Bind, catalyse, release

The active site is a small region of the folded enzyme where substrate binds and catalysis occurs. Its shape and chemical properties determine which substrates interact productively.

A SIMPLIFIED CATALYTIC CYCLE



free enzyme and substrate

enzyme-substrate complex

enzyme and product

Binding is reversible. Bound substrate is converted to product, which leaves. E is regenerated and can catalyse another cycle; ES is a temporary association, not a new permanent enzyme.

1. PROTEIN FOLDING CREATES THE ACTIVE SITE

Amino acid side chains from different parts of the polypeptide can come together when it folds. These groups provide the local shape and interactions needed for binding and catalysis.

2. SPECIFICITY IS MORE THAN SHAPE

A substrate needs suitable geometry and chemistry, such as compatible charges or hydrogen-bonding groups. A molecule that touches an enzyme may not bind productively. Some enzymes accept a related group of substrates rather than just one molecule type.

The diagram shows one substrate and one product for simplicity. Enzymes may also join substrates or split a substrate into several products.

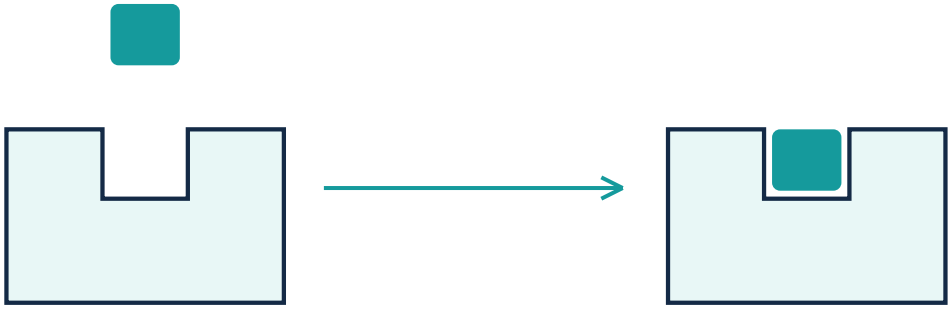
Supporting reading: The Cell: The central role of enzymes as biological catalysts.

Scope: Cambridge Biology 9700 syllabus, section 3.1, outcome 2, p. 20.

Two models of substrate binding

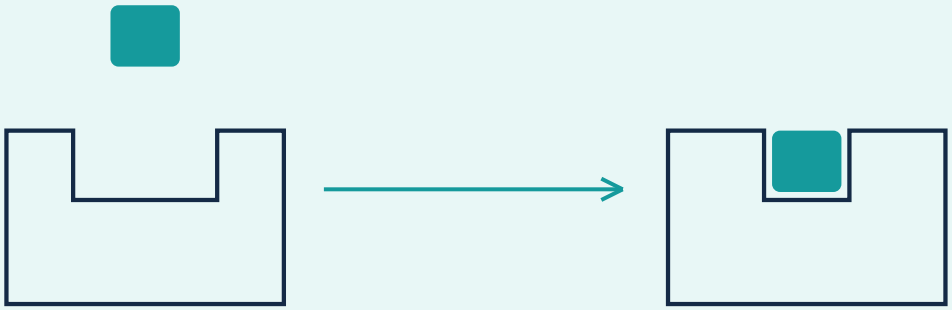
Both models explain selective binding at an active site. They differ in whether the site is treated as a pre-existing fit or as a flexible structure that changes during binding.

1. LOCK-AND-KEY: PRE-EXISTING FIT



The site is treated as fixed and already complementary to the substrate.

2. INDUCED FIT: BINDING CHANGES THE SITE



Binding induces a change in enzyme conformation, bringing catalytic groups into suitable positions.

Teal blocks represent substrate; notches represent active sites. These are simplified shape models, not atomic structures. Induced fit is a normal reversible change, not denaturation.

Flexibility does not mean any molecule can fit: chemical compatibility still matters.

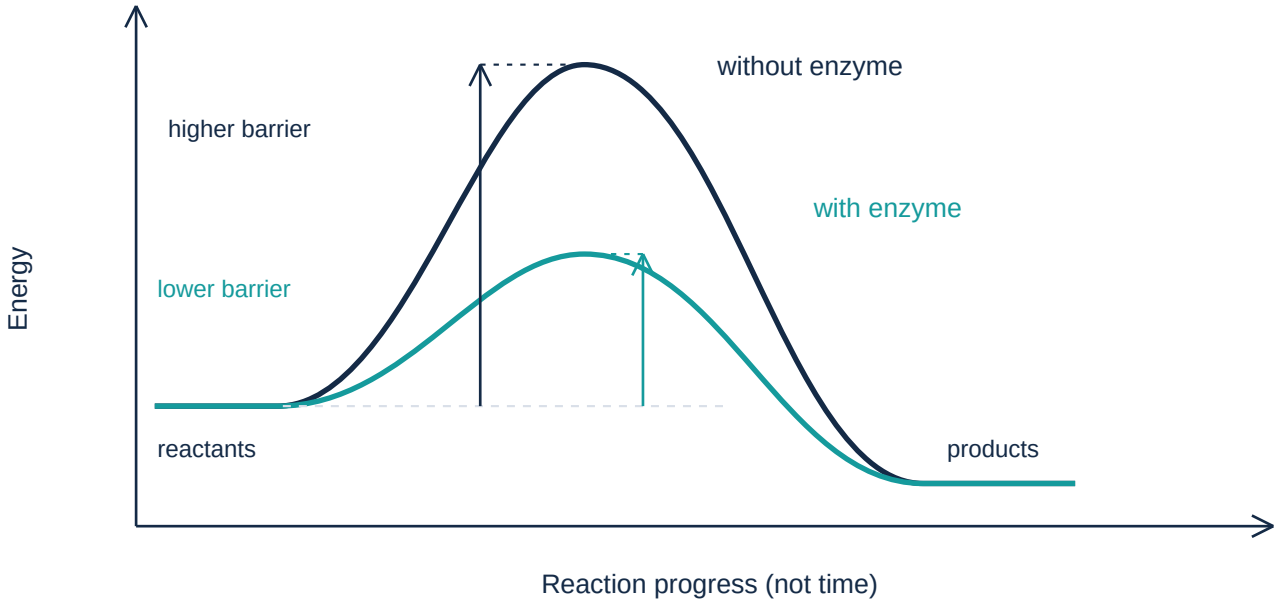
Supporting reading: OpenStax Biology 2e, 6.5: Enzymes.

Scope: Cambridge Biology 9700 syllabus, section 3.1, outcome 2, p. 20.

Lower the barrier, not the endpoints

Activation energy is the energy barrier between reactants and the transition state. An enzyme provides a pathway with a lower barrier, increasing reaction rate at the same temperature.

SCHEMATIC ENERGY PROFILE



1. HOW THE ACTIVE SITE HELPS

Interactions can orient substrates, strain selected bonds and stabilise the transition state. Lowering the barrier allows more substrate molecules to react per unit time. The enzyme does not supply the energy as fuel.

2. WHAT THE GRAPH DOES NOT SHOW

Both curves start at the same reactant energy and end at the same product energy. The enzyme does not change the overall energy difference or the equilibrium position. The graph shows a lower-energy product as one example, not a rule for all reactions.

Read activation energy from the reactant level to the barrier peak, not from the horizontal axis.

Supporting reading: The Cell: The central role of enzymes as biological catalysts.

Scope: Cambridge Biology 9700 syllabus, section 3.1, outcome 2, p. 20.