Knowledge-based Learning Outcomes

Upon completion of *Mitosis Explored*, students should be able to:

1. Describe the relationship between DNA and chromosomes.
2. Draw and/or label a diagram of a replicated, condensed chromosome, identifying parts of the chromosome and associated proteins needed to understand mitosis (e.g., histones, kinetochore, cohesion, sister chromatids).
3. Identify sister chromatids (where they exist) on diagrams of chromosomes at various stages of mitosis.
4. Describe the state of chromosomes (e.g., position in cell, attachments, condensation), spindle, and nuclear envelope at each stage of mitosis. Similarly, name the stage of mitosis corresponding to a description of a cell's chromosomes, spindle, and nuclear envelope.
5. Describe the role of the spindle and its composition, emphasizing that spindles are composed of many microtubules, and that microtubules are polymers of a protein called tubulin.
6. Describe the overall cell cycle (M, G1, S, G2), indicating when in the cycle DNA is replicated and when mitosis occurs.
7. Describe the overall goal of mitosis in terms of partitioning chromosomes between daughter cells to make genetically equivalent daughter cells.
8. Explain why DNA must be replicated before mitosis begins.
9. Describe the importance of the spindle assembly checkpoint and how it helps to safeguard against aneuploidy.

Skills-based Learning Outcomes

Upon completion of *Mitosis Explored*, students should be able to:

1. Guide a cell through mitosis, correctly specifying the timing and order of the events, including: chromosome condensation, nuclear envelope dissolution, spindle attachments, chromosomes lining up at the cell's midline, sister chromatid separation, and cytokinesis.
2. Predict how mitosis will be affected if one of the major processes (e.g., chromosome condensation, nuclear envelope dissolution, attachment of sister chromatids, formation of spindles, attachment of spindles to chromosomes, dissolution of cohesion, spindle forces) does not happen correctly, or if mitosis is otherwise perturbed.
3. If there is an error in mitosis, predict the consequences of the mistake on the daughter cells and the DNA content (e.g., some DNA is doubled, some chromosomes missing, etc.).
4. Predict which DNA/chromosomes will end up in which cells after mitosis (assuming no errors occur), identifying destinations of sister chromatids, and showing that daughter cells are genetically equivalent.
5. Visually identify stages of mitosis from a photograph/schematic of the nucleus and chromosome attachments/position, and correctly order a sequence of images from mitosis.
6. From a photograph/schematic showing chromosome attachments/position, determine whether a cell can proceed past the spindle assembly checkpoint.
7. Identify the direction that the spindle will move a chromosome at different stages of mitosis.
8. Predict whether a cell is ready to begin mitosis, based on replication state of chromosomes.