A2 BIOLOGY 9700 CHAPTER C ENZYMES

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Introduction:

Tertiary and beyond protein structure

Globular protein — Enzymes — Enzyme inhibitors

Function — Measuring rate of activity

(a) explain that enzymes are globular proteins that catalyse metabolic reactions;

Keypoints:

- Enzymes are biological catalysts.
- Catalysts increase the rate of chemical reactions without being changed themselves
- Enzymes are protein molecules and are made up of long chains that are folded to produce a special shape: 3D (precise), active site (enables specific molecules to fit into the enzyme), globular (makes it soluble).
- Tertiary protein (spherical) are 3D shape with hydrophilic R-group facing water and hydrophobic R-group inside the core.
- Metabolism is the biochemical modification of chemical compounds in living organisms and cells. This includes the biosynthesis of complex organic molecules (Anabolism) and their breakdown (Catabolism). These reactions consist of sequences of enzymatic steps, also called metabolic pathways.

Metabolism
- Anabolism → Building complex
- Catabolism → Breaks complex

(b) explain the mode of action of enzymes in terms of an active site, enzyme/substrate complex, lowering of activation energy and enzyme specificity;

Keypoints:

- All enzymes speed up reaction rates by lowering the activation energy of a particular reaction, allowing reactions to take place more readily
- All enzymes proceed at optimum physiological temperatures (37°C).
- Enzymes may be extracellular, (acting outside the cells) which produce them (e.g. pepsin, amylase, zymase) or intracellular enzymes, (acting within the cell) - in the nucleus, cytoplasm and/or organelles (e.g. enzymes which catalyse photosynthesis in chloroplasts).

Own Notes

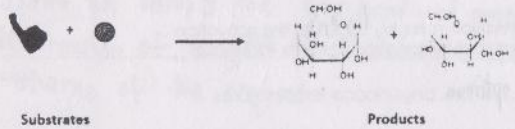
- Enzyme + substrate ↔ enzyme-substrate complex ↔ Enzyme-product complex ↔ Enzyme + product
  E + S ↔ ES ↔ EP ↔ E + P
- Active site is where substrate molecule can bind to an enzyme, producing an enzyme-substrate complex. It is also an expression of a protein structure, the tertiary structure.

- The active site within enzyme involves a small number of key residues that actually bind the substrates.
- These residues are the specific R-groups within the active site which finds themselves binding (forming bonds) specifically to the substrate. Such temporary bonds are hydrogen and ionic bonds.
- Once the substrate forms these temporary bonds, the whole conjugate is known as enzyme substrate complex.
- The rest of the protein structure is needed to maintain these residues in position: e.g bonds formed within the tertiary structure such as the ionic/H/disulphide/hydrophobic bonds.

Enzyme and activation energy.

- Most biochemical reactions can occur spontaneously, however they do so at extremely slow rates.
- An energy barrier associated with chemical reactions causes slow rates of reactions. This energy barrier is overcome by the activation energy (Ea) Slower reactions have higher activation energies to overcome.
- Ea - The minimum amount of energy needed to start the reaction, leading to the formation of a high energy intermediate.
- For example, for a reaction to occur the sucrose and water would have to collide with enough energy to break and form bonds.

Sucrose + H_2O ⟶ Glucose + Fructose



Substrates Products

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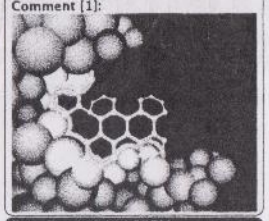
Comment [1]:



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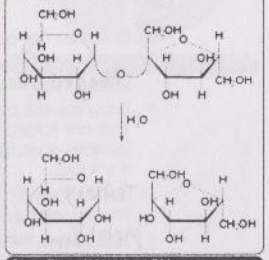
Comment [2]:
The collision between sucrose and water molecule is depending on the input of energy from its surrounding



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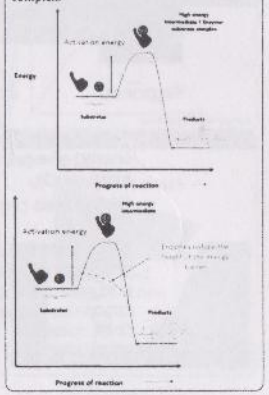
Comment [3]:
The substrate required additional input of energy to raise the energy level so that it can form a high energy intermediate = E-S complex.



Own Notes

induced fit/ lock-and-key hypothesis → enzyme works under

↳ picture of hand & glove

↳ enzyme & substrate is not 100% complementary to each other

lock

substrate must perfectly fit the active site

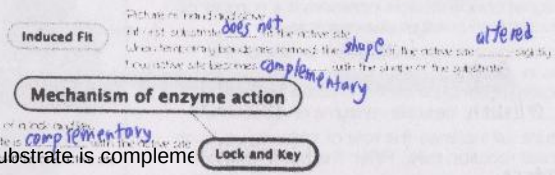
Temporary Bond - most of them are hydrogen bond & ionic bond

if no temporary bond is formed, substrate do not stay in active site

(precise)
← specific R group forms temporary bond → anchor the substrates into the active site
between the residue of substrate and active site

Product not released yet

- We need enzymes to lower down the activation energy without having to increase the heat energy.
- The mechanism of enzyme action can be explained via 2 hypotheses, lock and key and induced fit ← choose 1 when answering



Picture of a lock and keySubstrate is compleme

(c) [PA] follow the progress of an enzyme-catalysed reaction by measuring rates of formation of products (for example, using catalase) or rates of disappearance of substrate (for example, using amylase)

Keypoints:

- You can follow what happens over time in a rxn catalyzed by an enzyme by;
  - Measuring the rate of disappearance of the substrate
  - Measuring the rate of formation of the product

Measure so that we know how fast the enzyme works under certain condition

- E.g. Catalase is an enzyme found in tissues of most living thing which catalyze the breakdown of H202 (hydrogen peroxide) into H20 and 02
- Time course reaction of 02 production
- Rate of reaction ∱ 1/time
- Initial rate of reaction = Rate of reaction measured at t = 0, the initial slope of the graph represents the initial rate of reaction
- Initial rate of reaction is measured when all reactants are brought together - in the reaction, there shouldn't be any limiting factor (slows the reaction)
- Reaction rates slow down as the reaction approaches equilibrium. As products are formed, there are fewer reactant particles to react which means there will be fewer successful collisions, so, the reaction rate decreases.
- Measuring the disapperance of substrate by using amylase and starch can be done by using iodine test. Using an appropriate time-intervals, samples from the reaction mixture is allowed to mix with iodine's solution, and the end point seen here will be _____

Own Notes

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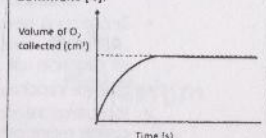
Comment [4]:



- Large volume of O2 collected in the first minute
- As the reaction continues, rate of O2 released gradually slows down
- Eventually the reaction stops because all the substrates are broken down

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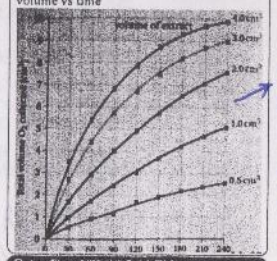
Comment [5]:
volume vs time



Use initial rate to find r.o.r.

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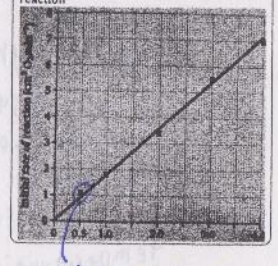
Comment [6]:
The rate of reaction for the first 30s of the reaction



Obtained by first 30s of the 1st graph

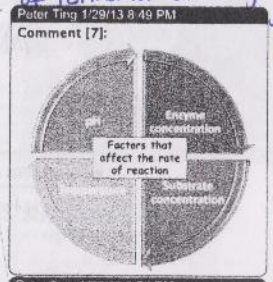
(d) [PA] investigate and explain the effects of temperature, pH, enzyme concentration and substrate concentration on the rate of enzyme-catalysed reactions;

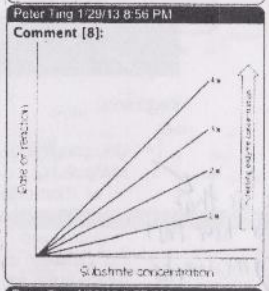
Keypoints:

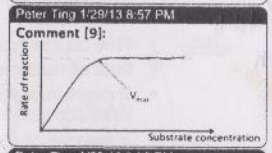
Share points

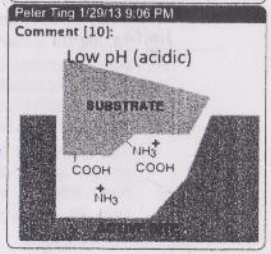
- Increasing enzyme concentration increase the rate of the reaction (if substrate is in excess)
  Reason: Increasing enzyme concentration increases the number of active site available to catalyze the reaction.
- Increasing substrate concentration increase the rate of the reaction (if enzyme is in excess)
  Reason: Increasing substrate concentration increases the rate of effective collision between enzyme and substrate
- Increasing temperature will increase the rate of reaction up to an optimum rate (highest reaction rate). After this point, the rate of reaction will decrease
- Before reaching the optimum temperature, increasing temperature increases E's and S's kinetic energy. E and S collide more often per quantity of time. Rate of effective collision increase
- Form more enzyme-substrate complex
- After the point, temperatures above the optimum cause increasing enzyme molecule vibration, breaking down internal bonds (e.g. hydrogen bond) and destroying the active site. The enzymes become denatured (lose its shape and activity).
- pH is the measure of the concentration of H^+ ions in a solution.
- The lower the pH the more the concentration of hydrogen ions.
- Hydrogen ions can interact with the R groups of amino acids, affecting the way in which they bond with each other (e.g.) and therefore affect their 3D structure arrangement.
- A pH which is very different from the optimum pH can cause denaturing of an enzyme or substrate unable to bind with the active site

high chance of collision between enzyme and substrate. high rate of formation of enzyme-substrate complex







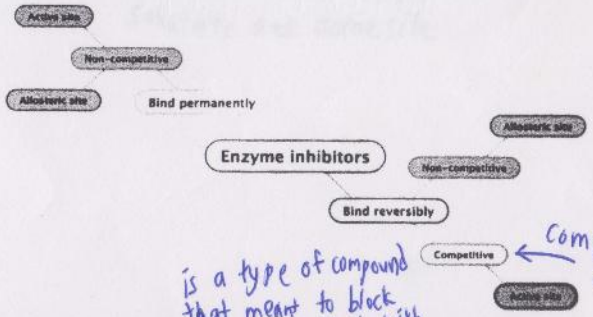


- extreme pH disrupts the ionic bond and causes denaturation of enzyme as it neutralises the charge of the enzyme.

Own Notes

- Q10 said that if there is increase in 10°C, it will result in doubled rate of reaction (provided before the optimum temperature is reached)
- If temperature increases beyond the optimum temperature, enzyme will denature.
- Why? Because when temperature increases beyond optimum temperature, hydrogen bonds will break as water molecules and enzymes are vibrating vigorously.
- When H_2O vibrates vigorously, it disrupts the H-bond between 2 amino acid in protein structure causing it to lose the shape.

(e) explain the effects of competitive and non-competitive inhibitors on the rate of enzyme activity;



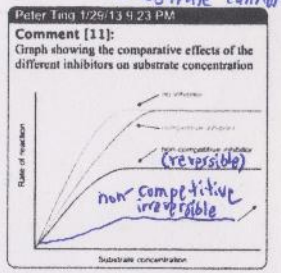
Inhibitors
N.C.I C.I.
To differentiate
(i) Permanently/reversibly
(ii) Place to bind
- active site
- allosteric site
  → forms bond changes shape of enzyme
  → substrate cannot bind

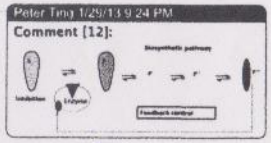
Compete with substrate

is a type of compound that meant to block enzyme to bind with its substrate

Keypoints:

- Competitive inhibitors bind reversibly to the enzyme, preventing the binding of substrate
- It is because inhibitor and substrate have similar shape.
- On the other hand, binding of substrate prevents binding of the inhibitor. Substrate and inhibitor compete for the enzyme. Therefore if there is increase amount of substrate, the effect of the inhibitor will be decrease
- Inhibitor binds reversibly to the allosteric site
- Induced fit alters the conformational structure of the enzyme.
- Active site is distorted and is not recognised by the substrate
- Increasing substrate concentration has (yes/no) effect on inhibition
- Inhibitor is not similar in structure to the substrate
- Permanent inhibition is (non-competitive/competitive) in nature.
- End product inhibition - Enzyme is inhibited by the final product of the pathway





Own Notes

Some reaction in body