

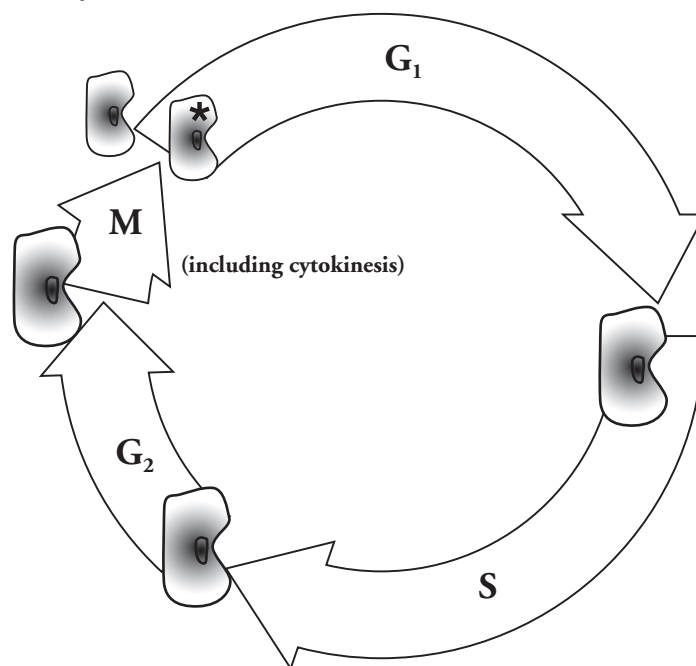
The Cell Cycle

What controls the life and development of a cell?

Why?

An old piece of poetry says “to everything there is a season... a time to be born, a time to die.” For cells, the line might say “a time to divide and a time to grow.” In multicellular organisms, different types of cells have different roles and need to complete specific tasks. For example, a cell that isn’t large enough is not useful for storing nutrients for later, but a cell that is too large will not be useful for transportation through a tiny capillary. In this activity, you will learn about the seasons of a cell’s life, and in turn better understand how organisms function.

Model 1 – The Cell Cycle



1. How many phases are in the cell cycle as shown in the diagram in Model 1?
2. Starting at the starred cell, what is the order of the stages of a cell’s life?
3. During which phase does the size of the cell increase?
4. During which phase does the number of cells increase?

5. Considering your answer to Questions 3 and 4, identify two ways that the growth of an organism can be accomplished through the events of the cell cycle.



6. Cancer, the uncontrolled growth of cells, often results in a tumor, or mass of abnormal cells. Some cancerous tumors consist of many cells that are much smaller than normal. According to Model 1, what part(s) of the cell cycle is (are) most likely being affected?
7. In Model 1, if the length of the arrow represents time, then for those cancerous cells, what happens to the time that is necessary for the cell cycle? What implication might this have for doctors who are treating cancer patients?


Model 2 – Cell Cycle Data

| Phase | Key Process | Time Interval (hours) | Sets of DNA present in each cell at end of phase | Number of organelles in each cell at end of phase |
|------------------|---------------------------------|-----------------------|--|---|
| Gap ₁ | | 11 | 1 | 560 |
| Synthesis | | 8 | 2 | 570 |
| Gap ₂ | Protein and organelle synthesis | 4 | 2 | 600 |
| Mitosis | Cell and nuclear splitting | 1 | 1 | 300 |
| | Total time: | 24 | | |

8. Model 2 presents cell cycle data for a typical human cell in culture. Use the phase names in Model 2 to label the G, M, and S phases in Model 1.
9. Looking at the third column of Model 2, compare the time spent in mitosis with the time spent in gap₁ in human cells and describe any difference.

10. Imagine 100 cells were chosen randomly from a tissue sample and examined under a microscope. In which phase of the cell cycle would you expect to find the largest number of cells? Explain.



11. Look again at Model 2. Compare the amount of DNA at the beginning and end of synthesis. Why did the amount of DNA change?
12. Fill in the “Key Process” column for synthesis phase in Model 2.
13. *Cyto* = cell, *kinesis* = cutting. What do you think takes place during cytokinesis?
14. Other than cytokinesis, what else occurs during the mitosis phase? *Hint*: Consider the sets of DNA in each cell.
15. Look carefully at information given to you in Model 1 and Model 2. Fill in the key process column in the table for gap_1 .
16. If a culture in the lab starts with one human cell, how many cells will there be after 24 hours?
17. The total time for the phases listed in Model 2 is 24 hours. How many human cells will be in the culture after another 24 hours? Explain.
-  18. Is the original cell “dead” or does it disappear after mitosis? Explain your answer.
19. If a starfish sustains damage to a limb, it often grows a new one. If a human adult sustains damage to his or her spinal cord, mobility is often impaired. If a gecko loses its tail, it may grow a new one. Which type of cell is less likely to go through the cell cycle after being damaged—starfish limb, human spinal cord, or gecko tail? Support your answer.
20. Occasionally cells stop dividing and enter another phase, G_0 . If you damage your liver, new liver cells can be produced to replace up to 75% of the liver. However, if you sustain brain damage, your body does not produce new brain cells. Explain this observation using what you have learned about the cell cycle.

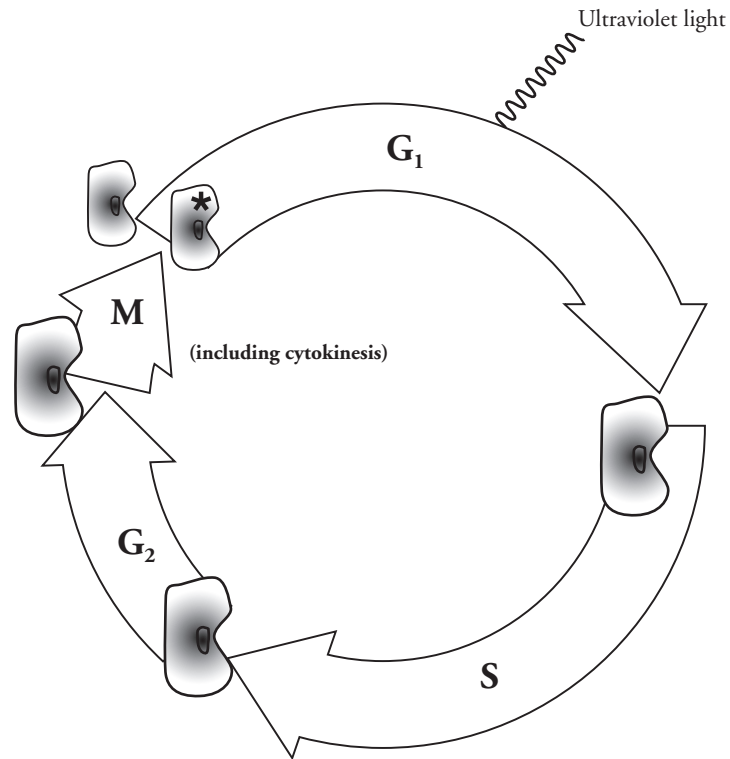



21. Keeping in mind the events of each part of the cell cycle, mark with a double arrow on Model 1 where those cells might (either temporarily or permanently) exit the cell cycle to G_0 . Label this as G_0 . Why did you choose this location for G_0 ? *Hint:* Think of a place in the cell cycle where the cell is functioning normally, but not preparing to divide.



22. Consider a cell in G_0 . Use the information in both Models 1 and 2 to answer the following questions.
- In order for this cell to divide normally, what would need to occur?
 - What if the phase(s) you identified in part *a* of this question did not occur? What would be the outcome for the cell in that case?

Model 3 – Radiation



 23. According to Model 3, ultraviolet light is affecting a cell in which phase of the cell cycle?

24. Ultraviolet light may cause DNA damage, which is known as a mutation. How might such damage affect events taking place during the synthesis phase? *Hint:* Use information from Model 2.

Read This!

The cell cycle has a regular system of checks and balances that prevents damaged or mutated cells from proceeding to the next phase. One way an organism deals with the problems is to kill the damaged cell before it passes on the problem to its daughter cells. This is a normal process called **apoptosis**. (Some normal cells also go through this process.)

25. How might the DNA damage go on to affect the rest of the cell cycle if apoptosis did not occur?

26. Why might it be beneficial to an organism for damaged cells to enter G₀ instead of dividing once they exist?

27. What could happen, after several cell cycles, to an organism whose damaged cells did not go through apoptosis? In other words, what if a damaged cell that is supposed to die does not?

Extension Questions

28. For each phase, describe at least one way mistakes during the cell cycle could result in problems.

| | |
|-------|--|
| G_1 | |
| S | |
| G_2 | |
| M | |
| G_0 | |

29. Some types of cancers are treated with radiation, similar to ultraviolet light. Why might it be beneficial to irradiate cancer cells?

30. Plasmodial slime mold is an example of a multinucleated cell. It can be referred to as “one huge cytoplasmic mass with many nuclei” as seen to the right. What part of Model 1 is skipped in the formation of such a cell? Explain your answer.



31. Chemotherapy utilizes chemicals that disrupt various parts of the cell cycle, targeting rapidly growing cells. Paclitaxel (Taxol®) is one such drug that prevents the mitosis phase from taking place.

- Explain how this drug is useful as a cancer treatment.
- How might targeting rapidly growing cells explain common chemotherapy side effects such as hair loss and nausea?