

The human digestive system

4.2.2.1 · Biology · revision notes

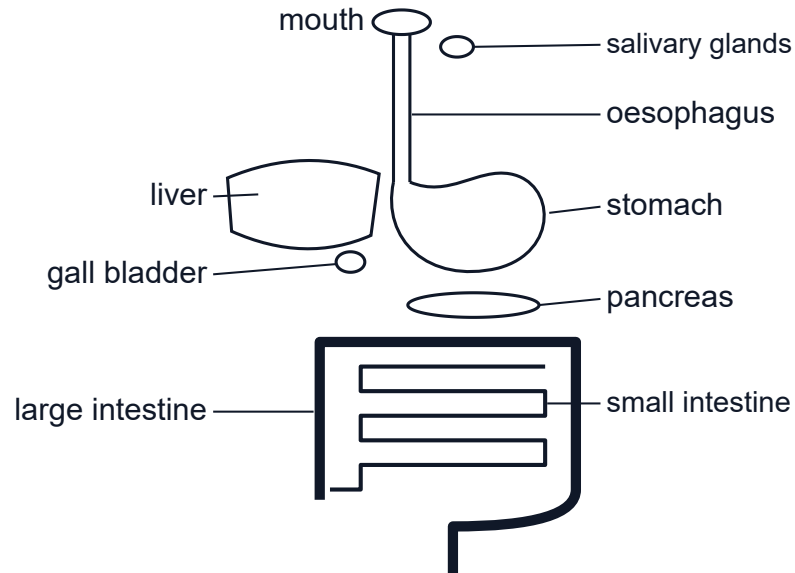
How the organs of the digestive system work together to digest and absorb food, how enzymes work, and what bile does. Expect recall of enzymes and their products, 'explain' questions on the lock and key model and denaturing, and questions on two required practicals: food tests and the effect of pH on amylase.

Key facts

- Amylase: starch → sugars (salivary glands, pancreas, small intestine)
- Lipase: lipids → fatty acids + glycerol (pancreas, small intestine)
- Benedict's (heated): blue → brick red = sugar
- Biuret: blue → purple = protein
- Denatured = active site has changed shape, so the substrate no longer fits
- Protease: proteins → amino acids (stomach, pancreas, small intestine)
- Bile: made in liver, stored in gall bladder; alkaline and emulsifies fat
- Iodine: orange-brown → blue-black = starch
- Sudan III: red-stained layer on top = lipid
- Amylase practical: rate = $1000 \div \text{time}$ (shorter time = faster rate)

Digestion and digestive enzymes

- The digestive system is an organ system: several organs work together to **digest** food (break large, insoluble molecules into small, soluble ones) and **absorb** the products into the bloodstream.

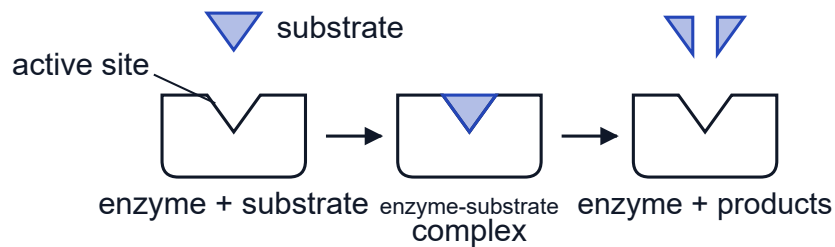


The digestive system (a simplified front view)

- Carbohydrases** break carbohydrates down into simple sugars. **Amylase** is a carbohydrase: starch → sugars. It is made in the salivary glands, pancreas and small intestine.
- Proteases**: proteins → amino acids. Made in the stomach, pancreas and small intestine.
- Lipases**: lipids (fats) → fatty acids + glycerol. Made in the pancreas and small intestine.
- The stomach also makes hydrochloric acid, giving the acidic pH at which the stomach protease works best.
- The products of digestion are used to build new carbohydrates, lipids and proteins. Some glucose is used in respiration.

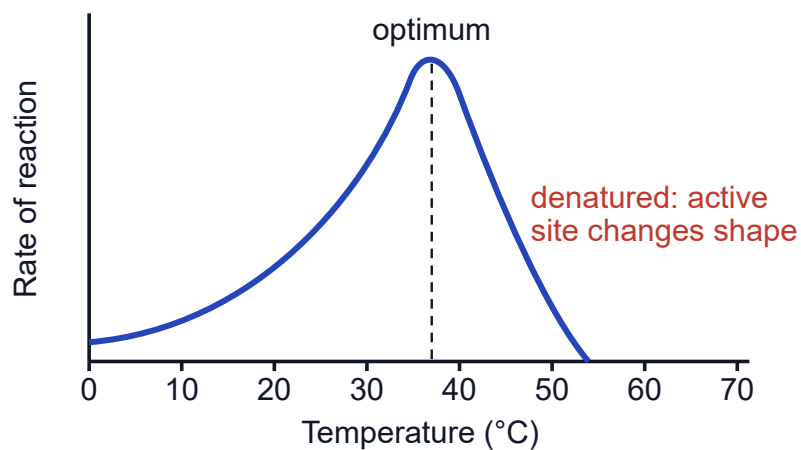
How enzymes work

- Enzymes are biological catalysts: large protein molecules that speed up reactions without being used up.
- Each enzyme has an **active site** with a specific shape. Only a substrate with the matching (complementary) shape fits, so each enzyme catalyses one specific reaction. This is the **lock and key** model.



Lock and key: only a substrate with the complementary shape fits the active site.

- As temperature rises, the rate increases up to the **optimum** (about 37 °C for most human enzymes), because the molecules move faster and collide more often.



Enzyme activity and temperature. Above the optimum the enzyme is denatured.

- Each enzyme has its own optimum pH: the stomach protease works best in acid; amylase works best at around neutral pH.

Bile

- Bile is made in the **liver**, stored in the **gall bladder** and released into the small intestine. It is not an enzyme.
- It is **alkaline**, so it neutralises the hydrochloric acid from the stomach.
- It **emulsifies** fat: it breaks large drops into small droplets, which have a much larger surface area.
- The alkaline conditions and the larger surface area both increase the rate at which lipase breaks down fat.

Required practicals

- Sugars: add Benedict's reagent and heat in a hot water bath. Blue → green, yellow or brick red if sugar is present.
- Starch: add iodine solution. Orange-brown → blue-black. Protein: add Biuret reagent. Blue → purple. Lipids: add Sudan III stain; a red-stained layer floats on top.
- pH and amylase: mix starch solution, amylase and a pH buffer in a water bath at a constant temperature. Every 30 seconds, put a drop of the mixture into iodine on a spotting tile. Record the time when the iodine stays orange-brown (no starch left). Repeat at other pH values.
- The shorter the time, the faster the rate. The pH with the shortest time is closest to the optimum.

How to answer each type of question

Recall enzymes, where they are made and their products

1 to 4 marks

Grade 4

1. Learn each enzyme with its substrate, its products and where it is made.
2. Give the specific product: 'amino acids', not 'smaller molecules'.
3. For lipase, give both products: fatty acids and glycerol.

Example. (a) Name the type of food molecule that proteases break down.
(b) Name the **two** products when lipase breaks down lipids.
(c) Name **one** organ that makes amylase.

Model answer. (a) proteins (1)
(b) fatty acids (1) glycerol (1)
(c) salivary glands / pancreas / small intestine (1)

Describe a food test

2 to 3 marks

Grade 4

1. Name the correct reagent.
2. Give any extra step, e.g. heat in a water bath for Benedict's.
3. Give the positive result as a colour change 'from ... to ...'.

Example. Describe how a student could test a sample of food for sugar.
Give the result if sugar is present.

Model answer. Add Benedict's reagent (1) and heat in a hot water bath (1). It changes from blue to brick red (or green / yellow) if sugar is present (1).

Don't lose marks

- ✗ Saying bile is an enzyme or that it breaks down fat. It emulsifies fat; lipase breaks it down.
- ✗ Saying bile is made in the gall bladder. It is made in the liver and stored in the gall bladder.
- ✗ Saying enzymes are 'killed' at high temperature. Enzymes are not alive: they are denatured.

- ✗ Saying enzymes are denatured at low temperature. They are just slower, because the molecules move more slowly.
- ✗ Writing 'the active site changes' but not saying that the substrate no longer fits.
- ✗ Forgetting to heat the Benedict's test, or giving a colour change the wrong way round.

More tips

Memory tricks

- The enzyme name gives away its substrate:
lipase → **lipids**, **protease** → **proteins**,
carbohydrase → **carbohydrates**.
- Lipids → 'FAG': Fatty Acids + Glycerol.
- Food test colours: Benedict's → Brick red (and it needs heat); Biuret → purple; Iodine → Inky blue-black.
- Bile does two jobs, 'neutralise and emulsify'. Neither job breaks molecules down, so bile is not an enzyme.
- Sense check for rates: a shorter time must give a bigger rate. If it does not, you divided the wrong way round.

Exam technique

- In enzyme explanations use the key words: active site, substrate, specific (complementary) shape, denatured.
- For the pH practical, examiners often ask how temperature is controlled (water bath) and how pH is controlled (buffer solutions).
- Give colour changes as 'from ... to ...' to get the mark.
- When a graph of rate against temperature or pH is given, read the optimum from the graph and give its unit.

What each grade needs

What you need to be able to do, from the first marks up to the top grade.

Grade 3

Name the organs of the digestive system

Mouth and salivary glands, oesophagus, stomach, liver, gall bladder, pancreas, small intestine and large intestine.

Grade 4

State what each digestive enzyme produces

Amylase turns starch into sugars, proteases turn proteins into amino acids, and lipases turn lipids into fatty acids and glycerol.

Grade 4

Describe the food tests and positive results

Benedict's turns from blue to brick red when heated with sugar, iodine from orange-brown to blue-black with starch, and Biuret from blue to purple with protein.

Grade 5

Recall where each digestive enzyme is made

Amylase in the salivary glands, pancreas and small intestine; proteases in the stomach, pancreas and small intestine; lipases in the pancreas and small intestine.

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