

# INHERITANCE



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3/7/2024

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# CELL DIVISION

*Cell division is a process by which a parent cell divides to give rise to two or more daughter cells.*

One cell divides into two, two into four, four into eight and so on.

Cell division does not necessarily mean halving the cell and its contents but forming new components to form daughter cells.

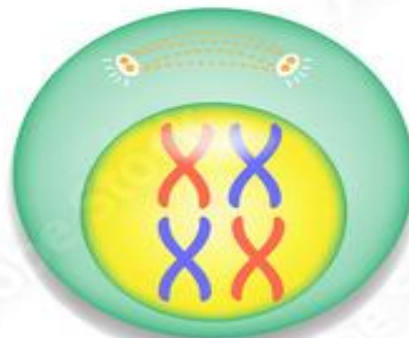
Cell division involves two types

- i. Mitotic cell division (**mitosis**)
- ii. Meiotic cell division (**meiosis**)

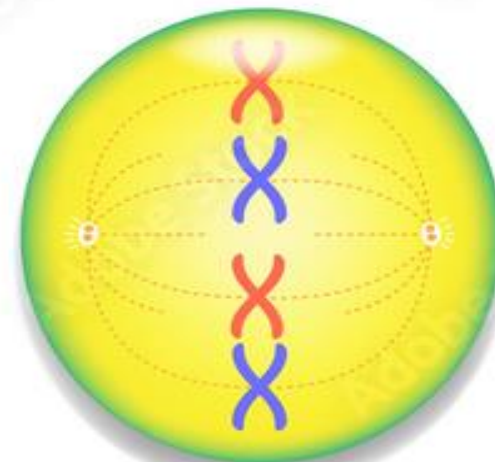
Cell division involves **nuclear division** followed by **cytoplasm division** immediately (cytokinesis) both of which comprise a **cell cycle**



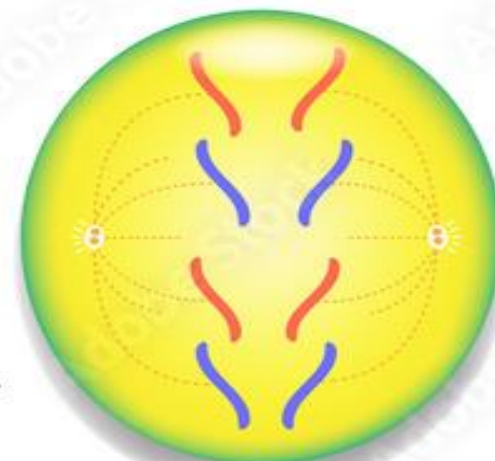
Interphase



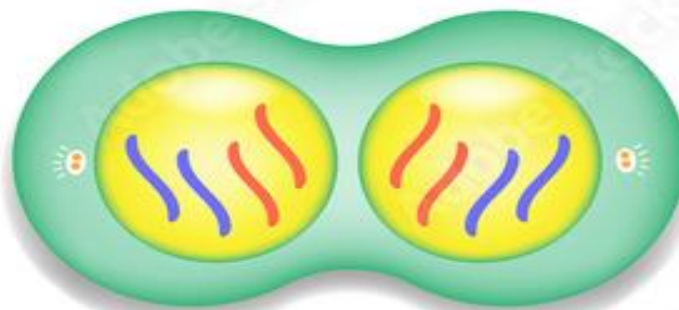
Prophase



Metaphase



Anaphase



Telophase



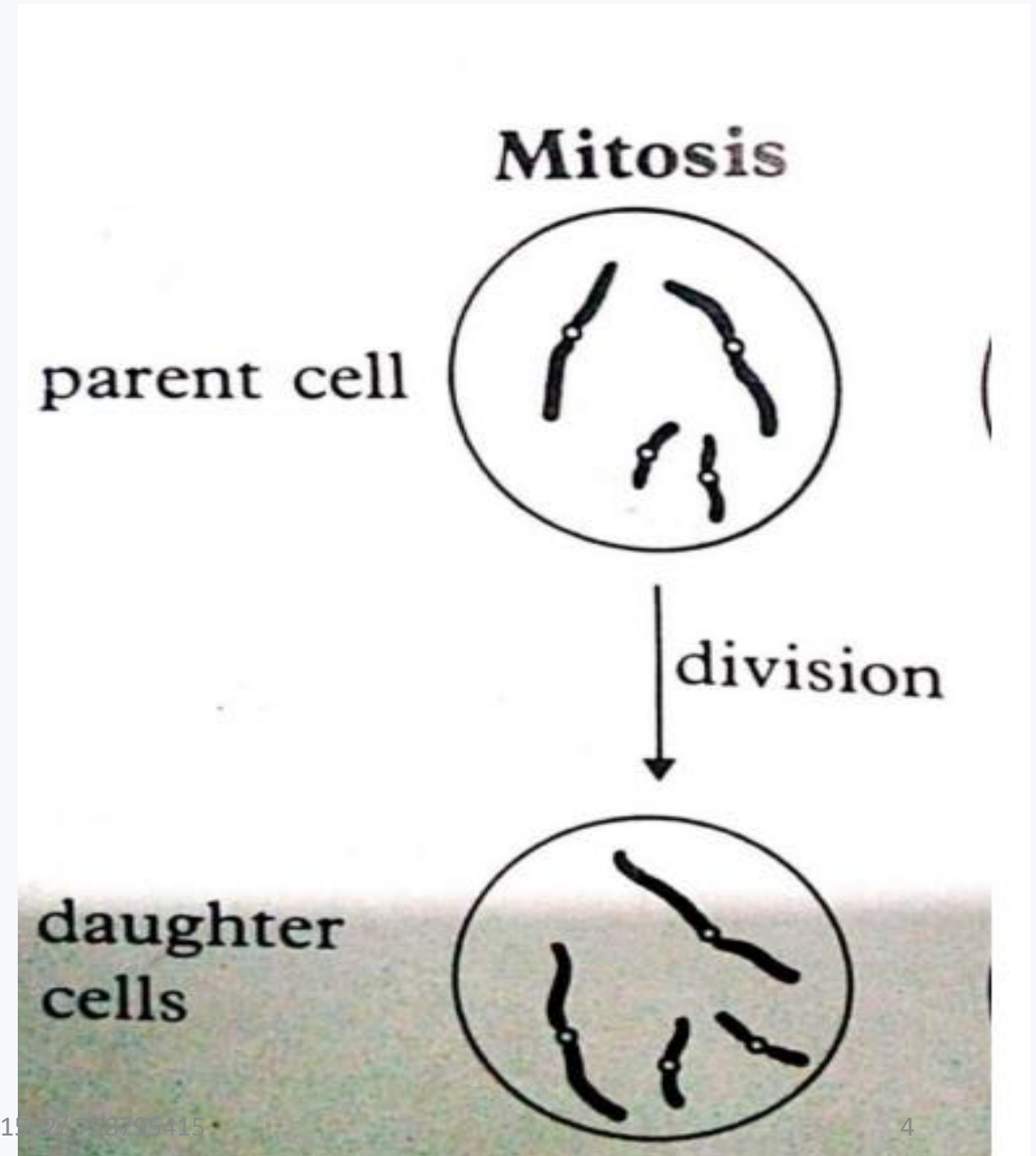
Daughter cells

# MITOSIS

# MITOSIS

This is the type of cell division in which the parent cell divides into **two** daughter cells each having the **same number of chromosomes as the parent cell**.

The daughter cells are **diploid (2n)** i.e. They have 2 sets of chromosomes.



## In man, mitosis occurs in;

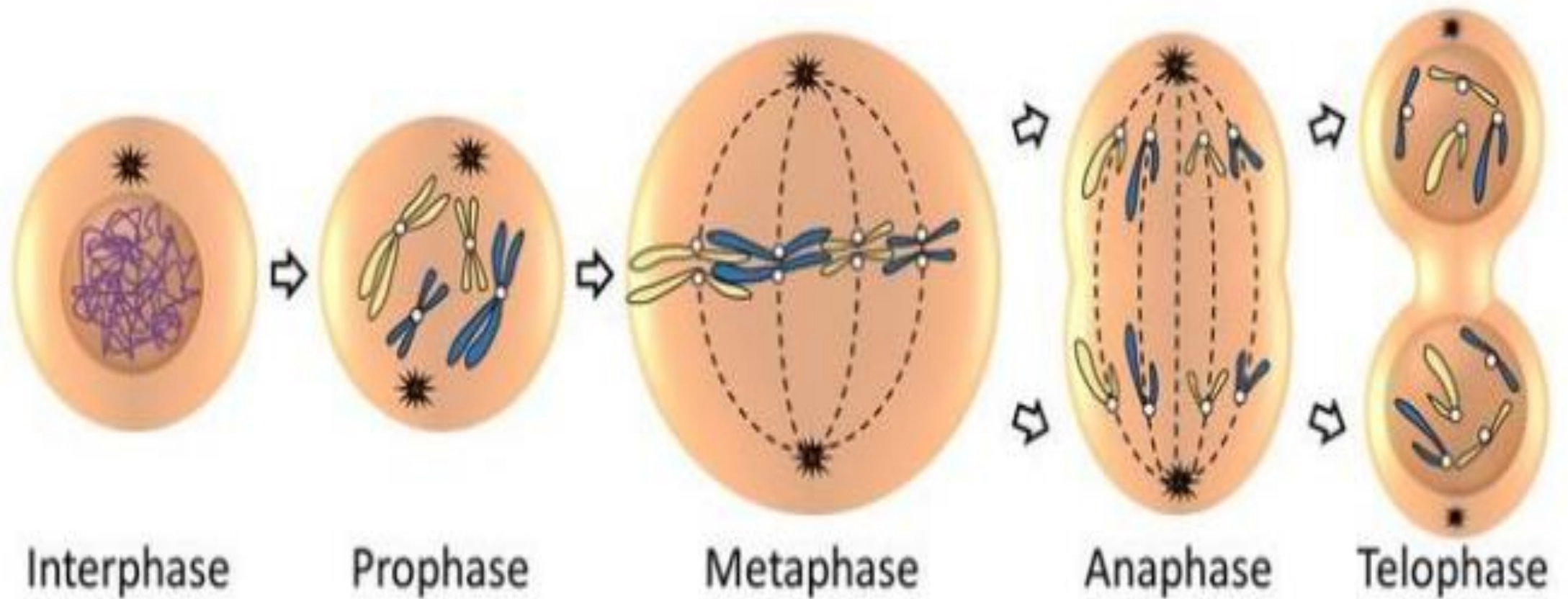
- The bone marrow.
- The epidermal cells of the gut.
- The Malpighian cells of the skin epidermis, etc.

In plants, it occurs in the apical meristems of the stem, root tip and the cambium.

## Mitosis occurs in the somatic cells.

This type of division involves four stages **Prophase**, **Metaphase**, **Anaphase** and **Telophase**. And a main growth and resting phase **Interphase**.

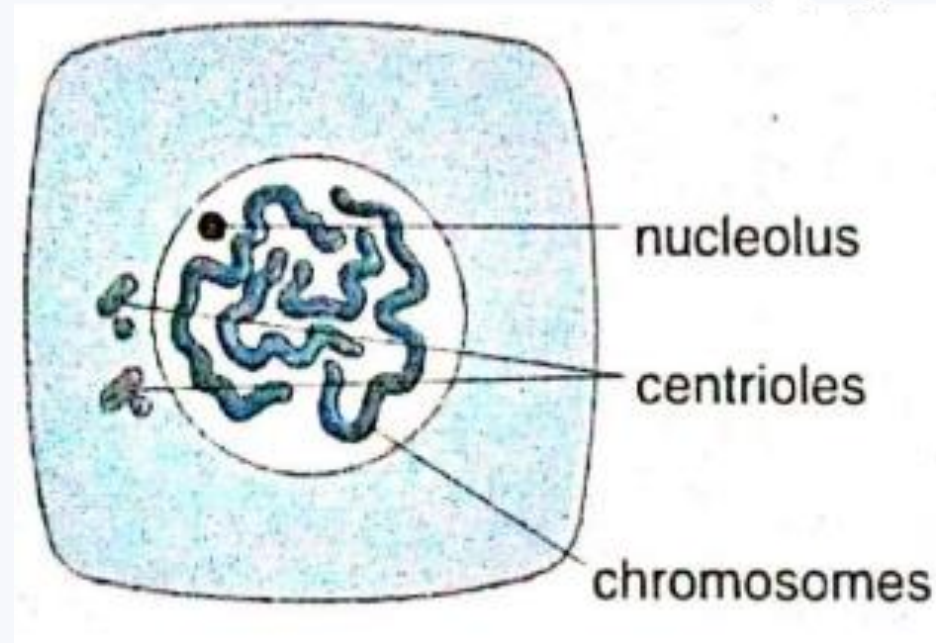
The whole process of cell division can take an hour or two roughly



AMERICAN PEOPLE  
HAPPY

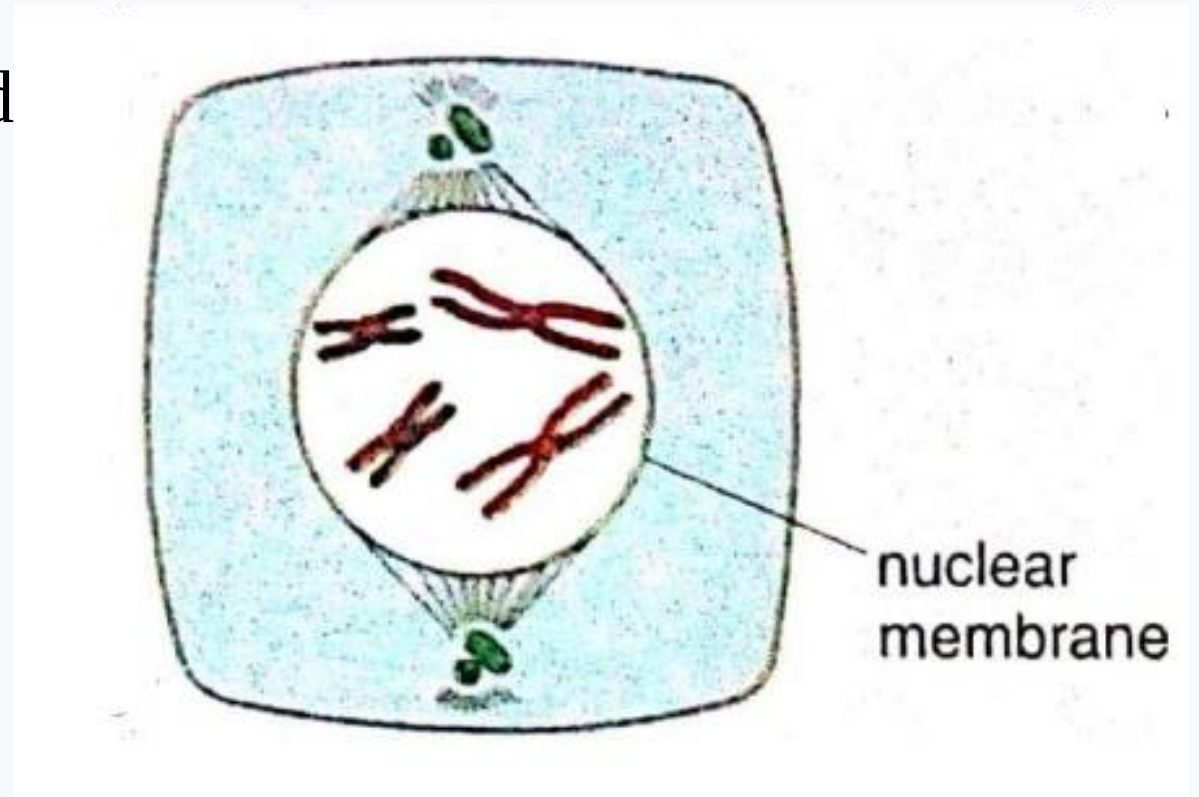
# Interphase (replication)

- Chromosomes not visible (are thread like)
- Chromatins present
- Centrioles replicate
- Replication of DNA (double)
- Production of ATP (energy)
- Formation of new organelles (mitochondria, ribosome, chloroplast), duplication



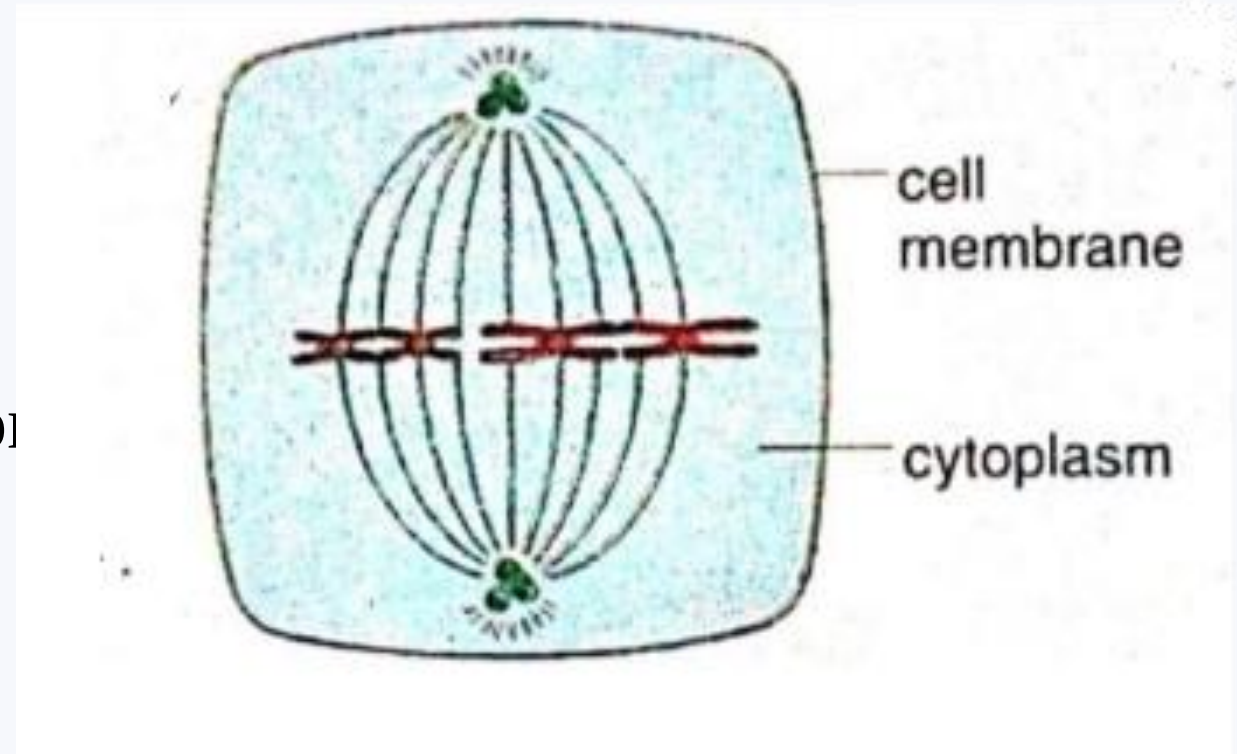
# Prophase (thickening)

- Chromatin threads condense to form distinct chromosomes (chromosomes formed from the chromatids are joined at the centromere)
- Centrioles at opposite sides of the nucleus
- Spindle fibres start to form
- Nucleolus disappears
- Nuclear membrane breaks down



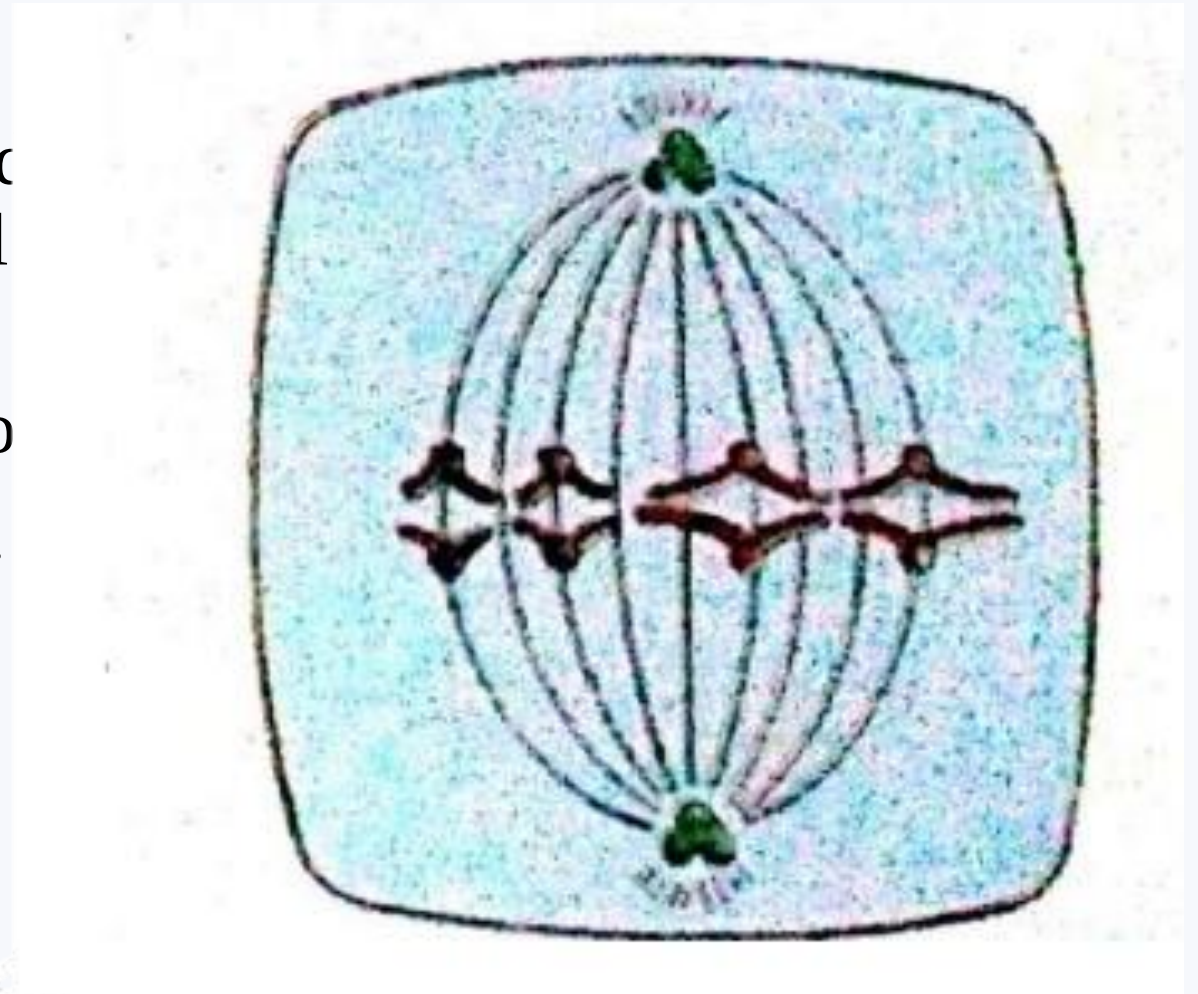
# Metaphase (arrangement)

- Chromosomes arrange themselves on equator of spindle
- Homologous chromosomes do not associate
- Chromatids draw apart at the centromere towards opposite poles
- Chromosomes migrate at the equator



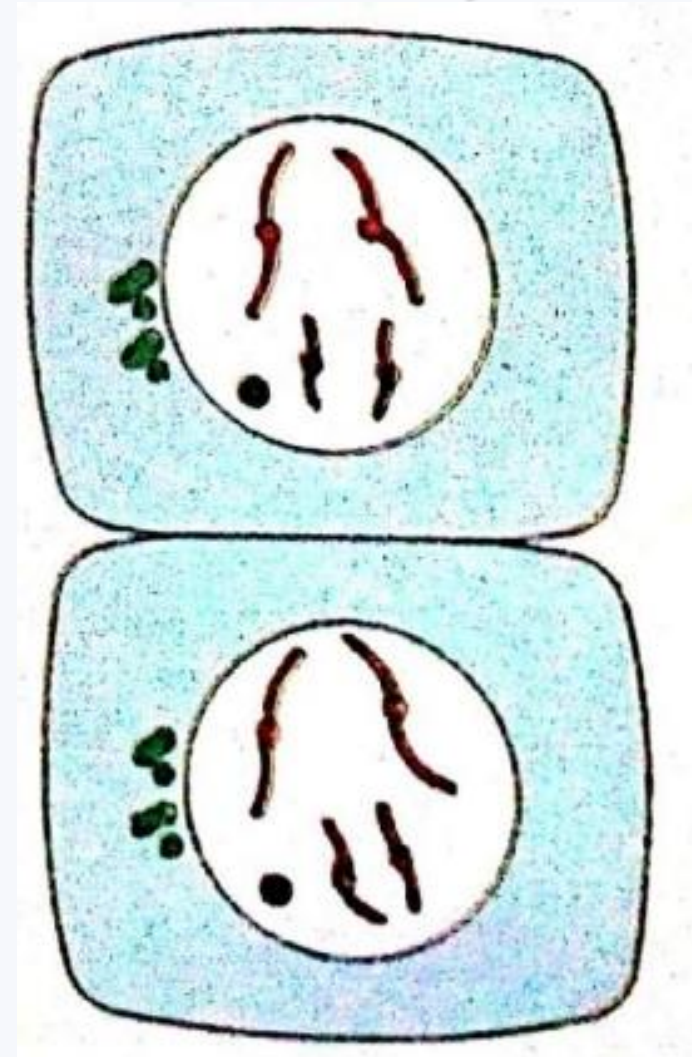
# Anaphase (migration)

- Spindle fibres contract and shorten
- Sister Chromatids part company and migrate to opposite poles of the cell with the centromeres leading
- Chromosomes reach their destination
- Spindle fibres begin to break down.



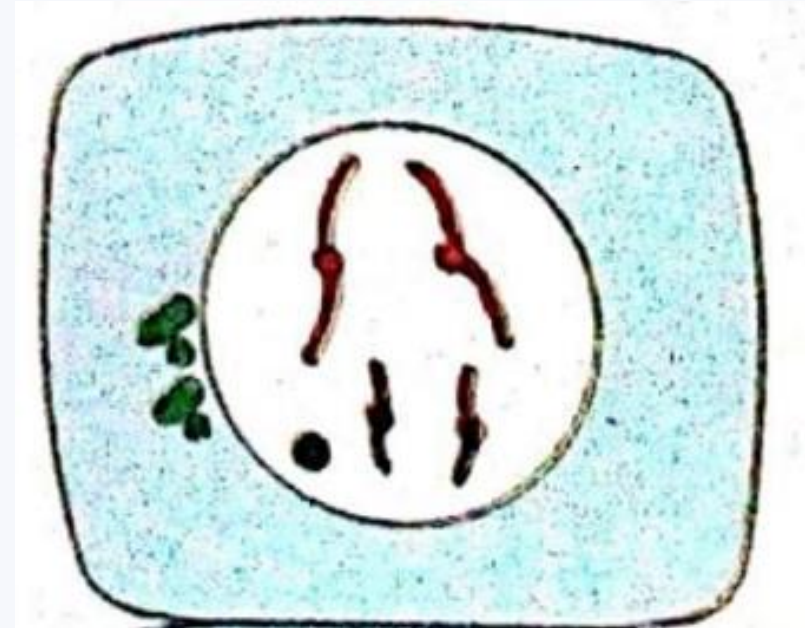
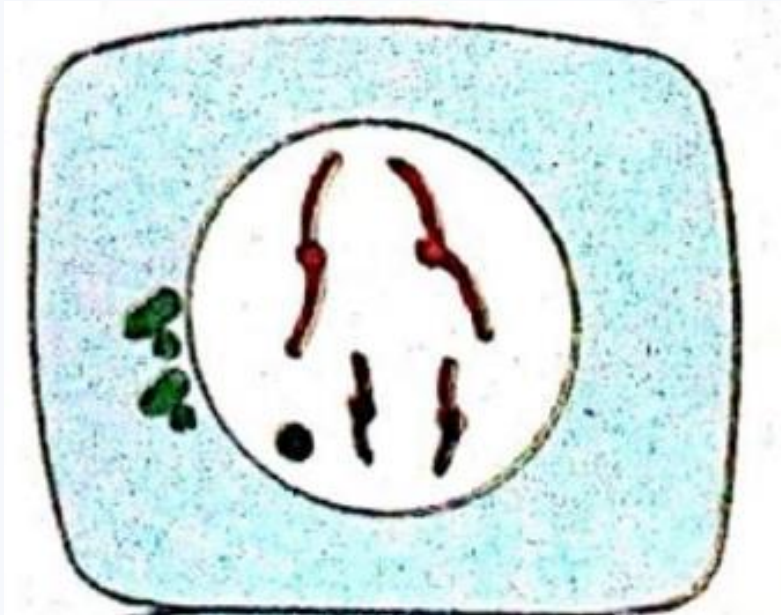
# Telophase (cell constrict)

- Cell membrane starts to constrict across the middle
- Nuclear membrane reforms
- Nucleolus reform
- Spindle apparatus degenerates
- Cytoplasm divides into two new daughter cells with exact number of chromosomes as the parent cell
- Chromosomes uncoil, become thread like



# Cytokinesis (division of cytoplasm)

The cell cytoplasm is then divided equally to form two daughter cells.



ARIF KHAN

There are two features in mitosis that **ensure that the chromosome constitution is preserved**

- Replication of chromosomes before cell division
- Arrangement of the chromosome on the spindle

## **Roles of mitosis**

- **Growth** of an organisms e.g. development of fertilized egg into adult
- **Asexual reproduction** e.g. protist with binary fission
- **Genetic** stability (no variation)
- **Cell replacement** e.g. skin cells
- **Regeneration** e.g. legs in crustacean and arms in star fish

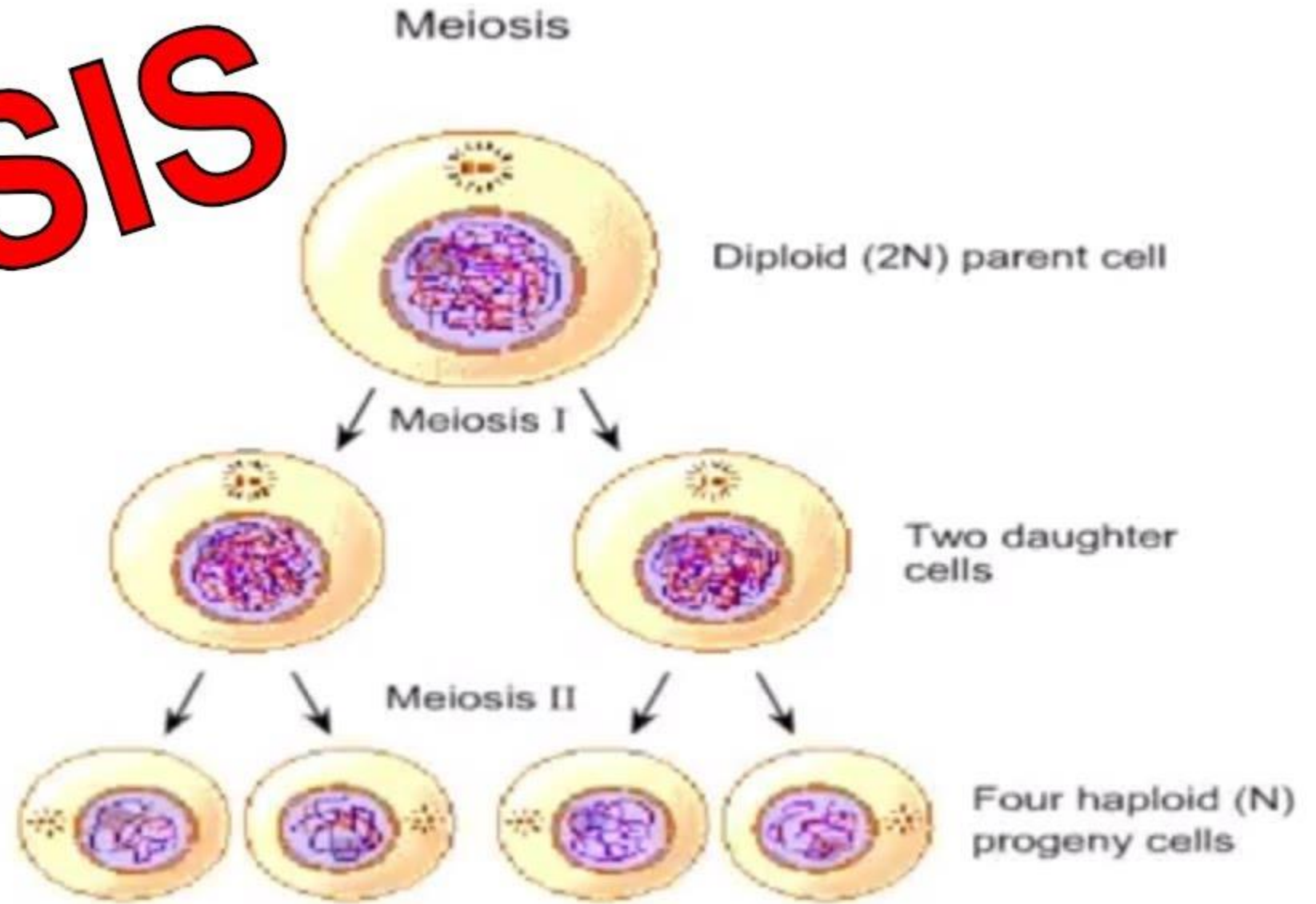
# Note:

Species in which there are two sets of chromosomes are referred to as **diploid** ( $2n$ ) animals.

Those with one set of chromosomes are referred to as **haploid** ( $n$ ).

Some plants are **polyploid** ( $3n$ ,  $4n$ , etc.)

# MEIOSIS



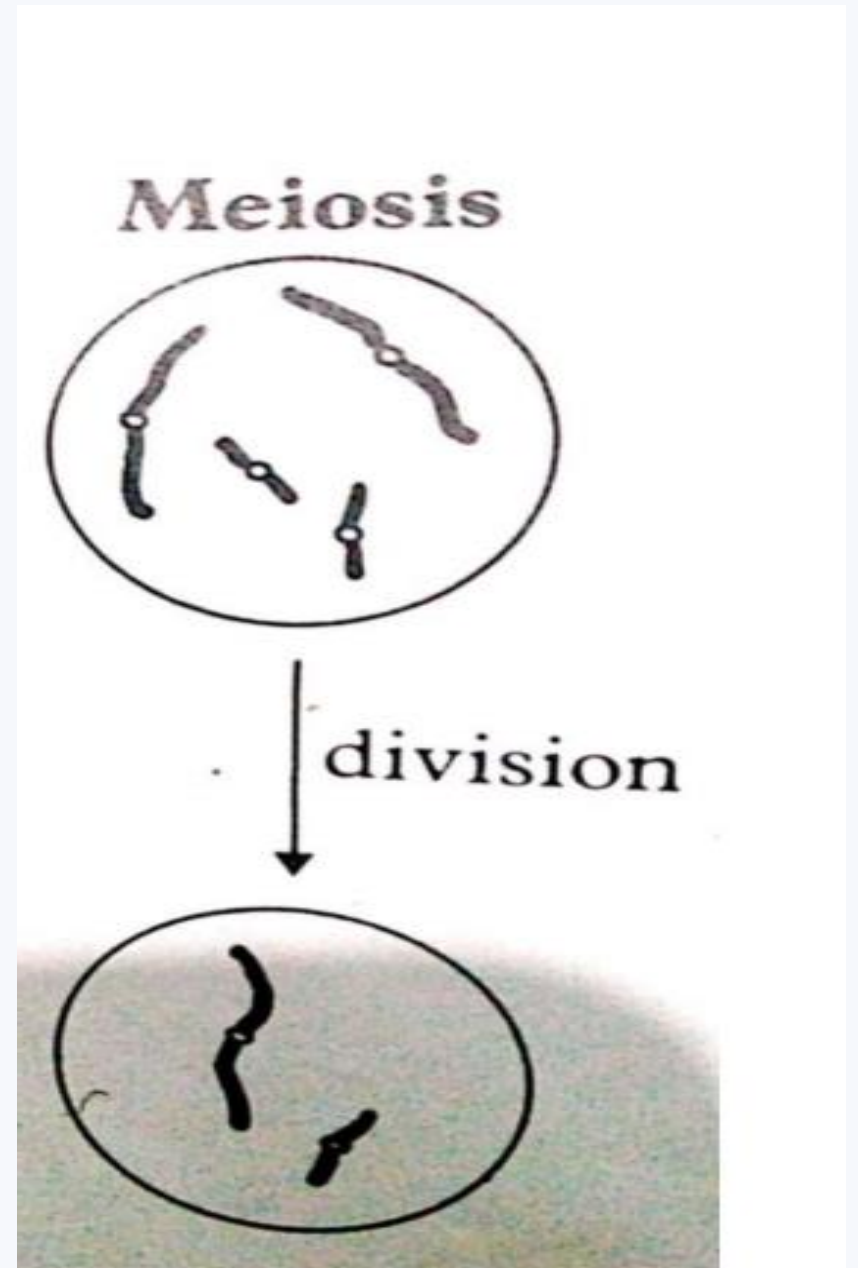
# MEIOSIS

This is the type of cell division in which diploid parent cell divides into **four** daughter cells each having *half the number of chromosomes as the parent cell*.

Meiosis takes place in the **testes** and the **ovaries** of animals.

In plants, it occurs in the **anthers** and **ovaries**.

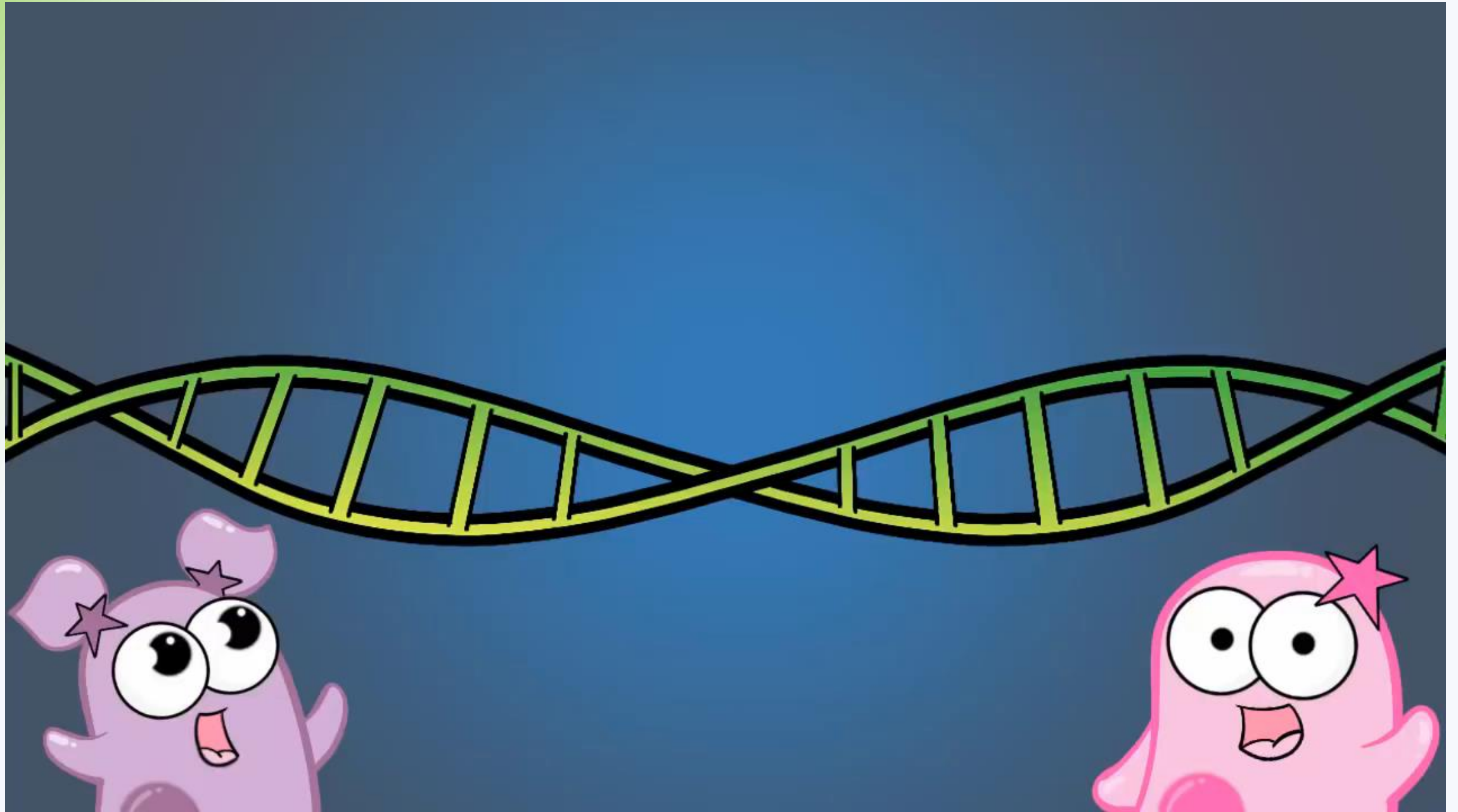
NB: MEIOSIS is also known as Reductional division.



## *Contrary to mitosis,*

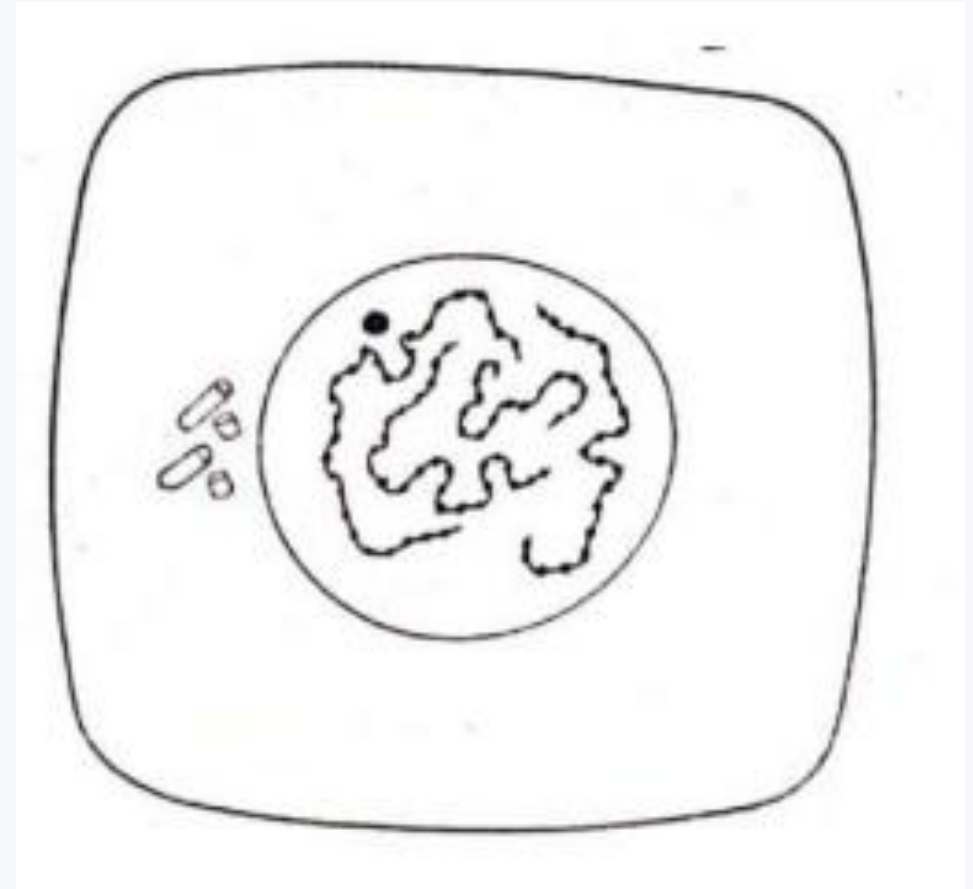
**MEIOSIS** consists of two successive divisions 1<sup>st</sup> meiotic division were the parent divides into two and the 2<sup>nd</sup> meiotic division were the products divide to produce four daughter cells.

The process involves the four stages **Prophase**, **Metaphase**, **Anaphase** and **Telophase** but distinguish by **I or II** for the first and second meiotic division respectively



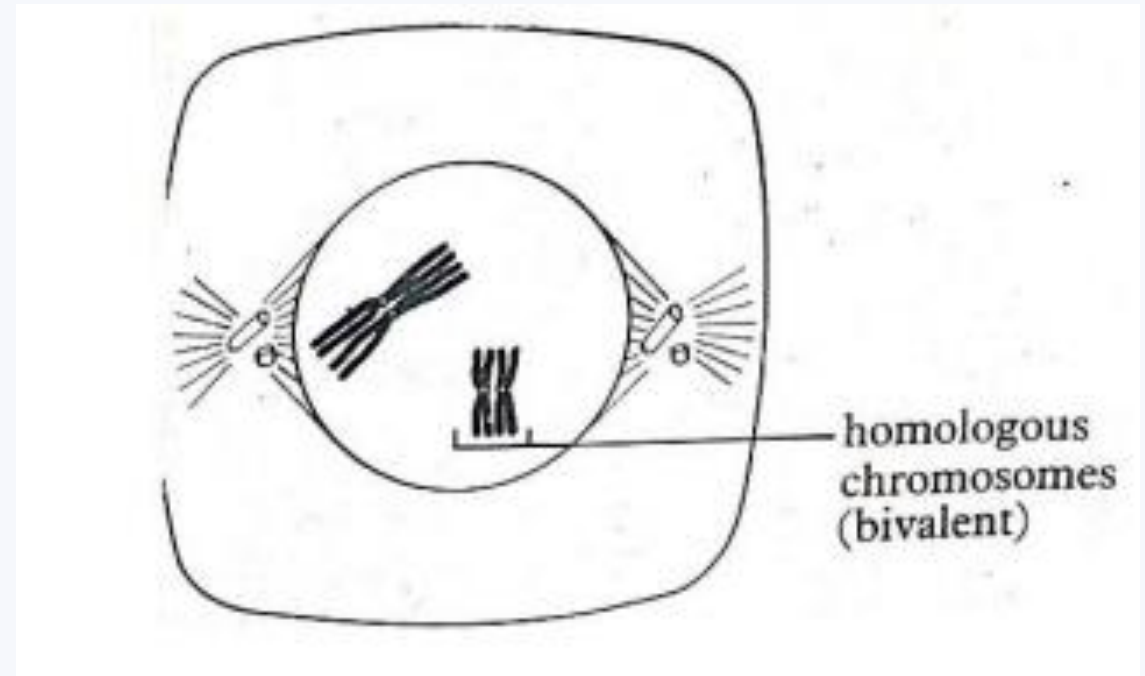
# Interphase

- Chromosomes not visible are thread like
- Chromatins present -  
Replication of DNA
- Production of ATP
- Formation of new organelles



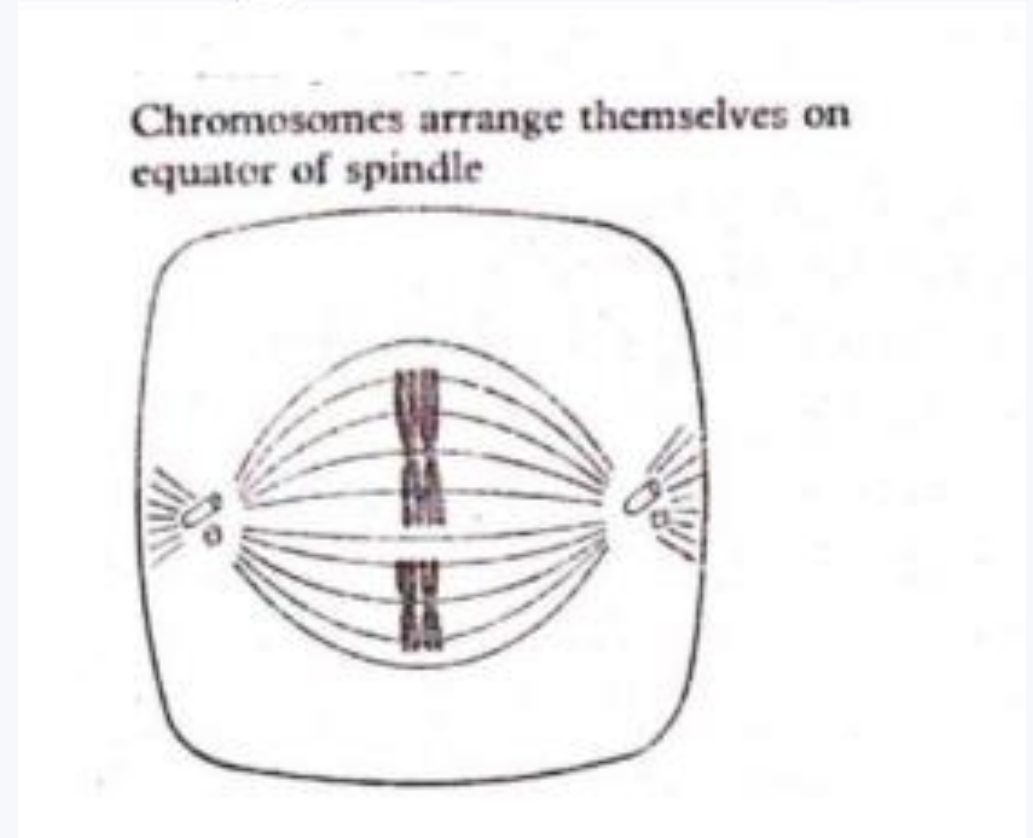
# Prophase I

- Nucleolus disappears
- Centrioles arranged on opposite sides of nucleus
- Spindles form
- Chromosomes condense
- Homologous chromosomes come together (synapsis) forming a bivalent



# Metaphase I

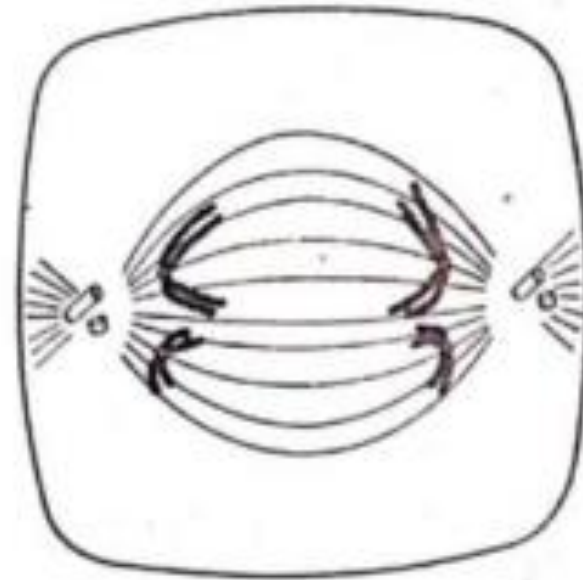
- Homologous chromosomes move to the equator of the spindle together (behaves as a unit)



# Anaphase I

- Homologous chromosomes part company and move towards opposite poles of the spindle

Homologous chromosomes part company and migrate to opposite poles of the cell.



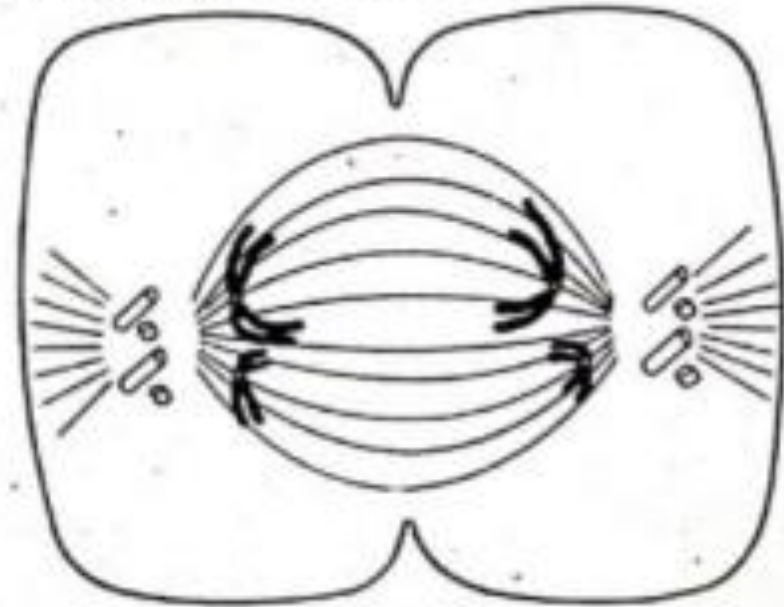
# Telophase I

- The chromosomes have reached their destination and the cell constricts across the middle as in mitosis

**NB:**

The first meiotic division results into separation of homologous chromosomes.

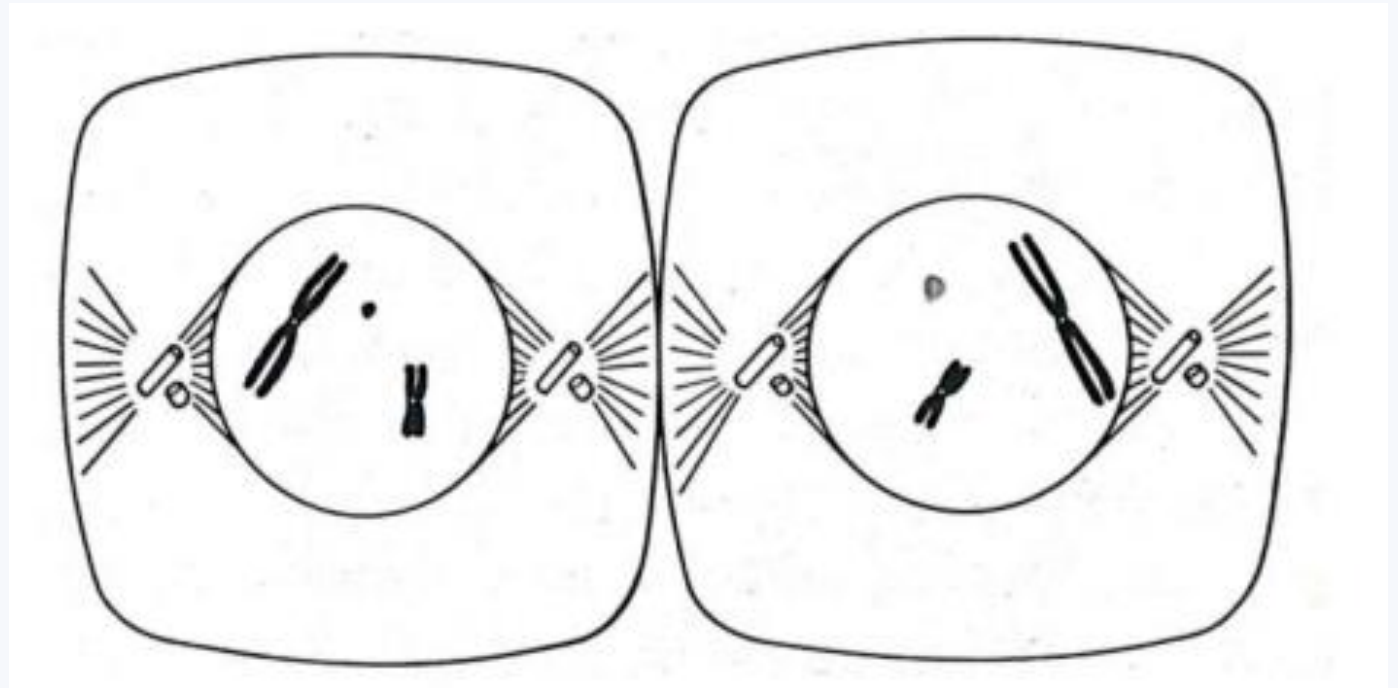
The chromosomes have reached their destination and the cell constricts across the middle as in mitosis.



2<sup>ND</sup> meiotic division aims at separating Chromatids

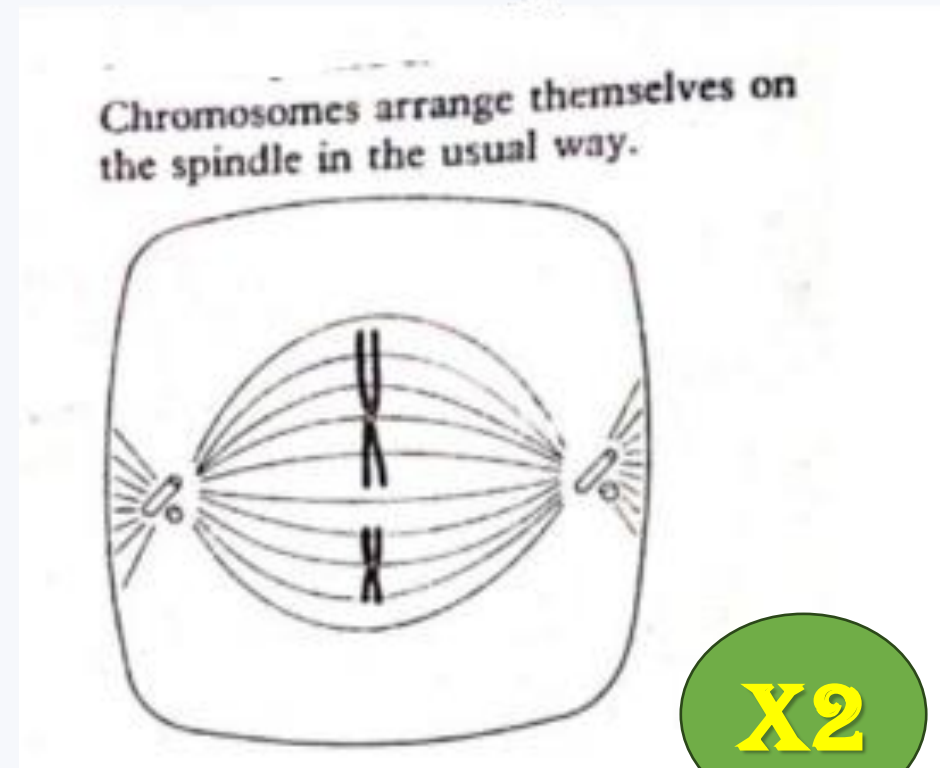
# Prophase II

- Two daughter cells prepare for the 2nd division
- Centrioles replicated
- New spindles are formed



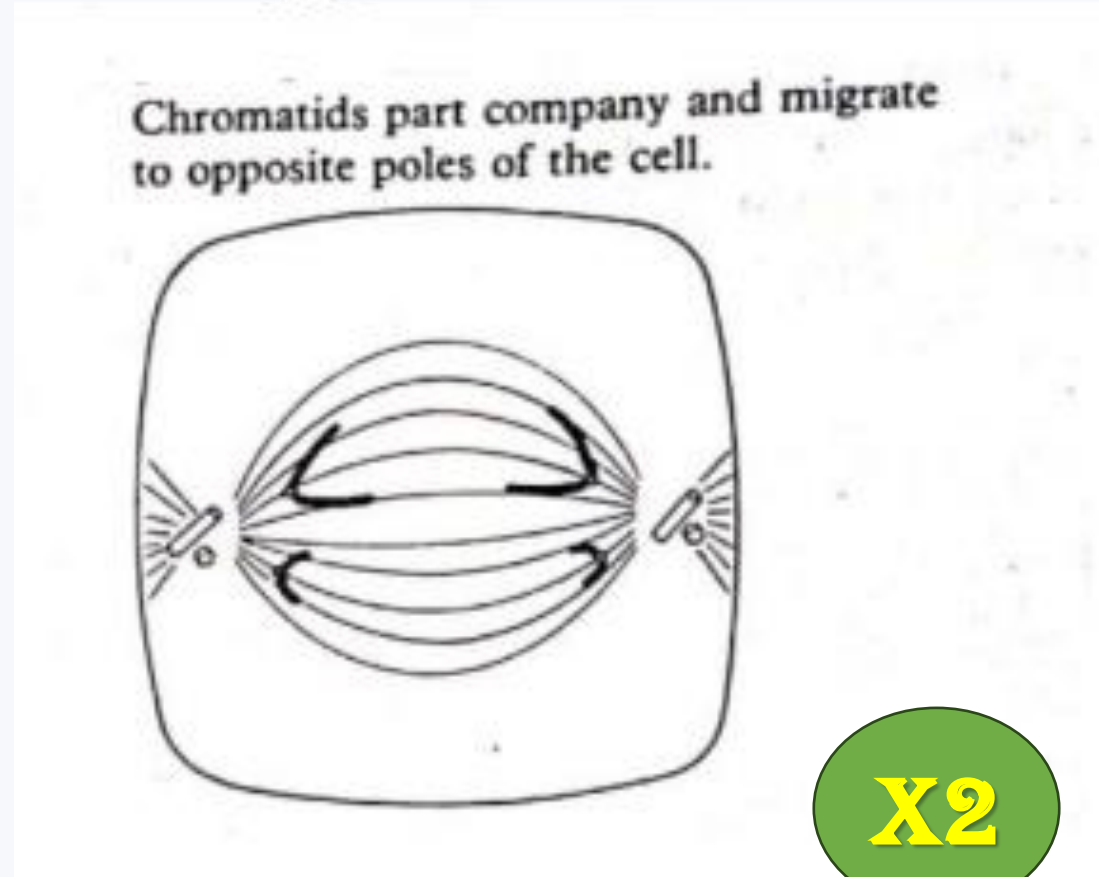
# Metaphase II

- Chromosomes arrange themselves on the spindle in the usual way



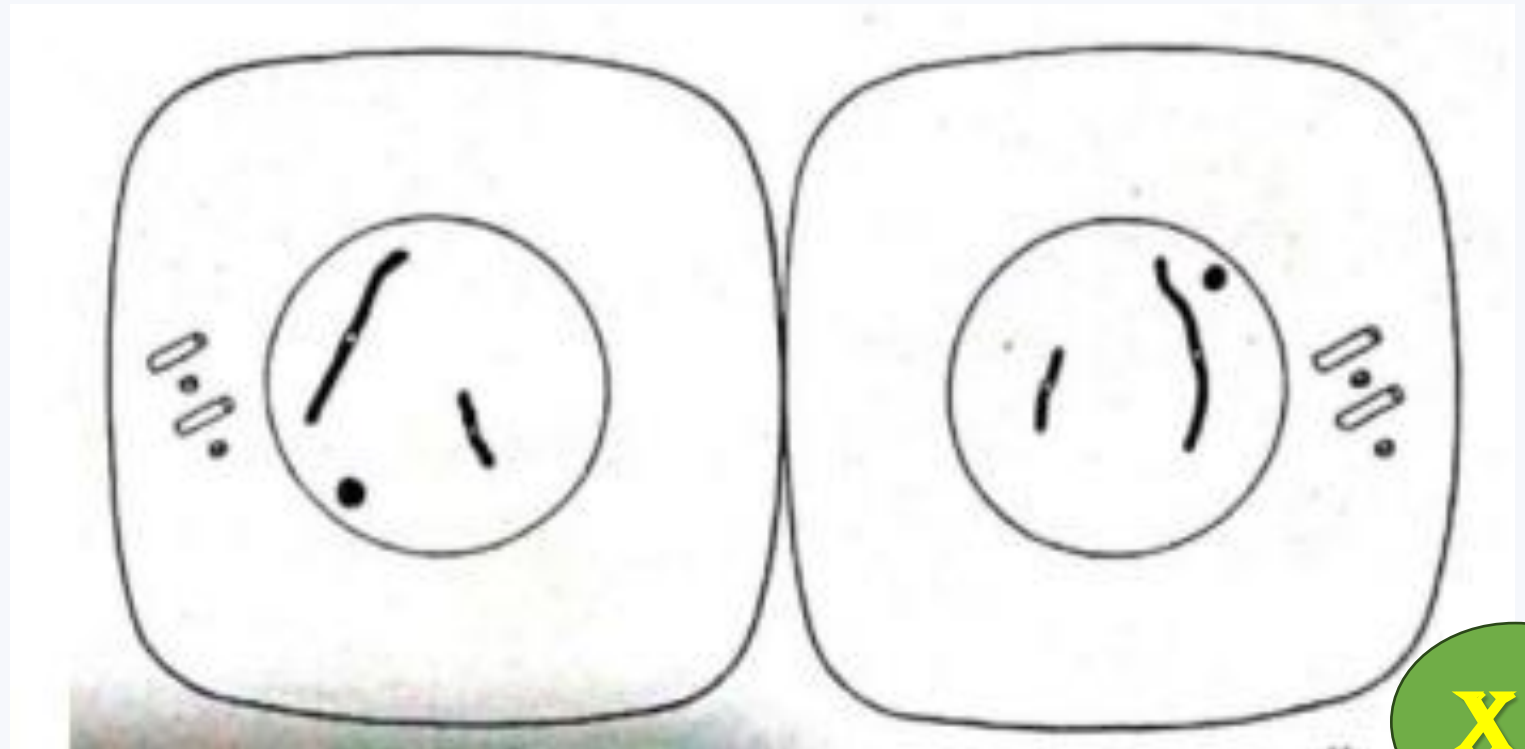
# Anaphase II

- Chromatids part company and arrange to opposite poles of the cell



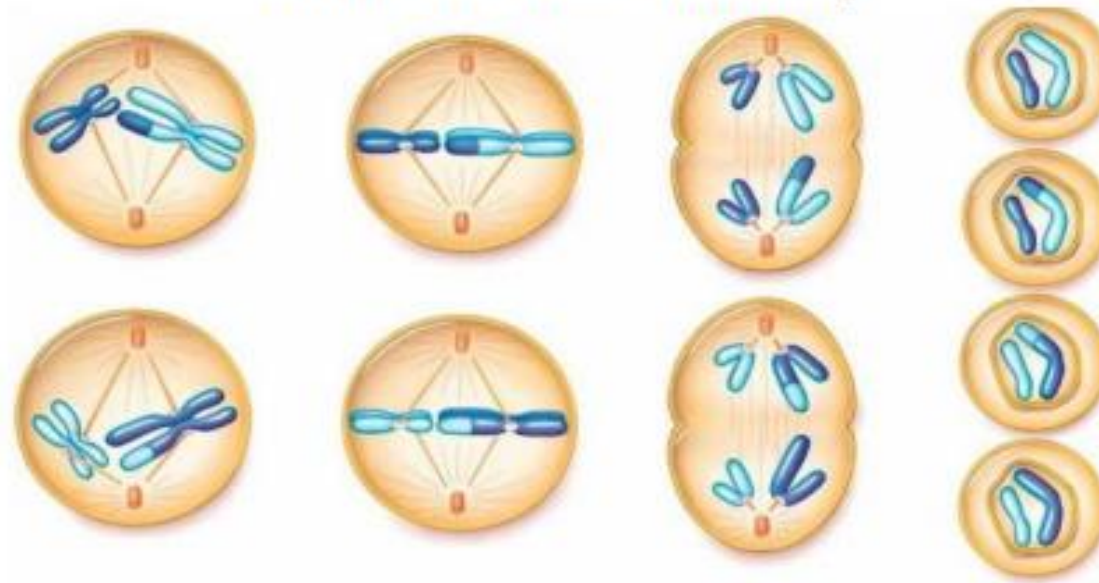
# Telophase II

- Cells constrict across the middle
- The nuclear membrane and nuclei reform





## Meiosis II summary



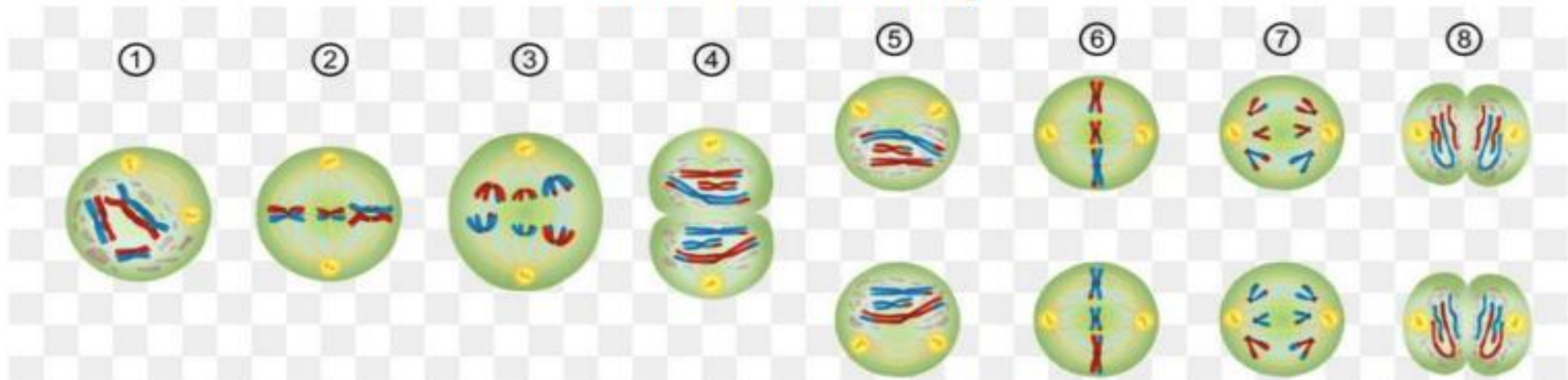
Prophase II

Metaphase II

Anaphase II

Telophase II

## Meiosis summary



# Significance of meiosis

- Sexual reproduction which involves production of **gametes**
- **Genetic variation:** provides opportunity for new combinations of genes to occur in the gametes the is through crossing over and independent assortment

# *1. Independent assortment*

Orientation of bivalents at the equator of the spindle in metaphase I is random.

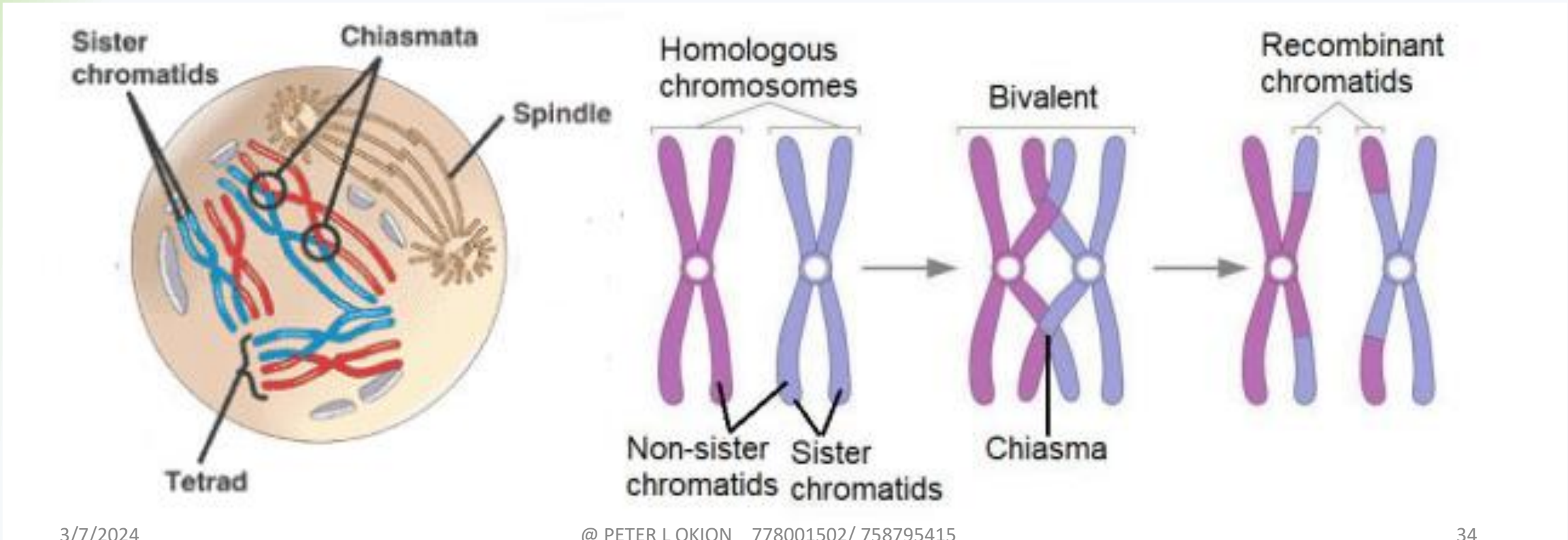
The bivalents line up independently and therefore the chromosomes in each bivalent separate (assort) independently of these in other bivalents during anaphase I

## **2. Crossing over**

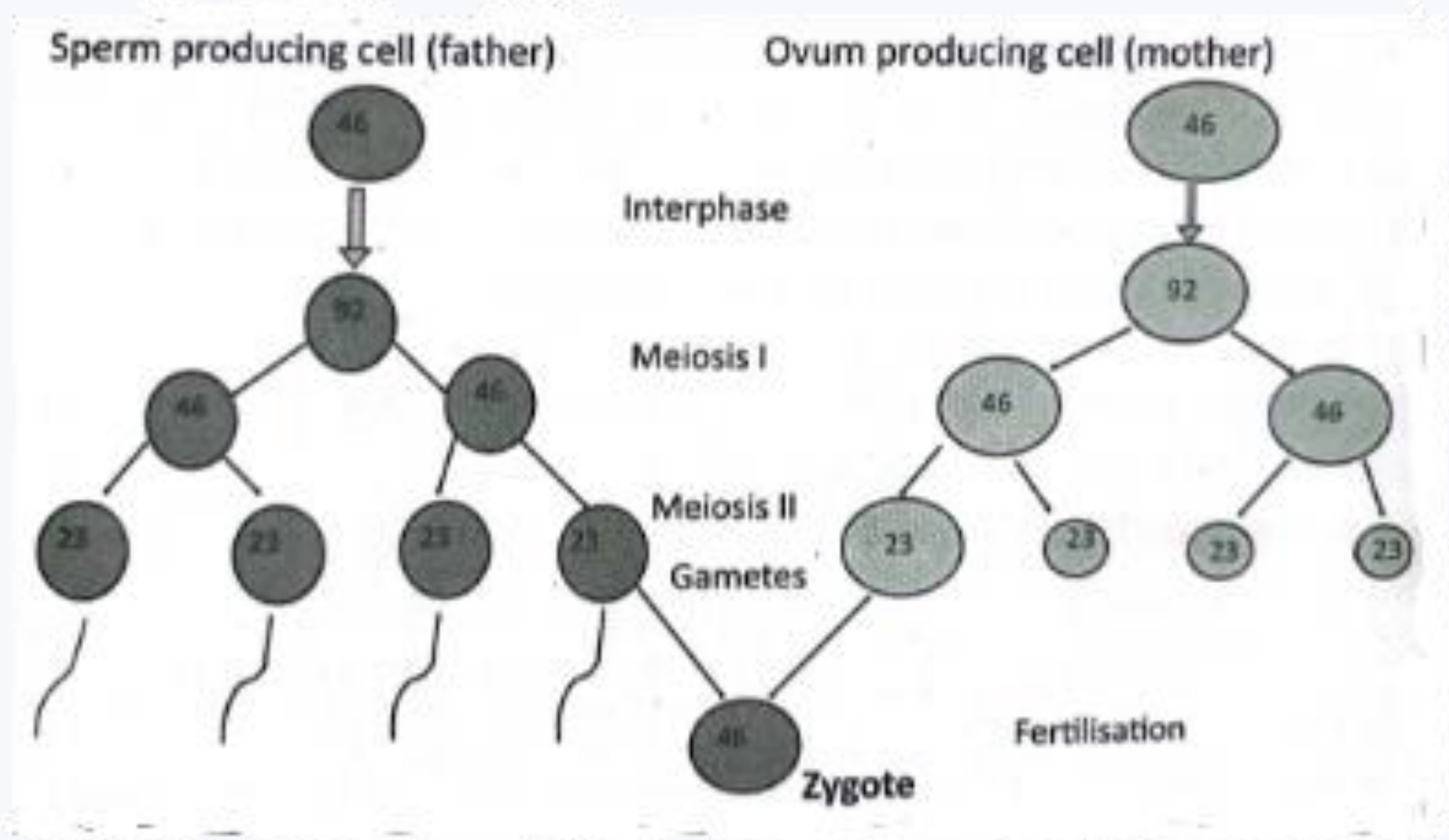
As a result of chiasmata, crossover of segments of Chromatids occurs between homologous chromosomes during prophase I leading to the formation of new combinations of genes on the chromosomes of the gametes.

# PROCESS OF CROSSING OVER

**Non-sister chromatids** of homologous chromosomes join at certain points called **chiasmata** (singular-chiasma) to form a **bivalent**, a process called **Synapsis** and exchange portions in a process called crossing over. Several chiasmata may be formed.



# Role of meiosis in maintaining chromosome number in cells of organisms



Before meiosis in humans, each of the gametes producing cell has **46 chromosomes**,

Just before meiosis I begins (during interphase), each chromosome replicates and thus appears as **two sister chromatids** joined at the centromere ( a chromatid is actually a full chromosome)

At this point, a cell has **92** chromosomes (if you count chromatids).

Meiosis I divides the **92** chromosomes into two cells each with **46** chromosomes.

Meiosis II divides each of these into two other cells (gametes) with 23 chromosomes (**Haploid**) in each.

When two gametes fuse during fertilization, the formed Zygote will have **46** chromosomes just like in the parents

# ASSIGNMENT

Compare the process of Mitosis and Meiosis i.e. give the similarities and differences between the two processes.

# Similarities between mitosis and meiosis

- Both begin with diploid nucleus
- Both have single duplication
- Have similar stages
- In both there is spindle formation
- In both chromosome arrange at the equator

## Differences between mitosis and meiosis

| <b>Mitosis</b>                                                               | <b>Meiosis</b>                                                                        |
|------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| Occurs in somatic cells.                                                     | Occurs in reproductive cells.                                                         |
| Involves a single division of chromosomes and cytoplasm                      | Involves two divisions of chromosomes and cytoplasm.                                  |
| Does not involve the process of synapsis                                     | It involves synapsis                                                                  |
| Crossing over does not occur                                                 | It involves crossing over between homologous chromatids.                              |
| Formation of bivalents does not occur.                                       | There is formation of bivalents.                                                      |
| Two daughter cells are produced.                                             | Four daughter cells are formed.                                                       |
| Diploid cells are formed.                                                    | Haploid cells are formed.                                                             |
| Daughter cells formed have the same number of chromosomes as the parent cell | Daughter cells formed have half the number of chromosomes compared to the parent cell |
| Does not involve formation of chiasmata.                                     | It involves formation of chiasmata                                                    |

| STAGE     | MITOSIS                                                                                                                                                     | MEIOSIS                                                                                                                                                                                                 |
|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Prophase  | <ul style="list-style-type: none"> <li>- Homologous chromosomes remain separate</li> <li>- No formation of chiasmata</li> <li>- No crossing over</li> </ul> | <ul style="list-style-type: none"> <li>- Homologous chromosomes pair up</li> <li>- Chiasmata form</li> <li>- Crossing over may occur</li> </ul>                                                         |
| Metaphase | <ul style="list-style-type: none"> <li>- Pairs of Chromatids lineup on the equator of spindle</li> </ul>                                                    | <ul style="list-style-type: none"> <li>- Pairs of chromosomes lineup on the equator of spindle</li> </ul>                                                                                               |
| Anaphase  | <ul style="list-style-type: none"> <li>- Centromeres divide</li> <li>- Chromatids separate</li> <li>- Separating Chromatids identical</li> </ul>            | <ul style="list-style-type: none"> <li>- Centromeres do not divide</li> <li>- Whole chromosomes separates</li> <li>- Separating chromosomes and their Chromatids may not be identical due to</li> </ul> |

|            |                                                                                                                                                                                                                     |                                                                                                                                                        |
|------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
|            |                                                                                                                                                                                                                     | crossing over                                                                                                                                          |
| Telophase  | <ul style="list-style-type: none"> <li>- Same number of chromosomes in daughter cells as parent cells</li> <li>- Bothe homologous chromosomes present in daughter cells if diploid.</li> <li>-</li> </ul>           | <ul style="list-style-type: none"> <li>- Half</li> <li>- Only one of each pair</li> </ul>                                                              |
| Occurrence | <ul style="list-style-type: none"> <li>- May occur in haploid, diploid or polyploidy cells</li> <li>- Occurs during formation of somatic cells and some spores</li> <li>- Formation of gametes in plants</li> </ul> | <ul style="list-style-type: none"> <li>- Only occurs in diploid or polyploidy cells</li> <li>- Occurs during formation of gametes or spores</li> </ul> |



# TERMS USED

**Chromosome:** These are thread-like structures bearing genes and located in the nucleus.

**Chromatid:** This is half of a chromosome split longitudinally.

**Bivalent:** This is a pair of homologous chromosomes.

**Gene:** This is a unit of the hereditary material found on the chromosome and responsible for controlling a particular trait/character.

**Allele:** This is the alternative form of the same gene. Most genes are made up of two alleles. Alleles of the same gene are represented by the same letter but the dominant allele is represented by a capital letter and the recessive allele by a small letter in the case of dominant-recessive characters.

**Diploid:** This is a description of a cell, which has a whole set of chromosomes.

**Haploid:** This refers to a cell with half the set of chromosomes.

**Genotype:** This refers to the genetic composition of an organism.

**Phenotype:** This is the physical appearance or the outward expression of an individual.

**Dominant gene/dominant allele:** This is a description of a gene /allele whose effect is seen in the phenotype of the heterozygous individual. The effect of the dominant gene/allele is seen in the phenotype even in the presence of another gene/allele.

**Recessive gene/ allele:** This is a description of a gene whose effect is not phenotypically expressed in the heterozygous state. The effect of a recessive gene/allele is not seen in the presence of another (dominant) gene/allele.

**Homozygous:** This refers to a gene with two identical alleles for example if **T** represents the gene for height where tallness is dominant to shortness then the allele for tallness is **T** and that for shortness is **t**.

An individual with **TT** is said to be homozygous tall and **tt** is said to be homozygous short.

**Homozygous dominant:** This is where both alleles of a gene determine a dominant character.

**Homozygous recessive:** This is where both alleles of a gene determine a recessive character.

**Heterozygous:** This refers to a gene with two different alleles for example if **T** represents the allele for tallness and **t** for shortness then **Tt** is the heterozygous state of this gene.

**Hybrid:** This is an offspring produced by parents of two different pure lines.

**Incomplete dominance:** This is a condition where neither of the genes is dominant over the other.

**Gametes:** These are reproductive cells.

**Fertilization:** This is the fusion of the male and female gametes to form a zygote.

**Monohybrid inheritance:** This is a type of inheritance, which involves studying a single pair of contrasting characteristics.

**Dihybrid inheritance:** This is a type of inheritance, which involves studying two pairs of contrasting characteristics at a go.

**Test cross:** This is a type of back cross which involves crossing an offspring having a dominant character with its recessive parent in order to determine the test of that offspring.

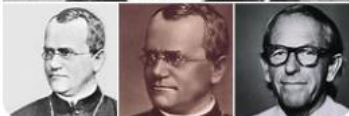
**Back cross:** This is the mating of an offspring with one of its parents.



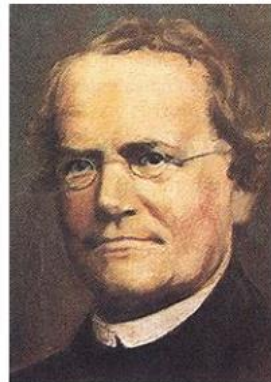
Gregor Mendel - Wikipedia



Gregor Mendel | Biography, Experiments, & Facts | Britannica



Gregor Mendel Biography - Facts, Childhood, Family Life & Achiev...



TheBigSociety: Mendel's Biography



Gregor Mendel - Wikiwand



Gregor Mendel Biography - Childhood, Life Achievements ...



Mendelian Genetics - Genetics Generation



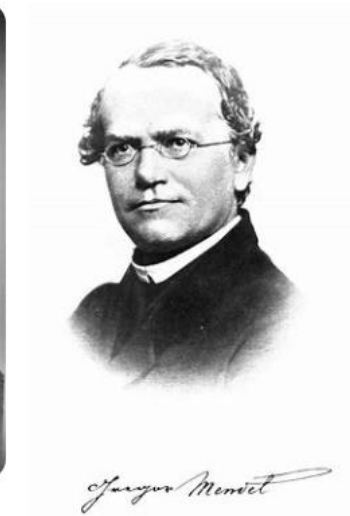
Plant Life: Genetics: Mendelian



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# *Mendel's experiment*

For his experiment he collected one of the varieties of garden peas (*Pisum sativum*) with **contrasting** features such as one variety was producing tall plants when stems are about 200cm and another short plant with stems of 25cm.

He crossed these plants for his experiments.

He crossed **pure** tall pea plants with **pure** short pea plants and all the offsprings were tall (F1 generation) Tallness was the dominant character and shortness the recessive character.

The dominant character is represented using a capital letter while the recessive character is represented using a small letter.

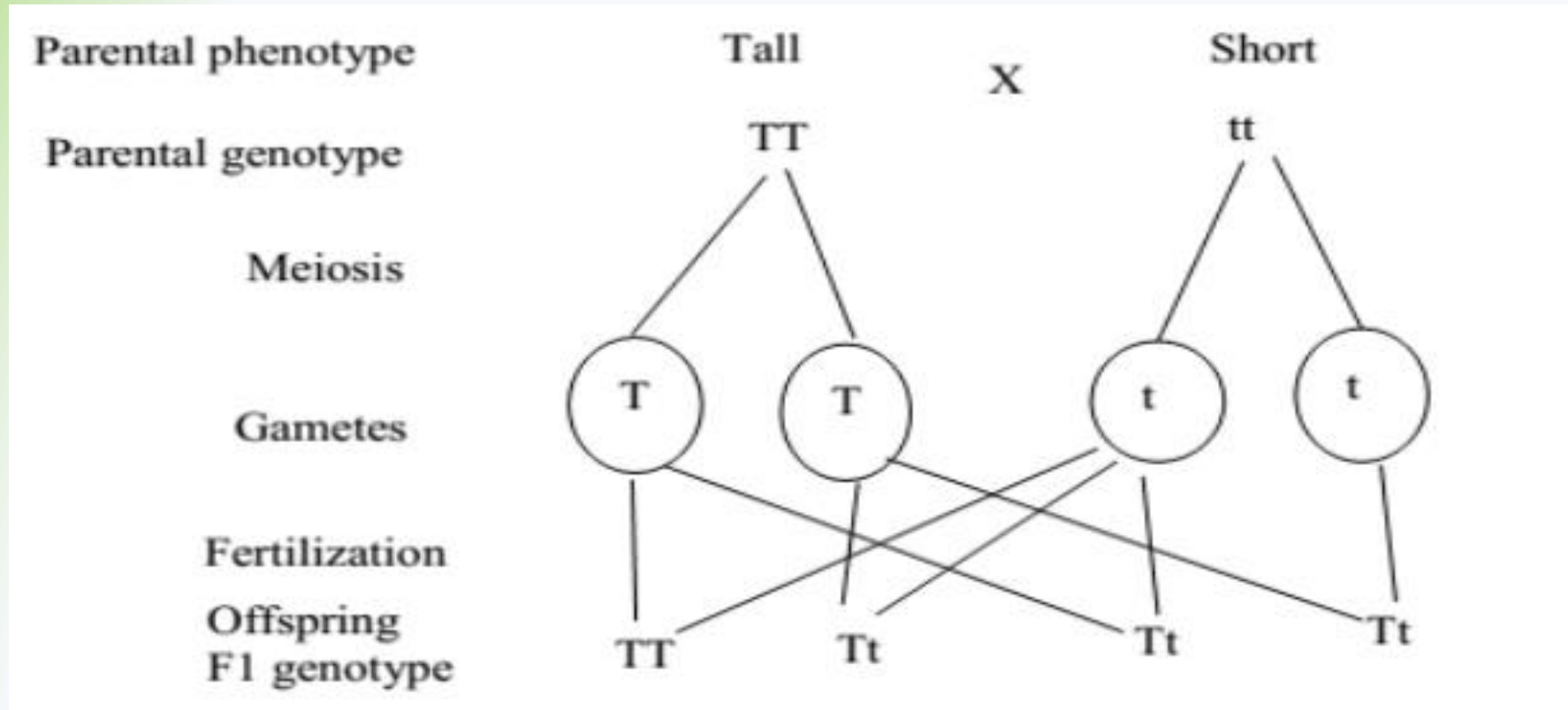


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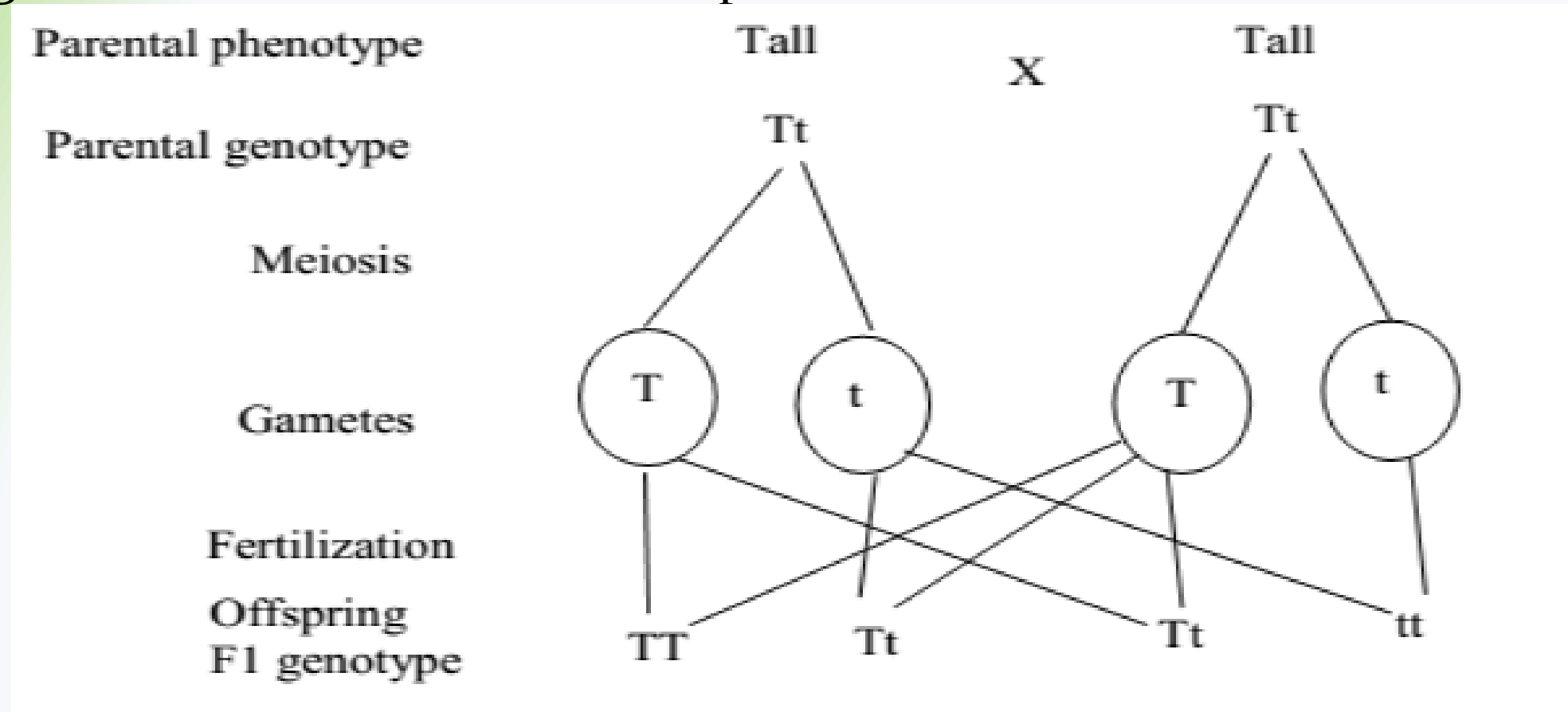
Let **T** represent allele for tallness

Let **t** represent allele for shortness



Offspring phenotype: **All tall**

Mendel then selfed the plants of the **F1** generation and obtained an **F2** generation with **tall** and **short** plants in a ratio of **3:1**



Genotypic ratio; **TT: Tt: tt = 1:2:1**

Phenotypic ratio; **3 tall: 1 short**

# *Conclusions from Mendel's' crosses.*

1. A character can be transmitted from parent to offspring independent of other characters.
2. Genes occur as a pair of alleles.
3. Only one allele of the same gene is carried in a single gamete.

# *Mendel's laws of inheritance*

From his observations, Mendel put up two laws of inheritance.

## ***First law: The law of segregation.***

This law states that the character of an organism is determined by a pair of alleles. Only one allele of such a pair is carried in a gamete.

## ***Second law: The law of independent assortment.***

This states that each of the alleles in a pair may combine with another allele from another pair randomly.

# ***Monohybrid inheritance***

Inheritance is the passing over of characteristics of the parents to their off springs.

***Monohybrid inheritance*** involves the study of how one character is inherited from the parents to the off springs.

Mendel carried out several experiments on peas to study monohybrid inheritance.

***Mendel chose garden peas for his experiments because of the following reasons:***

1. They grow very fast and produce results in a very short period of time.
2. They are relatively small and can be grown on a small plot for study purposes.
3. Some of their characters are controlled by single genes, which make it easy to study them.
4. They have characteristics, which show clear-cut differences without intermediates like tall and short, green and yellow cotyledons, etc.

***He therefore concluded that their reproduction can be manipulated by pollination.***

## Examples:

1. What would be the offsprings for a cross between homozygous **black** and homozygous **brown**.

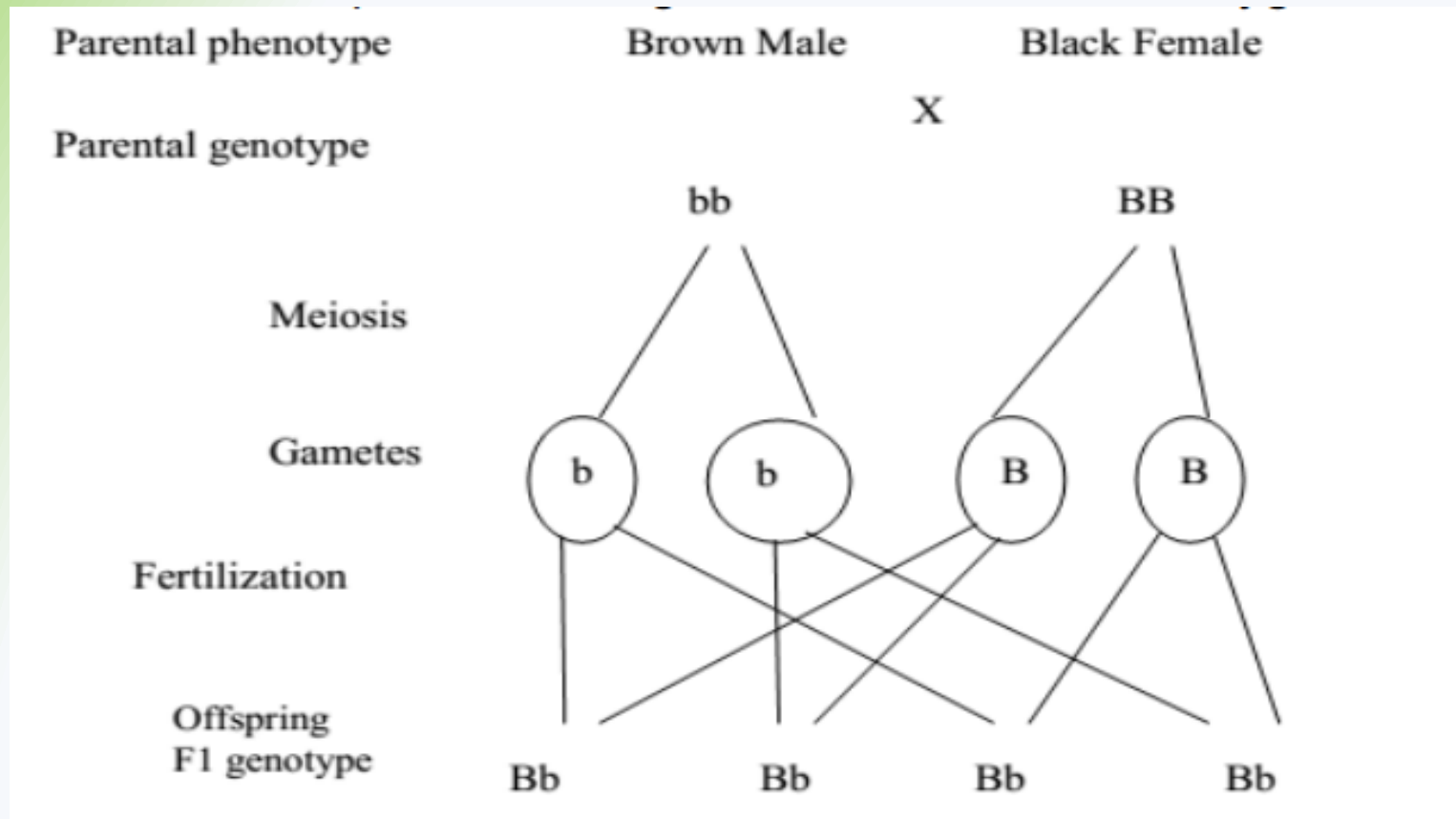
Take **B** for **black** and **b** for **brown**.

Let **B** represent the allele for **black** fur.

Let **b** represent the allele for **brown** fur.

### **Note.**

1. It is one gene controlling a character, which is fur Color. For this reason, we use the same letter
2. **Black** Color is dominant that is why we use (**B**) and **brown** is recessive (**b**)
3. The term pure-breeding is used to mean homozygous for that particular gene.

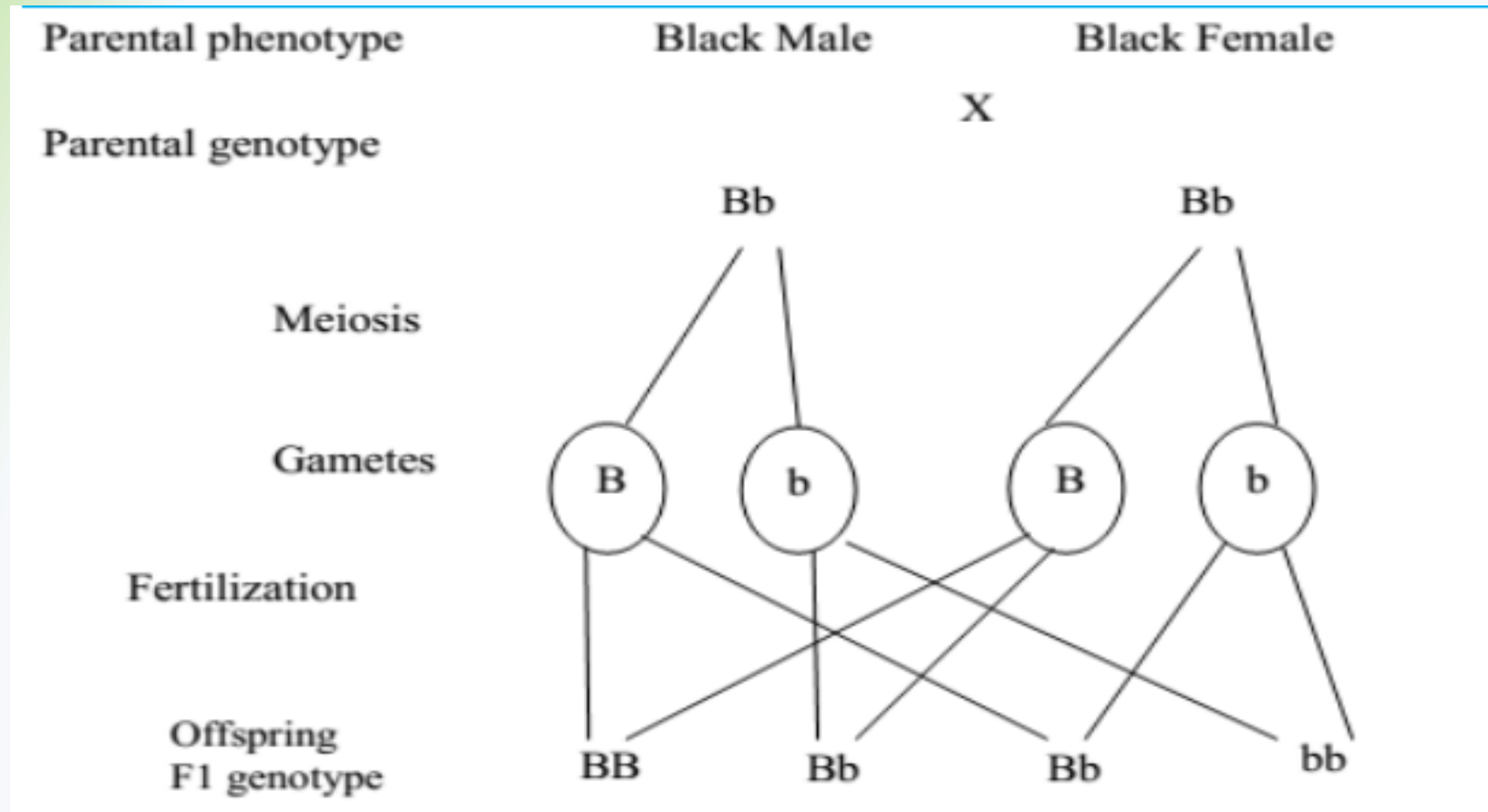


Offspring genotype: **all Bb** (heterozygous)

Offspring phenotype: **all black.**

They are all black because black is **dominant** to brown and it shows up in the **heterozygous state.**

# Consider Selfing of F1 (crossing two offsprings of F1 above).



F2 phenotypic ratio: **3 black: 1 brown, 3:1**

# EXERCISE 1

The fruit fly (***drosophila melangaster***) usually has wings twice as long as its abdomen but some drosophilae have very short or vestigial wings. A long-winged drosophila (male) was crossed with a vestigial winged female drosophila and all the F1 off springs were long winged. The long winged F1 generation were then mated.

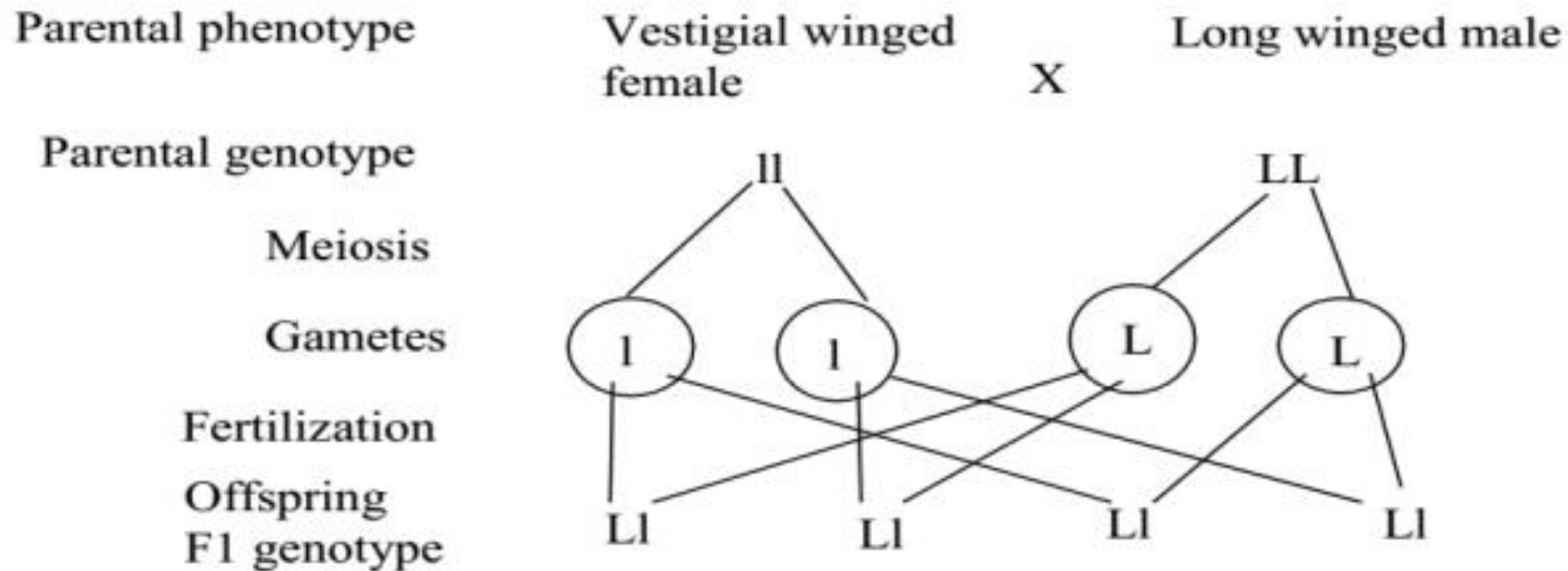
- i) How can the cross be represented diagrammatically
- ii) State the phenotypes of the off springs in the F2 generation and state their genotypic ratio.
- iii) What is the percentage of the vestigial winged drosophila flies in the F2 generation?
- iv) A drosophila is normally used in experiments on heredity, why do you think it is suitable for such experiments



# Solution:

Let **L** represent the allele for long wing and **l** represent the allele for vestigial wing

i)



F1 phenotype: **All long winged.**

ii)

Parental phenotype

Parental genotype

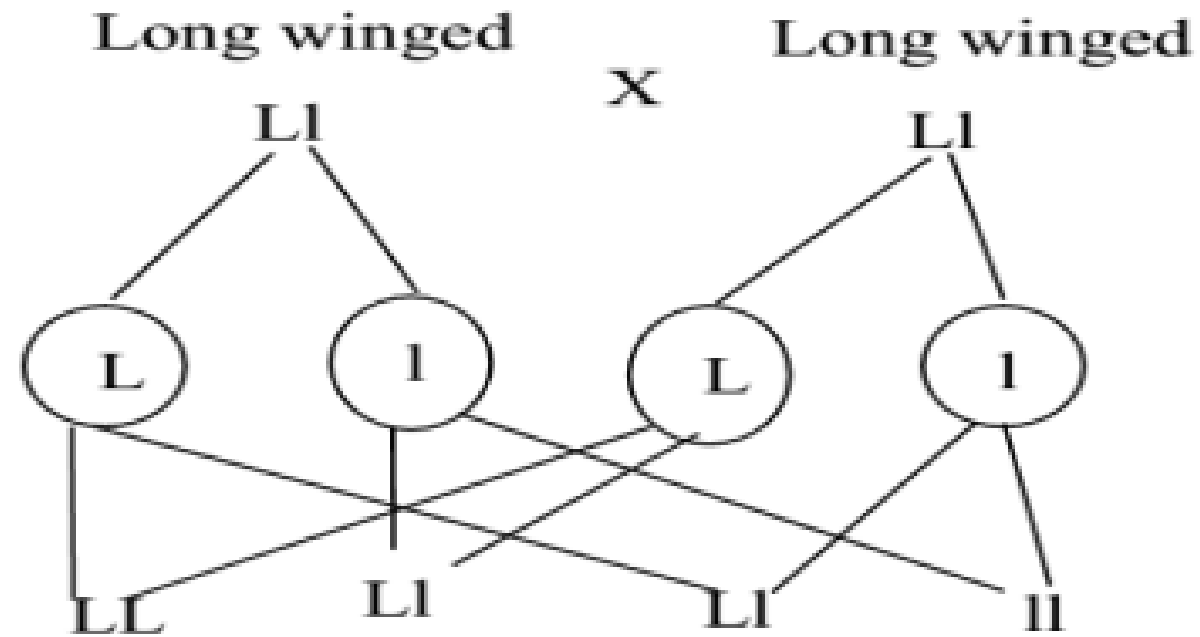
Meiosis

Gametes

Fertilization

Offspring

Genotype



Genotypic ratio; **1:2:1**

**One** of the off springs will be homozygous long winged

**Two** of them will be heterozygous long winged

**One** of them will be homozygous short winged or vestigial winged

iii)  $\frac{1}{4} \times 100 = 25\%$

iv) It's because they:

- Have contrasting characters
- Have short life span
- Show clear cut differences.

# EXERCISE 2

In cattle, the gene for hornless condition is dominant over one for horns. A pure hornless cow was mated with a horned bull. Using genetic symbols, show the possible phenotype and genotype of the F1 offspring.



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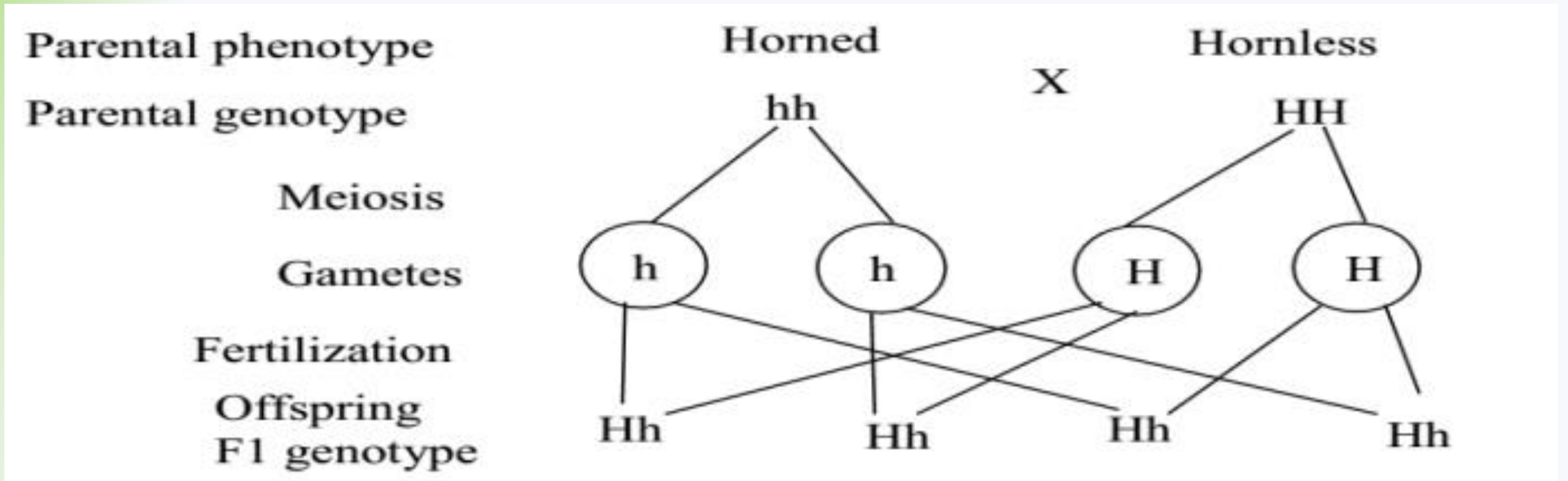


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# Solution:

Let **h** represent the allele for horned condition.

Let **H** represent the allele for hornless condition



F1 Phenotype: **All were horned cows.**

# Exercise 3 (continuation of exercise2)

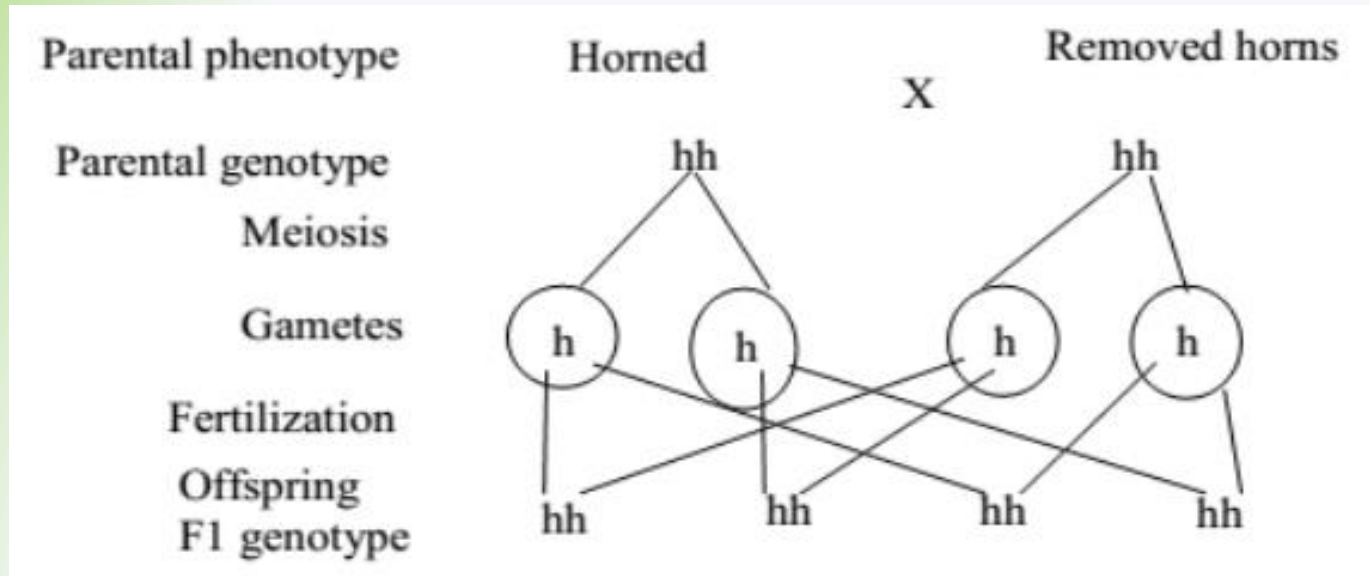
A bull whose horns were removed was mated to a horned cow.  
Show the possible genotypes and phenotypes of the F1 offspring.  
Give a reason for your answer.



# Solution:

Let  $h$  represent the allele for horned condition.

Let  $H$  represent the allele for hornless condition



F1 Phenotype: **All are horned**

**Note:** cutting the horns doesn't change the genetic make-up (genotype) of the horned bull. Genetic composition of an organism is permanent and can't be manipulated.

# Assignment:

In peas, yellow seed Color is dominant over green seed Color. What would be the phenotype of the offsprings if a true breeding yellow-seeded plant is crossed with a green-seeded plant?

# Monohybrid inheritance in human beings

## 1. Albinism

This is a condition in human beings where the individual fail to produce skin pigments called **melanin**.

Albinos have;

- ✓ Light skin
- ✓ White hair
- ✓ Pink eyes
- ✓ They are sensitive to bright light

Albinism is caused by a **recessive gene**.





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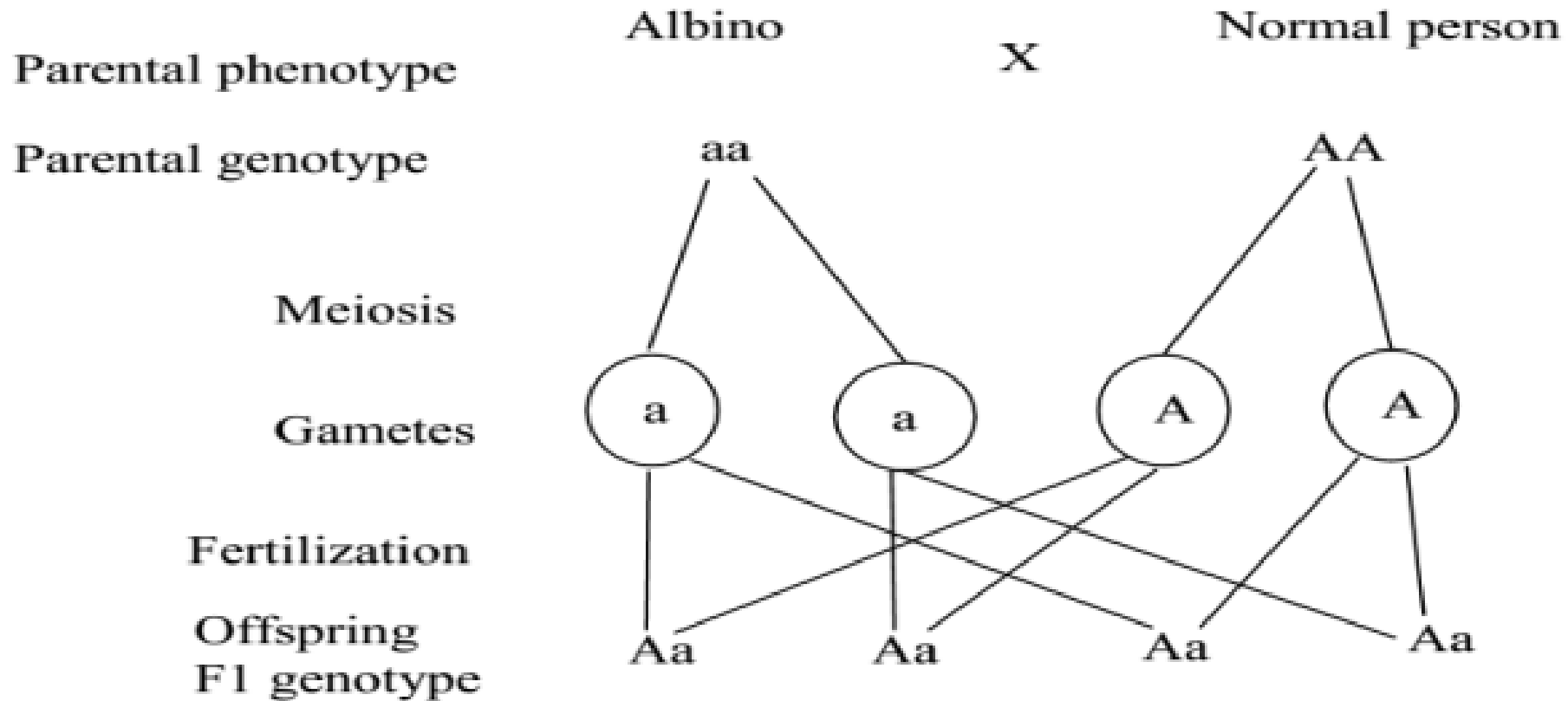
# Examples

1. What would be the off springs if an albino marries a normal person?

Let **A** represent the allele for normal skin Color

Let **a** represent the allele for no skin Color.

| Genotype | Phenotype            |
|----------|----------------------|
| AA       | Normal skin colour   |
| Aa       | Carrier for albinism |
| aa       | albino               |



All the off springs will be carriers of albinism

2. What would be the off springs when 2 individuals who are carriers of albinism get married?

# Soln

Parental phenotype

Carrier

X

Carrier

Parental genotype

Aa

Aa

Meiosis

Gametes



Fertilization

Offspring

F1 genotype

AA

Aa

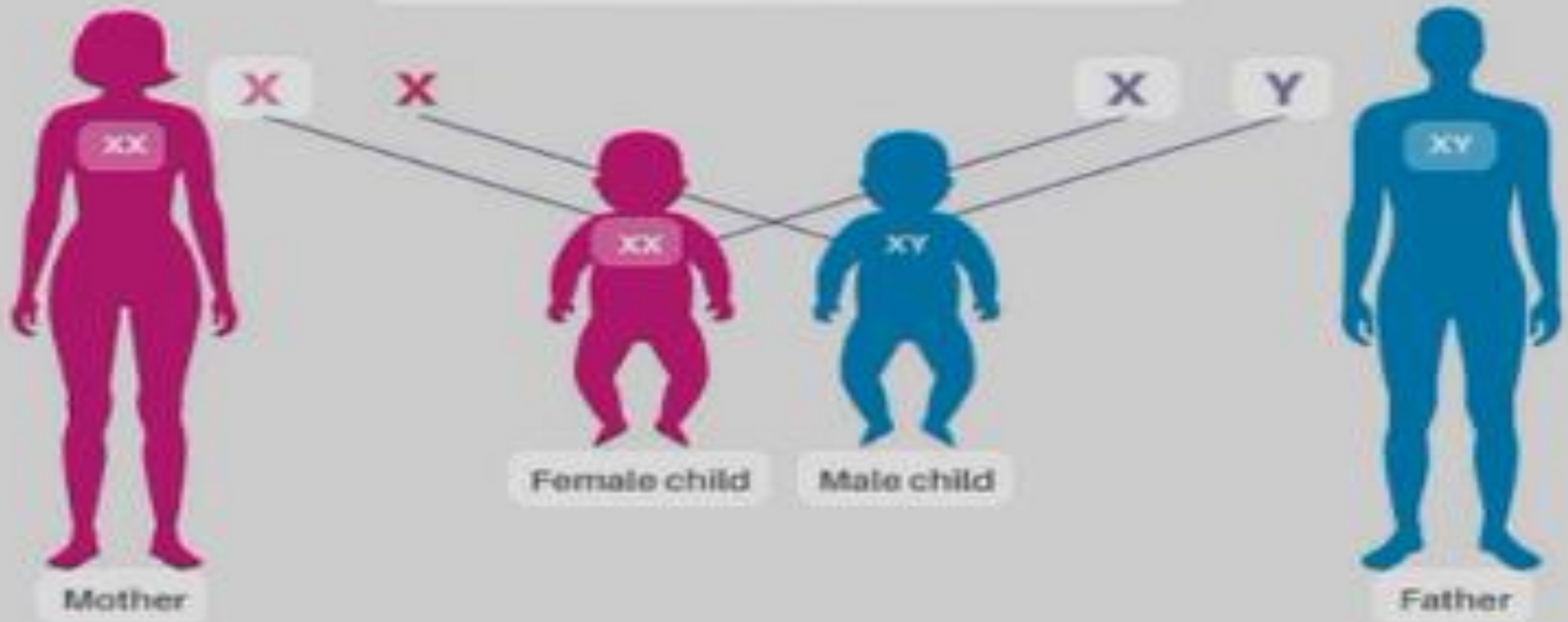
Aa

aa

Genotypic ratio; **1 normal: 2 carrier: 1 albino; 1:2:1**

Phenotypic ratio; **3:1**

## SEX DETERMINATION IN HUMANS



# Sex determination in human beings

There are **23 pairs** of chromosomes in each cell of the human body.

**One** pair determines the sex of the individual and they are called sex chromosomes.

There are two sexes, i.e. male and female.

The gene controlling sex is carried in the reproductive cells on the sex chromosomes.

There are two sex chromosomes the **X** chromosome and the **Y** chromosome. These chromosomes occur in a pair to determine the sex of an individual.

Each gamete carries one of the sex chromosomes.

In males some of the sperms contain the X chromosome while some contain the Y chromosome.

Y only occurs in males.

In females all the eggs contain the X chromosome.

**At fertilization**, a sperm fuses with the egg.

If the X sperm fuses with an egg (X), the resulting offspring is **XX** and is a female.

If a Y sperm fuses with an egg (X), the resulting individual is **XY** and is a male.

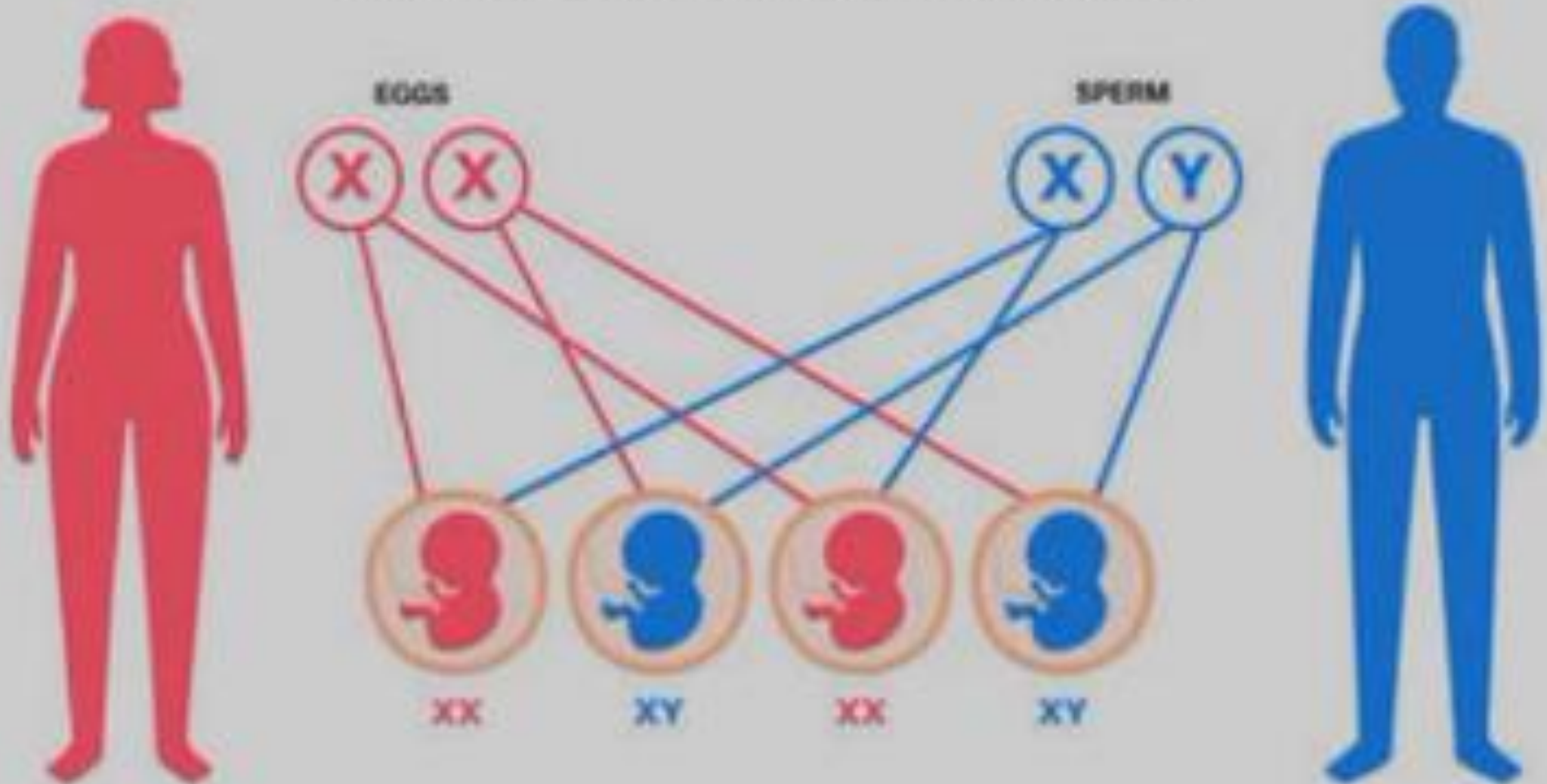
Therefore, the **male determines the sex of the offspring**.

This is because the male produces two different sperms (X and Y) while the female produces only eggs with X chromosomes.

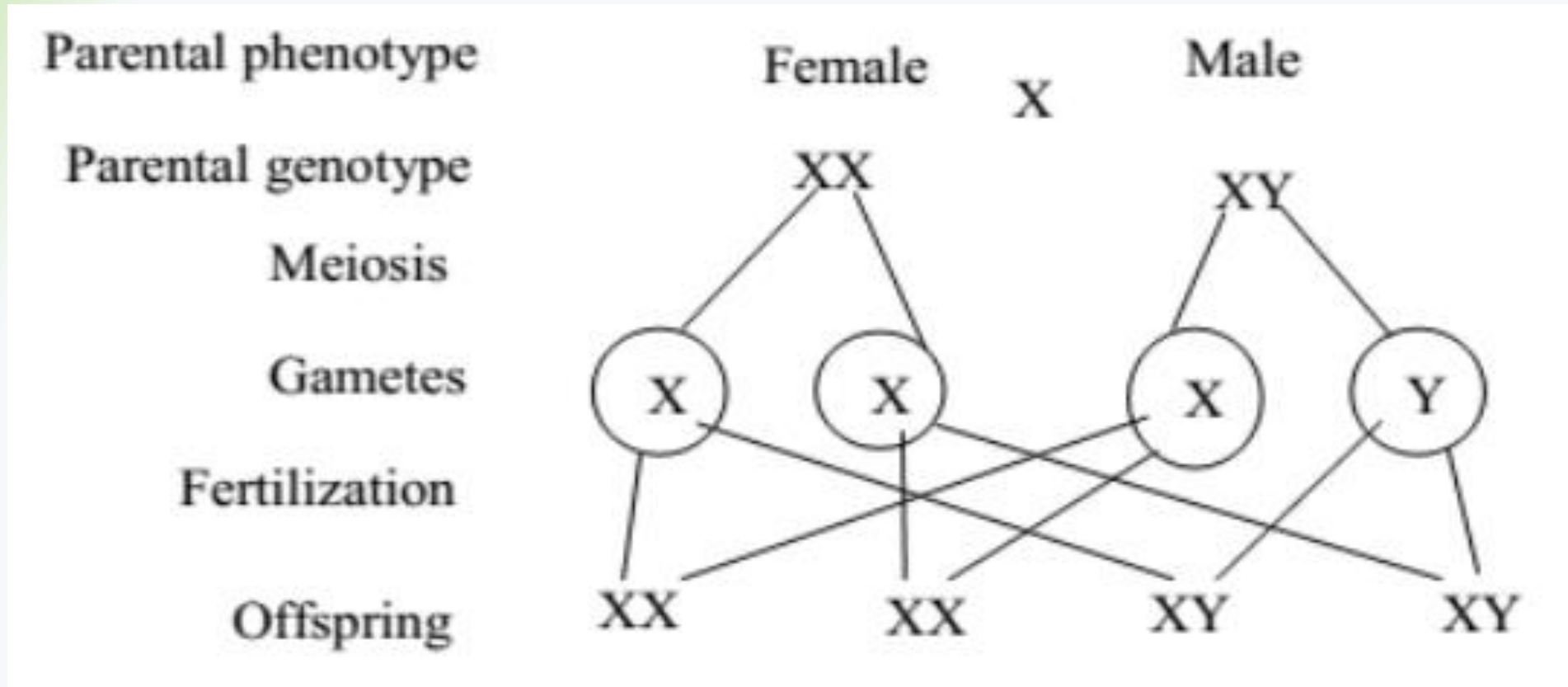
### **Note:**

The Y sperms are more active and persistent than the X sperms. This increases the chances of an ovum to be fertilized by a Y sperm. So, to every 100 girls, 120 boys are born but more boys than girls die at the time of birth.

## SEX DETERMINATION IN HUMANS



# Illustration:



Phenotypic ratio; **2 boys: 2 girls**

# Sex linked traits/characters in Humans

These are traits or genes associated with the sex of the individual.

These characters are carried on the sex chromosomes and are controlled or determined by the genes on those chromosomes.

Such characters appear in a recessive form hence are very common in males than in females.

Such characters include;

- ✓ Color blindness

- ✓ Haemophilia (bleeder disease)

# Inheritance of Color blindness

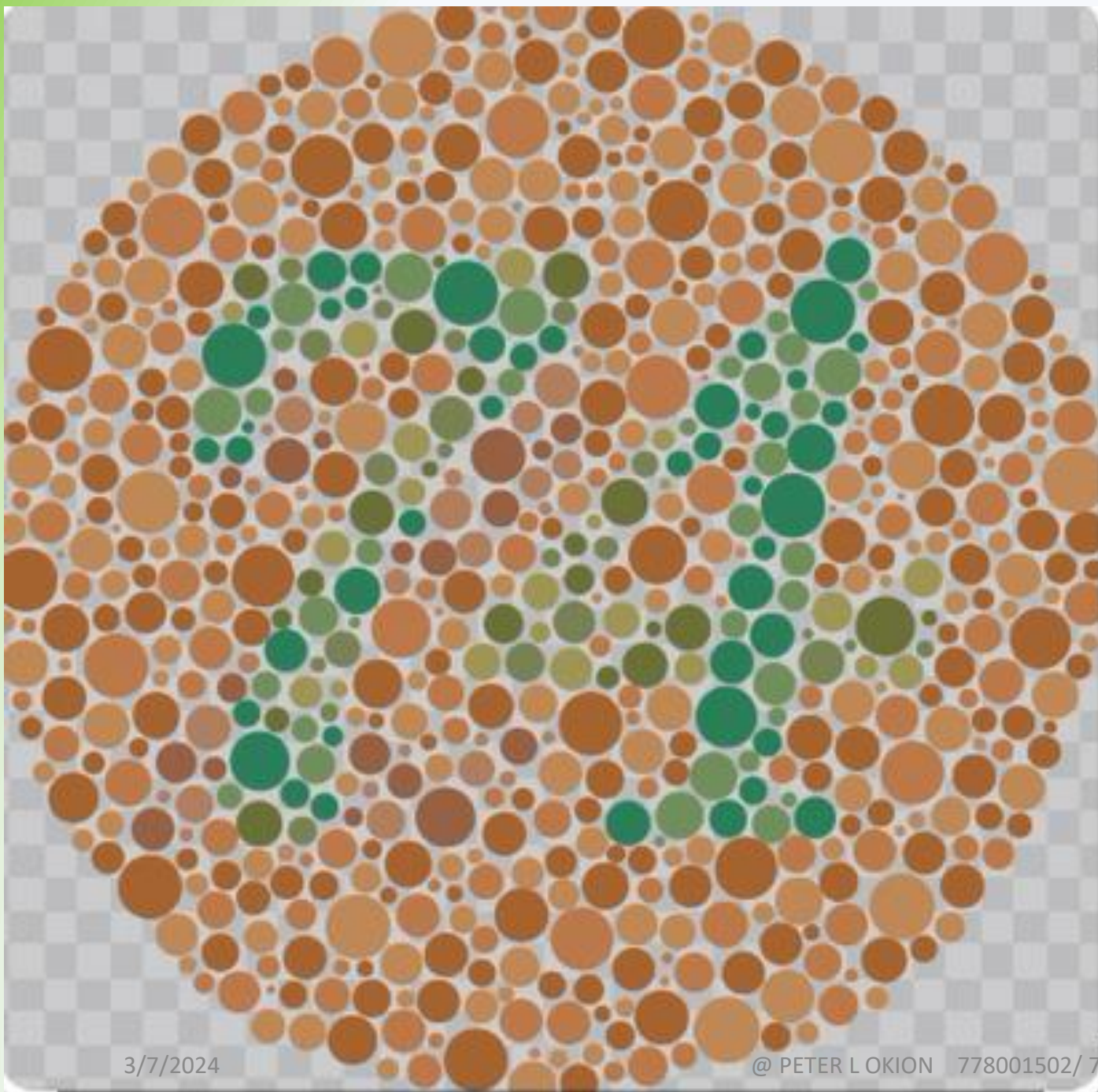
Color blindness is a defect of the eyes where eyes have a reduced ability to distinguish between certain Colors caused by a recessive gene on the X chromosome.

## Example

Let **B** represent the allele for normal Color vision

Let **b** represent the allele for Color blindness

| Genotype  | Phenotype           |
|-----------|---------------------|
| $X^B X^B$ | Normal female       |
| $X^B X^b$ | Carrier female      |
| $X^b X^b$ | Colour blind female |
| $X^B Y$   | Normal male         |
| $X^b Y$   | Colour blind male   |





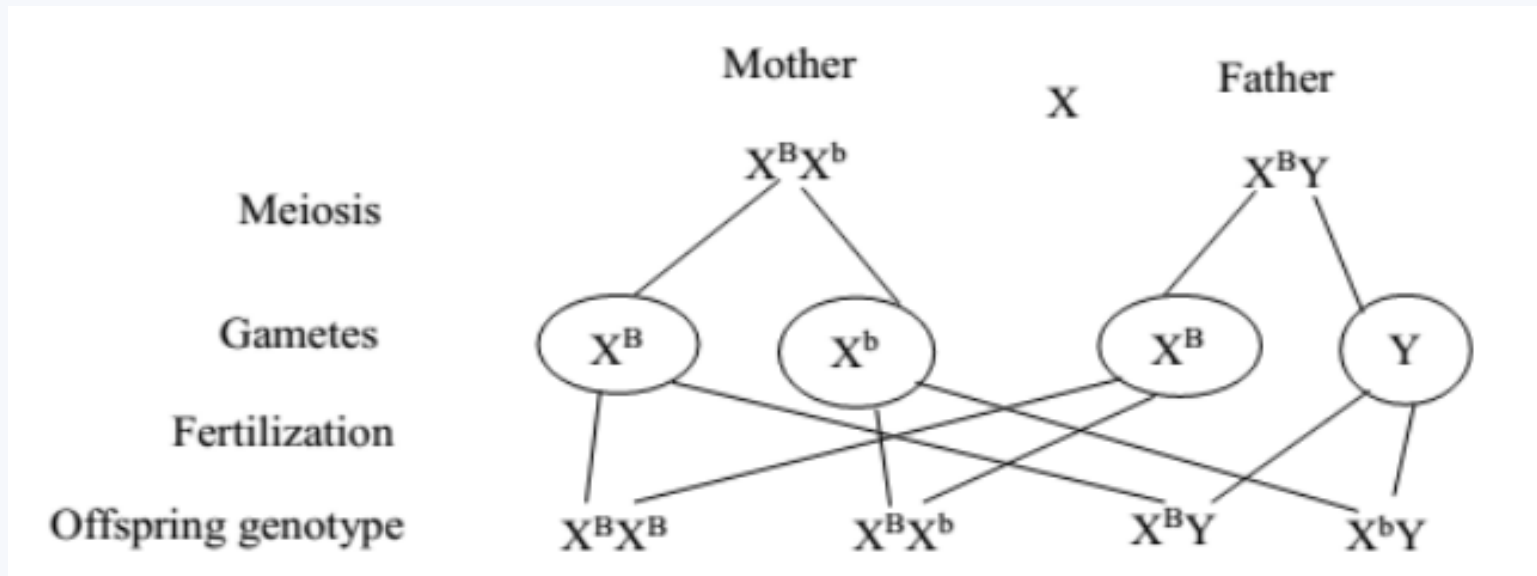
# Question:

- i) What would be the off springs when a carrier female for Color blindness marries a male with normal Color vision?
- ii) Write the genotypic ratio of the off springs and make a comment of their condition.

# Solution:

Let B represent the allele for normal Color vision

Let b represent the allele for Color blindness.



Genotypic ratio; **2:1:1**

2 will be normal girls (females)

1 will be normal boy (male)

1 will be carrier girl (female)

1 will be Color blind boy (male)

**Assignment:** Red - green color blindness is a defect caused by a recessive gene carried on the X chromosome. What would be the phenotype of the offspring when a normal women marries a color blind man? Show your working.

# Inheritance of haemophilia (bleeder disease)

It is a disease in which blood takes a long time to clot at a wound.

It is also known as the bleeder's disease.

This disease is caused by a recessive gene which is carried on the X chromosome.

Let **H** represent the allele for normal blood clotting

Let **h** represent the allele for haemophilia

| Genotype  | Phenotype           |
|-----------|---------------------|
| $X^H X^H$ | Normal female       |
| $X^H X^h$ | Carrier female      |
| $X^h X^h$ | Haemophiliac female |
| $X^H Y$   | Normal male         |
| $X^h Y$   | Haemophiliac male   |

# World "Hemophilia" Day

17TH APRIL

Hemophilia is a rare bleeding disorder where blood doesn't clot properly leading to excessive (internal & external) bleeding.

Hemophilia patients lead a normal life if regular factor supply is ensured.

STAY CONNECTED TO STAY AWARE !

- Dr. Siddhesh Kalantri



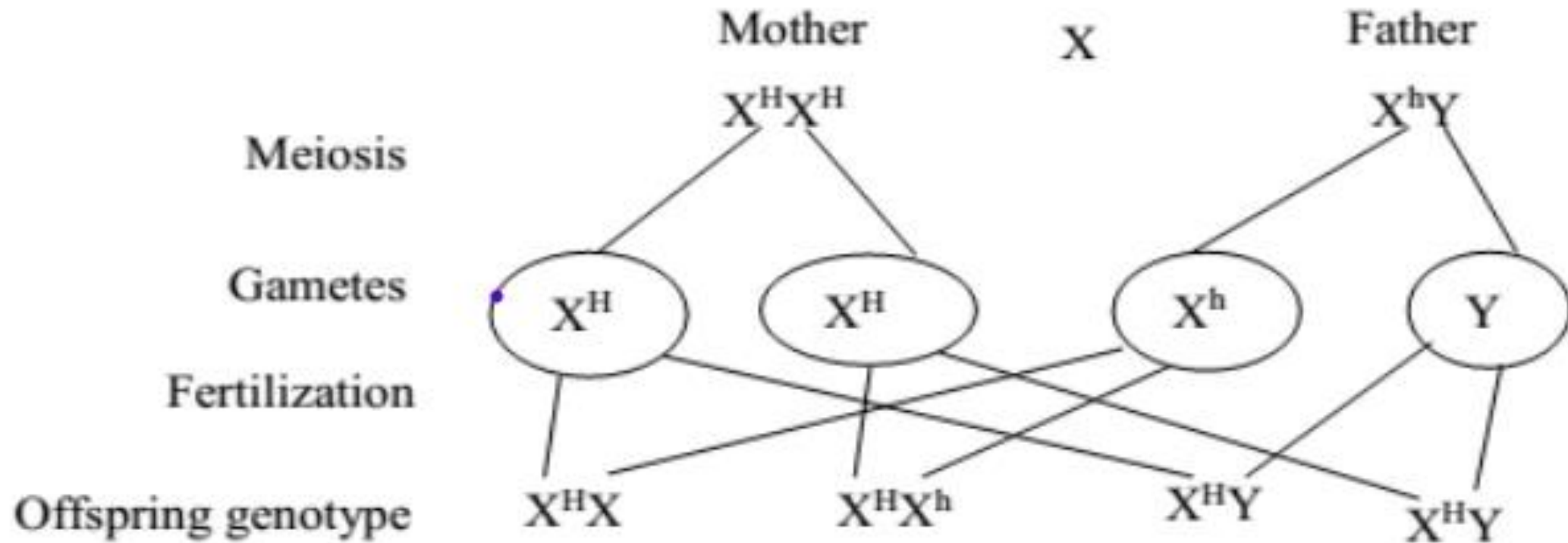
# Question:

What would be the off springs if a normal woman marries a haemophiliac man?

## **Solution:**

Let H represent the allele for normal blood clotting

Let h represent the allele for haemophilia



2 carrier females: 2 normal males

# Sex limited traits

These are characteristics that only show in one sex e.g. secondary sexual characteristics, hairy pinna, etc.

## Exceptions to mendelian inheritance

The following do not conform to the process of inheritance as illustrated by Mendel.

1. Linkage
2. Incomplete dominance.
3. Co-dominance
4. Multiple alleles.



# Co-dominance

This is a condition where genes determining a particular character all show up such that the phenotype of the offspring is a mixture of that of the parents.

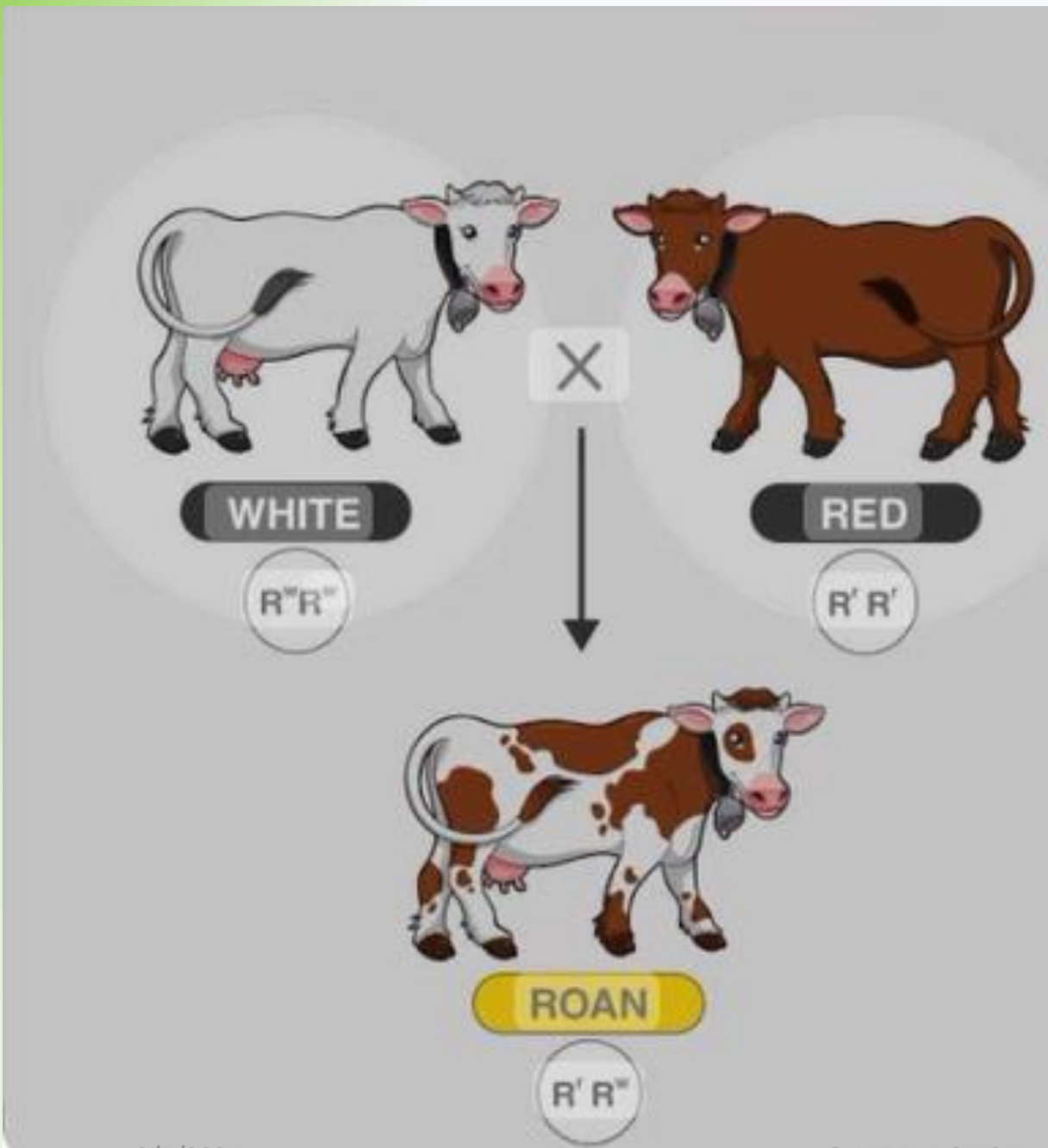
All the characters of either parent appear in the offspring, e.g. **black** and **white** gives **white and black spots** in the offspring.

It mainly occurs in animals.

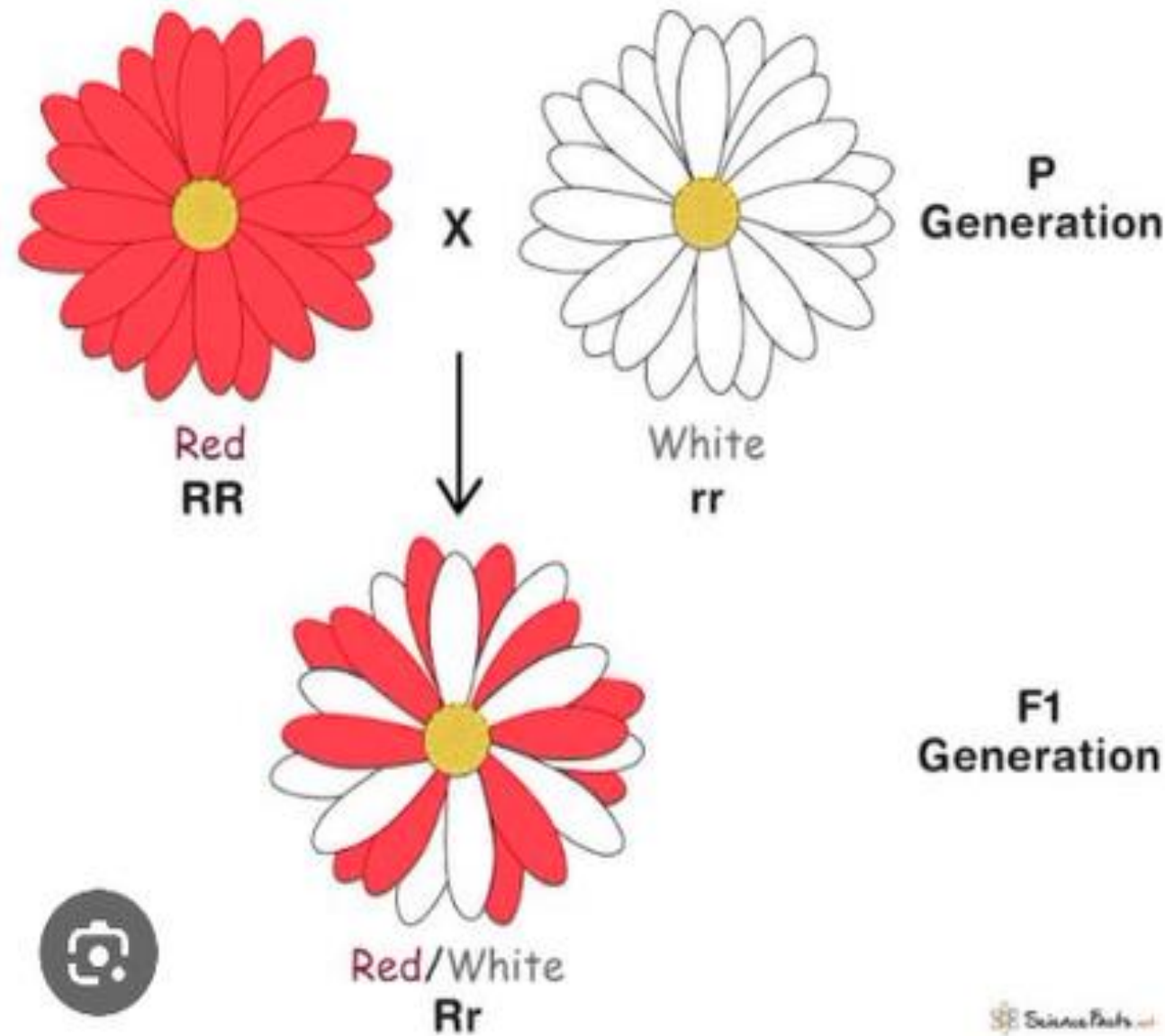
Co-dominance is where in the heterozygous state neither allele is completely dominant over the other i.e. the 2 alleles are co-dominant.

This results in the phenotype intermediate between the parent's appearances.

The alleles for each trait are represented with different capital letters.



## Codominance

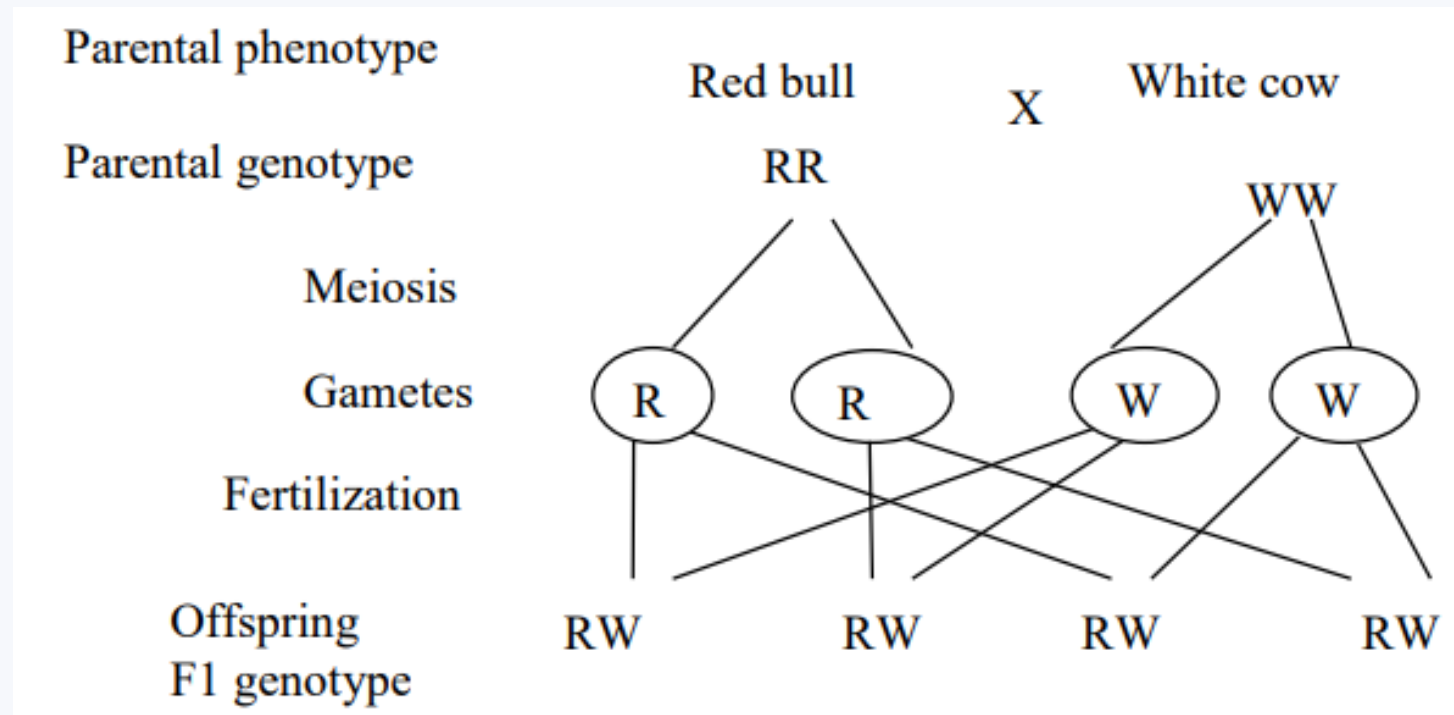


# EXAMPLE

In animals, what will be the offsprings when a red bull is crossed with a white cow.

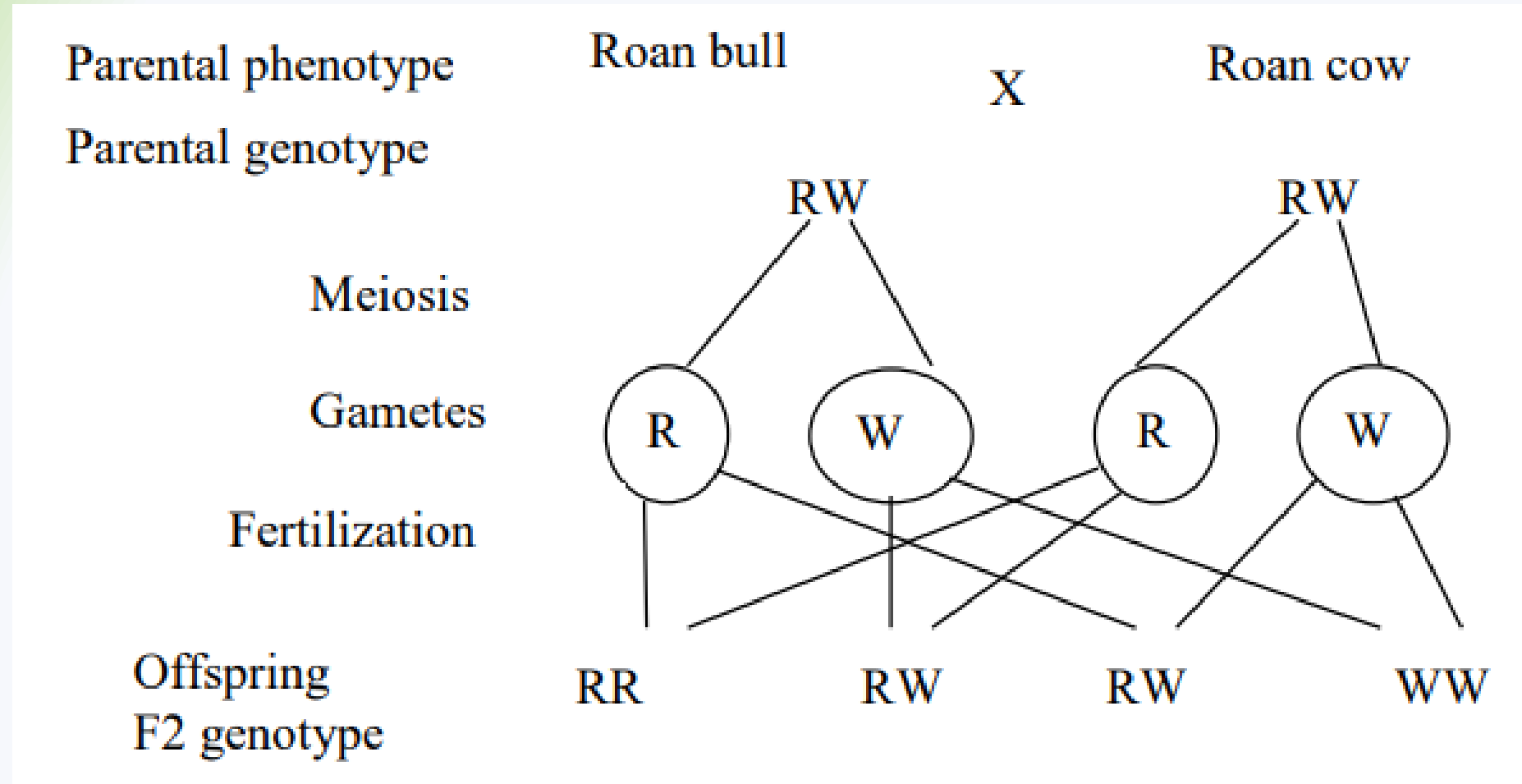
Let **R** be the allele for red bull

Let **W** be the allele for white cow



*F1 phenotype:* all the offsprings will be **roan**.

*what would be the offsprings in the 2nd generation*



***F2 phenotype: 1 red, 2 roan and 1 white.***

# *Exercise 1*

The gene for normal production of haemoglobin is dominated to the mutant gene which causes sickle cell anaemia.

If a female heterozygous for the sickle cell anaemia marries a Normal man, illustrate, using suitable symbols, the possible genotypes and phenotypes of the offspring.

# Incomplete dominance

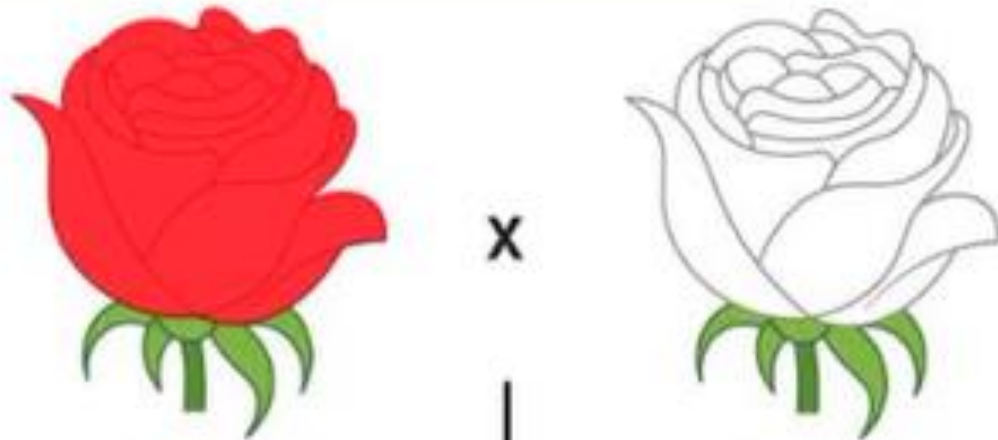
This is a condition in the heterozygous where neither of the alleles is dominant over the other and the phenotype of the offspring is an **intermediate** between that of the parents.

An intermediate of the parents' phenotype results, e.g. **black** and **white** gives **grey**.

It mainly occurs in plants.

For example, consider petal Color in flowers: when a **red** flowered plant is crossed with a **white** flowered plant, the offsprings produced are all **pink** Colored petal flowers.

# Incomplete Dominance



Red  
RR

White  
rr

Pink  
Rr

P  
Generation

F1  
Generation

Example of Incomplete Dominance



Crossing between a red rose and a white rose producing a pink phenotype.



 Search inside image

# Incomplete Dominance



**BB**  
Brown Horse

+



**WW**  
White Horse

=



**BW**  
Cream Colt  
(Palomino)

# Multiple alleles

This is where one character is determined by more than two alleles.

This implies that a single gene contains more than two alleles.

An example is **blood group inheritance**.

The gene controlling blood groups is made up of three different alleles (multiple alleles). These alleles are **A**, **B** and **O**.

The inheritance of blood groups is also an example of **co-dominance**. There are 4 blood groups that is group A, B, AB and O.

An individual inherits two of these alleles one from each parent.

The table below shows the possible blood groups that can arise from the different genotypes.

| Genotypes | Phenotypes<br>(blood types) |
|-----------|-----------------------------|
| $I^A I^A$ | A                           |
| $I^A I^B$ | AB                          |
| $I^A i$   | A                           |
| $I^B I^B$ | B                           |
| $I^B i$   | B                           |
| $ii$      | O                           |

| Genotype<br>(Alleles) | Blood group<br>(Phenotype) |
|-----------------------|----------------------------|
| $I^A I^A$             | A                          |
| $I^A I^O$             | A                          |
| $I^B I^B$             | B                          |
| $I^B I^O$             | B                          |
| $I^A I^B$             | AB                         |
| $I^O I^O$             | O                          |



# *Exercise 1*

Work out the possible blood groups of the offsprings produced if a man of blood group A marries a woman of blood group AB

## *Exercise 2*

In a mixed day school, Angela got pregnant and she is of blood group B, Kapere a fellow student was accused to be responsible for her condition, which he denied.

Angela gave birth to bouncing baby boy of blood group O.

As an investigation was done Kapere was un cooperative and his blood group would not be discovered, but both his parents were of blood group A.

Work out to find whether Kapere would be the likely father of the baby.

# *Exercise 3*

A woman of blood group A claims that a man of blood group AB is the father of her child.

A blood test reveals that the child's blood group is O.

is it possible that the woman's claim is correct? Could the father have been of blood group B?

Explain your reasoning.

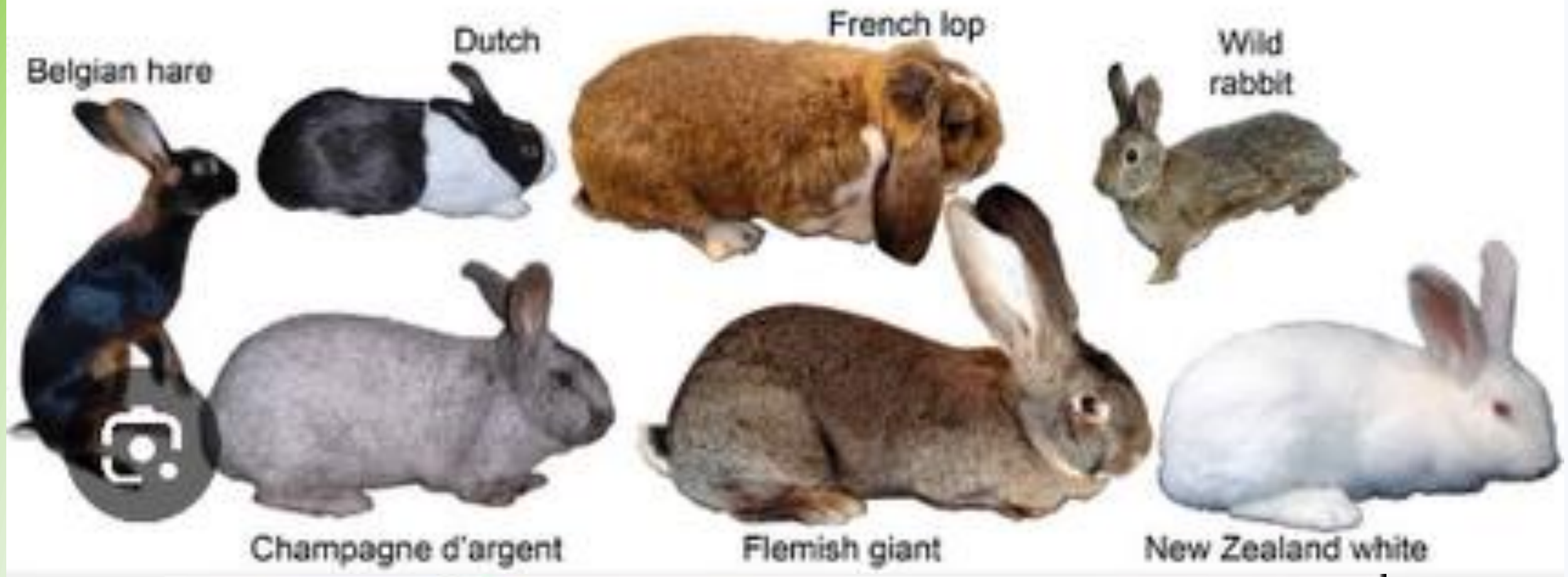
# Application of genetics

- *The study of genetics encourages breeding of animals with good characteristics to improve livestock.*
- *To eliminate or reduce harmful characteristics through the study of genetics.*
- *Through genetic counseling and advice individuals may be advised on the possibility of their off springs.*
- *In prediction of offspring from two mating individuals and solves problems like fraternal uncertainty.*

# VARIATION & SELECTION

Variation is any difference between individual organisms of any species caused either by genetic differences or by the effect of environmental factors on the expression of genetic potentials.

It allows some individuals within a population to adapt to the changing environment.





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There are two types of genetic variations.

## **1. Continuous variations.**

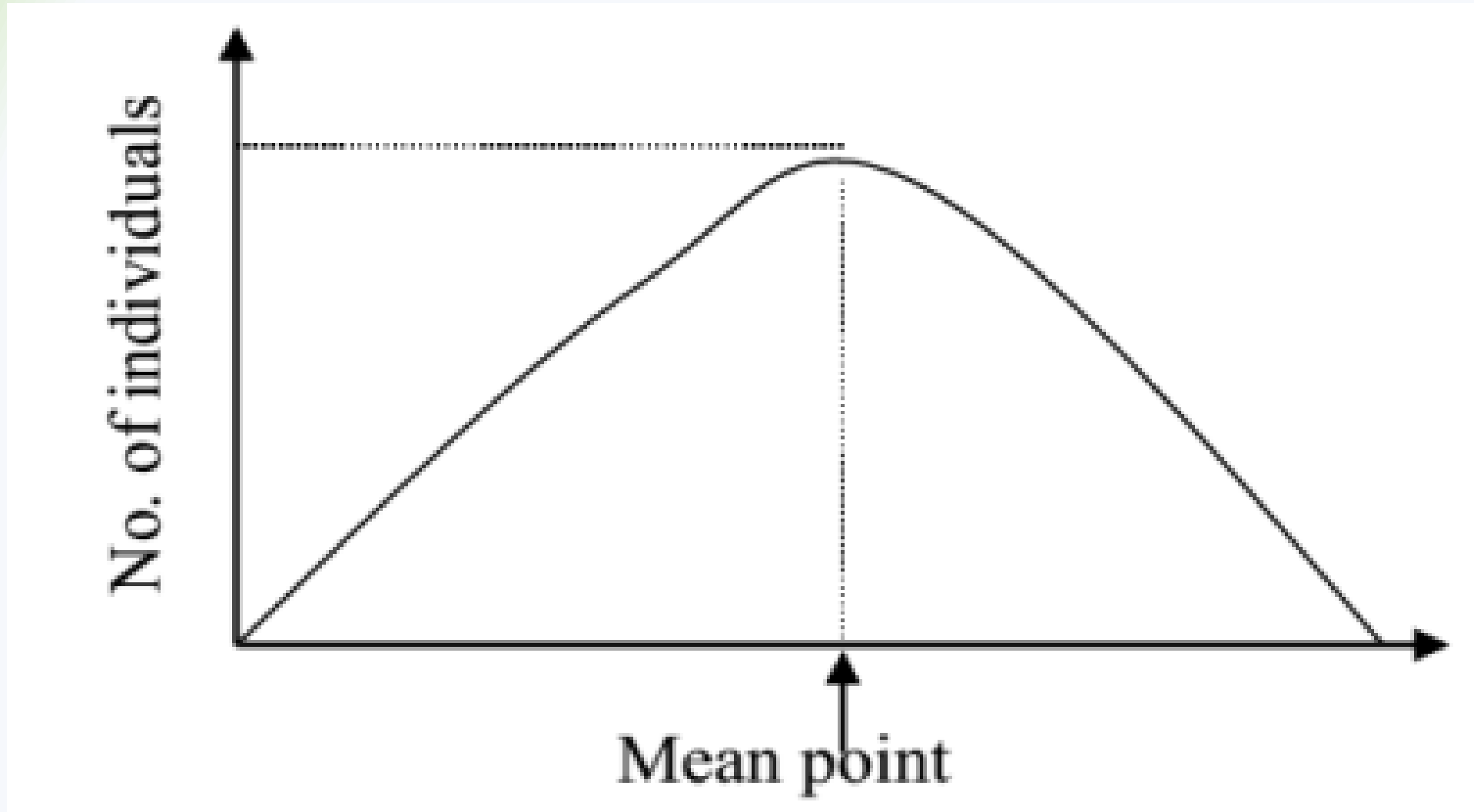
These are variations that show a gradual change in individuals without a clear-cut difference between the two extremes.

It results into formation of intermediates.

Such variations include **height, intelligence, skin Color, yield in plants,** etc.

In such variations, organisms are usually very many around the mean/average point.

# Graphic illustration of continuous variations

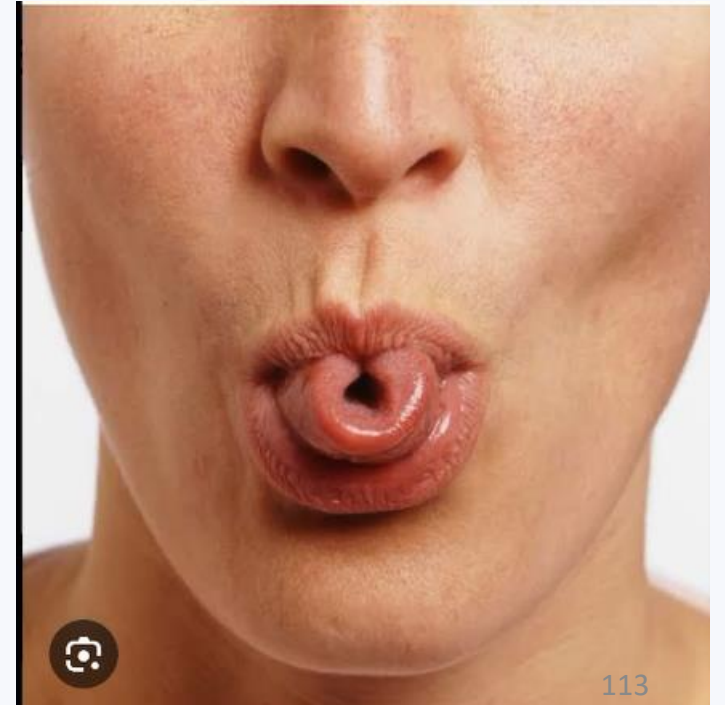


## 2. Discontinuous variation.

This is a variation, which shows a clear-cut difference between the two extremes without intermediates.

This results into expression of only two phenotypes.

Examples of discontinuous variations include, tongue rolling, blood groups, sex, etc.



# Causes of variation

Some variations are **inherited** and are called inherited variations while others are occupied as a result of the environment hence called **environmental** variations.

Examples of inherited variations are; **blood groups, eye Color, albinism, hair, etc.**

Examples of environmental variations are **knowledge**, etc.

# *Environmental factors that cause variations*

- ✓ Diet
- ✓ Pathogens
- ✓ Altitude
- ✓ Light

# *Factors that cause inherited variations*

- ✓ Mutation
- ✓ Crossing over
- ✓ Fertilization

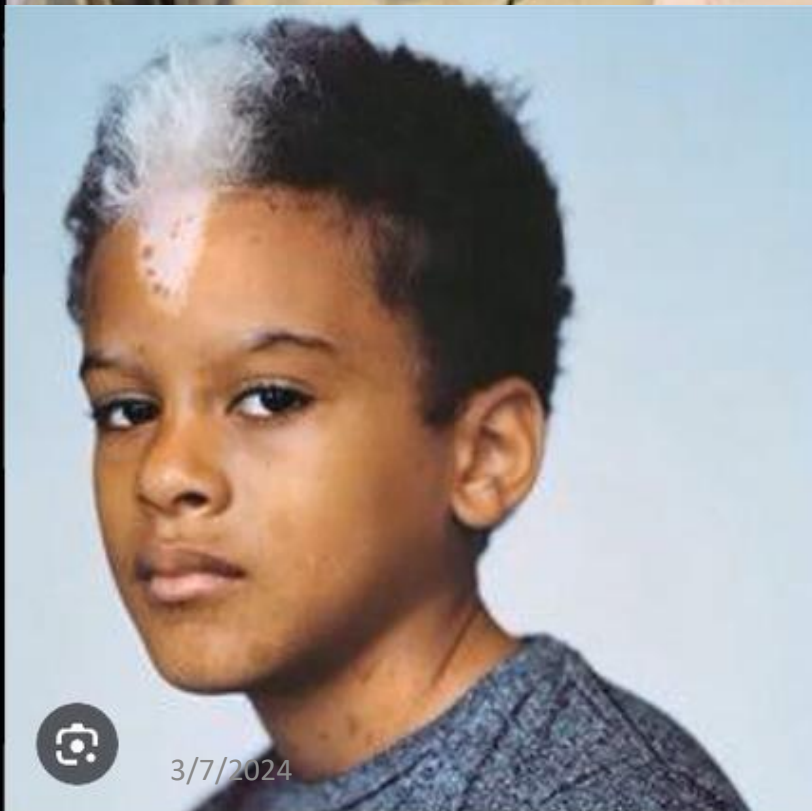
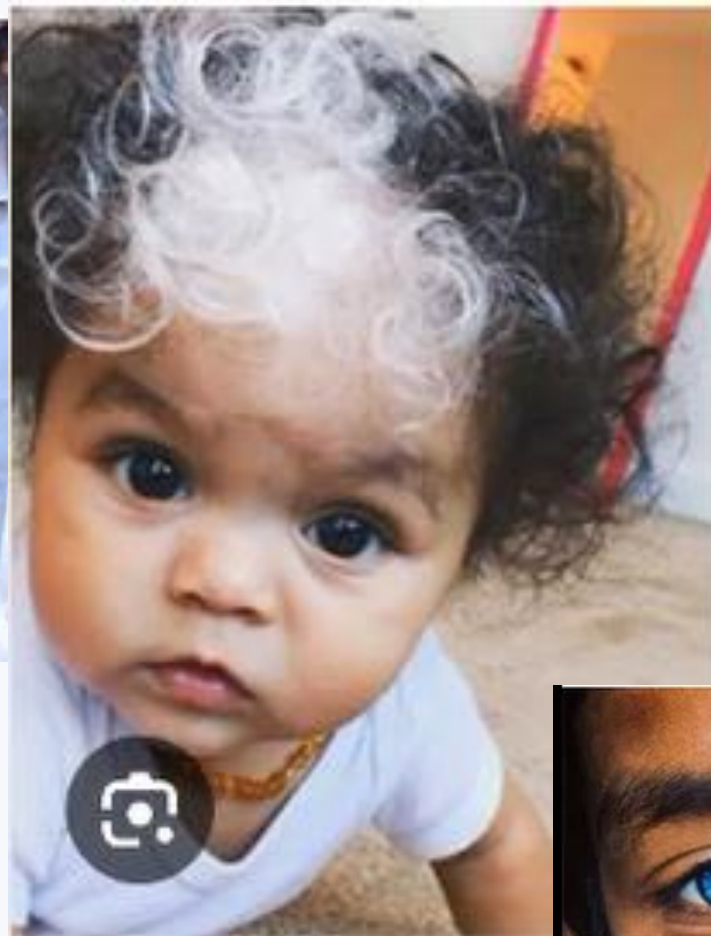
# ***Mutation***

This is a sudden/spontaneous change in the structure and composition of a gene or chromosome.

## ***Types of mutation***

- i) Chromosome mutation:*** this is a sudden change in the number or structure of a chromosome.
- ii) Gene mutation:*** This is a sudden change in the chemical nature of a gene.

Examples of gene mutation/genetic disorders are albinism and sickle cell anemia.



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# Albinism

**CAUSE:** Albinism is caused by a mutation in one of several genes involved in production or distribution of a pigment called Melanin.

The defect may result in the absence or reduced amount of Melanin production. The defective gene passes down from both parents to the child leading to albinism.

## **SYMPTOMS:**

- ✓ Absence of Color in the hair
- ✓ Skin or eyes lighter than normal Coloring of the hair, skin or eyes
- ✓ Patches of skin that have an absence of Color
- ✓ Vision problems

# Treatment

***No known medical cure.*** But early intervention for infants and children can improve their quality of life. Treatment depends on individual needs because each child is unique and different stages of life may require different services.

The most recommended treatment is **Team Care**. Involves relying on a team of specialists to provide medical care and help the child develop skills as fully as possible.

Depending on the needs of the child, the team of specialists may include a speech pathologist, developmental pediatrician, pediatric cardiologist.

# *Sickle cell anaemia*

**Causes:** Its an inherited recessive condition that results from a mutation in a gene responsible for production of normal *Haemoglobin*, the defective gene results into production of abnormal *haemoglobin* which makes Red Blood Cells *sickle* shaped.

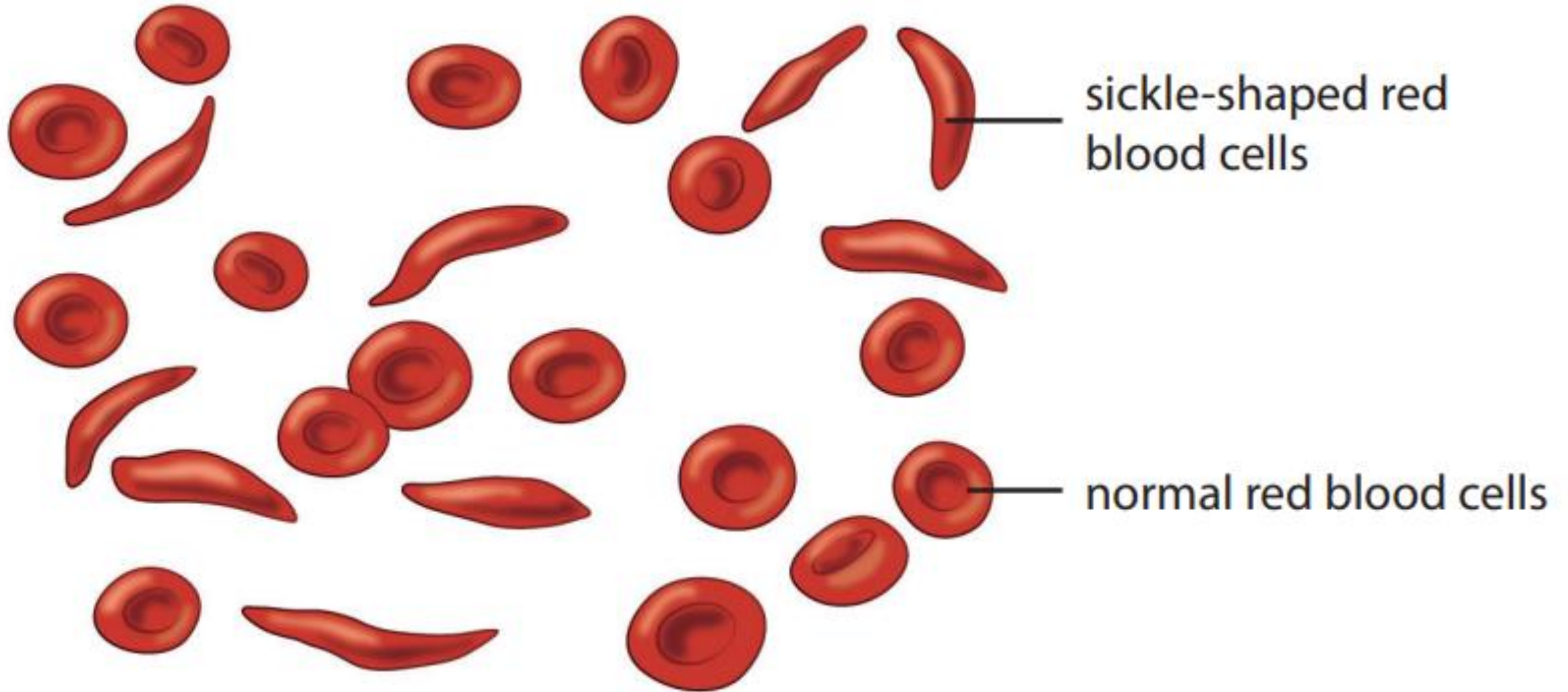
## **SYMPTOMS:**

*Anaemia:* sickle cells break apart easily and die leaving one with few red blood cells

*Episodes of pain:* pain develops when sickle-shaped RBCs block blood flow through tiny blood vessels to the chest, abdomen and joints

*Swelling of hands and feet:* swelling occurs when sickle-shaped cells block blood flow to hands and feet.

*Vision problems, delayed growth at puberty, frequent infections.*



Sickle-shaped red blood cells and normal red blood cells

# Treatment

***No known cure.*** But for some children and teenagers, a stem cell transplant might help on the disease. Management of sickle cell anaemia is usually aimed at avoiding pain episodes, relieving symptoms and preventing complications.

Children with sickle cell anaemia might receive *penicillin* between ages of 2 months to at least 5 years. This helps to prevent infections e.g. *pneumonia*, which is very threatening to children with sickle cell anaemia

Adults with sickle cell anaemia might need to take *penicillin* for the *rest* of *their lives*

*Surgical procedures include:* blood transfusions and stem cell transplant

*Life style remedies include:* drinking plenty of water, avoid temperature extremes, exercising regularly but not over exercising, quit or avoid smoking

# Examples of chromosome mutation in man

## i) *Turner's syndrome:*

the individual has one X chromosome. This gives rise to a sterile abnormal short female and it is due to loss of one sex chromosome.



# *Down's syndrome (mongolism):*

this is due to the increase in the number of chromosomes. The individual is mentally retarded with weak muscles, a big or large head, a broad chest, stunted growth and dropped eyes.



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# *klinefelter's syndrome:*

this is due to an additional X chromosome in an individual. This results in a sterile male who may be mentally retarded.



## *Causes of mutations.*

Mutations are caused by substances generally referred to as mutagens. These include;

- i) High temperatures.
- ii) Chemicals such as mustard gas, colchine and caffeine.
- iii) High-energy particles such as alpha and beta particles.
- iv) High-energy radiations such as x-rays, gamma rays and ultra violet radiations.

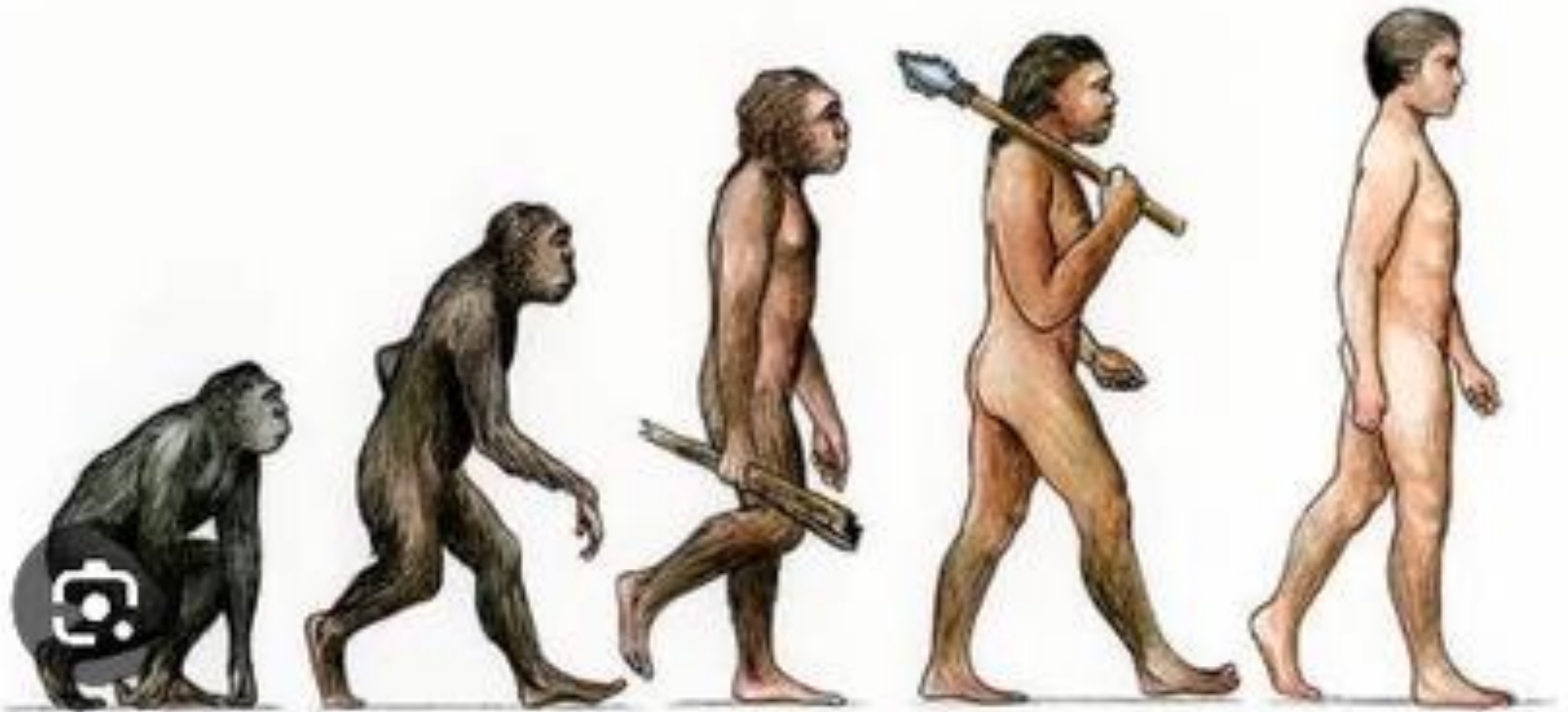
**Note;** most mutations are disadvantageous and recessive. They are rare but persistent in the population.

# *Evolution*

Evolution is the process by which more complex forms of organisms arise from simpler forms over a long period of time.

This is a gradual process by which organisms change from simple to complex forms over a period of time.

*(read about the different theories of Evolution)*



# Natural selection( how natural selection leads to evolution)

This is the process by which organisms that are better adapted to the environment survive to reproduce while those less adapted fail to do so and become extinct.

This is a process by which nature selects **for** the best adapted organisms and selects **against** the less adapted ones.

When the environment changes, it affects organisms and those, which possess characters that enable them to survive in the changing environment and pass their genes to the next generation while those **less** adapted, die over a long period of time.

This occurs because organisms possess **variations** (differences between them).

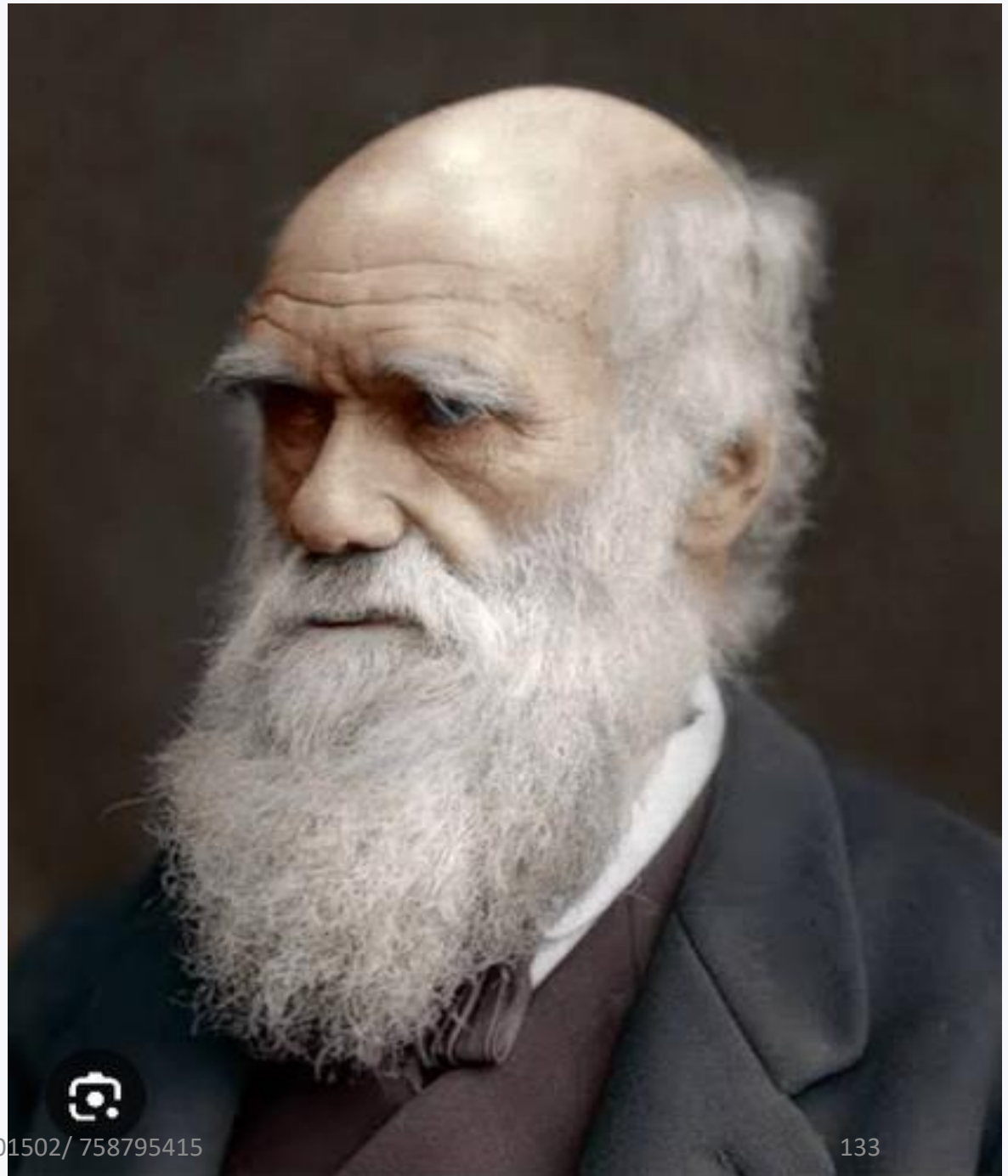
The survival of the best adapted and removal of the less adapted is known as **survival for the fittest**.

*This theory was stated by Charles Darwin.*

Darwin suggested that there must be a struggle for existence where by the fit individuals (**better adapted**) survive and the unfit ones die (survival for the fittest).

Over a very long period of time these organisms can change into a different species. (**Evolution**)

# *Charles Darwin*



# Artificial selection

This is sometimes called *selective breeding* which is the process by which humans use animal breeding and plant breeding to selectively develop particular traits (characteristics).

This is done by choosing which individual animal or plant (males and females) with the *most desirable* features to sexually reproduce and bear offsprings

## Examples:

Dog breeding

Breeding of bulls

Development of fleshy vegetables

Creation of high yielding crops



wolf



collie



dachshund



bulldog

# Advantages of artificial selection

1. *Accelerates the breeding process and produce offsprings with specific offsprings*
2. *Allows for development of crops with improved yields, animals with desirable traits e.g. docility or high milk production*
3. *Leads to creation of breeds suited for particular purposes e.g. working or companionship*
4. *Provides a controlled environment for breeding, enabling targeted genetic modifications to meet human needs in agriculture and animal husbandry*

# *Disadvantages of artificial selection*

- 1. Potential reduction in genetic diversity within populations, which can make organisms more susceptible to diseases and environmental changes*
- 2. Over emphasis on specific traits may lead to unintended consequences e.g. increased vulnerability to new threats*
- 3. Results into neglect of other important but non-selected traits, leading to loss of overall fitness in the organisms*
- 4. May result into potential unintended consequences and long term effects on the ecosystems*

***END***  
***BIOLOGY IS LIFE***  
***SLIDES PREPARED BY TR.***  
***PETER L OKION***