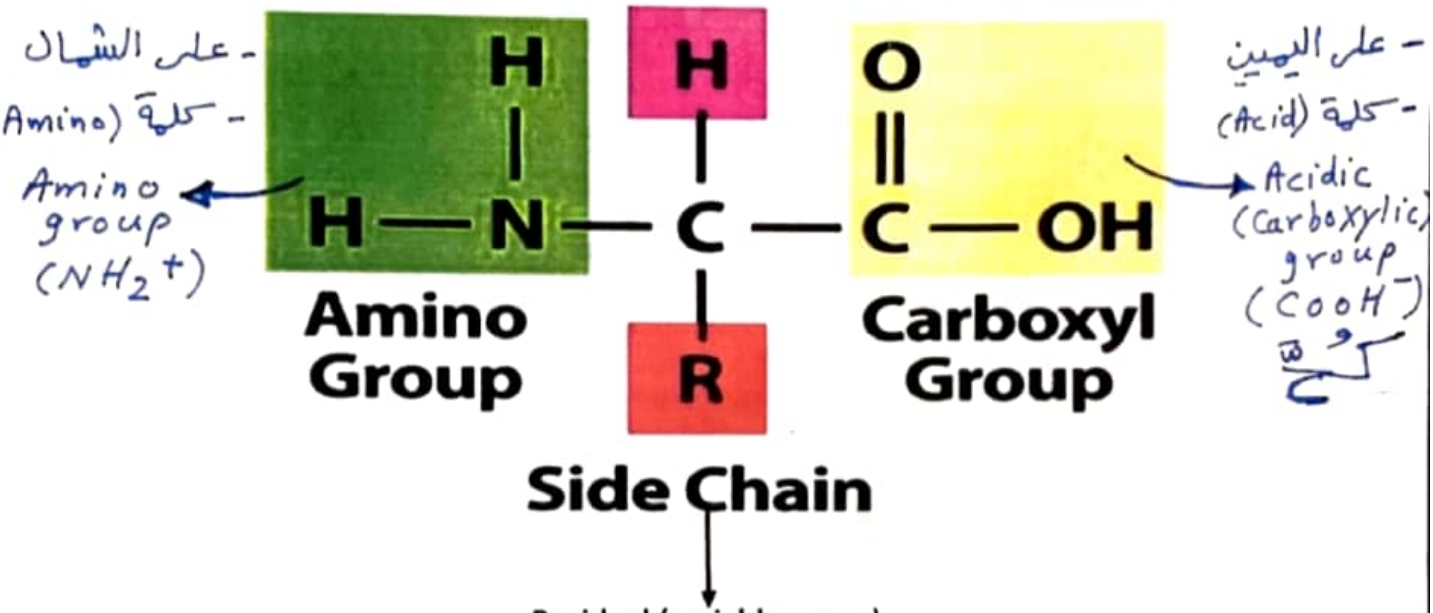
Proteins

Proteins consists of 4 basic elements (C,H,O,N)±S,P

Proteins are polymers formed from>monomers

Polypeptides>amino-acids

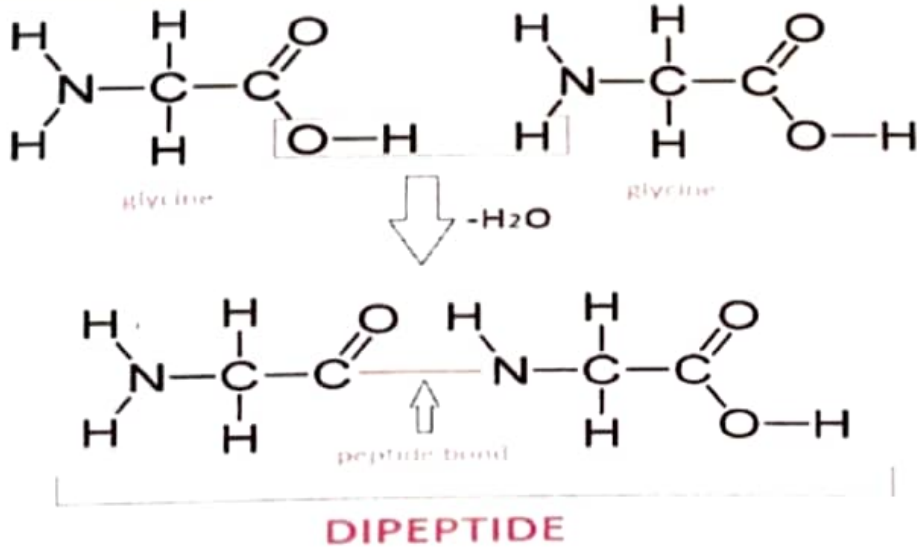
Structure of an amino-acid:



Residual (variable group)

- It differs (varies) from one amino-acid to another
- It determines the chemical and physical properties of an amino-acid
  If the R group is hydrophilic the A.A is hydrophilic and soluble in water
  If the R group is hydrophobic the A.A is hydrophobic and insoluble in water
- It is involved in bonding

Formation of a dipeptide:

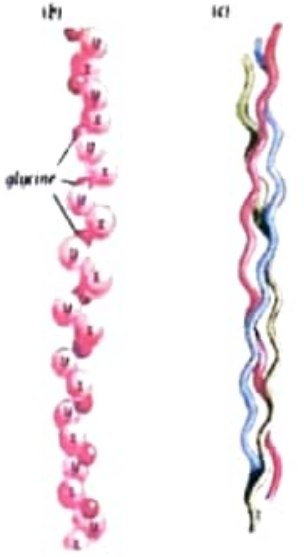


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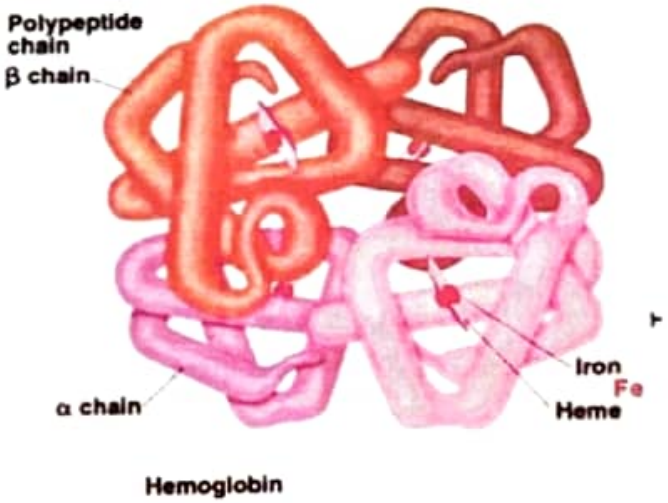
2) Classification of proteins according to their shape:

Fibrous proteins	Globular proteins
Eg. Collagen, keratin	Eg. Haemoglobin, enzymes
- Polypeptide chains are long and parallel (1^{ry} or 2^{ry} structure)	- Polypeptide chain is folded into a ball shape (3^{ry} or 4^{ry} structure)
Have structural functions>form bone, muscles, hair, skin, nails	**Have metabolic functions>**digestion, carry CO_2
Insoluble	Soluble
More stable (less affected by temperature and P.H)	Less stable (more affected by temperature and P.H)

Collagen	Haemoglobin
Fibrous protein	Globular protein
2^{ry} structure	4^{ry} structure
Has a structural function (so, insoluble, more stable)	Has metabolic function (so, soluble, less stable)
Each collagen molecule is triple helix> contain 3 polypeptide chains (only has hydrogen bonds)	Each HB molecule has 4 polypeptide chains(2α,2β)/has 4 types of bonds



- Each polypeptide chain in the collagen molecule folds into an extended alpha chains (approximately 1000 amino acids).
- Every 3rd A.A is glycine



Hemoglobin

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Describe the structure of collagen molecule and explain how the structure strengthens it?

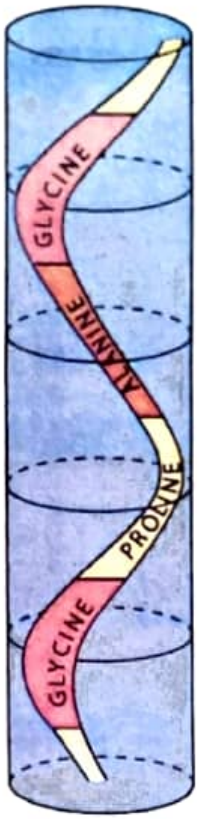
1. one collagen molecule>consists of three polypeptide chains wound around each other to form a triple helix
2. each polypeptide chain contains 1000 A.A every third A.A is glycine (small A.A)
3. collagen molecules are arranged parallel to each other, linked together by (cross links=covalent hydrogen bonds) to form collagen sheets (fibers)

What features that results in giving collagen its high tensile strength?

1. every third A.A in the polypeptide chain is glycine>small A.A, so it helps the coiling of the straight chain to form helix(secondary structure)
2. each triple helix(3 stranded molecule) is held together by (hydrogen bonds)
3. the adjacent collagen molecules are linked together by (cross links=covalent hydrogen bonds)

- That's why collagen sheets are used to reinforce the skin mammalian tissue in skin graft (MCQ - P. 1)

a



The polypeptides which make up a collagen molecule are in the shape of a stretched-out helix. Every third amino acid is glycine.

b



Three helices wind together to form a collagen molecule. These strands are held together by hydrogen bonds and some covalent bonds.

c



Many of these triple helices lie side by side, linked to each other by covalent cross-links between the side chains of amino acids near the ends of the polypeptides. Notice that these cross-links are out of step with each other: this gives collagen greater strength

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HB molecule is described as a globular protein, with quaternary structure

What's meant by the word: quaternary and globular?

Globular: it means that the polypeptide chain is folded into a ball shape, with hydrophobic R groups pointed inwards and hydrophilic R groups pointed outwards to male it soluble (metabolic function)

Quaternary: (just the association of 2 or more polypeptide chains together-each of them have a tertiary structure)

- One HB molecule contains 4 polypeptide chains together-2α and 2β
- 4 haem groups>can carry 4 oxygen molecules>8 oxygen atomes (1 haem carry 1 O_2 molecule)

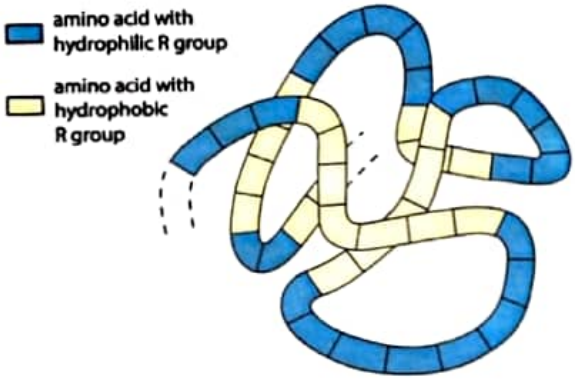
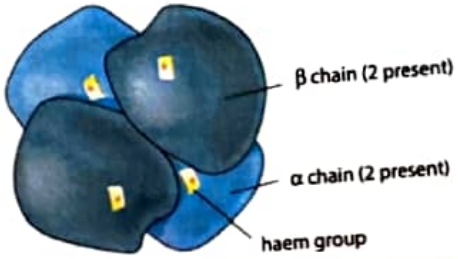


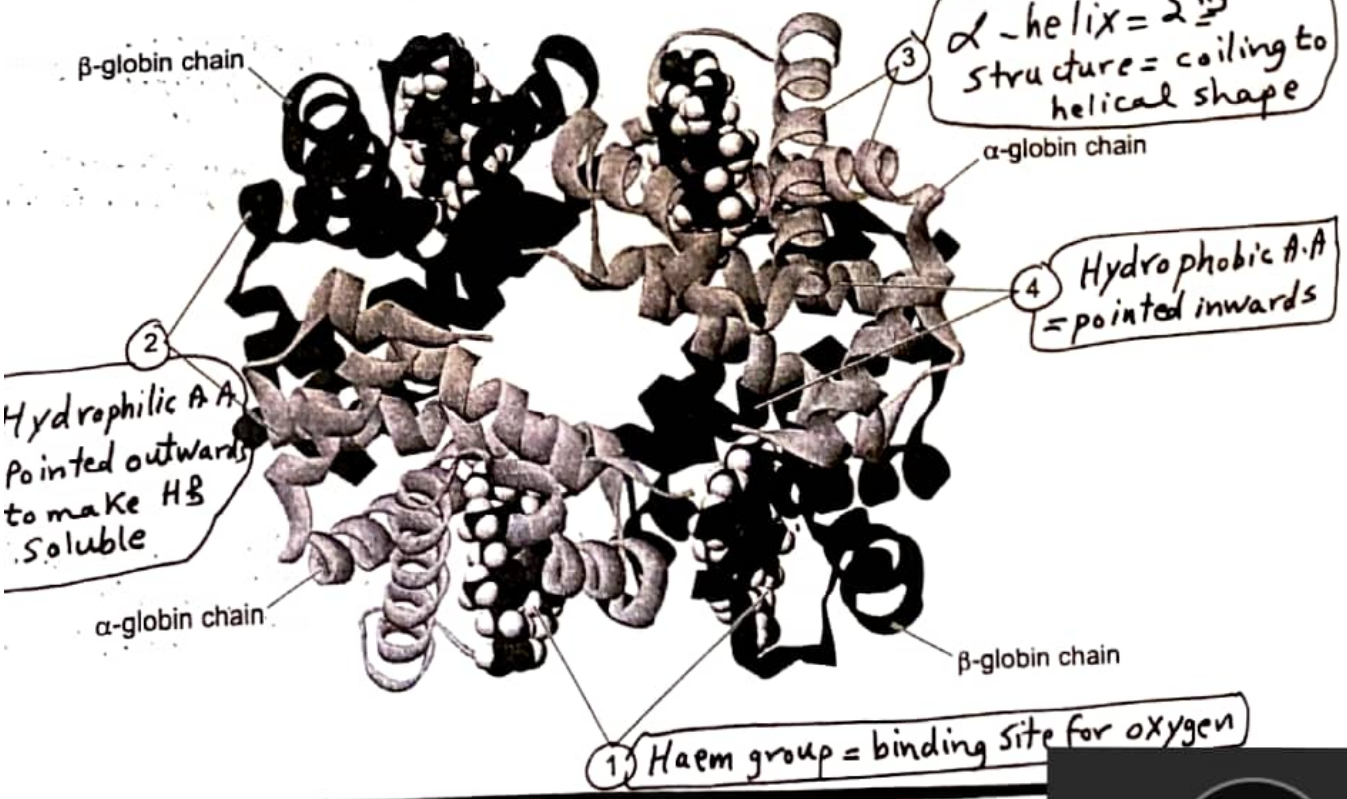
Figure 2.24 A section through part of a globular protein molecule. The polypeptide chain coils up with hydrophilic R groups outside and hydrophobic ones inside, which makes the molecule soluble.





Globular protein → Quaternary structure: ④ Polypeptide chains + ④ haem groups

The diagram shows a haemoglobin molecule.



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Enzymes

Properties of enzymes:

1. Enzymes are proteins:

Globular protein	with Tertiary structure
-the polypeptide chains is folded into a ball shape, with hydrophilic R groups of A.A are pointed outwards to make it soluble -kept in position by 4 types of bonds (hydrogen/ionic/disulphide/hydrophobic bonds)	-it is coiling of the secondary structure where the α-helix is super coiled and folded into a ball 3D shape with a depression on its surface called (active site)=3-12 A.A

2. Enzymes are biological catalysts:

They speed up the chemical reaction without being changed or used up

Ie. Enzymes can be used over and over again

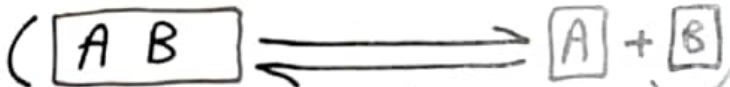
3. Enzymes are specific:

Each enzymes catalyze specific reaction



4. A small amount of enzyme, can digest big amount of substrate (1cc amylase + 9cc starch)

5. Enzymes work in both directions

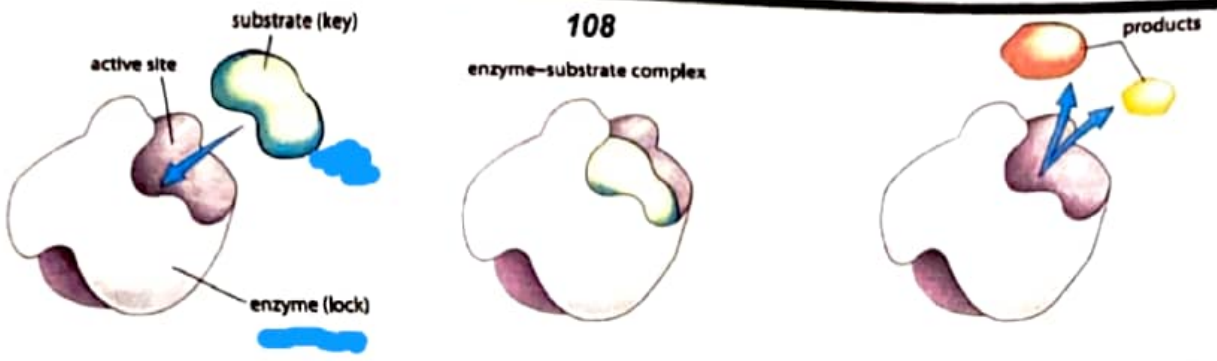


(Enzymes may be anabolic = building up or catabolic = breaking down)

Mechanism of action of enzymes

1. lock and key mechanism (in some enzymes)	2. induced fit mechanism (in most enzymes)
-the shape of the substrate is complementary to the shape of the active site of the enzymes- they fit together exactly, like lock and key -enzyme and substrate are held together by (temporary hydrogen bonds) between: Substrate x R group of A.A in the active site	-the arrival of the substrate into the active site of the enzyme, induces a slight change in the shape of the active site to fit with the substrate perfectly

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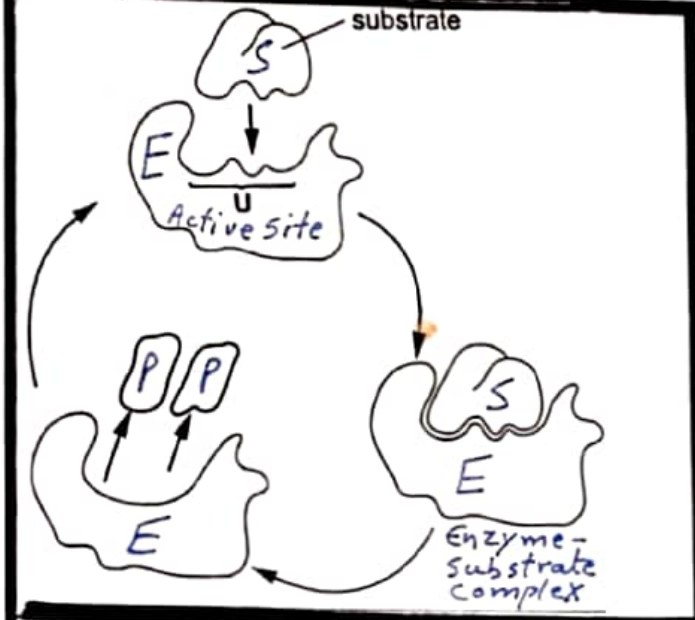


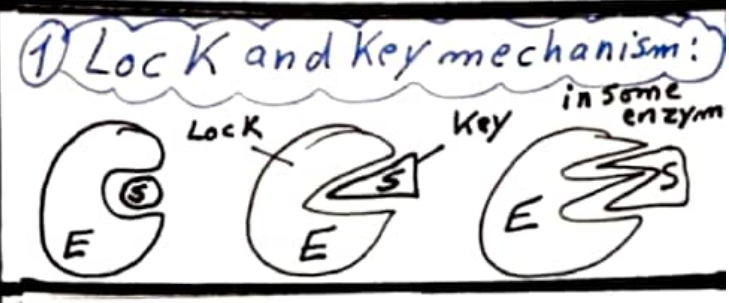
a An enzyme has a cleft in its surface, called the active site. The substrate molecule has a complementary shape.

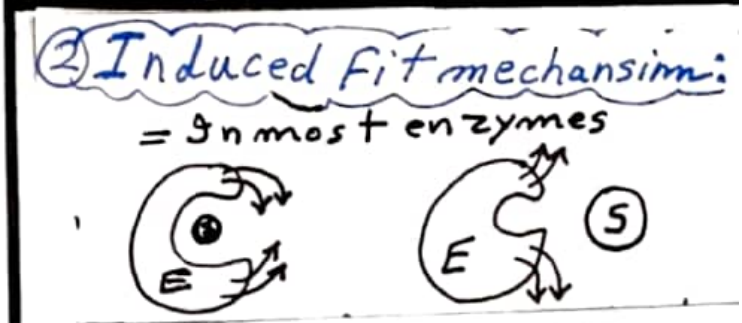
b Random movement of enzyme and substrate brings the substrate into the active site. An enzyme–substrate complex is temporarily formed. The R groups of the amino acids in the active site interact with the substrate.

c The interaction of the substrate with the active site breaks the substrate apart. An enzyme–product complex is briefly formed, before the two product molecules leave the active site, leaving the enzyme molecule unchanged and ready to bind with another substrate molecule.

Figure 3.2 How an enzyme catalyses the breakdown of a substrate molecule into two product molecules. (Catabolic/breaking do... enz...







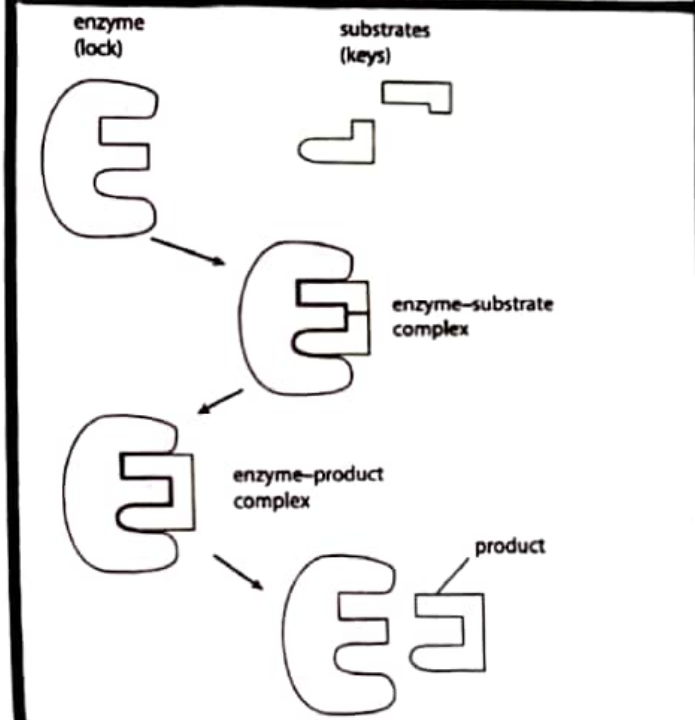
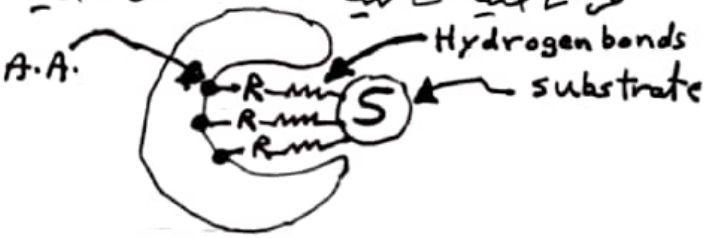


Figure 3.3 A simplified diagram of enzyme function. Note that in this example the enzyme is catalysing the joining together of two molecules. (Anabolic/building up enzyme)

- Enzyme and substrate are held together by (Temporary hydrogen bonds) between:

Substrate ✳ R-groups of A.A. in the active site



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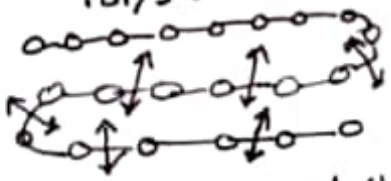
Activation energy

⊙ It is the energy needed to change:

substrate → to → Product

e.g. Starch → maltose sugar

Polysaccharide → Disaccharide



(I) Suppose that the starch molecule contain:

100 bonds → Which need → 100 K.J. to be broken → Activation energy without enzymes = 100 K.J.

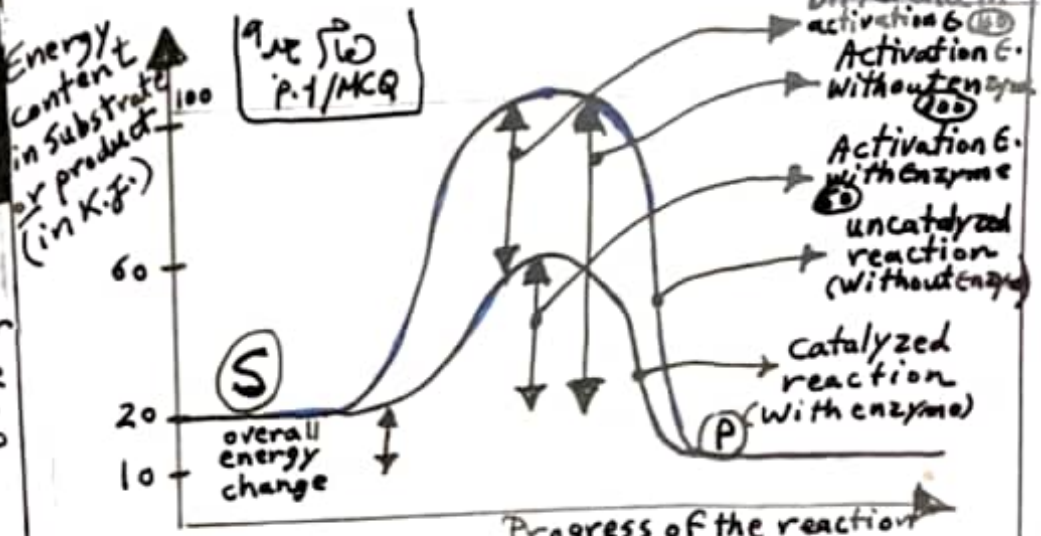
(II) Enzyme hold substrate in its active site causing mechanical breakdown of bonds (40 bonds)

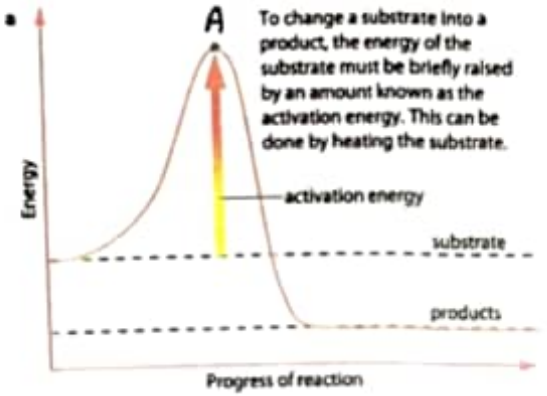


(III) So, enzymes lower the activation energy needed to start the reaction

(IV) 60 bonds → Which need → 60 K.J. to be broken → Activation energy with enzyme = 60 K.J.

MCQ - P.1 → Enzymes lower activation energy needed to start the reaction → by shifting the point of equilibrium (A → B) ⇒ see diagram





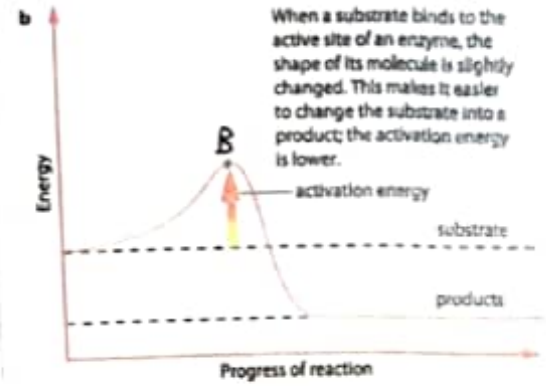
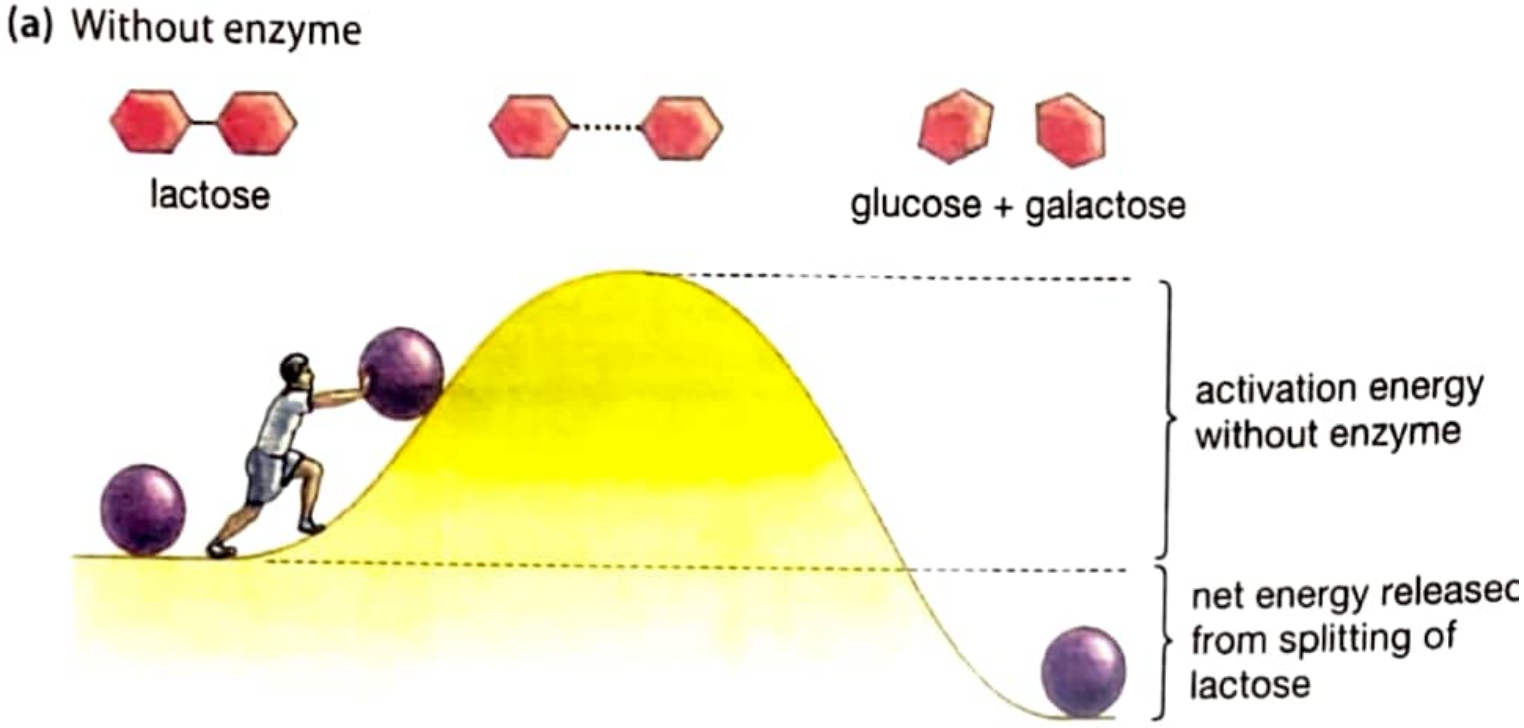
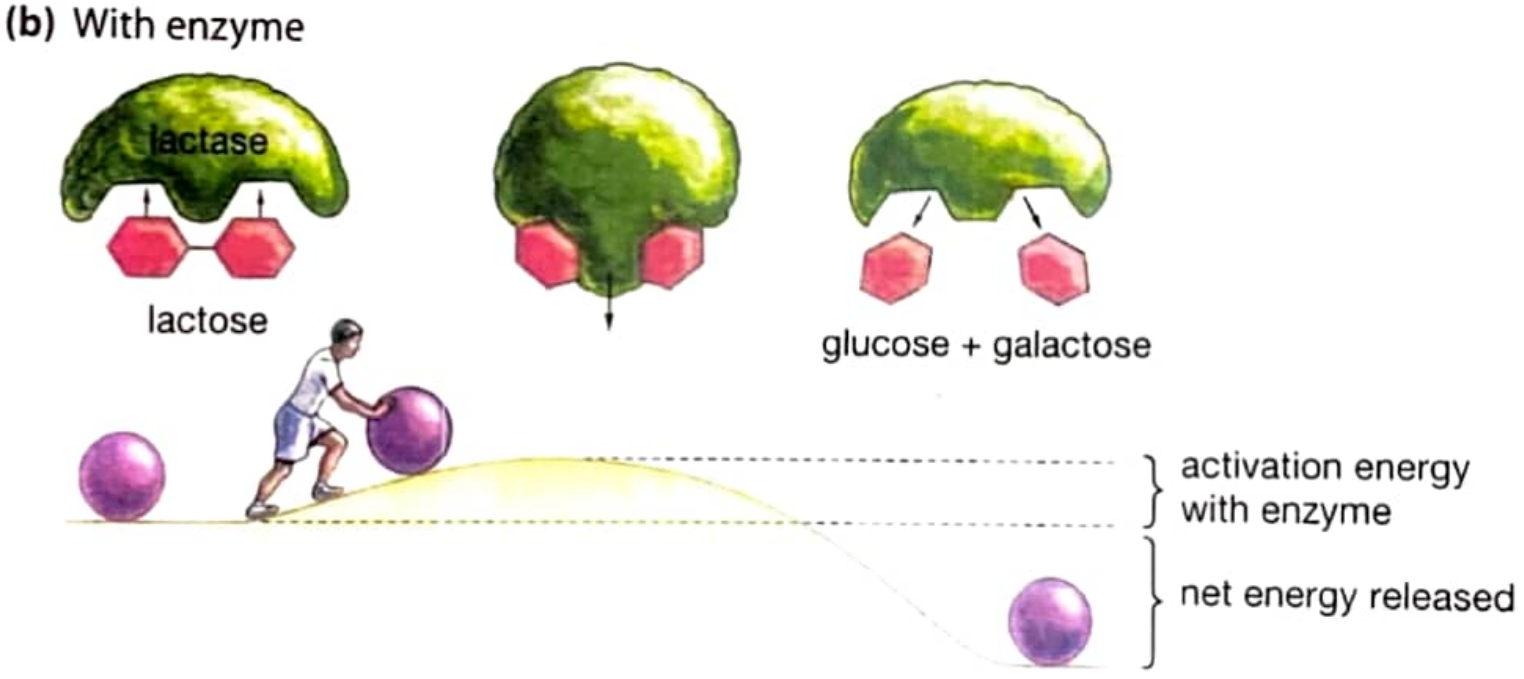


Figure 3.5 Activation energy a without enzyme; b with enzyme.

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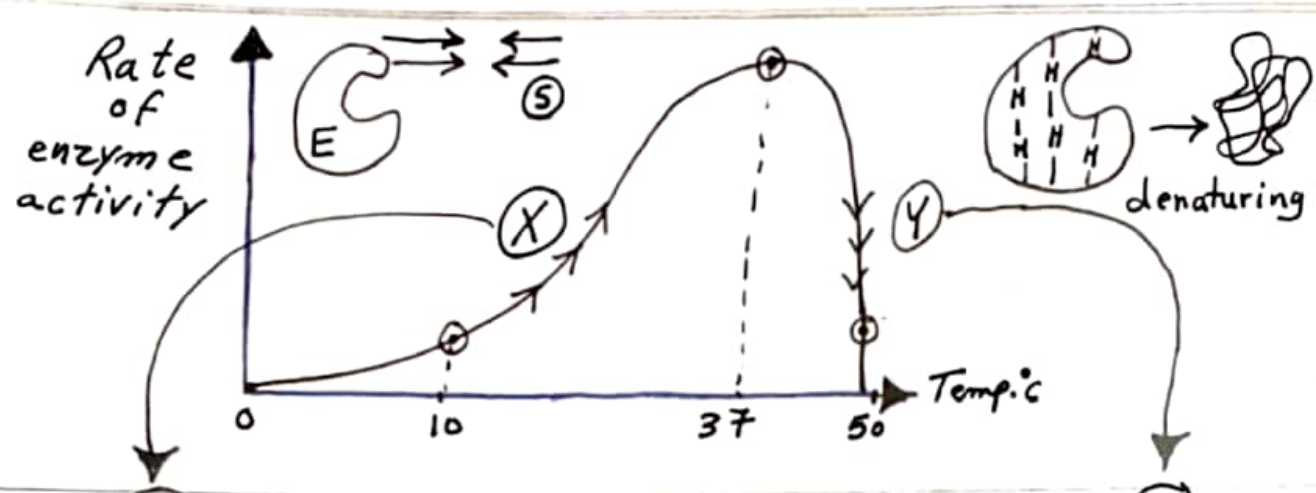
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① Effect of temperature on enzyme activity:



X (Rise 10°C = double the rate of reaction)

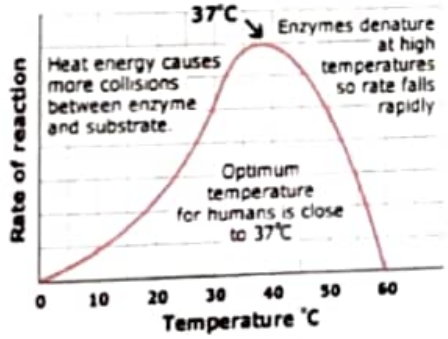
Describe?! → As temperature increases (from 0 → 37°C), the rate of enzyme activity increases (directly (P)) to reach maximum enzyme activity at optimum temperature (37°C)

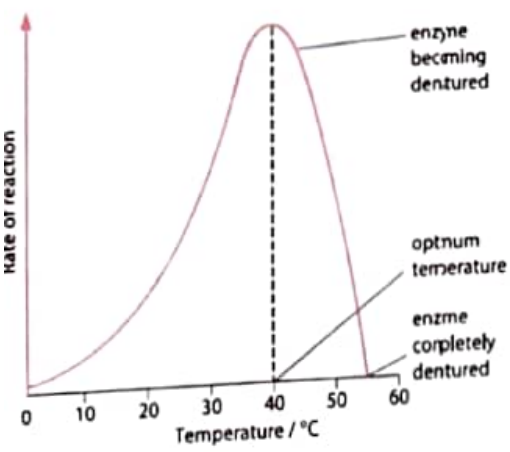
Explain?! → ① When temp. increases, the enzyme, substrate molecules gain heat energy → ② Move Faster (↑ in K.E.) → ③ More Frequent collisions → ④ More fitting of Enzyme and substrate → More release of Product.

Enzyme denatured = **Y**

Describe?! → As temp. increases (From 37 → 50 °C), the rate of enzyme activity decreases (inversely (P))
- N.B. → Enzyme is completely denatured before (50°C) - P.1/MCQ

Explain?! → ① When temp. increases the enzyme molecules vibrate strongly → ② breakdown of hydrogen, hydrophobic bonds → ③ No more bonds to keep the globular shape of the enzyme → ④ Enzyme loses its active site. Can't fit substrate anymore





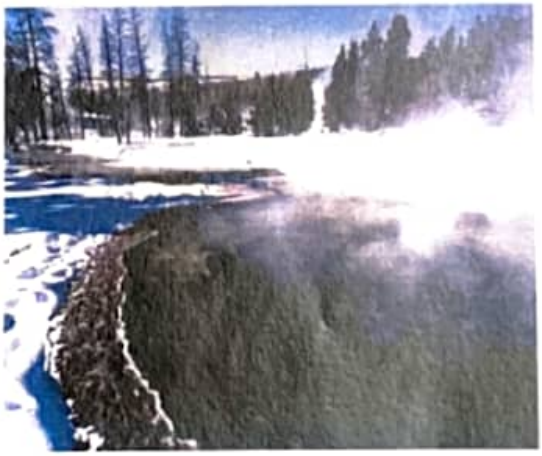
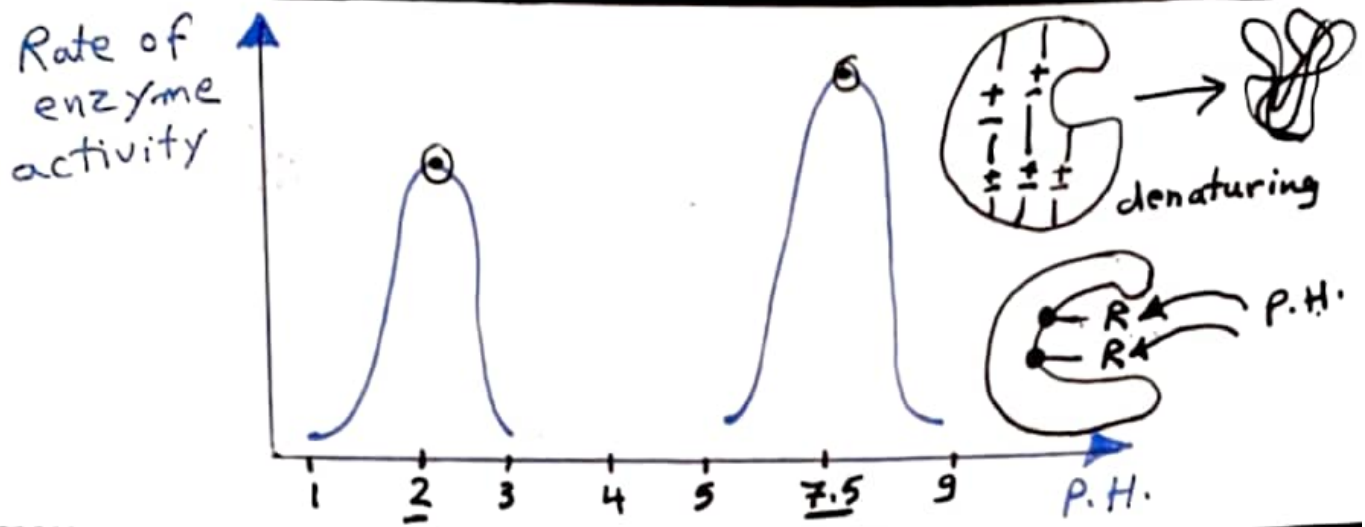


Figure 3.10 Not all enzymes have an optimum temperature of 40 °C. Bacteria and algae living in hot springs such as this one in Yellowstone National Park, USA, are able to tolerate very high temperatures. Enzymes from such organisms are proving useful in various industrial applications. (biological W.P.)

- Their optimum temperature is (80°C) so, they are not denatured by high temperature; That's Why they are added to biological Washing Powders, to tolerate high temp. of the wash.
- These enzymes are (Lipase, Protease), remove Fat and Protein Stains

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② Effect of P.H. on enzyme activity:



⊙ Each Enzyme has on optimum P.H., Where it works best, and has maximum enzyme activity.

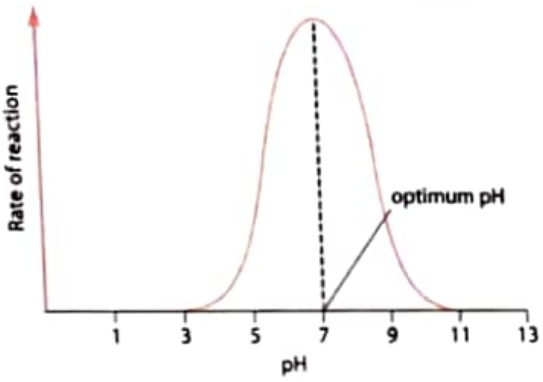
⊙ Examples (Pepsin = PH 2 / Catalase = PH 6 / Amylase = PH 7.5 / sucrase = invertase PH = 4.5

⊙ **Describe?!** → As we go nearer to the optimum P.H., enzym activity increases, and as we go further, activity decreases

⊙ **Explain?!** Changes in P.H. affect the enzyme as follows:

① Breakdown the ionic bonds, that are holding the enzyme in shape, so the enzyme loses its globular shape, its active site, can't fit substrate anymore (become denatured

② Affect R-groups of A.A. in active site of enzyme → Can't fit substrate any more.



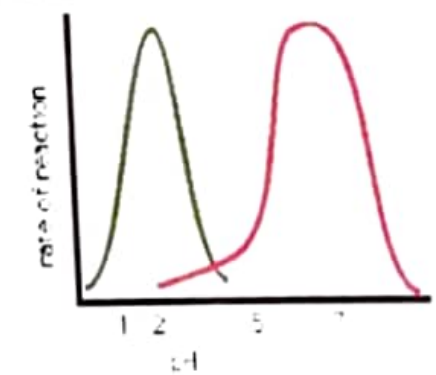
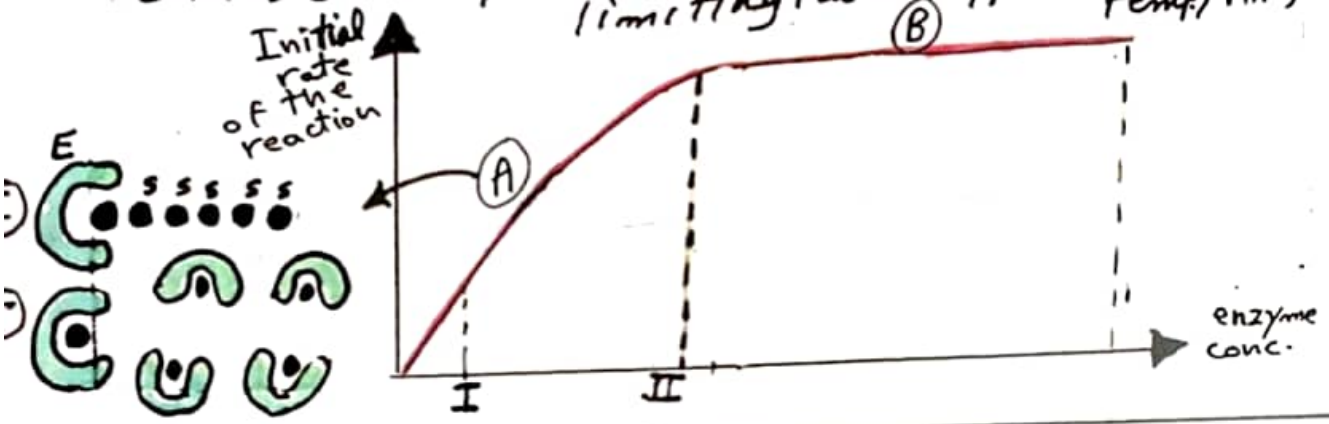


Figure 3.11 The effect of pH on the rate of an enzyme-controlled reaction.

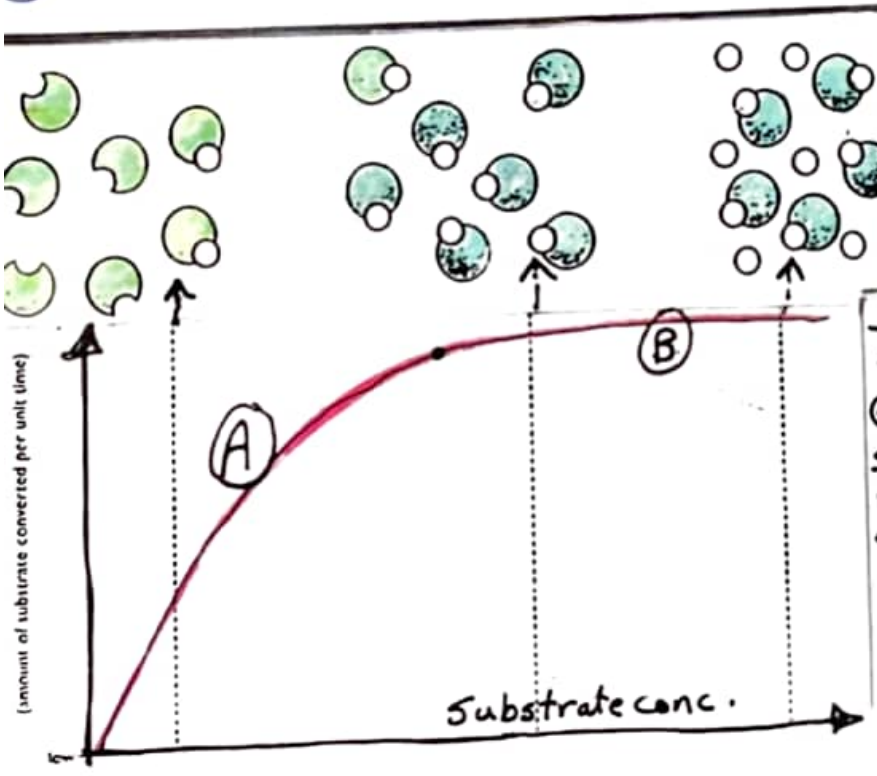
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③ Effect of enzyme concentration on enzyme activity:

- In (A) → As enzyme conc. ↑↑ → n° of enzyme molecules ↑↑ → more available active sites → more fitting with substrate → more release of product → Faster reaction
- In (B) → enzyme conc. ↑↑ → but rate of reaction remains constant, because all substrate was used up or limiting factors appear (e.g. low temp., P.H.)



④ Effect of substrate concentration on enzyme activity:

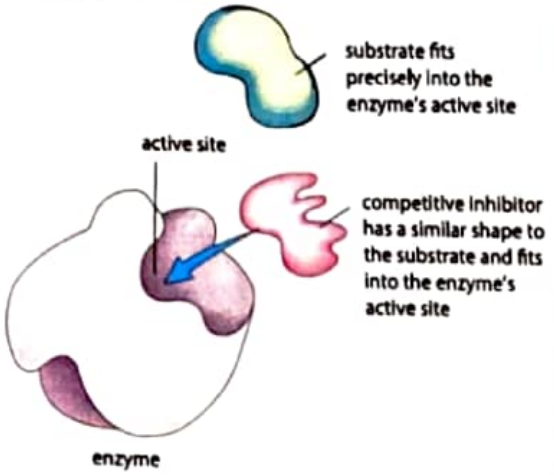
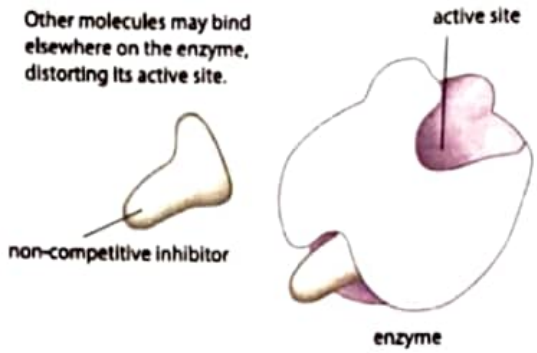
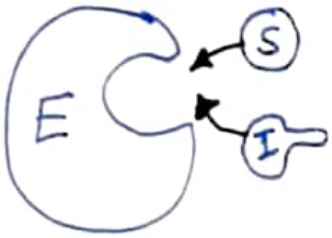


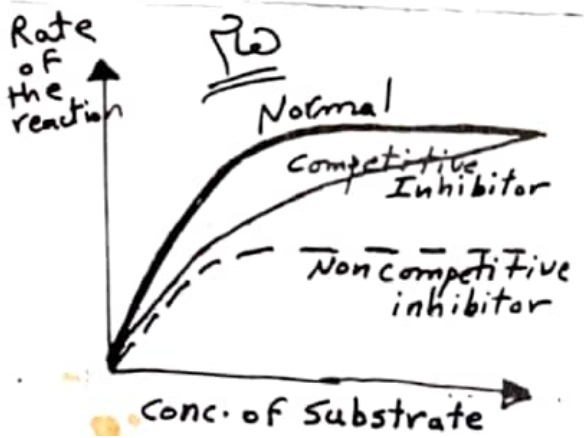
⊙ In stage (A) → As substrate concentration increases, the number of substrate molecules available increases → More frequent collisions → More fitting of enzyme and substrate → More release of product

⊙ In stage (B) → As conc. of substrate ↑↑ → rate of reaction remains constant → because all enzymes are working → all active sites are fully occupied with the substrates.

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Inhibitors

Competitive inhibitor	Noncompetitive inhibitor
a Competitive inhibition  	b Non-competitive inhibition  Figure 3.12 Enzyme inhibition. a Competitive inhibition. b Non-competitive inhibition.
 	
*competitive inhibitors has a molecular shape similar to substrate > so, inhibitor bind to active site>and prevent entry of substrate>rate of the reaction decreases	*non-competitive inhibitors (eg.heavy metals as lead, mercury)>bind to the allosteric site of the enzyme (site other than active site)>which changes the shape of the enzyme
Both substrate and competitive inhibitors compete for the active site of the enzyme	The enzyme loses its active site, can't fit substrate anymore
So, if S conc. > I conc. Rate of reaction increase If I conc. > S conc. Rate of reaction decrease	Non-competitive inhibitors are not affected by changing the conc. of substrate or enzymes



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End Product inhibition

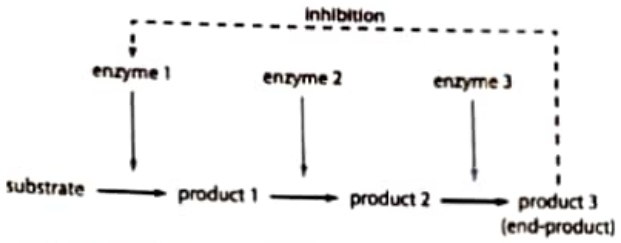
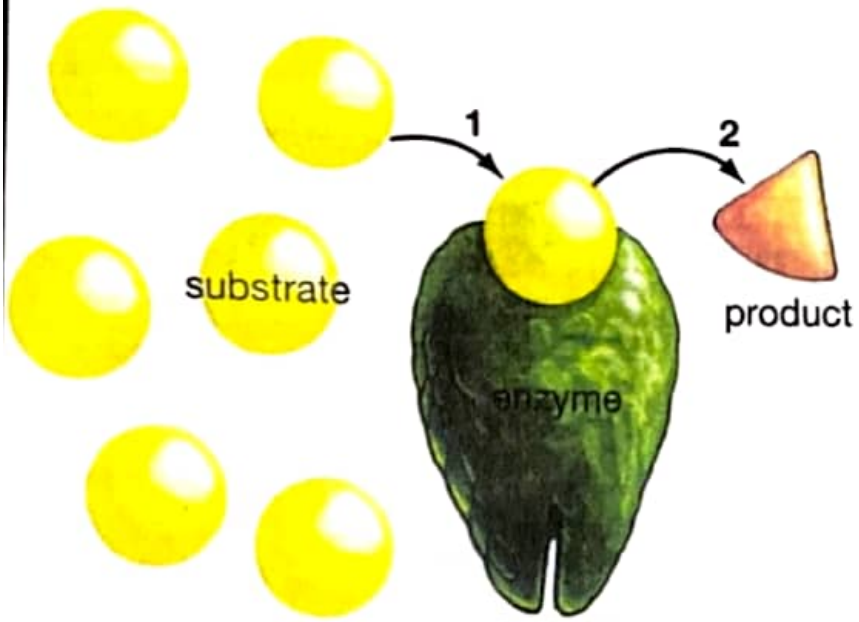


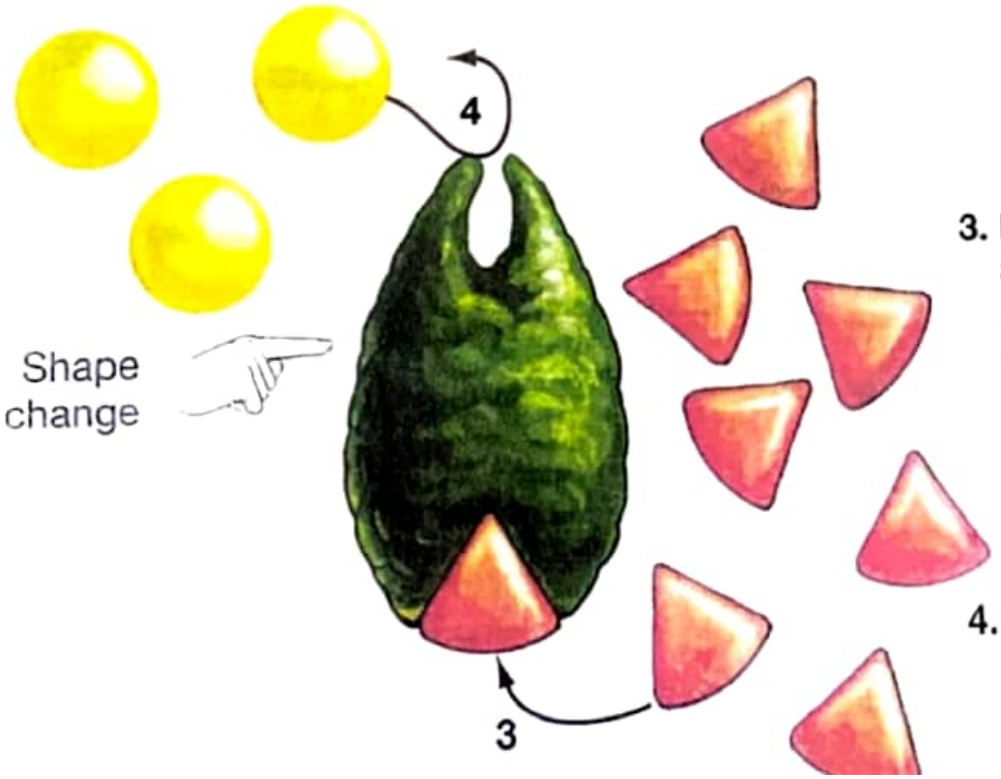
Figure 3.13 End-product inhibition. As levels of product 3 rise, there is increasing inhibition of enzyme 1. So, less product 1 is made and hence less product 2 and 3. Falling levels of product 3 allow increased function of enzyme 1 so products 1, 2 and 3 rise again and the cycle continues. This end-product inhibition finely controls levels of product 3 between narrow upper and lower limits, and is an example of a **feedback mechanism**.

(a) Substrate becomes product



1. Substrate binds to enzyme.
2. Enzyme transforms substrate to product.

(b) Product feeds back on enzyme

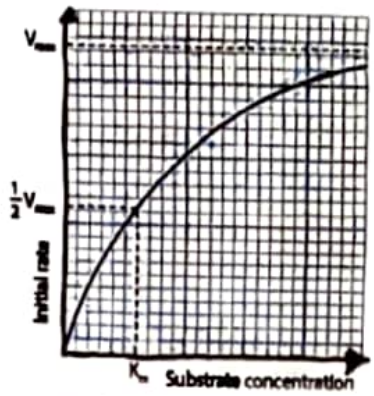


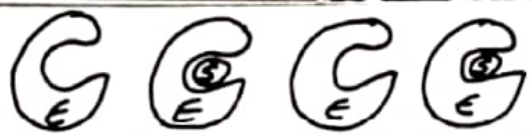
3. Product binds to a *different* site on the enzyme, causing the enzyme to change shape
4. The new shape of the enzyme prevents it from binding to any more substrate.

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Enzymes

Definitions



V max	Half Vmax
- Maximum velocity of the reaction - Maximum rate of the reaction	- Half of the maximum velocity - Half of the maximum rate
- At Vmax ALL active sites are fully occupied by substrates	- At half Vmax HALF the active sites are fully occupied by substrates
	

Km = Michaels constant:

- It is: the conc. of substrate, at which the enzyme is working at half of its maximum velocity (half Vmax)
- At this point, half the active sites of the enzymes are fully occupied by the substrates

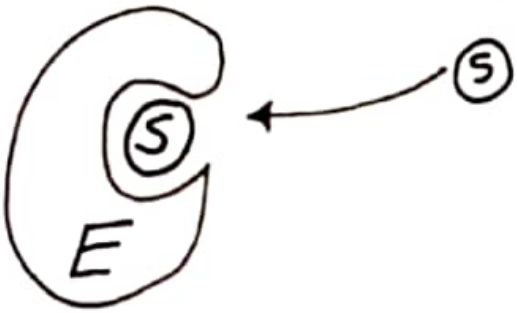
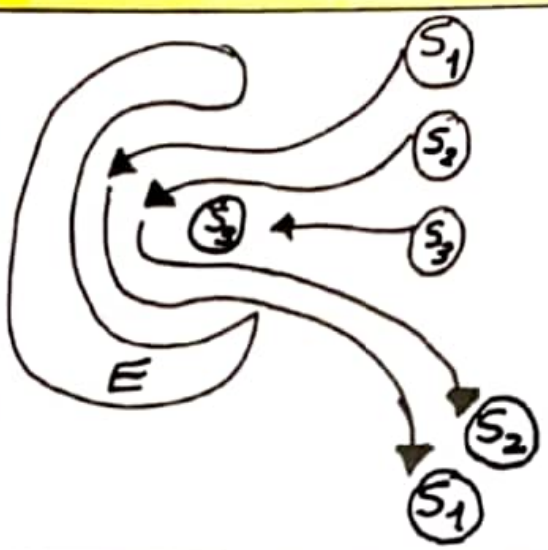
Km measures the affinity of the enzyme for the substrate

- lower km means higher affinity
- higher km means lower affinity

Significance of Km	Significance of Vmax
1. used to determine the affinity of the enzyme to different substrates - the lower the Km the higher the affinity - the higher the Km the lower the affinity	1. can be used to measure the velocity/rate of the reaction under different temperatures, PH
2. can be used to design better enzymes, using genetic engineering	2. can be used to compare the velocity/rate of the same enzyme coming from different organisms (eg. Cat amylase, goat amylase, cow amylase), and choose the best for commercial use

NB. Turnover rate > it is the rate by which the enzyme can change (substrate>product) per second

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Enzyme (X)	Enzyme (Y)
=Has HIGH affinity for substrate	=Has LOW affinity for substrate
	

Enzyme (x)	Enzyme (y)
=high affinity for substrate (lock and key)	=low affinity for substrate (induced fit)
① once substrate binds to active site > they make exact fit ② > reaction starts immediately ③ > substrate don't slip away from the active site, it stays inside	① once substrate binds to active site>they don't make exact fit ② >reaction doesn't start immediately ③ out of 3 substrates: 2 substrates bind, then slip away form active site only 1 substrate bind and stays inside the active site
Ie. HIGH affinity	Ie. LOW affinity
=low Km =low conc. of substrate (only 1) is needed to occupy the active site, ie. To reach Vmax (or half Vmax)	=high Km =high conc. of substrate(3) is needed to occupy the active site, ie. To reach Vmax (or half Vmax)
- if we have 10 active sites/10 molecules of enzymes(x)>then we will need 10 substrates	- if we have 10 active sites/10 molecules of enzyme (y)>then we will need 30 substrates

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