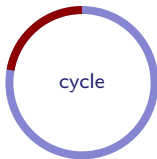


Cell Communication and Cell Cycle

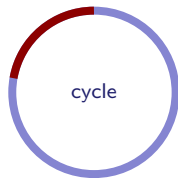
AP Biology ■ Unit 4

AP Biology



What we will cover

- 1 Cell communication
- 2 Signal transduction
- 3 Feedback and homeostasis
- 4 The cell cycle
- 5 Regulation of the cell cycle



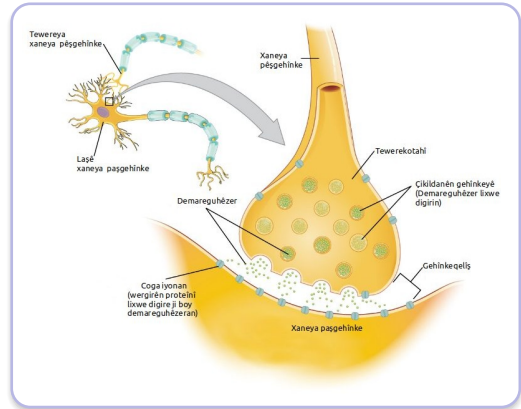


Cell communication

Cells talk with chemical **signals** over three distances:

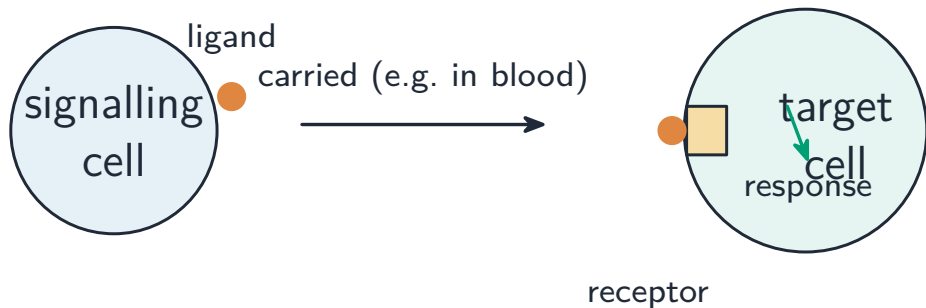
- **direct contact** – through channels
- **paracrine** – to nearby cells
- a **hormone** – far away via blood

A **ligand** fits its **receptor** like a key in a lock – giving signaling its **specificity** .



Chemical signals cross synapses and tissues

A signal molecule (ligand) binds a matching

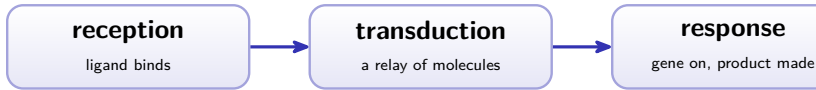


A signal molecule (ligand) binds a matching receptor on the target cell

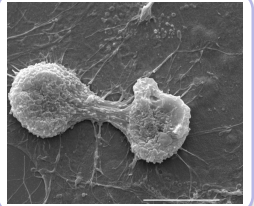


Signal transduction

Turning an outside message into an inside action, in three stages:

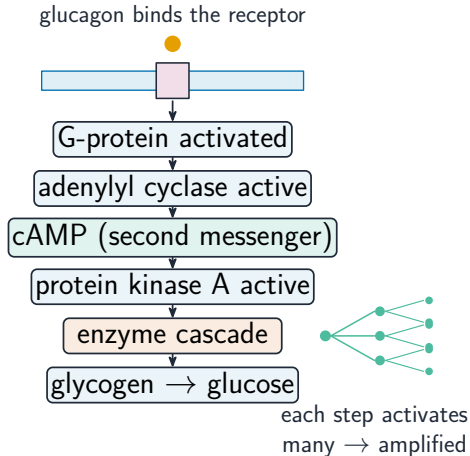


Second messengers (cAMP, Ca^{2+}) and a **phosphorylation cascade** give huge **amplification** :
 $1 \rightarrow 100 \rightarrow 10,000 \rightarrow \text{millions.}$



Cytokinesis fibroblast

Signal Transduction Pathways



A signalling cascade amplifies the message inside the cell

Transduction, and the checkpoints

reception	a signal molecule – often a hormone – binds a specific receptor
transduction	the signal passes through a pathway : often a cascade of proteins that activate one another
why a cascade	each step amplifies , so a few signal molecules can change thousands of targets
response	a change in gene expression, or in the activity of an existing protein
checkpoints	the cell cycle is controlled at points that verify conditions before proceeding
what they check	<i>Is the DNA intact? Are the chromosomes attached?</i> – and a failed check halts the cycle

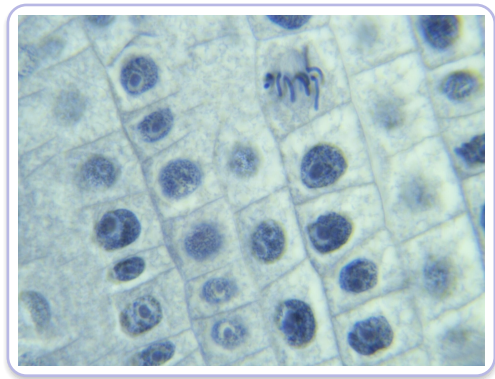
Cancer is largely a failure of these controls: a checkpoint that no longer stops the cycle, or a pathway stuck in the on position.



Feedback and homeostasis

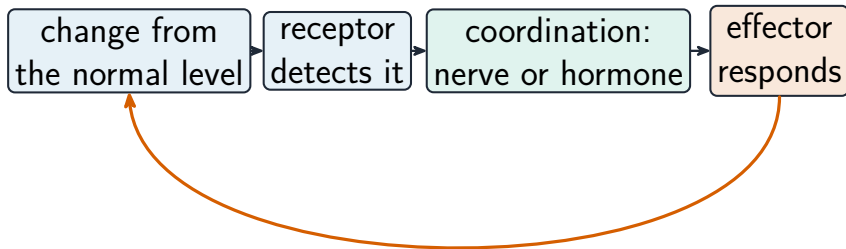
Feedback keeps the body steady
(**homeostasis**):

- **negative feedback** reverses a change back to a **set point** (temperature, **blood glucose**)
- **positive feedback** amplifies to finish an event (childbirth, clotting)



Mitosis onion metaphase

Negative feedback detects and corrects a change



the response pushes the level back to normal (negative feedback)

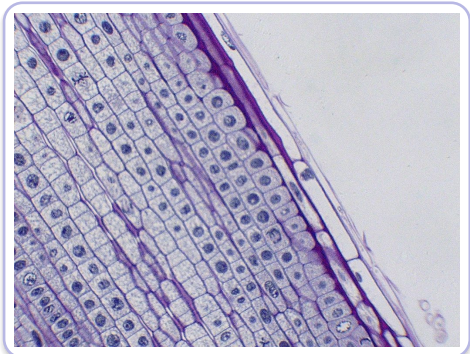
Negative feedback detects and corrects a change



The cell cycle

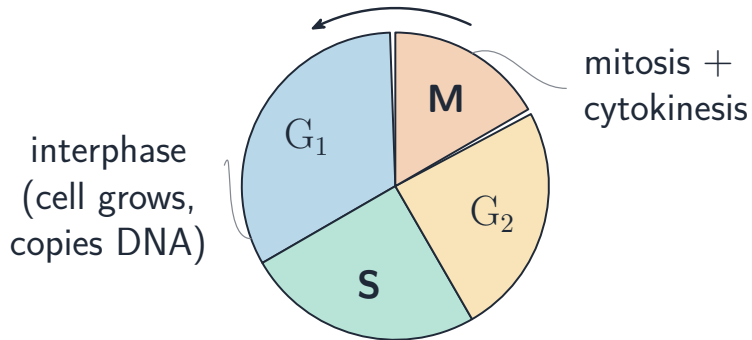
- **interphase** – grow and copy DNA
- **mitosis** (M) – split the nucleus:
Prophase, **M**etaphase, **A**naphase,
Telophase
- **cytokinesis** – split the cytoplasm

Two identical **diploid daughter cells** ; n divisions $\Rightarrow 2^n$ cells.



Mitosis produces two identical daughter nuclei

The cell cycle: interphase



The cell cycle: interphase, then mitosis and cytokinesis



Regulation of the cell cycle

Checkpoints stop and check before each step: cell size, DNA copied correctly, chromosomes aligned.

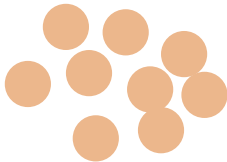
Cyclins + **CDKs** push the cycle past checkpoints.

Lose control $\Rightarrow$ endless division = **cancer** . Guard genes (p53) halt the cycle for DNA repair – if they fail, damage is copied.

Regulation of Cell Cycle



controlled: cells stop dividing



uncontrolled: a tumour grows

Uncontrolled division from failed checkpoints forms a tumour

Worked example – amplification in a cascade

One hormone activates one receptor, which switches on about 100 relay proteins, and each of those makes about 1,000 second-messenger molecules. How large is the response?

- $100 \times 1000 = 10^5$ product molecules from a single bound hormone.
- Which is why a hormone concentration as low as 10^{-9} M can trigger a large cellular response.

Amplification is the *point* of a cascade. Each step multiplies, so the numbers grow geometrically down the chain.

Exam tips

- In signal transduction name the three stages: **reception** → **transduction** → **response**.
- **Negative** feedback reverses a change to keep conditions steady (homeostasis); **positive** feedback amplifies a change to completion (childbirth, clotting).
- Order the **cell cycle**: interphase (grow, copy DNA in S phase) then mitosis → two **identical** daughter cells.
- The DNA is copied **once**, in S phase, so each daughter gets a full copy.
- Failed **checkpoints** allow uncontrolled division → cancer.



Unit 4 – key takeaways

1

Signaling

ligand-receptor specificity; three stages; amplification

2

Feedback

negative returns to a set point; positive amplifies

3

Cell cycle

interphase + mitosis (PMAT); two identical cells

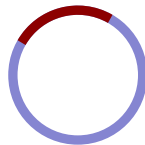
4

Control

checkpoints + cyclin/CDK; failure causes cancer

Check yourself

- 1 Why does only a target cell respond to a hormone?
- 2 Which feedback returns a value to its set point?
- 3 Name the four stages of mitosis.
- 4 What controls whether the cell cycle advances?



Answers 1. only it has the matching receptor 2. negative 3. prophase, metaphase, anaphase, telophase 4. checkpoints (cyclin/CDK)