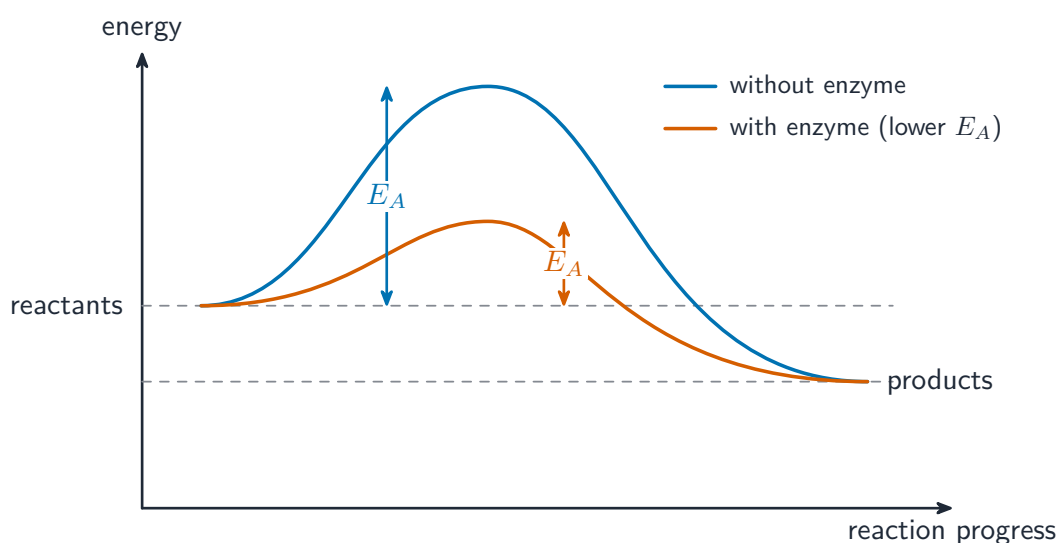


Cellular Energetics

AP Biology

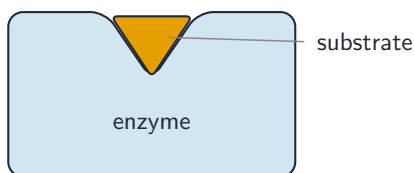
Enzymes as Biological Catalysts

An **enzyme** 酶 is a protein **catalyst** 催化剂 that speeds a reaction by **lowering its activation energy** 活化能, without being used up. Each enzyme has an **active site** 活性位点 that binds a specific **substrate** 底物 (the "lock and key" or induced fit), so enzymes are highly specific. They do not change whether a reaction is favorable –only how fast it goes.



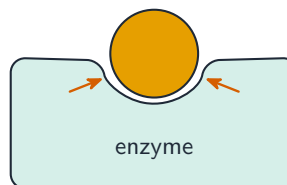
An enzyme lowers the activation energy of a reaction

lock-and-key



active site is a fixed shape

induced fit

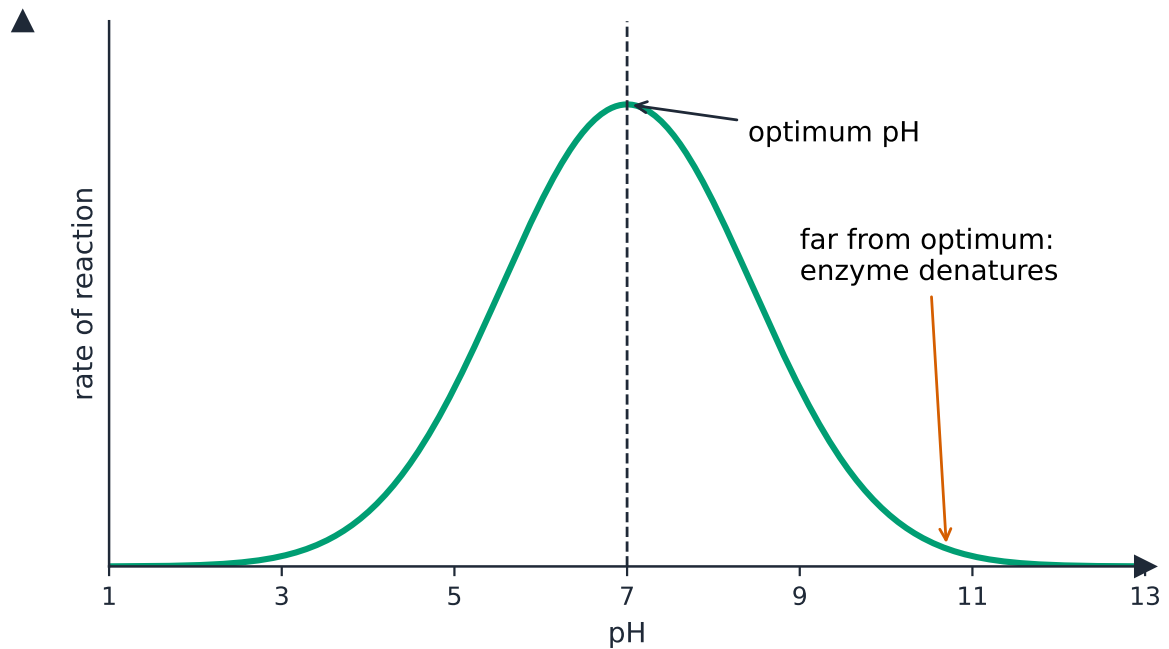


active site moulds to fit the substrate

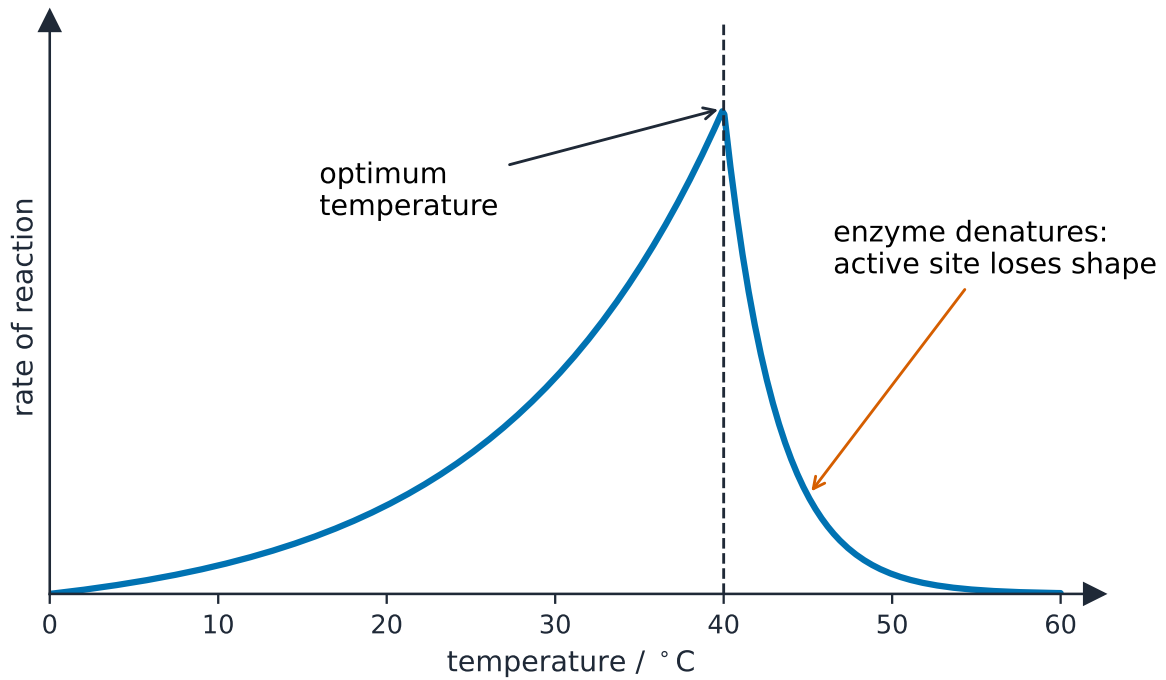
The lock-and-key and induced-fit models of enzyme action

Environmental Impacts on Enzyme Function

Enzyme activity depends on conditions. 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. **Inhibitors** 抑制剂 slow enzymes –**competitive** ones block the active site, **noncompetitive** ones bind elsewhere and change the shape.



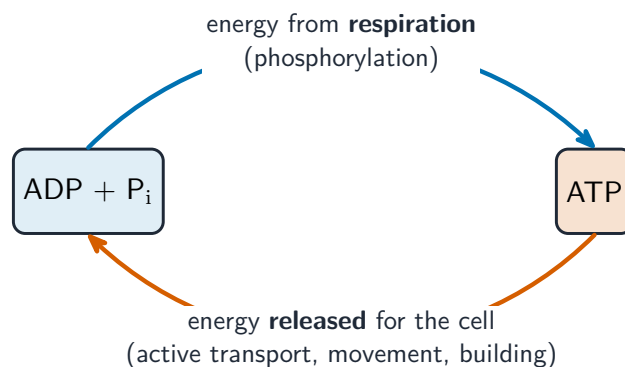
Each enzyme has an optimum pH



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

Cellular Energy and ATP

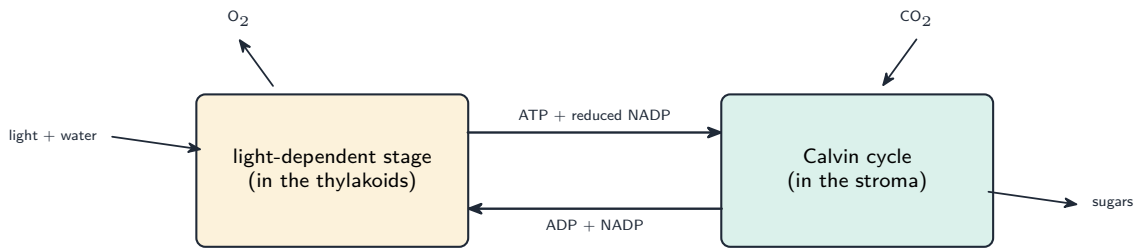
ATP (adenosine triphosphate) is the cell's energy currency. Energy is stored in its phosphate bonds; breaking off a phosphate ($\text{ATP} \rightarrow \text{ADP}$) **releases** energy to power cellular work, and reattaching one stores energy. Cells constantly recycle ATP, coupling energy-releasing reactions to energy-requiring ones.



The ATP-ADP cycle stores and releases energy

Photosynthesis

Photosynthesis 光合作用 captures light energy to build sugar from CO_2 and water, releasing O_2 . It has two stages:



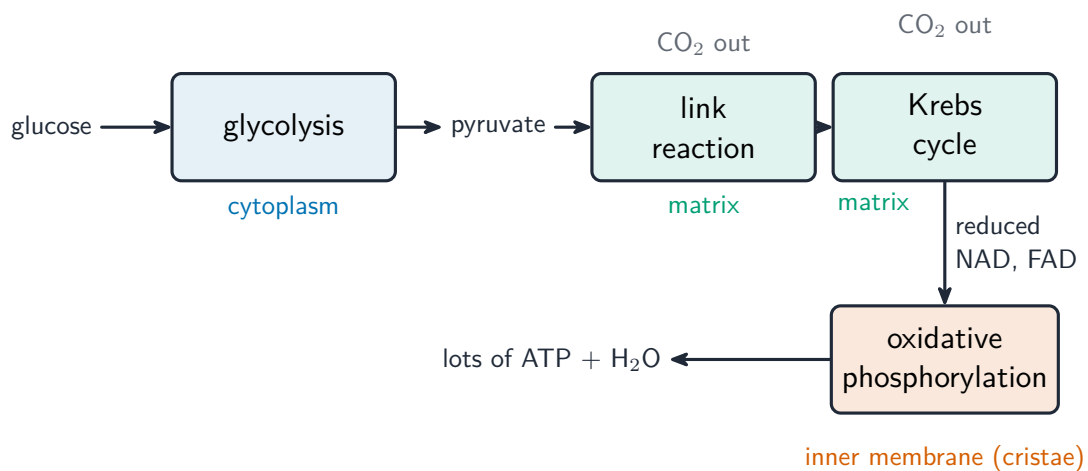
The two stages of photosynthesis are linked by ATP and NADPH

- The **light reactions** (in the thylakoid membranes) use light to make ATP and NADPH and split water, releasing oxygen.
- The **Calvin cycle** 卡尔文循环 (in the stroma) uses that ATP and NADPH to fix CO₂ into sugar.

So light energy becomes chemical energy stored in glucose.

Cellular Respiration

Cellular respiration 细胞呼吸 releases the energy in glucose to make ATP, mostly using oxygen. Its stages:



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

- **Glycolysis** 糖酵解 (in the cytoplasm) splits glucose, making a little ATP.
- The **Krebs cycle** 克雷布斯循环 (mitochondrial matrix) releases CO₂ and loads electron carriers.
- The **electron transport chain** 电子传递链 (inner membrane) uses those electrons to pump protons and make most of the ATP, with oxygen as the final electron acceptor.

Without oxygen, cells use **fermentation** 发酵 to keep glycolysis running, making far less ATP. Photosynthesis and respiration are complementary –the products of one are the reactants of the other.

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.