EXERCISE — ANSWER KEY

Chapter 4: The Cell Cycle | Fully Solved with Explanations

Every question from the original exercise, answered and explained in an easy, colourful format. Correct MCQ options are ticked in green, with a short reasoning box underneath. Short and detailed answers are boxed for quick revision.

SECTION A — Multiple Choice Questions

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

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

Why this answer? G1 phase is the longest phase of interphase, during which the cell grows in size, produces new proteins and organelles, and carries out most of its normal metabolic activities. This makes it the period of maximum cell growth, before the cell commits to DNA replication in the S phase.

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

a) Mitosis

b) G1 phase

c) G2 phase

✓ **d) S phase**

Why this answer? DNA replication happens specifically during the S (Synthesis) phase of interphase. Each chromosome is copied to form two identical sister chromatids joined at the centromere, doubling the genetic material before the cell divides.

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

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.

Why this answer? Mitosis produces two daughter cells that are genetically identical to the parent cell and have the SAME chromosome number as the parent (not halved). Halving of chromosome number is a feature of meiosis, not mitosis, which is why option (c) is the exception.

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

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

Why this answer? During metaphase, spindle fibres attach to the centromeres of chromosomes and align them precisely along the equatorial plane (metaphase plate) at the centre of the cell, ready for separation.

5. 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

Why this answer? In telophase, the two sets of separated chromosomes reach opposite poles of the cell and the nuclear envelope re-forms around each set, marking the formation of two distinct nuclei before cytokinesis completes cell division.

6. 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

Why this answer? Meiosis-I already reduces the chromosome number by separating homologous chromosomes, but each resulting chromosome still consists of two sister chromatids. Meiosis-II is needed to separate these sister chromatids (much like mitosis), producing four haploid cells each with single-chromatid chromosomes.

SECTION B — Short Answers

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

- The cell increases in size and volume.
- New proteins and cell organelles are synthesized.
- Cell carries out normal metabolic functions and gene expression.
- The cell prepares itself for DNA replication in the coming S phase.

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

- To replicate (duplicate) the DNA of each chromosome.
- Each chromosome forms two identical sister chromatids joined at the centromere.
- This ensures that after division, each daughter cell receives a complete and identical copy of the genome.

3. During which phase of mitosis sister chromatids separate?

- Sister chromatids separate during Anaphase.
- The centromere splits and spindle fibres pull the chromatids toward opposite poles of the cell.

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

- Crossing over occurs during prophase I between non-sister chromatids of homologous chromosomes.
- Segments of DNA are exchanged, creating new combinations of alleles on each chromatid.
- This produces genetically unique chromosomes that did not exist in either parent, increasing variation in offspring.

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

- Spindle fibres (made of microtubules) attach to the centromere/kinetochore of each chromosome.
- They align chromosomes at the metaphase plate.
- They pull sister chromatids apart toward opposite poles during anaphase, ensuring equal distribution of genetic material.

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

- In animal cells, a cleavage furrow forms as the cell membrane pinches inward, splitting the cell into two.
- In plant cells, since a rigid cell wall is present, a cell plate forms in the middle of the cell and grows outward to become a new cell wall separating the two daughter cells.

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

- In mitotic prophase, chromosomes simply condense; there is no pairing between chromosomes and no crossing over.
- In meiotic prophase-I, homologous chromosomes pair up (synapsis) to form bivalents/tetrads, and crossing over takes place between them.
- Prophase-I is much longer and more complex, divided into sub-stages (leptotene, zygotene, pachytene, diplotene, diakinesis), unlike mitotic prophase.

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

- Mitosis produces two daughter cells, each with the same (diploid) chromosome number as the parent cell.
- Meiosis produces four daughter cells, each with half (haploid) the chromosome number of the parent cell.
- This reduction in meiosis is essential to keep the chromosome number constant across generations after fertilization.

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

- The centromere joining each pair of sister chromatids splits.
- Sister chromatids separate and are pulled apart by spindle fibres toward opposite poles.
- The cell begins to elongate as chromosomes move to opposite ends.

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

- The centrosome organizes and nucleates microtubules.
- It forms the mitotic spindle apparatus.
- It ensures spindle fibres are correctly positioned to attach to chromosomes and separate them accurately.

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

- Sister chromatids are two identical copies of a single chromosome, produced by DNA replication in the S phase, joined together at the centromere.
- In meiosis, sister chromatids remain together through meiosis-I and separate during Anaphase-II.

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

- Mitosis produces genetically identical new cells that replace damaged, dead, or lost cells.
- This allows tissues and organs to repair and regrow (e.g., healing of a wound or re-growth of a lizard's tail), which is the basis of regeneration.

SECTION C — Detailed Answers

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

Prophase

- Chromatin condenses into visible chromosomes, each with two sister chromatids.
- The nuclear envelope begins to break down and the nucleolus disappears.
- Spindle fibres begin to form from the centrosomes.

Metaphase

- Chromosomes align along the equatorial (metaphase) plate.
- Spindle fibres attach to the centromere/kinetochore of each chromosome.

Anaphase

- Centromeres split and sister chromatids separate.
- Chromatids are pulled toward opposite poles by the shortening spindle fibres.

Telophase

- Chromosomes reach the poles and begin to decondense.
- Nuclear envelopes re-form around each set of chromosomes, forming two nuclei.
- The spindle apparatus breaks down, and cytokinesis usually follows.

2. Describe cytokinesis in animal and plant cells.

Cytokinesis is the division of the cytoplasm that follows nuclear division, producing two separate daughter cells.

In animal cells

- A contractile ring of actin filaments forms beneath the cell membrane at the equator.
- This ring contracts, pulling the membrane inward to form a cleavage furrow.
- The furrow deepens until the cell is pinched completely into two separate cells.

In plant cells

- Since plant cells have a rigid cell wall, a cleavage furrow cannot form.
- Instead, vesicles from the Golgi apparatus gather at the centre (equator) of the cell to form a cell plate.
- The cell plate grows outward and fuses with the existing cell wall, forming a new cell wall and separating the two daughter cells.

3. Describe the significance of mitosis.

Key significance

- Growth: Increases the number of cells in an organism, allowing multicellular organisms to grow.
- Repair: Replaces old, damaged, or dead cells with new, identical ones.
- Regeneration: Enables organisms to regrow lost body parts or heal wounds.
- Asexual reproduction: Allows many organisms (e.g., yeast, hydra) to reproduce without fertilization.
- Genetic stability: Maintains a constant chromosome number and produces genetically identical (clone) cells.

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

Prophase-I

- The longest and most complex stage; homologous chromosomes pair up in a process called synapsis, forming bivalents (tetrads).
- Crossing over occurs between non-sister chromatids, exchanging genetic material.
- Chromosomes condense and the nuclear envelope begins to break down.

Metaphase-I

- Bivalents (paired homologous chromosomes) align along the metaphase plate.
- Spindle fibres attach to the centromeres of homologous pairs.

Anaphase-I

- Homologous chromosomes (not sister chromatids) separate and move to opposite poles.
- This halves the chromosome number, though each chromosome still has two sister chromatids.

Telophase-I

- Two haploid cells form, each with chromosomes still made of two sister chromatids.
- Nuclear envelopes may re-form before the cell proceeds to meiosis-II.

5. Describe the significance of meiosis.

Key significance

- Gamete formation: Produces haploid sex cells (sperm and egg) needed for sexual reproduction.
- Maintains chromosome number: Halves the chromosome number so that, after fertilization, the offspring has the correct diploid number.
- Genetic variation: Crossing over and independent assortment of chromosomes create new combinations of genes, increasing diversity within a species.
- Evolutionary importance: The genetic variation produced provides the raw material for natural selection and adaptation.

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