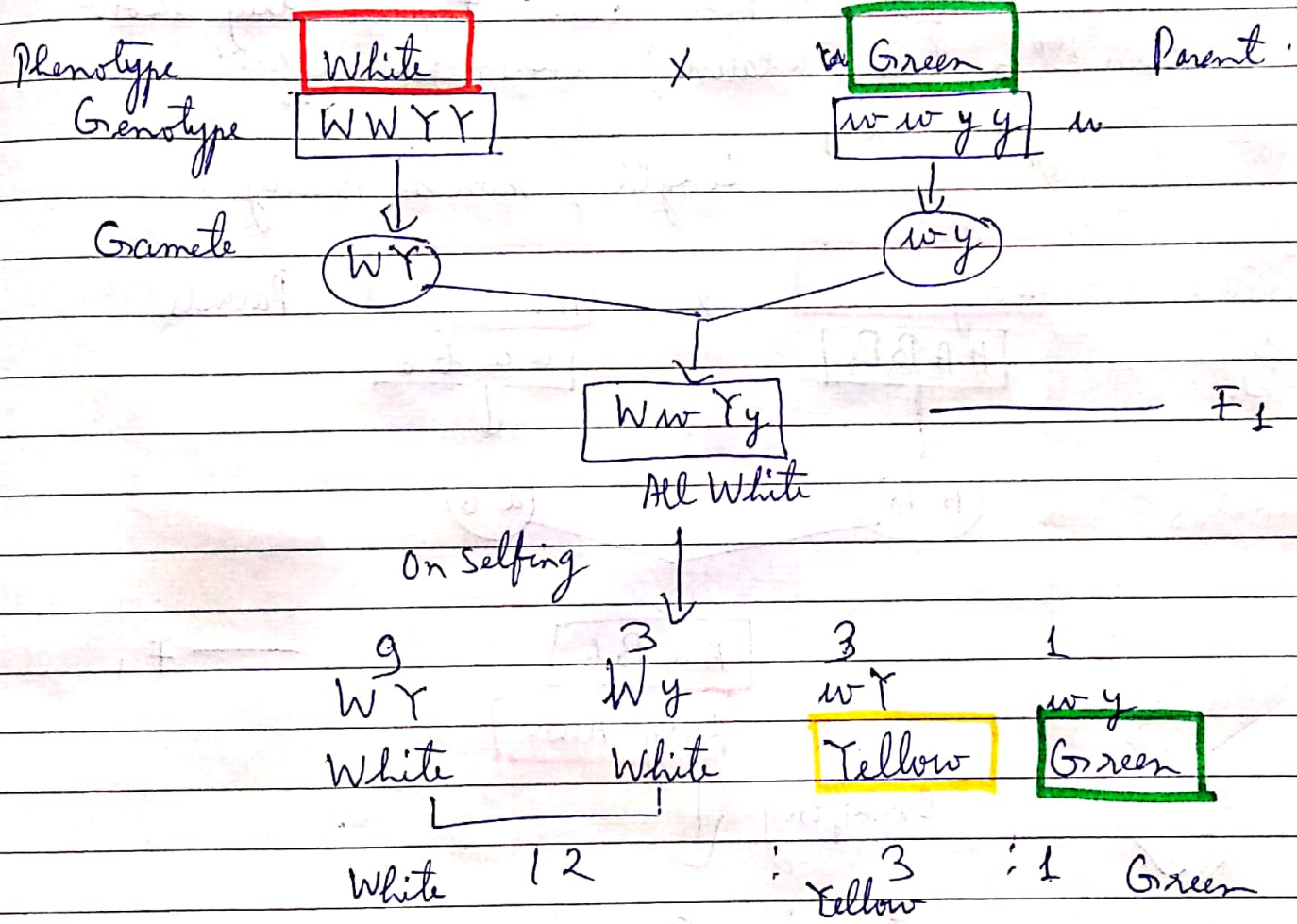
On Selfing

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

9 : 3 : 3 : 1
 9 : 3 : 4

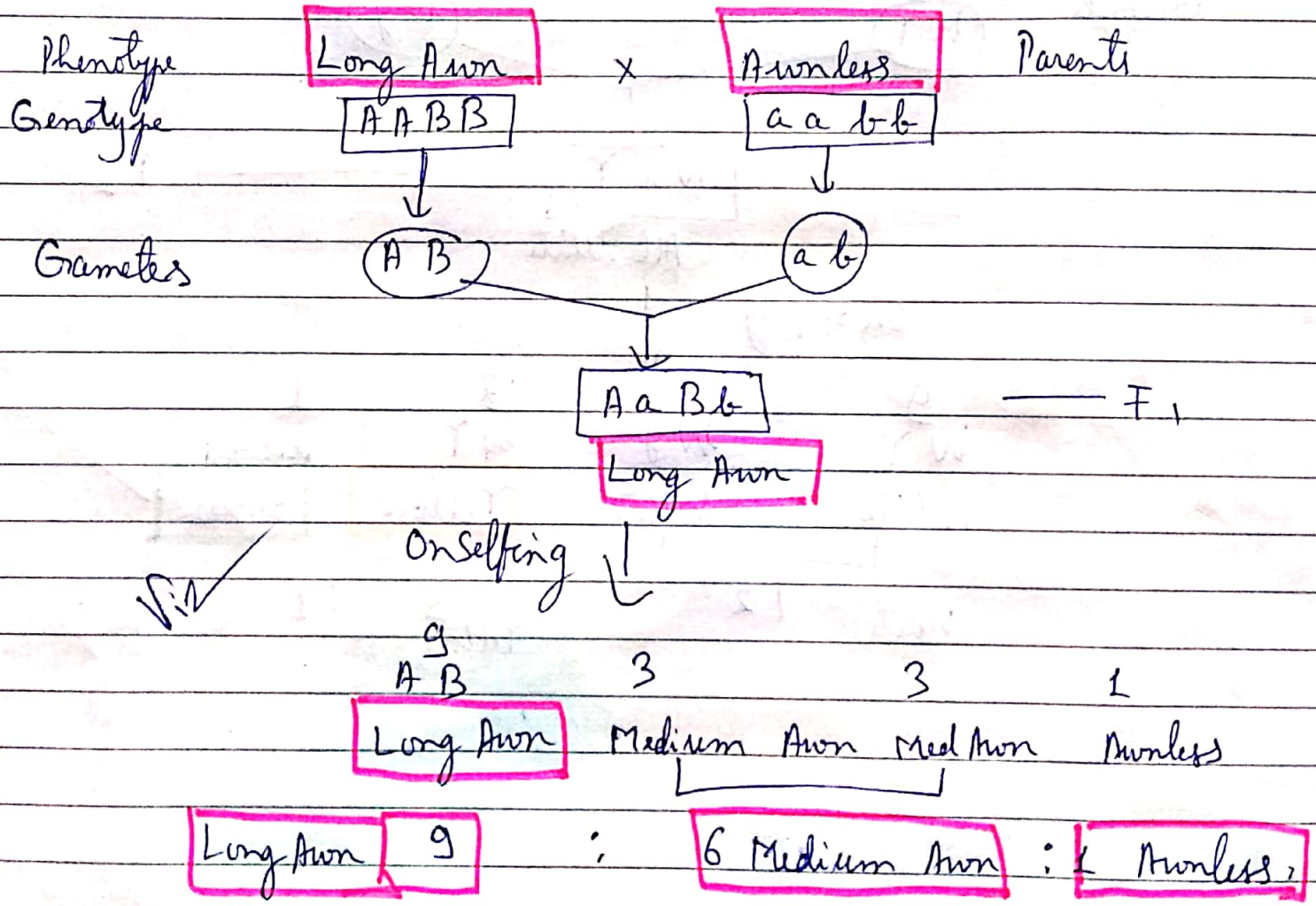
(b) Dominant Epistasis:

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



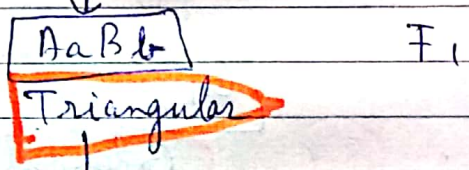
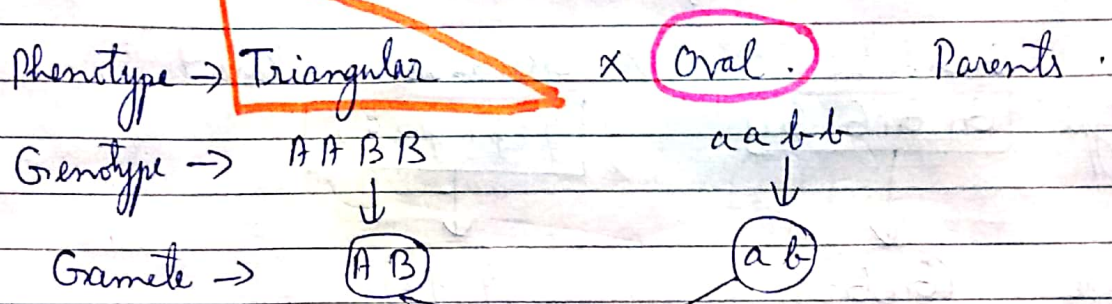
POLY MORPHIC GENE:

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.

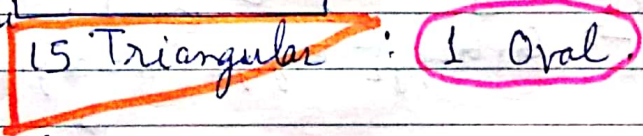
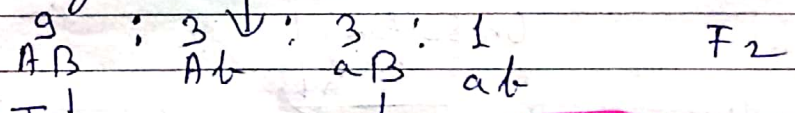


DUPLICATE GENE

In this case two pairs of genes of different genes locus controls the character resulting in same phenotype in either single (alone) or double (together) condition. eg shape of Capsule of Shepherd's purse. i.e. Capsella bursa-pastoris.



On Selfing



Other examples are

- a) Shape of seeds of Lathyrus sp.
- b) Colour of endosperm of Maize.
- c) Awned variety of Rice etc.

VA

Duplicate Gene with dominance Modification:

In such cases when two dominant genes pairs come together they i.e. the dominant phenotype 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 $G_1 G_1 G_2 G_2$ $g_1 g_1 g_2 g_2$

Gamete $(G_1 G_2)$ $(g_1 g_2)$

$G_1 g_1 G_2 g_2$ **Glandular** F_1

✓✓

On selfing ↓

Genotype → $G_1 G_1 G_2 G_2$ $G_1 G_1 g_2 g_2$ $G_1 g_1 G_2 G_2$ $G_1 g_1 g_2 g_2$ $G_2 G_2 g_1 g_1$ $G_2 g_2 g_1 g_1$ $g_1 g_1 G_2 G_2$ $g_1 g_1 g_2 g_2$

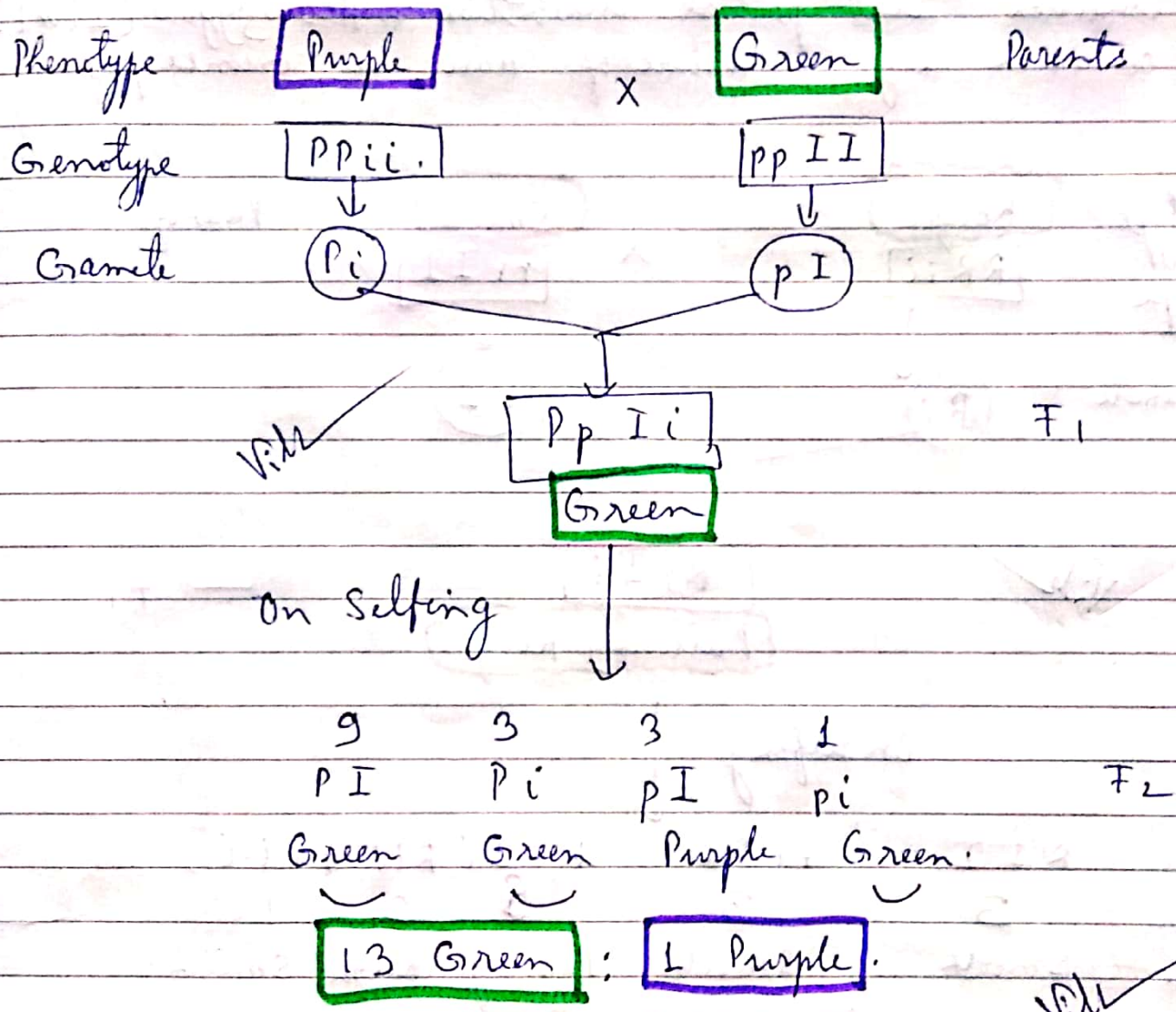
Genotype → $G_1 g_1 G_2 g_2$ $G_1 G_1 g_2 g_2$ $g_1 g_1 G_2 G_2$ $g_1 g_1 g_2 g_2$ = **11 Glandular**

Genotype : $G_1 g_1 g_2 g_2$ $g_1 g_1 G_2 g_2$ $g_1 g_1 g_2 g_2$ = **5 Glandless**

✓✓

INHIBITORY GENE:

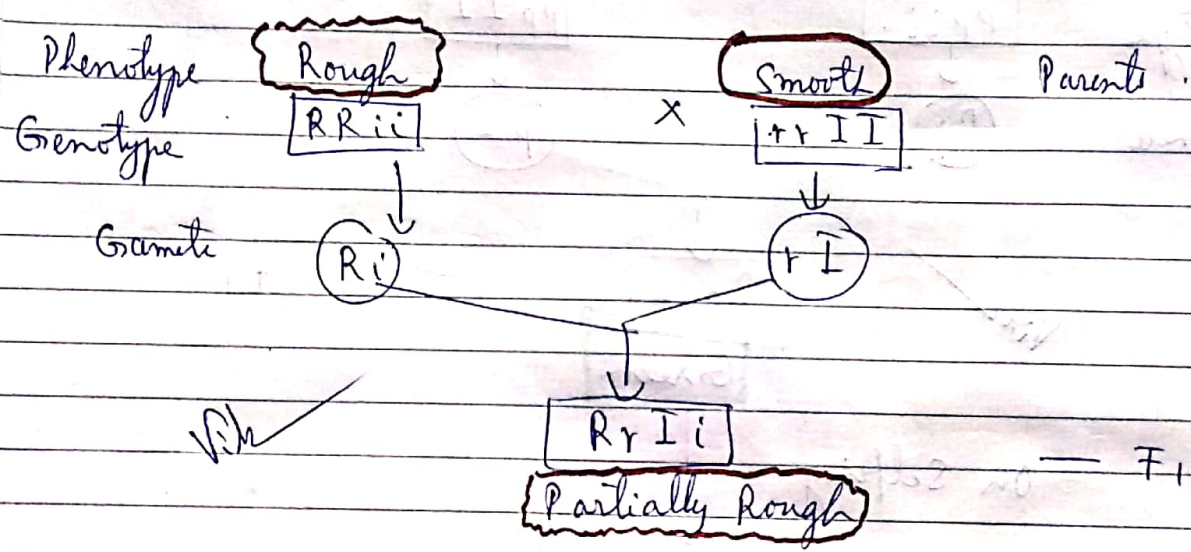
These genes have none of their phenotypes but they inhibits the expression of another non-allelic gene. e.g. In case of Rice, leaf colour.



e.g. Feather 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) condition. e.g. Nature of Hair in Guinea pig.



On selfing ↓

Genotype	RII	$rrII$	$RrIi$	$Rrii$	$rrii$
Number	3	3	6	3	1
Phenotype	Smooth	Smooth	Partially Rough	Rough	Smooth

7 Smooth : 6 Partially Rough : 3 Rough.

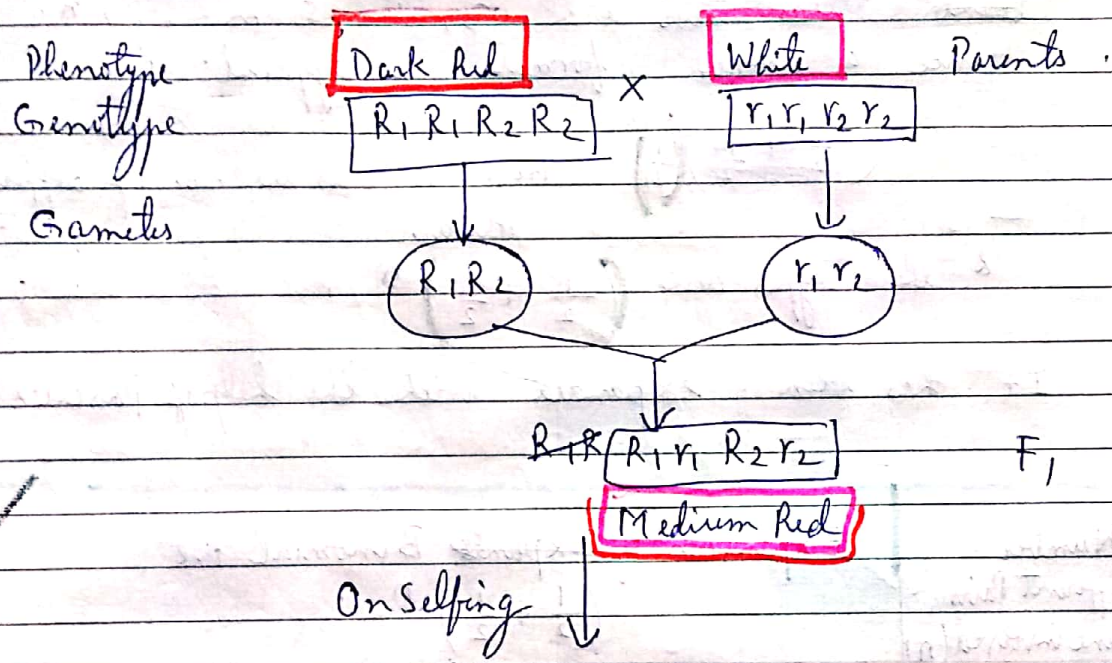
RII	$RrII$	$RRii$	$RrIi$	$RRii$	$Rrii$	$rrII$	$rrIi$	$rrii$
1	2	2	4	1	2	1	2	1
Smooth	Smooth	Partially	Rough	Smooth	Smooth	Smooth	Smooth	Smooth

7 Smooth : 6 Partially Rough : 3 Rough.

7 Smooth : **6 Partially Rough** : **3 Rough**

MULTIPLE GENE:

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



Genotype	Dominant Allele	Frequency	Phenotype	Ratio
$R_1 R_1 R_2 R_2$	4	1	Dark Red	1
$R_1 r_1 R_2 R_2$	3	2	Medium Dark Red	4
$R_1 R_1 R_2 r_1$	3	2		
$R_1 R_1 r_2 r_2$	2	1	Medium Red	6
$r_1 r_1 R_2 R_2$	2	1		
$R_1 r_1 R_2 r_2$	2	4		
$R_1 r_1 r_2 r_2$	1	2	Light Red	4
$r_1 r_1 R_2 r_2$	1	2		
$r_1 r_1 r_2 r_2$	0 (None)	1	White	1

Some other examples are

- Length of coeils 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 two i.e. 03, 04, 05 m... n.

Hence a simple formulæ is applied i.e.

$$\binom{n}{2} \left(\frac{1}{2}\right)^n$$

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 Expanded 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 : 252 : 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 Drosophila melanogaster are not different but only one.

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

- In case of Lathyrus odoratus same gene controls
 - 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 or reduce the quantitative effect.

e.g. Skin / Body colour of human beings

Suppressors:

Such genes inhibit the effect of mutant genes over wild one

e.g. Sm-s gene in Drosophila melanogaster suppresses the expression of dominant mutant star eye (S).

Genes for suppressors 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 phenotypic 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 (ancestors).

e.g. Appearance of tail in some human baby