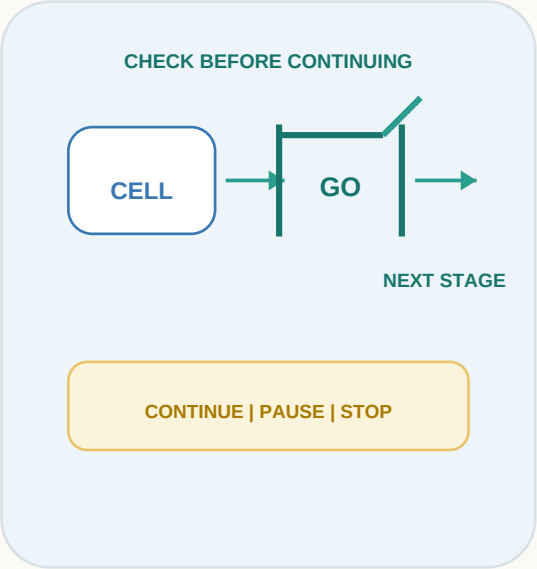
AP BIOLOGY | UNIT 4

TOPIC 4.6

Regulation of Cell Cycle

Checkpoint proteins, cyclins, and CDKs coordinate whether a cell continues, pauses for repair, or stops dividing.



THE CORE CAUSAL CHAIN

SIGNALS → inside and outside

CHECKPOINT → conditions evaluated

CYCLIN-CDK → targets activated

DECISION → continue or stop

BY THE END, YOU SHOULD BE ABLE TO...

1. Compare the G1, G2, and M checkpoints.
2. Explain how cyclins activate CDKs.
3. Connect failed regulation with cancer.

CENTRAL IDEA

Cell-cycle control integrates signals with checkpoint conditions. Progress occurs only when regulatory proteins activate the correct targets at the correct time.

1 Checkpoints make go or no-go decisions

At specific points, the cell evaluates internal conditions and external signals before committing to the next stage.

THREE MAJOR CHECKPOINTS

G1 — **Should the cell enter S phase?**

- adequate size and nutrients
- growth signals present
- DNA is undamaged

G2 — **Is the cell ready for mitosis?**

- DNA replication complete
- DNA damage repaired
- resources sufficient

M — **Can chromatids separate?**

- chromosomes aligned
- kinetochores attached
- spindle connection correct

POSSIBLE OUTCOMES

CONTINUE

requirements are met; the cycle advances

PAUSE + REPAIR

the cycle stops while problems are corrected

STOP / APOPTOSIS

unsafe cells exit the cycle or undergo programmed death

EXTERNAL SIGNALS + INTERNAL CONDITIONS

-> CHECKPOINT DECISION -> CELL RESPONSE

KEY DISTINCTION

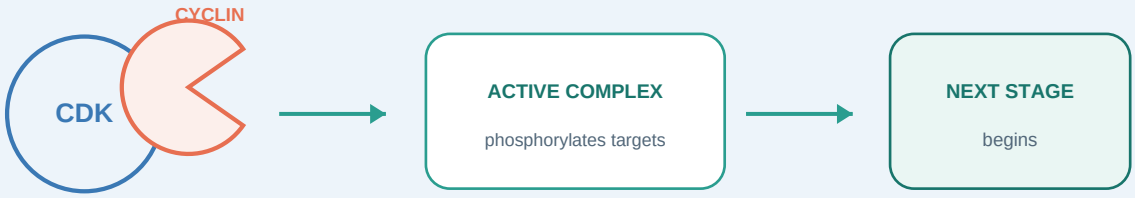
A checkpoint is not a physical structure. It is a regulatory control point where molecular signals determine whether the cycle proceeds.

2

Cyclins and CDKs coordinate cell-cycle timing

Cyclin concentrations rise and fall. When a cyclin binds its partner CDK, the active complex phosphorylates target proteins.

HOW THE MOLECULAR SWITCH WORKS



WHEN CONTROL FAILS

TUMOR SUPPRESSOR

THE BRAKE

Normally slows the cycle, promotes repair, or triggers apoptosis when damage is severe.

PROTO-ONCOGENE

THE ACCELERATOR

Normally promotes growth or division only when appropriate signals are present.

SEVERE DAMAGE -> APOPTOSIS REMOVES THE UNSAFE CELL

PROTO-ONCOGENE + ACTIVATING MUTATION -> ONCOGENE

LOST BRAKES OR STUCK ACCELERATORS -> UNCONTROLLED DIVISION

CONNECT THE IDEAS

Cancer is not caused by a cell dividing once. It develops when mutations disrupt regulatory pathways so cells repeatedly bypass normal checkpoints, survive damage, and continue dividing.