AP BIOLOGY · UNIT 4 · TOPIC 4.6

Regulation of Cell Cycle

Learning objective 4.6.A Describe the events that occur at checkpoints in the cell cycle.

Name: Date: Period:

Use the tool **Permission to Divide**. Part 1 uses **Try to get through**, Part 2 uses **Cyclin and CDK** and Part 3 uses **When a checkpoint fails**. Throughout, keep one idea in mind: a cell does not divide because it **can**. It divides because nothing stopped it.

Part 1 · Where does the cell get stuck?

Open **Try to get through** and press **Everything in order**. Then switch off one condition at a time, and switch it back on before the next. For each condition, predict where the cell will stop before you switch it off, then record the Stopped by readout.

Condition switched off	Predicted stop	Actual stop	Why that checkpoint asks about it
The cell has grown large enough to divide			
Nutrients and energy are available			
A growth signal from other cells has arrived			
The DNA is undamaged			
Every chromosome has been completely and correctly replicated			
Every chromosome is attached to spindle fibers from both poles			

1. One condition is checked at two different checkpoints.
(a) Identify the condition and the two checkpoints at which it is checked.

(b) Explain why it is useful to check this condition at both checkpoints.

2. Switch off only the condition “Every chromosome is attached to spindle fibers from both poles.” The cell passes the G1 and G2 checkpoints and stops at the spindle checkpoint. Explain why the G1 and G2 checkpoints do not stop the cell.

Part 2 · Which line decides the timing?

Switch to **Cyclin and CDK**. Leave the Cyclin needed to drive the transition slider at **0.70** and drag **Where in the cycle you are looking** to each tick in the table, and record the Cyclin here, CDK here and Complex activity readouts.

Tick	Cyclin	CDK	Complex activity
0			
20			
42			
60			
70			
85			

3. Compare tick 20 with tick 60 in the Part 2 table.
(a) Identify the quantity that is the same at both ticks.

(b) Identify the two quantities that differ between the two ticks.

(c) Explain what this comparison shows about which molecule sets the timing of the transition.

4. Set the Cyclin needed to drive the transition slider to 0.30, and then to 0.90.
(a) Identify the value of the Active for readout at each setting.

(b) Describe the effect of raising the threshold on the length of the active window.

(c) Explain this effect using the shape of the cyclin curve.

Part 3 · Four things that can happen next

Switch to **When a checkpoint fails**. A cell reaches the G1 checkpoint with damaged DNA. Select each of the four outcomes in turn and record the After 10 generations, Carrying the damage and Fault kept out of the tissue? readouts.

Outcome	Cells	Carrying the damage	Fault kept out of the tissue?
The damage is repaired			
The cell stops dividing			
Programmed cell death			
The checkpoint is ignored			

5. Two of the four outcomes in the Part 3 table end with the same number of cells.
(a) Identify the two outcomes.

(b) Describe the difference between the cells produced by these two outcomes.

6. With programmed cell death (apoptosis), no cells remain after 10 generations. Explain why apoptosis benefits the organism.

Part 4 · Putting it together

Answer questions 7 to 10 without the tool.

7. (a) Describe the role of cyclins in the cell cycle.

(b) Describe the role of cyclin-dependent kinases (CDKs) in the cell cycle.

(c) Explain how cyclins and CDKs work together to move a cell from one phase to the next.

8. After a transition, the cyclin that drove it is destroyed. Explain how destroying the cyclin helps the cell cycle run in only one direction.

9. A drug prevents spindle fibers from forming.
(a) Identify the checkpoint that would detect the effect of the drug.

(b) Predict the effect of the drug on a dividing cell. Justify your prediction.

10. (a) Explain how a failure of the G1 checkpoint in a single cell can lead to a tumor.

(b) Explain why the number of affected cells grows so quickly after a single checkpoint failure.

What the model simplifies

Six conditions are shown. A real cell monitors many more, and the checks are carried out by networks of proteins rather than by a single yes/no reading; the conditions here are the ones the course asks for.

The checkpoints are drawn as gates that are either open or shut. A real checkpoint is a delay rather than a wall: the cell holds, tries to fix the problem, and continues if it succeeds, which is what the 'repaired' outcome represents.

One cyclin is drawn. A real cell uses several, each partnered with its own CDK and each peaking at a different point, so there is a different complex driving each transition. The shape of one is the shape of all of them.

The cyclin curve is a straight rise and a straight fall in arbitrary units and arbitrary ticks. Real cyclin concentrations are measured relative to a peak, and the fall is faster than the rise, which is the feature the drawing keeps.

The lineage model divides every cell at every generation and adds no new damage. Real tissue has cells that stop dividing, cells that die, and further mutations accumulating, all of which make the untreated case worse, not better, than the one drawn.