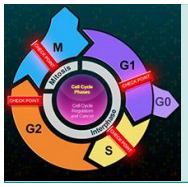


The Eukaryotic Cell Cycle and Cancer In Depth

hhmi | BioInteractive

Click & Learn
Student Worksheet

INTRODUCTION

This handout complements the Click & Learn *The Eukaryotic Cell Cycle and Cancer* and is intended as an in-depth examination of the cell cycle and the protein players involved. For a more general overview, please see the overview version.

PROCEDURE

Follow the instructions as you proceed through the Click & Learn and answer the questions in the spaces below.

Click on the "Background" tab on the right side.

1. Compare and contrast the reasons cell division is important for unicellular (single-celled) and multicellular organisms.

2. Provide an example of why cell division remains important to an adult organism even after it is fully developed.

3. What is the role of growth factors?

4. Cells divide, differentiate, or die. What is differentiation?

5. What is apoptosis? Explain its purpose.

6. Organisms maintain the right number of cells by regulating the cell cycle. What are "cell cycle regulators?"

7. *Watch the video clip of cells in the small intestine.* Name the general location along the villus where the following processes occur:

   Cell Division:

   Cell Differentiation:

   Apoptosis:

8. Name one harmless result of too little cell division.

9. Name one harmless result of too much cell division.

Click on the section of the circle labeled "Cell Cycle Phases" in the center purple circle on the right and use the "Overview" information in the window on the left to answer the questions below.

10. List, in order, the four events we collectively call the "cell cycle." Next to each event, write the correlating cell cycle phase name.

    a.

    b.

    c.

    d.

11. In general, what is the purpose of a checkpoint in the cell cycle?

12. What is one potential outcome when errors occur in this highly regulated cell cycle process?

Click on "Cell Cycle Regulators and Cancer" in the center purple circle on the right. Use the information under "Regulators Overview" in the window on the left to answer the questions below.

13. What type of protein that regulates the cell cycle is encoded by proto-oncogenes?

14. What type of protein that regulates the cell cycle is encoded by tumor suppressor genes?

15. The most important cell cycle regulators are the _____ .

16. What is a kinase, and what does it do?

17. When are CDKs present inside the cell during the cell cycle?

18. When are cyclins present inside the cell during the cell cycle?

19. CDKs form molecular complexes with cyclins. What do activated CDK-cyclin complexes do?

Using the cell cycle diagram on the right and both links in the center purple circle, complete the table below for each phase. Use bullet points and focus on major events that occur during each phase, checkpoint, and regulatory process. Complete the entire row before moving on to the next phase.

PHASE	PHASE EVENTS	CHECKPOINT EVENTS	REGULATORY PROCESSES
G1			
S			
G2			
M (mitosis)			

20. *Go to "Cell Cycle Phases" and click on "Interphase."* The interphase alternates with mitosis. What happens during interphase and what phases does it include?

21. *Go to "Cell Cycle Phases" and click on "G0."* The G0 phase is a resting or nondividing stage. What three factors determine if a cell enters G0?

22. Provide an example of a fully differentiated cell that is (a) permanently in G0 and (b) one that can leave G0 to progress through the cell cycle and divide again.

    a.

    b.

Click on "Cell Cycle Regulators and Cancer" in the center purple circle on the right. Then click on the "Cancer Overview" tab in the window to the left (right tab).

23. Cancer is an improperly regulated cell cycle. Name two reasons why cells can form tumors.

24. What causes uncontrolled cell division at the genetic level?

25. *Watch the video clip.* At the cellular level in this example, explain what occurs if the *APC* gene is mutated.

26. Normally, proto-oncogenes stimulate the cell cycle. What do mutated proto-oncogenes (i.e., oncogenes) cause?

27. Normally, tumor suppressor genes inhibit the cell cycle. What do mutated tumor suppressor genes cause?

28. To cause cancer, proto-oncogenes require ___ 1 (or) ___ 2 allele(s) to be mutated and are therefore considered ___ dominant (or) ___ recessive. This results in a _____ of function.

29. To cause cancer, tumor suppressor genes require ___ 1 (or) ___ 2 allele(s) to be mutated and are therefore considered ___ dominant (or) ___ recessive. This results in a _____ of function.

30. *Watch the video clip*.
    a. Using the gas pedal analogy, explain the impact on the cell cycle of a proto-oncogene versus an oncogene.

    b. Using the brake pedal analogy, explain the impact on the cell cycle of *one* mutated tumor suppressor gene allele versus *two* mutated tumor suppressor alleles.

ADVANCED EXTENSION QUESTIONS (OPTIONAL)

Now that you have finished the Click & Learn, use your knowledge to answer the following questions.

31. p53 is a protein that is encoded by a tumor suppressor gene, and some scientists refer to it as "the guardian of the genome."

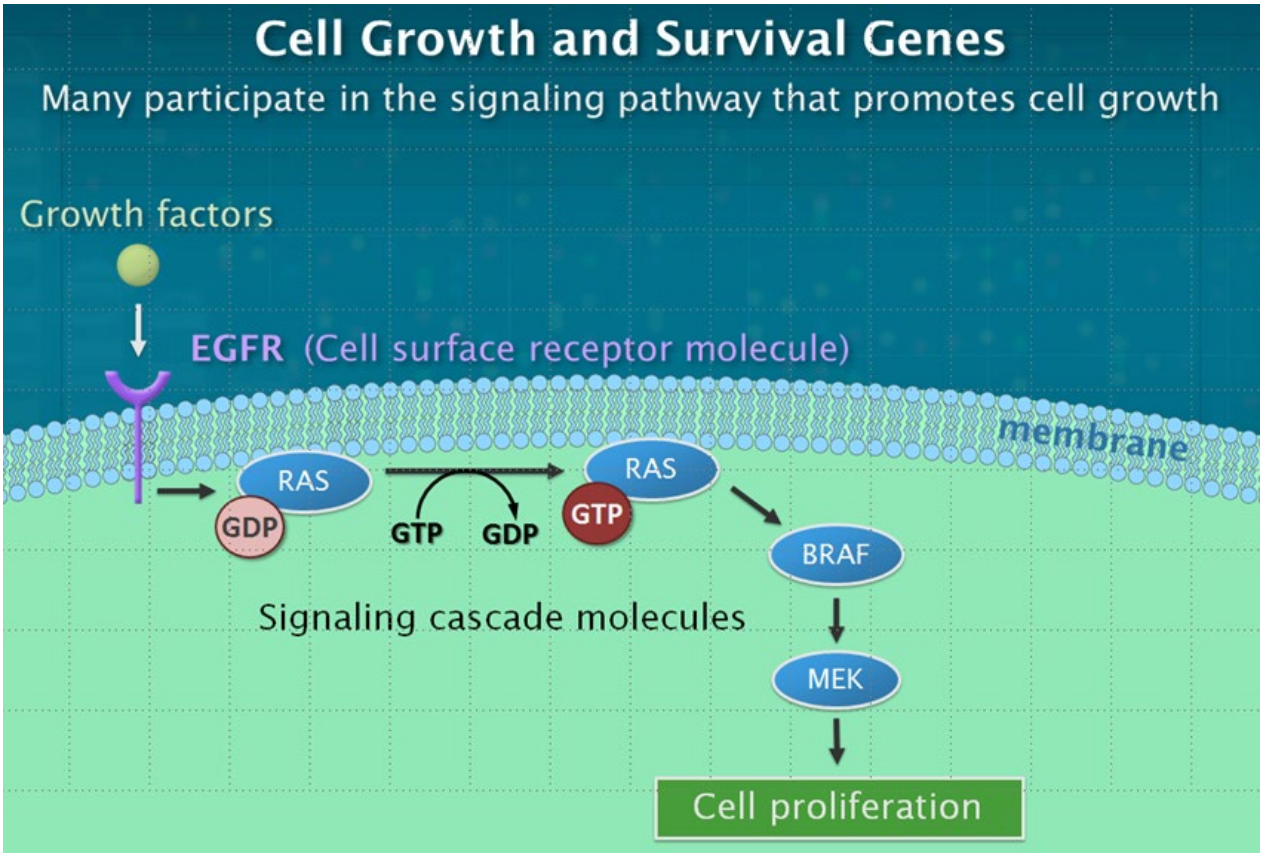
    a. Explain its normal role and why scientists would regard it as the "guardian of the genome."

    b. Explain what happens to the cell cycle if both alleles of the gene encoding p53 are mutated.

32. Explain why people who inherit one mutated allele of the *BRCA1* gene have a higher likelihood of developing cancer.

33. Predict a potential outcome of a mutated mitotic arrest deficient (MAD) protein.

34. Use the model illustrated in the figure below to answer the accompanying questions.



a. The human gene *EGFR* located on chromosome 7 is a proto-oncogene that codes for a growth factor cell surface receptor. The binding of growth factors to this receptor can lead to cell proliferation. Hypothesize what potential impact a mutated *EGFR* allele will have on a cell. Give one possible impact and explain your answer.

b. RAS is a G protein that is activated when a growth factor attaches to EGFR. Its activation results in the exchange of GTP for GDP. Once activated, the GTP cannot be hydrolyzed and RAS cannot be deactivated What is one potential outcome of a mutation in one of the two copies of RAS?

c. Mutations in the genes that code for proteins in this pathway have been linked to various types of cancer (i.e., RAS: pancreatic, BRAF: colorectal, MEK: melanoma, EGFR: lung). If you were developing a new cancer drug, what would be an appropriate target protein for the new drug therapy? Justify your answer.