Key

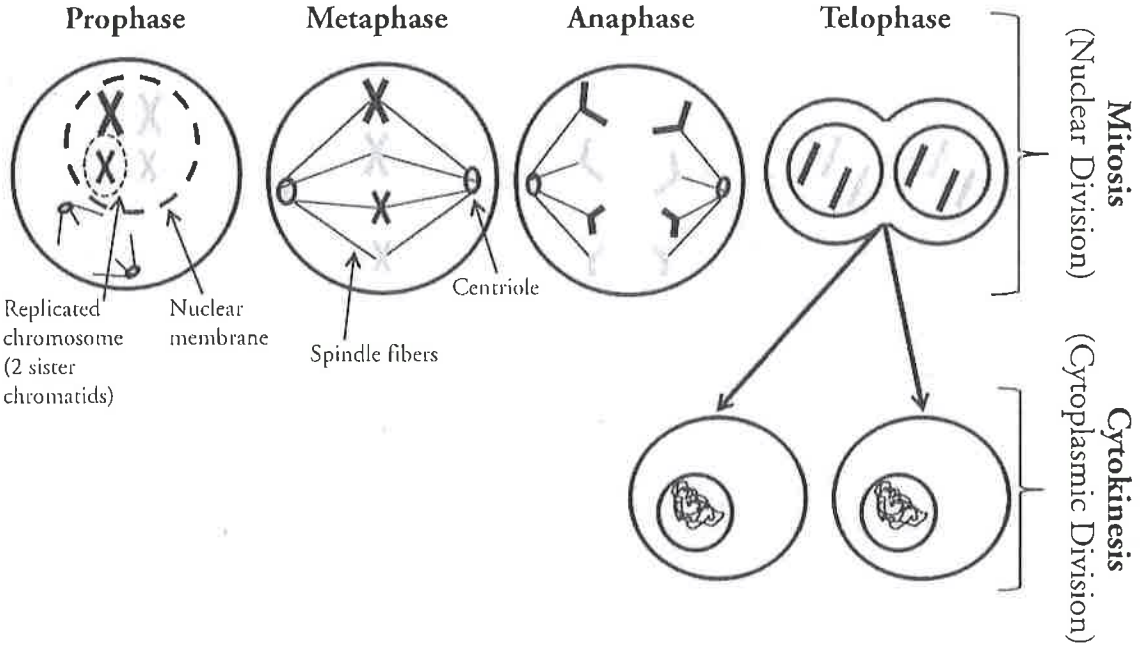
Mitosis & Cell Cycle Regulation

How do living things grow and repair themselves?

Why?

Living things must grow and develop. At times they suffer injuries or damage, or cells simply wear out. New cells must be formed for the organism to survive. What process must occur to make a new, properly-functioning cell?

Model 1 – Mitosis as Part of the Cell Cycle



1. Refer to Model 1. List the four phases in the mitosis process.

   Prophase, metaphase, anaphase, and telophase.

2. Where is mitosis in the cell cycle? Before *G_1, cytokinesis* and after *G_2*.

3. What three phases of the cell cycle are considered **interphase**?

   G_1, Synthesis, and G_2.

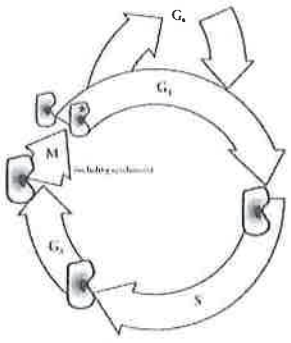
4. Refer to the cell cycle shown.

   a. How many cells are present at the beginning of mitosis?

   One.

   b. How many cells are present at the end of mitosis?

   Two.



5. Refer to the chromosomes in the cells in Model 1.

   a. Draw a single chromosome as it appears in Model 1.

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   b. Draw a replicated chromosome as it appears in Model 1.

   X

   c. How many chromatids are in each replicated chromosome?

   Two chromatids per replicated chromosome.

6. How many replicated chromosomes are in the original cell shown in Model 1 during prophase? *Hint:* When counting chromosomes, count "1" for a pair of sister chromatids.

   Four replicated chromosomes are in the original cell.

7. How many single chromosomes are in each of the new cells in telophase?

   Four single chromosomes are in each of the new cells.

8. As a group, write a grammatically correct sentence that explains what a chromosome is and why it is important.

   A chromosome is made of DNA wrapped around proteins and contains all the genetic information for the organism.

9. Refer to the cells in telophase in Model 1.

   a. Use a complete sentence to describe what the new cells in telophase might contain if replication of chromosomes did not occur before cytokinesis.

   The new cells might contain only half the original number of chromosomes, or one cell might contain more chromosomes than the other if replication did not occur before cytokinesis.

   b. If the situation in part *a* occurred, would the new cells be viable? Explain.

   The cells would not be viable because they would not have a complete set of DNA, which would affect cell processes necessary for survival.

10. The S phase stands for synthesis, which means to make or build something more complex out of simpler parts. Scientists know that during the S phase DNA is being made in the nucleus of the cell. Why do you think the cell needs to make more DNA at this time in the cell cycle?

    The cell must copy the chromosome material so there is enough to make two new cells with the correct chromosome number.

11. Refer to Model 1. The chromosomes that are shaped like "X" (made of two sister chromatids) have double the amount of DNA than the chromosomes that are shaped like "I." During what phase of the cell cycle do you think the chromosomes are replicated (copied)?

    Synthesis.

12. Refer to Model 1.

    a. In which phase of mitosis do you see the spindle fibers forming?

    The spindle fibers start to form in [late] prophase.

    b. At what phase of mitosis do the replicated chromosomes (sister chromatids) separate?

    Anaphase.

    c. In which phase do you see that the spindle fibers have disappeared?

    The spindle fibers disappear during [late] telophase.

    d. Look at metaphase and anaphase. Suggest the purpose of the spindle fibers during mitosis.

    The spindle fibers separate the replicated chromosomes and move each single chromosome to opposite sides of the cell.

13. Refer to Model 1.

    a. Describe what happens to the nuclear membrane after prophase.

    The nuclear membrane is disintegrating.

    b. Explain why it is necessary that the nuclear membrane disintegrates during mitosis.

    The nuclear membrane must be temporarily removed so the chromosomes can be divided into the two cells.

    c. At what point during mitosis has the nuclear membrane reformed?

    The nuclear membrane reforms during telophase.

14. What is actually dividing during cytokinesis?

    The cytoplasm of the cell and its non-nuclear contents are dividing in cytokinesis.

15. Cellular division has two parts—mitosis is the division of the nucleus and cytokinesis is the division of the cell into two new cells. Explain why mitosis has to come before cytokinesis in the cell cycle.

    The contents of the nucleus must be duplicated and the chromosomes must be correctly divided up before the actual cell can divide into two new cells.

16. During cytokinesis the chromosomes unwind and become a pile of very long, thin, thread-like DNA and the cell goes back to looking "normal" until mitosis begins again. Brainstorm with your group ideas why the DNA must coil up into chromosome structures before it divides.

    Students should understand the concept that it would be very difficult to accurately divide long, thin threads of DNA rather than smaller, more compacted chromosomes.

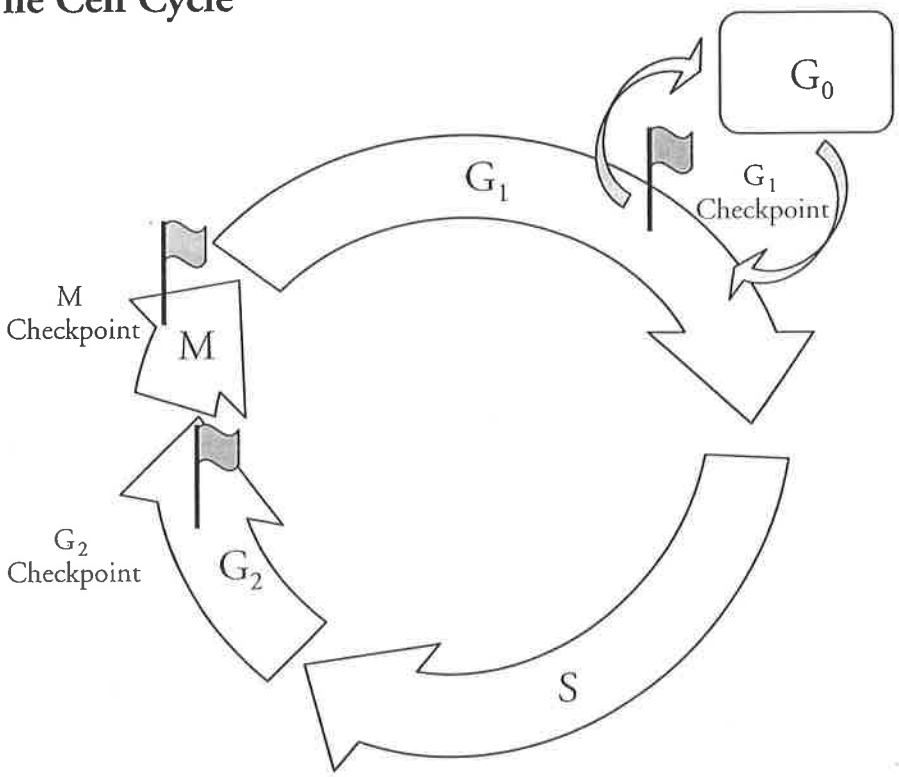
Cell Cycle Regulation

How does a cell know it is time to divide?

Why?

Quality control inspectors typically do not limit their product testing to the final product at the end of the assembly line. They monitor all aspects of production in hopes of preventing larger problems down the line. Likewise, when cells are progressing through the cell cycle there are processes in place that check on the cell's progress. Is everything happening according to plan? Are there sufficient resources to complete the task of cell division? Tightly regulating the cell cycle keeps a multicellular organism healthy by conserving materials. This ensures that new cells receive accurate genetic information, and also prevents uncontrolled growth that may lead to diseases like cancer.

Model 1 – The Cell Cycle



1. Review the phases of the cell cycle in Model 1 by placing the abbreviated phase name (G_1, S, G_2 or M) next to the proper description.

G_1	The cell grows by producing more proteins and organelles.
S	DNA replication occurs.
G_2	The cell prepares for cell division with the appearance of centrosomes.
M	Mitosis and cytokinesis occurs.

2. Some cells, like mature nerve cells or muscle cells, do not divide. Other cells will divide only when the cellular environment signals that it is necessary. According to Model 1, what "phase" of the cell cycle are these cells said to be in when they are not dividing or planning to divide?

When cells are not dividing or planning to divide, they go into a "phase" called G_0.

3. There are three regulatory checkpoints built into the cell cycle.

a. Name the three checkpoints as shown on Model 1.

G_1 checkpoint, G_2 checkpoint, and M checkpoint.

b. Indicate the phase of the cell cycle, and what part of the phase (early or later), where each checkpoint occurs.

The G_1 checkpoint occurs in the later part of G_1.

The G_2 checkpoint occurs in the later part of G_2.

The M checkpoint occurs in the later part of Mitosis.

4. Progression through the cell cycle is dependent on both extra- and intra- cellular conditions. Consider the following conditions. Indicate which checkpoint(s) most likely responds to that condition.

a. The DNA has been completely replicated and checked for errors.

G_2 checkpoint.

b. There is ample supply of energy and raw materials available.

G_1 and G_2 checkpoints.

c. All chromosomes are attached to the spindles.

M checkpoint.

d. There is adequate room in the environment for more cells.

G_1 checkpoint.

5. Which checkpoint appears to regulate whether the cell is in G_0 or not?

The G_1 checkpoint is the point in the cycle where the cell goes into or out of G_0.

6. Predict the result of a mutation that allows a cell to move past checkpoint G_1 even though the cell has not grown sufficiently.

The daughter cells would be small and possibly not able to store enough nutrients within the cell to survive.

7. Predict the result of a mutation that allows a cell to move past checkpoint G_2 even though DNA replication has not been completed.

The DNA in the daughter cells would not be complete and the cells would not survive.

8. Predict the result of a mutation that allows a cell to move past checkpoint M even though the chromosomes were not prepared for division.

The chromosomes might end up in the wrong daughter cell. For example, one cell might get both copies of a chromosome while the other gets none.

STOP