

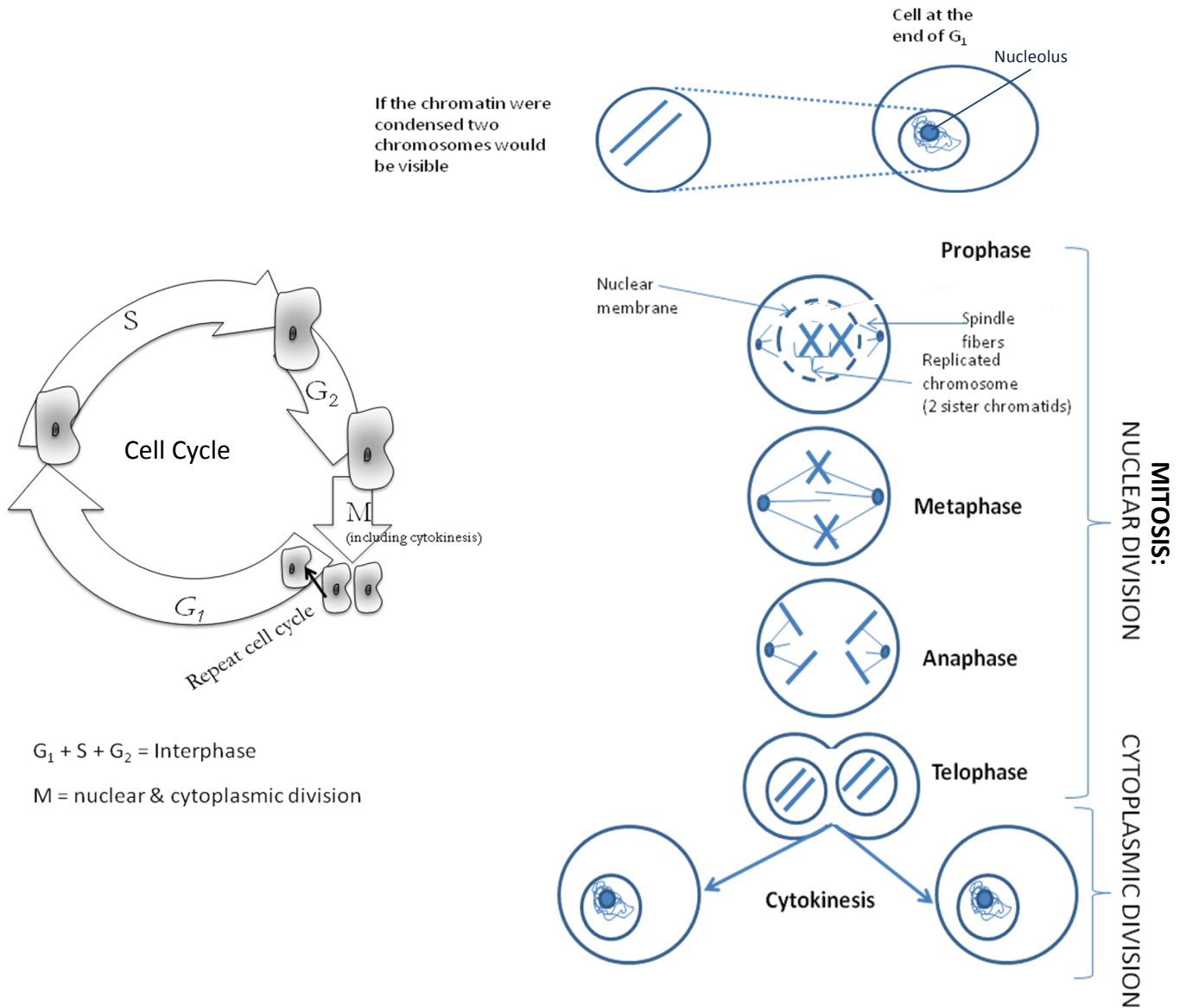
Mitosis

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 living thing to survive.

Model 1



1. List the phases in the mitosis process by looking at Model 1. There are four phases.

2. Where is mitosis in the cell cycle? Before _____ and after _____

3. What three phases of the cell cycle are considered “interphase”?
4. a) How many cells are present at the end of G₂?
b) How many cells are present at the end of M?
5. What shape do the replicated chromosomes look like in prophase of the original cell?
6. How many chromatids are in each replicated chromosome?
7. How many replicated chromosomes are there in the original cell during prophase? (Hint: When counting chromosomes, count “1” for a *pair* of sister chromatids)
8. How many single chromosomes are there in each of the new cells in telophase?
9. Your answers to 7 and 8 should be the same. Why is this important?



Read This!

Chromosomes are made of DNA wound around proteins. They contain all the genetic information of the living organism. Before the cell divides the chromosomes in the original parent cell must first be doubled (replicated). This happens so that when the cell divides into two new cells, both will be identical to the parent cell.

10. As a group, write a grammatically correct sentence that explains what a chromosome is and why it is important.
11. The chromosomes that are shaped like “**X**’s” (made of two sister chromatids) have double the amount of DNA than the chromosomes that are shaped like “**T**’s”. During what phase of the cell cycle do you think the chromosomes are replicated (copied)?
12. Describe the difference in appearance between the chromosomes during prophase in the original cell and the chromosomes in the two new cells in telophase.
13. The **S** phase stands for **synthesis**, which means to make something. 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?
14. At what stage of mitosis do the replicated chromosomes (sister chromatids) separate?



15. During what phase do you see the spindle fibers forming?
16. During what phase do you see that the spindle fibers have disappeared?
17. Look at metaphase and anaphase. What do you think the function of the spindle fibers is during mitosis?
18. Describe happens to the nuclear membrane after prophase.
19. Why do you think it is necessary to disintegrate the nuclear membrane during mitosis?
20. By the end of what phase of mitosis has the nuclear membrane reformed?
21. What structure reappears in the nucleus after cytokinesis?
22. What is actually dividing during cytokinesis?
23. 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.
24. During cytokinesis the chromosomes unwind and become a pile of very long, thin, threadlike DNA and the cell goes back to looking “normal” until mitosis begins. Brainstorm with your group ideas why the DNA must coil up into chromosome structures *before* it divides.
25. Make a table below where you list each of the phases of nuclear and cell division in the left hand column and a word description of what is happening during that phase in the right hand column.





Phase of Cellular Division	Word description of what is occurring in the cell during this phase.
P	
M	
A	
T	

C	

26. In some cells, mitosis occurs WITHOUT cytokinesis. What would the resulting cell look like?

27. Explain the importance of mitosis of cells in a skinned knee and during the growth of a plant.

  28. With your group consider the effect on a cell if the sister chromatids did not line up correctly during metaphase. For example if some lined up side by side instead of single file along the middle, how might this affect the resulting cells?

Extension Questions

29. Colchicine is a poison that acts to inhibit the development of spindle fibers. Describe the effects on mitosis in a cell that has been treated with colchicine.

30. Binary fission is cell division in prokaryotic organisms (bacteria), which have no nucleus. In addition, prokaryotic cells typically have only one circular chromosome. Together with your group, predict how binary fission in prokaryotic cells might be different than mitosis in eukaryotic organisms.

Teacher Resources

Learning Objectives:

1. Students will visualize mitosis as part of the cell cycle.
2. Students will list and summarize the phases of mitosis.
3. Students will explain the importance of mitosis in the life of a cell and for the survival of the living organism.

Prerequisites:

1. Students should have background knowledge of cell anatomy and physiology, and know the difference between eukaryotic and prokaryotic cells.
2. Students should have been introduced to the cell cycle.

Assessment Questions:

1. Which of the following is true concerning mitosis and the cell cycle?
 - a. Mitosis occurs immediately before S phase
 - b. Mitosis occurs immediately after cytokinesis
 - c. Mitosis occurs after G₂ and before cytokinesis
 - d. Mitosis occurs in between G₁ and G₂.
2. The phases of mitosis in the correct order are:
 - a. prophase, telophase, anaphase and metaphase
 - b. prophase, metaphase, anaphase, and telophase
 - c. telophase, anaphase, prophase, and metaphase
 - d. metaphase, anaphase, prophase, and telophase
3. Describe two situations in normal human life when mitosis would be critically important.

Teacher Tips:

- Students may be confused by the terms “chromatids” and “chromosomes”
- Make sure students understand that the DNA is copied during S phase. The chromosomes are still “uncoiled” as chromatin material. The replicated chromosomes are not seen until prophase when they coil up.
- If you unwound all the DNA in EACH human cell and laid the chromosomes end to end, it would be approximately 2 meters long!

Assessment Target Responses:

1. c
2. b
3. Students may list cuts, broken bones, replacing worn out cells and/ or growth. Students should explain that replacing worn out cells, growth, or healing would all require cells to reproduce. In order for cells to reproduce, they must first copy their DNA so the new cells are identical to the original parent cells.

Target Responses:

1. List the phases in the mitosis process by looking at Model 1. There are four phases. *Prophase, metaphase, anaphase, and telophase.*
2. Where is mitosis in the cell cycle? *Before G1/cytokinesis and after G2*
3. What three phases of the cell cycle are considered “interphase”? *G1, S and G2*
4. How many cells are present at the end of G2? *1* How many cells are present at end of M? *2*
5. What shape do the replicated chromosomes look like in prophase of the original cell? *They look like X's.*
6. How many chromatids are in each replicated chromosome? *2 chromatids per replicated chromosome.*
7. How many replicated chromosomes are there in the original cell during prophase? (Hint: When counting chromosomes, count “1” for a pair of sister chromatids) *There are 2 replicated chromosomes in the original cell.*
8. How many single chromosomes are there in each of the new cells in telophase? *2 single chromosomes in each of the new cells.*
9. Your answers to 7 and 8 should be the same. Why is this important? *The number of chromosomes in the new cells must be the same as the number of chromosomes in the original parent cell. The original parent cell has two replicated chromosomes and the two new cells each have two single chromosomes.*
10. 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.*
11. The chromosomes that are shaped like “X’s” (made of two sister chromatids) have double the amount of DNA than the chromosomes that are shaped like “I’s”. During what phase of the cell cycle do you think the chromosomes are replicated (copied)? *S*
12. Describe the difference in appearance between the chromosomes during prophase in the original cell and the chromosomes in the two new cells in telophase. *The chromosomes in the original cell have been duplicated as so look like X's. These chromosomes are split during mitosis to make single chromosomes which look like I's.*
13. The **S** phase stands for **synthesis**, which means to make something. 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 that there is enough to make two new cells with the correct chromosome number.*
14. At what stage of mitosis do the replicated chromosomes (sister chromatids) separate? *anaphase*



15. During what phase do you see the spindle fibers forming? *Start to form in [late] prophase.*
16. During what phase do you see that the spindle fibers have disappeared? *The spindle fibers will disappear during [late] telophase.*
17. Look at metaphase and anaphase. What do you think the function of the spindle fibers is during mitosis? *The spindle fibers separate the replicated chromosomes and move each single chromosome into each of the two new cells.*
18. Describe what happens to the nuclear membrane after prophase. *The nuclear membrane is disintegrating.*
19. Why do you think it is necessary to disintegrate the nuclear membrane during mitosis? *The nuclear membrane must be temporarily removed so the chromosomes can be divided into the two cells.*
20. By the end of what phase of mitosis has the nuclear membrane reformed? *The nuclear membrane reforms during telophase.*
21. What structure reappears in the nucleus after cytokinesis? *Nucleolus.*
22. What is actually dividing during cytokinesis? *The cell and its non-nuclear contents are dividing in cytokinesis.*
23. 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 chromosomes must be correctly divided up and the nucleus duplicated before the actual cell can divide into two new cells.*
24. During cytokinesis the chromosomes unwind and become a pile of very long, thin, threadlike DNA and the cell goes back to looking “normal” until mitosis begins. 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.*
25. Make a table below where you list each of the phases of nuclear and cell division in the left hand column and a word description of what is happening during that phase in the right hand column.



Phase of Cellular Division	Word description of what is occurring in the cell during this phase.
<i>Prophase</i>	<i>Replicated chromosomes become visible (coil up). Each replicated chromosome is made of two identical chromatids. The spindle fibers start to form and the nuclear membrane starts to disintegrate.</i>
<i>Metaphase</i>	<i>Replicated chromosomes line up in the center of the cell. Spindle fibers attach</i>

	<i>to the replicated chromosomes at their center.</i>
<i>Anaphase</i>	<i>Spindle fibers separate the replicated chromosomes (sister chromatid pairs) into single chromosomes and move them to the opposite sides of the cells.</i>
<i>Telophase</i>	<i>The single chromosomes are now in two “piles” which will become two new nuclei. A new nuclear membrane begins to form around each of the piles of separated chromosomes.</i>
<i>Cytokinesis</i>	<i>The original cell pinches in two and makes two 2 new cells.</i>



26. In some cells, mitosis occurs WITHOUT cytokinesis. What would the resulting cell look like? *If mitosis occurred without cytokinesis, there would be multinucleated cells.*

27. Explain the importance of mitosis of cells in a skinned knee and during the growth of a plant. *In order for a skinned knee to heal, new cells must be formed. In order for a plant to grow, new cells must form. The process of new cells forming includes mitosis, where the chromosomes must be carefully divided into the new cells so they are identical to the original cell.*



28. With your group consider the effect on a cell if the sister chromatids did not line up correctly during metaphase. For example if some lined up side by side instead of single file along the middle, how might this affect the resulting cells? *If the division of chromosomes is not accurate, cells could end up with too few or too many chromosomes. This could lead to the death of the cell or a mutation.*

29. Colchicine is a poison that acts to inhibit the development of spindle fibers. Describe the effects on mitosis in a cell that has been treated with colchicine. *When a cell is treated with colchicine, the spindle fibers would NOT be form correctly. So the chromosomes would not be able to be divided correctly or be moved to the correct positions in the dividing cell.*

30. Binary fission is cell division in prokaryotic organisms (bacteria), which have no nucleus. In addition, prokaryotic cells typically have only one circular chromosome. Together with your group, predict how binary fission in prokaryotic cells might be different than mitosis in eukaryotic organisms. *Binary fission is more simplified than mitosis in eukaryotic organisms because there is no nucleus or multiple chromosomes. In binary fission the single chromosome would be copied and the cell pinches into two cells, each with a single chromosome. This is more simple operation than mitosis, where multiple, replicated chromosomes must carefully be split and moved into two equal “piles” which will become the two new cells after cytokinesis is complete.*