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

Options:
a) M phase
✓ **c) G1 phase**
b) S phase
d) G2 phase

Explanation:
During the **G1 phase**, the cell grows rapidly, synthesizes proteins and organelles — it's the **longest growth phase**.

---

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

Options:
a) Mitosis
b) G1 phase
✓ **d) S phase**
c) G2 phase

Explanation:
In the **S phase (Synthesis phase)**, DNA is replicated and chromosomes are duplicated.

---

3. Which of the following is NOT a characteristic of mitosis?

Options:
a) It occurs in somatic cells.
b) It results in genetically identical daughter cells.
✓ **c) The chromosome number is halved in daughter cells.**
d) It results in the formation of two daughter cells.

Explanation:
Mitosis maintains the same chromosome number; **halving occurs in meiosis**, not mitosis.

---

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

Options:
a) Prophase
✓ **b) Metaphase**

c) Anaphase
d) Telophase

Explanation:
During **metaphase**, chromosomes align at the **equator (middle)** of the cell.

---

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

Options:
a) Anaphase
✓ **b) Telophase**
c) Prophase
d) Metaphase

Explanation:
In **telophase**, the **nuclear membrane reforms** around chromosomes at each pole.

---

6. How does the centrosome contribute to mitosis?

Options:
a) Initiates DNA replication
✓ **b) Makes mitotic spindle**
c) Forms the nuclear envelope
d) Duplicates organelles

Explanation:
Centrosomes help form the **spindle fibers** that pull chromosomes apart during mitosis.

---

7. Centrosome makes mitotic spindle in:

Options:
✓ **a) Animal cells**
b) Plant cells
c) Prokaryotic cells
d) All of these

Explanation:
Animal cells have **centrosomes** that produce **spindle fibers**. Plant cells organize spindles without centrosomes.

---

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

Options:
a) 8 chromosomes and 16 chromatids
✓ **b) 4 chromosomes and 8 chromatids**
c) 4 chromosomes and 4 chromatids
d) 8 chromosomes and 8 chromatids

Explanation:
In **meiosis-I**, homologous pairs separate — so chromosome number is halved but each chromosome still has **2 chromatids**.

---

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

Options:
a) DNA replication
✓ **c) Crossing over**
b) Chromosome alignment
d) Nuclear division

Explanation:
Crossing over occurs only in **meiosis-I**, during **prophase I**, resulting in genetic variation.

B. Write Short Answers:

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

- Cell increases in size
- Synthesis of proteins and RNA
- Preparation for DNA replication
- Formation of organelles

---

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

The S (Synthesis) phase is for **DNA replication**, where each chromosome duplicates to form two sister chromatids.

---

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

Anaphase — spindle fibers pull the sister chromatids apart to opposite poles.

---

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

During **prophase-I** of meiosis, homologous chromosomes exchange segments of DNA. This **crossing over** results in **new gene combinations**, increasing genetic diversity.

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

Spindle fibers attach to centromeres of chromosomes and help in **separating sister chromatids** during anaphase.

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6. How is cytokinesis in animal cells different from plant cells?

- In **animal cells**, cytokinesis occurs by **cleavage furrow**.
- In **plant cells**, a **cell plate** forms between daughter nuclei due to the rigid cell wall.

---

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

- In **mitosis**, homologous chromosomes do **not pair up**.
- In **meiosis-I**, **homologous chromosomes pair (synapsis)** and undergo **crossing over**.

---

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

- **Mitosis**: Daughter cells have **same number** of chromosomes as parent cell.
- **Meiosis**: Daughter cells have **half the number** of chromosomes.

---

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

- **Sister chromatids separate** at the centromere.
- Move to opposite poles by spindle fibers.
- Each pole receives an identical set of chromosomes.

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

Centrosome helps **form the mitotic spindle**, which organizes and moves chromosomes during cell division.

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

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

- They **do not separate** in meiosis-I.
- They **do separate** in meiosis-II.

---

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

Mitosis produces genetically identical cells, helping in **regeneration** of lost tissues like skin, limbs (in some animals), and wound healing.

C. Write Answers in Detail (Enhanced Versions)

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1. Describe the events that occur during the phases of mitosis.

Mitosis is the process of nuclear division that produces two identical daughter cells. It occurs in five main stages:

a) Prophase:

- Chromatin condenses into visible chromosomes.
- Each chromosome appears as two sister chromatids joined at the centromere.
- The nuclear envelope (membrane) starts to disintegrate.

- Centrosomes move to opposite poles, forming the **spindle apparatus** made of microtubules.

b) Metaphase:

- Chromosomes align at the **metaphase plate (equator)** of the cell.
- Spindle fibers attach to the centromere of each chromosome from both poles.

c) Anaphase:

- Centromeres split, and **sister chromatids are pulled apart** toward opposite poles.
- The separated chromatids are now called **daughter chromosomes**.

d) Telophase:

- Chromosomes reach the poles and begin to decondense into chromatin.
- Nuclear membranes reform around each set of chromosomes.
- The spindle apparatus disappears.
- Two distinct nuclei are visible.

e) Cytokinesis:

- Division of cytoplasm follows nuclear division.
- In **animal cells**, it occurs by the formation of a **cleavage furrow**.
- In **plant cells**, a **cell plate** forms which later becomes the new cell wall.

---

2. Describe cytokinesis in animal and plant cells.

Cytokinesis is the final step in cell division where the cytoplasm divides, forming two daughter cells.

In Animal Cells:

- A **cleavage furrow** forms around the center of the cell.
- This furrow is created by a ring of contractile proteins (actin and myosin) that constrict the membrane.
- Eventually, the cell splits into two identical daughter cells.

In Plant Cells:

- Due to the rigid **cell wall**, cleavage cannot occur.
- Instead, a **cell plate** forms in the center of the cell.
- Vesicles from the Golgi apparatus gather in the middle and fuse to form the plate.
- This cell plate becomes a new **cell wall** separating the two daughter cells.

3. Describe the significance of mitosis.

Mitosis plays a vital role in the life of multicellular organisms:

- **Growth:** Helps in the growth of tissues, organs, and the whole organism.
- **Tissue Repair:** Replaces damaged or dead cells (e.g., wound healing).
- **Regeneration:** Enables organisms to regrow lost parts (e.g., starfish arm).
- **Asexual Reproduction:** Unicellular organisms (e.g., amoeba) reproduce through mitosis.
- **Genetic Stability:** Ensures that daughter cells have the **same number of chromosomes** and identical genetic content as the parent cell.

---

4. Describe the events that occur during the phases of meiosis-I.

Meiosis-I is the first division in meiosis and is also called **reductional division** because it halves the chromosome number.

a) Prophase-I:

- Longest and most complex stage.
- Homologous chromosomes **pair up** (synapsis) to form **bivalents or tetrads**.
- **Crossing over** occurs: Exchange of genetic material between non-sister chromatids at points called **chiasmata**, increasing genetic variation.
- Nuclear envelope disappears and spindle fibers begin to form.

b) Metaphase-I:

- Paired homologous chromosomes align at the **metaphase plate**.
- Orientation is random, contributing to **independent assortment**.

c) Anaphase-I:

- Homologous chromosomes are pulled apart to opposite poles.
- **Sister chromatids remain attached** at this stage.

d) Telophase-I and Cytokinesis:

- Chromosomes reach opposite poles.
- Cytoplasm divides, forming **two haploid daughter cells**, each with half the number of chromosomes.

---

5. Describe the significance of meiosis.

Meiosis is crucial for **sexual reproduction** and plays multiple roles:

- **Production of Gametes:** Produces haploid sperm and egg cells in animals and pollen and ovules in plants.
- **Maintains Chromosome Number:** Prevents chromosome doubling in every generation by halving the number in gametes.
- **Genetic Variation:** Through **crossing over** and **independent assortment**, meiosis introduces genetic differences among offspring.
- **Evolution:** These variations are essential for evolution and natural selection.

D. Inquisitive Questions – In Depth Answers

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

Cell cycle checkpoints ensure that cell division occurs properly:

- **G1 checkpoint:** Checks for DNA damage and cell size.
- **G2 checkpoint:** Ensures DNA replication is complete and accurate.
- **M checkpoint:** Checks proper chromosome attachment to spindle.

If any of these checkpoints **fail**, the following may occur:

- Cells with damaged or mutated DNA continue to divide.
- These cells can grow uncontrollably, forming a **tumor**.
- Such uncontrolled cell division is a hallmark of **cancer**.
- For example, mutations in **p53 gene**, a tumor suppressor, remove this checkpoint control.

---

2. Why do skin cells divide continuously, but nerve and muscle cells permanently exit the cell cycle?

- **Skin Cells:**
  - Exposed to constant friction, damage, and wear.
  - To replace dead/damaged cells, they **continuously divide** through mitosis.
  - They remain in the **active cycle** (G1 → S → G2 → M).
- **Nerve and Muscle Cells:**
  - Once fully developed, they become **highly specialized**.
  - Their structure and function do not support regular division.
  - They exit the cycle into **G0 phase (resting phase)** permanently.

- This ensures stable function but **limits regeneration**, making injuries to these cells harder to repair.