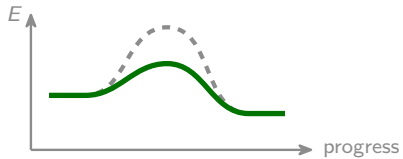


Cellular Energetics

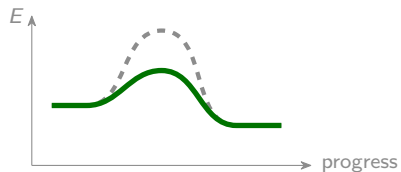
AP Biology ■ Unit 3

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





Enzymes as biological catalysts

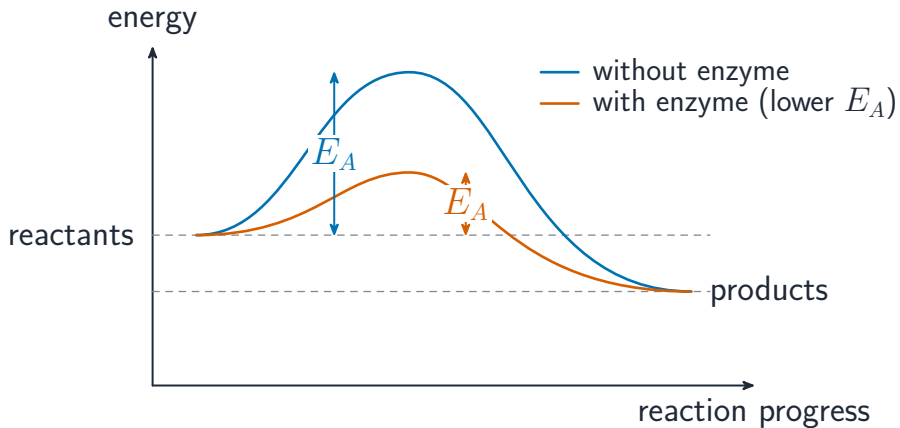
Enzymes speed reactions by **lowering the activation energy** – without being used up.

- the **substrate** binds the **active site**
- **induced fit** – the site reshapes to grip it
- each enzyme is **specific** to one reaction



Enzymes lower activation energy in living systems

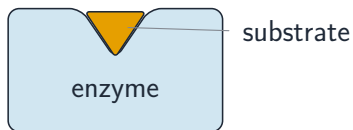
An enzyme lowers the activation energy of a – one



An enzyme lowers the activation energy of a reaction

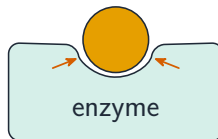
An enzyme lowers the activation energy of a – two

lock-and-key



active site is a
fixed shape

induced fit



active site moulds
to fit the substrate

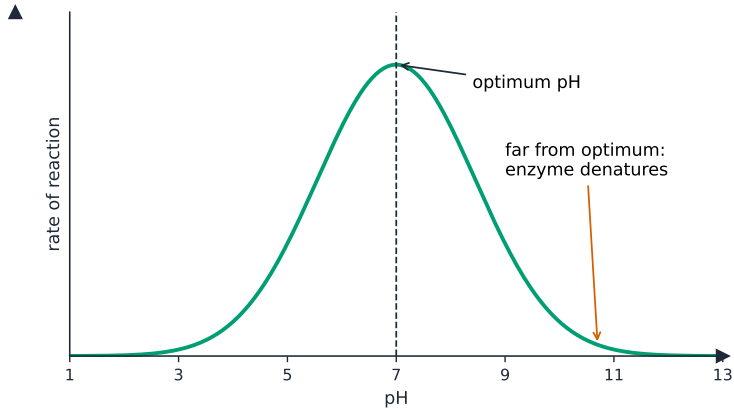
The lock-and-key and induced-fit models of enzyme action

Environmental Impacts on Enzyme Function

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

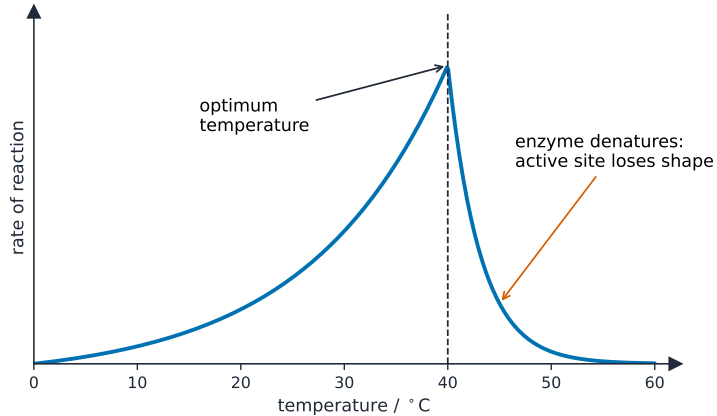
Substrate concentration raises the rate until the enzyme saturates.

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** temperature and pH; too far and it **denatures** . Adding substrate speeds it up until it **saturates** .

Competitive: blocks the active site
(more substrate helps)

Noncompetitive: binds elsewhere,
reshapes it

Feedback inhibition: the product
shuts off step 1



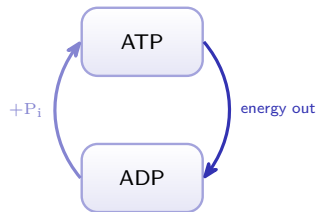
ATP and energy coupling

Exergonic reactions release **free energy** ;
endergonic ones absorb it.

The cell's energy currency

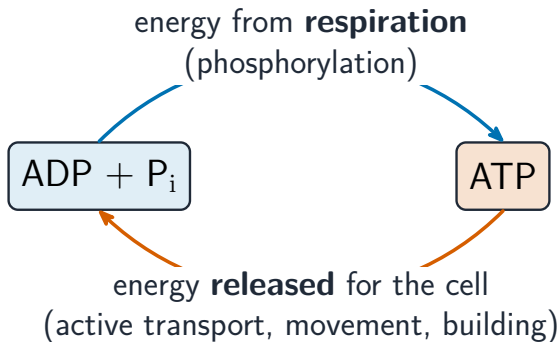


A **coupled reaction** links ATP breakdown to an uphill step – powering it.



Constantly
recycled; order needs a steady energy supply.

The ATP-ADP cycle stores and releases energy



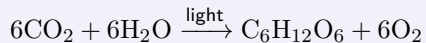
The ATP-ADP cycle stores and releases energy



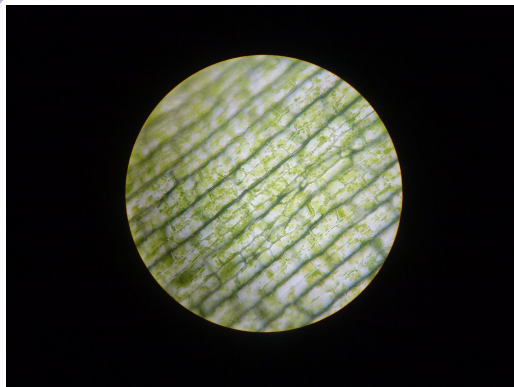
Photosynthesis

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

Overall

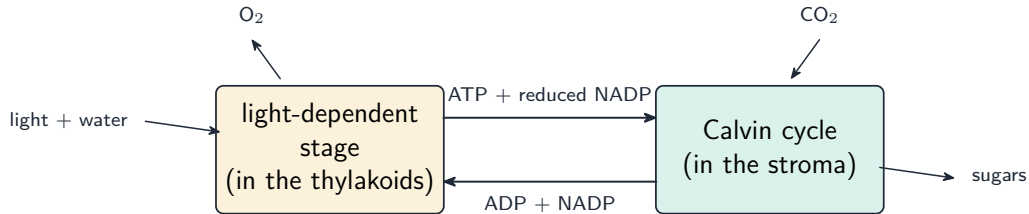


- **light reactions** – thylakoid: split H_2O , make O_2
- **Calvin cycle** – stroma: fix CO_2 into sugar



Chloroplasts capture light and fix carbon

The two stages of photosynthesis are linked



The two stages of photosynthesis are linked by ATP and NADPH



Cellular respiration

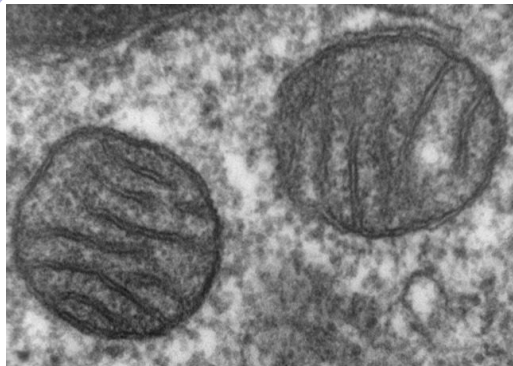
In the **mitochondrion**, glucose is broken down to make ATP:

Overall



glycolysis → Krebs → oxidative phosphorylation; aerobic $\approx 30\text{--}32$ ATP.

Chemiosmosis : H^+ flows back through ATP synthase.



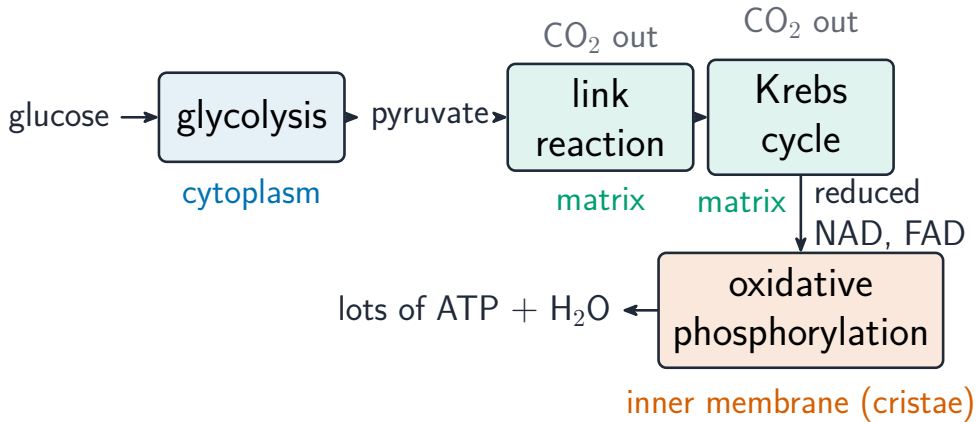
50 nm

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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

in the mitochondrial matrix: carbon leaves as CO_2 , and the coenzymes are loaded with electrons

the electron transport chain

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 $\text{ATP} \leftrightarrow \text{ADP}$ 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.



Unit 3 – key takeaways

1

Enzymes

lower activation energy; specific active site; denature

2

ATP

$\text{ATP} \rightarrow \text{ADP} + \text{P}_i$; couples to uphill steps

3

Photosynthesis

light reactions + Calvin cycle
build glucose

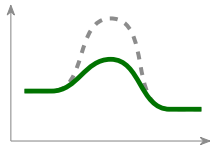
4

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