Enzymes

IGCSE Biology

What enzymes are

Biological washing powders contain enzymes that break down stains.

A **catalyst** 催化剂 is a substance that speeds up the **rate** 速率 of a **chemical reaction** 化学反应 but is **not** used up or changed by the reaction. The same catalyst can be used again and again.

Enzymes 酶 are biological catalysts — catalysts made by living cells. They are **proteins** 蛋白质. Enzymes take part in all the reactions of **metabolism** 新陈代谢, so they control almost every chemical reaction in a living thing.

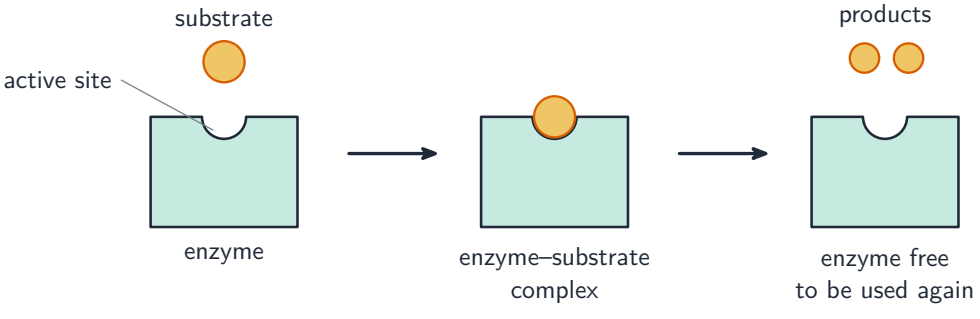
Enzymes are vital. Without them, the reactions that keep you alive would be far too slow. Enzymes raise the reaction rate enough to keep the organism alive.

How an enzyme works

Kiwi fruit contains a protease enzyme that breaks down protein.

Each enzyme has a special pocket called its **active site** 活性位点. The **molecule** 分子 it works on is called the **substrate** 底物.

- The shape of the active site is **complementary** 互补 to the shape of the substrate — they fit together like a key in a lock.
- The substrate slots into the active site. **(Supplement)** This makes an **enzyme-substrate complex** 酶底物复合物.
- The reaction takes place, and the substrate is changed into one or more **products** 产物.
- The products leave the active site, which is then free to be used again.



The substrate fits the active site like a key in a lock, then leaves as products

Why enzymes are specific (Supplement)

Each enzyme is **specific** 专一 — it works on only one kind of substrate. This is because only that substrate has the right shape to fit the active site. A substrate of a different shape will not fit, just as the wrong key will not open a lock.

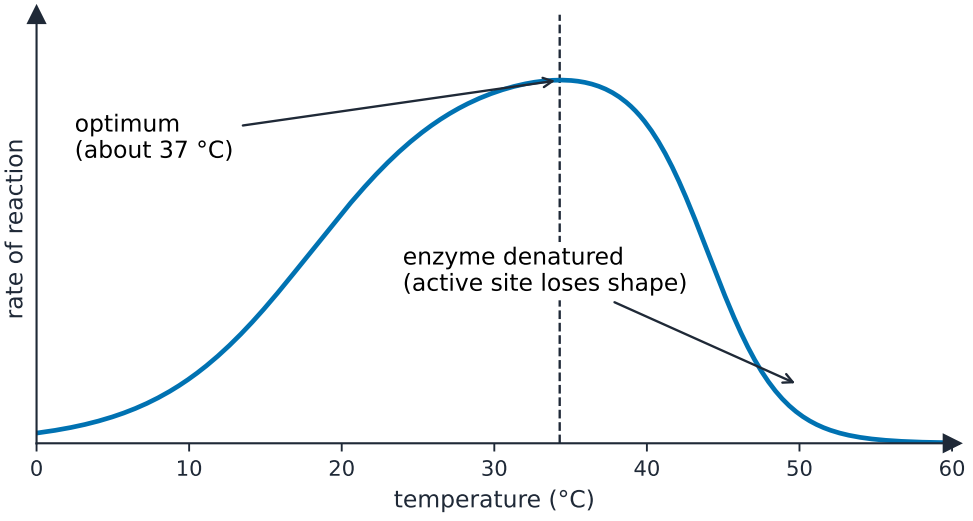
Only the matching substrate fits the active site

The effect of temperature and pH

The activity of an enzyme depends on **temperature** 温度 and pH. You can investigate this by measuring how fast the reaction goes at different temperatures or pH values.

Temperature

- As the temperature rises from cold, enzyme activity speeds up. The enzyme and substrate molecules have more **kinetic energy** 动能, so they move faster and meet more often. **(Supplement)** There are more useful **collisions** 碰撞 each second.
- Activity is highest at the **optimum temperature** 最适温度 (about 37 °C in the human body).
- Above the optimum, activity falls fast. The heat changes the shape of the active site, so the substrate no longer fits. The enzyme is **denatured** 变性. Denaturation is permanent — the enzyme cannot recover.



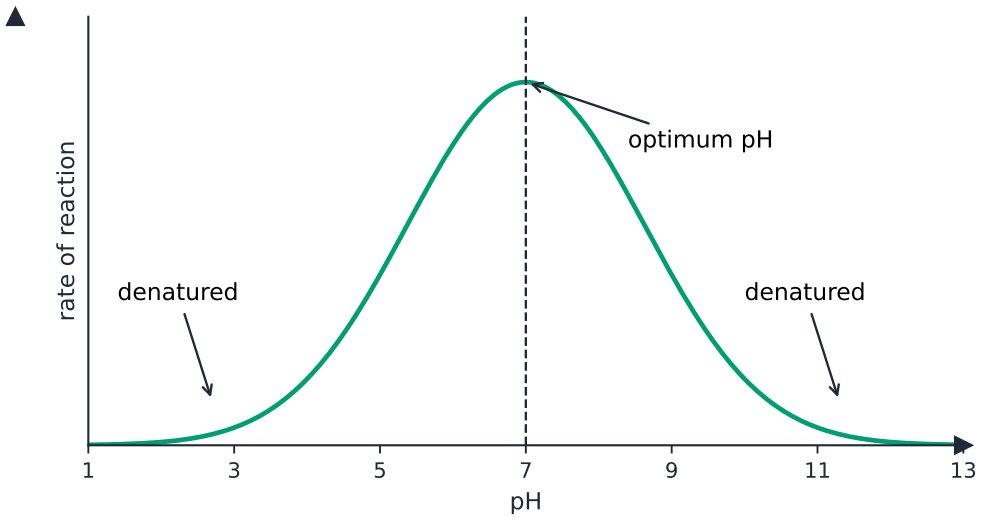
optimum ~37 °C for many human enzymes · higher *T* denatures the active site

Activity peaks at the optimum temperature, then falls sharply as the enzyme denatures

Worked example. A reaction finishes in 50 s at 20 °C, and in 20 s at 37 °C. Which temperature is faster, and by how much? A **shorter** time means a **faster** rate, so work out a rate with rate = 1000 ÷ time. At 20 °C the rate is 1000 ÷ 50 = 20 units; at 37 °C it is 1000 ÷ 20 = 50 units. So 37 °C is 50 ÷ 20 = **2.5 times faster**. Do not say the rate "went up by 30 s" - a time is not a rate. Turn the time into a rate first, and remember the bigger rate always goes with the smaller time.

pH

- Each enzyme works best at one particular pH.
- If the pH is too high or too low, the shape of the active site changes, the substrate stops fitting, and the enzyme is denatured.



optimum pH maximises rate; extremes denature the active site

Each enzyme has one optimum pH; far from it the enzyme is denatured

Exam tips

- An enzyme is both a **protein** and a biological catalyst: it speeds up a reaction and is **not** used up.
- Describe the shape: the active site is **complementary** to the substrate (the lock-and-key idea). Each enzyme is **specific** to one substrate.
- Low temperature → slow (too little kinetic energy). Optimum → fastest. Too hot → **denatured** (the active site loses its shape, permanently).
- The wrong pH also **denatures** the enzyme by changing the shape of the active site.
- "Denatured" does **not** mean "killed" — enzymes are not alive. Say that the shape of the active site has changed so the substrate no longer fits.