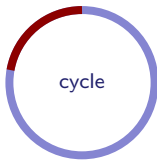


Cell Communication and Cell Cycle

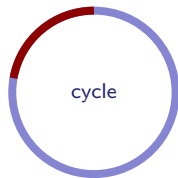
AP Biology ■ Unit 4

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



1

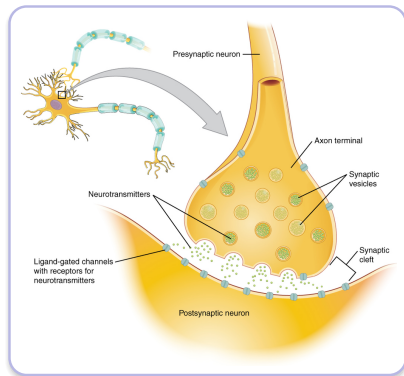
Communication

Cell communication

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

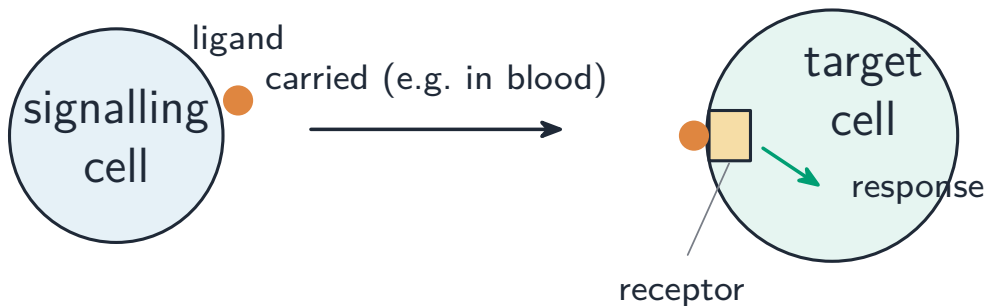
- **direct contact** 直接接触 – through channels
- **paracrine** 旁分泌 – to nearby cells
- a **hormone** 激素 – far away via blood

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



A ligand (neurotransmitter) crossing a synapse

A ligand binds its matching receptor



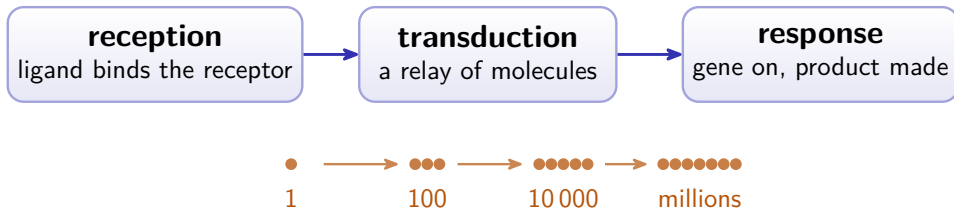
A signal molecule (ligand) binds a matching receptor on the target cell

2

Transduction

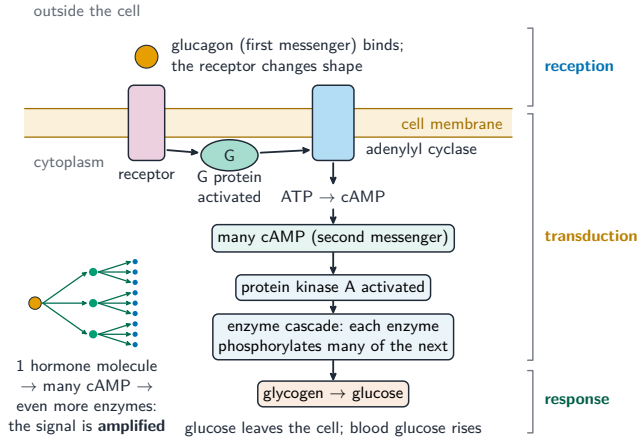
Signal transduction

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: $1 \rightarrow 100 \rightarrow 10,000 \rightarrow \text{millions}$.

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	<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.

3

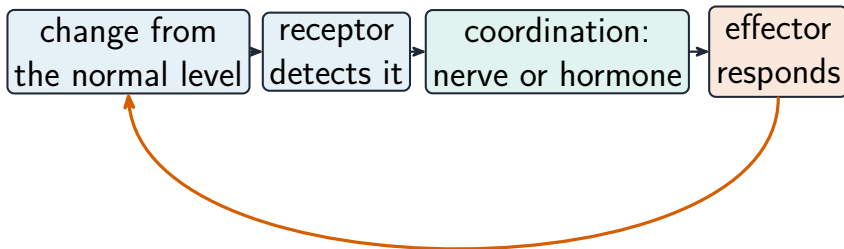
Feedback

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)

Negative feedback detects and corrects a change



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

A sensor detects the change, a control centre compares it with the set point, and an effector reverses it: sweating when body temperature rises.

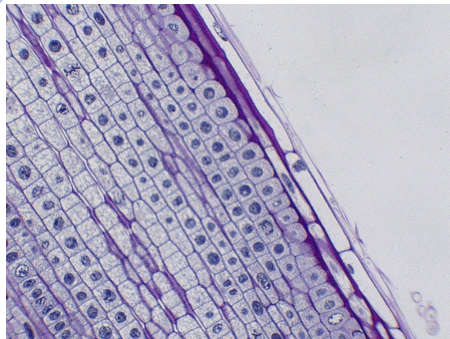
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Cell cycle

The cell cycle

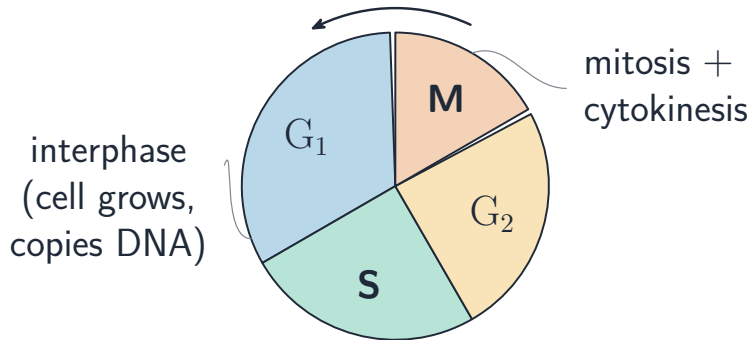
- **interphase** 间期 – grow and copy DNA
- **mitosis** 有丝分裂 (M) – split the nucleus: **P**rophase, **M**etaphase, **A**naphase, **T**elophase
- **cytokinesis** 胞质分裂 – split the cytoplasm

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



Mitosis produces two identical daughter nuclei

The cell cycle: interphase



The cell cycle: interphase, then mitosis and cytokinesis

5

Regulation

Regulation of the cell cycle

Checkpoints 检查点 stop the cycle until conditions are right; **cyclins** 周期蛋白 + **CDKs** 周期蛋白依赖性激酶 push it past them.

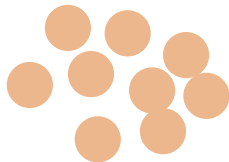
Checkpoint	It checks...
G₁	cell size, nutrients, DNA damage
G₂	DNA copied correctly
M (spindle)	every chromosome attached and aligned

Lose control ⇒ 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.

6

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

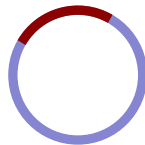
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Control

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)