Cambridge (CIE) IGCSE Biology

Your notes

Enzymes

Contents

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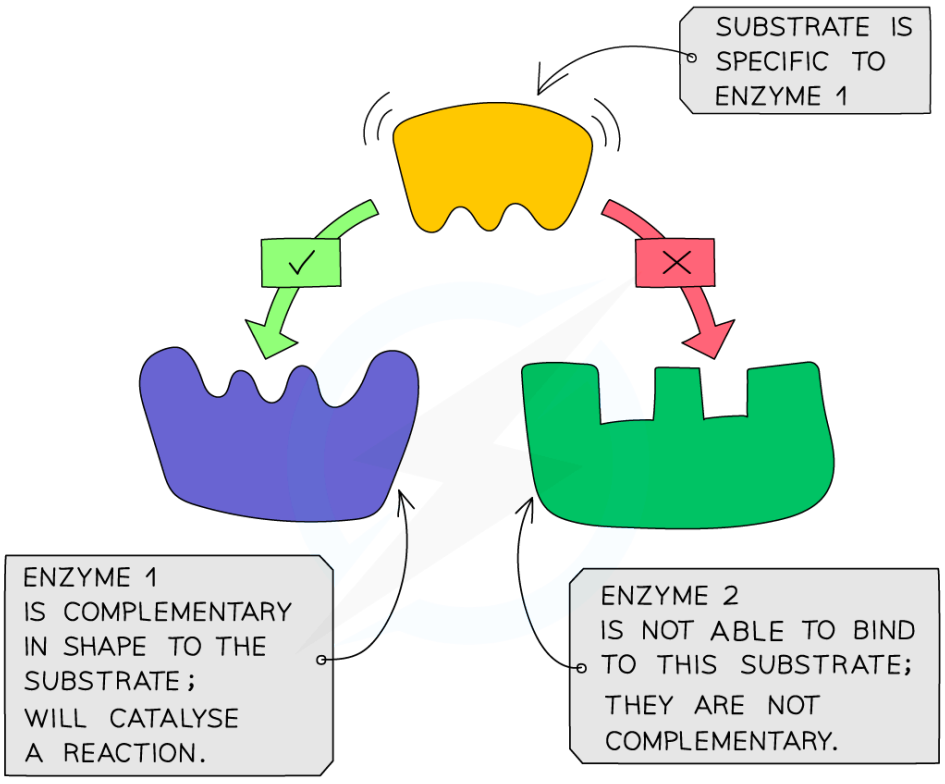
What are enzymes?

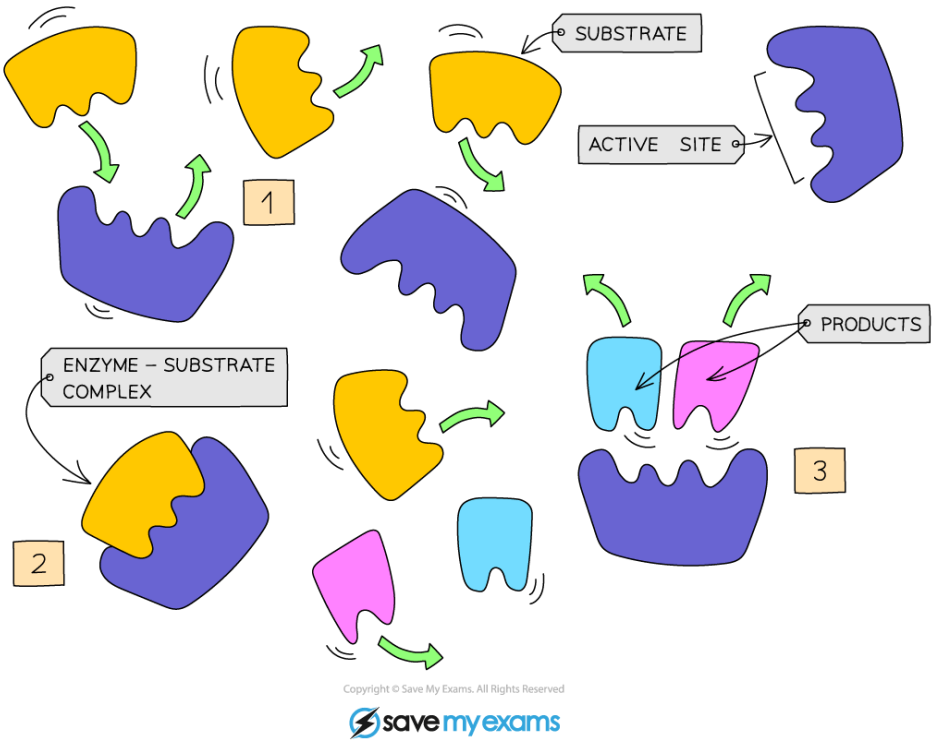
- Enzymes are:
  - **Catalysts** that **speed up** the rate of a chemical reaction **without being changed** or used up in the reaction
  - **Proteins**
  - **Biological catalysts** (biological because they are **made in living cells**, catalysts because they speed up the rate of chemical reactions without being changed)
  - Necessary to all living organisms as they **maintain reaction speeds** of all metabolic reactions (all the reactions that keep an organism alive) at a rate that can **sustain life**
    - For example, if we did not produce digestive enzymes, it would take around 2 - 3 weeks to digest one meal; with enzymes, it takes around 4 hours

How do enzymes work?



Enzyme substrate specificity

- Enzymes are **specific** to one particular substrate (molecule/s that get broken down or joined together in the reaction) as the enzyme is a complementary shape to the substrate
- The product is made from the substrate(s) and is released



Enzyme specificity: lock and key model of enzyme activity

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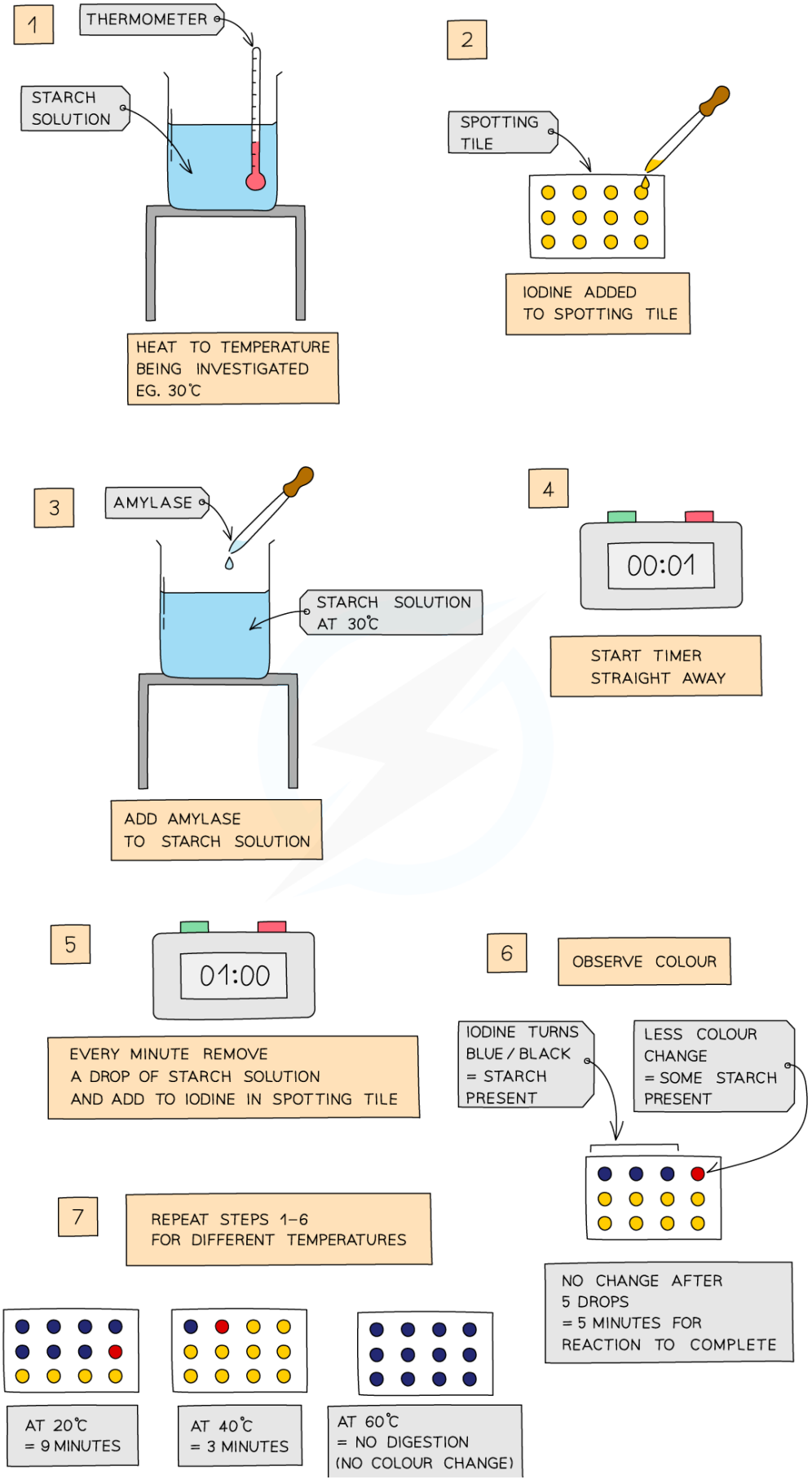
Investigating the Effect of Temperature on Amylase

- **Starch solution** is heated to a set temperature
- **Iodine** is added to wells of a spotting tile
- **Amylase** is added to the starch solution and mixed well
- Every minute, droplets of solution are added to a new well of iodine solution
- This is continued until the iodine **stops turning blue-black** (this means there is **no more starch** left in the solution as the amylase has broken it all down)
- Time taken for the reaction to be completed is recorded
- Experiment is repeated at different temperatures
- The quicker the reaction is completed, the faster the enzyme is working



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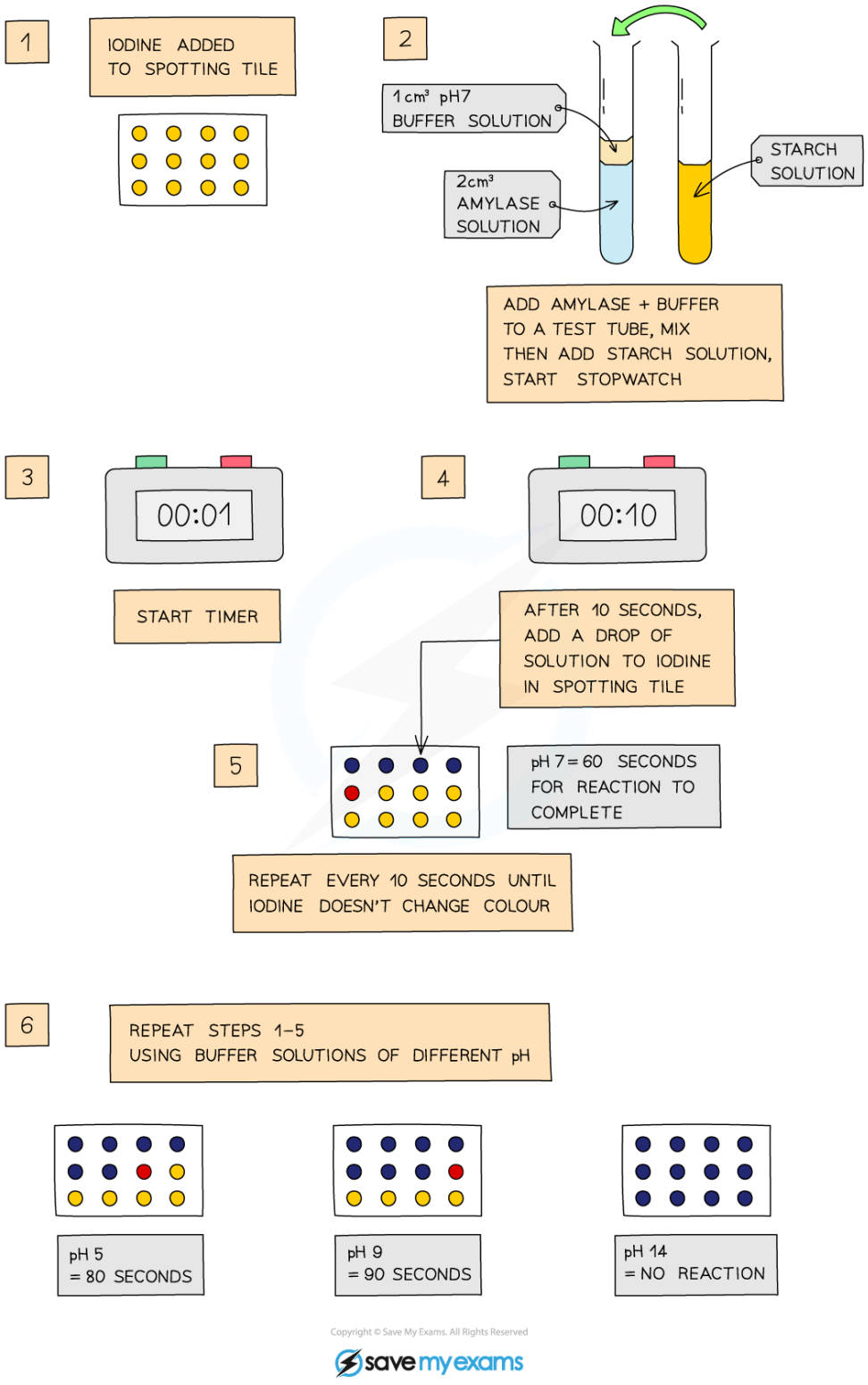
Investigating the Effect of pH on Amylase

- Place single drops of **iodine** solution in rows on the tile
- Label a test tube with the pH to be tested
- Use the syringe to place 2cm^3 of **amylase** in the test tube
- Add 1cm^3 of **buffer solution** to the test tube using a syringe
- Use another test tube to add 2cm^3 of **starch solution** to the amylase and buffer solution, start the stopwatch whilst mixing using a pipette
- After 10 seconds, use a pipette to place one drop of mixture on the first drop of iodine, which should turn blue-black
- Wait another 10 seconds and place another drop of mixture on the second drop of iodine
- Repeat every 10 seconds **until iodine solution remains orange-brown**
- Repeat experiment at different pH values - the less time the iodine solution takes to remain orange-brown, the quicker all the starch has been digested and so the better the enzyme works at that pH



Investigating the effect of pH on enzyme activity

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Examiner Tips and Tricks

Describing and explaining experimental results for enzyme experiments is a common type of exam question so make sure you understand what is happening and, for a 7, 8 or 9, can relate this to changes in the active site of the enzyme when it has denatured, or if it is a **low temperature**, relate it to the amount of kinetic energy the molecules have.

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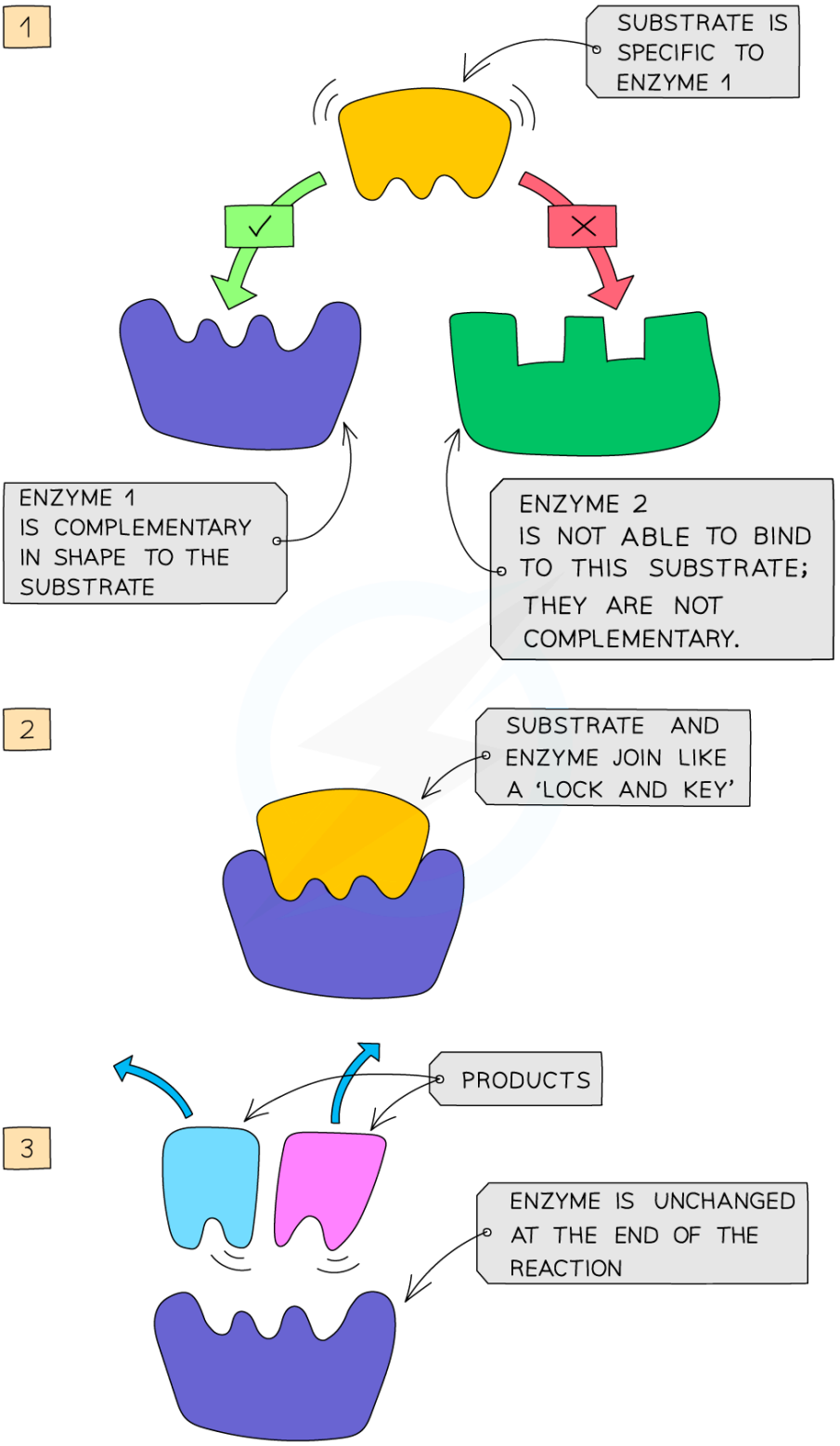
Enzyme Action & Specificity: Extended

Extended Tier Only

- Enzymes are **specific** to one particular substrate(s) as the **active site** of the enzyme, where the substrate attaches, is a complementary shape to the substrate
- This is because the enzyme is a protein and has a **specific 3-D shape**
- This is known as the **lock and key hypothesis**
- When the substrate moves into the enzyme's active site they become known as the **enzyme-substrate complex**
- After the reaction has occurred, the **products** leave the enzyme's active site as they no longer fit it and it is free to take up another substrate



How enzymes work

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1. Enzymes and substrates **randomly** move about in solution

2. When an enzyme and its complementary substrate randomly **collide** - with the substrate fitting into the active site of the enzyme - an **enzyme-substrate complex** forms, and the reaction occurs.

3. A product (or products) forms from the substrate(s) which are then released from the active site. The enzyme is unchanged and will go on to catalyse further reactions.

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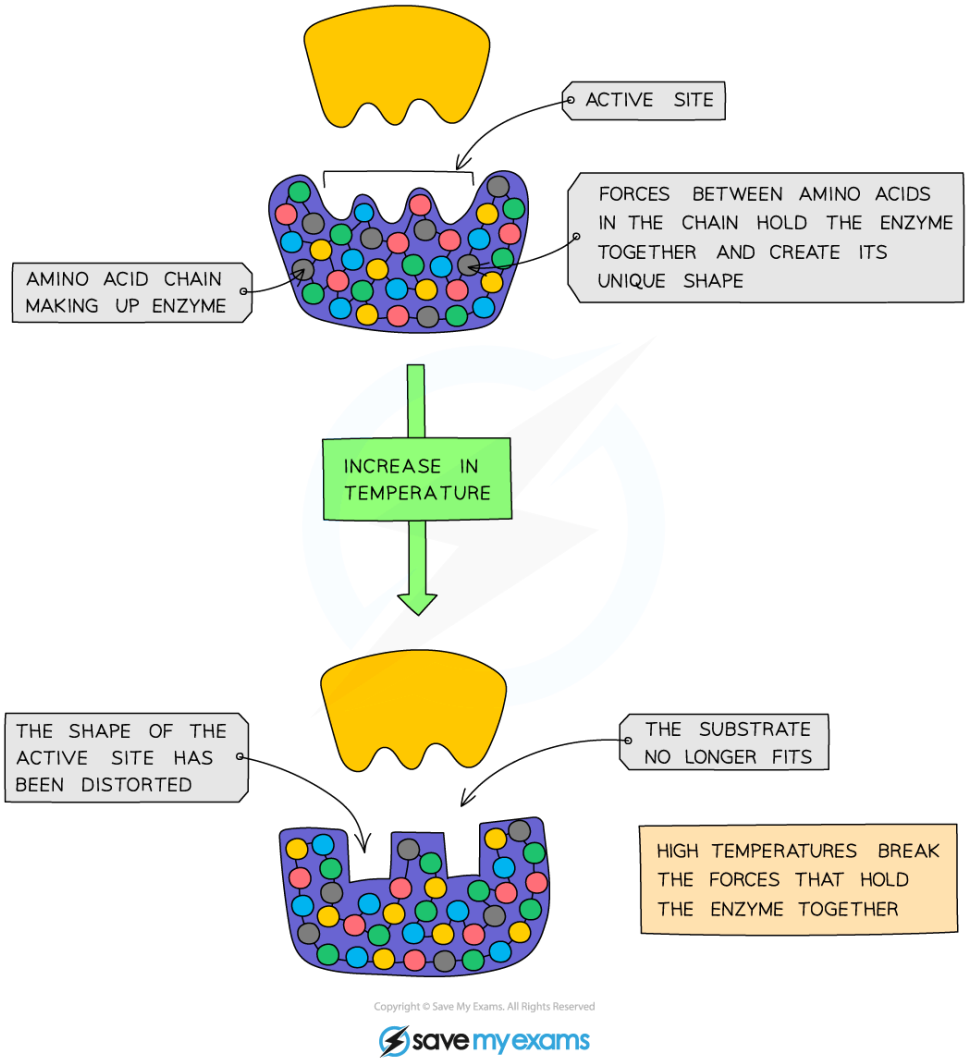
Enzymes & Temperature: Extended

Extended Tier Only

- Enzymes are **proteins** and have a **specific shape**, held in place by **bonds**
- This is extremely important around the **active site** area as the specific shape is what ensures the **substrate will fit into the active site** and enable the reaction to proceed
- Enzymes work fastest at their '**optimum temperature**' – in the human body, the optimum temperature is $37^{0}C$
- Heating to high temperatures (beyond the optimum) will **break the bonds** that hold the enzyme together and it will lose its shape -this is known as **denaturation**
- Substrates cannot fit into denatured enzymes as the shape of their active site has been lost
- Denaturation is **irreversible** - once enzymes are denatured they cannot regain their proper shape and activity will stop



Effect of temperature on enzyme activity

- Increasing the temperature from 0^{0}C to the optimum increases the activity of enzymes as **the more energy the molecules have the faster they move and the number of collisions with the substrate molecules increases**, leading to a faster rate of reaction
- This means that **low temperatures do not denature enzymes**, they just make them work more slowly

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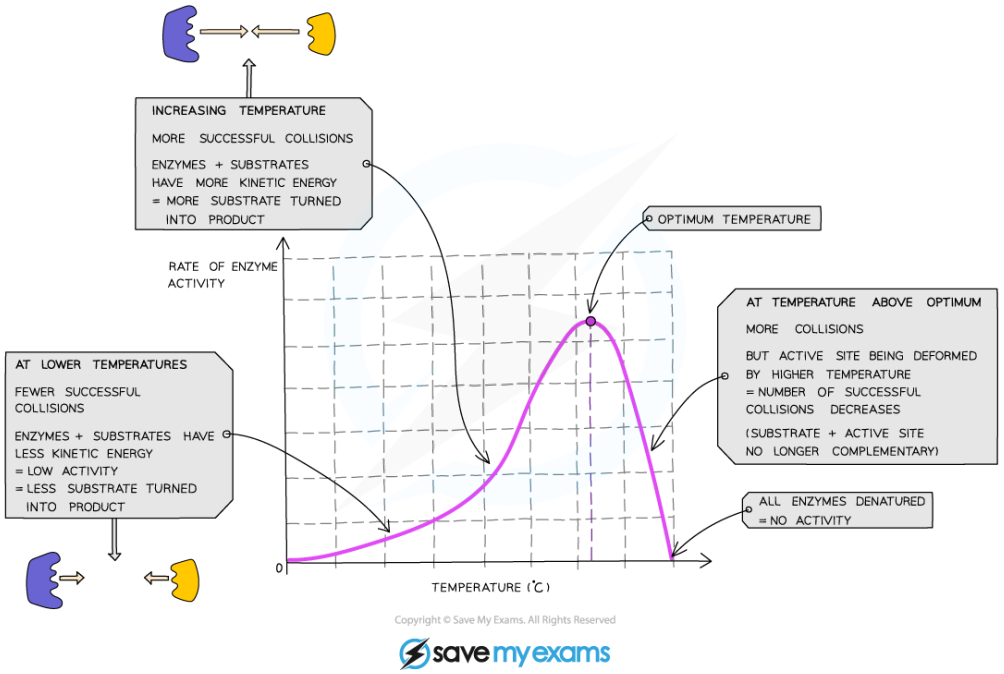

Graph showing the effect of temperature on the rate of enzyme activity

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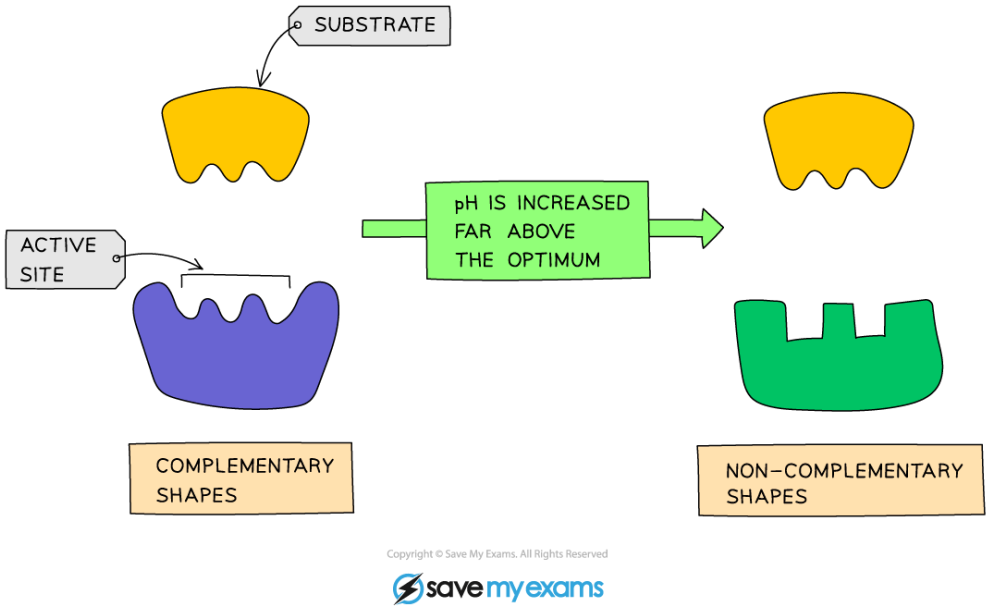
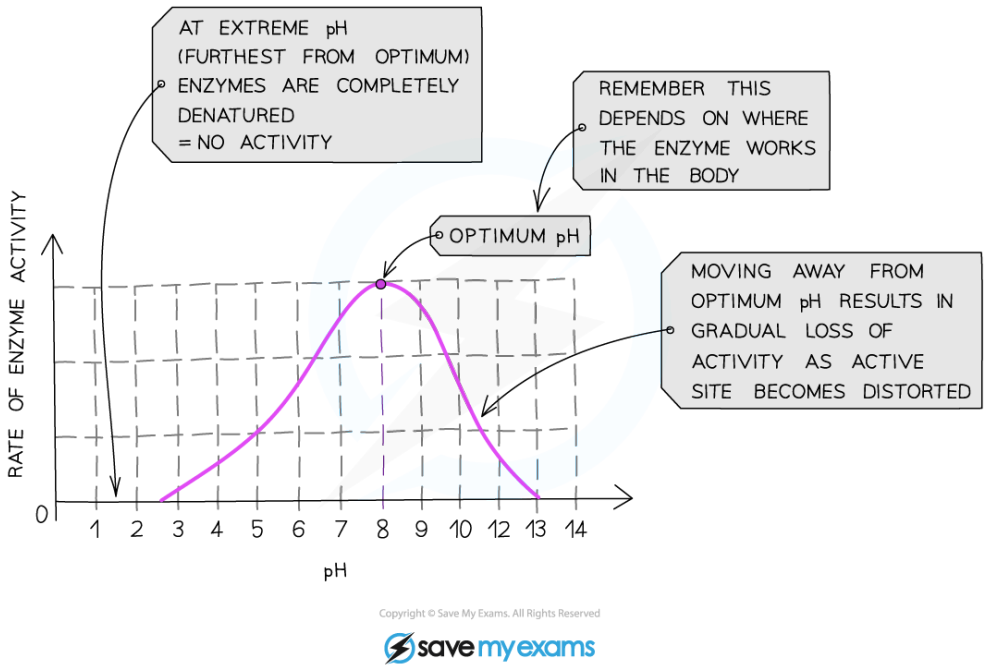
Enzymes & pH: Extended

Extended Tier Only

- The optimum pH for most enzymes is 7 but some that are produced in acidic conditions, such as the stomach, have a lower optimum pH (pH 2) and some that are produced in alkaline conditions, such as the duodenum, have a higher optimum pH (pH 8 or 9)
- If the pH is too high or too low, the bonds that hold the amino acid chain together to make up the protein can be destroyed
- This will change the shape of the active site, so the substrate can no longer fit into it, reducing the rate of activity
- Moving too far away from the optimum pH will cause the enzyme to denature and activity will stop



Effect of pH on enzyme activity



Graph showing the effect of pH on rate of activity for an enzyme from the duodenum

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