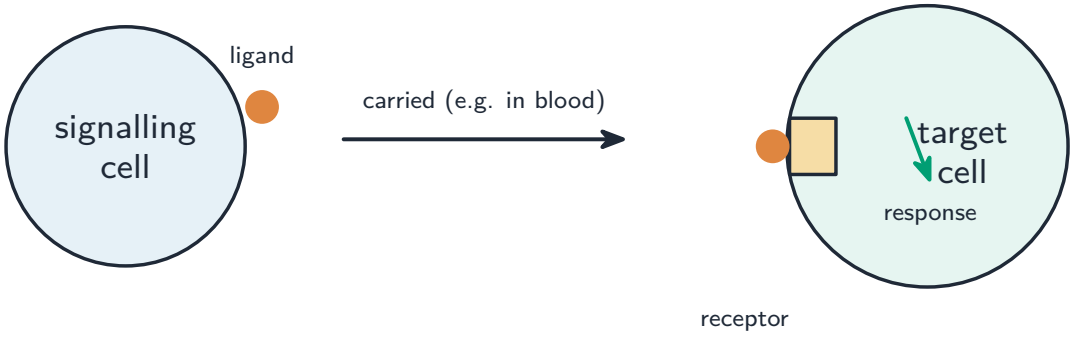
Cell Communication and Cell Cycle

AP Biology

Cell Communication

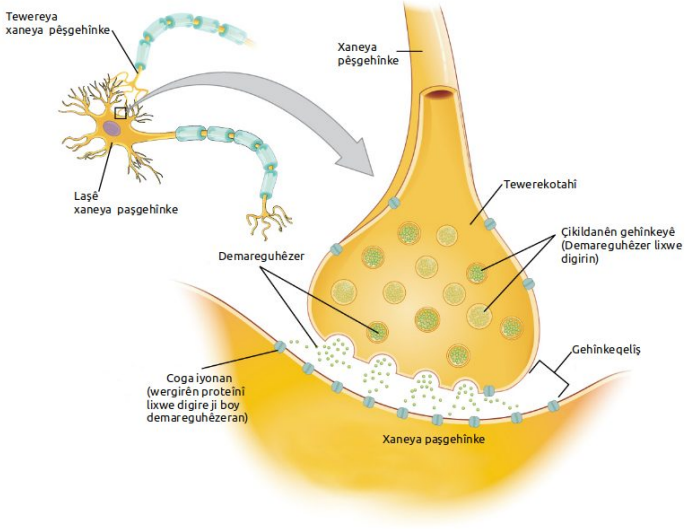
Cells coordinate by sending and receiving chemical **signals** 信号. A signaling cell releases a **ligand** 配体 that binds a **receptor** 受体 on a target cell. Signals travel over different ranges: **direct contact** (cell junctions), **local** signaling (nearby cells, like neurotransmitters), and **long-distance** signaling (**hormones** 激素 through the blood).



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

Introduction to Signal Transduction

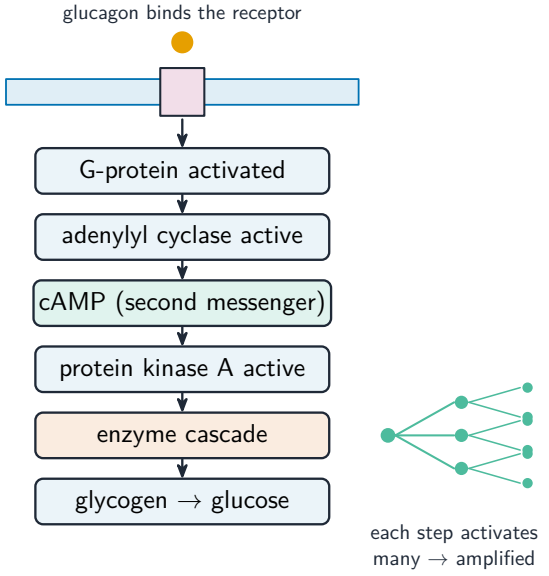
Signal transduction 信号转导 converts an outside signal into a cellular response in three stages: **reception** (ligand binds receptor), **transduction** (a relay of molecules inside the cell), and **response** (a change in the cell's activity, such as switching on a gene). Receptors are specific, so a cell only responds to signals it can receive.



A chemical synapse: signal transduction passes a message across a gap with a ligand and receptor

Signal Transduction Pathways

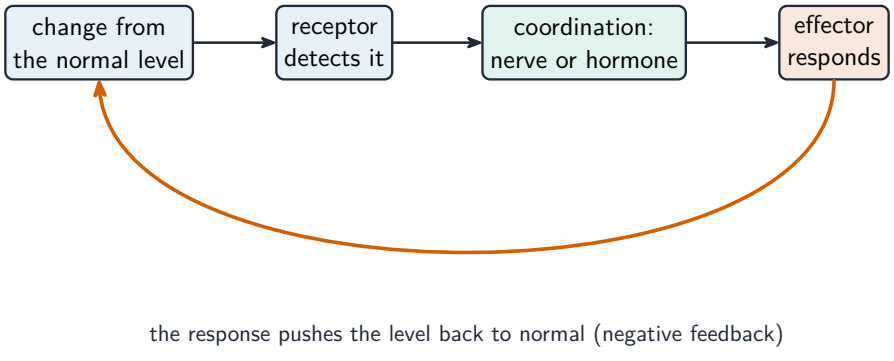
In the transduction stage, the signal passes through a **pathway** – often a cascade of proteins that activate one another, frequently amplifying the signal so a few ligands trigger a large response. **Second messengers** (like cyclic AMP or calcium ions) spread the signal quickly through the cell. A change in one step can alter the whole outcome.



A signalling cascade amplifies the message inside the cell

Feedback

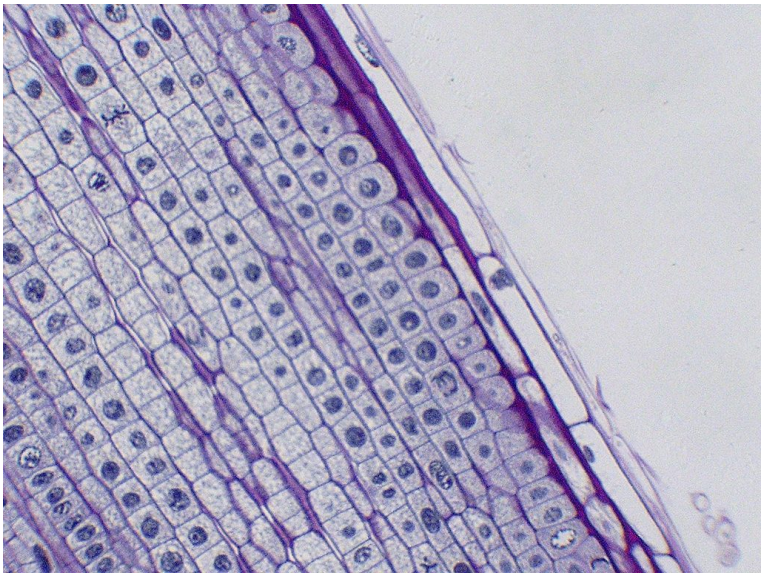
Feedback 反馈 keeps systems balanced:



Negative feedback detects and corrects a change

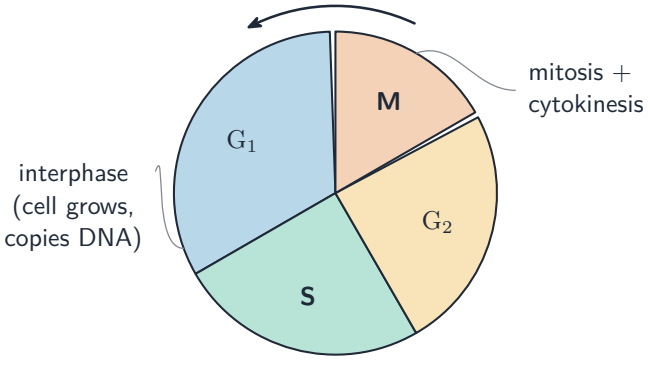
- **Negative feedback** 负反馈 counteracts a change to restore a set point (like a thermostat) – it maintains **homeostasis** 稳态.
- **Positive feedback** 正反馈 amplifies a change to push a process to completion (like childbirth contractions or blood clotting).

Cell Cycle

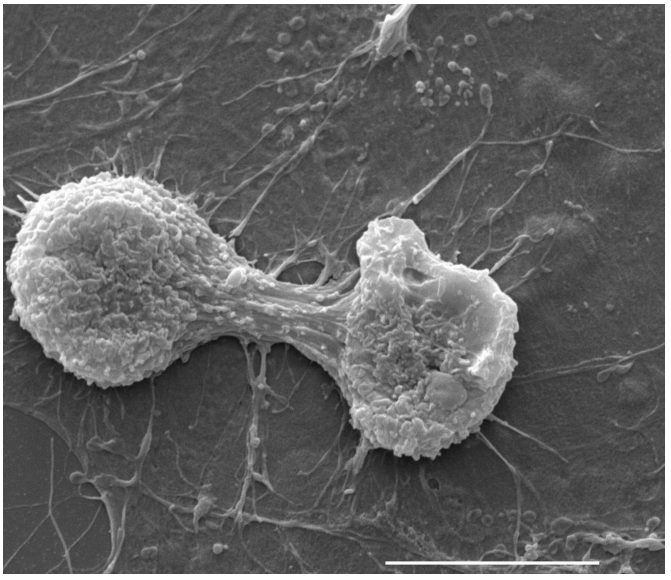


Onion root-tip cells at different stages of mitosis (light micrograph)

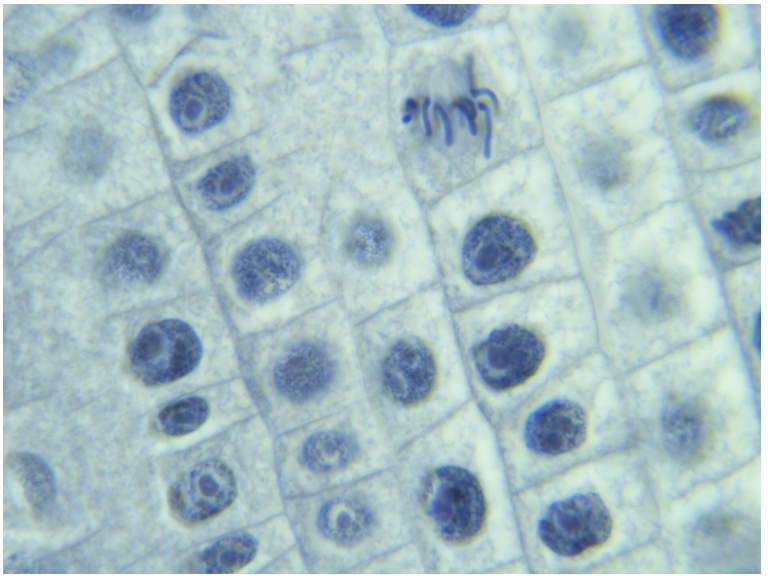
The **cell cycle** 细胞周期 is the life of a cell from one division to the next: **interphase** 间期 (G1 growth, S DNA replication, G2 preparation) followed by **mitosis** 有丝分裂 (M) and cytokinesis, which produce two identical daughter cells. Interphase takes most of the time; DNA is copied only in S phase.



The cell cycle: interphase, then mitosis and cytokinesis



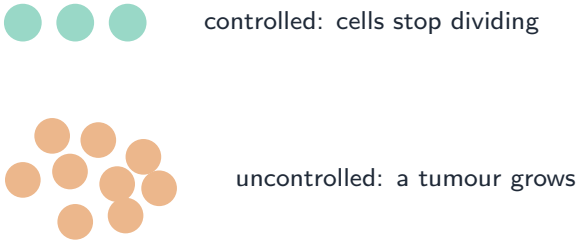
A fibroblast dividing: cytokinesis splits one cell into two after mitosis finishes



Onion root tip at metaphase: chromosomes line up before sister chromatids separate

Regulation of Cell Cycle

The cycle is controlled at **checkpoints** 检查点 that verify conditions before proceeding (Is the DNA intact? Are chromosomes attached?). Internal signals (cyclins and their kinases) and external signals drive the cycle forward. When this control fails – for example, a mutation that ignores a checkpoint – cells divide uncontrollably, which underlies **cancer** 癌症.



Uncontrolled division from failed checkpoints forms a tumour

Worked example. Signal 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 — so a single signal produces roughly $100 \times 1000 = 10^5$ product molecules. This is why a hormone concentration as low as 10^{-9} M can trigger a large cellular response.

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.