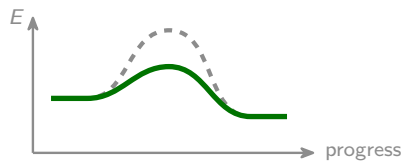
Cellular Energetics

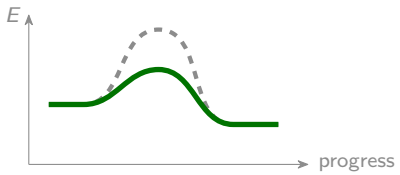
AP Biology ▪ Unit 3

AP Biology



What we will cover

1. Enzymes as catalysts
2. Enzyme conditions and inhibitors
3. ATP and energy coupling
4. Photosynthesis
5. Cellular respiration



1

Enzymes

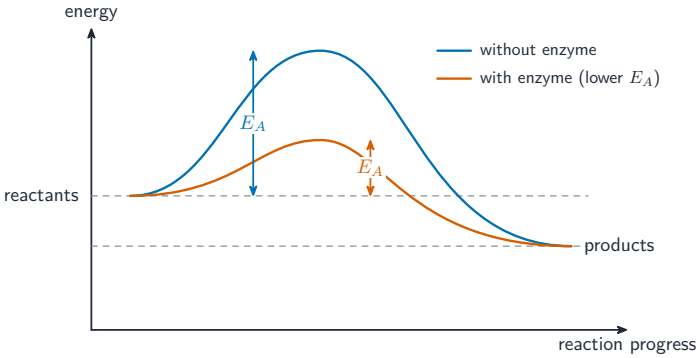
Enzymes as biological catalysts

Enzymes 酶 speed reactions by lowering the activation energy – without being used up.

- the **substrate** 底物 binds the **active site** 活性位点
- **induced fit** 诱导契合模型 – the site reshapes to grip it
- each enzyme is **specific** 专一的 to one reaction

Enzymes lower activation energy in living systems

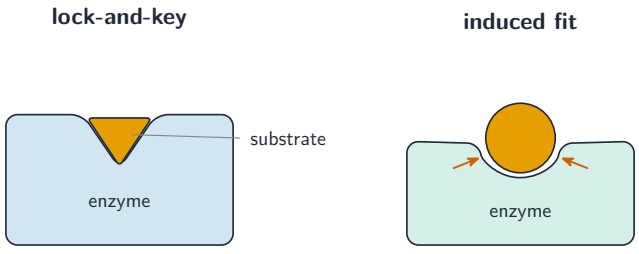
An enzyme lowers the activation energy of a – one



An enzyme lowers the activation energy of a reaction

An enzyme lowers the activation energy of a reaction

An enzyme lowers the activation energy of a – two



The lock-and-key and induced-fit models of enzyme action

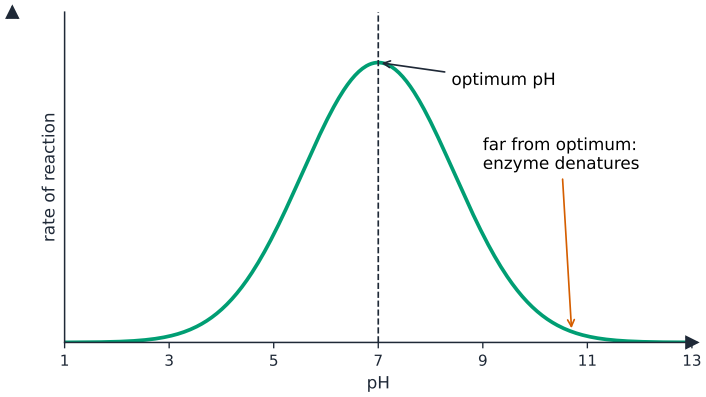
The lock-and-key and induced-fit models of enzyme action

Environmental Impacts on Enzyme Function

Each enzyme has an **optimal** temperature and pH; beyond it, the protein **denatures** 变性 (loses shape) and stops working.

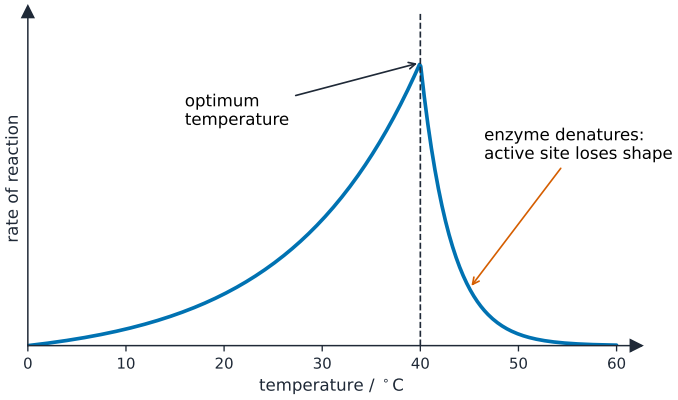
> **Substrate concentration** raises the rate until the enzyme saturates.

Environmental Impacts on Enzyme Function, in detail



Each enzyme has an optimum pH

Rate rises to an optimum temperature



Rate rises to an optimum temperature, then falls as the enzyme denatures

Conditions and inhibitors

Each enzyme has an **optimum** 最适 temperature and pH; too far and it **denatures** 变性. Adding substrate speeds it up until it **saturates** 饱和的.

Competitive: blocks the active site (more substrate helps)

Noncompetitive: binds elsewhere, reshapes it

Feedback inhibition: the product shuts off step 1

2 ATP

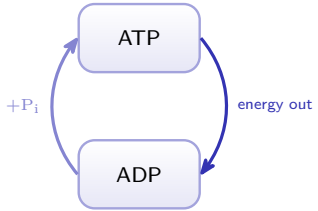
ATP and energy coupling

Exergonic 放能反应 reactions release **free energy** 自由能; **endergonic** 吸能反应 ones absorb it.

The cell's energy currency

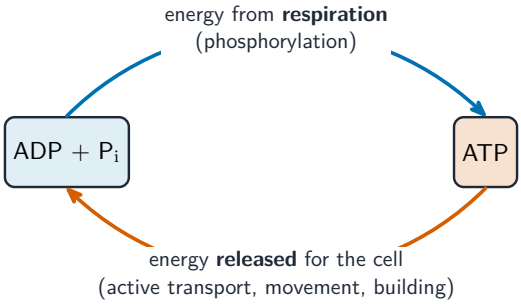
$$\mathrm{ATP} + \mathrm{H_2O} \rightarrow \mathrm{ADP} + \mathrm{P_i} + \text{energy}$$

A **coupled reaction** 偶联反应 links ATP breakdown to an uphill step – powering it.



Constantly recycled; order needs a steady energy supply.

The ATP-ADP cycle stores and releases energy



The ATP-ADP cycle stores and releases energy

3

Photosynthesis

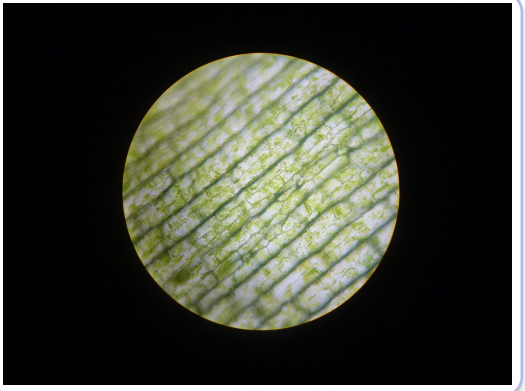
Photosynthesis

In the **chloroplast** 叶绿体, light energy becomes sugar:

Overall

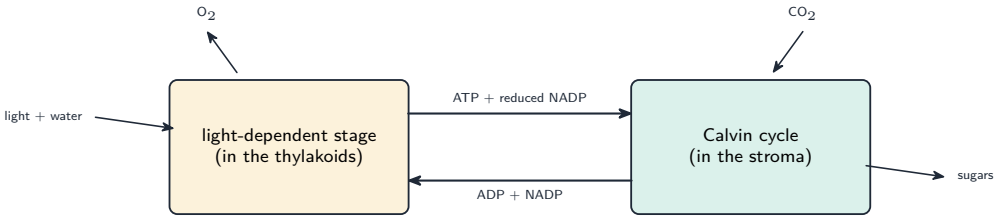
$$6\mathrm{CO_2} + 6\mathrm{H_2O} \xrightarrow{\text{light}} \mathrm{C_6H_{12}O_6} + 6\mathrm{O_2}$$

- **light reactions** – thylakoid: split $\mathrm{H_2O}$, make $\mathrm{O_2}$
- **Calvin cycle** – stroma: fix $\mathrm{CO_2}$ into sugar



Chloroplasts capture light and fix carbon

The two stages of photosynthesis are linked



The two stages of photosynthesis are linked by ATP and NADPH

4 Respiration

Cellular respiration

In the **mitochondrion** 线粒体, glucose is broken down to make ATP:

Overall

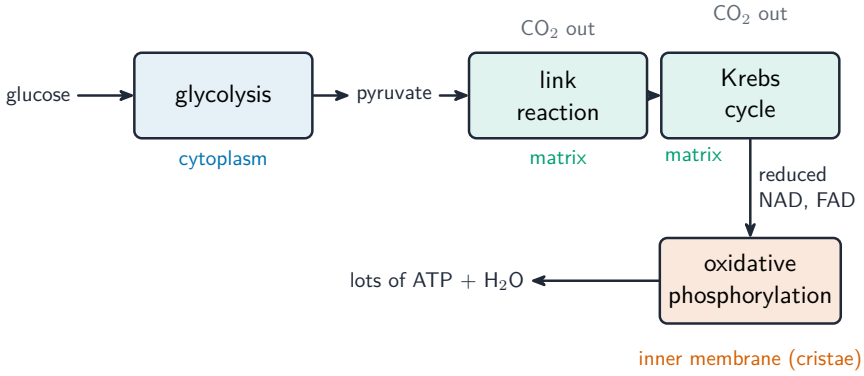
$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + \text{ATP}$$

glycolysis → Krebs → oxidative phosphorylation; aerobic ≈ 30–32 ATP.

Chemiosmosis 化学渗透: H^+ flows back through ATP synthase.

Mitochondria oxidise fuel to make ATP

The stages of aerobic respiration and where



The stages of aerobic respiration and where in the cell they happen

The stages of cellular respiration

glycolysis	in the cytosol: glucose to two pyruvate, with a small net ATP yield and NADH
the Krebs cycle 克雷布斯循环	in the mitochondrial matrix: carbon leaves as CO_2, and the coenzymes are loaded with electrons
the electron transport chain 电子传递链	on the inner membrane: those electrons pump protons across it
chemiosmosis	the protons flow back through ATP synthase – which makes most of the ATP
the final acceptor	oxygen, which becomes water – and without it the chain backs up and stops
without oxygen	fermentation regenerates NAD^+ so glycolysis alone can continue

Oxygen's only job is to accept the electrons at the end. That is why its absence stops the chain, the Krebs cycle, and nearly all the ATP.

Exam tips

- An **enzyme lowers the activation energy** and is not used up; its **active site** is specific to one substrate (lock and key).
- Rate rises with temperature only up to the **optimum** – beyond it the enzyme **denatures** and the rate falls (unlike an ordinary reaction).
- Know the ATP ADP cycle: breaking a phosphate **releases** energy to power the cell.
- Write the overall equations: photosynthesis **stores** energy (builds glucose); respiration **releases** it (breaks glucose down) – they are opposites.
- Match each stage to its location and whether it needs oxygen.

5 Recap

Unit 3 – key takeaways

1 Enzymes

lower activation energy; specific active site; denature

2 ATP

$\mathrm{ATP} \rightarrow \mathrm{ADP} + \mathrm{P_i}$; couples to uphill steps

3 Photosynthesis

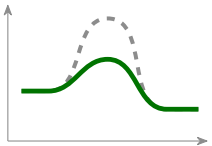
light reactions + Calvin cycle build glucose

4 Respiration

glycolysis, Krebs, oxidative phosphorylation

Check yourself

1. How does an enzyme speed up a reaction?
2. What molecule carries energy for the cell?
3. Which organelle carries out photosynthesis?
4. Aerobic respiration yields how many ATP vs fermentation?



Answers **1.** it lowers the activation energy **2.** ATP **3.** the chloroplast **4.** ∼30 vs 2