Course Materials for Week 9: Cell Cycle

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Assignment Questions

1. What are the four phases of the cell cycle and what happens during each phase?
2. What are the experimental advantages of studying the cell cycle in S. cerevisiae (select all that apply)?
    a. have short generation times
    b. can tell the stage of the cell cycle based on the bud size
    c. genome is already sequenced
    d. can use genetic techniques to isolate mutants
    e. none of the above
3. What is the major difference between the budding yeast cell cycle and the Xenopus cleavage division cell cycle?
4. What are the two major proteins that make up the cell cycle oscillator? _____ and _____
5. Where does the cell cycle arrest:
    a. if DNA replication is not completed during S-phase
    b. all the chromosomes are not bipolarly attached and under tension
    c. What is the name used to describe the mechanisms that monitor these events?
6. Why does the activity of cyclin-dependent kinases oscillate in the cell cycle (provide two reasons)?
7. How does the APC control the concentration of securin at anaphase onset and how does this lead to anaphase outset?
8. When a cell commits itself to progression through a cell-cycle transition like the metaphase-anaphase transition, it does so in an all-or-none, irreversible manner. Why is it important for the cell to make these total commitments?

Assignment Answers

1.
    a. G1: cell growth/differentiation before DNA duplication
    b. S-phase: DNA synthesis
    c. G2: further growth after DNA duplication, allowing the cell to make all components necessary for the cell division process
    d. M-phase: phase where duplicated chromosomes are segregated and packaged into genetically identical daughter cells

2. a, b, c, and d

3. Yeast undergo G1, S, G2, M phase during the cell cycle, Xenopus eggs only go through S and M phase

4. Cyclin and CDK

5.
    a. G2/M transition
    b. Metaphase (before the metaphase-anaphase transition)
    c. Checkpoints

6. Cdk oscillations depend primarily on changes in the cellular concentration of cyclins, Cdk activity is also regulated by phosphorylation at inhibitory and stimulatory sites on the Cdk subunit, Cdk activity is also regulated by inhibitory proteins that bind and inhibit cyclin-Cdk complexes at certain cell-cycle stages.

7. The APC attaches ubiquitin to its target proteins, which includes securin. The attachment of multiple ubiquitins to a protein, often in the form of ubiquitin chains, results in the protein being recognized by a large, multi-subunit protease called the proteasome. The proteasome binds the ubiquitinated protein, unfolds it, and chops it into short pieces.

    Securin binds and inhibits the protease separase, so when securin is destroyed by the APC in metaphase, separase becomes activated. Separase cleaves the protein cohesion, which is the protein that holds the sister chromatids together. This allows the sister chromatids to separate to opposite ends of the cell.

8. The simplest way to think about this question is to imagine what would happen if the cell initiated a cell cycle event only partly and then gave up and turned back. What would happen, for example, if a cell began to separate its sister-chromatid

pairs but then returned to metaphase: the result would likely be lethal errors in chromosome segregation due to partial separation of some but not all chromosomes. Similarly, it is very dangerous for a cell to initiate chromosome duplication and then turn back, because the cell would then contain some chromosome regions that are duplicated and some that are not, and re-entry into S phase under these conditions might eventually lead to errors when these unevenly duplicated chromosomes were pulled apart by the mitotic spindle