17/1/20

GENETICS – 1

L-1

① INTRODUCTION

* **Genetics** :- It is study of inheritance & variations.

* **Heredity** :- it is study of inheritance.

* Transfer of Hereditery characters from parents to progeny is Klg "inheritance".

* **Germplasm** :- Part of parents which is transferred into progeny in sexual reproduction.

  eg:- In oogamy Nucleus of ♂ + ♀ Gametes + Mitochondrial & Plastidial DNA of female parent.

* **Character** :- Any biological feature for eg:- color of flower, Height of Plant etc.

* **Traits** :- diff. forms of a character, eg:- Red, Blue, white;

* **Gene** :- Functional unit of Genetic material it may be structural (Cistron), or regulatory.

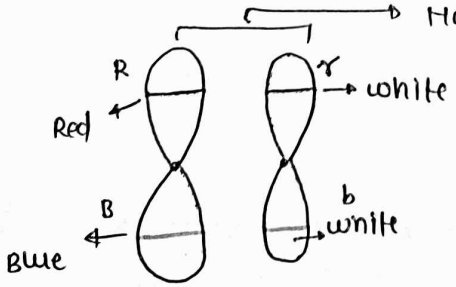
* **Allele / Allelomorphs** :- Diff forms of a gene which are fnt at same locus but produce diff traits

* A Gene may have many Alleles.

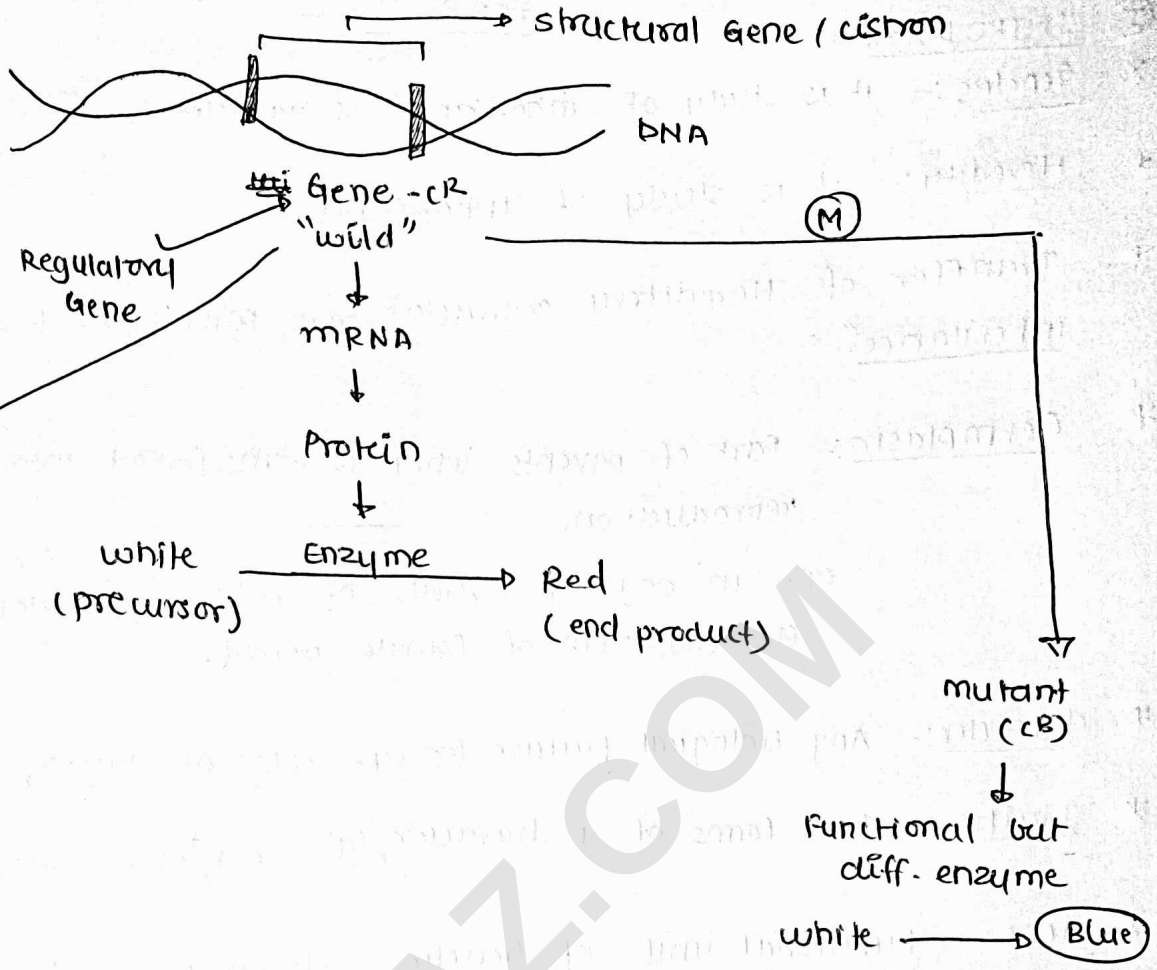
* Gene control characters by producing proteins. A Gene may control many characters & a character may be controlled by ~~may~~ many genes.

* **locus** :- Address or position of a gene.

  eg:- In foll. diagram there are



* characters = 1, colour of flower
* Traits = Blue, Red; white
* loci/Genes = 2 (R & B)
* Alleles → R has 2 Allele → R, r
  B " " " → B, b



★ Genotype $\xrightarrow{+\text{environment}}$ Phenotype

eg:- TT — eg:- Tall

★ Possible Genotypes $= \frac{n(n+1)}{2}$ for 2n

n = Types of Alleles.

* ABO system (in humans) has 3 Alleles.

so possible Genotypes $= \frac{3 \times 4}{2} = 6.$

Types of Gametes

Q. How many types of Gametes can be produced from AaBBCc

Ans.

Type of Gametes $= 2^n$

n = no. of Hybrid

AaBBCc $= 2^2 = 4$

A – B $\begin{matrix} C \\ c \end{matrix}$ $= ABC$
$= ABc$

a – B $\begin{matrix} C \\ c \end{matrix}$ $= aBC$
aBc

① RrTt $2^2 = 4$

② aaBb $= 2^1 = 2$

③ aabb $2^0 = 1$

④ Genotype of Mohan is AaBb due to human (♂) AaBbXY $= 2^3 = 8$

★ use of Probability ; Permutation & combination in Qs.

"AND" ——— "X" Multiply the probabilities

"OR" ——— "+" Addition

Ques:- Blood Group of parents is I^AI^B & I^OI^O Probability of boy with B Blood Group.

$I^AI^B \times I^OI^O$

I^A I^B I^O

I^AI^O I^BI^O

Probability of ♂ $= \frac{1}{2}$

" " B B.G $= \frac{1}{2}$

So ♂ of B $= \frac{1}{4}$

Q. A couple has a child what is probability of its being boy or Girl

Ans. $\frac{1}{2} + \frac{1}{2} = 1$

• TtRr × TtRr

P. of Tall & white.
T d R w
(3:1) (3:1)

$\frac{3}{16}$

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L-2

Q. A couple has 4 children, what is posibility of one boy & 3 girls?

Sol.

$$\frac{n_B!}{n_1! \times n_2!} (P_1)^{n_1} (P_2)^{n_2}$$

n = Total events = 4

n_1 = 1 (Boy)

P_1 = Probability of boy = $\frac{1}{2}$

n_2 = 3 (Girl)

P_2 = Probability of Girl = $\frac{1}{2}$

$$= \frac{4!}{1! \times 3!} \left(\frac{1}{2}\right)^1 \left(\frac{1}{2}\right)^3$$

$$= \frac{4 \times 3 \times 2 \times 1}{1 \times 3 \times 2 \times 1} \times \frac{1}{2} \times \frac{1}{8} = \frac{1}{4}$$

Q. ☆☆ Albinism in human is controlled by "a" (recessive gene), both (aa)

• parents are carriers / Heterozygous – Aa (Normal)

what is possibility of 1 Normal & 3 Albinic children in family of 4.

Sol. Aa × Aa

↓

AA : Aa : aa.
Normal diseased

$n = 4$

$n_1 = 1$ (Normal) $n_2 = 3$ (Albinic)

$P_1 = \frac{3}{4}$ $P_2 = \frac{1}{4}$

$$= \frac{4!}{1! \times 3!} \times \left(\frac{3}{4}\right)\left(\frac{1}{4}\right)^3 = \frac{3}{64}$$

Ques A couple has 7 children & All are boys what is probability of 8th. child ~~&~~ ~~girl~~. being a girl.

Sol. $\frac{1}{2}$

⑪ PRE- MENDELISM

* Acc. to ~~Kori~~ Kolreuter

i) Contribution of both parents is equal in characters of off spring.

ii) F_2 generation is more similar to F_1.

* John Goss has already worked on Garden Pea (1822)

* Blending Inheritance

→ Acc. to earlier scientist, character of parent inherit in liquid form & show blending in offspring
it was discarded by mendel by law of segregation.

⑫ MENDELISM

Ⓐ MONO HYBRID CROSS

⇒ study of one character only
eg:- colour of flower

Parents (P_1) ♂ Red × ♀ white
Gametes (G) RR rr
F_1 Generation (R) (r)

Rr All Red flowered

selfing

P_2: ♂ Rr Red × ♀ Rr red
G_2: (R) (r) (R) (r)

forked line ~~red~~ method

F_2: RR Rr Rr rr

* Genotypic ratio → RR : Rr : rr
1 : 2 : 1

Phenotypic Ratio (= Monohybrid Ratio) — Red : white
3 : 1

Note :- * Parents =? from the starting of cross
* Phenotype is preferred over Genotype if not mentioned in the Q.

* RR × rr → Rr
Rr × Rr → RR : Rr : rr (1 : 2 : 1)
Rr × rr → Rr : rr (1 : 1)
Rr × RR → Rr : RR (1 : 1)

(B) Dihybrid cross :- study of any two character
eg:- Height of plant & colour of the flower.

P_1 :- Tall, Red × Dwarf white
G_1 :- TTRR ttrr
F_1 :- TR tr
TtRr Tall, red

P_2 : ♂ TtRr Tall red × ♀ Tall red TtRr

* Results of F_2 Generation

Genotype	G. Ratio	Phenotype	Ph. Ratio
TTRR	$2^0 = 1$	Tall Red T_ R_	9 Parental
TTRr	$2^1 = 2$		
TtRr	$= 2$		
TtRr	$= 4$		
TTrr	$= 1$	Tall white T_ rr	3
Ttrr	$= 2$		

tt RR tt Rr	= 1 = 2	Dwarf Red tt R_	3
ttrr	= 1	Dwarf white ttrr	1 (Parental)

In F_2 Gen. (n=2 ; Dihybrid cross)

① Total phenotypes $= (2)^n = 2^2 = 4$

② Phenotyic Ratio $= (3:1)(3:1) = 9:3:3:1$

③ No. of boxes in checker board $= (4)(4) = 16$
(Total zygote)

④ Genotype $= (3)(3) = 9$

⑤ Genotypic Ratio $= (1:2:1)(1:2:1)$

$=$

⑥ Tri hybrid cross (in F_2 Gen.)

① $2^2 = 8$

② 27 : 9 : 9 : 3 : 9 : 3 : 3 : 1

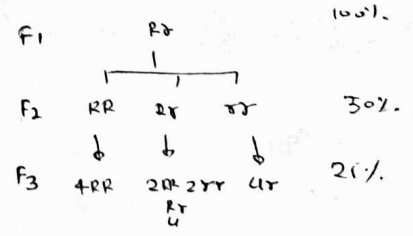
③ $(4)^3 = 64$

④ Genotype → $3 \times 3 \times 3 = 27$

Q. what is the % of hybrid in F_3 Gen. of a monohybrid cross?

Sol. % of hybrid in

$F_1 \longrightarrow F_2 \longrightarrow F_3 \longrightarrow F_4$
100% 50% 25% 12.5%



Q. In a typical dihybrid cross 800 plants are produced what is the no. of Tt Rr plant.

$\frac{4}{16} \times 800 = 200$

$\frac{2}{4} \times \frac{2}{4}$

* Parental : Recomb = 10 : 6
- Pure — 4/16
- Monohybrid — 8/16
- Dihybrid — 4/16

Q. A Tall plant with Red flowers is crossed with dwarf plant with white flowers & produce 100 Tall red & so dwarf ~~white~~ red what is Genotype of parents

Sol.

$T\_R\_ \times ttrr$

Tall red | Dwarf red

$TtRr$

Q A Tall plant with Red Axillary (dominant) flowers is crossed with dwarf plant having white & terminal flower & it produce all Tall plant with red flowers 50% plants are terminal & 50% with Axillary flower

$TTR\_A\_ \times ttrraa$

$T\_R\_aa.$

$TTRRAa$

Q A Person with AB B.G marrys a women of B B.G whose father was O what is possibility of B.G in their child

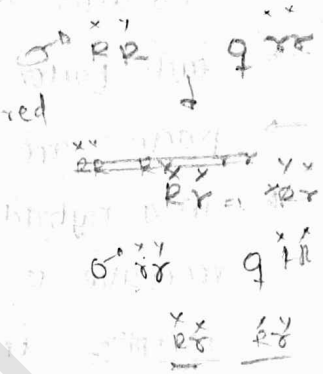
$AB \times BO$

A B | B O

AB | AO | BB | BO

(D) Reciprocal crosses

Q. In Drosophila color of eyes is X linked & red color is dominant over white, what is phenotype of offspring if red eyed male ♂s crossed with white eyed female?



Sol.

$\sigma^{\prime} X^R X^R \times \varphi X^r X^r$

$X^R \quad Y^R \qquad X^r$

$X^R X^r \qquad X^r Y^R$

Female red eyes & male white eyes

Sol.

$\sigma^{\prime} X^r Y^R \times \varphi X^R X^R$

$X^r \quad Y^R \qquad X^R \quad X^R$

$X^R X^r \qquad X^R Y^R$

Female red male ~~white~~ Red eyed

* In R.C parents i.e source of Gametes are inter changed to observe the effect of sex of parent on the phenotype of offsprings.

for eg:-

♂ Tall	×	♀	Dwarf
♀ Tall	×	♂	Dwarf

* results are changed in cytoplasmic & sex linked inheritance but results remain unchanged in mendalian inheritance (i.e Nuclear & Autosome).

(€) Laws of Mendel

- on basis of hybridisation experiment in Garden Pea (Pisum sativum; 2n=14)

① LAW OF DOMINANCE

→ character are controlled by particulate structures k/a "factors" (Gene)

→ each factor has 2 contrasting forms (Alleles).

→ factors are pnt in pairs. in organisms.

→ in a hybrid organism (Aa) only dominant trait is expressed & recessive is hidden.

exceptn:- incomplete & co-dominance.

② LAW OF SEGREGATION / PURITY OF GAMETES

→ factors do not show any blending & they separate / segregate during gametogenesis

→ each gamete receieve only one Allele. so gametes are Always pure

→ universal law i.e without any exceptation.

* segregatn occurs during Meiosis. (Anaphase-1) so during gametogenesis in Animals & sporogenesis in plants.

* Above mentioned laws were based on mono hybrid cross i.e 3:1 ratio.

③ LAW OF INDEPENDENT ASSORTMENT

→ based on dihybrid cross i.e (9:3:3:1) Phenotypic ratio

→ Acc. to this law inheritance of 1 character remains independent of other characters.

→ exception:- linkage

explanation:- gene pnt on same chromosome (Homologous) show linkage i.e inherit together while gene pnt on diff chromosome (Heterologous) show independent assortment.

Q. Opp. phenomenon of linkage is

(a) independent Assortment ✓

(b) crossing over

Q. ◇ccurence of recessive phenotype in F_2 generation is explained by

(a) law of segregation ✓

(b) law of purity of Gametes ✓

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④ TEST AND BACK CROSS

Back cross

F1 Hybrid

eg:- AaBb × AABB or aabb.

(Parental Genotype in typical cross)

Test cross

unknown Genotye x Recessive

OR

Aa x aa

Backcross / outcross

eg:- Aa x AA (Pure dominant)

→ To suppress the recessive Allele

OR

To tes Potential Genotype

* Each test cross is a back cross but back cross is not a test cross.

Significance:-

↳ To determine the Genotype

OR

linkage.

* **Test cross ratio (Typical)**

- Monohybrid (Aa x aa) = 1:1
- Di hybrid = 1:1:1:1
- Trihybrid = 1:1:1:1:1:1:1:1

Q. No. of characters in Pea Pod → 3 [Pod shaped, color, flower position]

Q Back cross is

1) AA x aa
2) Aa x Aa
3) Aa x aa (Test cross) } Back cross.
4) Aa x AA

(5) GENE INTERACTIONS

(A) Intra-Genic / Inter Allelic

blw Allele of a Gene (same cross)

eg:- incomplete dominance

(B) Inter-Genic or Non-Allelic

→ blw diff. Genes (at diff loci.

eg:- complementary Gene

(A) Intra-Genic / inter Allelic

(1) Incomplete Dominance

* Discovered by correns in Mirabilis
* in this phenomenon dominant Gene can't supress phenotype of recessive Allele so an intermediate phenotype in F1 generation.
* F_1 Generation is not similar to any parent.
* Test cross in not required.
* eg:- Pink color flower in
  - Mirabilis Jalapa (4 o' clock Plant)
  - Anthrhinum Majus (snapdragon / dog Flower)

Red Flower (RR) x white (rr)

↓

F1 Rr (PINK)

RR	Rr	rr
1	2	1
Red	Pink	ratio.

→ same Genotype + same phenotypic ratio.

Q. A pure red flowered plant is crossed with a white flowered plant. what is % of red flowered plant in F_2 generation.

(A) 25 (B) 50 (C) 75 (D) 100

Q. IN a ~~series~~ species, character of Height show complete dominance (Tall & Dwarf) and character of flower color show I.C. Dominance (Red, Pink & white) 800 plants are produced in F_2 generation then:.

(a) F_2 Phenotypic ratio

(b) No. of Tall, Pink plants

(c) No. of white flowered plants

(d) No. of TtRR plants.

Sol. (A) $\overset{T}{(3}:\overset{t}{1)}\ \overset{R}{(1}:\overset{R}{2}:\overset{W}{1)}$

3 : 6 : 3 : 1 : 2 : 1

(B) $\frac{6}{16}$ or $\frac{3}{4} \times \frac{2}{4} = \frac{6}{16} \times 800 = 300.$

(C) $\frac{4}{16} \times 800 = 200$

(D) $\frac{2}{16} \times 800 = 100.$

Ques. what is ratio of any one pair of contrasting character in dihybrid cross?

Sol:- 3:1

Ques:- what is ratio of 2 pair of contrasting characters in a trihybrid cross?

Sol. 9:3:3:1

② Co dominance (1:2:1)

↳ Both Alleles express themselves equally so F1 show mosaic of both phenotypes

eg:- • Skin color in cattles (Red x white → Roan  Red white { Resemblence to both parents }

• AB blood grp ; examples of multiple Allelism.

Q. same Genotypic & Phenotypic ratio are found in :-

a) incomplete
b) codominance } both (if given)
c) Dominance
d) complementary Gene

* ABO Blood Group system

↳ 3 Phenomenon → Multiple Allelism ⇒ 3 Alleles
→ Dominance I^A — I^o ; I^B — I^o
→ Co Dominance I^A — I^B = AB

Gene → I = Iso agglutinogens
(OR)
L = Discovered by Landsteiner & levine. [L^A + L^B or L°L]

↳ on 9th chromosone

• Rh factor on 1st chromosome

Ques:- ABO B.G syst. is controlled by three Alleles what is possible no. of Alleles in population, somatic cells & Gametes?

Sol.

Ques. what is no. of possible Genotypes in ABO B.G-s in humans.

Sol. Acc. to 2N

$$= \frac{3(3+1)}{2} \Rightarrow 6$$

③ Multiple Allelism

occurence of more than 2 Alleles for eg:
- Sexual incompatibility
- ABO Blood Group sysl.
- Coat color in most of Animals (eg:- cow, dog, Rabbit)
- eye color in drosophila.

④ Pleotropism

A Gene affects two or more characters

eg:- Most of genetic disorders, lethal Genes & 'B' Gene of Garden Pea.

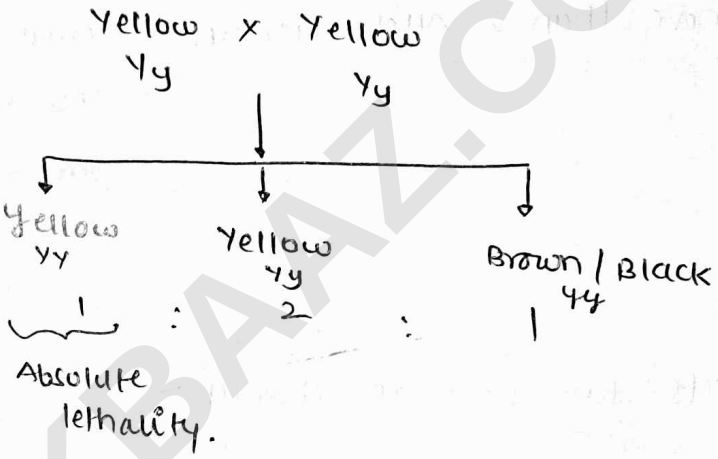
* ~~B= Branching~~
* B = starch branching enzyme

Genotype	starch Granules	shape of seed
BB	Larger	Round
Bb	Medium (incomplete domin.)	Round (Dominance)
bb	smaller	wrinkled

starch Granules → incomplete dominance
shape of seed → complete dominance

⑤ Lethal Genes

* These genes cause death or severe disability in organism
* lethality may appears • Before birth (Absolute lethality)
  • In childhood (sub lethality)
  • After sexuality mature (delayed lethality)
* lethal Gene are recessive in nature & also show Pleotropism.
* foreg:- • many genetic disorders
  • Yellow coat color in mice.



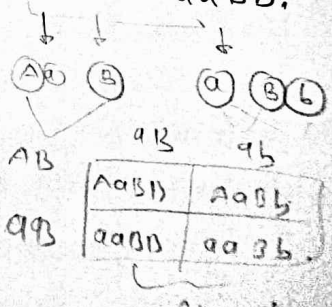
* "Y" Gene is dominant for skin color
  recessive for lethality.

Q. Flower color in a plant is controlled by 2 genes. Presence of any dominant Allele produce red color while color appears when both genes are in recessive form. presence of both gene also produce red color.

(i) what is phenotypic cross in ~~typical~~ F_2 generation

" " " " if Parents are AaBB x aaBb.

A_B_
aaB_



Hint:- Duplicate Gene

Q. In lathyrus odoratus (sweet Pea) Flower color is controlled by 2 gene)

- Purple color appears if both Gene are tht
- in other combinath color remain white.

Sol. (a) what is dihybrid ratio

(b) Phenotypic ratio if parents are $CcPP \times CcPp$.

(a) 9:7
Purple white

(b)

$CcPP \times CcPp$

↓ ↓

(C)(c)(P) (C)(c)(P)(p)

	CP	Cp	cP	cp
CP	P	P	P	P
cP	P	P	W	W

P.R = 6 : 2
P : W

दो Group हैं (C) & (P)
जब Pair बने Tb
(C)_ (P)_.
blank में दूसरा Gene भी रखो it will be dominant
C_P_
दूसरा Always white.

(B) Non- Allelic (OR) Intergenic Interactions

these interaction occur b/w diff. gene i.e Gene tht at diff. loci

① complementary Genes (9:7)

* Discovered by Bateson & Punnett while studying Flower color in sweet Pea.

* These genes show no phenotype or similar phenotype when tht Alone but interact to produce a new phenotype when tht together.

white x white
CCpp ccPP
↓
F1 CcPp All purple
↓ selfing
F2 9 Purple : 7 white
C_P_ (3 C_pp, 3 ccP_, 1 ccpp)

C_P_ → Dominant
कुछ भी recessive आया → white

Raw material
↓ enzyme 1 → C
Intermediate
↓ enzyme 2 → P
Pigment

Dominant form → जिसे ये to produce particular character

explanation

Raw material —C_→ Intermediate —P_→ Anthocyanin (Purple)
(end product)
↓ (white)
K/a chromagen.

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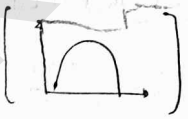
	Non Allelic G.I	Explaination
2)	Supplementary Genes (9:3:4)	white —A_→ Blue —B_→ Red (eg:- coat color in Mice) A_ : independent B_ : Dependent / Modifier
3)	Collaborative supp. Genes (9:3:3:1)	white —A_→ Blue; white —B_→ Red; A_B_ Purple * Both Gene show their own phenotypes when int alone but produce a new phenotype when int together.
4)	Duplicative Gene OR Pseudo Allely (15:1)	A_ = Red aa = white B_ = Red bb = white A_B_ = Red * similar behaviour at both loci.
5)	Additive (OR) collaborative Gene (9:6:1)	* Duplicative Gene with additive effect (A_B_ = Dark red)
6)	Inhibitory Gene (13:3)	white I_ →x R_ Red • I_ has no phenotype of its own but inhibits the expression of another gene.
7)	Epistasis	similar to dominance but a diff. loci.
a)	Dominant Epistasis (12:3:1)	A_ = Red (epistatic) ; aa = Neutral Hypostatic B_ Blue ; bb = white
b)	Recessive Epistasis (9:3:4) * Ratio is similar to supplementary genes eg:- coat color in mouse 9:3:4 Agouti Black Albino.	A_ = Neutral ; aa = Red (Epistatic) Hypostatic. B_ = Blue ; bb = white

(6) Quantitative (OR) Polygenic inheritance

* discovered by Kolreuter
  father of quantitative inheritance.
* detailed study by Nilsson - Ehle in kernel/seed color.
* controlled by 2 polygenic genes & ratio (phenotypic) 1 : 4 : 6 : 4 : 1
  Red | dark pink | pink | light pink | white
* each functional allele is kla contributing Allele & each ~~gene~~ is kla "Poly Gene"
* Polygene are duplicate gene.
* Monohybrid ratio = 1:2:1
  Dihybrid ratio = 1:4:6:4:1 (Binomial)
  Trihybrid ratio = for eg. skin color in Human beings.

  1 : 6 : 15 : 20 : 15 : 6 : 1
  AABBCC | AaBbCc | aabbcc
  Black/Nigro | Mullato | white (caucasian)
  ← Fesing Pigmentation.
* environmental effect is more on quantitative character, so phenotype show cont. variations. usually can't be characterised into discrete classes.



Quer:- A Mullato (AaBbCc) marries with another Mullato what is % of Parental phenotype in OFFspring

→ $\frac{20}{64}$ (consider the given)

Quer:- Nigro marries with caucasian what is % of parental phenotype in their children?

→ All mullato

Quer. In plant ht. is controlled by 2 polygenes. ht. of pure recessive (aabb) is 3 feet, ht. of Pure dominant (AABB) is 11 ft & ht. of F1 Hybrid (AaBb) is 7 feet

(a) what is contribution of each polygene? (contributing Allele)

→ 2

(b) what is phenotypic ratio if both parents are AaBB

→ 1:2:1

(c) what is RR if both parents are AaBb X AaBB.

1:3:3:1

Q. Study of polygenic inheritance is more easier in Plants due to i) large no. offspring
ii) controlled & easing Mating.

* In Human beings quantative characters are studied in population.

* 31/1/

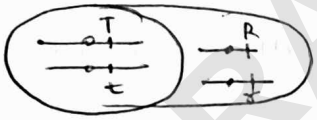
* In Humans color of eyes is controlled by 4 polygenes & height by 4 or more Polygenes.

(7) महत्वपूर्ण BASICS OF LINKAGE

(A) Type of Pollen grain

If Genotype of PMC (TtRr)

Independent Assortment



$= 2^2 = 4$ types

(TR) : (Tr) : (tR) : (tr)

1 : 1 : 1 : 1

Linkage

complete Linkage

→ Gene exchange/CO. =nl

→ No recombinat^n in Test cross

(TR/tr) cis → TR : tr
2 2

(Tr/tR) → Tr : tR
2 : 2

Incomplete linkage

→ GE/CO ↑nl

so Pollen from TR/tr PMC

Parentals: TR, Tr

Recombinant: Tr, tR

• Gametes from Hybrid = Always 2 types

• " " Pure = Always 1 type

★ In IC Linkage % of Parentals & recombination varies but specific for particular characters of a species

- Recombinant ≤ Parental

P_1 R_1 R_2 P_2

3 : 1 : 1 : 3.

★ Genotype of F1 Hybrid

	P	R	RF	Distance	Parents of F_1
AB/ab	AB : ab	Ab : aB	30%	30	
++/--	++ : --	+- : -+	10%	10	
AB/--	AB : --	A- : -B	20%	20	
a+/+b	a+/+b	a+ : +b	10%	10mu	
++/ab	++ : ab 40 40	+b : a+ 10 10	20%	20	
d^+w^+/dw	d^+w^+ : dw 80 80	d^+w : dw^+ 20 20	20%	20	

Q. In sweet Pea, color of Flowers & shape of pollen grains are controlled by two linked Gene, from test cross of F1 hybrid foll. plants were obtained.

Blue long = 10
Red round = 10
Blue round = 70
Red long = 70

Blue & long traits are dominant.

i) what is recombination freq.
ii) Distance
iii) crossing over freq.
iv) Genotype of F1
v) Genotype of parents

Recombinatn freq: = Distance = $\frac{1}{2}$(C.O.F)

C.O.F = crossing over freq.

Sol. i) $\frac{20}{160} \times 100 = 12.5\%$

ii) 12.5%.

iii) 25%.

iv) Bl/bL

v) Bl/Bl + bL/bL

Ques. From a test cross of F1 hybrid (d1) tall white + Dwarf red plants are obtained in 1:1 ratio

what is Genotype of F1 hybrid?

Sol.

$$TTrr \times tt RR$$

$$Tr/tR \;/\times\; trrr$$

Tr /tr Tall white

tr / tr ~~Tall white~~ Dwarf red

Q. In sweet Pea Homozygous Blue (BB) flower, long (LL) Pollen Plant go through cross with red (bb) flower round (ll) pollen (pure recessive) F1 Plant is test crossed & gives rise to 720 seed. How many of the offspring will be blue flower round Pollen. If both gene are located at dist. of 12.5 mu.

Sol.

Dist. = 12.5 mu = Recombinatn freq.

$$12.5 = \frac{x}{720} \times 100$$

$$x = 90$$

$$\boxed{x = 45 \text{ plants}}$$

Trick

	1:1
Monohybrid	1:2:1
	1:3:3:1
Dihybrid	1:4:6:4:1
	1:5:10:10:5:1
Trihybrid.	1:6:15:10:15:6:1

(8) CHROMOSOMAL BASIS OF INHERITANCE

In this section mechanism of inheritance is discovered and explained on basis of chromosome.

(A) chromosomal theory of inheritance (1902)

by Sutton & Boveri

- "Mendelian factors (Genes) are on chromosomes"
- It was based on 11ˡ behaviour b/w mendalian factors & chromosomes.
- it provide physical base to inheritance.
- chromosome are hereditary vechile & connecting link b/w various generation.

★ " inheritance of one pair is independent of other pairs" → Applicable to all chromosomes.

(B) ~~Gol~~

but not applicable to linked genes.

(B) coupling & repulsion hypothesis (1906-07)

- By Bateson & Punnett
- colour of flower and shape/size of pollen grains.
-

Blue long BBLL × Red round bbll

★ 1st linkage example
★ Autosomal & in plants.

↓

F_1 Blue, long BL/bl

↓

Test cross

↓

Blue long	Blue round	Red long	Red round
7	1	1	7

Acc. to Morgan

F_1 → BL/bl → coupling (Parental)
↓ c.o
Bl/BL → Repulsion (Recombinants).

© Chromosomal Theory of Linkage (1911)

* By T.H. Morgan et. al
* Position of a gene is const. & specific & kla "locus".
* Gene's are arranged in a linear fashion
* Gene's in! on same chromosome inherit together
* linkage may be complete or incomplete.
* Recombination freq. ∝ Distance

Strength on linkage ∝ 1 / Distance
(% of Parental)

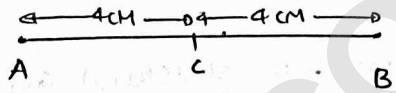
* TH Morgan is father of experimental genetics
* credit of discovery of linkage & crossing over
* study on Drosophila (Fruit fly) (2N=8)
* Reason to choose drosophila:-
  - large no. of offsprings.
  - life cycle short. (2 weeks)
  - can be easily cultured on banana or agar medium
  - Presence of many morphological contrasting characters.
  - sexual dimorphism → Female is larger

(D) Linkage Maps.

* Based on recombination freq. of Test cross.
  - so also k/a crossing over maps, genetic maps on chromosome maps.
* 1st Map was prepared by A. Sirutevent in drosophila. he was a student of Morgan
* 1% RF = 1MU / 1CM

Ques. What is Genetic Map of ABC Gene if R.F of various test cross are as follows:-

A & B = 10%.
B & C = 4%.
C & A = 4%.



Ques: Genetic Map on basis of foll. R.F.

- QR = 10%.
- PQ = 2%.
  RS = 8%.
  PR = 12%.
  QS = 18%.

(E) LINKAGE GROUPS

* A linkage Group represent a group of linked Genes i.e a chromosome

No. of linkage Grp = No. of chromosome (n)

eg:-

- Virus & phenotype = 1
- Neurospora (2n=14) = 7
- Garden pea (2n=14) = 7
- wheat (6N=42) = 7
- Maize 2n=20 = 10
- Drosophila → 4 (2n=8)

♂ Drosophila = 5 ($\frac{3A+1}{}$ × 1Y)

(F) Rate of c.o

$\propto$ dist.

$\propto$ length of chromosome

$\propto$ x-rays (some mutagens)

$\propto \frac{1}{\text{Age}}$

$\propto \frac{1}{\text{Interference}}$

* Interference :- c.o at 1 locus inhibits the c.o of nearby loci.

* Recon = 1 cistron → structural Gene

⑥ C.O in Neurospora

* Neurospora is imp. for study of C.O because it produce ordered tetrad

Q. In a population of Neurospora
100 Asci are Parental
100 " " non-Parental
200 " " Tetra types.

what is R.F.

Sol.

$$R.F = \frac{\text{No. of recombinants}}{\text{Total Asci}} \times 100$$

$$= \frac{NPD + \frac{1}{2}(TT)}{\text{Total Asci}}$$

$$= \frac{100 + 100}{400} \times 100$$

$$= 50\%.$$

C.O	Ascospores	Type of tetrad
-nt	AB : ab 4 4	Parental Di type (PD)
in 2 strand stage	Ab : aB 4 : 4 100% recomb.	Non parental Di type (NPB)
in 4 strand stage	AB : Ab : aB : ab 2 : 2 : 2 : 2 50%	Tetra types.

(H) data of linkage in Drosophila

character	Body color	color of eye	shape/size of wings
x-chromosome	←1.3mu→	←37.2 mu→	
Dominant Trait (wild)	Brown (y^+)	Red (w+)	Normal (m^+)
Recessive trait (mutant)	Yellow (y)	white (w)	Miniature (m)

★ Male Drosophila always show complete linkage (also for autosomal linkage)

(9) SEX DETERMINATION

ENVIRNOMENTAL

→ due to envirnoment during embryonic development

OR

early childhood (Post syngametic)

- Bonellia (marine worm)
- crocodile
- Turtle

GENETIC

NON CHROMOSOMAL

→ due to 1/a few gene

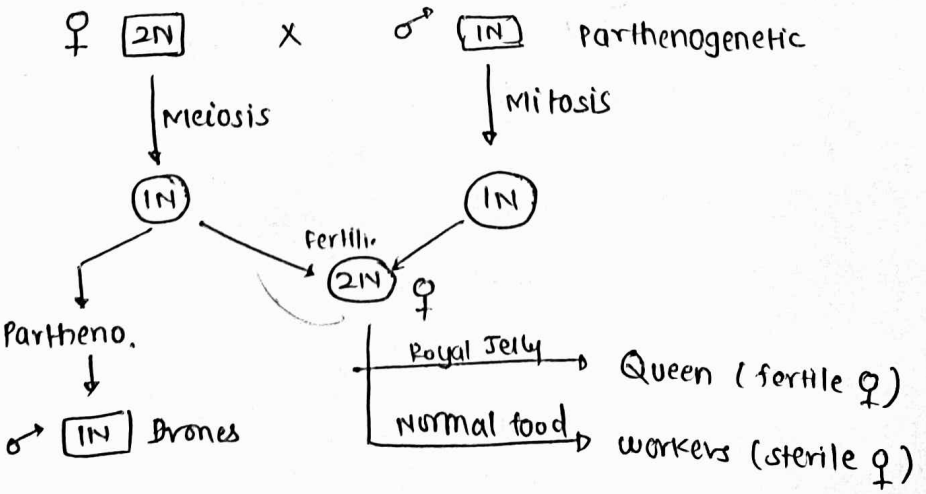
CHROMOSOMAL

→ Haplo-diploidy

→ Allosomal

(I) HAPLO-DIPLOIDY

eg:- Honey bee (2N=32)



* In animals gametes are produced by meiosis & haploid cells do not divide except- Parthenogenetic animals.
* Drones do not have father as well as sons however they have grand maternal father & Grandson.

(II) ALLOSOMAL SEX DETERMINATION

* Henking :- discovered x-Body
* Mc Clung :- x-body is x- chromosome + Imp. in sex determination } In insects (XX-XO)
* Stevens :- Discovery of "Y" chromosome . + its role in S.D.
* Wilsons + Stevens :- "chromosomal theory of sex determination" due to Allosomes.
* Correns :- "Theory of Heterogamesis".
  - Heterogametic (2A + XY) individual is reponsible for S.D
* Allosomal is syngametic i.e depends on the syngamy / Type of zygote

♂ Heterogamatic
Allosomes = X & Y

1) XX-XY
eg:- Humans, Drosophila*

♂ 2A+XY ; ♀ 2A+XX

→ (A+X) ~ Gynosperm
→ (A+Y) ~ Androsperm

A = one set of Autosomes

2) XX-XO
eg:- Grasshopper, Ascaris

♂ 2A+XO = 2A+X (zero) Monosomic (2n-1)

→ (A+X) Gynosperm
→ (A) Androsperm

♀ Heterogamaetic
Allosomes = Z & W

3) ZZ-ZW
♀ 2A+ZW
♂ 2A+ZZ
eg:- Birds, some Reptiles, some fishes.

4) ZZ-ZO
♀ 2A+ZO
♂ 2A+ZZ
Rare eg:- some Moth

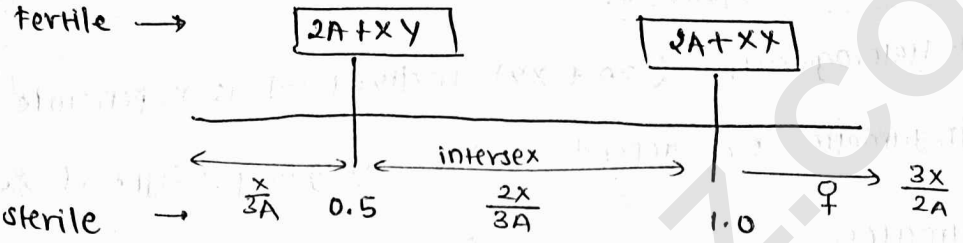
* Sex determination in Drosophila

* Genic - balance Theory by C-bridges (1987)

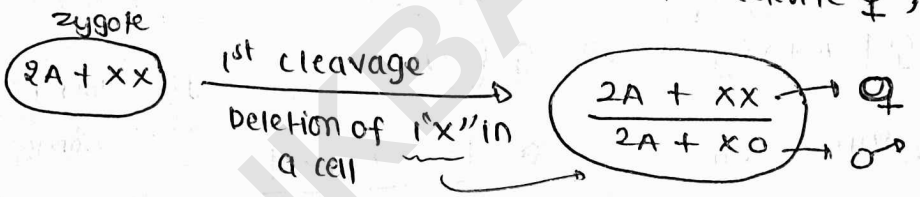
* In drosophila Y- chromosome has no role in sex determination However Y is essential for fertility of male.

* In Drosophila sex determination depend on sex ratio

$$\text{Genic / sex ratio} = \frac{\text{No. of X}}{\text{No. of "A"}}$$



* Best evidence - by ~~Eufand~~ Gynandromorphs (sterile ♀)



(10) HUMAN GENETICS

(A) PEDIGREE ANALYSIS

* It is a record of family history & it is important to study the pattern of inheritance of a particular character.
* Mostly it is based on monohybrid cross.
* Foll. preference order should be used to solve Q:

(I) Y-linked → All sons are affected if father is affected

(II) Recessive (OR) Dominant → Healthy parents but progeny is affected

(III) X-linked OR Autosomal

6/2

(11) GENETIC DISORDERS

This disorder may ~~auto~~ chromosomal or Mendalian.

(A) MENDALIAN DISORDERS

This disorder are due to mutation in 1 or more gene.

(a) SICKLE CELL ANAEMIA

- Gene of β-chain at 11th chromosome
- Autosomal recessive disease However it show co dominance at molecular level.
- It is due to substitution of 6th A.A of β-chain of Hb. (Glutamic acid is substituted by valine
- $Hb^S Hb^S$ in early childhood (sub lethality)

  $Hb^A Hb^S$ R.B.C are normal or biconcave until oxygen conc. is reduced in low O_2 conc. valine forms interaction with other Amino acid which cause reduced Permeability of memb., reduced O_2 carrying capacity but more stickyness (Pleiotropic effect)

this individual show more resistance against Malaria.

(b) THALLASAEMIA

- it is quantative or polygenic inheritance which occur due to absence of reduced no. of chain.

for β chain (ā)
- 11th chromosome
- Gene → HBB

For α-chain
- 16th chromosome
- 2 gene HBA_1 + HBA_2

- due to frame shift mutation.

(#) HARDY- WEINBER'S LAW

Q. in a population of Mirablis red flowered Plant are 100, Pink flowered 100 & while flowered 200 what is % of R

Sol.

RR	+	Rr	+	rr
Red		Pink		white.
↓		↓		↓
100		100		200

$$\% \text{ of } R = \frac{\text{No. of } R}{\text{Total Allele}} \times 100$$

$$\rightarrow \frac{300}{800} \times 100$$

Q. in a population of Mirablis white flowered are 64% what is % of Pink & Red Flowered.

Sol.

$$R + r = 100\%$$

$$\boxed{R + r = 1}$$

$$(R+r)^2 = 1^2$$

$$\Rightarrow \boxed{RR + 2Rr + rr = 1}$$

in qver. $rr = 0.64$

$r = 0.8$

$R = 0.2$

Red → $0.04 \rightarrow 4\%$.

~~White~~ →

Pink → $2Rr \rightarrow 2 \times 2 \times .8 = 32\%$.

Q. in a pop. of Garden pea pure Tall plants are @ 300, Hybrid tall 100 & dwarf 100 what is % of Hybrid tall plants in 3rd generatn

* TT + Tt + tt

300 100 100

$$T = \frac{700}{100} = 0.7$$

$t = 0.3$

$$2Tr = 2(0.7)(0.3) = 42\%.$$

* Acc. to it Allelic freq. remain const for generation if

- Population size is large.
- there is random mating.
- No evolution. (Natural select^n, mutation should be -nt).
- any process which change Allelic freq. should be -nt (Genetic drift, Migration, sampling error should be -nt.)

7/02

(12) MUTATION

* These are sudden changes in genetic material which are inheritable, uncertain non predictable & usually recessive.

* Mutation may occur at gene level or chromosome level.

A) Gene level / DNA level = Point mutation

Substitution

→ Replacement of 1 nt by mutation

on the basis of type of nucleotide

a) Transition

Pu ⇌ Pu

Py ⇌ Py

b) Tranversion

Pu ⇌ Py

effect

a) Mis-sense → Meaning of amino acid is changed

eg:- GAG → GUG
Glu. Val.

UGG. → UGA (Non sense Mutat^n
Trp. (Stop codon)

b) same sense

eg:- UAA → UGA (both are STOP codon)

CCC → CCG (" Produce Proline)

c) silent mutation

eg:- Mutat^n in introns

Imp. for study of evolution.

Frame shift Mutation

→ Whole reading frame is changed due to addition or deletion of 1/2 Nucleotide

(B) Mutations at chromosome level

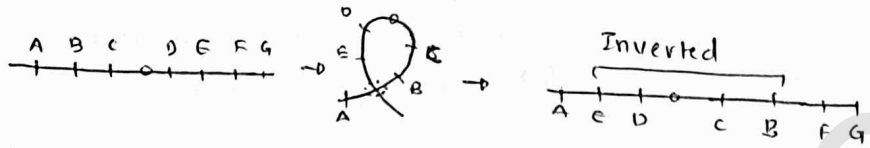
(I) CHANGES IN STRUCTURE OF CHROMOSOMES

* Para centric → without centromere
* Peri centric → involving centromere

i) Deletion

ii) Addition / Insertion

iii) Inversion



iv) Translocation (b/w Non Homologous chromosome)

a) Unidirectional

b) Reciprocal / bidirectional

↳ exchange of gene / chromosome fragments b/w non Homologous chromosomes

(II) CHANGES IN CHROMOSOME NO.

- Aneuploidy (2x ± 1 or more chromosome)
- Euploidy

* Due to non-disjunction during meiosis (usually from mother)

Hypoaneuploidy

(A) Monosomy [2x-1] ABC, AB–

(B) Nullisomy (2x-2) AB–, AB– → lethal

(C) Double monosomy (2x-1-1) AB–, A–C

Hyperaneuploidy

(A) Trisomy (2x+1) ABC, ABC

(B) Tetrasomy (2x+2)

(C) Double Trisomy AABBBCCC

Mixed

2x-1+1

eg: ABC, A–CC

Q. Pollen has 10 chromosome what is no. of monosomic & Trisomic plants.

Ans. 19 & 21 resp.

Q. what is no. of chromosomes in foll. cond.

	Garden Peg (2N=14)	wheat (6N=42)
Monoploidy (1N)	7	7
Haploid (1X)	7	21
~~Diploid (2X)~~		
Endosperm (3X)	21	63
Monosomic (2X-1)	13	41
Trisomic (2X+1)	15	43

(B) EUPLOIDY

2N ± 1N or "More N"

* changes in no. of set chromosomes.

i) **Autoploidy**:- in same species

it may be due to

(a) **Parthenogensis**:- 2N [AA] ⟶ 1N [A]

'A' = 1N of 'A' species

'B' = 1N of 'B' species

(b) **endomitosis / colchicine treatment**

2N [BB] ⟶ 4N [BBBB]

(c) **Fertilizatn b/w Apomitic gametes**

eg: 2N (egg) × 1N ♂ ⟶ 3N (CCC) eg. Banana embryo

- Alloeuploidy :- due to interspecific hybridisatn

eg:- Raphanobrassica 4N[AABB]

* Triticale 6N [AA BB DD]
8N [AA BB CC DD]

(iii) Auto allo euploidy

6N = AAAA BB.

15/2

EXAMPLE OF INTERSPECIFIC HYBRIDS

(1) Raphano brassica [4N-AABB]

↳ 1st man made / Artificial interspecific Hybrid

Raphanus sativus (Radish) x Brassica oleracaea (cabbage)
2N=[16] [AA] 2N=16 [BB].

"A"= 1N of A species "B"= 1N of B species

1N 1N

Allodiploid (2N) "AB" Amphimonodiploid

↓ Colchicine

Allotetraploid [4N "AABB"] Amphidiploid

(2) Triticale (6N/8N) → Man made

Secale cereale (Rye)
2N=14 (DD)

with → Triticum aestivum (6N=AABBCC) → Triticale 8N= AABBCCDD=56

with → T. durum (4N= AABB) → Triticale 6N= AABBCC = 42

Triticum aestivum / durum } are Natural interspecific Hybrid

(13) CYTOPLASMIC INHERITANCE

* Inheritance which is controlled by cytoplasmic genes (Plasma genes) or influenced by cytoplasm
* it is also kla maternal inheritance bcoz zygote ~~receive~~ receive cytoplasm from mother parent, it was discovered by correns in mirabils.
* it is of 3 types.

By Plasma Genes	Pre-Determination	Pseudodibrid
i) Plasmid in bacteria ii) Plastidial inheritance iii) Plastidial inheritance in Mirabilis eg:- Phenotype of mother → Phenotype of progeny	Nuclear gene express during oogenesis so Genotype of mother – Pheno of Prog eg:- eggshell coiling in limnea	* due to ~~modification~~ an external agent in cytoplasm eg:- Kappa particle in Paramaecium.

* some other points

(1) sex linked characters → characters controlled by X or Y-linked Genes.
characters may be somatic or sexual.

(2) sex limited characters (Autosomal) → Genes are int on autosomes and are related with 2° sexual characters
• expressn of gene depend on sex hormones.

(3) sex influenced characters (Autosomal) → Expressn of Hetero zygous individual depends on sex Hormones
eg:- Baldness
BB → baldness in both ♀ & ♂
Bb → No baldness
Bb → baldness in male only.

(4) Hybrid vigour / Heterosis → Hybrid of dissimilar parents show superior characters due to Heterozygous condith or supperesion of recessive alleles
eg:-

eg:- AAbb x aaBB

↓

AaBb.

⑤ Hybrid breakdown / inbreeding depressn →

⇒ Hybrid of very similar parents or offspring of self pollination may show inferior characters. due to Homozygous condition of recessive alleles.

eg:- Aa x Aa

↓

aa

⑥ Eugenics

* Birth of superior individual is promoted (+ve approach) & birth of inferior individual is inhibited (-ve approach) to improve quality of human population.