# Enzymes

## A-Level Biology ▪ Topic 3

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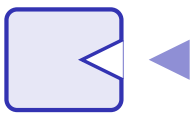


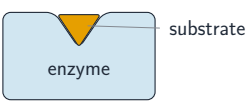
# What we will cover

1. How enzymes work
2. Activation energy
3. Measuring the rate
4. Temperature & pH
5. $V_{\max}$ & $K_{\mathrm{m}}$
6. Inhibitors & immobilisation

*enzymes catalyse reactions*

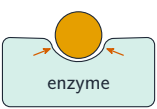
# How enzymes work

**lock-and-key**




active site is a fixed shape

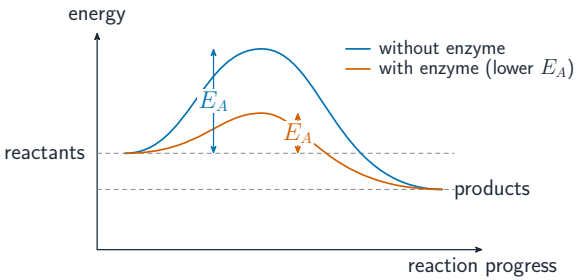
**induced fit**




active site moulds to fit the substrate

*washing powder*

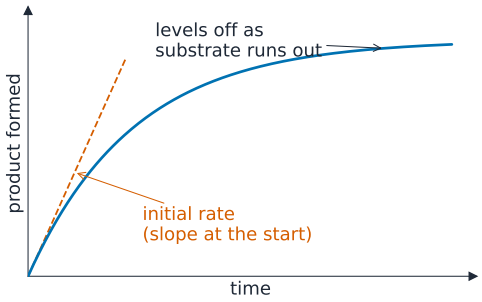
# Lowering activation energy




Every reaction needs an **activation energy** 活化能 to start.

> An enzyme lowers it, so the reaction runs fast at the cell's normal temperature – no high heat needed.

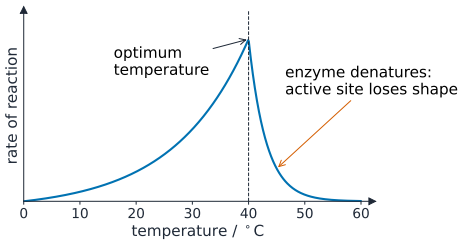
# Measuring the rate



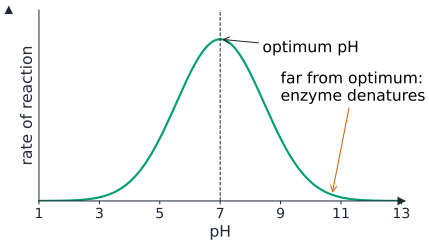

Follow product made or substrate used (a **colorimeter** 比色计 makes it exact).

> Product builds fastest at the start, so the **initial rate** 初速率 (slope at time zero) is the fairest value to compare.

# Temperature and pH



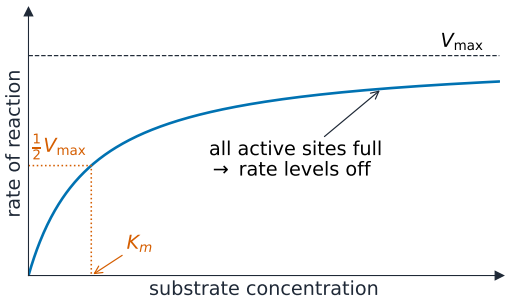

*optimum, then denatures*




*a bell-shaped optimum pH*

Past the **optimum** 最适温度, heat or wrong pH **denatures** 变性 the enzyme – the active site changes and no longer fits.

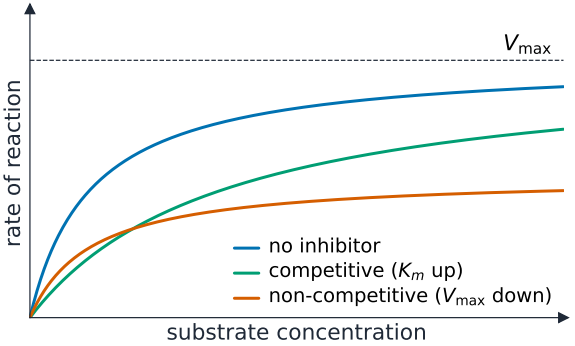
# $V_{\max}$ and the Michaelis–Menten constant




Rate climbs to $V_{\max}$ once all active sites are full.

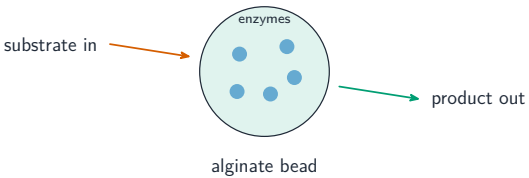
$K_{\mathrm{m}}$ (**Michaelis–Menten constant** 米氏常数) is the substrate concentration giving half $V_{\max}$ – a low $K_{\mathrm{m}}$ means high **affinity** 亲和力.

# Reversible inhibitors




- **competitive** 竞争性抑制剂 – binds the active site; more substrate overcomes it ($K_{\mathrm{m}}\uparrow$, $V_{\max}$ same)
- **non-competitive** 非竞争性抑制剂 – binds elsewhere; substrate can't help ($V_{\max}\downarrow$, $K_{\mathrm{m}}$ same)

# Immobilised enzymes




An **immobilised enzyme** 固定化酶 is fixed in beads while substrate flows past.

- not washed away – reused
- pure product; more stable; runs continuously

Used in **biological washing powders** 生物洗衣粉.

# Worked example – estimating a rate

**In the first $20\,\mathrm{s}$ of a catalase reaction, $16\,\mathrm{cm}^3$ of oxygen is collected. Estimate the rate.**

- Rate $= \dfrac{\text{volume of product}}{\text{time}} = \dfrac{16}{20} = 0.8\,\mathrm{cm}^3\,\mathrm{s}^{-1}$
- This is the average over the first $20\,\mathrm{s}$.
- The true initial rate is higher: the curve is steepest at $t = 0$ and flattens as substrate runs out.
- For an initial rate, draw a tangent at the origin and take its gradient.

Use the initial rate to compare conditions – at $t = 0$ substrate is not yet limiting, so the difference you see is the variable you changed.

# Topic 3 – key takeaways

**1 Active site**

substrate fits; induced fit gives specificity

**2 Activation energy**

enzymes lower it to speed reactions

**3 Factors**

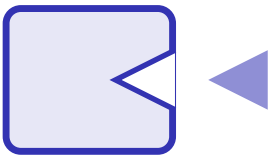
optimum temp & pH; denatures past them

**4 Inhibitors**

competitive raises $K_{\mathrm{m}}$; non-comp. lowers $V_{\max}$

# Check yourself

1. Which hypothesis says the active site moulds round the substrate?
2. What does an enzyme do to activation energy?
3. Above the optimum temperature, what happens to the enzyme?
4. A competitive inhibitor changes which constant?



**Answers** **1.** induced fit **2.** lowers it **3.** it denatures **4.** raises $K_{\mathrm{m}}$ ($V_{\max}$ unchanged)