3 Enzymes

3.1 Mode of action of enzymes

- enzymes are globular proteins that catalyse metabolic reactions
- function as biological catalysts
- specific in nature
- precise 3D shape with hydrophilic R-groups on the outside ensuring they're soluble
- possess active sites which are clefts/depressions to which a substrate can bind

ENZYMES	
INTRACELLULAR	**EXTRACELLULAR**
functions inside of cells	functions outside of cells
synthesised and retained in cell	synthesised in cell but secreted out

Lock and key

- idea that enzymes have particular shapes into which their substrate fits into exactly
- enzyme is said to be specific for a substrate

Induced fit hypothesis

- substrate is partially complementary to the active site
- the active site changes shape slightly to ensure a better fit and stronger binding of substrate
- this makes catalysis even more efficient

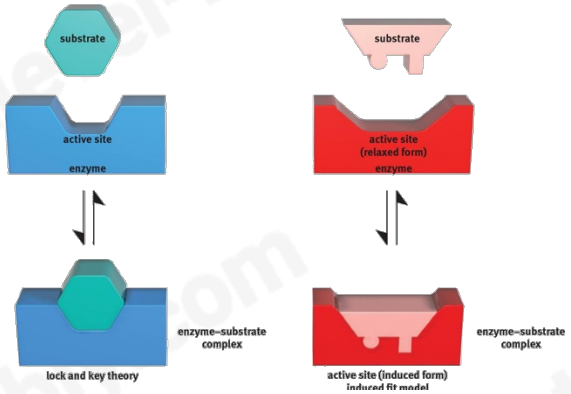


Image: https://schoolbag.info/chemistry/mcat_biochemistry/10.html

Enzymes reduce activation energy (E_a)

- in many chemical reactions, the substrate will not be converted to a product unless it's temporarily given extra energy
- this extra energy is activation energy (E_a)
- enzymes do this by holding their substrates in a way that bonds can be broken more easily hence reducing E_a
- or the shape is slightly changed, making it easier to change the substrate to a product (induced fit theory)

The course of a reaction

- when the enzyme and substrate are first mixed, there's a large number of substrate molecules therefore almost every enzyme has a substrate in its active site
- this makes the rate of enzyme-controlled reaction fastest at the beginning

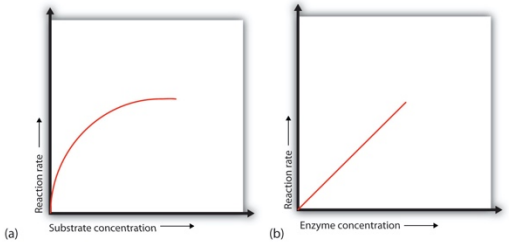


Image: https://2012books.lardbucket.org/

3.2 Factors that affect enzyme action

1) Temperature

- rate of reaction is slow at lower temperatures as molecules are moving slowly which makes collisions happen less frequently
- as temperature rises, enzymes and substrates move faster, and collisions happen more frequently
- when they collide, they do so with more energy which makes it easier for bonds to be formed and broken
- if temperature keeps increasing, bonds holding enzyme in shape (ionic, hydrogen bonds) break and the enzyme is said to be denatured
- the temperature at which enzymes catalyse a reaction at maximum rate is the 'optimum temperature'
- in humans, this is around 40°C

2) pH

- pH is a measure of the H^+ ions in a solution
- H^+ ions can affect the R-groups of amino acids which affects the ionic bonding between groups which in turn affects the 3D structure of the enzyme
- Active site may also be changed, reducing chances of a substrate fitting in

3) Enzyme concentration

- the more enzymes present, the more active sites are available for substrates to fit in
- as long as there's plenty of substrate available, initial rate of reaction increasing linearly with enzyme concentration

4) Substrate concentration

- as substrate concentration increases, initial rate of reaction also increases
- the more substrate molecules there are around, the more often an enzyme's active site can bind with one
- saturation point – enzymes working at max (V_{max})
- all active sites are filled up
- enzyme moves to find substrates as it gets less, collision forces start to decrease

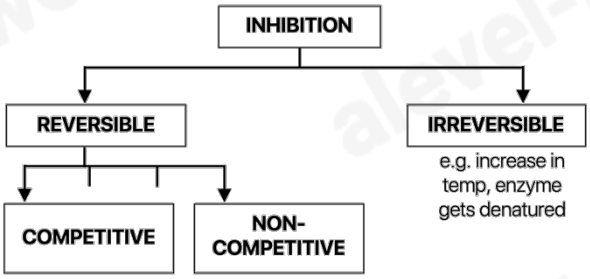
STARCH → MALTOSE → GLUCOSE

too much product so difficult to find substrate

acting as inhibiting agent

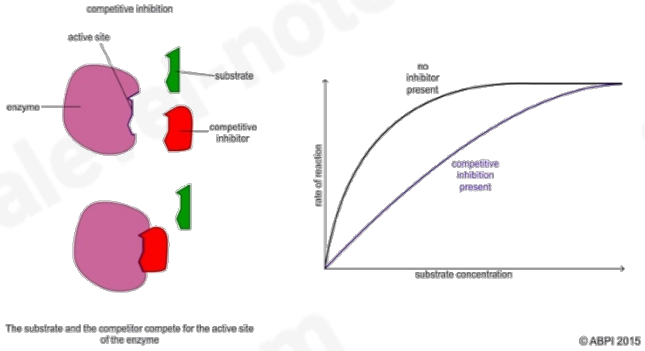
5) Inhibitor concentration

Decreases enzyme activity, slowing down the reaction.



a) Competitive inhibition

- compete with the substrate for the active site
- molecule similar in shape to the enzyme's substrate binds with the active site inhibiting the function



- if the concentration of inhibitor rises or substrate falls, it becomes less likely that the substrate will collide with an active site
- can be reversed by increasing the concentration of substrate

b) Non-competitive inhibitor

Molecule fits into the allosteric site of the enzyme rather than the active site.

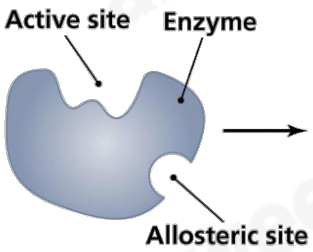
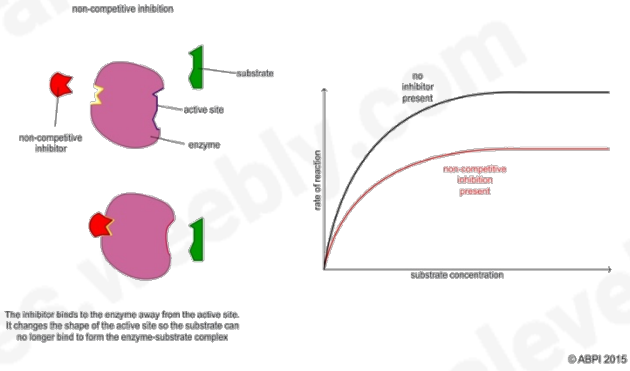


Image: https://aiimsrishikesh.edu.in/

- disrupts the three-dimensional shape of enzyme preventing the substrate from fitting into the active site as its distorted
- increasing the substrate concentration has no change on the rate of reaction here



- End product inhibition – as enzyme converts substrate into product, rate is slowed down at the end as the product binds to another part of the enzyme and prevents more substrate binding

Enzyme affinities

- affinity – enzyme willingness to bind to a substrate
- at V_{max}, all enzyme molecules are bound to substrate molecules; the enzyme is saturated with substrate

As substrate concentration is increased, reaction rate rises until the **max rate i.e., V_{max}**

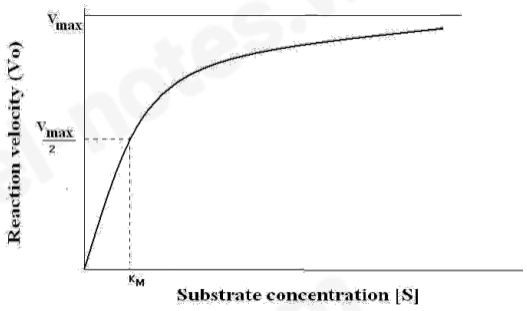


Image: https://commons.wikimedia.org/wiki/File:Michaelis-Memten.JPG

K_m (Michaelis-Menten constant)

- the substrate concentration at which enzyme works at half its maximum rate
- half the active sites of enzymes are occupied by substrate

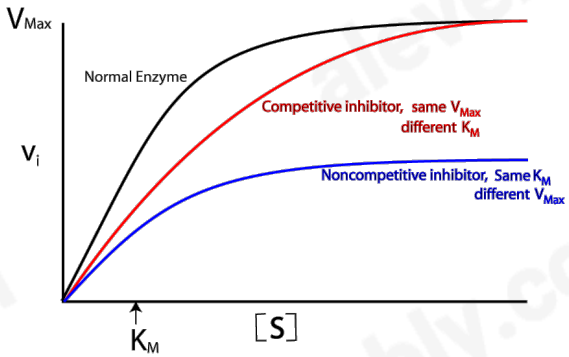


Image: https://teaching.ncl.ac.uk/bms/wiki/index.php/Non-competitive_inhibitor

- An enzyme with a lower value of K_m has a high affinity to its substrate

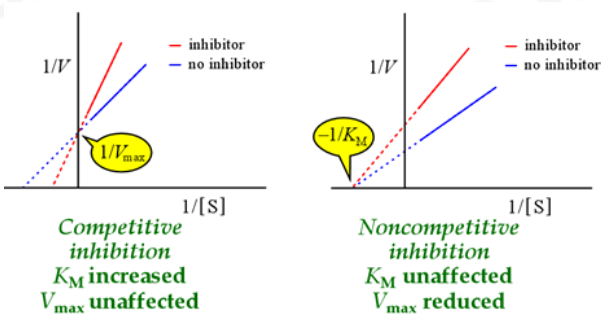


Image: https://epomedicine.com/medical-students/competitive-non-competitive-and-uncompetitive-inhibitors/

Immobilising enzymes

- enzyme is mixed with a solution of sodium alginate
- droplets of this mixture are added to calcium chloride solution
- a reaction occurs forming jelly/beads
- enzyme is immobilised in the bead

Advantages of immobilising enzymes

1) enzyme is reused
2) enzyme is easily recovered
3) product isn't contaminated with enzymes
4) reduces product inhibition
5) enzyme is more stable/less likely to denature
6) longer shelf-line of enzyme