B3 organisation and digestion mastery booklet

Lesson 1 – Tissues and organs

Reading

As mentioned cells are the building blocks of life. In multicellular organisms cells differentiate and specialise and then form a range of structures to allow the organism to survive. A group of specialised cells working together to complete a certain function is known as a tissue. Examples include muscular tissue which can contract and in the case of the stomach contracts to churn food, epithelial tissue which covers the outside of the body and internal organs like the stomach, and glandular tissue which contain secretory cells which can produce and release enzymes and hormones. Organs are collection of different tissues working together to perform a specific function. An example of an organ is the stomach. The stomach is made up of muscular tissue, glandular tissue and epithelial tissue. Other examples of organs include heart, brain, skin, pancreas, and kidney. The pancreas has two important functions creating the hormones that control blood glucose concentration and producing enzymes used in digestion.

A whole multicellular organism is made up of a range of organ systems. These organ systems are made up of many organs. An example of an organ system is the digestive system and it is made up of organs such as the mouth, stomach, small intestine and large intestine to name a few. Other examples of organ systems include reproductive system, circulatory system and respiratory system.

Comprehension

1. Rearrange the following parts of the body in the correct organisation levels: (1)
   Tissue Organ system Cell Organism Organ
2. Define 'tissue'. (2)
3. Define 'organ'. (2)
4. The stomach contains mainly three types of tissues. State their functions. (3)
   a.) Muscular tissue
   b.) Glandular tissue
   c.) Epithelia tissue
5. Decide for each of the following if they are a specialised cell, tissue or organ. Explain and state their functions. (6)
   a.) Pancreas
   b.) Neurone
   c.) Kidney

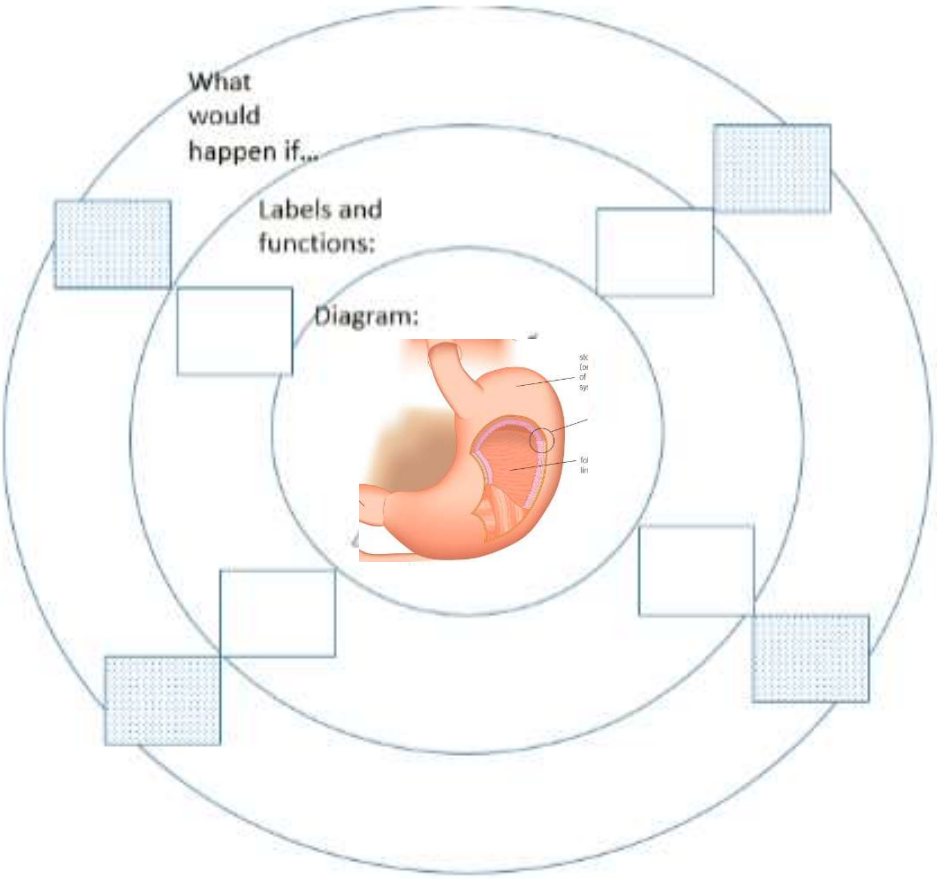
Task 4: Sophisticated sentences (Complete graphic organiser on next page first)

Using your graphic knowledge organiser and the key words below create a set of sophisticated sentences about the stomach.

Key words to use: The function of X is to, X allows, X's role is, were X to stop working, Example – Needs to be completed by student
The function of the stomach is…., muscular tissue's role is….

Now create your own ☺

Graphic organiser – The stomach

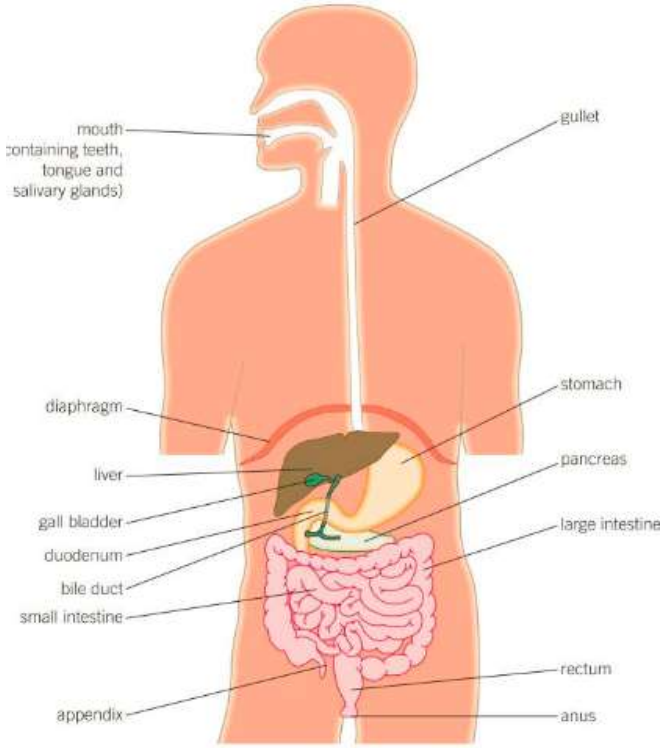


Extended response questions

1. Give three examples of organ systems in the body. For each of them, list three organs involved in that system. (9)
2. Describe how the stomach is adapted to its role in the digestion of food (5)

Lesson 2 – The digestive system

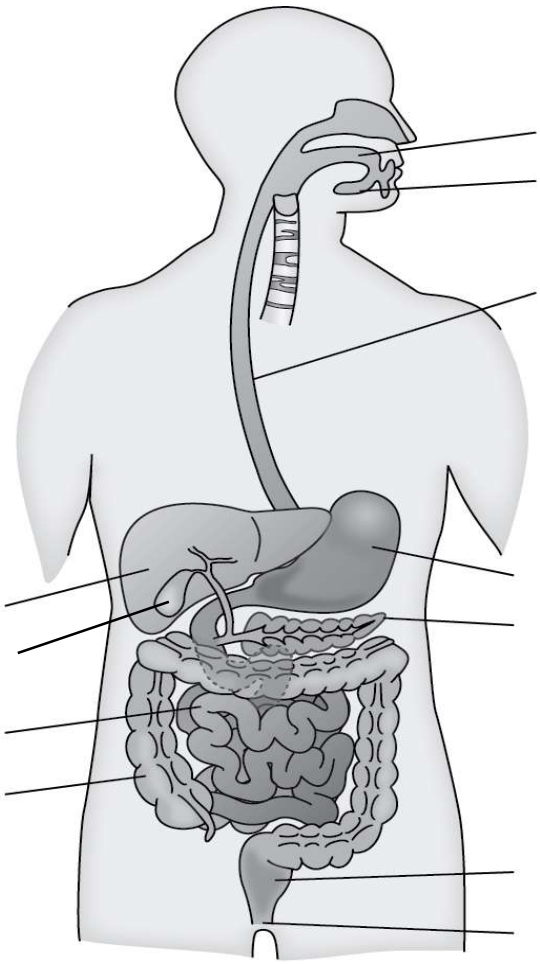
Reading



Your digestive system is up to 9m long. The digestive system is an organ system made of many organs that carry out digestion. Digestion is the break down of large food molecules into smaller ones. This is important because these large molecules are too big to be absorbed into our blood at the small intestine.. These organs include the salivary gland and pancreas that produce enzymes, the liver that produces bile which emulsifies, the stomach that produces certain enzymes and hydrochloric acid. The small intestine is a muscular tube that can contract to move food along it. It also produces and secretes enzymes. The large intestine absorbs water and contains bacteria to break down any undigested food The inside walls of the small intestine are covered in folds these folds are covered in finger-like projections known as **villi** The folds and finger-like villi **increase** the surface area inside the small intestine. On the villi are also micro-villi which also increase surface area. Like all exchange surface the small intestine has some common adaptations such as a good blood supply to maintain a steep concentration gradient, thin wall/membranes to provide a short diffusion distance and lots of villi and microvilli to increase surface area. All of these adaptations speed up the diffusion of digested food. Additionally cells in the small intestine may have lots of mitochondria to carry out respiration to release energy that is used for active transport of glucose.

Comprehension

1. What is digestion? (1)
2. Why is digestion important to us? (1)
3. Label the digestive system. (11)



4. On the labelled diagram above, annotate each organ with their functions. (11)
5. Explain why the digestive system is an organ system. (2)
6. Describe and explain the adaptations of the small intestine to help with nutrient absorption. (4)
7. State the functional difference between the small and large intestines. (2)
8. How is the liver important in helping digestion? (2)

Extended response question

Explain how the villi and the alveoli are adapted to absorb molecules into the bloodstream. [6 marks]

Answer for extended response

S = structural F = functional

- (S) both have a large surface area
- (S) villi have many microvilli
- (S) alveolar walls are not flat / are folded • (F) to maximise diffusion (of gases) / absorption of (food) molecules
- (S) both have many capillaries / good blood supply / capillaries near the surface • (F) to maintain concentration / diffusion gradient
- (S) both have thin walls / walls that are one cell thick / one cell thick surface • (F) to provide a short diffusion distance (for molecules to travel)
- (S) villi have many mitochondria • (F) to provide energy for active transport (of food molecules)
- (S) cells of the villi have microvilli / more projections • (F) to further increase the surface area/ increase the number of proteins in the membrane / to allow more active transport to take place

Lesson 3 – The chemistry of food

Reading

Carbohydrates, lipids and protein make up most of the parts of a cell. Therefore it is important we have lots of them and we do that through our diet.

Carbohydrates help provide us with energy. All carbohydrates contain carbon, oxygen and hydrogen. Glucose ($C_6H_{12}O_6$) is a simple carbohydrate made of a single sugar unit. Sucrose is also a simple carbohydrate made up of two glucose molecules joined together. Glucose molecules can be combined together in long chains to form complex carbohydrates. Examples of this include starch and glucagon which act as energy storage molecules in plants and animals respectively. Carbohydrate rich foods include break, pasta and potatoes.

Lipids are fats and oils. They are an energy store in our cells. When combined with other molecules they can be used to make cell membranes. Like carbohydrates they are made up of carbon, hydrogen and oxygen. They are also insoluble in water. Each lipid molecule is made up of three molecules of fatty acids combined with a molecule of glycerol. Olive oil, vegetable oil, cheese, butter and margarine are all sources of lipids.

Proteins are polymers made up of amino acids joined together. There are twenty different amino acids which can be combined in different orders to make new proteins. Proteins are used to build our cells and our enzymes. Protein is made up of carbon, hydrogen, oxygen and nitrogen. Protein rich foods include meat, fish and cheese

Comprehension

Carbohydrates

1. Give two functions of carbohydrates. (2)
2. Which atoms make up carbohydrates? (1)
3. State the monomer (the basic unit) of carbohydrates. (1)
4. State the chemical formula of glucose. (1)
5. Give two examples of complex carbohydrates. (2)
6. What types of food contain lots of carbohydrates? Give three examples. (3)

Lipids

1. What are the two types of lipids? (2)
2. Which atoms make up lipids? (1)
3. State two functions of lipids. (2)
4. Draw a labelled diagram to illustrate the structure of a lipid molecule. (2)
5. What types of food contain lots of lipids? Give two examples. (2)

Proteins

1. Give two functions of proteins. (2)
2. Which atoms make up proteins? (1)
3. What makes up proteins? (1)
4. Describe how different proteins can be made. (3)

Summary task

Draw a summary table, including a description, uses in living organisms and sources in our diet for all three types of biological molecules.

Task 4: Sophisticated sentences

Using your graphic knowledge organiser and the key words below create a set of sophisticated sentences about the stomach.

Key words to use: While, whereas, similarly, contrastingly, in much the same way

Example – Needs to be completed by student

The function of protein is …. Whereas the function of carbohydrates si…

Now create your own ☺

Lesson 4 – catalysts and enzymes

Reading

Catalysts are special chemicals that speed up reactions. They do this by providing an alternate reaction pathway that has a lower activation energy. Enzymes are examples of biological catalysts. Each enzyme only interacts with a particular substrate. They are specific. Enzymes are large protein molecules and so are made up of the same things as proteins- amino acids. The lock and key theory describes how enzymes work. Each enzyme has a specifically shaped active site which is where the substrate will bind. The substrate can then be broken down into two products. As well as breaking substrates down they can join them together to form a new larger product. The main enzymes in our digestive system are carbohydrases (amylase), protease and lipases.

Carbohydrases digest carbohydrates. In particular amylase breaks down starch into maltose. Amylases is produced in the salivary glands, pancrease and small intestine. Amylases carries out it's function in the mouth and small intestine. Protease digests protein into amino acid. Protease is produced in the small intestine, stomach and pancreas. Protease is used in the stomach and small intestine. Lipases digest lipids (fats and oils) into three fatty acids and glycerol. Lipase is made in the small intestine and pancreas but is only used in the small intestine.

Comprehension

1. What are enzymes? (2)
2. What is the active site of an enzyme? (1)
3. Match the following keywords with their functions.

Catalyst	The enzyme and substrate bound together.
Enzyme	The special site in the structure of an enzyme where the substrate binds.
Enzyme-substrate complex	The energy needed for a chemical reaction to take place.
Activation energy	A substance which changes the rate of a chemical reaction without being changed itself.
Active site	A biological catalyst.

4. Draw a labelled diagram to illustrate the lock-and-key model of enzyme mechanism.
5. Name the types of enzymes that catalyse the breakdown of: (3)
   a.) Carbohydrates
   b.) Lipids
   c.) Proteins
6. Which organs in the digestive system produce digestive enzymes?

Graphic organiser – complete the table

Enzymes	Substrate	Products	Produced in…	Works in…
	Starch			
	Proteins			
	Lipids			

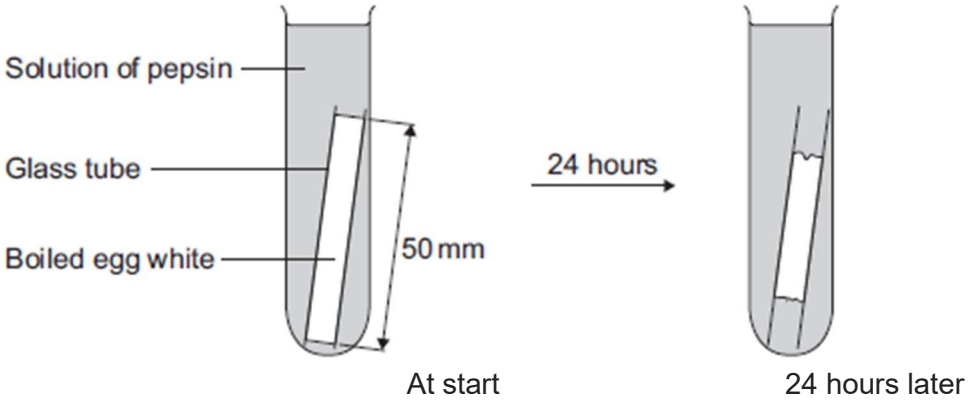
Exam questions

1Some students investigated the effect of pH on the digestion of boiled egg white by an enzyme called pepsin. Egg white contains protein.

The students:

- put a glass tube containing boiled egg white into a test tube
- added a solution containing pepsin at pH 7
- set up six more tubes with solutions of pepsin at different pH values
- left the test tubes for 24 hours at room temperature.

The image below shows one of the test tubes, at the start and at the end of the 24 hours.



(a) (i) Name the product of protein digestion.

_____

_____

(1)

(ii) What type of enzyme digests protein?

Tick (✓) **one** box.

amylase ☐

lipase ☐

protease ☐

(1)

(b) The egg white in each tube was 50 mm long at the start of the investigation.
The table below shows the students' results.

pH	Length in mm of boiled egg white after 24 hours
1	38
2	20
3	34
4	45
5	50
6	50

7	50

(i) At which pH did the pepsin work best?

pH _____

(1)

(ii) The answer you gave in part **(b)(i)** may not be the exact pH at which pepsin works best.

What could the students do to find a more accurate value for this pH?

_____

_____

_____

_____

(2)

iii) There was no change in the length of the egg white from pH 5 to pH 7.

Explain why.

_____

_____

_____

(2)

(c) Pepsin is made by the stomach.

Name the acid made by the stomach which allows pepsin to work well.

_____

(1)

(Total 8 marks)

2. The table shows the amounts of carbohydrate, fat and protein in 100 g portions of five foods,
A - E.

	MASS IN 100 g PORTION (g)		
FOOD	CARBOHYDRATE	FAT	PROTEIN
A	0	1	20
B	50	2	8

C	0	82	0
D	12	0	1
E	20	0	2

(a) A person eats 50 g of food E.

How much carbohydrate would the person eat?

_____ g

(1)

(b) Describe, in as much detail as you can, what happens to the protein after food A is swallowed.

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 5 marks)

Mark scheme

a) (i) amino acid(s)

accept peptide(s)

*do **not** allow polypeptide(s)*

1

(ii) protease

1

(b) (i) 2

1

(ii) repeat

do not allow other enzyme / substrate

1

using smaller pH intervals between pH1 and pH3

allow smaller intervals on both sides of / around pH2

allow smaller intervals on both sides of / around answer to (b)(i)

1

(iii) enzyme / pepsin denatured / shape changed

*do **not** allow enzyme killed*

allow enzyme 'destroyed'

1

enzyme / pepsin no longer fits (substrate)

allow enzyme / pepsin does not work

1

(c) hydrochloric (acid)

allow phonetic spelling

accept HCl

allow HCL

ignore hcl

*do **not** allow incorrect formula –e.g. H_2Cl / HCl_2*

1

[8]

(a) 10

for 1 mark

1

(b) digested / broken down / made soluble by protease / enzyme
in stomach / in small intestine / from stomach / from pancreas
into amino acids amino acids/smaller molecules/products of digestion
absorbed into blood

any four for 1 mark each

4

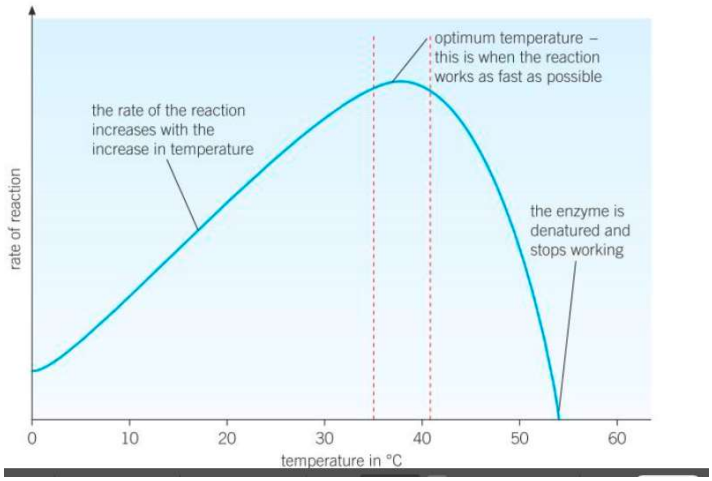
[5]

Factors affecting enzyme action

Reading

Biological reactions are affected by the same factors as any other chemical reaction: concentration, temperature, and surface area. In particular we are going to focus on the effect of two variables on enzyme-controlled reactions: temperature and pH.

An increase in temperature will increase the rate of an enzyme controlled reaction up to a certain amount. After about $41^{O}C$ the enzymes will start to become denatured. When an enzyme is denatured it loses its shape, the active site can no longer bind to the substrate and no enzyme-substrate complexes aren't formed. When temperature is too low the reaction is slow because the enzymes don't have much kinetic energy and so rarely collide with their substrate

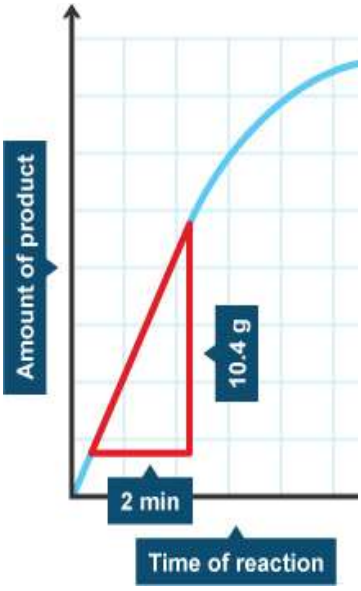


The graph to the left shows how enzymes in the human body are affected by temperature. But some extremophiles (organisms that live in extreme environments) have enzymes that work at temperatures up to 80^{O}C.

Each enzyme has an optimum pH, outside of this pH the enzyme becomes less effective and eventually can be denatured. This is because the forces that hold the enzyme together are weakened and the active site can change shape preventing the formation of enzyme-substrate complexes.

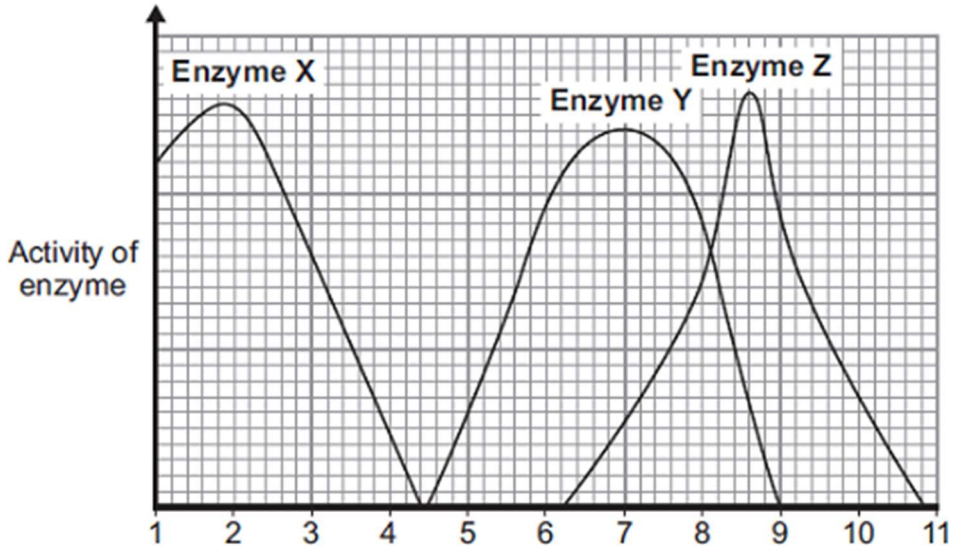
Comprehension

1. What does denatured mean? (2)
2. What happens to enzymes when the temperature is: (2)
   a.) Too low
   b.) Too high
3. Explain the effects of temperature on enzyme action. (5)
4. What is the optimum temperature for enzymes in the human body? (1)
5. What holds enzymes together?
6. How does a change in pH cause enzymes to denature? (3)
7. Using the graph given, calculate the rate of reaction of the enzyme. Remember to include units. (2)



Exam questions

(a) The graph shows the effect of pH on the activities of three enzymes, **X**, **Y** and **Z**.
These enzymes help to digest food in the human digestive system.
Each enzyme is produced by a different part of the digestive system.



(i) What is the optimum (best) pH for the action of enzyme **Z**?

_____

(1)

(ii) The stomach makes a substance that gives the correct pH for enzyme action in the human stomach.

Name this substance.

_____

(1)

(iii) Which enzyme, **X**, **Y** or **Z**, will work best in the human stomach?

_____

(1)

2. milk is a mixture of compounds including fat, protein and about 5 % lactose sugar. Lactose must be digested by the enzyme lactase, before the products can be absorbed.

Lactase can be added to fresh milk to pre-digest the lactose. This makes 'lactose-free' milk, which is suitable for people who do not produce enough lactase of their own.

A student investigated the effect of changing pH and temperature on the digestion of lactose in milk.

The results are shown in **Tables 1** and **2**.

Table 1
Effect of pH

Table 2
Effect of temperature

pH	Time taken to digest lactose in minutes
4.0	20
5.0	18
6.0	13
7.0	7
8.0	5
9.0	6

Temperature in°C	Time taken to digest lactose in minutes
30	20
35	14
40	11
45	6
50	12
55	23

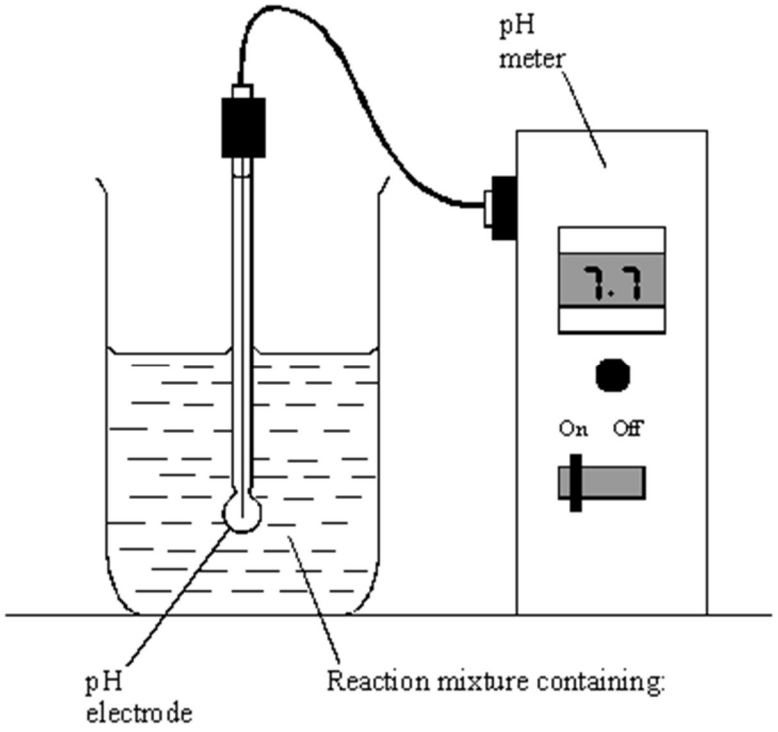
(a) The label on a carton of lactose-free milk states:

'Lactase is normally produced in the stomach of mammals.'

The results in **Table 1** show that this statement is unlikely to be true.

Explain how. (2)

3. The diagram shows the apparatus used to investigate the digestion of milk fat by an enzyme. The reaction mixture contained milk, sodium carbonate solution (an alkali) and the enzyme. In Experiment **1**, bile was also added. In Experiment **2**, an equal volume of water replaced the bile. In each experiment, the pH was recorded at 2-minute intervals.



Either: Experiment 1 **or: Experiment 2**

milk (contains fat)	milk (contains fat)
sodium carbonate solution	sodium carbonate solution
bile	water
enzyme	enzyme

The results of the two experiments are given in the table.

Time in minutes	pH	
	Experiment 1: with bile	Experiment 2: no bile
0	9.0	9.0
2	8.8	9.0
4	8.7	9.0
6	8.1	8.8
8	7.7	8.6
10	7.6	8.2

(a) Milk fat is a type of lipid. Give the name of an enzyme which catalyses the breakdown of lipids.

_____

(1)

(b) What was produced in each experiment to cause the fall in pH?

(1)

(c) (i) For Experiment **1**, calculate the average rate of fall in pH per minute, between
4 minutes and 8 minutes. Show clearly how you work out your final answer.

_____ pH units per minute

(2)

(ii) Why was the fall in pH faster when bile was present?

(1)

(Total 5 marks)

Mark scheme

(2a) stomach is acidic / has low pH

allow any pH below 7

ignore stomach is not alkaline

1

lactase works best / well in alkali / high pH / neutral / non-acidic conditions

allow any pH of 7 and above
accept works slowly in acid conditions

*allow figures from table with a **comparison***

ignore reference to temperature

1

3. (a) lipase

1

(b) fatty acid

ignore glycerol

1

(c) (i) 0.25 or $\frac{1}{4}$

if <u>correct</u> answer ignore working or lack of working

$\frac{(8.7-7.7)}{4}$ *for **1** mark*

2

(ii) fats emulsified **or** described re. Small droplets **or** large S.A. (for enzyme action) **or** fats 'mix' better with water

*do **not** allow breakdown / breakup unqualified*

1

Making digestion efficient

Reading

Previously we have learnt about the factors that affect enzyme action. It is in our bodies best interest for digestion to happen as effectively as possible. Next we will learn about how our body ensures that this is the case.

Glands in the stomach release a protease known as pepsin. This pepsin is adapted to work at low pH (acidic). The stomach also produces hydrochloric acid to ensure that pepsin can work most effectively. The stomach produces a thick layer of mucus which coats your stomach and prevents the hydrochloric acid from digesting the walls of the stomach. After being digested in the stomach, food moves into the small intestine. The enzymes in the small intestine, such as pancreatic amylase, prefer an alkaline environment. To produce an alkaline environment bile is produced in the liver. Bile is stored in the gall bladder and is then released into the small intestine to neutralise the acidic solution coming from the stomach. Bile has another job. It emulsifies the fats in our food. This increases the surface area of the fat molecules and allows lipase to break down fats faster.

Comprehension

1. What is pepsin? (1)
2. Where is bile produced?
3. State where bile is stored
4. What are two differences between pepsin and pancreatic amylase? (2)
5. What is the difference between pepsin and proteases produced by the pancreas? (2)
1. What are the functions of hydrochloric acid in the stomach? (2)
2. How is the stomach adapted to protect itself from pepsin and the hydrochloric acid? (1)
3. Suggest the optimum pH for enzymes to work in the small intestine. (1)
4. Suggest the optimum pH for enzymes to work in the stomach
5. What happens to an enzyme outside its preferred pH?
6. What else can cause enzymes to be denatured?
7. Which organ produces bile? (1)

Challenge

8. Describe and explain the functions of bile. (4)
9. Why is emulsification important to lipid digestion? (3)
10. Is it correct to say "the stomach produces hydrochloric acid to digest food"? Why/Why not? (2)
11. Is it correct to say "bile breaks down lipids to glycerol and fatty acids"? Why/Why not? (3)

Exam questions

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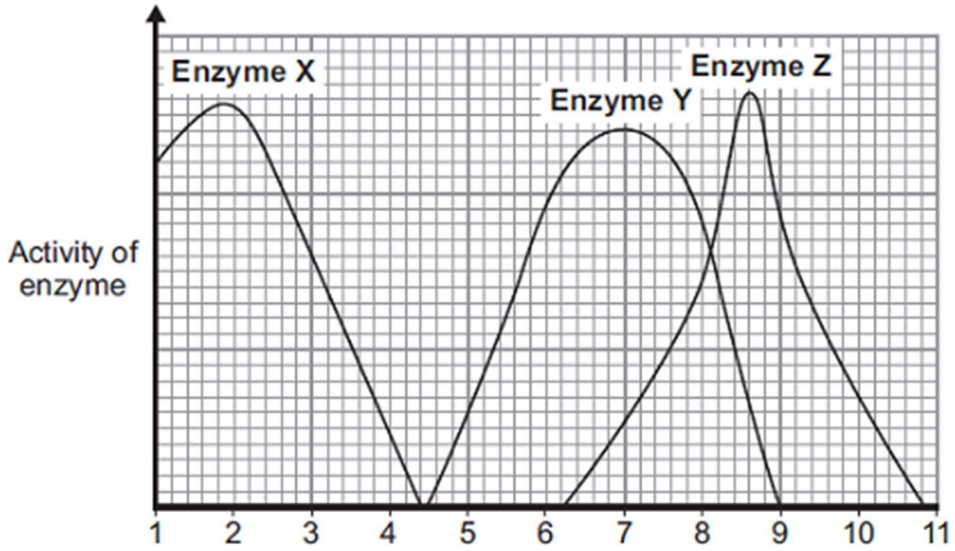

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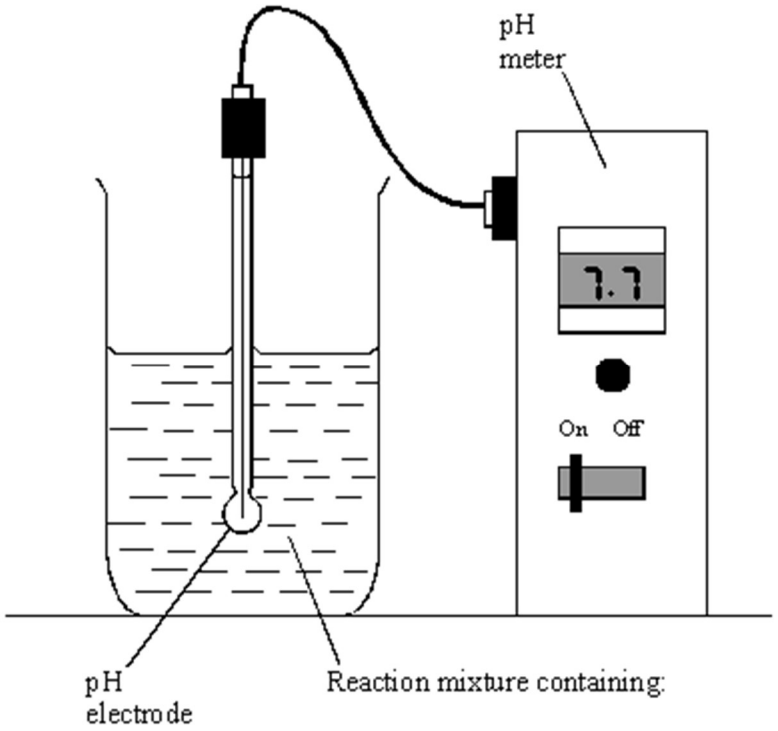

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(Total 5 marks)