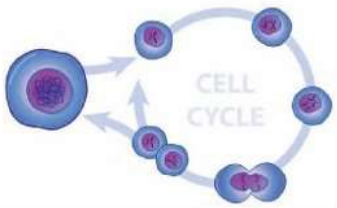
4 CHAPTER

CELL CYCLE



4.1 CELL CYCLE

LONG ANSWER QUESTIONS

Q.4 Define cell cycle and explain its phases in detail with a diagram. (K.B)

Ans:

CELL CYCLE AND ITS PHASES

Definition:

It is the series of events that take place in a **eukaryotic cell** from its **formation** to its **division** into two daughter cells.

Phases of Cell Cycle:

The cell cycle can be divided in **two** main phases i.e. **interphase** and the **mitosis** phase.

Interphase:

- This phase **lasts** for about 90% of the **total time** of cell cycle.
- During interphase, the cell performs the life functions according to its specialty and prepares itself for next division.
- Interphase consists of the following three phases.

1. **G1 Phase (First Gap Phase)**
   - It starts from the end of the Mitosis phase.
   - It is also called the **growth phase**.
   - During this phase cell makes **proteins** and **organelles** and so **grows** in size.
   - Cell also makes **enzymes** that are required in S phase for the **replication** of DNA.
2. **S Phase (Synthesis Phase)**
   - During this phase, the **DNA** of each chromosome is **replicated** (copied).
   - It results in the **duplication of chromosomes** (each chromosome consists of two sister chromatids).
   - The total number of chromosomes in cell remains the same.
3. **G2 Phase (Second Gap Phase)**
   - In this phase, the cell **continues to grow** and produces **proteins** necessary for cell division.
   - The cell checks for any **DNA damage** that may have occurred during replication and makes necessary repairs.
   - It also begins to **reorganize** its contents in preparation for mitosis.

Mitosis Phase:

- After interphase, the cell enters the division phase and **divides** into the two **daughter cells**.
- The events of cell cycle are **controlled** by special **genes**.
- All phases occur in a **sequence**.

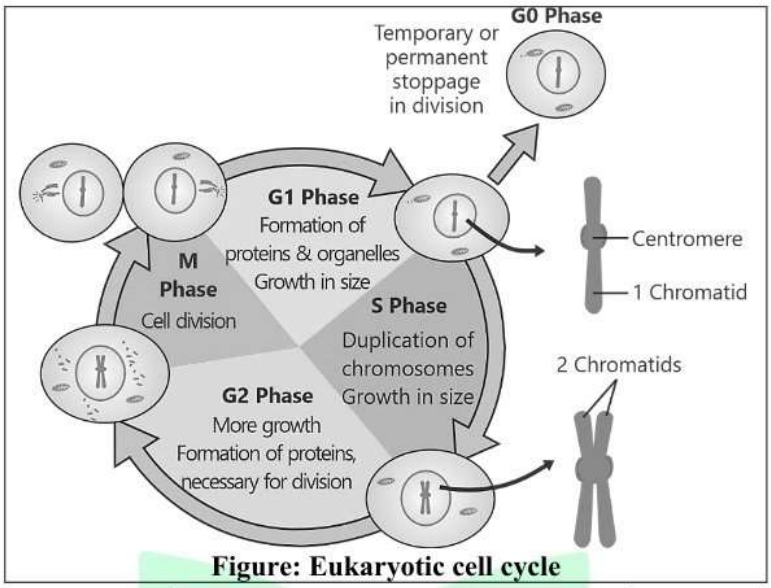


Figure: Eukaryotic cell cycle

SHORT ANSWER QUESTIONS

Q.39 Define cell cycle. **(K.B)**

Ans:

CELL CYCLE

Definition:

It is the series of events that take place in a **eukaryotic cell** from its **formation** to its **division** into two daughter cells.

Phases of Cell Cycle:

It consists of two main phases:

- Interphase
- Mitotic phase

Q.40 Define reproduction. Write its importance. **(K.B)**

Ans:

REPRODUCTION AND ITS IMPORTANCE

Reproduction:

The ability of an organism to **reproduce** their own kind.

Importance:

Reproduction is the one major characteristic that best **distinguishes** living things from non-living things.

- As we **grow** and **develop**, the cells of our body are constantly dividing.
- Cells grow to a certain size and divide.
- Cells divide to **replace** dead or injured cells.
- Our body is constantly making **new blood cells** to replace the ones that have died.
- The cell division is necessary for an organism's growth.

Q.41 What happens during S-phase? **(K.B)**

Ans:

S-PHASE

- During this phase, the DNA of each chromosome is **replicated** (copied).
- It results in the **duplication of chromosomes** (each chromosome consists of two sister chromatids).
- The total number of chromosomes in cell remains the same.

Q.42 Explain G0 phase of cell cycle? **(K.B)**

Ans:

G0-PHASE

Definition:

Many cells **stop dividing** and start performing their specific functions. This phase is called G0 phase.

Examples:

- Many cells (e.g. **neurons**) remain in G0 for indefinite periods.
- Some cell (e.g. cells of **liver** and **kidney**) remain in G0 phase temporarily.
- Other cells (e.g. **epithelial cells**) do not enter G0 and continue to divide throughout life.

Q.43 Give an overview on the main phases of eukaryotic cell cycle. (K.B)

Ans:

EUKARYOTIC CELL CYCLE

An overview on the phases of eukaryotic cell cycle is given below:

Phases	Description
Interphase	**The cell prepares for division and goes through growth in size and DNA replication.**
Gap (G1) Phase	The cell grows and carries out normal functions, preparing for DNA replication.
Synthesis (S) Phase	The cell replicates its DNA, making an exact copy of its genetic material.
Gap 2 (G2) Phase	The cell grows further, ensuring all preparations are complete for division.
Gap 0 (G0) Phase	The cell exits the cycle and stops dividing, often to carry out specialized functions (not all cells enter this phase).
M Phase	**The cell divides its genetic material equally into two new, identical cells**

MULTIPLE CHOICE QUESTIONS

1. It is the series of events that take place in a eukaryotic cell from its formation to its division into two daughter cells: (K.B)

(A) Cell cycle (B) Interphase
(C) Karyokinesis (D) Cytokinesis

2. During interphase: (K.B)

(A) Cell prepares for DNA duplication (B) Duplication of chromosomes takes place
(C) Cell is divided into two daughter cells (D) Both A and B

3. The major phases of cell cycle are: (K.B)

(A) 5 (B) 4
(C) 3 (D) 2

4. Metabolic activity of cell is very high during: (K.B)

(A) Interphase (B) Mitosis
(C) Cytokinesis (D) Karyokinesis

5. 90% of the total time of the cell cycle is occupied by: (K.B)

(A) Mitosis (B) Interphase
(C) Cytokinesis (D) Karyokinesis

6. Interphase is divided into how many phases? (K.B)

(A) Four (B) Three
(C) Two (D) One

7. Which of the following is the longest phase in cell cycle? (K.B)

(A) Mitotic phase (B) Inter phase
(C) G0 phase (D) G_1 phase

8. During G1 phase: (K.B)

(A) Cell increases its supply of proteins (B) Increases its number of organelles

(C) Duplication of chromosomes (D) Both A and B

9. In which stage of cell cycle, the cell is preparing enzymes for chromosomes duplication? (U.B)
(A) S phase (B) G_1 phase
(C) G_2 phase (D) M phase

10. In which phase cell duplicates its chromosomes? (K.B)
(A) G_1 phase (B) S phase
(C) G_2 phase (D) G_0 phase

11. The phase in which cell prepare its proteins required for spindle fibers formation. (U.B)
(A) G_1 (B) G_2
(C) S (D) G_0

12. The phase of interphase in which cell prepares for mitosis: (U.B)
(A) G_1 phase (B) S phase
(C) G_2 phase (D) G_0 phase

13. Inhibition of protein synthesis prevents the cells from undergoing mitosis during _____ phase. (U.B)
(A) G_1 (B) G_2
(C) S (D) G_0

14. At which stage of cell cycle cell stops dividing? (U.B)
(A) G_0 (B) G_1
(C) G_2 (D) S

15. The cells that do not enter G_0 phase and continue to divide throughout an organism's life:
(A) Neurons (B) Epithelial cells
(C) Liver cells (D) Kidney cells

16. Cells that remain in G_0-phase for indefinite period of time are: (K.B)
(A) Skeletal cells (B) Muscle cells
(C) Neurons (D) Blood cells

17. Cells that enter G_0 phase temporarily are: (K.B)
(A) Epithelial cells (B) Liver cells
(C) Kidney cells (D) Both b and c

4.2 MITOSIS

LONG ANSWER QUESTIONS

Q.1 Describe the events that occur during the phases of mitosis. (K.B)

Ans:

PHASES OF MITOSIS

Definition:

Mitosis is the type of cell division in which a cell divides into **two daughter cells**, each with the **same number of chromosomes** as were present in the parent cell.

Occurrence:

- Mitosis occurs in the **somatic cells** of **eukaryotes**.
- **Prokaryotes** also divide to make identical cells. But the events of their division are different from mitosis. That is why we call it **binary fission**.

Phases of Mitosis:

The **German biologist**, **Walther Flemming** discovered the events of mitosis in 1880s. There are 2 major phases of mitosis i.e.

- Karyokinesis (division of nucleus)
- Cytokinesis (division of cytoplasm).

A) Karyokinesis:

Karyokinesis means the **division of the nucleus**.

Phases of Karyokinesis:

It is further divided into four phases.

1. **Prophase**

Condensation:

- During prophase, the **thread-like chromatin** material **condenses** and makes thick **chromosomes**.
- Each chromosome consists of 2 sister chromatids with a single **centromere**.

Nuclear Envelope:

The **nuclear envelope** and **nucleolus** break down during prophase.

Centrosome:

- The **centrosome** of cell duplicates into two.
- The two centrosomes **migrate** to opposite side of the nucleus.

Mitotic Apparatus:

- When centrosomes are migrating, they make a **network of microtubules** called **spindle fibres** (complete set is called mitotic spindle).
- In plant cells, there is **no centrosome**.
- Their mitotic spindle is formed by the **aggregation of spindle fibres** present in cytoplasm.

2. **Metaphase**
   - During this phase, some spindle fibres **bind** with chromosomes.
   - They attach at the point of **centromere** where special **kinetochore proteins** are present.
   - Two spindle fibres from both sides bind with one chromosome.
   - The chromosomes attached with spindle fibres **arrange** themselves along the **equator** of the cell.
   - In this way a plate is formed called **metaphase plate**.
3. **Anaphase**
   - The spindle fibres attached with chromosomes **pull** toward the poles.
   - Due to this pulling, the chromosome's **sister chromatids separate**.
   - In this way, there are two similar sets of chromatids, which move towards the poles of the cell.
4. **Telophase**
   - In this phase, new **nuclear envelope forms** around each set of separated chromosomes.
   - Both sets of chromosomes **unfold** back into chromatin.

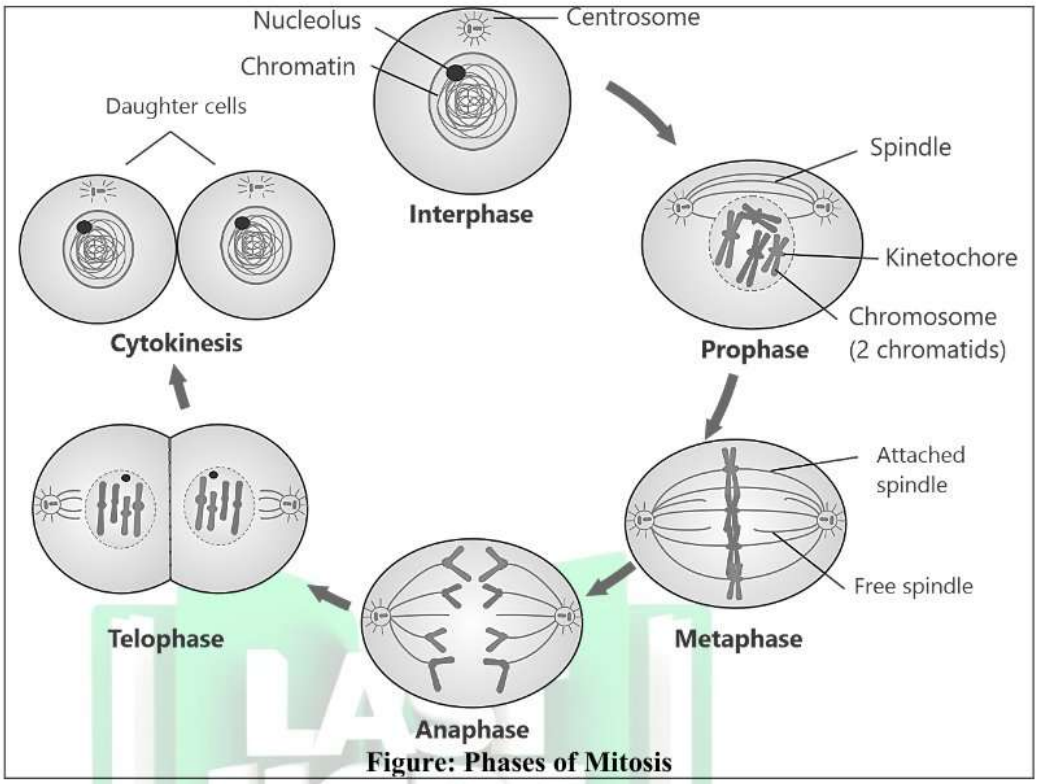


Figure: Phases of Mitosis

B) Cytokinesis

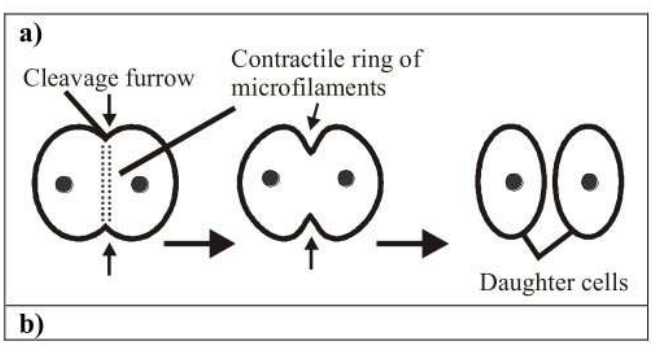
It is the **division of cytoplasm**.

Cytokinesis in Animal Cells:

- In animal cells, a **furrow** develops at the **equator**.
- At this furrow, the cytoplasm has a **ring of microfilaments**.
- The ring **contracts** and the furrow moves inward.
- In this way parent cell is **pinched** into two.

Cytokinesis in Plant Cells:

- In plant cells, **Golgi apparatus** makes vesicles.
- These vesicles move to the middle and fuse to form a plate called **phragmoplast**.
- The plate grows outward and its membranes fuse with the cell membrane.
- The result is two daughter cells.



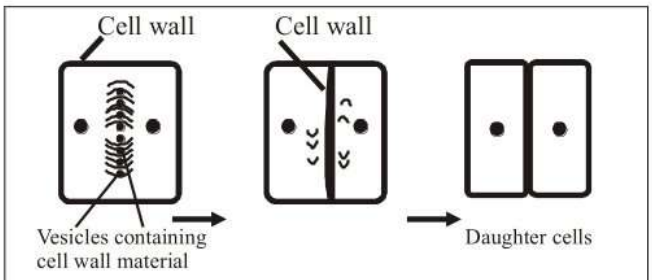


Figure: Cytokinesis; (a) In animal cell, (b) In plant cell

Q.2 Describe the significance of mitosis. (K.B)

Ans:

SIGNIFICANCE OF MITOSIS

Mitosis has great significance in living organisms. Some of these are given below:

Growth:

- Growth in organisms means an increase in size and the number of cells.
- Mitosis plays a crucial role in growth by producing **new cells** that are identical to the original cell.

Development of Organism:

- Our body consists of about **200 trillion cells**.
- All these cells were formed from a single cell (**zygote**) at the start of our life.
- Millions of cell divisions occurred while our body was reaching its present form.
- In each of these divisions the **genetic material** was **equally distributed** between the daughter cells.
- It happened through mitosis.

Cell Replacement:

- Many cells are constantly **dying** in our bodies.
- For example, the **red blood cells** and the cells of the walls of **intestine** and **skin** etc.
- These are **replaced** by new ones which are exact copies of the older cells.
- The new cells are formed by mitosis.

Regeneration:

- Some animals can **regenerate** parts of the body.
- For this purpose, they form new cells by carrying out mitosis in the cells of remaining parts.

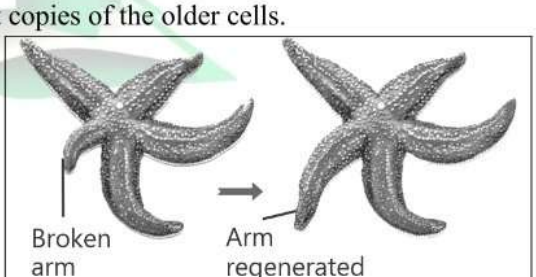


Figure: Regeneration in sea star

Asexual reproduction:

Mitosis is a means for **asexual reproduction**.

Example

- **Hydra** reproduces asexually by **budding**.
- During this process mitosis forms a mass of cells called **bud** on the surface of Hydra.
- Mitosis continues in the cells of the bud and it grows into a new individual.

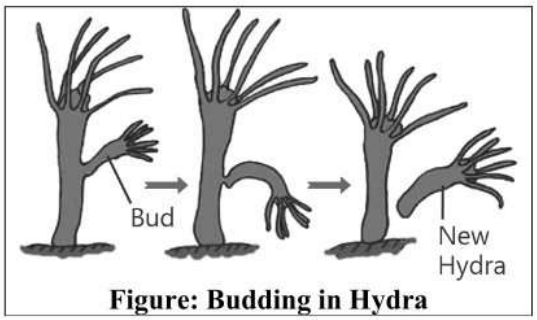


Figure: Budding in Hydra

Q.3 Can mitosis be dangerous? Explain. (U.B)

Ans:

ERRORS OF MITOSIS

Sometimes the process of mitosis goes wrong.

Abnormal Chromosomal Distribution:

- During the anaphase of mitosis, the **sister chromatids** of a chromosome may **fail to separate**.
- As a result, one daughter cell receives both sister chromosomes and the other will receive none.
- Chromosomes may also be **damaged** during mitosis.

Tumor Formation:

- If the **genes** that regulate mitosis are **mutated** (changed), the cells continue to divide.
- Due to this **uncontrolled division**, masses of cells are formed.
- These masses are called **tumors**.

Metastasis:

- If the tumors remain in their original location, they are called **benign**.
- If they **migrate** and **invade** other tissues, they are called **malignant tumors** (cancer).
- It is called **metastasis** (spreading of disease).

SHORT ANSWER QUESTIONS

Q.1 What is mitosis? (K.B)

Ans:

MITOSIS

Definition:

Mitosis is the type of cell division in which a cell divides into **two daughter cells**, each with the same number of chromosomes as were present in the parent cell.

Q.2 What is the difference between somatic and germ line cells? (K.B)

Ans:

DIFFERENTIATION

Somatic cell	Germ line cell
Cell type	
Somatic cells are those which form the body of organism.	Germ line cells are those which give rise to gametes.
Cell division	
Somatic cells undergo mitosis.	Germ line cells undergo meiosis.

Q.3 Write the main features of prophase of mitosis? (K.B)

Ans:

PROPHASE OF MITOSIS

Condensation:

- During prophase, the **thread-like chromatin** material **condenses** and makes thick chromosomes.
- Each chromosome consists of 2 sister chromatids with a single centromere.

Nuclear Envelope:

The **nuclear envelope** and **nucleolus** break down during prophase.

Centrosome:

- The **centrosome** of cell duplicates into two.
- The two centrosomes **migrate** to opposite side of the nucleus.

Mitotic Apparatus:

- When centrosomes are migrating, they make a **network of microtubules** called **spindle fibres** (complete set is called mitotic spindle).
- In plant cells, there is no centrosome.
- Their mitotic spindle is formed by the **aggregation** of spindle fibres present in cytoplasm.

Q.4 Name the phase of mitosis in order. (K.B)

Ans:

PHASES OF MITOSIS

There are two major phases:

- Karyokinesis
- Cytokinesis

Karyokinesis:

Karyokinesis is further divided into four phases.

- Prophase
- Metaphase
- Anaphase
- Telophase

Q.5 What are spindle fibers? (K.B)

Ans:

SPINDLE FIBERS

Centrosomes give rise to microtubules by joining **tubulin proteins** present in cytoplasm. The microtubules thus formed are called **spindle fibers**. Complete set of spindle fibers is knowns as the mitotic apparatus.

Q.6 What is difference in cytokinesis in animal and plant cells? (U.B)

Ans:

DIFFERENTIATION

In animal cell	In plant cell
In animal cells, cytokinesis occurs by a process known as **cleavage**.	In plant cells, cytokinesis occurs by **phragmoplast** formation.
PROCESS	
• In animal cells, a **furrow** develops at the equator. • At this furrow, the cytoplasm has a **ring of microfilaments**. • The ring contracts and the furrow moves **inward**. • In this way parent cell is **pinched** into two.	• In plant cells, **Golgi apparatus** makes vesicles. • These vesicles move to the middle and fuse to form a plate called **phragmoplast**. • The plate grows outward and its membranes **fuse** with the cell membrane. • The result is two daughter cells.

Q.7 Define phragmoplast. (K.B)

Ans:

PHRAGMOPLAST

In plant cells, **vesicles** derived from **Golgi apparatus** move to the middle of the cell. These vesicles fuse to form a membrane bounded disc/plate which is called **cell plate** or **phragmoplast**.

Q.8 What is the function of spindle apparatus. (K.B)

Ans:

FUNCTION OF SPINDLE APPARATUS

Function:

- The spindle apparatus separates **chromatid** or chromosomes during cell division and move them to opposite poles.

- In this way **hereditary material** of the parent cell is equally distributed into daughter cell.

Q.9 How mitosis plays role in development of an organism? (U.B)

Ans:

ROLE OF MITOSIS IN DEVELOPMENT

Explanation:

- Our body consists of about **200 trillion cells**.
- All these cells were formed from a single cell (**zygote**) at the start of our life.
- Millions of cell divisions occurred while our body was reaching its present form.
- In each of these divisions the genetic material was equally distributed between the daughter cells.
- It happened through mitosis.

Q.10 Discuss the process of regeneration. (K.B)

Ans:

REGENERATION

Regeneration:

- Some animals can **regenerate** parts of the body.
- For this purpose, they form new cells by carrying out mitosis in the cells of remaining parts.

Example:

- **Sea star** can regenerate arm.
- **Earthworms** can regenerate head.
- **Salamander** can regenerate its limb.

Q.11 How mitosis and asexual reproduction are related. (U.B)

Ans:

MITOSIS AND ASEXUAL REPRODUCTION

Mitosis is the basis of asexual reproduction. This reproduction involves only one parent.

- All asexually produced offspring are genetically identical to their parent organism.
- The **vegetative propagation** is very common in plants.
- It involves new generations from root, stem or leaf of parent plant.

Q.12 Explain asexual reproduction in Hydra. (K.B)

Ans:

ASEXUAL REPRODUCTION IN HYDRA

Asexual reproduction:

Mitosis is a means for **asexual reproduction**.

Hydra:

- **Hydra** reproduces asexually by **budding**.
- During this process mitosis forms a mass of cells called **bud** on the surface of Hydra.
- Mitosis continues in the cells of the bud and it grows into a new individual.

Q.13 Give examples of asexually reproducing organisms. (K.B)

Ans:

ASEXUALLY REPRODUCING ORGANISMS

Asexual Reproduction in Plants:

Potato, onion, garlic, ginger, grasses etc. reproduce asexually.

Asexual Reproduction in Animals:

Many animal species like sponges, planaria and hydra undergo asexual reproduction.

Q.14 How tumors are formed? (K.B)

Ans:

TUMOR

Tumor Formation:

- If the genes that regulate mitosis are **mutated** (changed), the cells continue to divide.
- Due to this **uncontrolled division**, masses of cells are formed.
- These masses are called **tumors**.

Q.15 What do you mean by metastasis? (K.B)

Ans:

METASTASIS

Definition:

- If the tumors remain in their original location, they are called **benign**.
- If they **migrate** and **invade** other tissues, they are called **malignant tumors** (cancer).
- It is called **metastasis** (spreading of disease).

MULTIPLE CHOICE QUESTIONS

1. Mitosis was discovered in: **(K.B)**
(A) 1860's (B) 1870's
(C) 1880's (D) 1890's

2. Who discovered mitosis? **(K.B)**
(A) Walther Flemming (B) Oscar Hertwig
(C) T.H. Morgan (D) August Weismann

3. The cells which form the body of an organism are called: **(K.B)**
(A) Somatic cells (B) Epithelial
(C) Germ cell (D) All cells

4. The germ line cells give rise to: **(U.B)**
(A) Liver (B) Gametes
(C) Germs (D) Kidney

5. Germ line cells undergo: **(U.B)**
(A) Mitosis (B) Meiosis
(C) Binary fission (D) Budding

6. Prokaryotic cells undergo a process similar to mitosis called: **(K.B)**
(A) Binary fission (B) Multiple fission
(C) Regeneration (D) Meiosis

7. The division of cytoplasm: **(K.B)**
(A) Karyokinesis (B) Cytokinesis
(C) Prophase (D) Metaphase

8. The division of nucleus is called: **(K.B)**
(A) Karyokinesis (B) Cytokinesis
(C) Prophase (D) Metaphase

9. The duplication of centrioles occurs in: **(K.B)**
(A) Prophase (B) Cytokinesis
(C) Anaphase (D) Metaphase

10. Mitosis consists of phases: **(K.B)**
(A) One (B) Two
(C) Three (D) Four

11. The genetic material in nucleus is in a loose thread like form called: **(K.B)**
(A) Chromosomes (B) Chromatin
(C) Chromatids (D) Centromere

12. Characteristics associated to S phase: **(K.B)**
(A) Duplication of chromosomes (B) Growth in size
(C) Synthesis of proteins (D) Both A and B

13. It is impossible to reverse the cell cycle because its events are: **(U.B)**
(A) Ordered (B) Directional
(C) Sequential (D) All of these

14. Chromatin is condensed at the onset of: **(K.B)**
(A) Metaphase (B) Prophase
(C) Anaphase (D) Telophase

15. A complex protein which is present in centromere is called: **(K.B)**
(A) Centrosome (B) Centromere
(C) Kinetochore (D) Chromatic

16. During mitosis one cell divides into daughter cells: **(K.B)**

(A) 2 (B) 3
(C) 4 (D) 5

17. Which of the following is the longest phase of karyokinesis? (U.B)
(A) Prophase (B) Metaphase
(C) Anaphase (D) Telophase

18. Complete set of spindle fibres is known as: (K.B)
(A) Chromatin (B) Kinetochore
(C) Mitotic spindle (D) Cleavage

19. Spindle fibers are formed during: (K.B)
(A) Prophase (B) Metaphase
(C) Anaphase (D) Telophase

20. Spindle fibers are made by special protein is called: (K.B)
(A) Keratin (B) Tubulin
(C) Actin (D) Myosin

21. The chromosomes arrange themselves along the equator of the cell in phase: (U.B)
(A) Prophase (B) Metaphase
(C) Anaphase (D) Telophase

22. Which phase is a reversal of prophase? (U.B)
(A) Interphase (B) Metaphase
(C) Anaphase (D) Telophase

23. In animal cells, cytokinesis occurs by a process known as: (K.B)
(A) Regeneration (B) Cleavage
(C) Binary fission (D) Phragmoplast

24. New red blood cells are formed by: (A.B)
(A) Mitosis (B) Meiosis
(C) Multiple fission (D) Binary fission

25. Which animal shows regeneration? (U.B)
(A) *Amoeba* (B) *Paramecium*
(C) Sea star (D) Hydra

26. Budding takes place in: (K.B)
(A) *Volvox* (B) *Euglena*
(C) Sea star (D) Hydra

27. Asexual reproduction in hydra takes place by: (K.B)
(A) Mitosis (B) Budding
(C) Cutting (D) Spore

28. It is localized (i.e., remains at fixed location): (K.B)
(A) Tumor (B) Benign tumor
(C) Malignant tumor (D) All of these

4.3 MEIOSIS

LONG ANSWER QUESTIONS

Q.1 Describe the events that occur during the phases of meiosis I. (K.B)

Ans:

PHASES OF MEIOSIS I

Definition:

It is the type of cell division in which each daughter cell receives **half the number of chromosomes** as compared to the parent cell. In meiosis, a diploid parent cell divides to produce **four haploid** daughter cells.

Diploid and Haploid:

Diploid means the cells in which chromosomes are in **pairs** (homologous pairs) while haploid means the cells with no pairs of chromosomes.

Phases of Meiosis:

Meiosis was discovered in I876 by a German biologist **Oscar Hertwig**. Meiosis consists of two divisions.

- Meiosis-I
- Meiosis-II

MEIOSIS I

In meiosis-I, the **homologous chromosomes** in a diploid cell separate and so two haploid daughter cells are produced. It is subdivided into prophase-I, metaphase-I, anaphase-I and telophase-I.

1. **Prophase-I**

Condensation:

- During this stage, **chromatin condenses** and takes the shape of chromosomes.
- Each chromosome consists of two sister chromatids, because the DNA has already replicated before meiosis.

Synapsis:

- Homologous chromosomes move close together.
- They pair up in a process called **synapsis**.
- Each pair of homologous chromosomes is called **tetrad**.

Chiasmata:

Non-sister chromatids of homologous chromosomes become "**zipped**" together, forming X-shaped structures called **chiasmata**.

Crossing Over:

- Each chiasma is the site for **crossing over** i.e., **exchange** of portions of chromosomes between non-sister chromatids.
- Crossing over leads to **recombination** of genetic material.

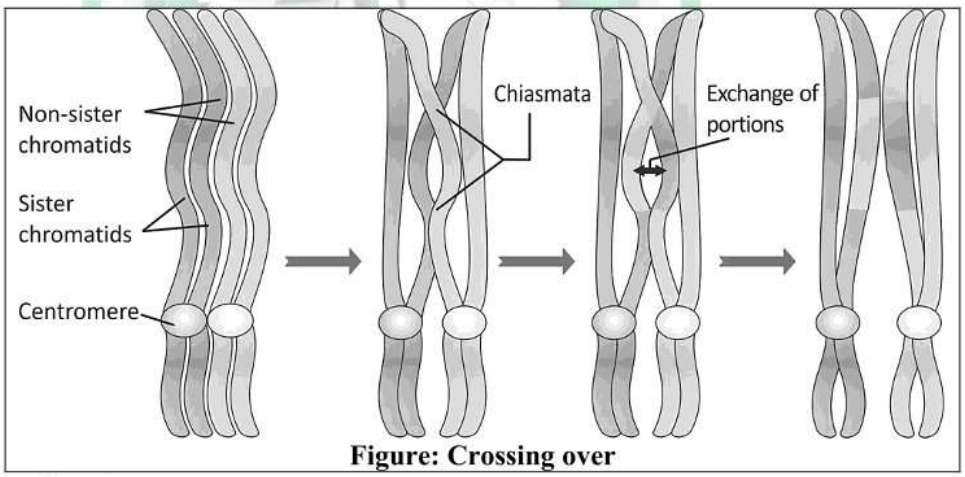


Figure: Crossing over

Other Events:

- Other events of prophase-I are similar to prophase of mitosis.
- The **nucleoli disappear** and nuclear envelope breaks.
- **Centrioles** migrate to opposite poles and make **spindle fibres** to which chromosomes attach.

2. **Metaphase-I**

- The tetrads attached with spindle fibres align along the **equator**.
- In this way, they form **metaphase plate**.

- Two spindle fibres from both poles attach with one chromosome of the pair.

3. **Anaphase-I**
   - Each spindle fiber attached with **kinetochores** of a single chromosome pulls towards the pole.
   - In this way the paired chromosomes are **separated**.
   - One chromosome is pulled toward one pole and the other towards opposite pole.
   - So, two haploid sets of chromosomes are formed.
   - Each chromosome still contains a pair of sister chromatids.
4. **Telophase-I**
   - **Spindles disappear** and a new nuclear envelope is made around each haploid set.
   - The chromosomes **uncoil** into chromatin.
   - **Cytokinesis** occurs and two daughter cells are made.

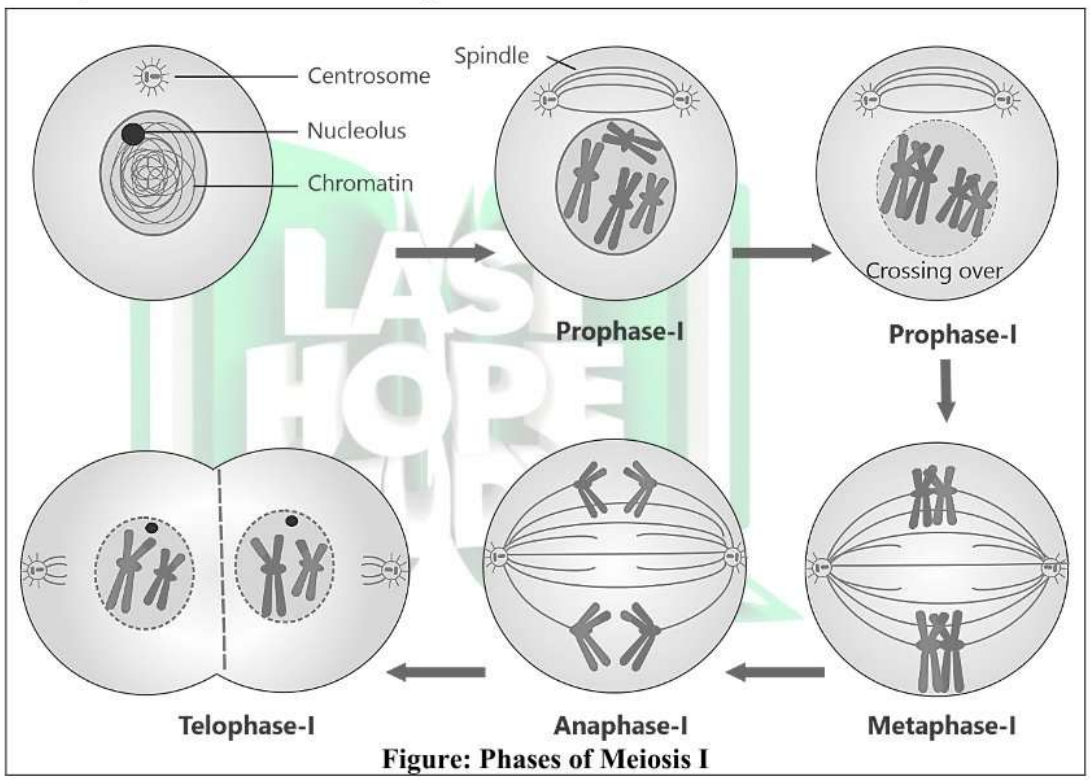


Figure: Phases of Meiosis I

Q.2 Explain the process of meiosis II. (K.B)

Ans:

MEIOSIS II

Explanation:

Meiosis-II closely **resembles** mitosis and consists of four phases: prophase-II, metaphase-II, anaphase-II, and telophase-II.

Prophase II:

- In prophase-II, the nucleoli and nuclear envelope disappear.
- The chromatin **condenses** into chromosomes.
- Centrioles move to the poles, forming spindle fibres.

Metaphase II:

During metaphase-II, spindle fibres attach to the **kinetochores** of chromosomes, **aligning** them at the cell's equator.

Anaphase II:

In anaphase-II, spindle fibres pull **sister chromatids** apart toward opposite poles.

Telophase II:

- Finally, in telophase- II, chromosomes **uncoil** back into **chromatin**.
- **Nuclear envelopes reform**, and cytokinesis occurs.
- This results in the formation of four daughter cells, each with half number of chromosomes.

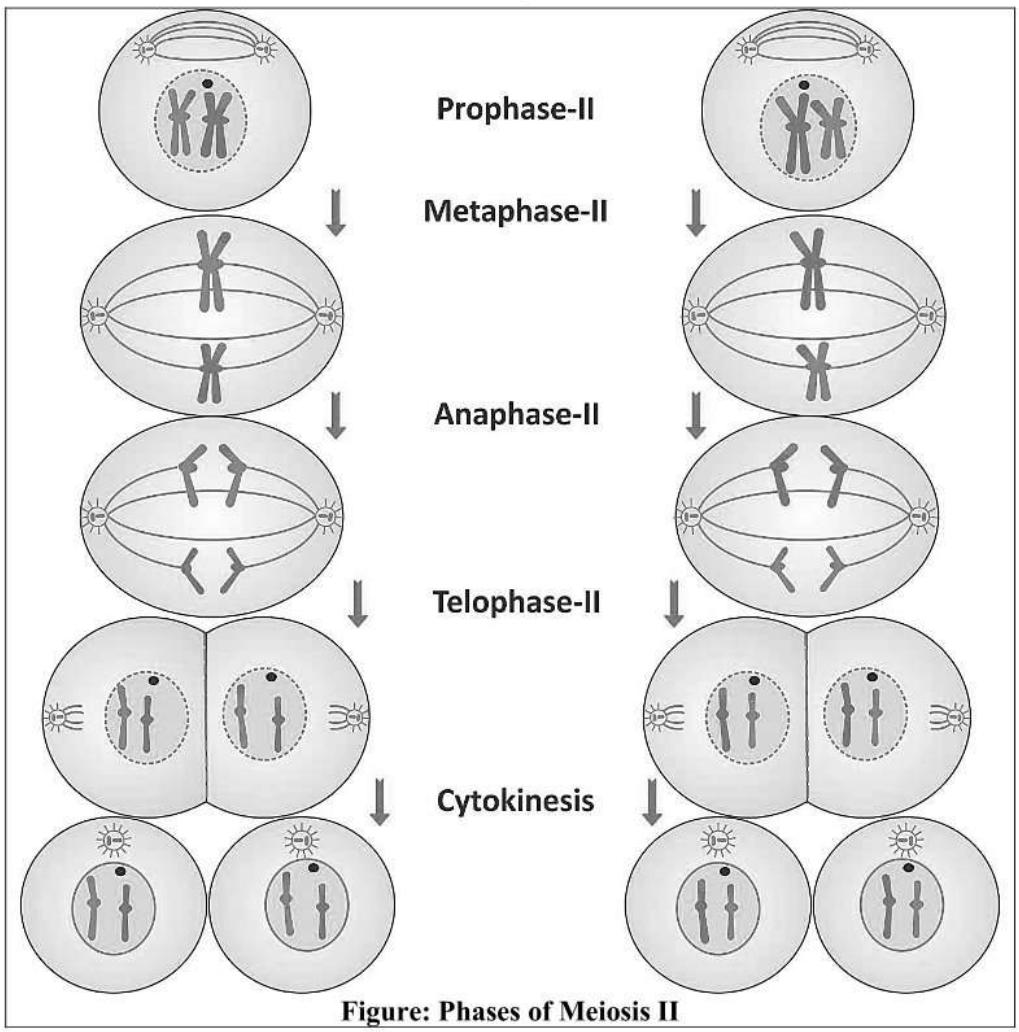


Figure: Phases of Meiosis II

Q.3 Describe the significance of meiosis. (U.B)

Ans:

SIGNIFICANCE OF MEIOSIS

The significances of meiosis are described below.

1. **Meiosis Maintains the Number of Chromosomes**

In Animals:

- In animals, special cells in **reproductive organs** undergo meiosis.
- The daughter cells, called **gametes**, have half the number of chromosomes (with no pairs).
- During **sexual reproduction**, male and female gametes join to make the first cell (zygote) of new generation.
- The original number of chromosomes is **restored** in zygote.

- It undergoes mitosis many times and develops into the **new animal**.

In Flowering Plants:

- In flowering plants, specialized cells in flowers undergo meiosis.
- The daughter cells, called **spores**, have half number of chromosomes.
- These spores grow into new generation inside the flowers.
- This generation produces **gametes** by mitosis.
- The gametes join to make zygote with full set of chromosomes.
- The zygote undergoes mitosis and develops into new plant.

2. Meiosis brings Genetic Diversity

- Crossing over creates new **combinations of genes** on chromosomes.
- Each chromosome in the gametes carries a unique set of genes.
- When **diverse** gametes from two parents combine, the resulting zygote is genetically different from both parents.
- In this way, meiosis contributes to **genetic diversity** in populations.

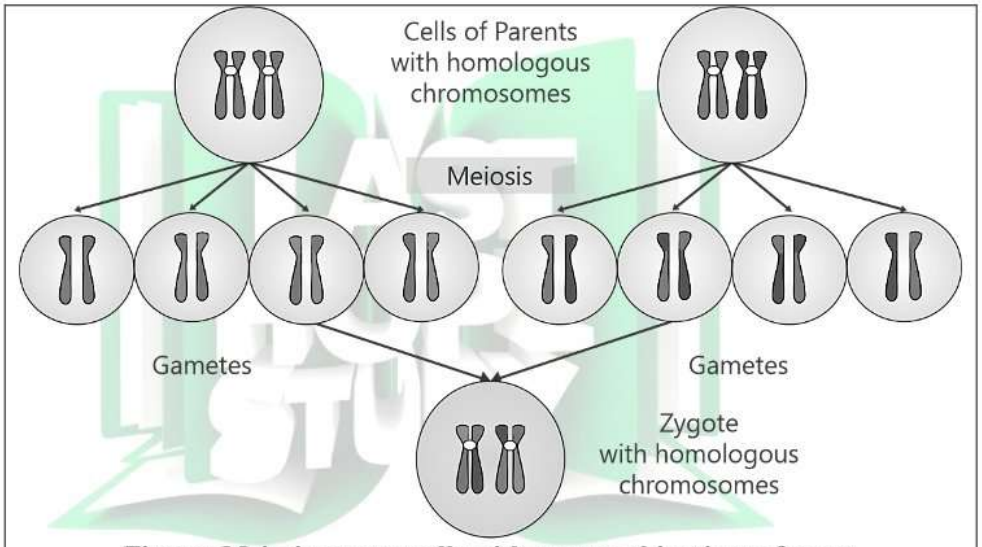


Figure: Meiosis creates cells with new combinations of genes

Q.4 Describe the errors in meiosis. (K.B)

Ans:

ERRORS IN MEIOSIS

The errors in meiosis are described below.

Disjunction:

During meiosis-l, chromosomes separate while during meiosis-Il sister chromatids separate. It is called **disjunction**.

Non-disjunction:

- Sometimes **non-disjunction** occurs.
- Due to it, the daughter cells (gametes) receive more or less than the normal number of chromosomes.
- If such gametes **fuse** to form zygote with abnormal number of chromosomes, the resulting baby suffers from **severe medical problems**.

Q.5 Give a Comparison between Meiosis and Mitosis. (K.B)

Ans:

COMPARISON

Similarities:

1. **DNA replication** occurs during **interphase** (S phase) before both divisions.
2. Both divisions begin with a parent cell that has chromosomes in pairs.
3. In both divisions, **chromatin condenses** and chromosomes become visible during prophase.
4. Both mitosis and meiosis involve the formation of a **spindle apparatus**.
5. Both involve prophase, metaphase, anaphase, and telophase. However, meiosis has **two rounds** i.e., meiosis-I and meiosis-II.
6. In both divisions, **sister chromatids** separate. In mitosis, it happens during anaphase. In meiosis, it happens in anaphase II.
7. **Cytokinesis** occurs at the end of both divisions. During cytokinesis, the cytoplasm divides and two new cells are formed.

Differences:

Mitosis	Meiosis
DIVISIONS	
A parent cell divides only once; two daughter cells are produced.	A parent cell undergoes two divisions: four daughter cells are produced.
CHROMOSOME NUMBER	
Chromosome number in daughter cells remains the same as the parent cell.	The chromosome number is reduced by half in daughter cells
VARIATIONS	
Variations are not generated	Variations occur due to crossing-over
OCCURRENCE	
Occurs in somatic cells.	Occurs in germ line-cells.
CHROMOSOMAL PAIRING	
Homologous chromosomes do not form pairs.	Homologous chromosomes form pair.
CROSSING OVER	
No crossing over occurs during prophase	Crossing over occurs during prophase
METAPHASE PLATE	
Single chromosome aligns to form a metaphase plate.	Homologous pairs align to form a metaphase plate
ANAPHASE	
During anaphase, chromosomes break and individual chromatids are pulled towards poles.	During anaphase-I, individual chromosomes are pulled towards poles.
PURPOSE	
Occurs for **growth**, **development**, and	Occurs for producing **gametes** in animals and

maintenance of multicellular organisms.	**spores** in plants for sexual reproduction.

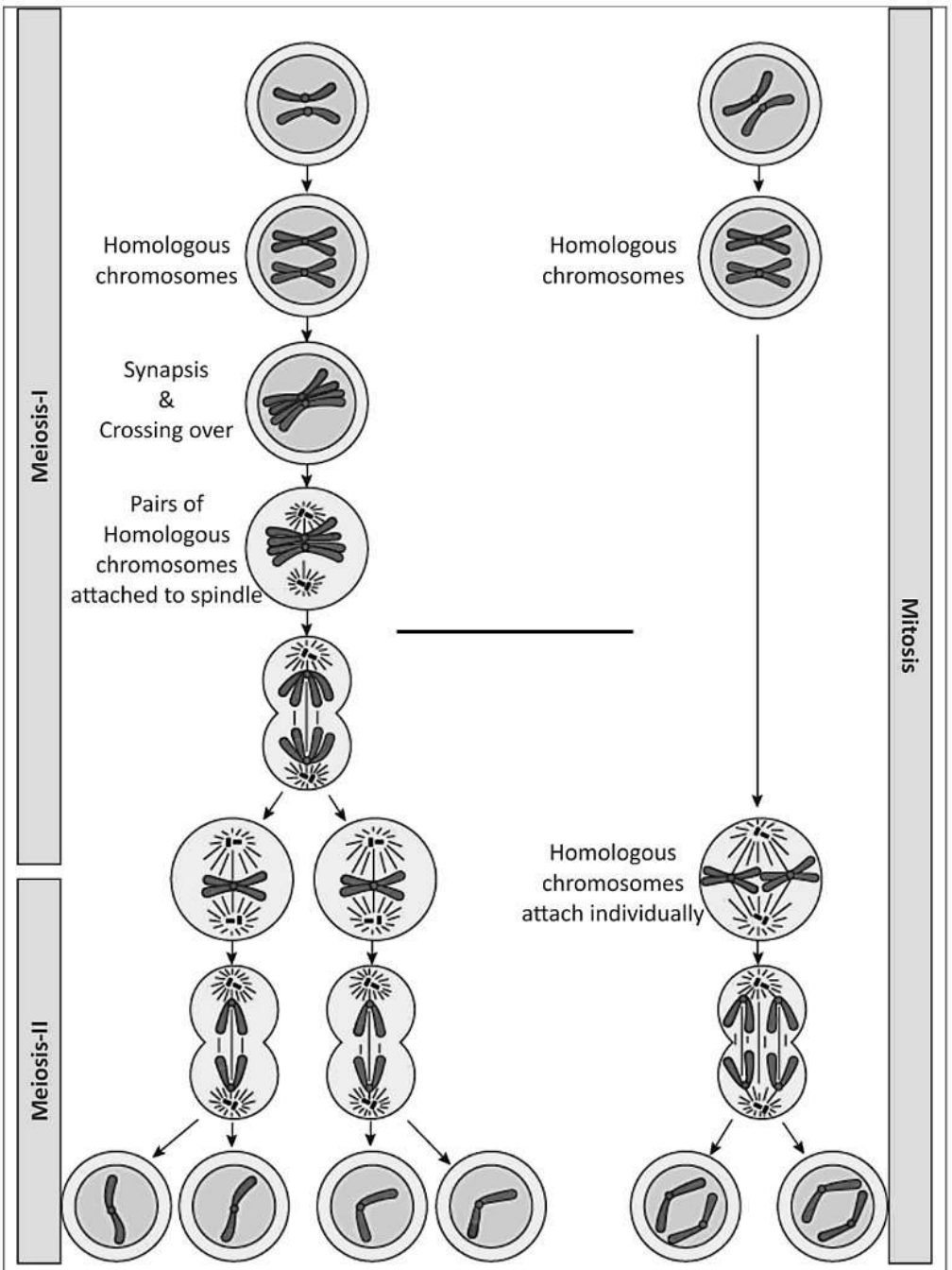


Figure: Comparison between mitosis and meiosis

SHORT ANSWER QUESTIONS

Q.1 Define meiosis. **(K.B)**

Ans: **MEIOSIS**

Definition:

It is the type of cell division in which each daughter cell receives **half** the number of chromosomes as compared to the parent cell. In meiosis, a diploid parent cell divides to produce **four haploid** daughter cells.

Q.2 Define synapsis. (K.B)

Ans:

SYNAPSIS

During Prophase I, **homologous chromosomes** move close together. They pair up in a process called **synapsis**. Each pair of homologous chromosomes is called **tetrad**.

Q.3 What is chiasmata? (K.B)

Ans:

CHIASMATA

During Prophase I, **non-sister chromatids** of homologous chromosomes become "**zipped**" together, forming **X-shaped** structures called **chiasmata**.

Q.4 How anaphase of mitosis and meiosis I are different. (U.B)

Ans:

ANAPHASE

Anaphase of Mitosis:

During anaphase of mitosis, spindle fibres pull the **centromeres** which **split** and the sister chromatids are separated from each other.

Anaphase of Meiosis I:

Each spindle fiber attached with **kinetochores** of a single chromosome pulls towards the pole. In this way the paired chromosomes are separated. One chromosome is pulled toward one pole and the other towards opposite pole.

Q.5 Differentiate between Bivalent and tetrads. (K.B)

Ans:

DIFFERENTIATION

Bivalent	Tetrads
Homologous chromosomes line up with each other and form pairs called bivalent.	Each bivalent has four chromatids so it may be called tetrads.

Q.6 What is the difference between meiosis I and meiosis II? (K.B)

Ans:

DIFFERENTIATION

The differences between meiosis I and meiosis II are as follows:

Meiosis I	Meiosis II
Separation	
In meiosis I, the homologous chromosomes in a diploid cell separate and so two haploid daughter cells are produced.	In meiosis II, two haploid cells separate and so four haploid daughter cells are produced. It is the second part of meiosis and is similar to mitosis.
Genetic Variation	
In meiosis I, genetic variations occur during crossing over.	In meiosis II, no genetic variation takes place.
Time	
Prophase I takes more time.	Prophase II takes less time.

Q.7 Describe process of crossing over in meiosis? (K.B)

Ans:

CROSSING OVER

Chiasmata Formation:

Non-sister chromatids of homologous chromosomes become "**zipped**" together, forming **X-shaped** structures called **chiasmata**. Each chiasma is the site for crossing over.

Crossing Over:

It is the **exchange** of portions of chromosomes between non-sister chromatids at chiasmata. Crossing over leads to **recombination** of genetic material.

Q.8 Which cells of the body undergo mitosis and meiosis? (K.B)

Ans:

CELLS OF BODY

Germ Cells:
Germ cells are **diploid** and undergoes meiosis to form haploid gametes
Somatic Cells:
All diploid cells of the body, except the germ cells, undergo mitosis. The are called **somatic cells**.

Q.9 How meiosis maintains the number of chromosomes in next generations? Explain with the reference of animal cells. (U.B)

Ans:

MAINTENANCE OF CHROMOSOMES

Maintenance of Chromosomal Number:

- In animals, special cells in **reproductive organs** undergo meiosis.
- The daughter cells, called **gametes**, have half the number of chromosomes (with no pairs).
- During **sexual reproduction**, male and female gametes join to make the first cell (zygote) of new generation.
- The original number of chromosomes is **restored** in zygote.
- It undergoes mitosis many times and develops into the new animal.

For Example:

- Human have **46 chromosomes** in their somatic cells.
- The haploid gametes (**eggs** and **sperms**) formed by meiosis have 23 chromosomes.
- In **fertilization** process, a 23 chromosome sperm fuses with an egg also having 23 chromosomes.
- The original chromosome number of 46 is **restored** in the zygote.

Q.10 How meiosis results in genetic variations? (U.B)

Ans:

VARIATIONS

Variations are the **differences** among the members of same species.

Variations due to Meiosis:

- **Crossing over** creates new combinations of genes on chromosomes.
- Each chromosome in the gametes carries a **unique** set of genes.
- When diverse gametes from two parents combine, the resulting zygote is genetically different from both parents.
- In this way, meiosis contributes to **genetic diversity** in populations.

Q.11 Write any four similarities between mitosis and meiosis. (U.B)

Ans:

SIMILARITIES

- **DNA replication** occurs during interphase (S phase) before both divisions.
- In both divisions, **chromatin condenses** and chromosomes become visible during prophase.
- Both involve prophase, metaphase, anaphase, and telophase. However, meiosis has two rounds i.e., meiosis-I and meiosis-II.
- In both divisions, sister chromatids separate. In mitosis, it happens during anaphase. In meiosis, it happens in anaphase II.

MULTIPLE CHOICE QUESTIONS

1. Meiosis takes place in: (K.B)
(A) Eukaryotic cells (B) Prokaryotic cells
(C) Haploid cells (D) Cyanobacteria

2. Those cells which give rise to gametes are called: (K.B)
(A) Somatic cells (B) Spindle Fibers
(C) Germ line cells (D) Neurons

3. Meiosis was discovered in: (K.B)
(A) 1875 (B) 1876
(C) 1877 (D) 1878

4. **In meiosis, one diploid cell divides into how many haploid cells?** **(K.B)**
   (A) 2 (B) 4
   (C) 6 (D) 8
5. **Diploid means the cells in which chromosomes are in:** **(K.B)**
   (A) Pairs (B) Recombination state
   (C) Crossing over (D) All of these
6. **The longest phase in meiosis is:** **(U.B)**
   (A) Prophase I (B) Metaphase I
   (C) Anaphase I (D) Telophase I
7. **Genetic variations take place during:** **(K.B)**
   (A) Prophase I (B) Prophase II
   (C) Anaphase I (D) Telophase II
8. **In which phase of meiosis1 the pairs of homologous chromosomes align along equatorial plane forming the metaphase plate?** **(U.B)**
   (A) Prophase I (B) Metaphase I
   (C) Anaphase I (D) Telophase I
9. **The process in which homologous chromosomes line up with each other and form pairs:** **(K.B)**
   (A) Tetrad (B) Crossing over
   (C) Chiasmata (D) Synapsis
10. **The phase in which crossing over occurs:** **(K.B)**
    (A) Anaphase (B) Metaphase
    (C) Prophase II (D) Prophase I
11. **The two non-sister chromatids of homologous chromosomes join each other at:** **(U.B)**
    (A) Centromere (B) Kinetochore
    (C) Chiasmata (D) Sister chromatids
12. **After crossing over, each pair of homologous chromosomes remain as:** **(U.B)**
    (A) Tetrad (B) bivalent
    (C) Condensed (D) All of these
13. **Many haploid fungi and protozoans produce haploid gametes through:** **(U.B)**
    (A) Mitosis (B) Meiosis
    (C) Regeneration (D) Budding
14. **The abnormal separation of homologous chromosomes during anaphase I is:** **(A.B)**
    (A) Disjunction (B) Non-disjunction
    (C) Synapsis (D) Crossing over
15. **The abnormal number of chromosomes in humans:** **(K.B)**
    (A) 45 or 43 (B) 47 or 45
    (C) 46 (D) 23 Homologous pairs
16. **Somatic cells always undergo:** **(K.B)**
    (A) Mitosis (B) Meiosis
    (C) Meiosis I only (D) Both mitosis and meiosis
17. **The number of chromosomes in human somatic cells is:** **(K.B)**
    (A) 23 (B) 46
    (C) 26 (D) 47
18. **Separation of sister chromatids occur in:** **(U.B)**
    (A) Meiosis I (B) Anaphase II
    (C) Cytokinesis (D) Prophase I
19. **Variations are not caused by:** **(U.B)**
    (A) Crossing over (B) Fertilization

(C) Cytokinesis (D) Chromosomal combination

20. Which is not related with meiosis? (U.B)

(A) Four daughter cells are produced (B) Crossing over takes place during prophase I
(C) Daughter cells can divide again (D) It occurs in germ line cells

21. Chiasmata is the joining or overlapping of chromosomes in: (K.B)

(A) Z-shape (B) Y-shape
(C) W-shape (D) X-shape

TEXTBOOK EXERCISE

MULTIPLE CHOICE QUESTIONS

32. In which phase of cell cycle, maximum growth occurs in cell?

(A) M phase (B) S phase
(C) G1 phase (D) G2 phase

33. In which phase of cell cycle, the chromosomes duplicate?

(A) Mitosis (B) G1 phase
(C) G2 phase (D) S phase

34. At which stage of mitosis chromosomes line up in the centre?

(A) Prophase (B) Metaphase
(C) Anaphase (D) Telophase

35. If you observe a cell in which nuclear membrane is reforming around two sets of chromosomes, what stage of cell cycle is this?

(A) Anaphase (B) Telophase
(C) Prophase (D) Metaphase

36. How does the centrosome contribute to mitosis?

(A) Initiates DNA replication (B) Makes mitotic spindle
(C) Forms the nuclear envelope (D) Duplicates organelles

37. Centrosomes make mitotic spindle in;

(A) Animal cells (B) Plant cells
(C) Prokaryotic cells (D) All of these

38. An organism has 4 pairs of chromosomes. After meiosis-1, how many chromosomes and chromatids will be present in each daughter cell?

(A) 8 chromosomes and 16 chromatids (B) 4 chromosomes and 8 chromatids
(C) 4 chromosomes and 4 chromatids (D) 8 chromosomes and 8 chromatids

39. Which one is the feature of mitosis but not of meiosis II?

(A) Daughter cells with same number of chromosomes
(B) Separation of homologous chromosomes
(C) Crossing over
(D) Separation of sister chromatids

40. Which event is unique to meiosis but not mitosis?

(A) DNA replication (B) Chromosome alignment
(C) Crossing over (D) Nuclear division

41. Why is meiosis II necessary after meiosis I?

(A) To replicate chromosomes (B) To reduce chromosome number
(C) To separate sister chromatids (D) To ensure genetic recombination

SHORT ANSWER QUESTIONS

Q.1 Enlist the events that occur during the G1 phase of interphase?

Ans: **EVENTS OF G1 PHASE**

Events:

- It starts from the end of the Mitosis phase.
- It is also called the **growth phase**.
- During this phase cell makes **proteins** and **organelles** and so grows in size.
- Cell also makes **enzymes** that are required in S phase for the replication of DNA.

Q.2 What is the main purpose of the S phase in the cell cycle?

Ans:

S PHASE

S Phase:

It is the phase in which the cell **replicates** its DNA, making an exact copy of its genetic material.

Purpose:

The main purpose of the S phase in the cell cycle is **DNA replication**, ensuring that each daughter cell receives an identical copy of the genetic material after division (mitosis or meiosis I).

Q.3 During which phase of mitosis sister chromatids separate?

Ans:

In mitosis, separation of sister chromatids take place during **Anaphase**.

Events of Anaphase:

- The spindle fibres attached with chromosomes pull toward the poles.
- Due to this pulling, the chromosome's sister chromatids separate.
- In this way, there are two similar sets of chromatids, which move towards the poles of the cell.

Q.4 How does crossing over contribute to genetic variation in meiosis?

Ans:

CROSSING OVER

Genetic Variation:

- Crossing over creates **new combinations** of genes on chromosomes.
- Each chromosome in the gametes carries a **unique set of genes**.
- When **diverse gametes** from two parents combine, the resulting zygote is genetically different from both parents.
- In this way, **crossing over** contributes to genetic diversity in populations.

Q.5 What is the role of spindle fibres in mitosis?

Ans:

SPINDLE FIBRES

The role of spindle fibers in mitosis is to ensure accurate **chromosome segregation**.

During Metaphase:

They attach to chromosomes at the **kinetochores** during metaphase and align them at the **metaphase plate**.

During Anaphase:

Spindle fibres then pull the **sister chromatids** apart toward opposite poles during anaphase, ensuring each daughter cell receives an identical set of chromosomes.

Q.6 How is cytokinesis in animal cell different from plant cell?

Ans:

CYTOKINESIS

In animal cell	In plant cell
In animal cells, cytokinesis occurs by a process known as **cleavage**.	In plant cells, cytokinesis occurs by **phragmoplast** formation.
PROCESS	

• In animal cells, a **furrow** develops at the equator. • At this furrow, the cytoplasm has a **ring of microfilaments**. • The ring contracts and the furrow moves inward. • In this way parent cell is **pinched** into two.	• In plant cells, **Golgi apparatus** makes vesicles. • These vesicles move to the middle and fuse to form a plate called **phragmoplast**. • The plate grows outward and its membranes **fuse** with the cell membrane. • The result is two daughter cells.

Q.7 What is the difference between prophase of mitosis and prophase-I of meiosis-I?

Ans:

PROPHASE

The main difference is that in **prophase of mitosis**, homologous chromosomes do not pair or exchange genetic material, while in **prophase-1 of meiosis-1**, homologous chromosomes undergo synapsis (pairing) and crossing over, allowing for genetic recombination.

Q.8 How does meiosis differ from mitosis in terms of chromosome number?

Ans:

CHROMOSOME NUMBER

Meiosis reduces the chromosome number by half, producing haploid cells (n) from diploid cells (2n), while **mitosis maintains** the chromosome number, producing two diploid cells (2n) identical to the parent cell.

Example:

Mitosis: A diploid skin cell (46 chromosomes) divides to form two identical diploid skin cells, each with 46 chromosomes.

Meiosis: A diploid germ cell (46 chromosomes) undergoes meiosis to produce haploid gametes (sperm or egg cells), each with 23 chromosomes.

Q.9 What are the key events of anaphase in mitosis?

Ans:

ANAPHASE OF MITOSIS

Events of Anaphase:

- The spindle fibres attached with chromosomes pull toward the poles.
- Due to this pulling, the chromosome's **sister chromatids separate**.
- In this way, there are two similar sets of chromatids, which move towards the poles of the cell.

Q.10 What is the function of the centrosome during cell division?

Ans:

CENTROSOME

During cell division (Prophase), the centrosome **duplicates** and **migrates** to opposite sides of the nucleus, and give rise to spindle fibres.

Function of Centrosome:

As **centrosomes** give rise to spindle fibres, they are essential for **aligning chromosomes** at the metaphase plate during metaphase and separating sister chromatids during anaphase.

Q.11 What are sister chromatids, and when do they separate in meiosis?

Ans:

SISTER CHROMATIDS

Definition:

Sister chromatids are identical copies of a chromosome, joined together at the centromere.

Separation:

In meiosis, they separate during **anaphase II** when spindle fibers pull them toward opposite poles, similar to the process in mitosis.

Q.12 How is mitosis related to the process of regeneration?

Ans: **REGENERATION**

Explanation:

Some animals can **regenerate** the lost parts of their body. For this purpose, they form new cells by carrying out mitosis in the cells of remaining parts.

EXTENSIVE ANSWER QUESTIONS

Q.11 Describe the events that occur during the phases of mitosis.

See Q.No.1 of topic 4.2

Q.12 Describe cytokinesis in animal and plant cells.

Consult Q.No.1 of topic 4.2

Q.13 Describe the significance of mitosis.

See Q.No.2 of topic 4.2

Q.14 Describe the events that occur during the phases of meiosis-1.

See Q.No.1 of topic 4.3

Q.15 Describe the significance of meiosis.

See Q.No.3 of topic 4.3

INQUISITIVE ANSWER QUESTIONS

Q.1 What role might mistakes in the cell cycle checkpoints play in the emergence of cancer?

Ans: **EMERGENCE OF CANCER**

Role of Cell Cycle Checkpoints in Cancer:

Cell cycle checkpoints are crucial for regulating **cell division** and ensuring **DNA integrity**. Mistakes in these checkpoints can lead to cancer in the following ways:

1. **G1 Checkpoint**
   Function:
   Checks for DNA damage before the cell enters the S phase.
   Mistake Impact:
   If damaged DNA is not repaired, it gets replicated, leading to mutations.
2. **G2 Checkpoint**
   Function:
   Ensures all DNA is replicated and undamaged before mitosis.
   Mistake Impact:
   Errors can result in damaged chromosomes being passed to daughter cells.
3. **Spindle Checkpoint**
   Function:
   Verifies proper chromosome alignment before division.
   Mistake Impact:
   Failures can cause aneuploidy (abnormal number of chromosomes), common in cancer cells.

Consequences of Checkpoint Failures:

- Unchecked errors lead to more **mutations** over time.
- Increases chances of further genetic changes, promoting **tumor growth**.
- Cells divide uncontrollably, leading to tumor formation.

Q.2 Why do skin cells divide continuously throughout an organism's existence, but nerve and muscle cells permanently exit the cell cycle?

Ans: **EVENTS OF G1 PHASE**

Skin Cells:

- Skin cells divide constantly to replace those **lost** from wear and tear.
- This maintains the skin's **integrity** and respond to **injuries**.

Nerve and Muscle Cells:

- Nerve and muscle cells exit the cell cycle after **maturation**.
- They are specialized for **transmitting signals** (nerve cells) and **contraction** (muscle cells), which requires stability.
- They have a very low capacity for division, which helps maintain their complex structures.

Conclusion:

Skin cells continuously divide for repair and renewal, while nerve and muscle cells do not divide to preserve their specialized functions.

EXTRA CONCEPTUAL MCQs

1. The word meiosis comes from which language?
(A) Latin (B) Italian
(C) Greek (D) French

2. Who discovered meiosis?
(A) Walter Flemming (B) Oscar Hertwig
(C) August Weismann (D) T. H. Morgan

3. Who discovered crossing over?
(A) Walter Flemming (B) Oscar Hertwig
(C) August Weismann (D) T. H. Morgan

4. The period of cell cycle between two consecutive divisions is termed as:
(A) Prophase (B) Metaphase
(C) Telophase (D) Interphase

5. Which of the following phases of mitosis is essentially the opposite of prophase in terms of nuclear change?
(A) Telophase (B) Interphase
(C) Metaphase (D) Anaphase

6. When do homologous chromosomes pair up:
(A) Only in mitosis (B) Only in meiosis I
(C) Only in meiosis II (D) In both mitosis and meiosis

7. The arms of chromosomes are called:
(A) Chromatin (B) Chromatids
(C) Diploids (D) Centromere

8. Cytokinesis is:
(A) Division of nucleus (B) Mitosis
(C) Division of cytoplasm (D) Division of centromere

9. Meiosis produces:
(A) Cell with one homologue of each chromosomes pair
(B) Cells with diploid number of chromosomes
(C) An increasing number of cells all with same DNA compliment
(D) An increase in the amount of RNA

10. It is difficult to observe chromosomes during interphase because:
(A) The DNA has not been replicated
(B) They have uncoiled to form long thin strand
(C) They leave the nucleus and dispersed to other parts of the cell
(D) Homologous chromosomes do not pair up until division starts

11. Which events occur during telophase?
(A) Chromosomes align in the middle (B) Spindle fibers disappear
(C) Nuclear envelope disintegrates (D) DNA replication

12. Which of the following phase is involved in ensuring the exact copy of genetic material?
(A) G1 (B) S-Phase

(C) G2 (D) M-Phase

13. What is the significance of Meiosis in sexual reproduction?
(A) It produces identical daughter cells (B) Ensures genetic diversity
(C) Doubles the chromosome number (D) Occurs in somatic cells

14. What role do spindle fibers play in Mitosis?
(A) Cell growth (B) Separating sister chromatids
(C) Aligning chromosomes during metaphase (D) Both B and C

15. What does not occur during Prophase in Mitosis?
(A) Chromosome condenses (B) DNA replicates
(C) Nuclear envelope breaks down (D) Centrioles duplicate

16. The cell cycle describes:
(A) how cells die (B) how cells consume energy
(C) the life cycle of a cell (D) cell movement

17. Which cellular process is responsible for tissue repair?
(A) Meiosis (B) Cytokinesis
(C) Mitosis (D) Replication

18. What type of cell division is responsible for sexual reproduction:
(A) Binary fission (B) Mitosis
(C) Meiosis (D) Budding

19. In which phase of meiosis do homologous chromosomes separate?
(A) Prophase II (B) Anaphase I
(C) Metaphase I (D) Anaphase II

20. What is the outcome of non-disjunction during meiosis?
(A) Genetically identical cells (B) Genetically different cells
(C) Trisomy or monosomy in the offspring (D) No effect

21. A bivalent consists of:
(A) Two chromatids and one centromere (B) Four chromatids and two centromeres
(C) Four chromatids and four centromeres (D) Two chromatids and two centromeres

22. During cell division spindle fibres attach with chromosome at:
(A) Centromere (B) Telomere
(C) Upper arm of chromosome (D) Lower arm of chromosome

23. Some student of SSC observed a thin cross section from root tip of onion plant under the microscope. They found dividing cells at different stages of their life cycle. One of the students found a cell at late prophase and counted 28 chromosomes in it. The number of chromosomes in daughter cells should be:
(A) 14 (B) 28
(C) 56 (D) 07

24. Crossing over results in genetic recombination. It occurs between:
(A) Two chromatids of the same chromosome
(B) Two chromatids of any two non-homologous chromosomes
(C) Two chromatids of opposite gametes
(D) Two chromatids of homologous chromosomes

25. The spindle apparatus of plants differs from that of animals in not having:
(A) Microtubules (B) Equator of spindle
(C) Centrioles (D) Centromere

26. Substance and energy required for the replication of DNA is accumulated in the cell during:
(A) G1 (B) G2

(C) S Phase (D) M Phase

27. All of the following events take place both in mitosis and meiosis except:

(A) Condensation of chromatin to form chromosomes

(B) Formation of spindle apparatus

(C) Nuclear envelop and nucleolus disappear

(D) Chromosomes pair for crossing over

28. The cell shown in this diagram is passing through:

(A) Prophase I of meiosis (B) Prophase of mitosis

(C) Telophase of meiosis I (D) Anaphase of meiosis II

29. The longest phase of meiosis is:

(A) Interphase I (B) Prophase I

(C) Interphase II (D) Prophase II

30. What causes the number of chromosomes to reduce to half when a cell divides by meiosis?

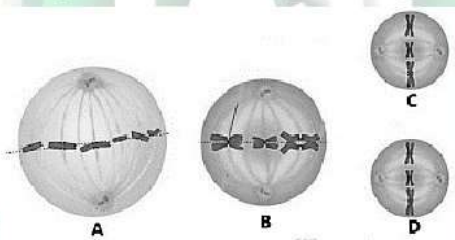
(A) Replication of DNA during interphase I

(B) Separation of homologous chromosomes during meiosis I

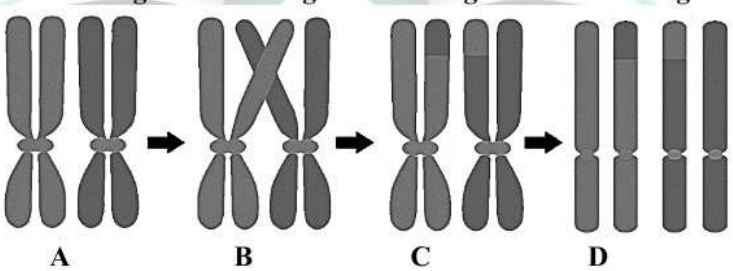
(C) Separation of sister chromatids of all the chromosomes during meiosis I

(D) Crossing over during meiosis I

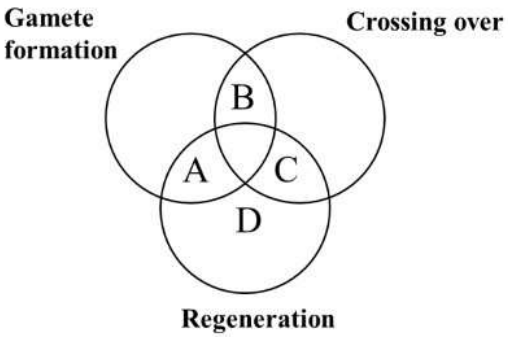
31. Which of the following cell is not at metaphase stage?



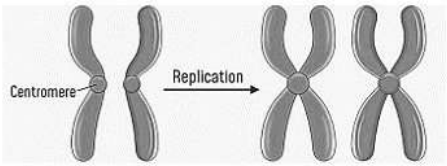
32. This diagram is showing different stages of crossing over. Which stage contains chiasma?



33. Which processes involve meiosis?



34. **The diagram shows replication of chromosomes. What is the total number of chromosomes in this diagram?**



(A) 2 (B) 3
(C) 4 (D) 6

35. **Chromosomal number of fruit fly is 8. The gametes of fruit fly contain:**

(A) 2 chromosomes (B) 4 chromosomes
(C) 8 chromosomes (D) 16 chromosomes

STUDENT LEARNING OUTCOMES (SLOs)

SHORT ANSWER QUESTIONS

Q.6 **What are the two broad categories of the cell cycle?**

Ans:

CATEGORIES OF CELL CYCLE

The cell cycle has two main parts:

Interphase:

During interphase, the cell **grows**, copies its DNA, and gets ready to divide.

Mitotic phase:

The mitotic phase is when the actual **splitting** happens. First, the nucleus divides (**karyokinesis**), and then the rest of the cell splits (**cytokinesis**), making two new cells.

Q.7 **What is the significance of mitosis?**

Ans:

SIGNIFICANCE OF MITOSIS

Definition:

Mitosis is when one cell divides to make **two identical daughter cells** with the same number of chromosomes as the parent cell.

Significance:

Mitosis is essential for

- **Growing**
- Fixing damaged parts
- Making **new cells** in multicellular organisms

Q.8 **What is the role of spindle fibers during metaphase?**

Ans:

ROLE OF SPINDLE FIBERS

The spindle fibers from **centrosomes**, which are present at the opposite poles, attach to the **kinetochore** at the centromeres of each **chromatid** of a chromosome.

Metaphase Plate:

The spindle fibers **align** the chromosomes in the middle of the cell, forming the **metaphase plate**.

Q.9 What is so special about human liver, in terms of mitosis?

Ans:

HUMAN LIVER

Ability of Liver:

The human **liver** has an incredible ability to regenerate via mitosis.

Regeneration:

If part of the liver is damaged or removed, the remaining liver cells can undergo mitosis to expand and restore the liver's full function.

Q.10 How does mitosis support the growth of organisms from a zygote to adulthood?

Ans:

GROWTH

Cellular Need:

As a living organism like a human develops from a **zygote** to a multicellular baby and then grows into an adult, it needs more cells for its body to get bigger and more complex.

Role of Mitosis in Growth:

- Mitosis helps with this by making more cells.
- It allows parts like **bones** and **muscles** to grow.
- So, when a baby grows into an adult, it is not just the cells getting bigger, but the body is making a large number of cells through mitosis.

Q.11 How does asexual reproduction in certain plants and animals relate to mitosis?

Ans:

ASEXUAL REPRODUCTION AND MITOSIS

Asexual Reproduction:

Asexual reproduction allows some **plants** and **animals** make offspring from just one parent. The offspring get all their genes from this parent.

Mitosis:

Mitosis is really important in this, as it makes sure the off spring are exactly like the parent.

For Example:

- A **hydra** is a small aquatic animal that reproduces by **budding**.
- A small **bump**, or bud, grows on its body.
- This bud splits into new cells by mitosis, forming a new, small hydra.
- When it is ready, this bud separates from the parent and lives on its own.
- The new hydra is just like its parent because of mitosis.

Q.12 What happens when the process of mitosis goes wrong?

Ans:

ERRORS IN MITOSIS

Cancer:

When mitosis goes wrong, cancer occurs because cells divide too much and do not stop. These cells keep dividing and form **lumps** called **tumors**.

Cause of Cancer:

- Cancer happens because of mistakes in the genes that control cell division.
- These mistakes disrupt the cell's normal control over growing and dividing, which leads to too much growth and can cause health problems.

Q.13 Why are the cells produced at the end of meiosis genetically unique?

Ans:

CELLS OF MEIOSIS

Uniqueness of Cells:

Meiosis ends with four haploid cells that are **genetically different** from each other and from the original diploid cell due to the **crossing over**.

Importance of Unique Cells:

These cells are the gametes that can fuse with another gamete during **fertilization** to form a new diploid cell (**zygote**). This is how these cells play an essential role in the continuation of life.

Q.14 How meiosis is significant in evolution?

Ans:

EVOLUTIONARY SIGNIFICANCE OF MEIOSIS

Meiosis:

Meiosis makes offspring different from their parents and each other, which is good for **evolution**.

Meiosis and Evolution:

- Because of meiosis, animals and plants have lots of different genes.
- When things change in their environment, some of these genes can be really helpful.

Survival of Species:

- The ones with the best genes **survive** longer and have more babies.
- Over time, this can lead to new traits or even new kinds of animals or plants.
- So, meiosis helps nature choose the best genes for living things to survive.

Q.10 What is the significance of crossing over?

Ans:

SIGNIFICANCE OF CROSSING OVER

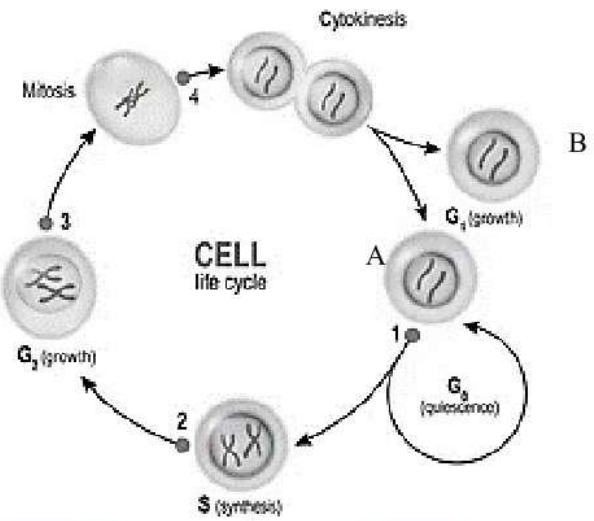
Definition:

The **exchange of segments** of non-sister chromatids during prophase I is called crossing over.

Significance:

1. **New Combinations**
   Crossing-over creates new combinations of genes in the offspring.
2. **Survival of Species**
   By increasing genetic variation, crossing over helps **populations** adapt to changing environments over time and this is important for the **survival of species**.
3. **Disease Resistance**
   More genetic diversity in a population means a lower chance of everyone being affected by the same disease.
4. **Chromosome Repair**
   During crossing over, chromosomes can fix some types of damage by **exchanging** pieces with their homologue.

Q.11 Cell cycle below shows the formation of two daughter cells, cell A and cell B. Cell A continues in the cell cycle while cell B exits in G_0. What will be the difference in materials they synthesize after the production of cell A and cell B?



Ans: **CELL CYCLE**

Cell A:

- Cell A continues in the cell cycle and will **synthesize** materials needed for cell growth, DNA replication, and division.
- This includes proteins, DNA, and other molecules required for making new cells.

Cell B:

- Cell B enters the G0 phase and does not continue to divide.
- It will mainly synthesize materials needed for normal cell function and maintenance, rather than preparing for cell division.

Q.12 Why do epithelial cells of skin divide continuously?

Ans: **EPITHELIAL CELLS**

Definition:

Epithelial cells of skin are the cells that form the **outermost layer** of the body.

Division of Epithelial Cells:

Many epithelial cells divide continuously and never enter G0 phase. Following are the reasons of their continuous division:

1. **Protection**
   The skin acts as a **barrier** to protect our body. **Continuous cell division** helps maintain the number of cells in this protective layer.
2. **Repair**
   The skin can get damaged from **cuts**, **scrapes**, and other **injuries**. Continuous cell division allows the skin to heal and repair itself quickly.
3. **Growth**
   As our bodies grow, our skin needs to grow as well. Continuous cell division helps the skin expand and cover the entire body.

Q.13 In rapidly dividing cells, which phase of cell cycle is reduced? Explain.

Ans: **RAPIDLY DIVIDING CELLS**

If a cell has to divide rapidly, the time spent in G_1 and G_2 will be reduced.

Reduction in G_1 Phase:

- G_1 is typically the **longest phase** of the cell cycle.

- This phase ensures that all conditions are suitable for DNA replication.
- In case of rapidly dividing cell, G_1 phase is reduced because this adaptation is crucial for processes requiring quick **cell proliferation**.

Reduction in G_2 Phase:

- The G_2 phase in which cell **accumulates energy** to complete the division process, will be reduced.
- This phase is reduced because the cell has **streamlined processes** to quickly prepare for and enter mitosis, minimizing the time spent in this phase.

Q.14 Both skin cells and cancerous cell divide rapidly. Why cancerous cells are harmful but skin cells are not?

Ans:

SKIN AND CANCER CELLS

Cancerous cells are harmful while rapidly dividing skin cells are not due to several key differences:

1. **Uncontrolled Growth:**
   - Cancer cells **divide uncontrollably** without the normal regulatory signals that stop cell division when enough cells are present.
   - Skin cells divide rapidly but stop when the **wound** is **healed**.
2. **Lack of Maturation:**
   - Cancer cells divide so quickly that they don't have time to **mature** into specialized cell types.
   - Skin cells that divide to heal a wound still mature into the normal skin cell types.
3. **Invasion and Metastasis:**
   - Cancer cells **invade** nearby tissues and can spread to other parts of the body.
   - Skin cells stay in the skin and do not invade other organs.
4. **Lack of Cell-Cell Adhesion:**
   - Cancer cells lose the normal **cell-cell adhesion** that keeps cells organized in tissues. This makes them to invade and spread.
   - Skin cells maintain normal adhesion to each other and the **extracellular matrix**.

Q.15 How haploid organisms produce gametes?

Ans:

GAMETES IN HAPLOID ORGANISMS

Type of Chromosomes in Haploid Organisms:

Haploid organisms have cells with only one set of chromosomes.

Gamete Production:

- When haploid organisms produce gametes (**sex cells**), they don't need to undergo meiosis because their cells already have the correct number of chromosomes for reproduction.
- Instead, they simply use mitosis to produce gametes that are **genetically identical** to the parent cell.
- This way, the gametes remain haploid, and when they combine during **fertilization**, they form a new organism with the correct number of chromosomes.

Q.16 Down syndrome is due to extra copy of chromosome number 21. That is why Down syndrome people have 47 chromosomes. Why their chromosome number is high?

Ans:

DOWN SYNDROME

Explanation:

- Sometimes an egg or sperm cell gets an **extra copy** of chromosome number 21 due to **mutation** or **abnormal separation** in anaphase.
- When this egg or sperm cell combines with a normal one during fertilization, the resulting baby ends up with three copies of chromosome 21 instead of the usual two.

- This extra chromosome causes **Down syndrome**, and people with this condition have 47 chromosomes in total instead of the usual 46.

Q.17 If a cell completes meiosis I but meiosis II fails to occur, what type of anomalies will appear in the two daughter cells thus formed?

Ans:

ANOMALIES IN CELL

When a cell completes meiosis I but meiosis II fails to occur, it results in two daughter cells with following specific characteristics:

1. **Non-Duplicated Chromosomes:**
   - After meiosis I, homologous chromosomes separate, and each daughter cell receives one chromosome from each pair.
   - These daughter cells are haploid, meaning they have half the number of chromosomes compared to the original diploid cell.
   - However, the chromosomes in these daughter cells are still duplicated (i.e., they consist of sister chromatids).
2. **Lack of Genetic Variation:**
   - Meiosis II is crucial for genetic diversity because it involves the separation of sister chromatids.
   - During meiosis II, sister chromatids **segregate independently**, leading to the formation of genetically distinct gametes.
   - Without meiosis II, the daughter cells produced after meiosis I will have identical genetic material (since sister chromatids remain together).

Conclusion:

In summary, the absence of meiosis II results in non-duplicated chromosomes and reduces genetic variation in the daughter cells.

Q.18 A cell is shown in this diagram. Answer following questions after observing it.

a) Give at least one finding on the basis of which you can identify it as animal or plant cell.

Ans: There are centrioles present in this cell which are giving rise to spindle fibres. As centrioles are absent in plant cells, so we can say that this is an animal cell.

b) Identify the stage of cell division the given cell is passing through?

Ans: This cell is passing through Anaphase of Mitosis.

c) Enlist the reasons of your identification.

Ans: There is separation of sister chromatids in this cell. On the basis of this, we can say that this cell is passing through Anaphase.

MULTIPLE CHOICE QUESTIONS

25. Mitosis was first observed and described by:

(A) Carolus Linnaeus (B) Walther Flemming
(C) Carl Woese (D) August Weismann

26. In male humans, meiosis occurs in:

(A) Somatic Cells (B) Cells of ovaries

(C) Cells of testes (D) Skin cells

27. In female humans, meiosis occurs in:

(A) Somatic Cells (B) Cells of ovaries

(C) Cells of testes (D) Skin cells

28. The protein that plays role in the attachment of spindle fibers to the centromere during cell division is:

(A) Histone (B) Helicase

(C) Kinetochore (D) Both A and C

29. The structure that gives rise to cell plate during cytokinesis:

(A) Cleavage furrow (B) Metaphase plate

(C) Phragmoplast (D) Chiasmata

30. The genes that cause cancer when they are not working:

(A) Metagenes (B) Oncogenes

(C) Mitotic genes (D) Tumor genes

31. In flowering plants, meiosis takes place in:

(A) Anthers (B) Ovules

(C) Petals (D) Anther and Ovule

32. Two chromosomes in a pair, one inherited from the mother and other from the father, are called:

(A) Sister chromosomes (B) Non-sister chromatids

(C) Homologous chromosomes (D) Sister chromatids

33. What is not correct about meiosis:

(A) It keeps the amount of genetic material stable over generations

(B) It plays role in evolution

(C) Parent cell divides into four daughter cells in a single phase

(D) It produces genetically different cells resulting in variations

34. Meiosis results in:

(A) Formation of gametes

(B) Genetic variations

(C) Reduction of chromosome number

(D) All of these

35. What is the outcome of non-disjunction during meiosis?

(A) Genetically identical cells

(B) Genetically different cells

(C) Trisomy or monosomy in the offspring

(D) No effect

ASSIGNMENT

LET'S DRAW AND LABEL

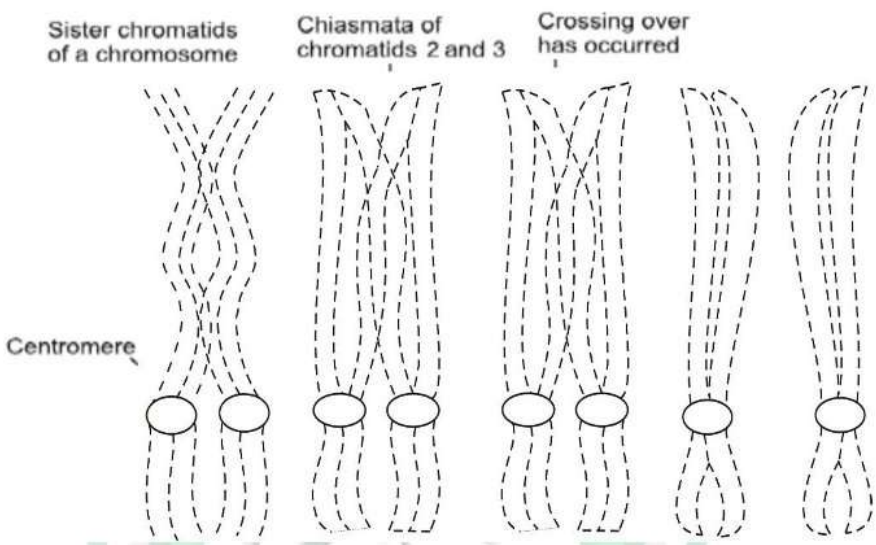
(A) Phases of Mitosis
Instructions:
Draw the cells showing different phases of mitosis.

Interphase **Prophase**

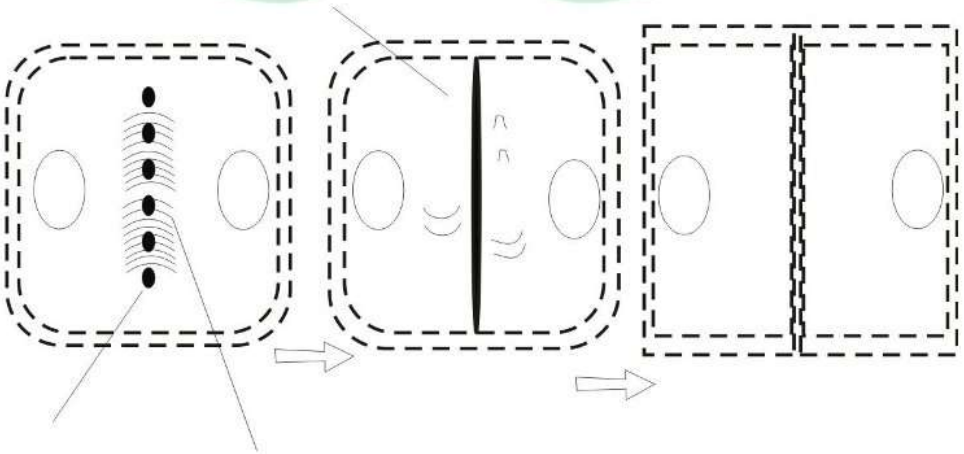
Metaphase **Anaphase**

Telophase **Cytokinesis**

(B) Crossing over during Prophase I
Instructions:
Trace the patterns of chromosomes as given in diagram.



(C) Cytokinesis in Plants
Instructions:
Trace the patterns and marks the labels



Answer Key

TOPIC 4.1

1	A	**2**	D	**3**	D	**4**	A	**5**	B
6	B	**7**	B	**8**	D	**9**	B	**10**	B
11	B	**12**	C	**13**	B	**14**	A	**15**	B
16	C	**17**	D						

TOPIC 4.2

1	C	**2**	A	**3**	A	**4**	B	**5**	B
6	A	**7**	B	**8**	A	**9**	A	**10**	B
11	B	**12**	A	**13**	D	**14**	B	**15**	C
16	A	**17**	A	**18**	C	**19**	A	**20**	B
21	B	**22**	D	**23**	B	**24**	A	**25**	C
26	D	**27**	B	**28**	B				

TOPIC 4.3

1	A	**2**	C	**3**	B	**4**	B	**5**	A
6	A	**7**	A	**8**	B	**9**	D	**10**	D
11	C	**12**	B	**13**	A	**14**	B	**15**	B
16	A	**17**	B	**18**	B	**19**	C	**20**	C
				21	D				

EXERCISE MCQs

1	C	**2**	D	**3**	B	**4**	B	**5**	B
6	A	**7**	B	**8**	A	**9**	C	**10**	B

EXTRA CONCEPTUAL MCQs

1	C	**2**	B	**3**	D	**4**	D	**5**	A
6	B	**7**	B	**8**	C	**9**	A	**10**	B
11	B	**12**	B	**13**	B	**14**	D	**15**	B
16	C	**17**	C	**18**	C	**19**	B	**20**	C
21	B	**22**	A	**23**	A	**24**	D	**25**	C
26	A	**27**	D	**28**	A	**29**	B	**30**	B
31	A	**32**	B	**33**	B	**34**	A	**35**	B

SLOs MCQs

1	B	**2**	C	**3**	B	**4**	C	**5**	C
6	B	**7**	D	**8**	C	**9**	C	**10**	D
				11	C				