

Cell Communication and Cell Cycle

AP Biology • Unit 4

AP Biology



Cell Communication and Cell Cycle

What we will cover

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



1 Communication

Cell Communication and Cell Cycle

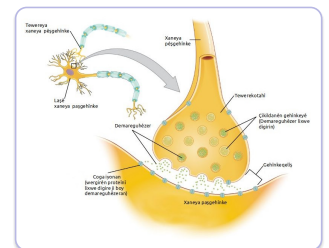
Communication

Cell communication

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

- **direct contact** 直接接触 – through channels
- **paracrine** 旁分泌 – to nearby cells
- **a hormone** 激素 – far away via blood

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

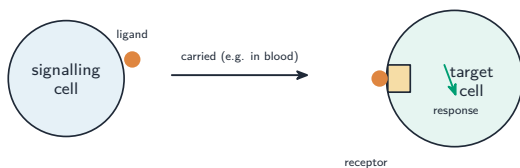


Chemical signals cross synapses and tissues

Cell Communication and Cell Cycle

Communication

A signal molecule (ligand) binds a matching

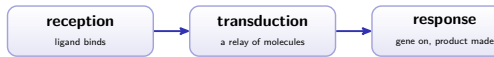


A signal molecule (ligand) binds a matching receptor on the target cell

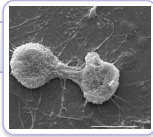
2 Transduction

Signal transduction

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

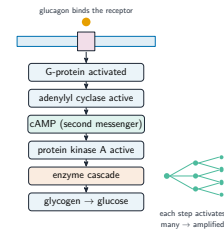


Second messengers 第二信使 (cAMP, Ca^{2+}) and a **phosphorylation cascade** 磷酸化级联 give huge **amplification** 放大: $1 \rightarrow 100 \rightarrow 10,000 \rightarrow \text{millions}$.



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 激素 – 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 检查点	the cell cycle is controlled at points that verify conditions before proceeding
what they check	Is the DNA intact? Are the chromosomes attached? – and a failed check halts the cycle

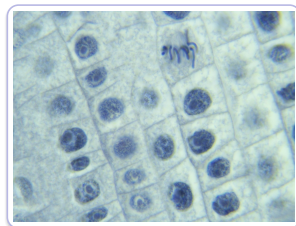
Cancer is largely a failure of these controls: a checkpoint that no longer stops the cycle, or a pathway stuck in the on position.

3 Feedback

Feedback and homeostasis

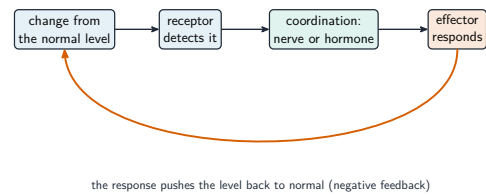
Feedback 反馈机制 keeps the body steady (**homeostasis** 稳态):

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



Mitosis onion metaphase

Negative feedback detects and corrects a change

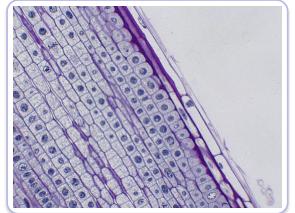


Negative feedback detects and corrects a change

4 Cell cycle

The cell cycle

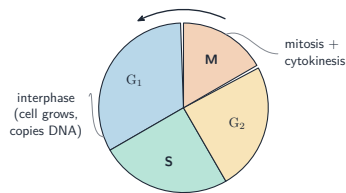
- **interphase** 间期 – grow and copy DNA
- **mitosis** 有丝分裂 (M) – split the nucleus: **Prophase**, **Metaphase**, **Anaphase**, **Telophase**
- **cytokinesis** 胞质分裂 – split the cytoplasm



Mitosis produces two identical daughter nuclei

Two identical **diploid** 二倍体 **daughter cells** 子细胞; n divisions $\Rightarrow 2^n$ cells.

The cell cycle: interphase



The cell cycle: interphase, then mitosis and cytokinesis

5 Regulation

Regulation of the cell cycle

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

Cyclins 周期蛋白 + **CDKs** 周期蛋白依赖性激酶 push the cycle past checkpoints.

Lose control $\Rightarrow$ endless division = **cancer** 癌症. 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.

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Recap

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)