EDEXCEL INTERNATIONAL GCSE (9–1)

HUMAN BIOLOGY

eBook included

Student Book

Phil Bradfield and Steve Potter

Pearson

TEACHER RESOURCE PACK

Unit 1 Chapter 2 Worksheet 4: Diffusion, osmosis and active transport

Write the number of each statement in the correct section of the Venn diagram.

1 Involves water only

2 Requires energy

3 Is passive (does not require energy)

4 Involves the movement of particles

5 Needs a partially permeable membrane

6 From high to low concentration

7 Against a concentration gradient

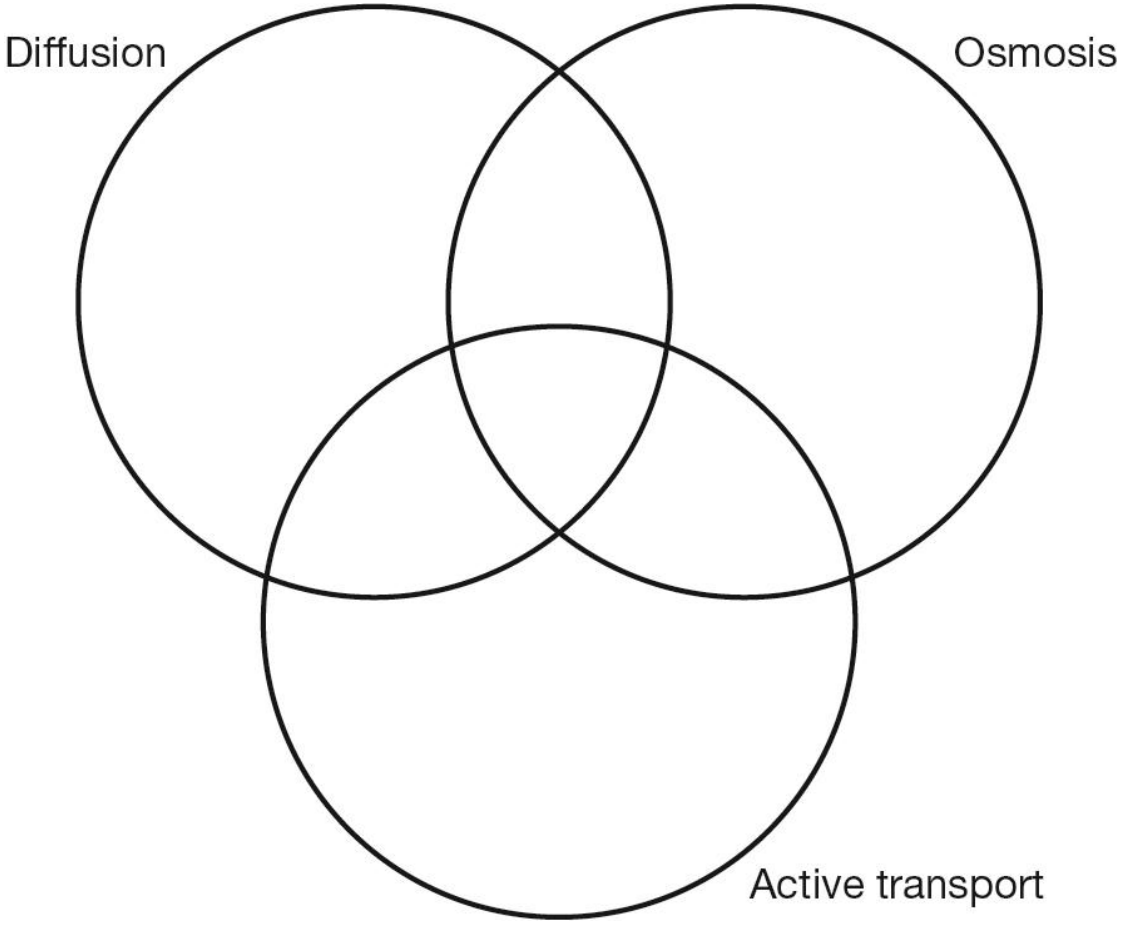
8 Occurs in nature

9 How glucose is absorbed from the gut

10 Can be demonstrated using Visking tubing

11 How oxygen enters cells for respiration

12 Involves transport of solutes



Chapter 2: Movement of substances into and out of cells

Alignment with Student Book: pages 24–31

Chapter overview

Students may already have an idea about which nutrients are needed by cells (for example, for respiration) and the waste products that are released. However, they may be less aware of how these substances move across the cell membrane. This chapter will explore the various ways in which molecules and ions move into and out of cells and the factors that can affect the rate of this movement.

Students should:

- 3.1 – know simple definitions of diffusion, osmosis and active transport
- 3.2 – understand that movement of substances into and out of cells can be by diffusion, osmosis (understanding of water potential is required) and active transport
- 3.3 – understand the factors that affect the rate of movement of substances into and out of
  cells, to include the effects of surface area to volume ratio, temperature and concentration gradient

Before students can understand diffusion, osmosis and active transport, they need to fully understand particle theory (this should have been covered in earlier science lessons) and how particles move randomly due to their kinetic energy. This could be demonstrated as a simple role play, depending on space, where students behave as if they are particles in a solid, liquid and a gas. If you do this, make sure you point out the boundaries or walls of the 'container'. It may also be a good idea to check their understanding of the terms 'molecule' and 'ion'. Finally, check students' understanding of a concentrated solution (more solute and less solvent) and a dilute solution (less solute and more solvent).

Teaching notes

Starter activities

Diffusion: Stand at the front of the class room and spray some air freshener (maybe open a window if any students are asthmatic). Ask students to stand up when they can smell it. Ask students why this occurred. You could also use the analogy of being able to tell when someone is cooking food etc.

Diffusion: Place chocolate M and M's or similar sweets that contain food colouring around the rim of a plate and then add water. Ask students what they see and why this is happening. You could then discuss what factors affect the movement of the dye particles and how you could make the rate of movement faster (for example, by increasing the temperature – adding hot water). There is a video of this experiment on YouTube: search for 'M&Ms Science – Crazy Science (Rainbow)'.

Osmosis: Once you have taught students the theory surrounding osmosis, you could give them some real life scenarios to explain, using their knowledge and understanding of osmosis. For example:

- Why should fish that live in sea water not be placed in fresh water?
- In a hospital, why is it harmful to give someone an intravenous drip of pure water?
- Why do supermarkets spray their fruit and vegetables with water?
- Why is salt used to preserve food?

There are many YouTube videos which may help students to remember the theory. For example, you could search for 'Osmosis! Rap Science Music Video'.

Surface area to volume ratio: Surface area to volume ratio affects the rate of diffusion or osmosis. To gauge students' understanding, show them three agar jelly cubes of different sizes (preferably one large, one medium and one small). Inform the students that the jelly cubes contain universal indicator and ask them to predict what will happen when the cubes are placed in a beaker containing hydrochloric acid. Students will most likely predict that the smallest cube will change colour first, but many will struggle to explain why. Ask them the question again when you have explained the theory.

Main activities/practicals

Diffusion

Place some potassium permanganate crystals in a beaker of distilled water and observe what happens. Ask students to predict what the contents of the beaker may look like at the end of the lesson. Ask students why it is important that the water in the beaker has settled before the crystals are added. (Answer: To show that the colour disperses due to the kinetic energy of the water molecules moving and colliding, and not due to the movement of the water as a result of filling the beaker and moving it to the bench.)

Osmosis

Cut up pieces of fruits, vegetables and eggs and place them in concentrated salt or sugar solutions or in distilled water. Ask students if they can observe any differences between the food samples in the different liquids. Encourage students to feel the samples by placing their hands in the beakers.

Surface area to volume ratio

Ask students to complete **Worksheet 2** and **Worksheet 3**. The first of these worksheets introduces the calculations. For the second worksheet, students will assemble two cubes of different sizes and then calculate the surface area and volume of each cube. Ask students what happens to the surface area to volume ratio when the cube gets bigger. Point out that we are using this concept and applying it to cells. Most students will appreciate that cells are irregular in shape, so it is difficult to calculate the actual SA : V ratio; however, the principle remains the same. A smaller cube (or cell) will have a larger surface area to volume ratio, resulting in a faster rate of diffusion etc.

Explain that this is why newborn babies need to be kept warm – due to their large SA : V ratio, they can exchange heat with their surroundings much more quickly than adults (or older children). This is also the reason why elephants try to increase their surface area for efficient heat exchange – for example, by having large ears.

Ask students to identify structures inside the human body that are adapted for efficient exchange of nutrients and waste products by having a large surface area in comparison to their volume.

Students can then carry out Activity 1 in the textbook, paying attention to the safety note.

Practical: Demonstrating diffusion in a jelly

If possible, reinforce some experimental skills and ask students to identify the independent, dependent and control variables of this experiment.

Explain to students that investigations of osmosis in non-living situations use Visking tubing, which acts like an artificial partially permeable membrane.

Demonstrate how an osmometer works and ask students to describe how this apparatus could be used to measure the rate of osmosis.

Students can then carry out Activity 2 in the textbook, paying attention to the safety note.

Practical: Demonstrating the effects of osmosis on red blood cells.

You could briefly mention the role of the kidneys in osmoregulation, and how these organs work to ensure there is no net movement of water into or out of red blood cells. Link this back to the starter activity in which students were asked why a patient should not be given an IV of pure water. More able students may be able to guess what type of liquid should be given instead.

Active transport

Ask students to discuss why there is no glucose in faeces. Students should come to realise that glucose is needed for respiration, and so it is actively transported from the gut into the blood. (Otherwise, it would move by diffusion from the blood into the large intestine.)

Show students an epithelial cell in the gut and ask them to deduce why there are more mitochondria here than in other comparable cells.

You could also link this to Chapter 10 (selective reabsorption in the first coiled tubule of the kidney). Students could draw a comic strip to explain this process.

Homework

Ask students to complete Worksheet 4, summarising the similarities and differences between these processes.

Possible misunderstandings

- Students occasionally find it difficult to define osmosis in terms of high and low concentration – the confuse the concentration of a solute in a solvent and the concentration of water. To avoid this, students could be encouraged to state that osmosis is the net movement of water from a solution with a higher water potential to one with a lower water potential.
- Students sometimes find it difficult to grasp that, when equilibrium has been reached, particles still possess kinetic energy and continue to move, even though there is no **net** movement of particles. Spend time reinforcing this point and ensure students understand the idea of net movement.
- Many students find it relatively easy to calculate SA : V ratios (having covered the theory in maths lessons) but struggle to grasp how this relates to the movement of substances into and out of cells. They may also find it difficult to interpret how we record this. For example, a 6 : 1 ratio means that for every 1 cm^3 of volume there are 6 cm^2 of surface area available for exchange.
- Examination questions often ask about osmosis using potatoes as an example in plants. Questions can also focus on boiled potatoes. Some students do not grasp that the membranes within cells are disrupted or damaged during the cooking / heating process. Students need to understand how osmosis might be affected if there is no cell membrane.

Differentiation

- More able students could be introduced to the terms hypertonic, hypotonic and isotonic. Students may have heard the term isotonic in relation to sports drinks.
- In the main activity on osmosis, ask students how we can use this experiment to determine the concentration of cytoplasm inside the cell. The term osmolarity needn't be introduced.

Unit 1 Chapter 3: Multiple-choice questions

1 Which reagent is used to test for protein?

A Benedict's solution
B biuret solution
C iodine solution
D ethanol

2 What name is given to the small molecules that make up carbohydrates?

A amino acids
B simple sugars
C glycerol
D fatty acids

3 What word is used to describe all the chemical reactions in the body?

A digestion
B respiration
C excretion
D metabolism

4 What is the name of the enzyme that catalyses the breakdown of starch into maltose?

A maltase
B amylase
C catalase
D invertase

5 Which of the following is glycogen an example of?

A disaccharide
B monosaccharide
C polysaccharide
D protein

6 Which element is not found in carbohydrates?

A carbon
B hydrogen
C oxygen
D nitrogen

7 What determines the specificity of an enzyme for its substrate?

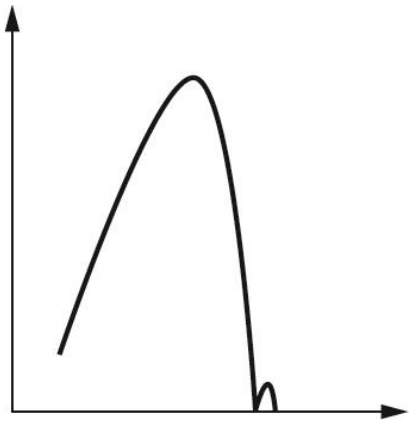
A The temperature at which it is working

B The optimum pH of that enzyme

C The concentration of the substrate

D The shape of the protein molecule

8 A number of factors affect the activity of enzymes. Look at the graph below.



This graph shows how a particular factor affects the rate of an enzyme-controlled reaction. Which factor is this?

A temperature

B substrate concentration

C pH

D the presence of inhibitors

9 Which of the following is not a protein?

A haemoglobin

B collagen

C glycerol

D keratin

10 A food sample turned brick red when tested with Benedict's solution and purple when tested with Biuret solution. Based on these observations, which nutrients were present in the food?

A protein and starch

B protein and glucose

C starch and lipids

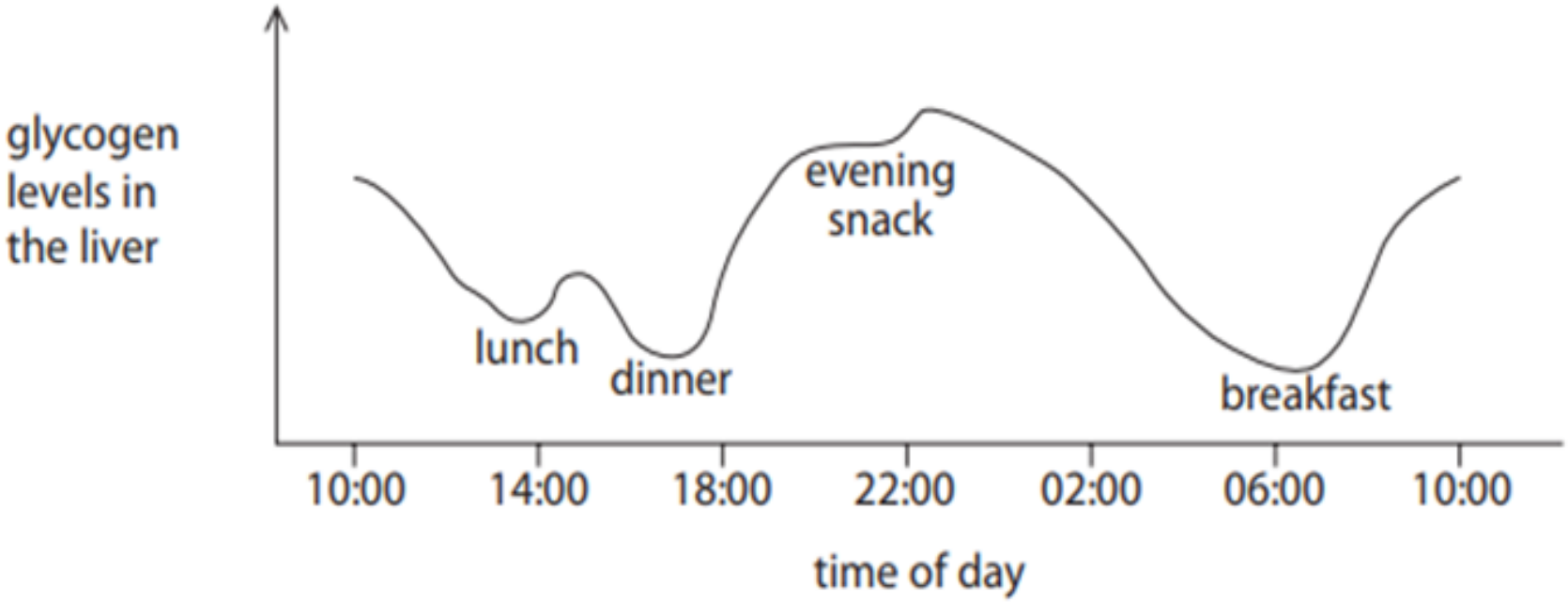
D lipids and glucose

Answers

1 B
2 B
3 D
4 B
5 C
6 D
7 D
8 A
9 C
10 B

Biology Paper 1: Exam question

The graph shows the glycogen levels in the liver of a healthy male during 24 hours.



(a) State the time when the glycogen in the liver is at its highest level. (1)

(b) Explain why glycogen levels in the liver increase after a meal. (4)

Mark scheme

Question number	Answer	Notes	Marks
2(a)	Any value from 22.00 hours to 23.00 hours	Accept 'from 10 pm to 11 pm'	(1)
2(b)	An explanation linking four of the following: • **blood glucose** levels increase (1) • (**increased** glucose means) insulin is released (1) • (insulin is released) from the pancreas (1) • (insulin stimulates the) conversion of glucose into glycogen (1) • glycogen is stored in the liver (1)	Accept **glucose** absorbed into the blood	(4)

Student response 1

(a) 10 o’clock

(b) Glycogen levels increase in the liver after a meal because the person has probably eaten sugary foods. The pancreas makes insulin if there is sugar in the body. Insulin is a hormone that tells the liver to store glycogen. This is why the glycogen levels increase in the liver.

Is this a good answer?

Is this a good answer?

Good answer

- The candidate has correctly stated that the pancreas releases insulin (mark scheme point 3).
- The candidate has correctly stated that glycogen is stored in the liver (mark scheme point 5).

Could be improved

- The candidate has probably interpreted the graph correctly, but credit cannot be given for 10 o'clock as it is not precise enough.
- The candidate has understood that glycogen has increased due to more sugar but the imprecise language means no credit can be awarded.
- There is no mention of glucose.
- The candidate needs to explain how glycogen is formed before it is stored in the liver.

Student response 1: Commentary

10 o'clock	It is not clear if this is 10 am or 10 pm so no credit can be given.
Glycogen levels increase in the liver after a meal because the person has probably eaten sugary foods.	Sugar is not the appropriate term in this context. The student needs to refer to glucose.
The pancreas makes insulin	Mark scheme point 3 (not sufficient for mark scheme point 2)
if there is sugar in the body.	There is always 'sugar' in the body. The student needs to be more precise and refer to increased blood glucose levels.
Insulin is a hormone that tells the liver to store glycogen. This is why the glycogen levels increase in the liver.	Mark scheme point 5. This is not sufficient for point 4, because the student has not explained how glycogen is made in the liver.

Student response 2

Food we eat contains carbohydrates which are digested by enzymes into glucose. Glucose is absorbed into the blood in the intestines, so blood glucose levels rise after a meal. The increase in blood glucose is detected by receptors and the pancreas will make the hormone insulin and release it into the blood. The insulin will travel to the target organ: the liver. Insulin stimulates the liver cells to take in glucose from the blood and join the glucose molecules together to form glycogen. Glycogen is then stored in the liver cells until needed.

Is this a good answer?

Student response 2: Commentary

Food we eat contains carbohydrates which are digested by enzymes into glucose. Glucose is absorbed into the blood in the intestines, so blood glucose levels rise after a meal.	Mark scheme point 1 can be awarded for either underlined section.
The increase in blood glucose is detected by receptors	This shows links between concepts. It does not earn a mark here but is important in longer answer questions.
and the pancreas will make	Mark scheme point 3
the hormone insulin and release it into the blood.	Mark scheme point 2
The insulin will travel to the target organ: the liver.	Shows good understanding and use of terminology.
Insulin stimulates the liver cells to take in glucose from the blood and join the glucose molecules together to form glycogen.	Marking point 4
Glycogen is then stored in the liver cells until needed.	Mark scheme point 5