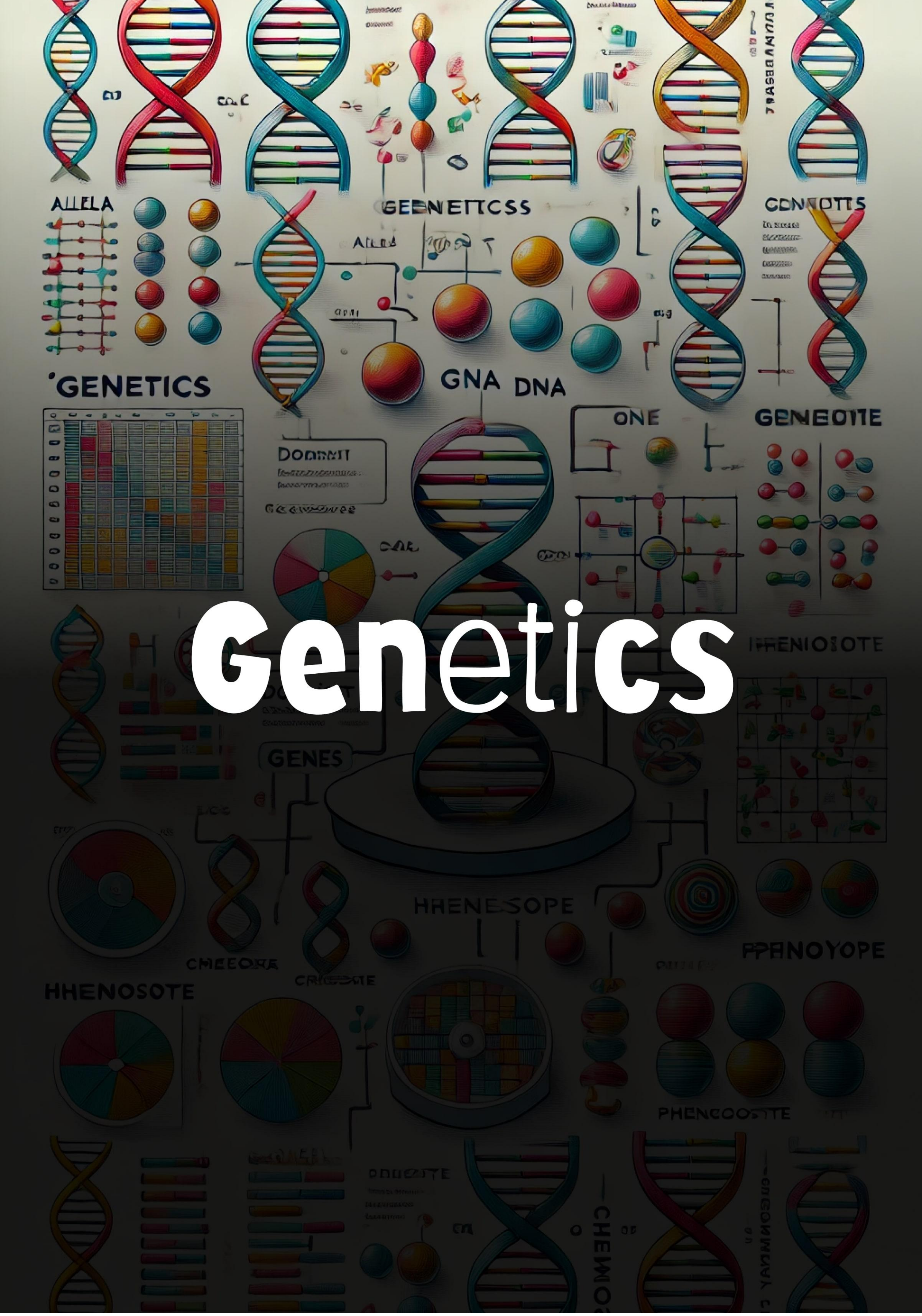

ALLELA
GEENETICSS
CDNFOTTS
GENETICS
GNA DNA
ONE
GENEOTTE
GENES
HHENESOPE
PPHNOYOPE
HHENOSOTE
PHENCOOTE

Genetics

Genetics

It is the study of heredity and Variations.

Heredity Transmission of characters from one generation to another (from parents to progeny).

Variation These are differences Existing Among members of same species.

G.J. Mendel

- Father of Genetics
- 'unit factor' term was given for Medelion characters controlling genes.
- Term gene was given by Johannsen.

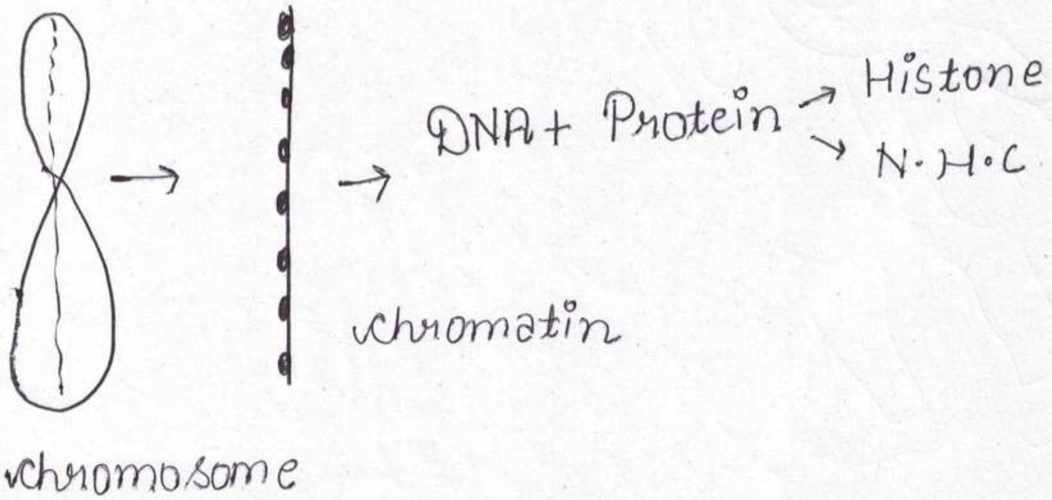
William Bateson

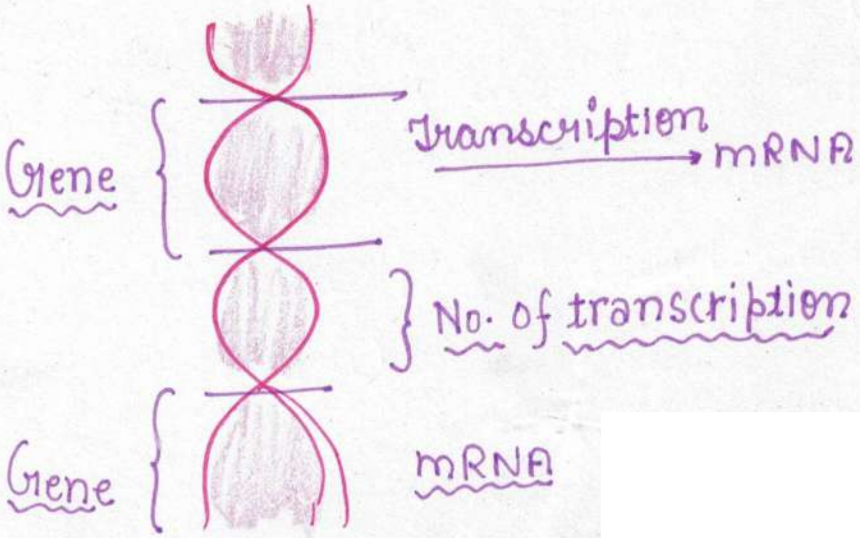
- Father of Modern genetics.
- Terms given by Bateson:-
  - Genetics
  - Homozygous (Pure)
  - Heterozygous (Impure)
  - Hemizygous (one out of two)
  - Allele.
  - flial generations ($f_1, f_2 ---$)

- If in any question flial generations (f_1, f_2, f_3 ---) is mentioned then parent means pure parental
- If flial generation is not mentioned then parent means Immediate parent (for f_2 generation immediate parent in F_1)

T.H. Morgan

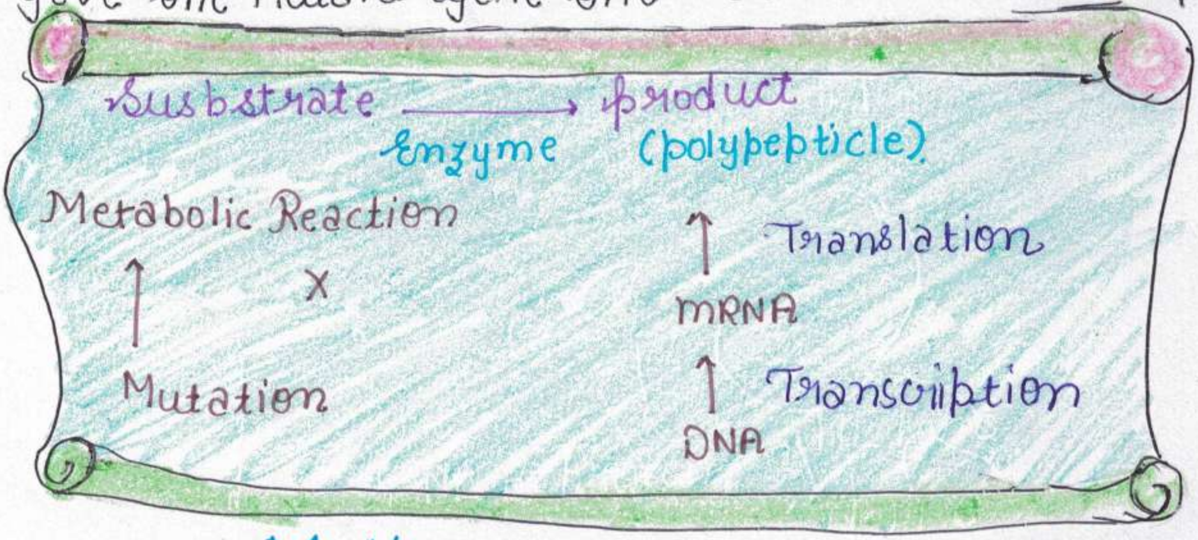
- father of Experimental genetics
- Mendel worked on Pisum Sativum, Garden Pea,
  - sweat pea → Lathyrus odoratus
- Morgan worked on Drosophila Melonogaster also called fruit fly and Banana fly.
- fruit fly can grow on ripened Banana.
- Term given by Morgan:-
- Linkage हम साथ-साथ है।
- crossing over नया combination बनाना।
- Sex linkage.
- chromosomal Map.





A. Garrod

- Father of human Genetics'
- He studied Alkaptonuria → A.R
  ↓
  due to deficiency of Enzymes Homogentisic Acid Oxidace.
- Alkaptonuria is Black urine disease.
- He gave 'one Mutant gene one Metabolic' block concept



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Muller

- father of Actinobiology.
- Actionology is the study of Effect of radiation of living cell.
- Muller introduced Mutation in Drosophila.

"Paul · Berg"

- father of genetic Engineering.

Variations

- Somatic
- Germinal
  - continuous
    - observable (Substrattive)
    - countable (Meristic)
  - discontinuous
    - observable (Subtantive)
    - countable (Meristic)

Somatic Variations	Germinal Variations
Seen in somatic cells	Seen in germinal cells
Non - heritable.	Inheritable
Acquired Variation (Not present Since birth)	Congenital (present since birth)
No role in Evolution	Role in Evolution.

Causes of Somatic Variation

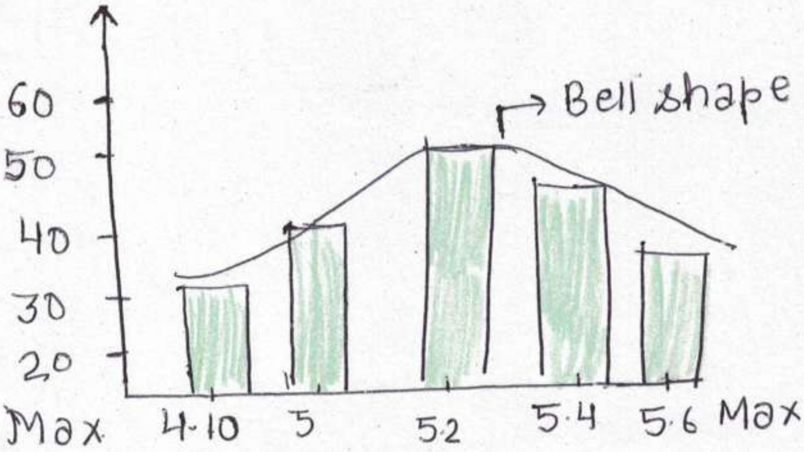
(a). Environment :- Heterophyllic in Butter cup.

(b). Conscious Effort :- Regular Exercise for Muscles.

(c). Use and Disuse :- Difference in hunting Nature of two cub when they are placed different Environment.

Germinal Variation

Continuous	Discontinuous
1 slow variation, small Magnitude/small scale	1 sudden Variation large scale
2 Due to crossing over	2 Due to Mutation
3 seen in Every generation	3 sudden appearance in any generation.
4 Maximum population shows Average value	4 Maximum population present at Extreme Value.
Bell shape curve is Obtained	No such curve.



Continuous Variation

Observable (Subtentive)

Example-
- Human height,
- Human weight,
- Skin colour,
- intelligence.

countable (Meristic)

Example→
- No. of Arms in hydra.
- No. of body segment
- In Earthworm

Discontinuous Variation

Observable (Substentive)

Example

(i) Ancon sheep (small leg)
↓
Observed by Seth wright
↓
1st observed Mutation

(ii) Hairless cat

(iii). ~~Hat~~ Polled cattle (Hornless)

(iv) Piabaldism.

countable (Meristic)

Example

1) Polydectyly

It is Autosomal dominant condition

2) Single kidney in a human.

Terminologies

(i) **character** : Any feature of an organism.

(ii) **Trait** : Different forms of a character are trait.

- At Individual level character are traits are same but at population level they are different.

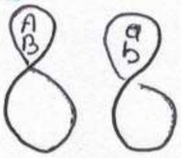
(iii). **Gene/Elementi/factor**:-

- unit of Inheritance/unit of heridity
- Segment of DNA
- Every gene is DNA segment but Every DNA segment is not gene.
- Represent by English Alphabet

Gene Symbol

Dominant	Recessive
A	a
+	a
a^+	a

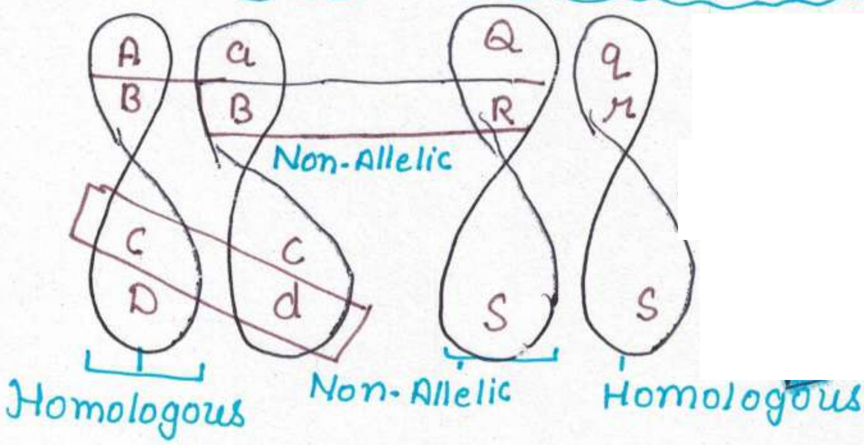
$AB/ab \rightarrow ++/ab \Rightarrow a^+b^+/ab$



(4). Allele/ Allelomorph → Alternative form of a gene is diploid organism (which may be similar or dissimilar).

- Allels are located at homologous pair of chromosomes.

They are located at same locus/ loci.



(5.) Homozygoys/ (Pure) :- when both forms of a gene are similar in diploid organism.

Eg → TT, tt.

(6). Heterozygous / Impure :- when both forms of a gene are dissimilar in diploid organism.

Eg :- Tt.

7.) **Dominant** : form of a gene which can Express itself in homozygous and heterozygous state

8.) **Recessive** :- form of a gene which can Express itself only in homozygous state.

(9.) **Genotype** :- Genetic constituent / constitution of a cell.

(10) **Phenotype** :- External Appearance which is seen due to Expression of gene.

- Dominating is decided in Heterozygous state
- for one phenotype more than one genotype an possible,

(i) Tall → TT
Tt → Tall

Dwarf = tt
t = Recessive

(ii) $\underbrace{\text{Tall}}_{\text{Phenotype}} \rightarrow \underbrace{\text{TT}}_{\text{Genotype.}}$

Dwarf = tt

(11.) **Inbreeding** :- when breeding takes places between closely related Members of same species

(12.) Example - ~~cross pollination~~. Self pollination

↷ Inbreeding Increases homozygosity, out breeding increases heterozygosity.

(12.) **Outbreeding** :- when breeding takes place between distantly related member of same species. Example. cross pollination.

(13.) **Hybrid Vigour / Heterosis**:- when hybrid progency is superior to both parent such progency is Hib vigour progeny.

14.) **Inbreeding depression**:- when hybrid, Vigour loose superiority over parent it is inbreeding depression. (due to Repeated selfing / Inbreeding).

Marriges between close relatives → consanguious marriages between close relatives increases recessive disorder.

Eg:- Sickle cell Anaemia (Autosomal Recessive)

P_1 AA BBccdd

P_2 aabbCCDD

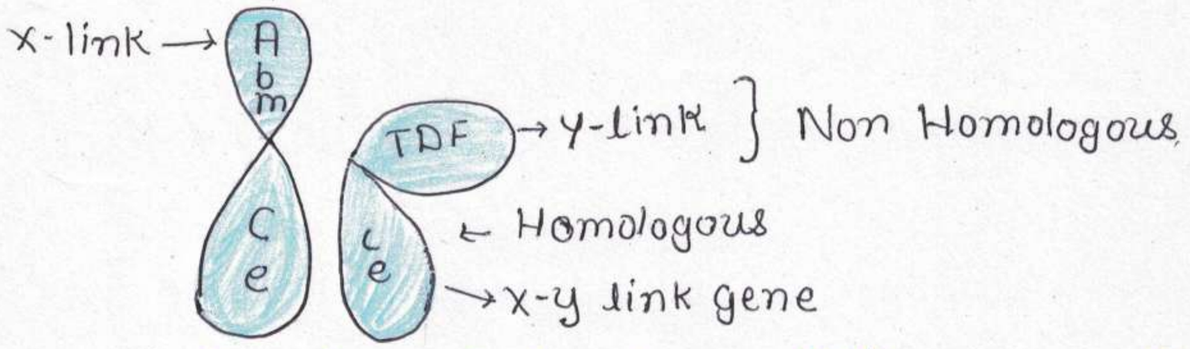
AaBbCcDd

Hybrid Vigour progency.

(15.) **Hemizygous**:- when only one form of a gene is present out the two forms in diploid.

X-link recessive diseases are most common in males in comparison to females.

Eg:- colourblindness, Haemophilia.



A = x-link; B = y-link; C, e = x-link; c, e = y-link

(16.) **Phenocopy**:- when two different genotype which are producing different phenotype under same Environment but when Environment is changed they are producing same phenotype such genotype are known as phenacopy.

(i) TT tt
↓ ↓ G.A.
tall tall

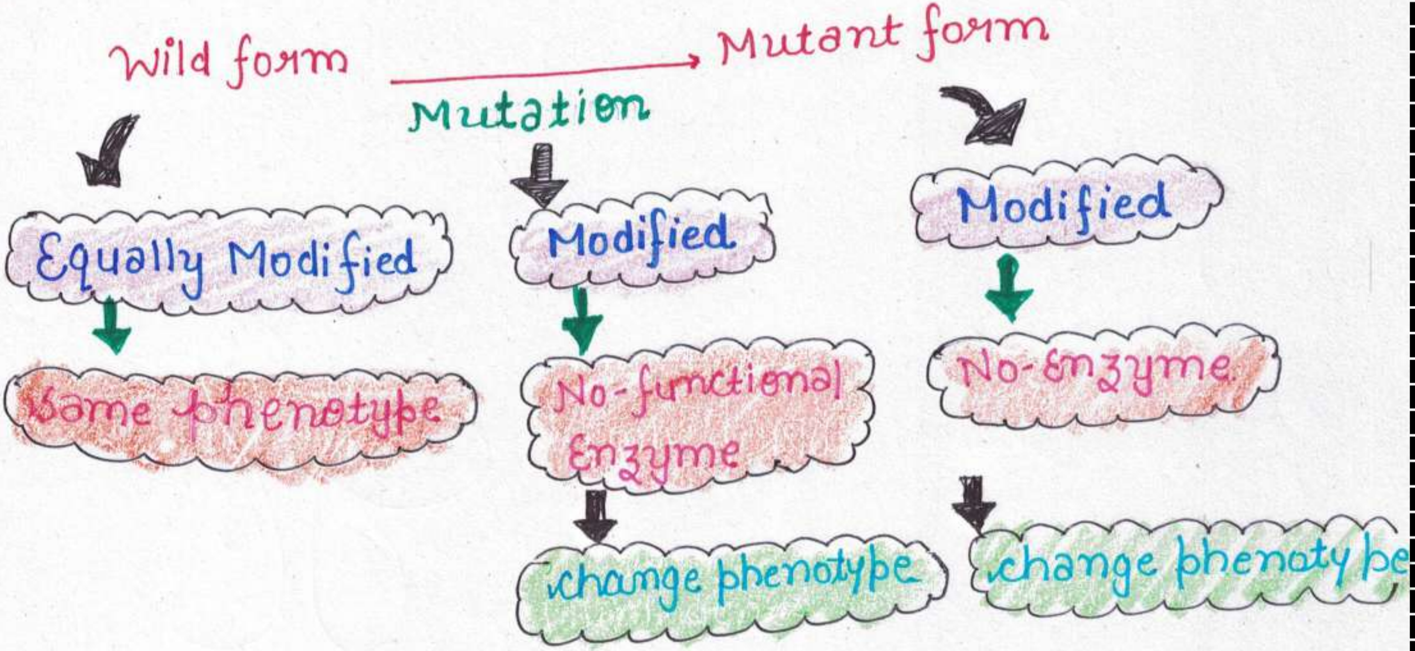
(ii) Tt tt
↓ ↓ G.A
tall tall

(iii) Tt TT
↓ ↓
tall tall

(iv) · TT tt
G.A ↓ ↓
Dwarf Dwarf phenocopy

Wild form

- form of a gene which is present in since starting (first to Appear Nature).
- This are dominant form.



⑲. **Forward Genetics** :- Identification of genotype for given phenotype.

Also called Mendelian Genetics

$$\text{Phenotype} \xrightarrow[\text{forward}]{} \text{Genotype}$$

20. **Reverse Genetics** :- Identification of phenotype of a given genotype.

$$\text{Genotype} \xrightarrow{\text{Reverse}} \text{phenotype}$$

21.) **Classical Genetics** :- Mendelian Genetics.

22.) **Modern Genetics** :- Molecular Analysis.

Heredity.

- Study of heredity is divided into three parts:-
  - (i) Pre Mendelism.
  - (ii) Mendelism
  - (iii) Post Mendelism

(i) Pre Mendelism

- All the theories of pre-Mendelism Era are collectively known as theories of Blending Inheritance.
  - (a.) Moist vapour theory → Pythogorus.
  - (b). Reproductive blood theory → Aristotle.
  - (c). Semen theory. Empedoile
  - (d.) pre-formation theory - Leuvonhoeic, Swammerden
  - (e) Theory of pangenesis - Drawin
- All these theories were rejected by Cross and Knight

↓

Garden Pea (Seeds colour)

- Kanbreveter and Navdin → they also rejected theories of Blending Inheritance.

Mendelism

- 1822 to 1884 → died due to Bright disease (Kidney failure)
- In 1849 Mendel Went to Vieana university
- In 1854 Mendel Returns.
- Experimental years = 1856/57-1863.
- In 1865 Mendel presented his work at 'Natural History Science Society' BRNO city.
- 1866, Mendel's work was published
  Title " Experiments in plant hybridisation"
- In the year 1900 three Scientists working Independent reached to same conclusion.
  (i) carl comens - Germany - Maize.
  (ii) Hugo-de-Varies - Holland - Evening primrose (oeinthera) (Lmarkiana).
  (iii) Erich-von-Tsehemak - Austria.
- In 1901, Hugo-de-Varies republished Mendel's work in flora Magzine.
- carl-correns form two two laws from Mendel's postulate.
  (i) law of seggregation.
  (ii) law of Independent Assortment

Q) Why Mendel's work remain hidden from Society?

Reason (i) his work was ahead from his time.
(ii) communication techniques were poor at that time.
(iii) Mendel could not provide any physical proof in support of unit factor.

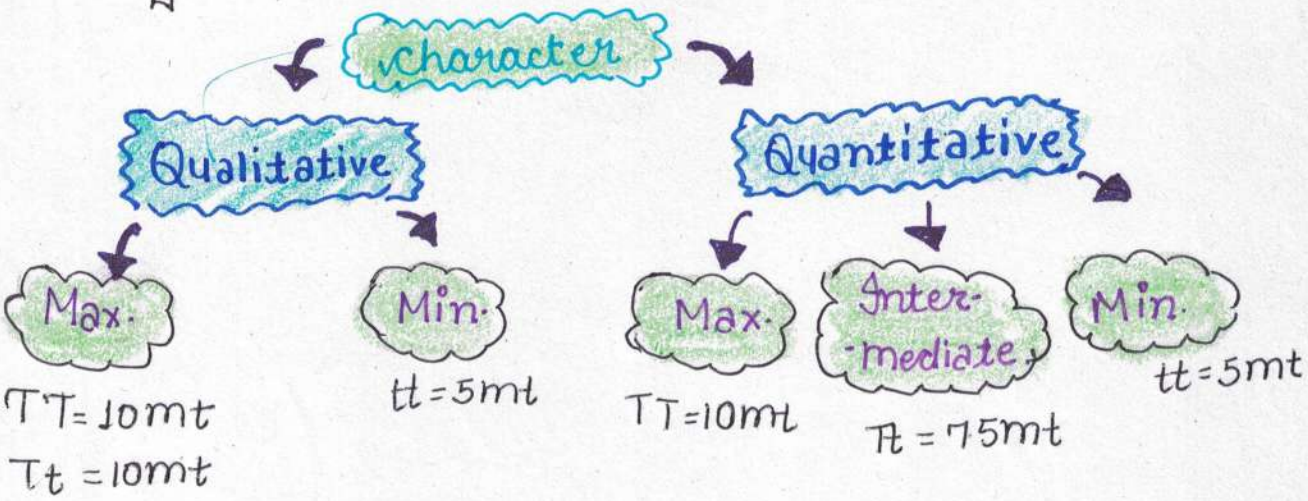
(iv). Mendel could not replicate his results on Hawk Weed (Hiematium)

(v). Origin of Species was very famous book at that time.

(vi) Mendel used Mathematics.

Reason for Mendel's Success:

- Mendel's kept all records intact
- Mendal studied 1 character at a time
  34 → 22 → 7
- Mendel was lucky F1 → hybrids were fertile.
- Mendel studied qualitative characters and result was given in Quantity



- Mendel Selected pea plant :-

(a.) Small life cycle (3-4 months)

(b.) Many contrasting characters are present.

(c.) Natural Self pollinating, but cross pollination can also be performed.

(d.) Easy to grow.

Technique of Mendel's Work

Step 1 Selection of parent :-

- Mendel selected pure parent and he performed self pollination to confirm purity.

Step 2 Hybridisation :-

(a.) **Emasculation** :- Removal of Anthers.

Timing :- Before Maturity.

Purpose :- To Ensure cross pollination.

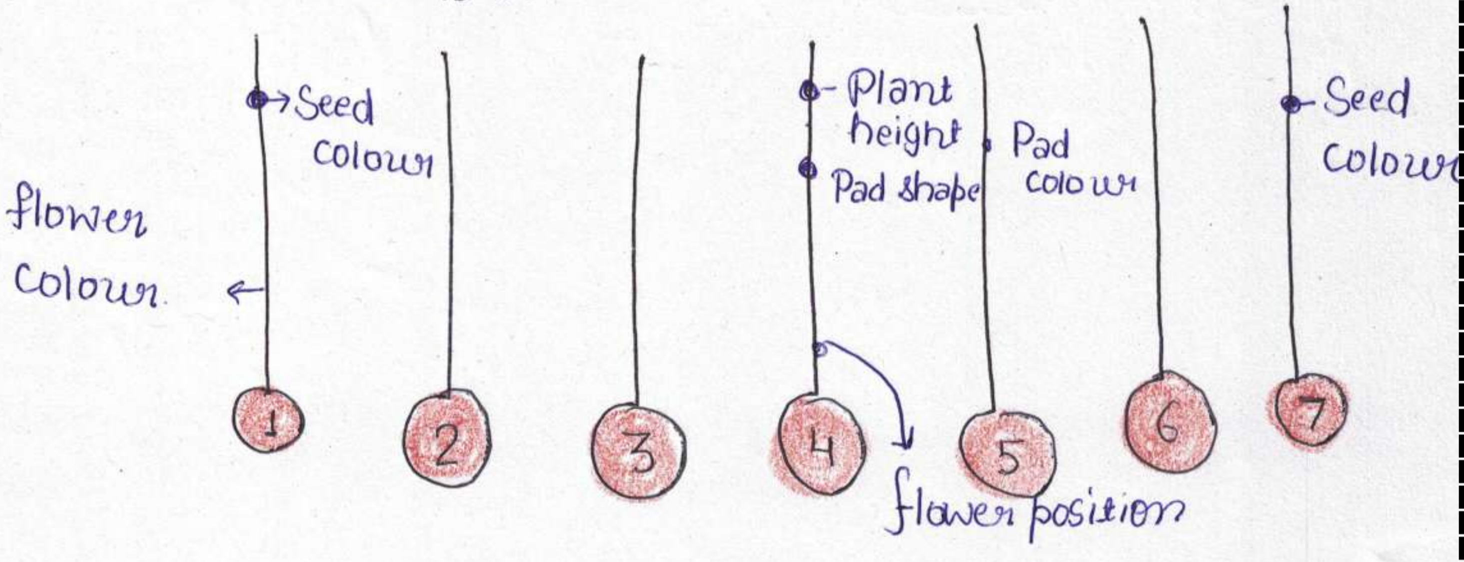
(b.) **Bagging and Tagging** :- Butter paper is used for covering female part, to Ensure desired cross pollination.

Tagging to Identify.

Step 3 Selfing of f_1 to obtain F_2 generation and so on :-

Pea plant :- 7 chromosome pair - 7 characters

St. Blixe → 1457.



Character	Dominant	Recessive
Plant · Height	Tall	Dwarf
flower · colour	Violet	white
flower - Position	Axial	Terminal
Seed - Shape.	Round	Wrinkled.
Seed - colour.	Yellow	Green
Pod - colour.	Green.	Yellow.
Pod - Shape.	Inflated.	Deflated.

Start Branching Enzyme

Maturation
H_2O loss.

Dominant

starch → Max.
sugar → Min.
H_2O → Min.
→ Round

Recessive

starch → Min
sugar → Max
H_2O → Max
→ Wrinkled

Monohybrid Cross.

- In Monohybrid cross one pair of constrasting traits. (character) are studied together.
- Mendel studied all 7 Monohybrid cross

(P) **Tall** Dwarf

TT tt

$\downarrow$ $\downarrow$

T $\leftarrow\!\!\!\rightarrow$ t

G → Tt [heterozygous tall]

$\downarrow$

F_2

♀ \ ♂	T	t
T	TT Tall	Tt tall
t	Tt Tall	tt dwarf

(a.) **Phenotypic Ratio/ Mendelian Ratio:**

3T : 1D

(b.) **Genotypic Ratio/Real Ratio:**

$1/4\,TT : 2/4\,Tt : 1/4\,tt$

1 : 2 : 1

(c.) $3/4$ tall → $3/4\,T\text{-} \begin{cases} 1/4\,TT \\ 2/4\,Tt. \end{cases}$

Dihybrid

(d.) $y\text{-}R\text{-} \Rightarrow 3/4 \times 3/4 = 9/16$

$y\text{-}rr \Rightarrow 3/4 \times 1/4 = 3/16$

$yyR\text{-} \Rightarrow 1/4 \times 3/4 = 3/16$

$yyrr \Rightarrow 1/4 \times 1/4 = 1/16$

(e) $(a+b)^2 = a^2 : 2ab : b^2$

$(1/2\,T + 1/2\,t)^2 = 1/4\,TT : 2/4\,Tt :$

$1/4\,tt.$

Mendel Gave 4 postulate

(i) Unit factor } Ist law] Monohybrid.
(ii) Dominance
(iii) Segregation]- IInd law
(iv) Independent Assortment } III law dihybrid.

Law of Dominance

- In diploid organism one pair of unit factor are present which may be similar or dissimilar. (postulate of unit factor)
- when dissimilar forms are present together one form will Express itself (dominant form and) and another for which will not Express itself (Recessive form)
- f_1 generation → Dominancy proved.

Law of Segregation

- In diploid organism two forms of unit factor. are present together when both forms are dissimilar these forms remain stable and discrete. so gamete will receive only one form of gametes are pure for the form of unit factor (purity of gamete)
- During gamate formation segregation take place. so Gamete receives only one form form the pair known as law of segregation.
- This law is mostly widely accepted law.

Exception:- Non·disjunction.

Eg:- Dawn syndrome. -21 chromosome trisomy.

F2 generation:- segregation proved. (first choice)
Dominance proved. (second choice)

Question A monohybrid cross is performed for height character in F_2 generation total 1200 plant obtained. calculate.
① Pure tall. ② Total pure plant (3) Total dominant phenoty plant.

1.) $\frac{1}{4} \times 2200 =$ pure tall. $3500 =$ pure tall.

2.) $\frac{1}{4}TT \times 1\frac{1}{4} \times 1200 =$ Total pure plant.

$\frac{2}{4} \times 1200 =$ Total pure plant.

$600 =$ Total pure plant.

3.) Total dominant phenotype $= \frac{3}{4} \times 1200$

Total dominant phenotype $= 900$

Question A cross is performed for flower colour red colour is dominant over white colour a pure red plant is crossing with white flower plant and 1020 progency obtained- comment on phenotype.

(i) 30R : 60P : 30W (2) 90R : 30W

(3) 30R : 90W (4) All red. ✓

→ अगर बच्चा homozygous recorsive हो तो parent कभी vgh homozygous नहीं हो सकते.

Question A cross is performed for height character between two unknown gygote plant and in F2 generation 45 tall and 14 dwarf obtained. what is the genotype of parent.

[✓ 1.) TT×tt] (ii) TT × tt (iii) Tt × TT (iv). Tt × Tt

Question A cross is performed between two unknown genotype and 45 tall and 14 dwarf plant obtained. what will be genotype of parent.

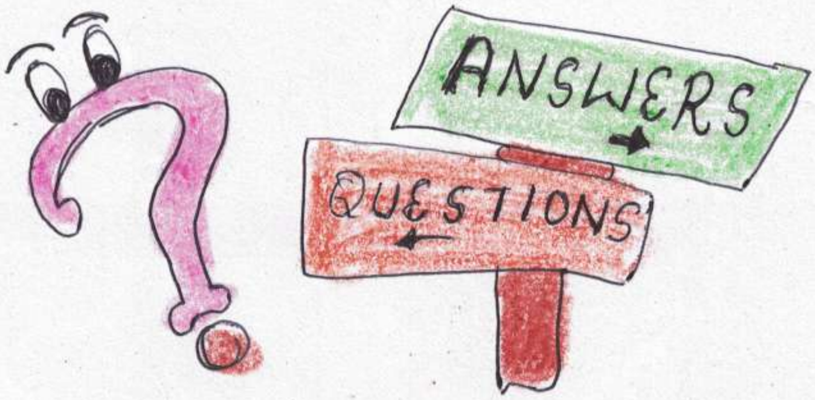
(i) TT×tt (ii) Tt×tt (iii) Tt×TT [✓ (iv) Tt×Tt .]

Question In human black eye colour is dominant over blue Eyes. A blue Eye child is born in a hospital. which one of the following couple is biological parent of this child.

(i) BB×bb (ii) Bb×bb (iii) BB×BB [✓ (iv) Bb×bb]

Question A monohybrid is cross performed for flower colour and in F2 generation 80 Red x and 20 White plants are obtained. If a heterozygous flower is obtained undergoing selfing then what will be the phenotypic ratio.

[✓ (i) 72:24] (ii) 60:40 (iii) 80:20 (iv) 100:20



Dihybrid Cross

- When two pairs of contrasting traits are studied together such cross is dihybrid cross.
- Mendel did not performed all 21 dihybrid crosses.

seed colour → 1
seed shape → 7

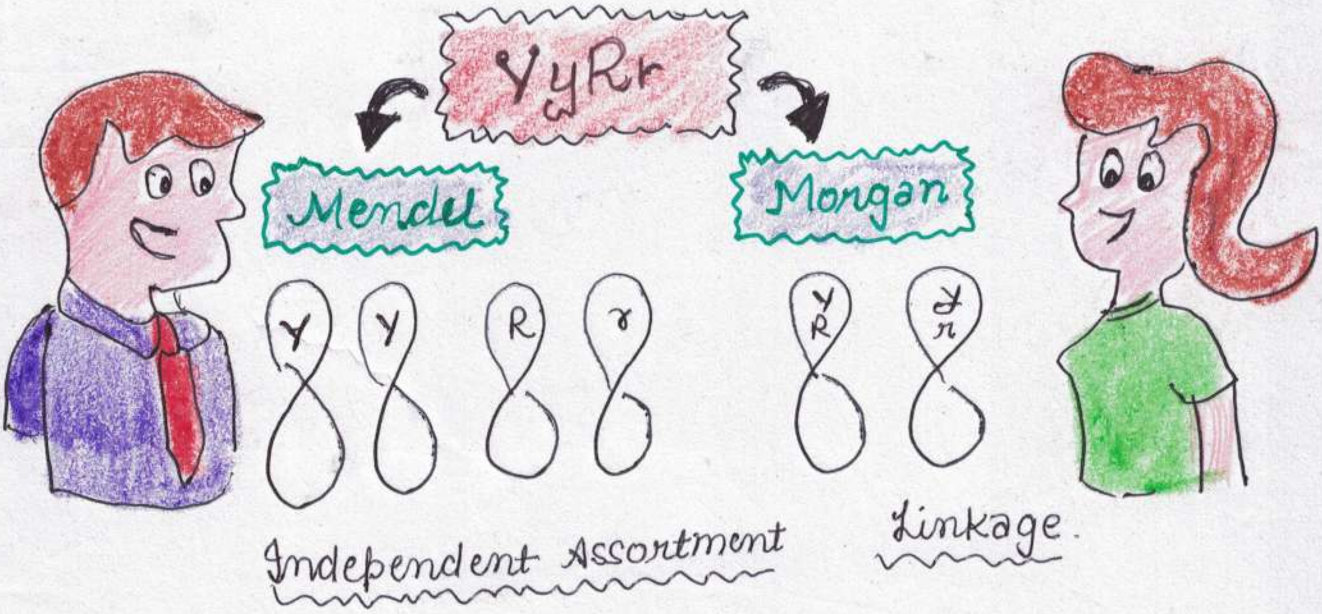
Yellow Round — **Green Wrinkled**

YY+RR → YR

yyrr → yr

F1 → YyRr (yellow Round)

YR — Yr — yR — yr



D·C = M·C × M·C.

seed colour (3Y : 1G)

seed shape (3R : 1W)

P.R. ⇒

	3Y	1G
3R	9 YR	3 GR
1W	3 Yw	1 GW

(1:2:1) (1:2:1)

	1	2	1
1	1	2	1
2	2	4	2
1	1	2	1

Ⓟ Yellow Round Green Wrinkled

YYRR yyrr

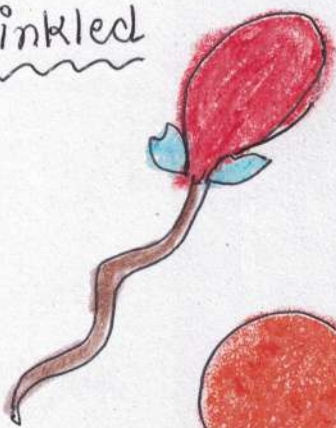
↓ ↓

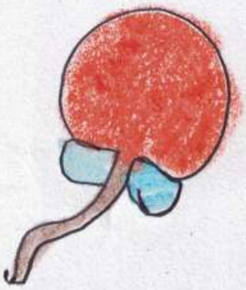
YR yr

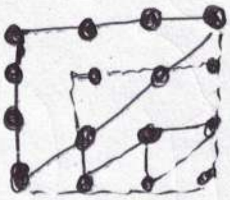
Yellow Round (F1) ⟶ YyRr

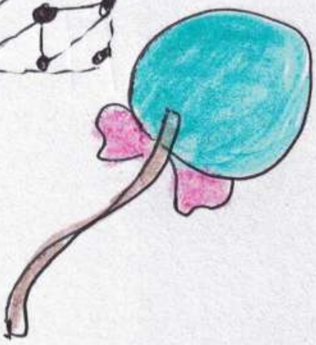
YR Yr yR yr

♀ \ ♂	YR	Yr	yR	yr
YR	YYRR *	YYRr *	YyRR *	YyRr
Yr	YYRr *	YYrr *	YyRr *	Yyrr *
yR	YyRR *	YyRr *	yyRR *	yyRr
yR	YyRr	Yyrr	yyRr	yyrr









(a) Phenotypic ratio 9YR : 3YW : 3GR : 1GW

(b) Genotypic Ratio 1:2:2:4:1:2:1:2:1

(c) Parental phenotype shown by :- 10/16

(d) Recombinant phenotype by :- 6/16

(e) Parental Genotype by :- 2/16

(f) Recombinant Genotype shown by :- 14/16

(g) F1 - phenotype shown by :- 9/16

(h) F1 - genotype shown by 4/16.

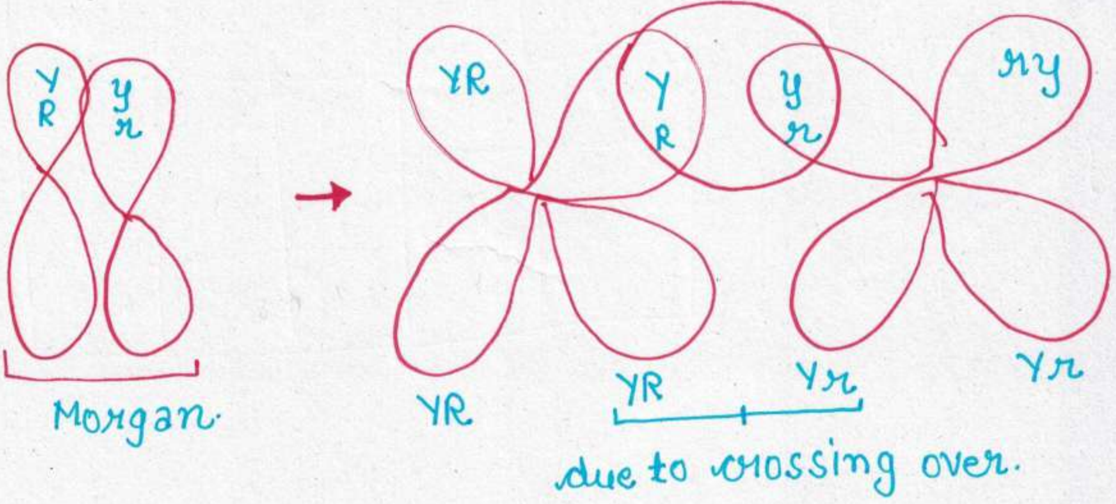
Law of Independent Assortment

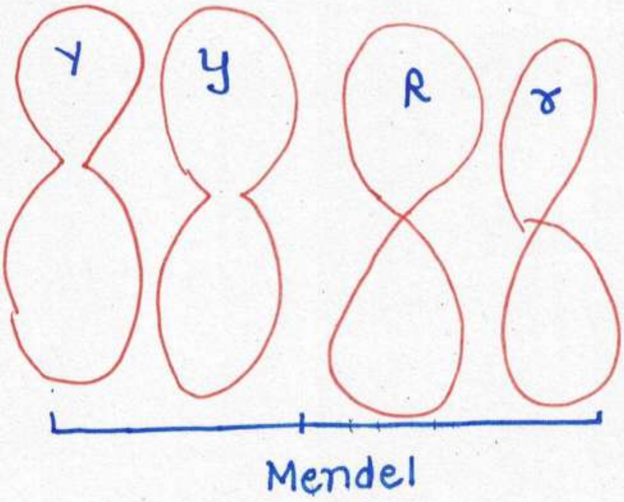
SS;S
- when two pairs of contrasting traits are combined together in hybrid, segregation of one pair of trait is Independent from other pair of trait (character).

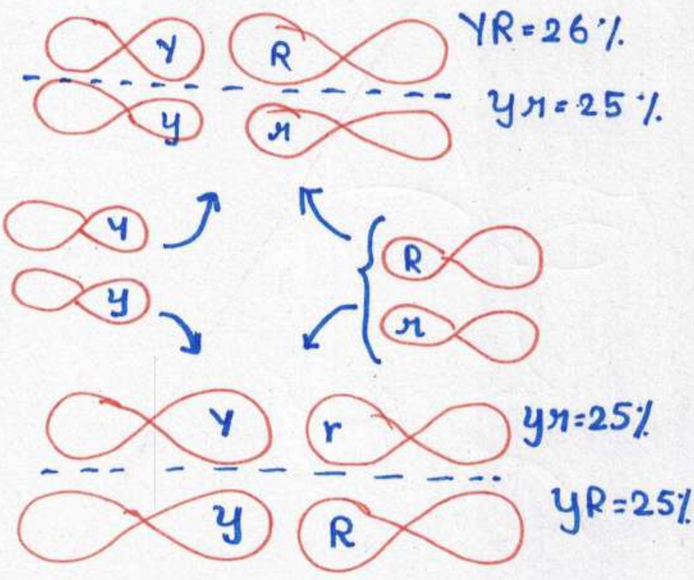
SS;S
- This law is Applicable for those characters which are located in non-homologus chromosome.

SS;S
- Linkage is Exception to their law (Morgan).

SS;S
- Linkage and crossing over are opposite phenomenon







1:1:1:1

25:25:25:25

Gamete formation

(i) fork line Method

Type of gamete = 2^n

n = no. of heterozygous state

(a). AA → n=a , 2=2

AA → A

(b). Aa → n=1, $2^1=2$

$Aa \nearrow A$
$\searrow a$

(c) $\underset{1}{\underline{Aa}}\ \underset{0}{\underline{BB}}$ = n=1

$2^1=2$

AaBB ↗ AB
↘ aB

(d) $\underline{AaBb}$ = n=2

$2^2=4$

AaBb ↗ A ↗ B = AB
↘ b = Ab
↘ a → B = aB
↘ b = ab.

(e). AaBbCc → n=3

$2^3=8$

AaBbCc ↗ A ↗ B ↗ C = ABC
↘ C = ABc
↘ b ↗ c = Abc
↘ a ↘ B ↗ C = aBC
↘ c = aBc
b ↘ c = abc

(f·) AaBbXX → n=2

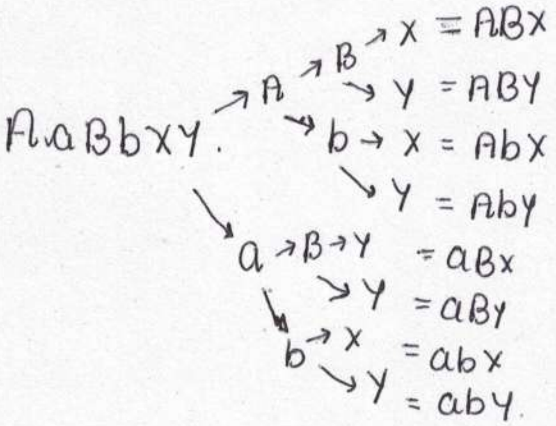
$2^2=4$

AaBbXX ↗ A ↗ BX = ABX
↘ a ↘ bX = AbX
↘ a → B X = aBX
↘ b X = abX

(g). AaBb X^cX → $2^3=8$

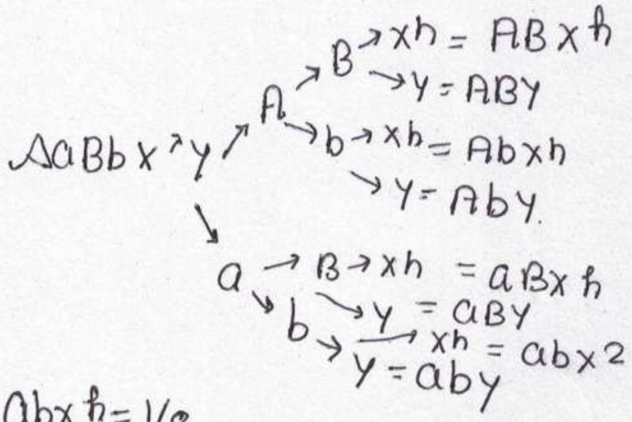
(h.) AaBbxY = n = 3

$2^3 = 8$



(i) AaBbxhy = n = 3

$2^3 = 8$



Abxh = 1/8

Total No. of Zygote = Total type of Zygote

Total type of Genotype in Zygote.

Question (i) $\frac{Aa}{1}\frac{Bb}{1}\frac{Cc}{1}\frac{dd}{0}$ × $\frac{Aa}{1}\frac{bb}{0}\frac{Cc}{1}\frac{Dd}{1}$

$= n = 3 \Rightarrow 2^3 = 8$ $n = 3 = 2^3 = 8$

×

64

(ii) AaBbCcDd × AaBbCcDd

2^4 × 2^4

16 × 16

↓

256

(iii) Aabbccdd × aaBbcc$\textcircled{D}$d.

2^2 × 2^2

× 4

↓

16.

Question

♀ Aabb x AaBb ♂

♀|♂	AB	Ab	aB	ab
Ab	AABb	AAbb	AaBb	Aabb
ab	AaBb	Aabb	aaBb	aabb

Aabb x AaBb

AABB : aabb : AaBb : Aabb

0 : 1 : 2 : 2

In case of Selfing

AaBb x AaBb

AaBb : AABb : aabb : Aabb

⇒ $\frac{2}{4} \times \frac{2}{4} : \frac{1}{4} \times \frac{2}{4} : \frac{1}{4} \times \frac{1}{4} : \frac{2}{4} \times \frac{1}{4}$

⇒ $\frac{4}{16} : \frac{2}{16} : \frac{1}{16} : \frac{2}{16}$

⇒ 4 : 2 : 1 : 2

Question

AaBbCcDd x AaBbCcDd then what will be the ratio.

aa Bb Cc Dd : aabbccdd : AaBbCcDd : AaBb CcDd.

⇒ aaBbCcdd : aabbccdd : AaBbCcDd : AaBbCCDd

$\frac{1}{4} \times \frac{2}{4} \times \frac{2}{4} \times \frac{1}{4} : \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} \times \frac{1}{4} : \frac{2}{4} \times \frac{2}{4} \times \frac{2}{4} \times \frac{2}{4} : \frac{2}{4} \times \frac{2}{4} \times \frac{1}{4} \times \frac{2}{4}$.

$\frac{4}{256} : \frac{1}{256} : \frac{16}{256} : \frac{8}{256}$

QUESTION :- A dihybrid cross is performed for seed colour and seed shape in F2 generation 640 total plant obtained. calculate following:-

- No. of plant showing parental phenotype 10/16
- Plant showing recombinant Genotype 14/16.
- Plant showing F1 genotype. 4/16
- Yellow colour seed plant 12/16.

⇝ 1) $10/16 \times 640 = 400$ 2) $4/16 \times 640 = 560$

3) $4/16 \times 640 = 160$ 4) $12/16 \times 640 = 480$

Question :- Select add combination:-

♀|♂	YR	Yr	yR	yr
YR	a	b	c	d
Yr	e	f	g	h
yR	i	j	k	l
yr	m	n	o	p

(i) b, e

(ii) g, j

[✓ (iii) f, m]

(iv). l, O

Trihybrid Cross

When three pairs of constrasting traits are studied together such cross is trihybrid cross.

$$T.C = \underset{\text{Height}}{m.c} \times \underset{\text{Seed colour}}{m.c} \times m.c \rightarrow \text{Shape.}$$

$$(3T:1D)\ (3Y:\underbrace{1G)\ (3R}:1W)$$

$$9YR : 3Yrs : 3GR : 1GW.$$

	9YR	3YW	3GR	1GW
3T	27	9	9	3
1D	9	3	3	1

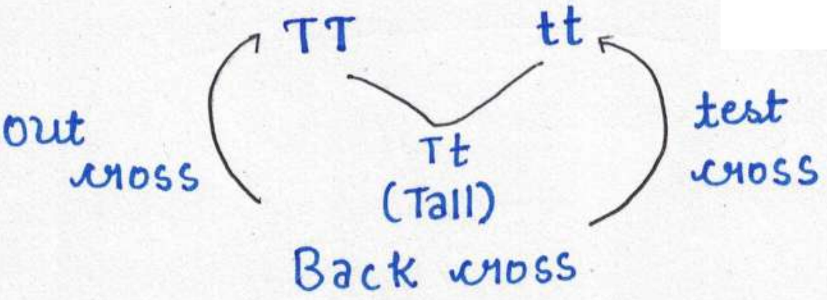
In case of Selfing:-

	Mono.	Di.	Tri.	Tetra.
(i) Types of gametes:	2	4	8	16
(ii) Types of phenotype:	2	4	8	16
(iii) Types of Genotype:	3	9	27	81
(iv) Total No. of Zygote:	4	16	64	256

Special Crosses

Two types of crosses:-

(i) **Back Cross**
- → Out cross
- → Test cross



- **Out cross**

(F1) heterozygous × Dominant homozygous (Parent)

Tt × TT

T t T

PR = All-tall.

GR:- TT : 1Tt

Test Cross :-

(F_1) - heterozygous × Recessive homozygous parent

(a.) Monohybrid test cross :-

Tt × tt G·R = 1Tt : 1tt

↙ ↘ ↓

T t t

GR: 1Tt : 1tt

PR: 1tall : 1dwarf

(b.) Dihybrid test cross :-

YyRr x yyrr.

	YR	Yr	YR	yr
Yr	YyRr	YyRr	yyRr	yyrr
	Yellow	Yellow	Green	Green
	Round	Wrinkles	Round	Wrinkles

G·R = 1:1:1:1

P.R. = 1:1:1:1

(c.) Trihybrid test cross :-

AaBbCc x aabbcc

G·R → 1: 1: 1: 1: 1: 1: 1: 1

PR → 1: 1: 1: 1: 1: 1: 1: 1

SSC

- Test cross is identification of genotype of a plant showing dominant phenotype

Tall

TT x tt Tt x tt

(Tall) Tt Tt tt (Dwarf) 50%.

- Test cross gives Information regarding type of gametes.
- Test cross gives Information regarding linkage.
- Mendel performed test cross for F2-generation to Identify genotype of a plant showing dominant phenotype.

Reciprocal Cross

When cross is repeated for second time and characters are reversed in parent such cross is reciprocal cross.

Reciprocal cross gives same Result :-

cross I

♂ TT ♀ tt

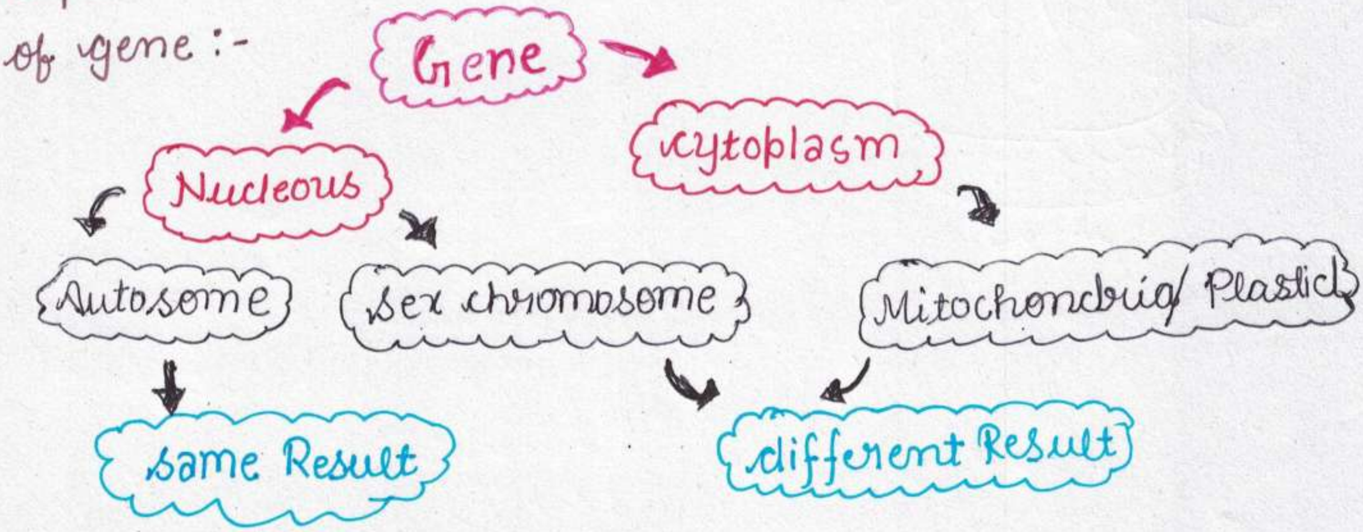
Tt (tall)

cross II

♂ tt ♀ TT

Tt (tall)

→ Reciprocal cross gives Information regarding location of gene :-



Question what is the phenotype and genotypic ratio of the test cross Ttrr x ttRr.

⇝ Ttrr x ttRr   G.R. = 1:1:1:1

Tr tr tR tr   PR = 1:1:1:1

	Tr	tr
tR	TtRr	ttRr
tr	Ttrr	ttrr

Question Identify test cross

AabbCc x aaBbcc

⇝ Aa bb Cc x aa Bb Cc

$2^3 = 8$ → 1:1:1:1:1:1:1:1

Question AA Bb Ccdd x AABbCcdd

⇝ 9:3:3:1

Post Mendelian Genetics

Gene Interaction :-

Gene Interaction take place at gene product level. so, phenotyphic ratio will change but genotypic ratio will remain same.

Gene Interaction is of two types

- one gene Interaction
- Two gene Interaction.

(i) One gene interaction/ Allelic Interaction/ Introgenic Interaction:-

Eg:- ⓐ Incomplete Dominance.

(b). Co-dominance.

(c.) Multi- Allele.

(d.) Pleiotrophy.

(e) Lethality.

(ii) Two gene interaction/Non-Allelic Interaction/ Intergenic interaction:-

Eg:- (a.) Epistasis. (b). Complementary gene.

Incomplete Dominance :-

- when dissimilar forms are present together in a hybrid then one form is not able to Express itself fully over another form such condition is incomplete dominance.
- F1 phenotype is new phenotype and do not resemble to any of parent.
- F1 phenotype is intermediate and uniformly mixed.
- F1 generation shows phenotypic blending some scientists called it Monogenic. quantitative inheritance.
- Phenotypic and genotypic ratio in F2 generation is some

Eg:- (i) Mirabills jalpa/ 4-o-clock/ Gul-e-bans } Flower
(ii) Antinhinum Majus/ Samapdrogan/ Dog flower. } colour

Ⓟ Red White

RR rr

(f_2) Rr (Pink)

↓ Selfing.

F_2

	R	r
R	RR red	Rr Pink
r	Rr Pink	rr white

Phenotypic ratio : 1:2:1

Genotypic ratio : 1:2:1

(iii) Andolusion foul (Roosters):-

Ⓟ Black white

BB bb

Bb

↓

	B	b
B	BB	Bb
b	Bb	bb

Phenotypic ratio 1:2:1

Genotypic Ratio 1:2:1

99

Starch grain Size in pea plant

Bb
- Seed shape
  - BB Round
  - Bb Round (Dominant)
  - bb wrinkled
- Starch grain size
  - BB large
  - Bb Intermediate (Incomplete dominant)
  - bb small

For pleiotrophic gene only. Dominancy of a gene depend on two things.

(i) Gene product (Enzyme)

(ii) Particular phenotype under study.

Co-Dominance

When dissimilar forms of a gene are present together and both forms are Expressing them-selves Equally such condition is codominant state.

- f_1 phenotype resembles to both parent.
- f_1 phenotype is intermediate and non-uniformly mix.
- Genotypic and phenotypic Ratio is same in F_2 generation.

Example (i) Roon cattle

(P) Black B_1B_1 white B_2B_2

$F_1 \rightarrow B_1B_2$ (Roan)

$B_1 B_2$ (Roan)

↓

	B_1	B_2
B_1	B_1B_1 Black	B_1B_2 Roan
B_2	B_1B_2 Roan	B_2B_2 white

(2) A-B Blood Group = $I^A I^B$

(3) Sickle-cell-Anemia = $Hb^A Hb^B$

(4) M-N blood group → $L^M L^N$

Multiple Allele

- when more than two forms of a genes are present in a population such condition is multiple Allele condition.
- Multiple Alleles are produced by mutation in a gene.
- Mutation are generally harmful but recessive in Nature.

  So, only those mutations are considered significant which are seen in at least one percent population or their frequency is at least 0.01.
- Multiple Alleles are studied in a population.
- Multiple Alleles are located on homologous chromosome pair at some locations.

Total genotypes are calculated by $\frac{n(n+1)}{2}$

Example Blood group, $n=3$

Total Genotype = $\frac{3(3+1)}{2} = 3 \times 2 = 6$

Blood Group	Genotype	Antigen	Antibody
A	I^AI^A I^AI^o	'A'	'b'
B	I^BI^B I^BI^o	'B'	'a'
AB	I^AI^B	'AB'	–
O	I^oI^n/ii	–	'ab'

Rh antigene :-

R → Rh ⊕

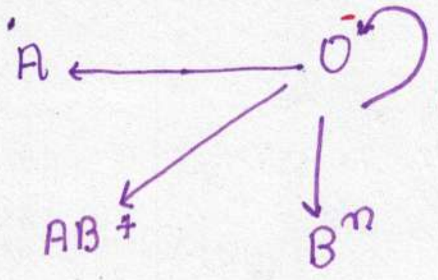
r → Rh ⊖

Gene → I^o/i, → I^A, → I^B

RR / Rr → Rh ⊕ve

rr → Rh ⊖ve

Blood transfusion



O⁻ → universal donor

AB⁺ → Universal Acceptor

- Two Rh(-)ve parent can never have Rh(+ve) child

Ⓟ rr × rr → rr

- The two Rh(+)ve parent can have Rh (-)ve child.

Ⓟ Rr × Rr

rr

- If any of parent is having AB blood group they cannot have 'O' blood group child (vice-versa)

- If one parent is having A blood group and another is having B blood group then they can have all four blood groups.

	I^A	I^O
I^B	I^AI^B	I^BI^O
I^O	I^AI^O	I^OI^O

Question John is having 'O' Blood group. Suzi is having 'A' blood group and her child is having AB Blood group and Suzi is claiming the John is biological father of the child.

(1) Data Insufficient (ii) Suzi is correct [✓ (iii) Suzi is lier.]

Solution

AB

	I^A	I^O
I^A	I^AI^A A	I^AI^O B
I^B	I^AI^B AB	I^BI^O B

$\leftarrow$ A $\rightarrow$

	I^A	I^A
I^A	I^AI^A A	I^AI^A A
I^B	I^AI^B AB	I^AI^B AB

B will Indicate.

Example Skin coat colour in Rabbit :-

Solution Given $n=4$, Total Genotype $= \frac{4(4+1)}{2} = 20/2 = 10$

Dominance order $C > c^{ch} > c^{h} > c \rightarrow$ Albino

Agouti Chinchila Himalyan Grey

(a). CC, Cc^{ch}, Cc^{h}, Cc

(b). $c^{ch}c^{ch}, c^{ch}c^{h}, c^{ch}c$

(c.) $c^{h}c^{h}, c^{h}c$

(d). Cc

Example Self incompatability in tobacco :-

Solution $n=4$, Total genotype $= 10$.

S_1, S_2, S_3, S_4

$\boxed{S_1S_1, S_2S_2, S_3S_3, S_4S_4}$ Not possible

Example Eye colour in Drosophila :-

Solution $n=15$, Total genotype $= \frac{15(15+1)}{2} = 15 \times 8 = 120$

Total genotype = 120.

Example If dihybrid cross is performed in Mirabilis Jalpa for flower colour and height. what will be phenotypic ratio in F2 generation.

Solution $D.C = m.c \times m.c$

P.R. (1:2:1) (3:1)

	1	2	1
3	3	6	3
1	1	2	1

G.R = (1:2:1) (1:2:1)

	1	2	1
1	1	2	1
2	2	4	2

Pleiotrophy :-

when one gene is controlling phenotypic Expression of more than one character such genes are pleiotropic gene.

SSs

- In pleiotropic gene their gene product participates in more than one metabolic reaction.

SSs

- One gene → Multiple Effects :-

(i) Pea plant

- flower colour.
- seed coat colour.
- Read spot on axis of leaf

(ii) Peaplant :-

- seed shape
- starch grain size

(iii) Drosophila :-

- Longivity
- wings size
- Bristle on wings
- fertility.

- human genetic disorders are Example of pleiotrophic genes.

Lethality

- Lethal Gene are those genes which control Viability of organism and they are also controling other characters.
- Lethal genes are Example of pleiotrophic genes.
- skin coat colour in mice [[illegible]not]

Y and y

colour

YY → Yellow

Yy = Yellow

yy = Brown

Y = Dominant

lethality

YY → Death

Yy = Alive

yy - Alive

Y - Recessive

Yellow x Yellow

Yy Yy

1YY 2Yy 1yy

Death : 2 yellow : 1 Brown

Phenotype ratio

2 : 1.

Leaf colour in snapdragon:-

G = Golden (Aurea) g = green

Golden × Golden

Gg Gg

1GG : 2Gg : 1gg

↓ ↓ ↓

Death : 2 Green : 1 Green

Phenotypic ratio = 2 : 1

Sickle Cell Anaemia

I → DNA 3' Ⓣ .... CTC ... 5' ... CAC ---

5' Ⓒ ---- GAG ... 3' ... GTG ---.

MRNA ---- GAG --- GUG -----

Polypeptic chain → Glutamic → Valine →

6th position.

Pant Mutation

II

(a) $HbA\ HbA$ Homogygous Ⓝ

(b) $Hb^S\ Hb^S$ Disease

(Recessive)

Ⓒ $Hb^A\ Hb^S$ $\xrightarrow[\text{(low } O_2 \text{ tension)}]{O_2 \text{ partial pressure} \downarrow\downarrow}$ $\boxed{\text{Hb polymerisation}}$

(Co-dominant)

(Ⓝ but carrier)

Hb polymerisation

- R.B.C shape → Sickle shape
- Membrane → Stiff/Rigid
- Capillaries → Block
- Blood supply → Increased → O_2 supply ↓ → Pain → Death (Tissue)
- Life span RBC 80-90 dyz

Question ① A Male who is having sickle cell trait is getting married to Sickle cell disease female what are the chances of having disease progency.

Solution ⑥

♂ × ♀

$Hb^A Hb^S$, $Hb^S Hb^S$

$Hb^A Hb^S$ $Hb^S Hb^S$

1 : 1

50% - 50%

2) Leaf colour in snapdragon:-

Ex 1 Q.85

Solution ⑥

♀ ♂

AA Aa

♀ Aa × aa ♂

1Aa 1aa

Ⓝ diseased.

Albinism :-

AA Aa aa

↓ ↓

Ⓝ/carriers diseases

Two Gene Interaction

(i) complementary gene :-

When two non-Allelic genes dominant ~~from~~ come together they produce particular phenotype which is not produced when their dominant forms are not together.

Example:- flower colour, in Lathyrus odoratus
(Sweet pea).

$$\text{Substrate} \xrightarrow[\text{Gene 'C'}]{} \overset{\text{(colourless)}}{\text{chromogen}} \xrightarrow[\text{Gene 'P'}]{} \underset{\text{(Blue)}}{\text{Antrocynine.}}$$

CCPP × ccPP
colour   colourless

CcPp - F1 (colour)

9C- P-	3C-pp	3ccP-	1ccPP
9 colour	7 colourless		

Ex:3/Q.33 Solution

Solution (6)

CcPp → C → P = CP
→ p = Cp
→ c → P = CP
→ p = cp

	CP	CP	CP	CP
CP	CcPp	CCpp	CcPp	CcPP
CP	CcPp	CcPp	ccPp	ccPP

3:5

Epitasis

- when Allelic suppression is seen it is known as dominance.

- when non-Allelic gene supresses phenotypic Expression of another gene is known as Epistasis.

Epistasis

1.) W → Y, ↘ y } Dominant Epitasis

Hypostatic

2.) bb → A, ↘ a } Recessive Epistasis

Epistatic

Hypostatic

- **Epistatic gene :-** Gene which suppress phenotype Expression of another gene.

- **Hypostatic gene :-** Gene which is going to be suppressed

Epistasis is of two types

(i). Dominant Epistasis :-

Example :- fruit colour in summer squash (Cucurbita pepo).

(a) Y - Yellow y = Green

W = Epistatic gene (white) w = no role

(b) W → Y, ↘ y

Epistasis

Hypostatic

(c) WWYY x wwyy

white green

WwYy

9W-Y- 3W-yy 3wwY- 1wwyy

12W : 3Y : 1G

(ii). Recessive Epistasis :-

skin coat colour in mice

I
ⓐ B → ▲ Black
ⓑ b → △ Albino
ⓒ B-A- → ▲ Agouti

II
$$\begin{tikzcd} \text{Raw material} \arrow[r, "b"] \arrow[d, "B"] & \text{Albino} \\ \text{Black} \arrow[d, "A"] & \\ \text{Agouti} & \end{tikzcd}$$

III
BBAA × bbaa
Agouti   Albino
BbAa
$9B\text{-}A\text{-}$ $3B\text{-}aa$ $\underbrace{3bb\text{-}A\text{-}\ \ 1bbaa}$
9 Agouti : 3 black : 4 Albino.

IV
bb → A
↘ a

Supplementary Gene :→ when one non-Allelic gene modifies phenotypic expression of another non-Allelic gene.

Cytoplasmic Inheritance

carl correns discovered cytoplasmic inheritance and Incomplete dominance.

Karyogene - Genes Inside the nucleus.

Plasmons/ Plasmogenes Genes present in cytoplasm (mitochondria and plastids)

G = Green, chloro

P = Leucopl.

V = chloro and leuco.

Polygenic Inheritance

- It is also known as quantitative Inheritance / continuous inheritance / additive inheritance.
- When one character is controlled by more than one such Inheritance is polygenic inheritance.

  1 gene → Multiple Effect → pleiotrophic gene.

  >1 gene → one Effect → polygenic gene
- Every dominant form contributes Equally.
- **Maximum phenotypic Expression** → homozygous dominant genotype
- **Minimum phenotypic Expression** → homozygous recessive genotype.
- Other than maximum and minimum phenotype intermediate phenotype are also observed.
- Contribution by Each dominant allele →

$$\frac{\text{Max. phenotypic Expression} - \text{min. phenotypic Expression}}{\text{Max. possible Number of dominant Allele (gene) (Dominant homozygous)}}$$

- Total type of phenotypes in polygenic inheritance $(2n+1)$

  n = no. of polygenes controlling a character.

Multiple Allele	Polygenic Inheritance
IA, IB, IO	A and B and C
In one individual Maximum two forms are present (similar or dis-similar) eg - I^AI^A, I^BI^B, I^AI^O, I^BI^O, I^OI^O	All Genes which are controlling characters are present in Individual eg:- AABBCC --- AaBBCC ----
Present on homologous pair	Present on homologous or non-homologous both

Genes controlling character	Maximum dominant Alleles	Phenotypes (2n+1)
2-A and B	ABBB-4	5
3-A & B & C	AABBCC → 6	6
4-A&B&C&D	AABBCCDD → 8	7

Example :- fruit weight in tomato is controlled by two genes (A and B).

- Maximum Weight of tomato 140gm
- Minimum Weight of tomato 20gm

Minimum phenotype is never considered zero in polygenic Inheritance.

$\frac{140-20}{4}$ = 30gm by Each dominant form.

AABB × aabb

(140gm) (20gm)

AaBb

140	110	80	50	20
homozygous Dominant (4D) 1AABB	3D 2AABb 2AaBb	2D 4AaBb 1AAbb 1aaBB	1D 2Aabb 2aaBb	All Recessive 1aabb
1	4	6	4	1

AaBb x AaBb

aabb : AABB : aaBB : AAbb : AABb : aaBb
1 : 1 : 1 : 1 : 2 : 2

Example of polygenic inheritance.

I.

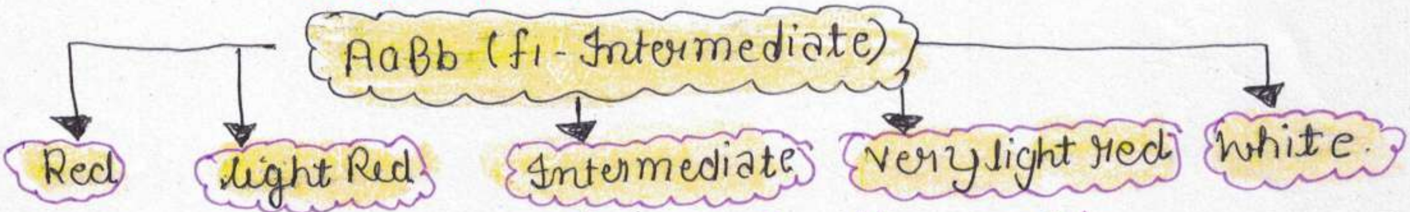
- Human Skin colour (three polygenes controlling the character)
- Human height.
- Human Intelligence.
- **In plants** :- Plant height
  Pi fruit weight
- **Animals** :- Body weight
  Milk production
  Meat production etc.

II. Kernel colour in wheat : controlled by 2 polygenic pair :-

- Korlreuter first Explained polygenic inheritance.
- Mison-Ehel performed first Scientific study for Kernel colour in wheat.
- Davenport studied human Skin colour.

AABB x aabb

AaBb (f1- Intermediate)



1 : 4 : 6 : 4 : 1

Human Skin colour :-

♂ × ♀

PPQQRR × ppqqrr

(Negro) (Albino)

$\boxed{PpQqRr}$ (f₁ · Mullato)

6D	5D	4D	3D	2D	1D	Recessive
1 :	6 :	15 :	20 :	15 :	6 :	1
Negro (Black)	very dark (brown)	Dark Brown	$\boxed{\text{Mullato}}$	Light Brown	Very light Brown	Albino

sSsS

No. of plant showing parental genotype or phenotype.

one gene	two gene	three gene
Incomplete Dominance	Kernel Colour	Human Skin colour.
2/4 → 50%	2/16 → 12.5%	2/64 → 3.25%

SSs

No. of plant showing F₁ phenotype.

one gene	Two gene	Three gene
2/4	6/16	20/64

SSs

No. of plant showing Intermediate phenotype in F₂

one gene	Two gene	Three gene
2/4	14/16	62/64

Question In a tomato fruit weight is controlled by two polygenes A and B Maximum weight of tomato is 180 gm. Minimum weight is 100 gm.

calculate (i) contribution by Each dominant Allele.

(ii). What is the weight of AABb tomato.

Solution (i) $\frac{AABB}{4} \rightarrow \frac{18-100}{4} = 20gm.$

(ii) Here, 2genes are controlling and there is 4 dominant Allele (Max). → so phenotype will be

(2n+1) = 5

	+20	+20	+20	
180	160	140	120	100
4D	3D	2D	1D	
1 :	4 :	6 :	4 :	1

Weight of AABb → 160gm (Here, 3 Dominant grow).

Question In a plant, height is controlled by three polygenes A; B; C, minimum height = 27cm maximum height = 45cm. calculate :-

(i). contribution by Each dominant allele:

(ii). Rage of plant having 30cm height.

Solution (i) $\frac{AABBCC}{6} = \frac{45-27}{6} = 18/6 = 3cm.$

(ii) (2n+1) = n=3 → 7 phenotype.

+3	+3	+3	+3	+3	+3	
45	42	39	36	33	30	27
6D	5D	4D	3D	2D	1D	
6 :	15 :	20 :	15 :	6 :	1	

16

There are 6 out of 64 plants which have 30 cm height.

Their % age → $6/64 \times 100 = 75/8 = 9.375$

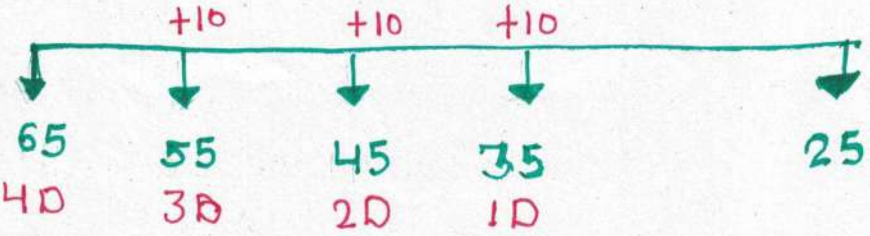
Question In a plant, height is controlled by 2 polygenes minimum height is 25cm Maximum height is 65 cm. calculate:-

(i) contribution by Each dominant Allele.

(ii). Height of a plant having Aabb genotype.

(iii) % age of plant in F2 having 55cm height.

Solution (i) $\frac{AABB}{4} \rightarrow \frac{65-25}{4} = 40/4 = 10cm.$



1 : 4 : 6 : 4 : 1

height of plant having Aabb genetype = 35cm.

(iii) No. of plants having 55 cm height in F2 is $4/16$ plants, so % age $= 4/16 \times 100 = 25\%$.

Question A molato male is getting married to negro female. How many types of phenotype are possible in their progency.

(i) only two types (ii). only four types (iii) Six type.

✓(iv). four of two types.

PPQqrr   PPQQRR   PpQqRr

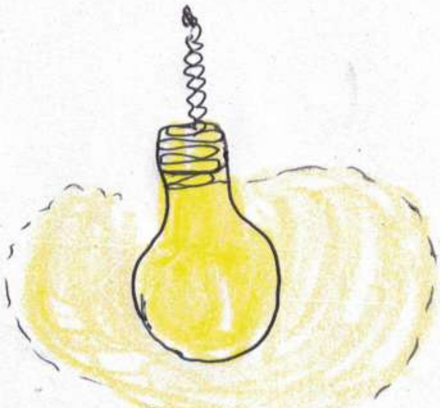
PQr Pqr   [PQR] → PQR → 6D

5D 4D   (3D)

PQr
PqR → 5D
PQR

Pqr
PQr → 4D
PqR

Pqr → 3D



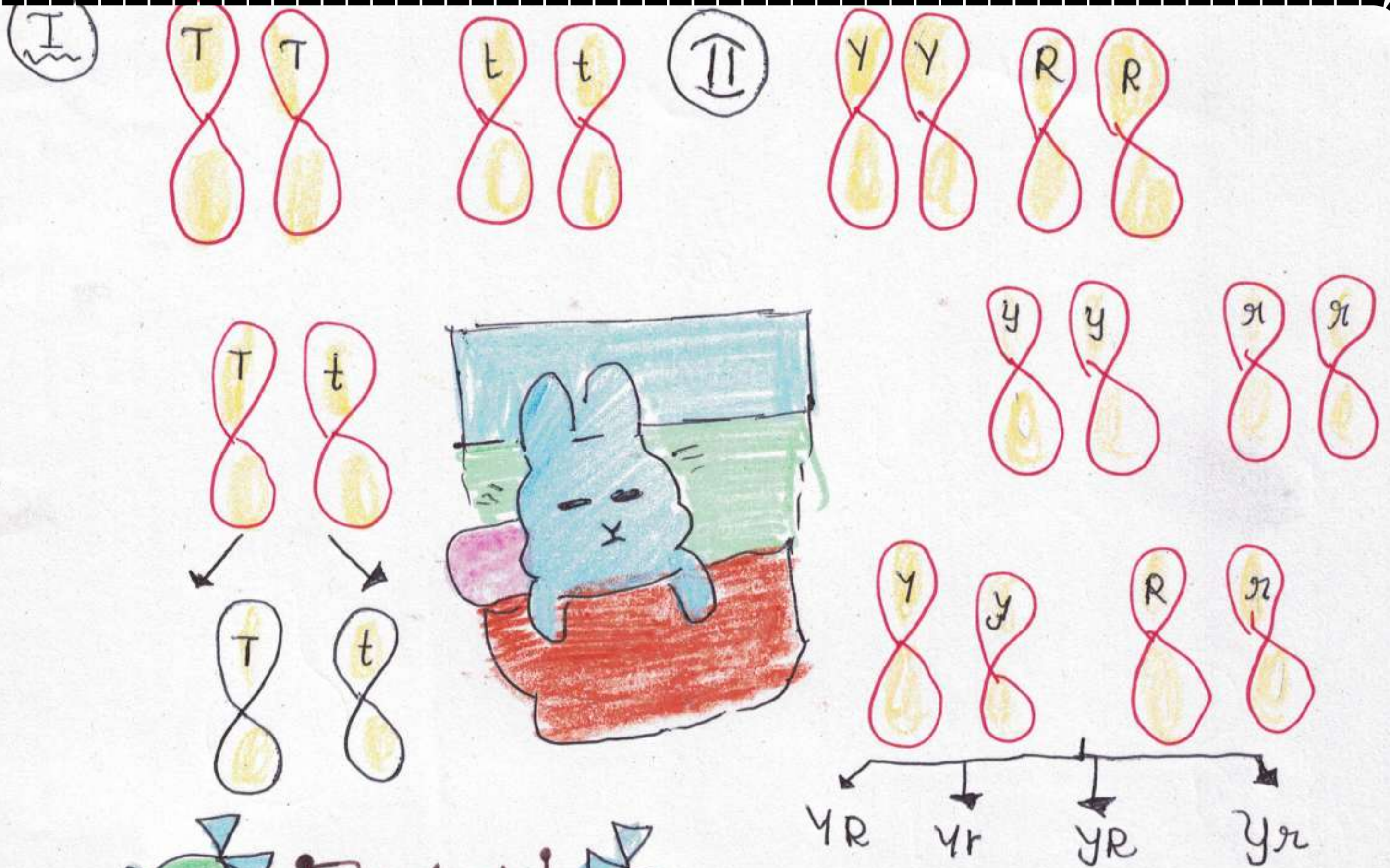
Linkage

Bateson and Punnett were first one to ~~d~~observe linkage but they called it coupling and Repulsion. so, credit for discovery of linkage goes to Morgan.

Cromosomal theory of inheritance (Sutten and Boveri)

Sutton and Boveri stablished parallel behaviour shown by genes and chromosomes

CHROMOSOME	GENE
They are present in pairs	They are also present in pairs
During gamete formation chromosomes get segregated.	During gamete formation genes are also get segregated
One pair get independent segregation from another pair.	one independent pair gets segregated independent from other pair



Result:

- Genetic Information is transmitted from one generation to another through gametes.
- Gamete contain nucleus which has chromosomes
- Inside Nucleus these chromosomes have genes and these genes are Arranged in linear fusion.

Buteson and Punnett Experiment-

Coupling:- If both dominant are coming from one parent and both recessive are also coming from another one parent then they show tendency to remain together (7:1:1:7)

Repulsion:- If both dominant are coming from different parent and both recessive are also coming from different parent then they do not show tendency to come together (1:7:7:1)

Sweet Pea

Flower colour	Pollen Shape
Blue (B)	Long (L)
Red (b)	Round (l)

(A). coupling :- BBLL × bbll

Bl→ Blue long   Red Round blue

BL/bl

Bbll × bbll

Blue-long   Blue-Round   Red-long   Red-Round

Expected 1 : 1 : 1 : 1

Observation 7 : 1 : 1 : 7

P.C R.C R.C P.C

(B). Repulsion :- BBll × bbLL

Bl   Blue-Round   Red long   bL

Bl/BL

BbLl × bbll

Blue long   Blue-Round   Red-long   Red-Round

Expected :- 1 : 1 : 1 : 1

Observation: 1 : 7 : 7 : 1

R.C P.C P.C R.C

Linkage :- All the genes present over one chromosome they show tendency to remain together from one generation to another generation this is known as linkage.

All the genes over one chromosome are collectively known as one linkage group:-

Organism	chromosome Number	Linkage Group
Drosophila →	4 pair →	4
Pea plant →	7 pair →	7
Maize →	10 pair →	10
Mice →	21 pair →	21
Neurospora →	7 chromosome →	7
Bacteria →	One-unit →	1
Female →	22 AA + 1 X X →	23
Male →	22 AA + X + Y →	24

Neurospora is haploid that is why :-

(i) Every Mutation will be Expressed.

(ii) Test cross can not be performed in Neurospora.

If Mendel had worked on Eight constracting characters or pea plant have six pair of chromosomes.

(first choice) law of Independent arrotment might not been discovered.

{Second choice} :→ Linkage might have been discovered

Gene Arrangement

Cis- Arrangement

AB   AABB × aabb   ab

AB/ab   AaBb × aabb

Gametes	AB	Ab	aB	ab
Zygote	AB/ab	Ab/ab	aB/ab	ab/ab
	++/ab	+b/ab	a+/ab	ab/ab

Trans Arrangement :-

AAbb × aaBB

AaBb × aabb

Gamete-	AB	Ab	aB	ab
Zygote :-	AB/ab	Ab/ab	aB/ab	ab/ab

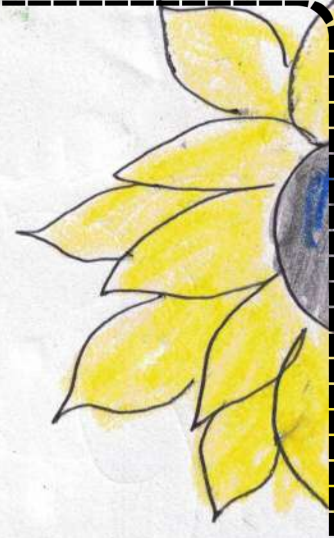
Important AB = ab ⇒ Ab = aB

PC >> RC

PC → Arrangement

Total RC → Distance

Question If dihybrid test cross is performed PpNn × ppnn and PN/Pn = 22% obtain what is the distance between gene p & n and their arrangement



Solution

PN/pn = 22%. PN = 22%. Pn = 28%.
pn = 22%. pN = 28%.

$$\frac{100-44}{2} = 56/2 = 28$$

Pn = pN = 28%

(∵ PC > RC), so, pN and Pn and Pc.
therefore, Arrangement trans.
Total RC = Distance
22 + 22 = Distance
44 cm = distance between gene p and n

Question

A dihybrid cross is . AaBb is formly four type of gametes . AB = 16%.

Solution

We know, AB = ab = 16% (Given).
Also, aB = Ab

$$AB = aB = \frac{100-32}{2} = 68/2 = 34$$

AB = 16
ab = 16 } Distance = 32 CM

Ab = 34
aB = 34 } PC (Trans).

Question

A dihybrid test cross is performed and follows four type of gametes obtained.
PN = 200, Pn = 800, pn = 200, pN = 800.

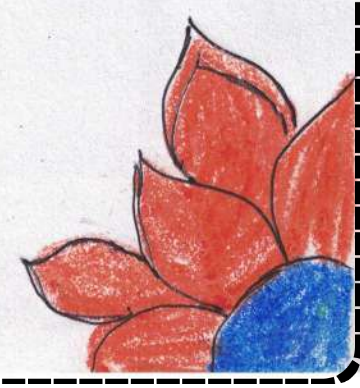
Solution

$$PN = \frac{200}{2000} \times 100 = 10\%$$

so, PN = Pn = 10% [∵ PN = PN]

$$Pn = \frac{800}{2000} \times 100 = 40\%$$

so, Pn = pN = 40% [∵ Pn = pN]



P·C = Pn & PN ⇒ so, arrangement = Trans.

Distance = 10+10

Distance = 20 cM

TYPES OF LINKAGE

Complete linkage

- Rare phenomena
- P·C = 100%. , R·C = 0

Example: Male Drosophila, female silk worm.

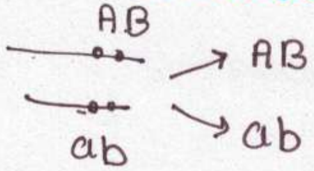
Incomplete linkage

- very common phenomen
- P·C ≥ 50% R·C ≤ 50%.

Example :- Human

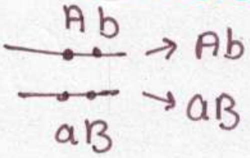
- In case of complete linkage any given hybrid state will behave as Monohybrid.

(a.) AaBb → A and B complete link



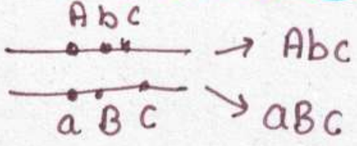
Ab = 0

(b.) AaBb → A and b complete link



AB = 0

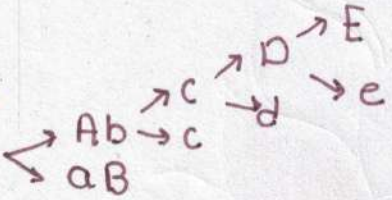
(c). AaBbCc ⇒ A, b, C complete link



ABC = 0

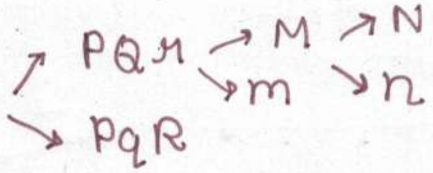
abc = 0

(d). AaBbCcDdEe ⇒ A and b complete link.



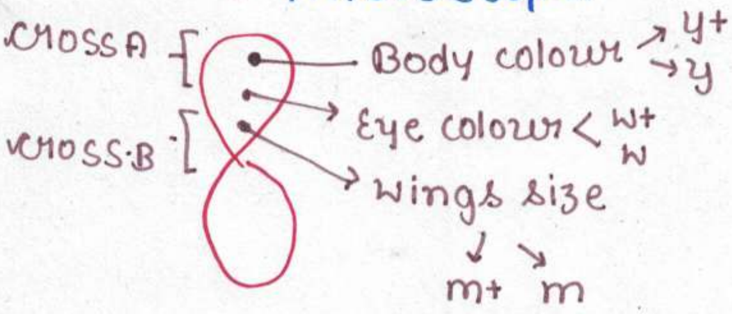
(e) $\boxed{PpQqRr}$ MmNn → PQr complete link:-

1 1 1



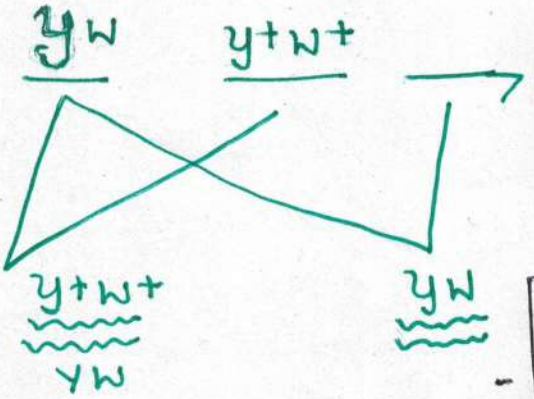
Question:- Why Morgon Selected Drosophila?

Reason:-
- Life span is short (15 days)
- No. of progenies Very high
- Many contrasting characters are present
- Easy to grow
- features can be studied under low power microscope.



(P) ♀ $\frac{y\,w}{y\,w}$ ♂ $\frac{y^+w^+}{y\,w}$

(F₁) $\underline{\underline{y^+w^+}}$ $\underline{\underline{y\,w}}$



		yw	y^+w^+ ⇀	
P·C	y^+w^+	$\frac{y^+w^+}{y\,w}$	$\frac{y^+w^+}{\rightharpoonup}$	98.7%
	yw	$\frac{y\,w}{y\,w}$	$\frac{y\,w}{\rightharpoonup}$	
R·C	y^+w	$\frac{y^+w}{y\,w}$	$\frac{y^+w}{\rightharpoonup}$	1.3%
	yw^+	$\frac{y\,w^+}{y\,w}$	$\frac{y\,w^+}{\rightharpoonup}$	

CROSSING OVER

- crossing over never Introduces new gene it brings New combination between old Existing genes.
- Mutation is Responsible for Introducing New gene.

Question 6 In a cross between +a+b x aabb, 700 out of 1000 Individuals were parental type what is the distance between A and B gene

Solution 6 for distance we must have to find d.R.c

$R.C = 1000 - 700 \rightarrow R.C = 300$

$R.C\% = \frac{30\cancel{0}}{100\cancel{0}} \times 1\cancel{00} = 30\%$

Distance : 30cM (Trans)

$$\%\ \text{crossing over value (Recombination frequency)} \Rightarrow \frac{\text{New Combination (R.C)}}{\text{Total combination (P.C+R.C)}} \times 100$$

% crossing over value = 1CM = 1mp unit
(centi Morgan

Question 6 Distance between two genes is 66cm what is total recombinant percentage?

(i) 100% 2.) 75% 3.) 66% [✓ 4.) Maximum upto 50%]

- Maximum recombinants can reach upto 50%. when all gamete forming cells are undergoing crossing over between some gene.

Factors Affecting Linkage and Crossing Over (C.O.)

- Distance ↑ ⇒ Linkage ↓, C.O ↑
- Temperature ↑ ⇒ Linkage ↓, C.O ↑
- X-Rays ↑ ⇒ Linkage ↓, C.O ↑
- Age ↑ ⇒ Linkage ↑, C.O ↓
- Heterochromatin ↑ ⇒ Linkage ↑, C.O.
- female ⇒ Linkage ↓, C.O ↑
- Male ⇒ Linkage ↑, C.O. ↓

Gene Mapping

Morgan and Stuartvent gave gene mapping and they stablished gene position on chromosomes.

Ques Recombinant frequency between PQRS gene is given below, what is the arrangement order of these genes over chromosomes

PQ = 20%, PR = 4%, RQ = 16%, SP = 25%, Q.S = 5%

(i) PQRS (ii) PRSQ

(iii) PSRQ ✓(iv) PRQS

(i) $\overbrace{P \rightarrow Q \quad R}^{4}$ S (x) not possible.

(ii) $^{20}\overbrace{P \xrightarrow[4]{} R \xrightarrow[21]{} S}^{25}$, Q (x) not possible.

(iii) $\underbrace{P \underset{25}{\text{———}} S \quad R \quad}$ Q not possible.

(iv) $P \underset{4}{\text{———}} R \underset{16}{\text{———}} Q \overset{5}{\text{——}} S$ / satisfy, all given / R.C.%age.

25

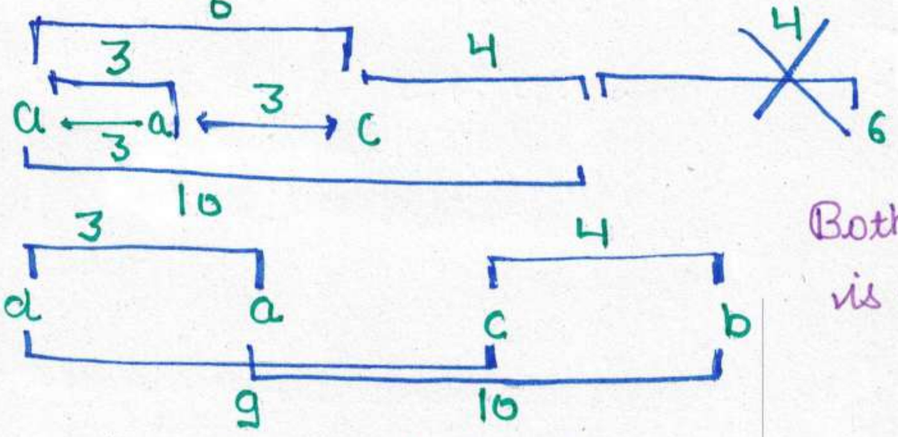
Question ⑤ AD = 20% , AC = 4% , CD = 16% , BC = 9% , AB = 5%

(i) A B C D (ii) C B A D

(iii) C A B D ✓ (iv) B A C D

Similar as above Question

Question ⑥ Recombinant frequency between a-b = 10, b-c = 4, a-d = 3, a-c = 6. what is their arrangement.



Both arrangement is possible.

Sex Linkage

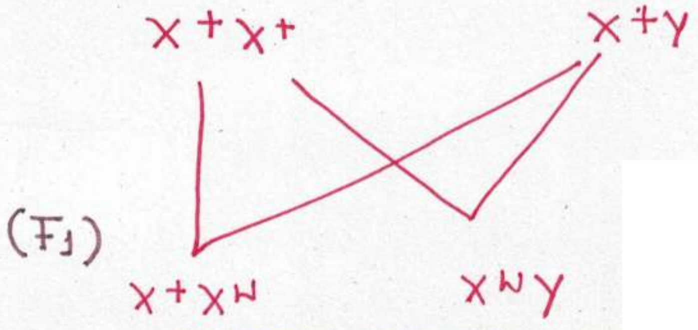
While studying eye colour in drosophila Morgan reached to conclusion the sex chromosomes not only have gene for sex determination but they also have genes for controlling other characters all these genes show tendency to remain together this phenomenon is known as sex linkage and these genes are known as sex linked genes.

♀ → X^+X^+ - Red Eye
→ X^+X^w - Red Eye
→ X^wX^w - white eye

♂ → X^+Y → Red Eye
→ X^wY → white Eye

Cross I

Homozygots Red Eye ♀ x whit Eye ♂

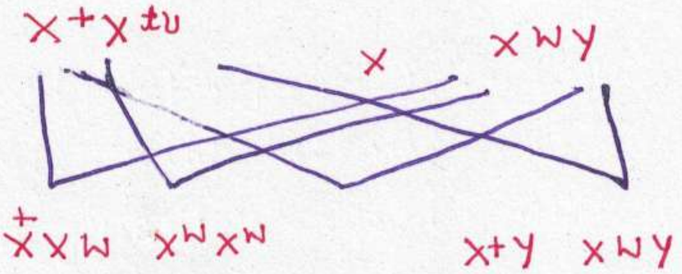


F2

	X^+	Y
X^+	X^+X^+ ♀R	X^+Y ♂R
X^w	X^+X^w ♀R	X^wY ♂w

CASE II

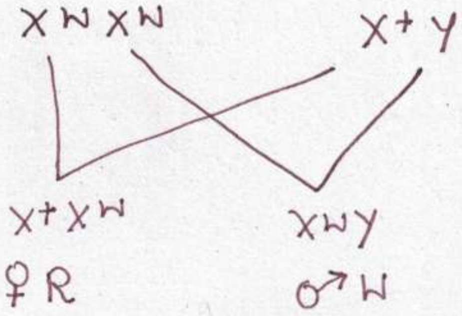
Heterozygous Red Eye ♀ x white eye ♂ .



Test cross

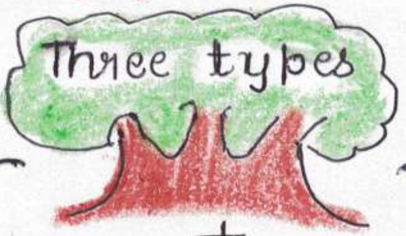
CROSS 3

White eye ♀ x Red Eye ♂



Reciprocal cross.

Sex linked Genes :-



- (i) X-Link
  - Dominent
  - Recessive
- (ii) Y-link
- (iii) X-Y link

(i) **X-Link Recessive :-** These genes are present on non-homologous part of X-chromosome.

Example :- colourblindness.

(ii) Duchanan Muscular dystrophy (D.M.D)

Myotonic dystrophy is Autosomal Dominant condition

(iii) Diabetes Insipidus (iv) fragile x-syndrome.

(v) G-6-P-D deficiency (favism)
(Glucose 6 phosphate dehydrogenase deficiency)

(vi) Haemophilia (vii) Lesch Nyan syndrome.

(viii) Night blindness → Vit. A deficiency.
→ Genetics. Rare

X-Link Dominant

Example :- Pseudorickets.

Y-Link Gene :-

(i) TDF → Testes Determining factor or SRY - sex determining region on Y-chromosome.

(ii) Porcupine skin (iii) Webbed toe

(iv) Hypertrichosis - hair growth on Ear pinna in males.

(v). Keratoderma.

X-Y Link Gene

Example : Xeroderma pigmentosa.

Colourblindness

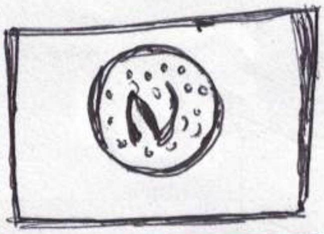
- Horner described colourblindness.
- cones are responsive for three basic colours :-
  Red, Green and Blue.
- colourblind person cannot differentiate particular colour, three types of colourblindness:-

a.) protoanopia for Red colour.

b.) Deutaroanopia for Green colour.

c.) Tritoanopia : for blue colour.

- for diagonasis Inchiara card test is used.



Haemophilia

Also known as "Bleeders" disease discovered by John otto

It is of three types

Haemophilia A :-
- Most lethal, most common
- Known as Royal's Disease
- Due to deficiency of factor VIII

Sex Influenced Characters

- Genes for these characters are present on Autosome
- Their Expression is seen in both sex male and female but more Expressive in one sex.

Example Baldness :-

	♂	♀
BB	Bald	Bald
Bb	Bald	Normal
bb	Normal	Normal

Question (a) A Male whose father was bald is getting married to a female who is suffering from albanism both parents of ~~ha~~ female have normal hair what are chances of having albinic and bald child.

Solution Bb AA × bbaa

Bb Aa Albimism = 0

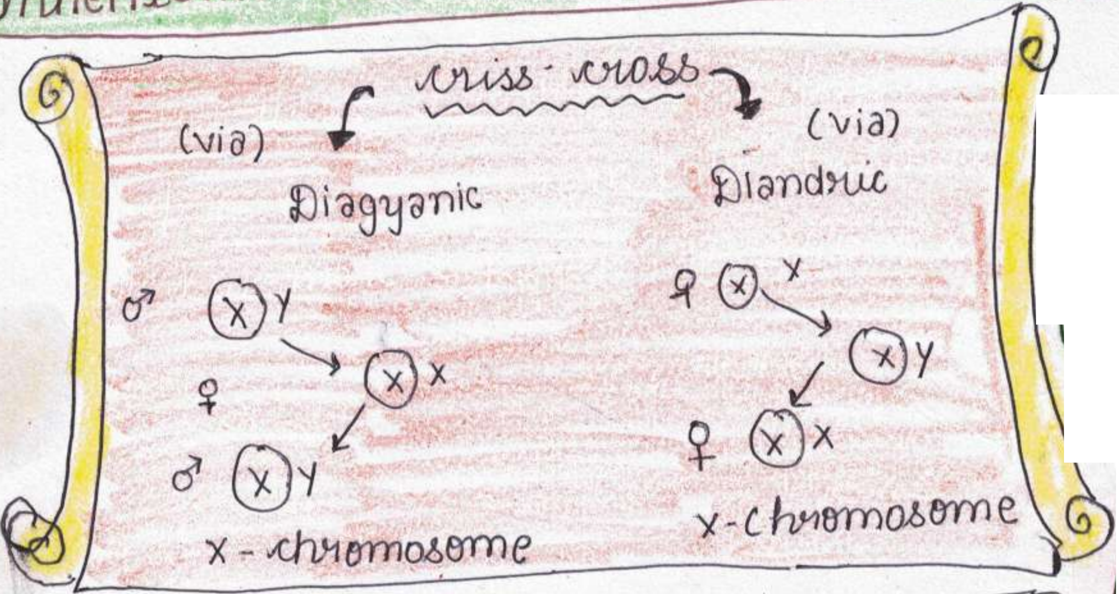
chance of Albanism is zero so no progency can have both disease together.

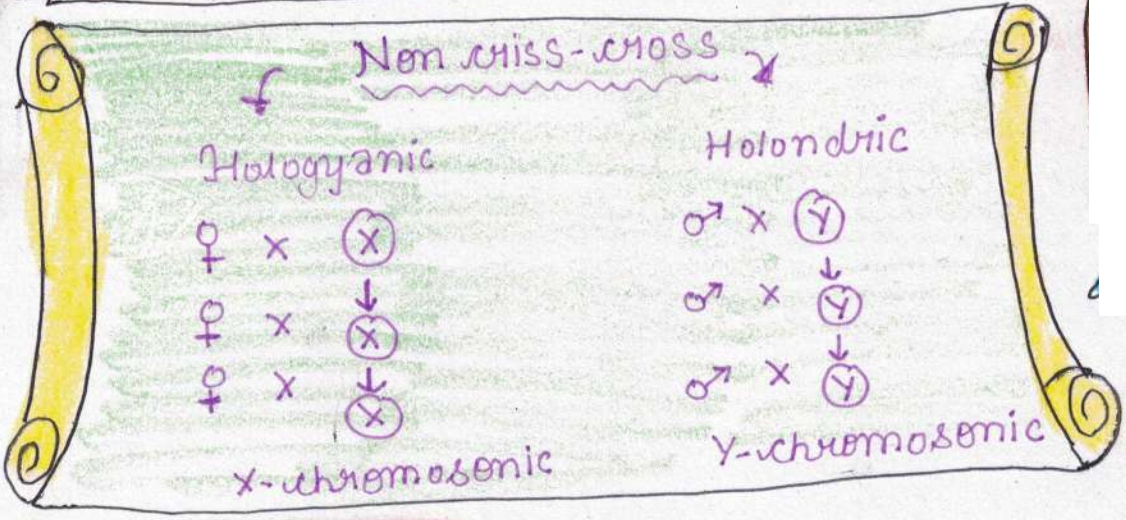
(b) couple had Male child what are the chance of Baldness.

Bb × bb

Bb $1/2 = 50\%$

Inheritance Pattern of Sex Linked Gene





Sex determination

- sex is determined during early point of life.
- on the basis of timing of fertilisation sex determination is of three types:-

(i) Progamic :- sex is determined before fertilisation

Example :- Male in honeybee.

(ii) Syngamic :- sex is determined during fertilisation

Example:- Human.

(iii) Epigamic:- sex is determined after fertilisation.

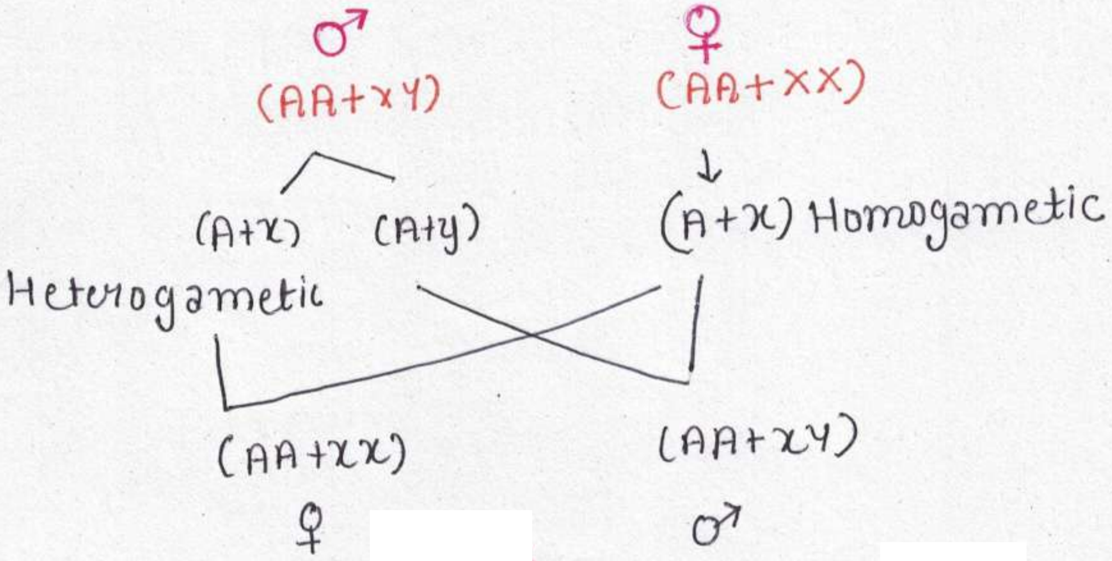
Example:- crocodile and Lizards.

Methods of Sex determination

- Chromosomal theory of sex determination
- Genic balance theory
- Harmonal Role
- Environmental Role.
- Pshyceological basis of Sex determination

(1) Chromosal theory of Sex determination

- Wilson and stevens gave this theory
- Mc clong discovered sex chromosome in grasshopper.
- Montgomery gave the term Allosome or Heterosome for Sex chromosome.
- Henkings discovered x-chromosome.
- Stevens discovered Y-chromosome.



Sub types:-

(a) XX → XY
↓ ↓
♀ ♂

Most common Method of Sex determination.

Example Human, Drosophila, plant

This Method is useful in dioeccous plant.
Example Milendrium, Couineae.

(b) ZW → ZZ
↓ ↓
♀ ♂
Heterogametic Homogamatic

Example :- Birds, Butterfly, fish, Silkworm, Reptiles.

In plant : frogaria, Elator

(c) XX — XO
↓ ↓
♀ ♂ Heterogametic
Homogametic

Example: cockroach, Ascaris, Grasshopper.

In plants :- Discoria, Valisneri.

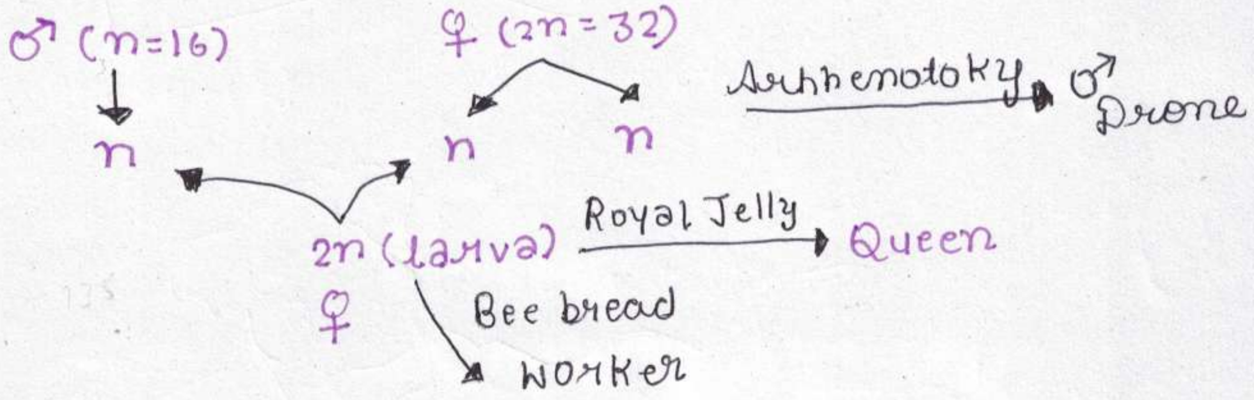
♂ (AA + XO)
↙ ↘
(A+x) (A+O)

(d.) ZO → ZZ
↓ ↓
Heterogametic Homogametic

It is very rare Method.

Example :- Duck

(e) Haplo-diploid Method :- Example :- Honey bee



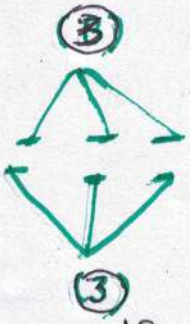
- In honeybee males do not have father but they have Grand father (maternal)

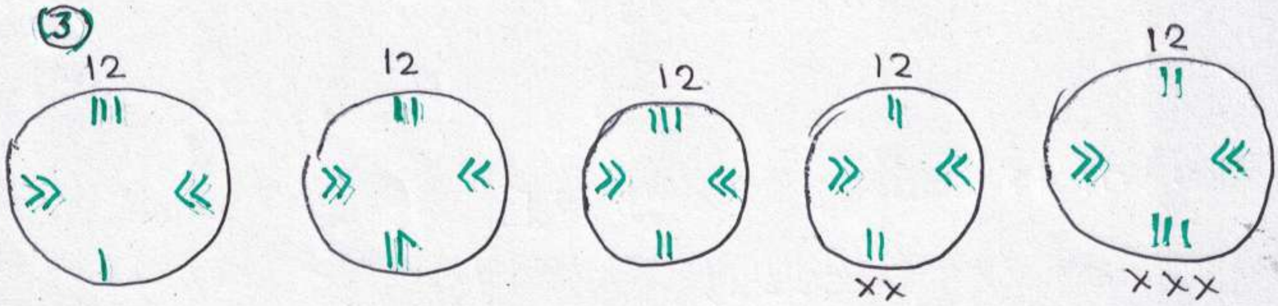
2. Genic Balance Theory:-

This theory was given for Drosophila by C.B bridge.

- Y-chromosome do not play any role in sex determination
- Y-chromosome has its role in fertility only in case of Male.
- Autosomes are responsible for Maleness features.
- X-chromosome is Responsible for femaleness features.

Sex Index Ratio (S.I.R): $\frac{\text{no. of x chromosome}}{\text{no. of Autosome set}}$





$\frac{X}{AAA} = 1/3$ $= 0.33$ Supermale

$\frac{X}{AA} = 1/2$ $= 0.5$ ♂

$\frac{XX}{AAA} = 2/3$ $= 0.66$ Intersex

$\frac{XX}{AA} = 2/2$ $= 1$ ♀

$\frac{XXX}{AA} = 1/2$ $= 1.5$ Superfemale.

3. Hormonal Role in Sex Determination:-

Hormones are responsible for sex differentiation they are not Important in sex determination.

Example :-

(i) **Crew's hen :-** If ovaries were removed in Early part of life. then these hen developed maleness features.

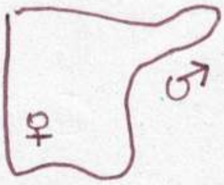
(ii) **free-Martins :-** Applicable in cattles and sheep.

- ⇨ when opposite sex twins are present in Embryo.
- ⇨ Male Embryo hormones will suppress female Embryo
- ⇨ Such Males will be Normal.
- ⇨ females will be sterile.

(4) Environmental Role

- seen in lower Organism

Example (i) Bonnelia, crepidula
(Marine worm)



→ Larva → Remains Isolated ♀

Larva → In presence of other female Develops into ♂

(ii) Turtle and Medusa

>32°c = ♀

<28°c = ♂

28-32°c = Equal chance.

(iii) Crocodile and Lizards

hot temperature = ♂

low temperature = ♀

Cytological basis of Sex determination / Lyon Hypothesis / Doses Compensation theory

- In females More than one x-chromosome is present in males one x-chromosome is present

- Except one x-chromosome remaining x-chromosome becomes temporarily inactive heterochromatin content increased and during staining they take darker stain and they will appear as drumstick and known as bar body.

No. of bar body = No. of chromosome -1

Bar body studied in WBC and Mucosa cell.

Organism	Bar body
XY	0
XO	0
XX	1
XXY	1
XXX	2

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