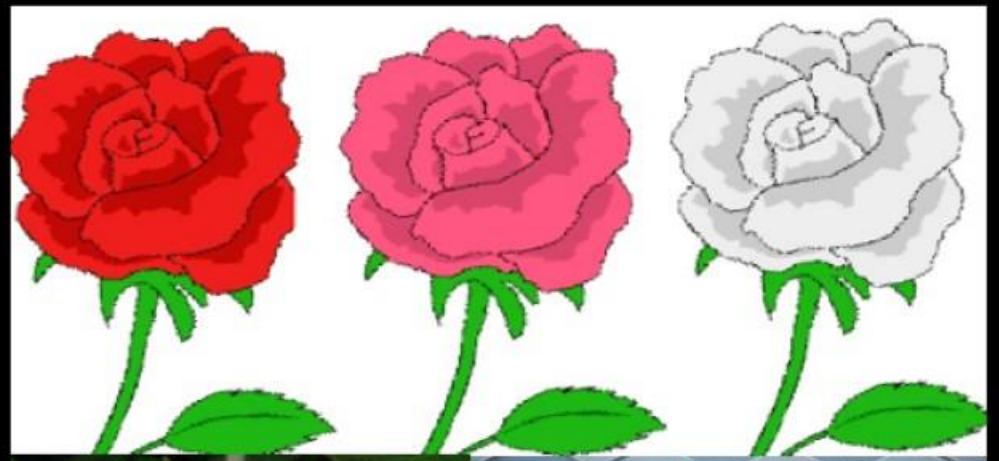
Part 3

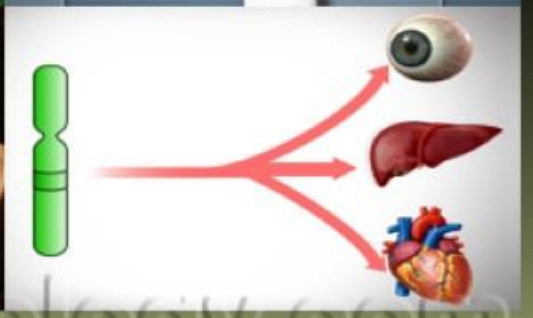
NON-MENDELIAN INHERITANCE

NON-MENDELIAN INHERITANCE

Non-Mendelian inheritance

- Incomplete Dominance
- Co-dominance
- Multiple allelism
- Polygenic inheritance
- Pleiotropy





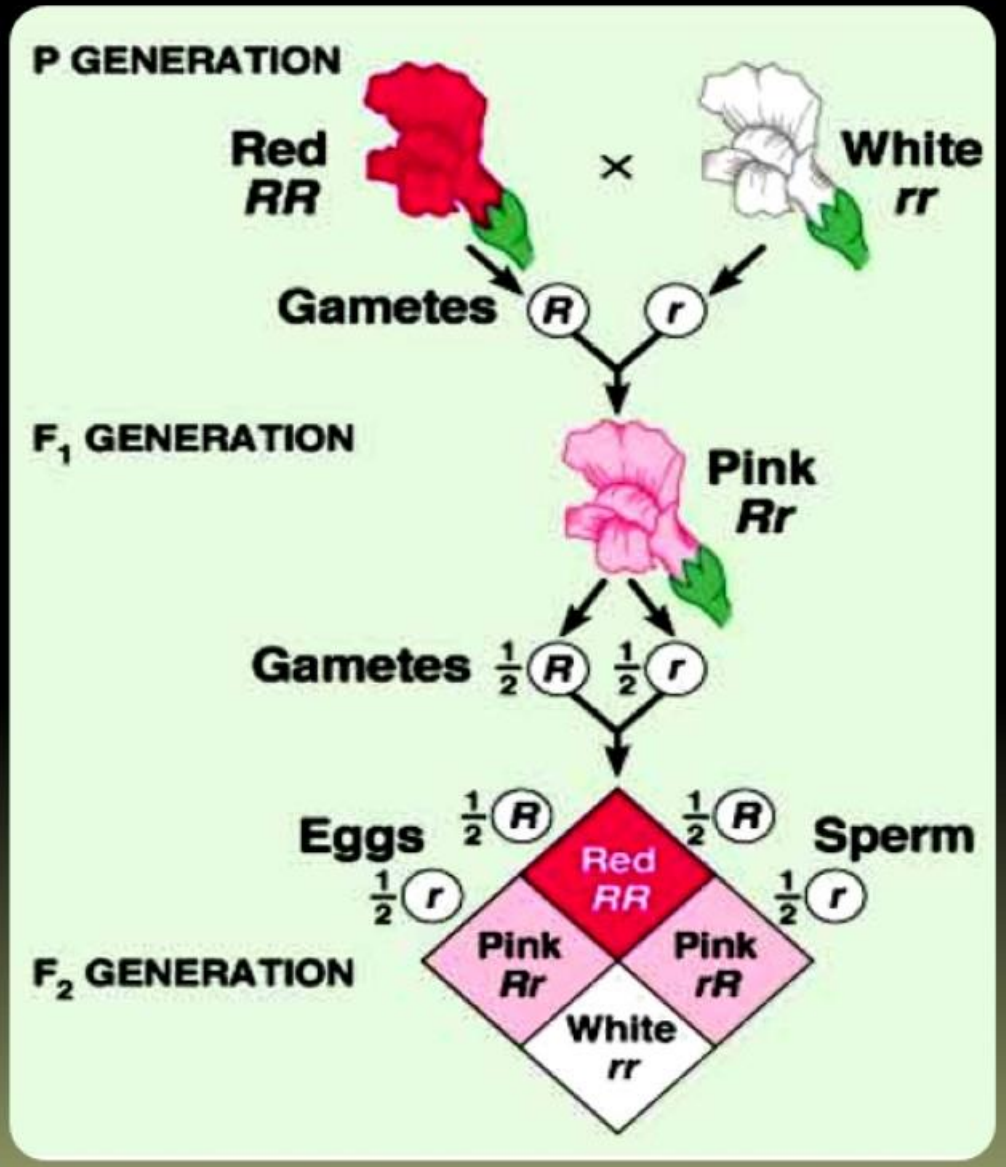
NON-MENDELIAN INHERITANCE

1. INCOMPLETE DOMINANCE

- It is the inheritance in which the offspring shows intermediate character between two parental characteristics.
- E.g. Flower colour in snapdragon (dog flower or *Antirrhinum sp.*) and *Mirabilis jalapa* (4'O clock plant).
- Here, cross between homozygous red & white produces pink flowered plant.

NON-MENDELIAN INHERITANCE

1. INCOMPLETE DOMINANCE



Phenotypic ratio= 1:2:1 (1 Red: 2 Pink: 1 White)

Genotypic ratio = 1:2:1 (1 RR: 2 Rr : 1 rr)

Thus phenotypic and genotypic ratios are same.

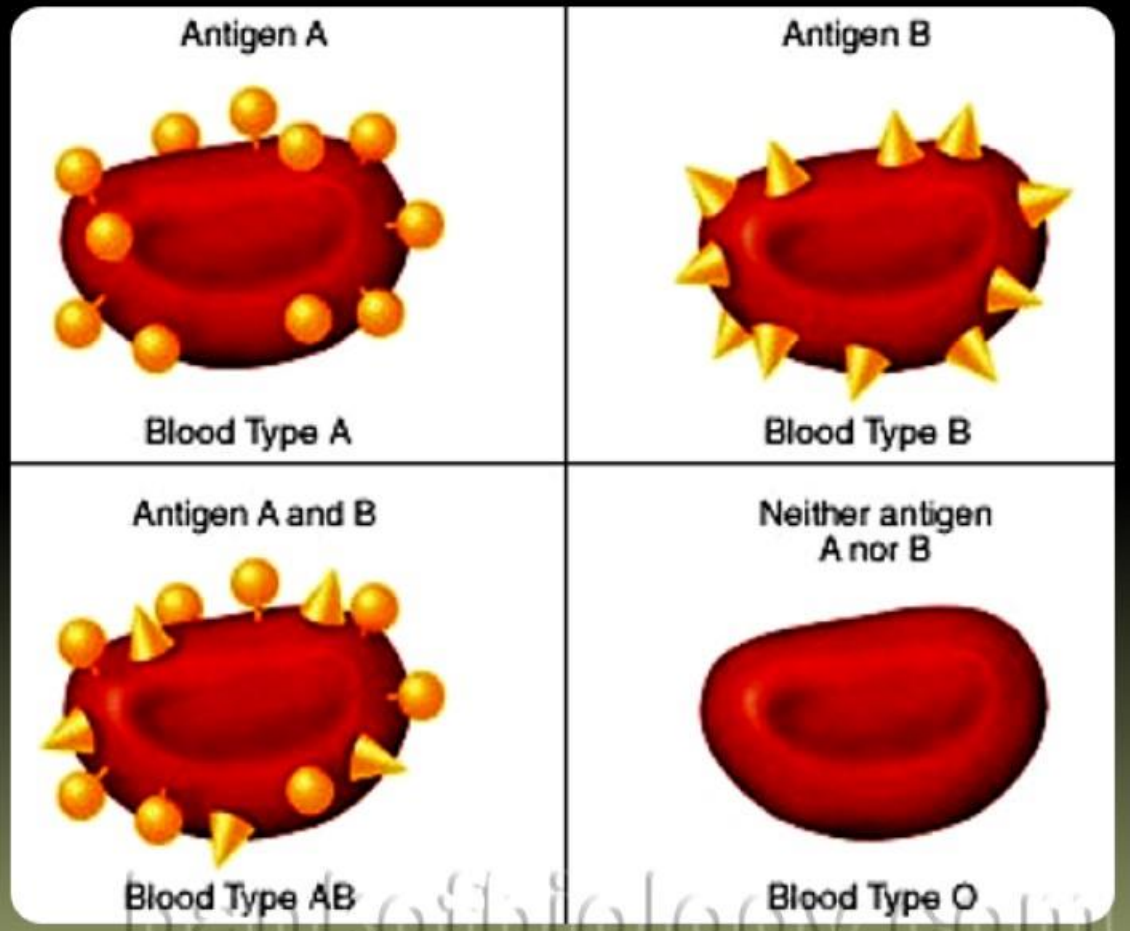
- This means that **R** was not completely dominant over **r.**
- Pea plants also show incomplete dominance in other traits.

NON-MENDELIAN INHERITANCE

2. CO-DOMINANCE

- It is the inheritance in which both alleles of a gene are expressed in a hybrid.
- E.g. ABO blood grouping in human.

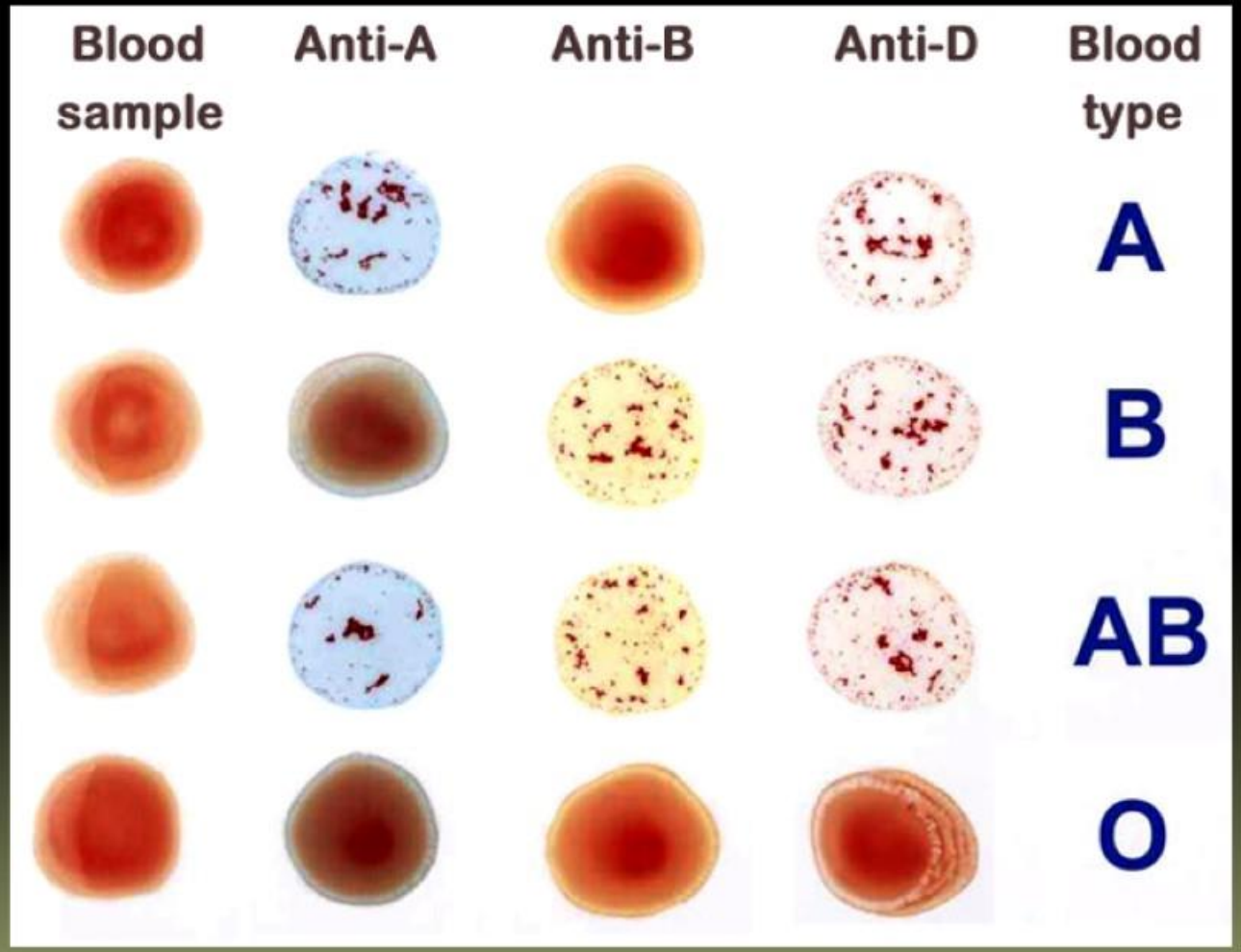
- ABO blood groups are controlled by the gene I.
- It controls the production of sugar polymers (antigens) that protrude from plasma membrane of RBC.
- The gene I has three alleles I^A, I^B & i.
- I^A & I^B produce a slightly different form of the sugar.
- Allele i doesn't produce any sugar.



NON-MENDELIAN INHERITANCE

2. CO-DOMINANCE

Genotypes of different blood groups

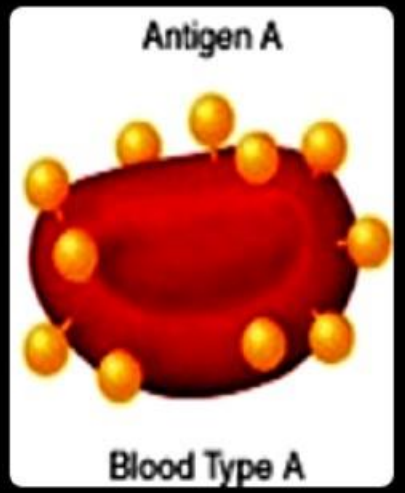


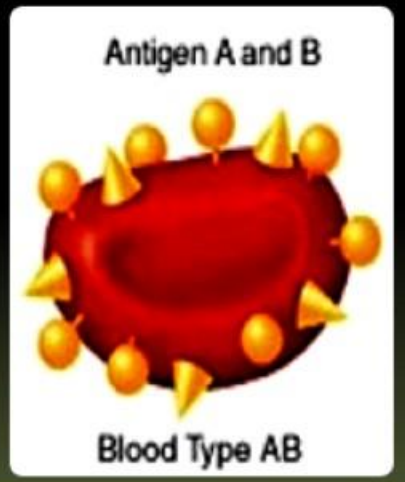
Blood group	Genotype
A	I^AI^A or I^Ai
B	I^BI^B or I^Bi
AB	I^AI^B
O	ii

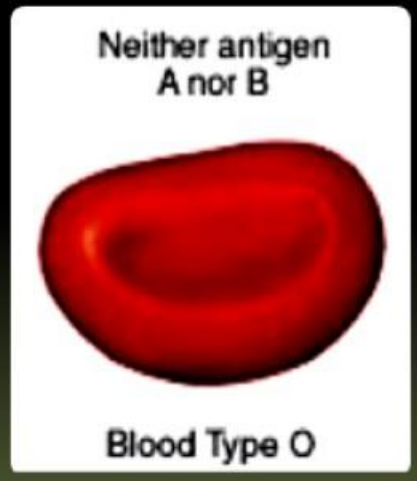
NON-MENDELIAN INHERITANCE

2. CO-DOMINANCE

Alleles from parent 1	Alleles from parent 2	Genotype of offspring	Blood types (phenotype)
I^A	I^A	$I^A I^A$	A
I^A	i	$I^A i$	A
I^B	I^B	$I^B I^B$	B
I^B	i	$I^B i$	B
I^A	I^B	$I^A I^B$	AB
I^B	I^A	$I^A I^B$	AB
i	i	ii	O







When I^A and I^B are present together, they both express their own types of sugars. This is due to co-dominance.

NON-MENDELIAN INHERITANCE

2. CO-DOMINANCE

Examples

Father	x	Mother
I^Ai	x	I^Bi

Father / Mother	I^A	i
I^B	I^AI^B	I^Bi
i	I^Ai	ii

Offspring are
A group (I^Ai)
B group (I^Bi)
AB group (I^AI^B)
O group (ii)

Offspring are
A group (I^Ai)
B group (I^Bi)

Father	x	Mother
I^AI^B	x	ii

Father / Mother	I^A	I^B
i	I^Ai	I^Bi
i	I^Ai	I^Bi

NON-MENDELIAN INHERITANCE

3. MULTIPLE ALLELISM

- It is the presence of more than two alleles of a gene to govern same character.
- E.g. Alleles of ABO blood grouping (3 alleles: I^A, I^B & i).
- In an individual, only two alleles are present.
- Multiple alleles can be found only in a population.

$I^A I^A$ $I^A i$ $I^B I^B$ $I^B i$ $I^A I^B$ ii

NON-MENDELIAN INHERITANCE

4. POLYGENIC INHERITANCE

- It is the inheritance in which some traits are controlled by several genes (multiple genes).
- E.g. human skin colour, human height etc.
- It considers the influence of environment.
- In a polygenic trait, phenotype reflects the contribution of each allele, i.e., the effect of each allele is additive.

4. POLYGENIC INHERITANCE

Human skin colour

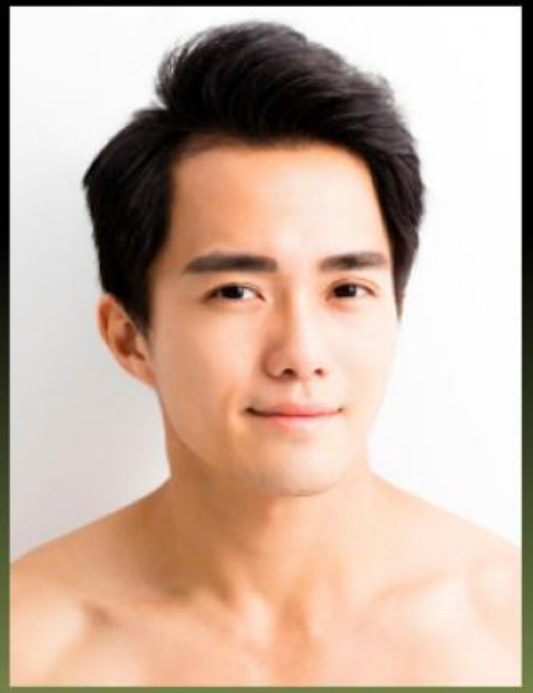
- Assume that 3 genes A, B, C control human skin colour.
- Dominant forms A, B & C responsible for dark skin colour.
- Recessive forms a, b & c for light skin colour.

NON-MENDELIAN INHERITANCE

4. POLYGENIC INHERITANCE

Human skin colour

- Genotype with all the dominant alleles (AABBCC) gives darkest skin colour.
- Genotype with all the recessive alleles (aabbcc) gives lightest skin colour.
- Genotype with 3 dominant + 3 recessive alleles gives intermediate skin colour.

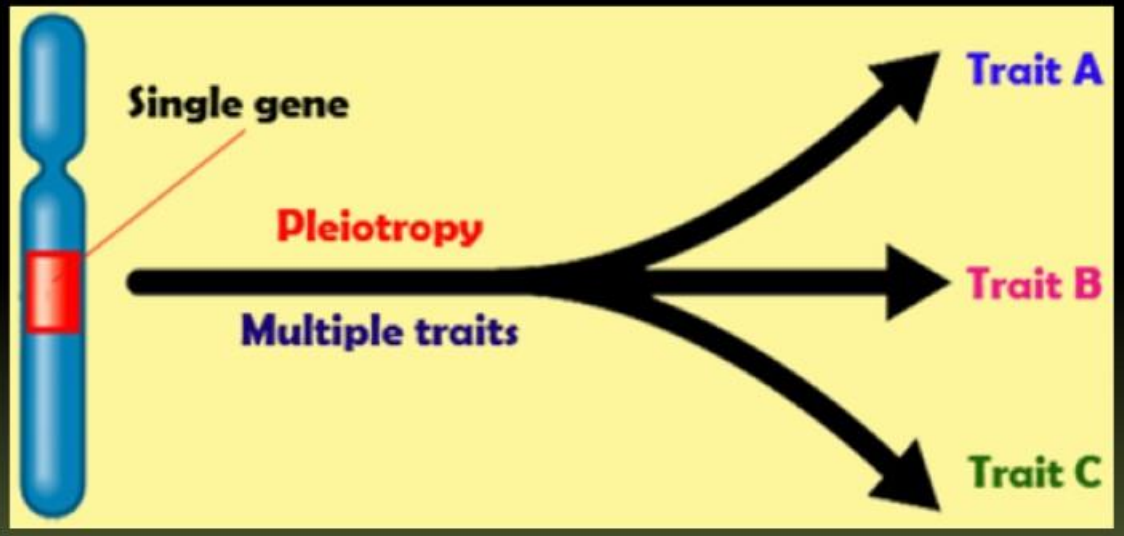


Thus, number of each type of alleles in the genotype determine the darkness or lightness of the skin.

NON-MENDELIAN INHERITANCE

5. PLEIOTROPY

- Here, a **single gene** exhibits **multiple phenotypic** expressions. Such a gene is called **pleiotropic gene.**
- In most cases, mechanism of pleiotropy is the effect of a gene on metabolic pathways which contributes towards different phenotypes.
- E.g. Starch synthesis in pea, phenylketonuria, sickle cell anaemia etc.



In **Phenylketonuria & sickle cell anaemia,** the mutant gene has many phenotypic effects. E.g. Phenylketonuria causes mental retardation, reduction in hair and skin pigmentation.

5. PLEIOTROPY

Starch synthesis in pea plant

- Starch is synthesized effectively by **BB** gene. Therefore, large starch grains are produced.
- **bb** have lesser efficiency in starch synthesis and produce smaller starch grains.
- Starch grain size also shows **incomplete dominance.**

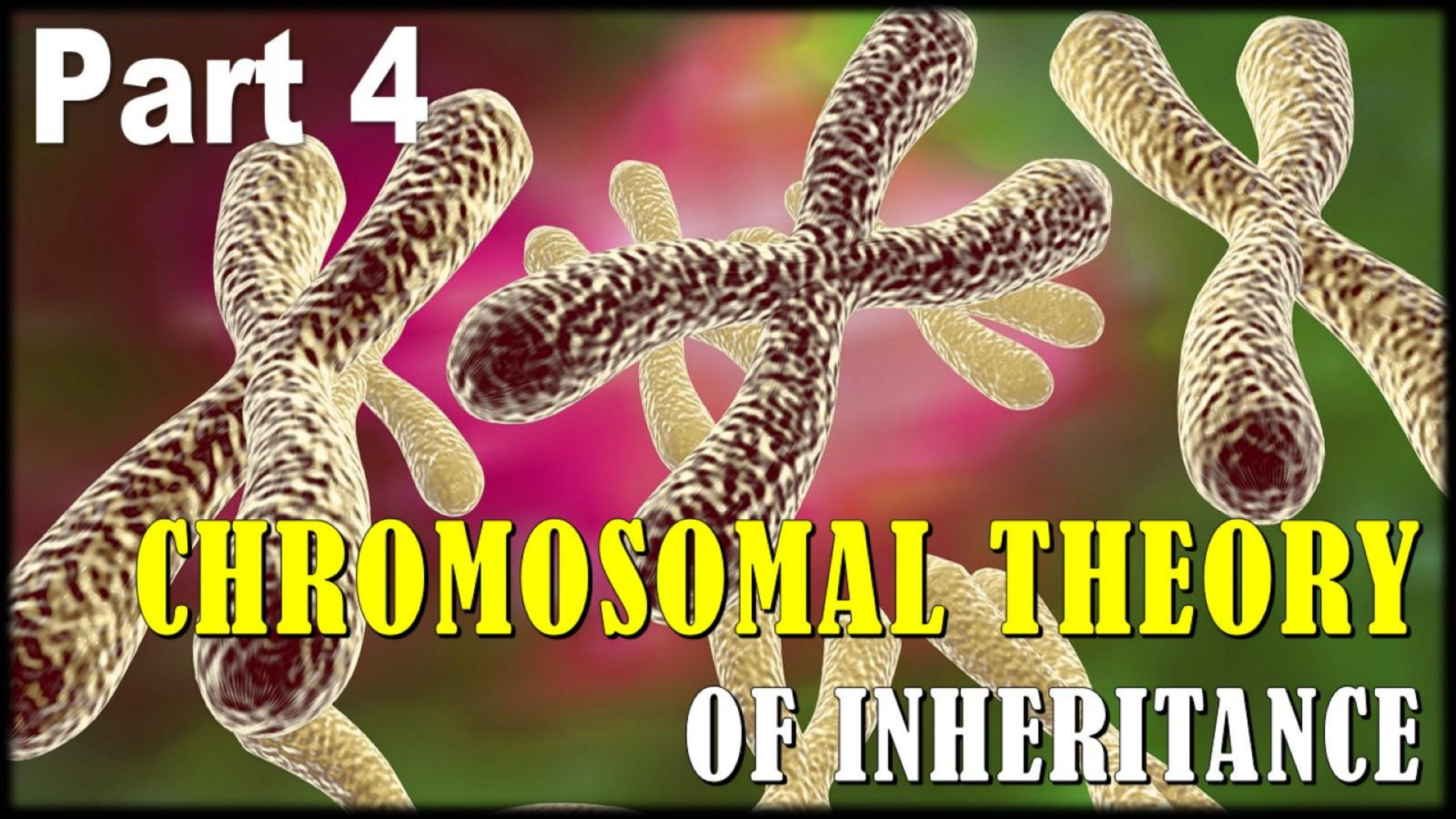
Effective starch synthesis x **Lesser starch synthesis**

BB x **bb**

Large sized seeds x **Small sized seeds**

Gametes: **B** and **b**

Incomplete dominance ← **Bb (intermediate sized seeds)**


Part 4
CHROMOSOMAL THEORY
OF INHERITANCE

Why did Mendel's work remain unrecognized?

- Communication was not easy.
- His mathematical approach was new and unacceptable.
- The concept of genes (factors) as stable & discrete units could not explain the continuous variation.
- He could not give physical proof for the existence of factors.

Mendel's words

"Meine zeit wird schon kommen" (My time will yet come)

20 Jul 1822 – 6 Jan 1884

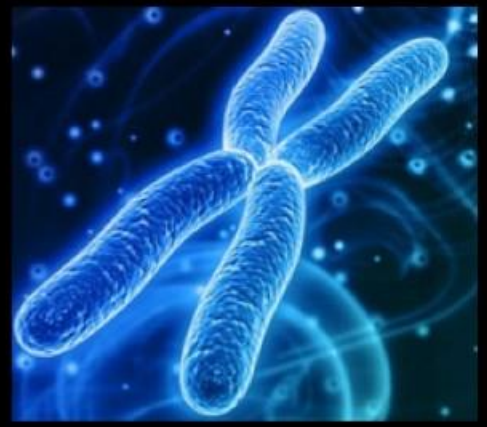
Hugo de Vries
(1848-1935)

Carl Correns
(1864-1933)

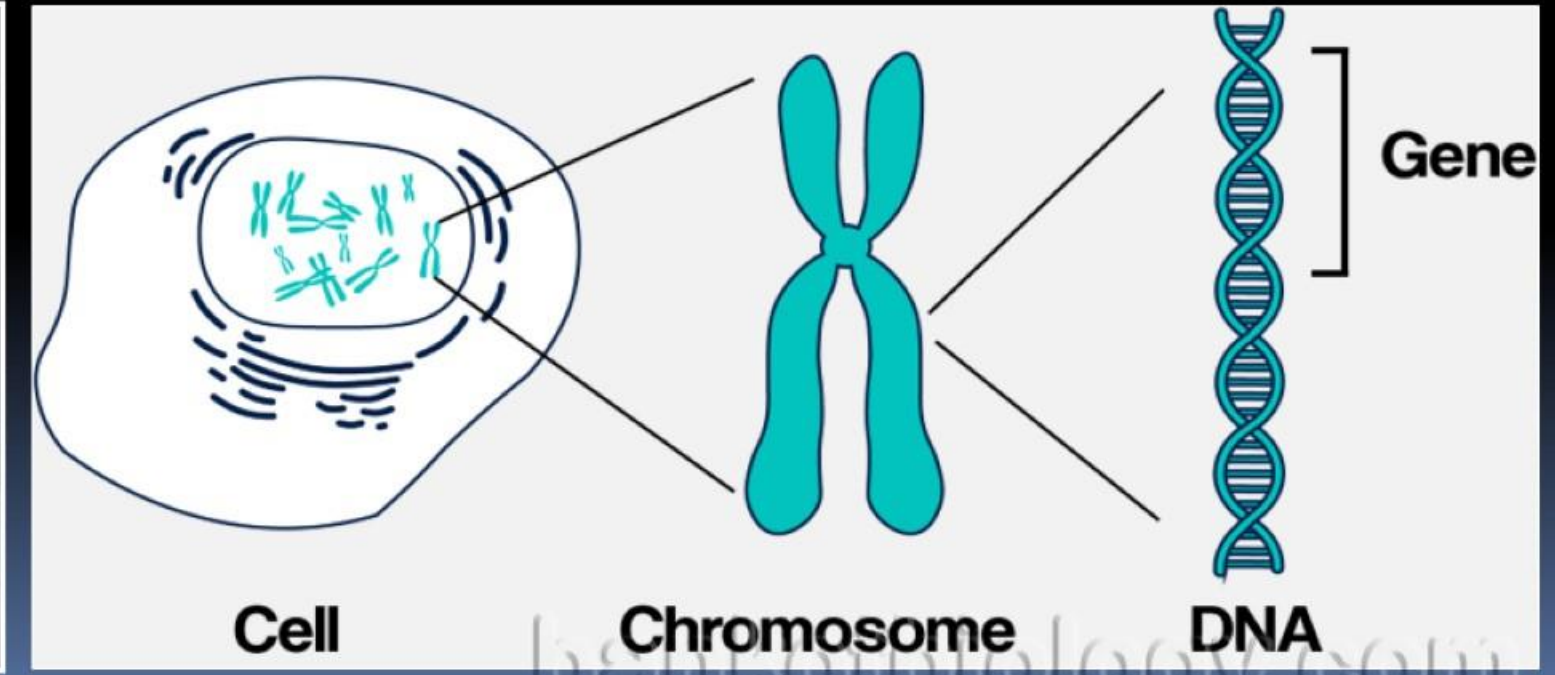
Erich von Tschermak
(1871-1962)

In 1900, de Vries, Correns & von Tschermak independently rediscovered Mendel's results.

CHROMOSOMAL THEORY OF INHERITANCE



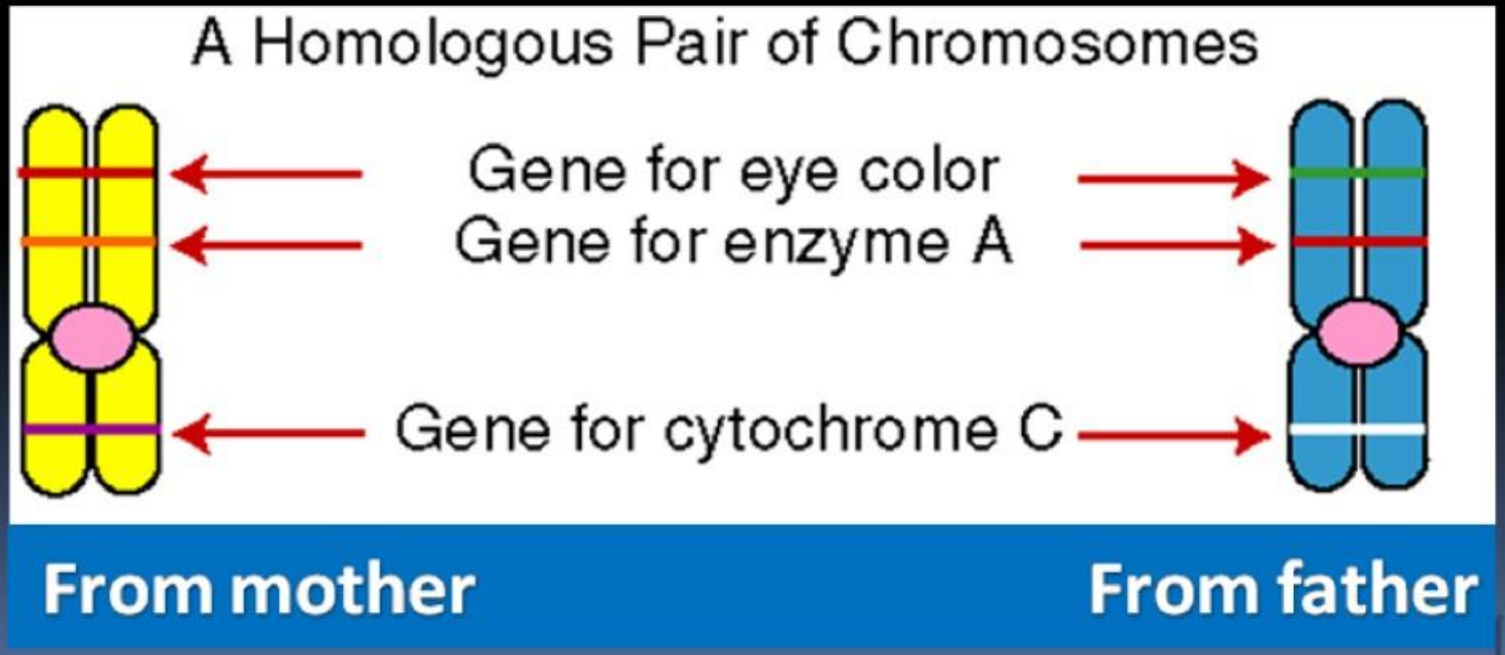
- Proposed by **Walter Sutton** & **Theodore Boveri (1902).**
- They said that the pairing and separation of a pair of chromosomes lead to segregation of a pair of factors they carried.
- Sutton united chromosomal segregation with Mendelian principles and called it the **chromosomal theory of inheritance.**

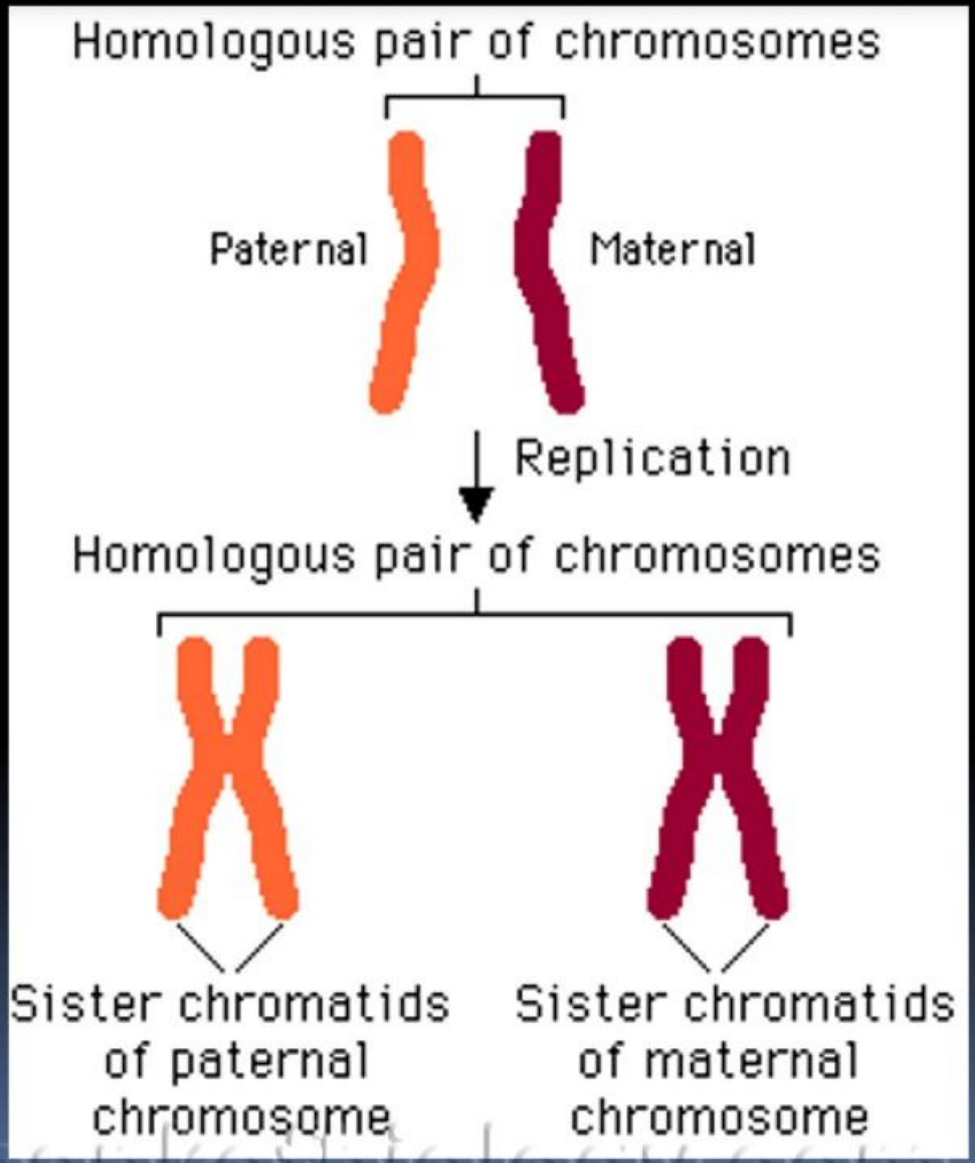


CHROMOSOMAL THEORY OF INHERITANCE

Important statements

- ✓ Chromosomes are vehicles of heredity.
- ✓ Two identical chromosomes form a homologous pair.





CHROMOSOMAL THEORY OF INHERITANCE

Important statements

- ✓ Chromosomes are vehicles of heredity.
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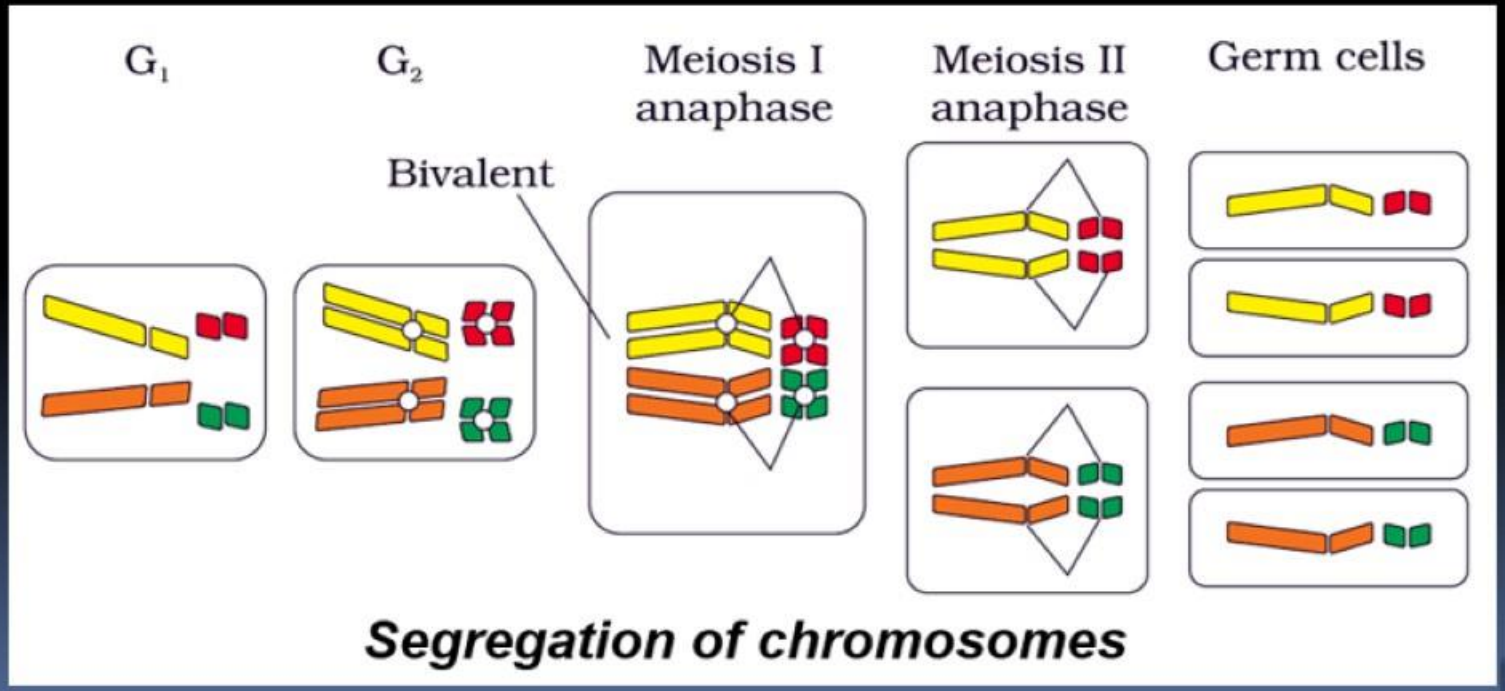
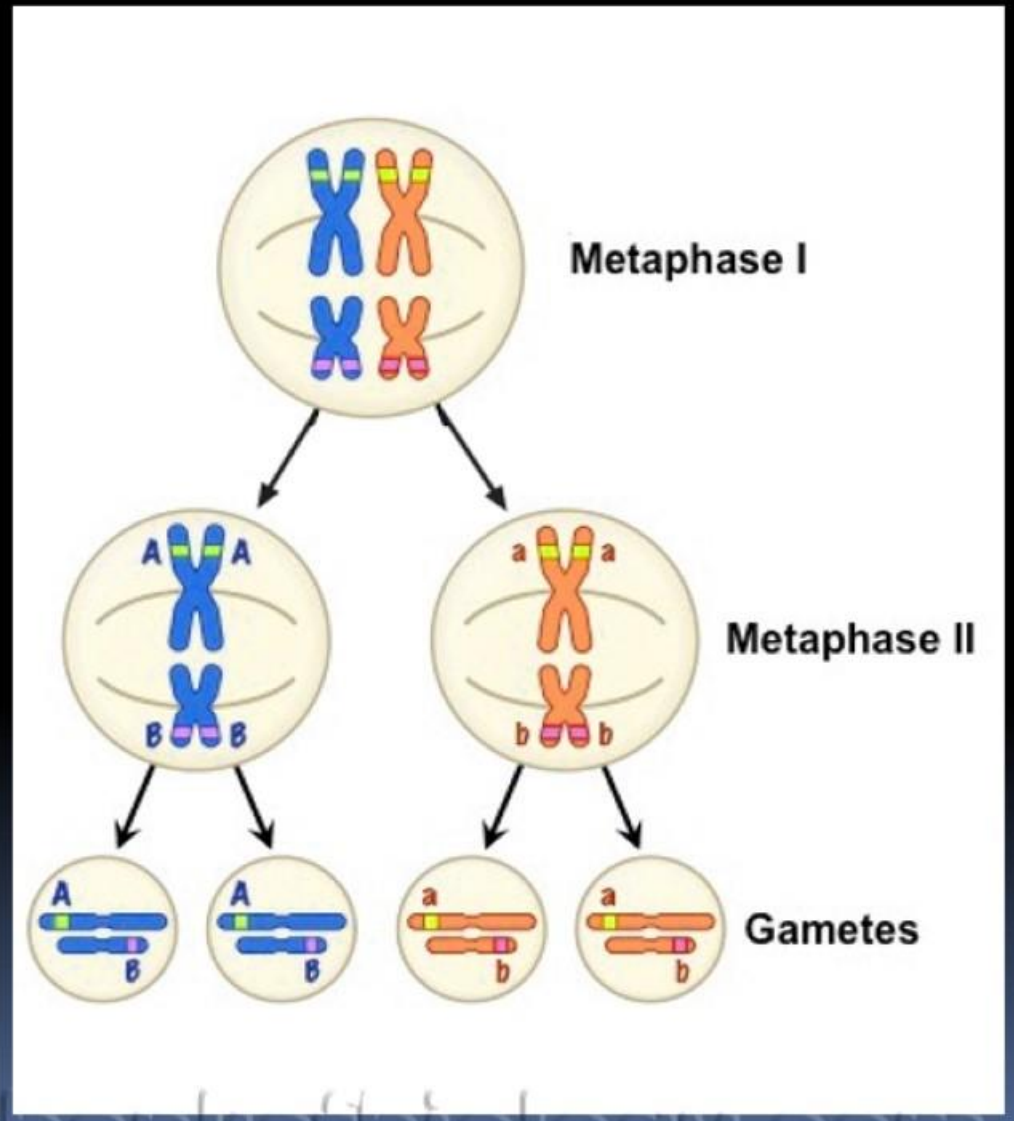
- ✓ Homologous pair segregate during gamete formation.



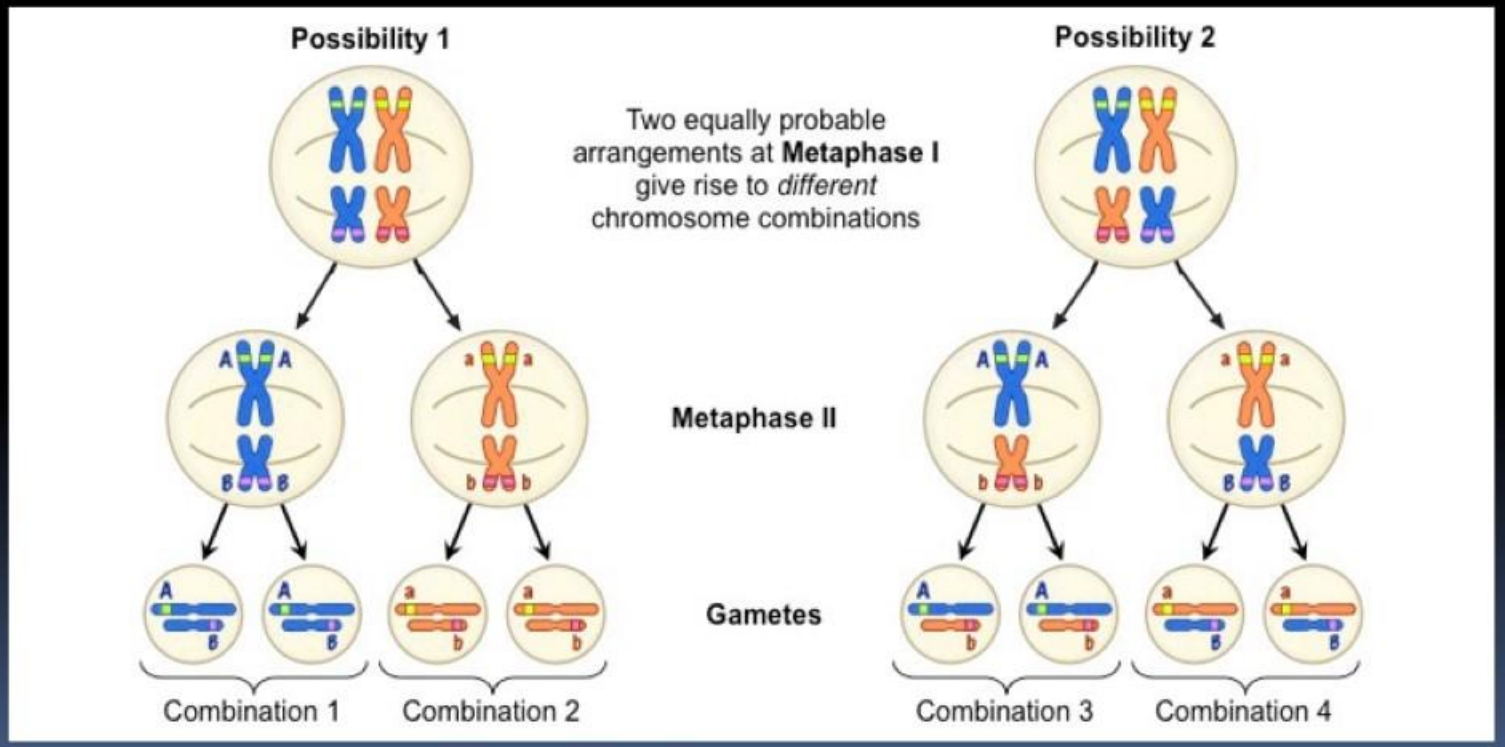
Segregation of chromosomes

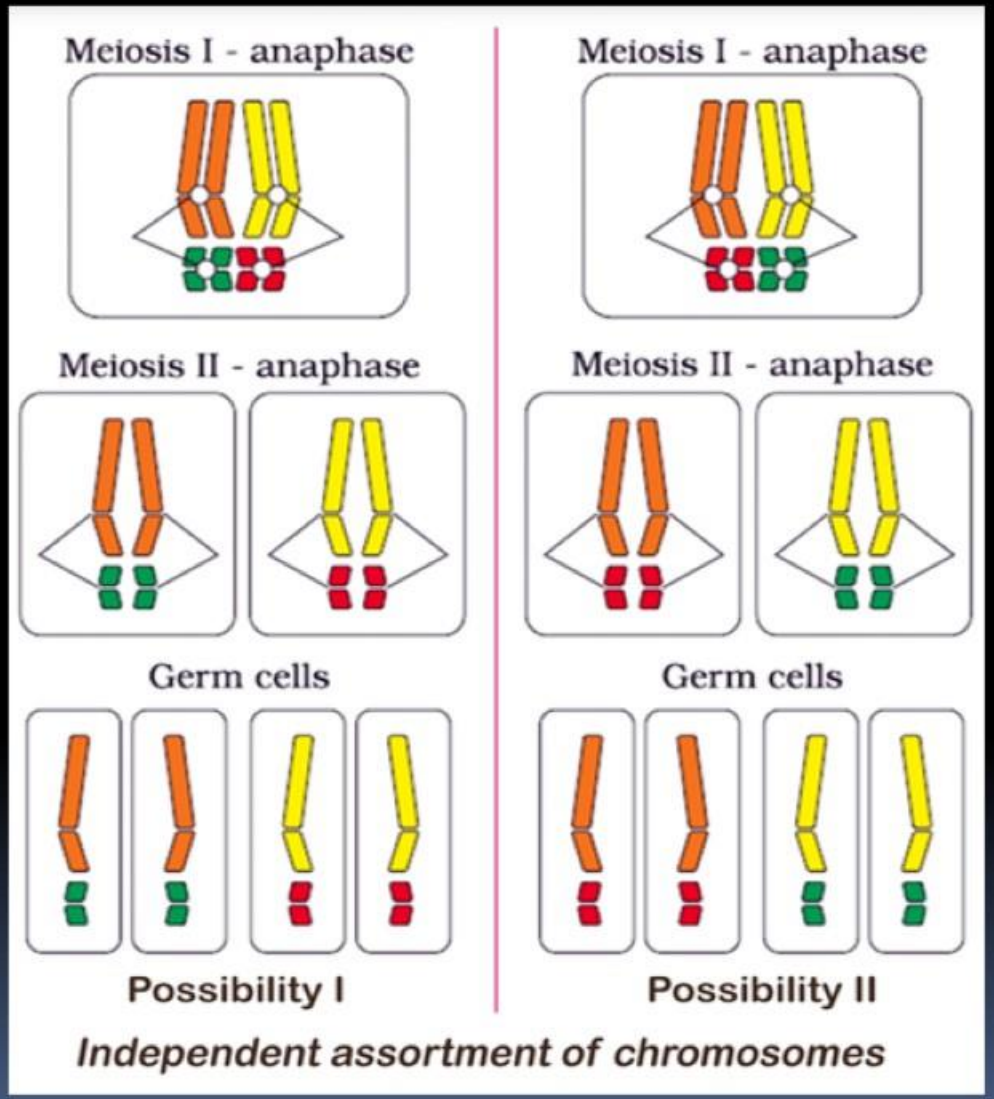


CHROMOSOMAL THEORY OF INHERITANCE

Important statements

- ✓ Chromosomes are vehicles of heredity.
- ✓ Two identical chromosomes form a homologous pair.
- ✓ Homologous pair segregate during gamete formation.
- ✓ Independent pairs segregate independently.





Genes are present on chromosomes. Hence they show similar behaviours.

CHROMOSOMAL THEORY OF INHERITANCE

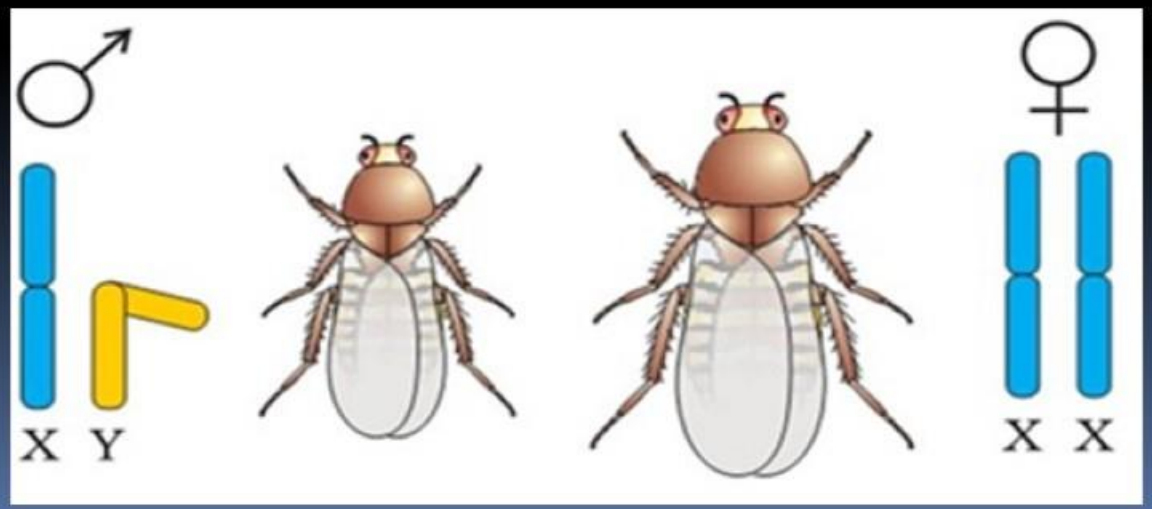
Thomas Hunt Morgan worked with the **fruit files** (***Drosophila melanogaster)*** to prove chromosomal theory of inheritance.

CHROMOSOMAL THEORY OF INHERITANCE

Drosophila **is a suitable material for genetic study because,**

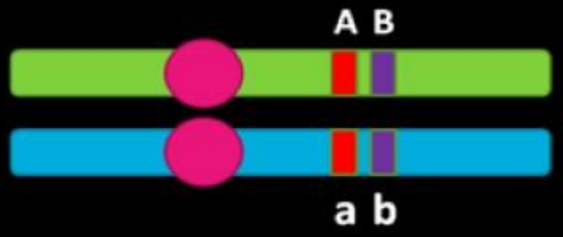
- ✓ They can grow on **simple synthetic medium.**
- ✓ **Short generation time** (life cycle: 12-14 days).
- ✓ **Breeding** can be done throughout the year.
- ✓ **Hundreds of progenies** per mating.

- ✓ Male & female flies are **easily distinguishable.** E.g. Male is smaller than female.
- ✓ It has many types of **hereditary variations** that can be seen with low power microscopes.

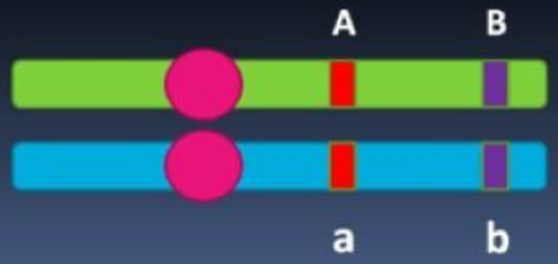


LINKAGE AND RECOMBINATION

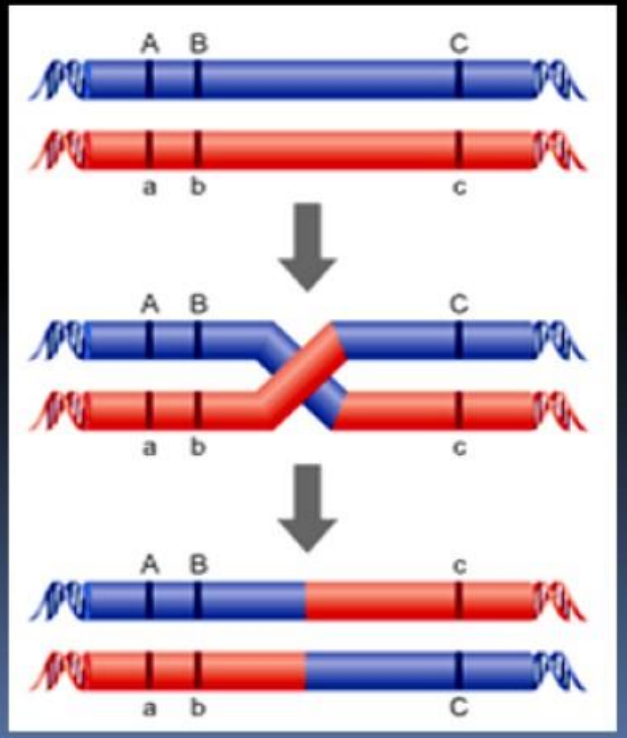
- **Linkage** is the physical association of 2 or more genes on a chromosome.
- Linked genes do not show independent assortment.
- **Recombination** is the generation of non-parental gene combinations.
- Recombination occurs due to **independent assortment or crossing over.**

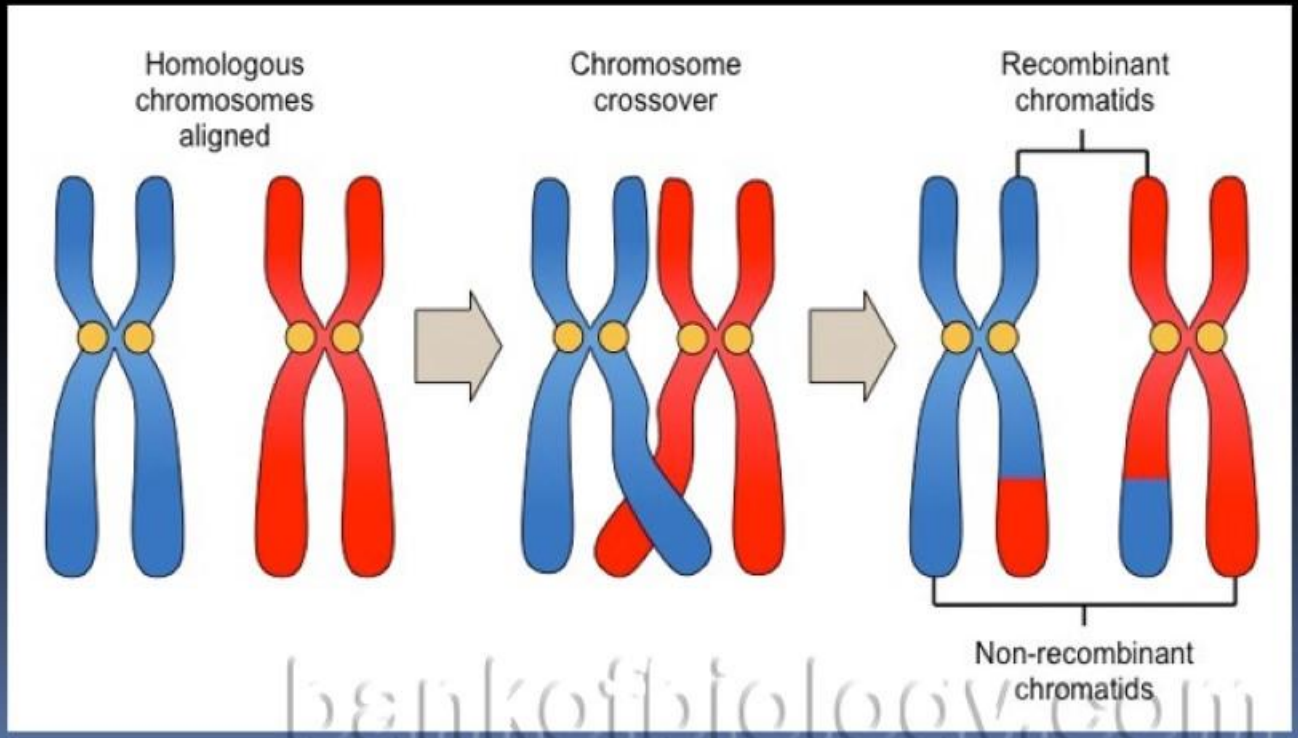


Tightly linked



Loosely linked





LINKAGE AND RECOMBINATION

Morgan carried out several dihybrid crosses in *Drosophila* to study sex-linked genes. E.g.

Cross 1

Yellow-bodied, white-eyed females (yyww)

X

Brown-bodied, red-eyed males (wild type, $y^+y^+w^+w^+$)

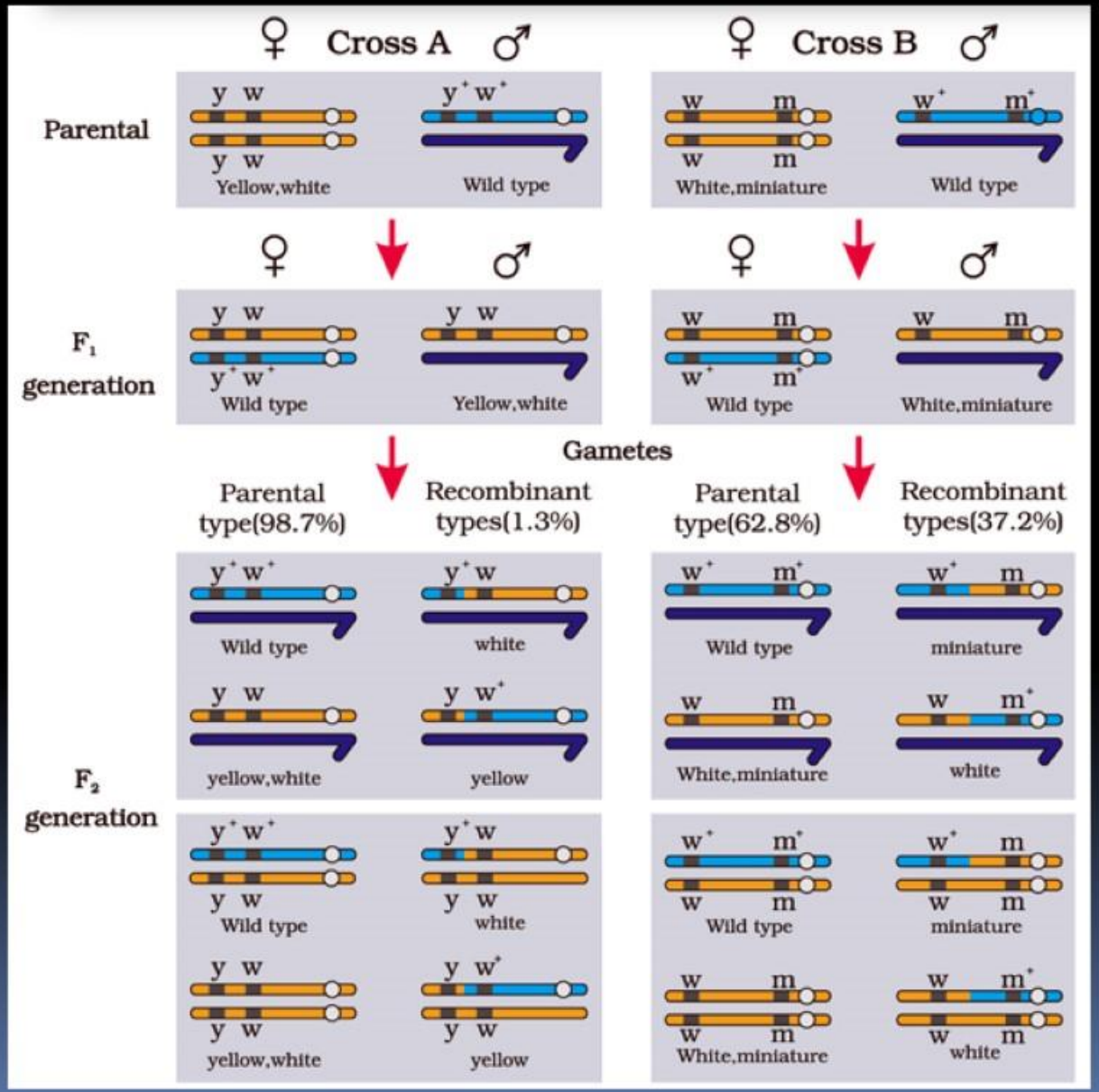
Cross 2

White-eyed, miniature winged (wwmm)

X

Red eyed, large winged (wild type, $w^+w^+m^+m^+$)

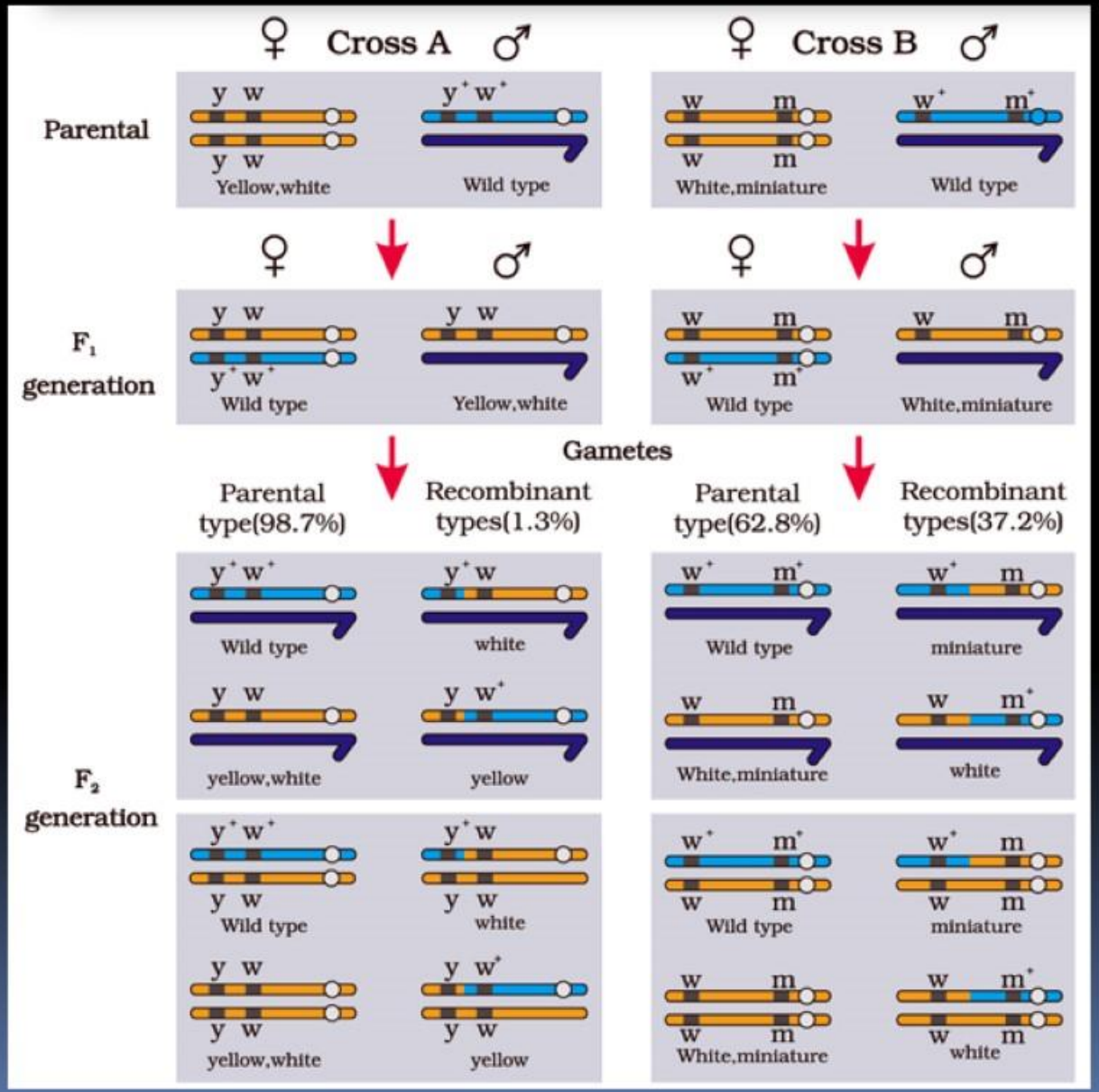
LINKAGE AND RECOMBINATION



Major findings of Morgan's experiment

- ✓ The two genes **did not segregate** independently and the F2 ratio deviated from the 9:3:3:1 ratio.
- ✓ Genes were located on **X chromosome.**
- ✓ When two genes were situated on same chromosome, proportion of parental gene combinations was much higher than the non-parental type. This is due **linkage.**

LINKAGE AND RECOMBINATION



Major findings of Morgan's experiment

- ✓ Genes of **white eye & yellow body** were very **tightly linked** and showed only **1.3%** recombination.
- ✓ Genes of **white eye & miniature wing** were loosely linked and showed 37.2% recombination.
- ✓ **Tightly linked genes** show **low recombination. Loosely linked genes** show **high recombination.**

LINKAGE AND RECOMBINATION

- **Alfred Sturtevant** used the recombination frequency between gene pairs for measuring the distance between genes and 'mapped' their position on the chromosome.
- Genetic maps are used as a starting point in the sequencing of genomes. E.g. **Human Genome Project.**