

Answers

Chapter 3 Cells undergo chemical reactions

Questions 3.1

Recall knowledge

1 Define 'metabolism'.

Answer: All the chemical reactions occurring in a living organism.

2 Describe the structure of lipids.

Answer: Large organic molecule made up of one, two or three fatty acid molecules and one molecule of glycerol.

3 Explain why amino acids bonding to form a protein is an example of anabolic metabolism.

Answer: Anabolism is a reaction where small molecules are combined to make larger molecules. Amino acids are the smallest component of a protein, adding amino acids together to make the larger protein molecule is anabolism.

4 Describe the role of water in chemical reactions.

Answer: Water provides the fluid where the substances are dissolved in, or provides molecules that are needed in the reactions.

Apply knowledge

5 Classify each of the following as either organic or inorganic: water, dipeptide, protein, minerals, polysaccharide, lipids, carbohydrates, nucleic acids, vitamins, monosaccharide, triglyceride.

Answer:

Organic: dipeptide, protein, polysaccharide, lipids, carbohydrates, nucleic acids, monosaccharide, triglyceride.

Inorganic: minerals, vitamins, water

6 Compare and contrast carbohydrates and proteins.

Answer:

Compare: Both contain carbon, hydrogen and oxygen atoms. Both can be used as an energy source (proteins, only when carbohydrate and lipid sources are used up)

Contrast: Proteins also contain nitrogen atoms.

7 Conduct research to identify common foods that are high in simple sugars, complex carbohydrates, proteins and lipids.

Answer:

Simple sugars: Raw sugar, brown sugar, corn syrups and high-fructose syrup, fruit juice concentrate, honey, fruit

Complex carbohydrates: Brown rice, corn, wheat, barley, oats, quinoa, peas, beans, whole grains, vegetables.

Proteins: beef, lamb, veal, pork kangaroo, chicken, turkey, goose, duck, fish, prawns, crab, lobster, eggs, milk, yoghurt, cheese

Lipids: avocados, vegetable oil, cheese, olives, butter, whole milk, nuts

Questions 3.2**Recall knowledge****1 List the factors that affect the activity of enzymes.**

Answer:

- Enzyme concentration
- Substrate concentration
- Product concentration
- Temperature
- pH
- Presence of cofactors or coenzymes
- Presence of enzyme inhibitors

2 Use a diagram to demonstrate the lock-and-key model of enzyme activity.

Answer: Student diagrams will vary. Should show a specific active site shape, complementary to the substrate, and the enzyme-substrate complex. Refer to Figure 3.9 on page 67 of the student book.

3 Explain why an increased temperature can:

a increase the rate of the reaction

Answer: As temperature increases, the energy of the molecules increases as well. They will collide more frequently and increase the chance of an enzyme-substrate complex forming, thereby increasing the rate of the reaction.

b decrease the rate of the reaction.

Answer: Enzymes have an optimum temperature range (between 30°C and 40°C), higher than that the shape of the enzyme changes, and will not be complimentary to the substrate any longer, as such the rate of reaction decreases. The enzyme has become denatured and is inactive. At low temperatures, the molecules in the reaction have less energy, as such will move more slowly, collide less frequently and will also slow reaction rate. This can be recovered by providing more heat energy.

Apply knowledge

4 Explain the difference between a cofactor and a coenzyme.

Answer: A cofactor is an ion or non-protein molecule that will change the shape of the active site so an enzyme-substrate complex can be formed. A coenzyme is a non-protein organic molecule such as a vitamin.

5 Lipase is an enzyme that catalyses the breakdown of lipid molecules. Would lipase be able to break a protein down into smaller peptides? Justify your answer.

Answer: No. Enzymes are specific. Lipase will have an active site that is specific to lipid molecules and will not be complementary to protein molecules.

6 Tay-Sachs disease is a genetic disorder where the enzyme hexosaminidase A is not produced. Without the enzyme, a fatty substance builds up on neurons, causing a degeneration of the central nervous system. Use this information to discuss the importance of enzymes.

Answer: The enzyme hexosaminidase A is found in the cell's lysosomes. When this enzyme is present, it will break down the fatty substance (called GM2 ganglioside). Without it, the fatty substance builds up on neurons in the brain and spinal cord leading to the destruction of these neurons, and the symptoms of Tay-Sachs. Children born with Tay-Sachs usually only live to early childhood.

Enzymes are important in normal functioning of the body, both in catabolic and anabolic reactions. Without them the body is unable to function normally.

Questions 3.3

Recall knowledge

1 Define 'cellular respiration'.

Answer: The process by which organic molecules, taken in as food, are broken down in the cells to release energy for the cell's activities.

2 What does 'ATP' stand for?

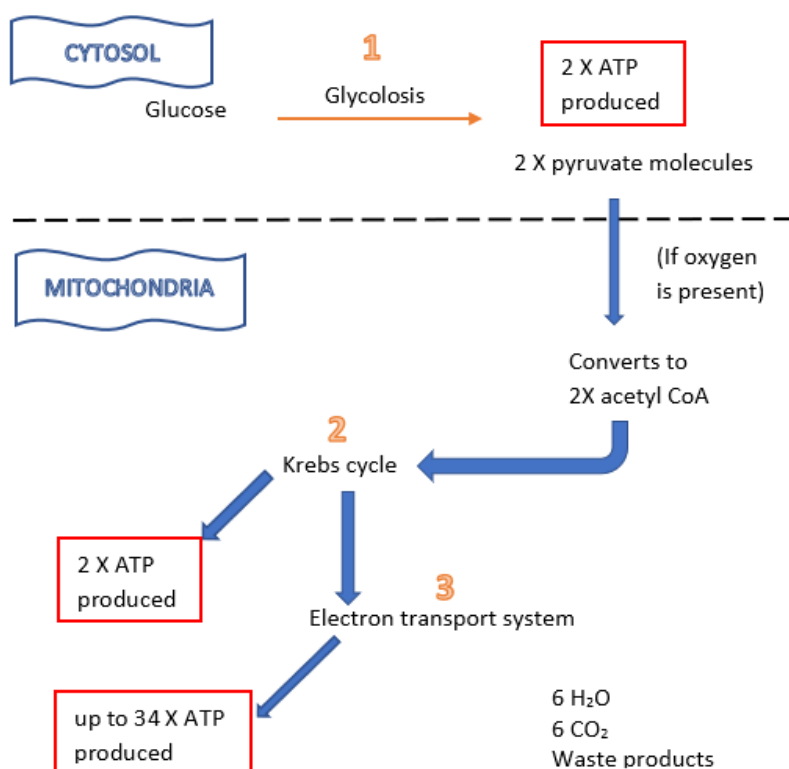
Answer: Adenosine triphosphate

3 Describe aerobic respiration.

Answer: The complete breakdown of glucose to form carbon dioxide and water in the presence of oxygen. Occurs in the mitochondrion.

4 Draw a flow chart to summarise the processes that occur during aerobic respiration.

Answer:



Apply knowledge

5 Explain how ATP is able to store energy.

Answer: ATP stores energy in the bond between the adenosine diphosphate (ADP) molecule and the third phosphate group. This bond is more easily broken, allowing the energy it stores in the bond to become available when the cell requires it.

6 Describe the importance of the electron transfer system.

Answer: The electron transport system (ETS) uses the available oxygen to completely breakdown the organic molecules produced at the end of the Krebs's cycle. It thereby accesses the energy from the broken bonds to produce up to 34 molecules of ATP. Without the ETS, only four ATP molecules would be produced per glucose molecule consumed.

7 Construct a table to summarise the inputs and outputs for the stages of aerobic respiration, including glycolysis.

Answer:

	Glycolysis	Citric Acid cycle	Electron transport system
Inputs	Glucose	2 pyruvate molecules (converted into acetyl CoA)	oxygen
Outputs	2 Pyruvate molecules and 2 ATP molecules	2 ATP Carbon dioxide	Water and up to 34 ATP molecules

Questions 3.4

Recall knowledge

1 Define 'catabolic reaction' and 'anabolic reaction'.

Answer:

Catabolic reaction: Chemical reactions that break down large organic molecules into smaller ones, with the release of energy.

Anabolic reaction: Chemical reactions that build up large organic molecules from smaller ones, requiring energy. May also be called synthesis.

2 List five ways that cells use energy.

Answer:

- Building complex molecules (Anabolic reactions)
- Cell division and growth
- Movement of cell organelles
- Movement of the whole cell
- Maintaining cell organisation
- Active transport
- Transmission of nerve impulses

3 Explain why energy is released when ATP forms ADP.

Answer: To form ADP from ATP the third phosphate group must be removed. The energy stored in this bond is released for use by the cell.

Apply knowledge

4 Approximately 60% of the energy produced during cellular respiration is released as heat. Discuss whether this energy is 'waste'.

Answer: Heat energy is only deemed a waste product if it is not needed by the body to maintain its 37°C temperature. Humans are homeothermic and can maintain body temperature despite changes in the external environment. The heat produced from cellular respiration contributes to the homeostatic mechanism. If the body produces more than what is required, then other physiological mechanisms are used to remove this excess heat as waste.

5 Explain why cells that require a large amount of energy contain a lot of mitochondria.

Answer: The mitochondria is the site for aerobic respiration. Up to 36 ATP molecules can be produced in the mitochondria, as opposed to the 2 ATP molecules produced by glycolysis in the cytoplasm. Very active cells require more ATP, and therefore will contain more mitochondria.

Chapter 3 activities

Activity 3.1 Investigating the effect of temperature on trypsin activity

Discussion

1 What is your independent variable?

Answer: The temperature at which each test is run.

2 What is the range of your independent variable?

Answer: 20–60°C

3 What is your dependent variable?

Answer: The time taken for the X to become visible. This is the time taken to break down the proteins.

4 What are your control variables and how did you control them?

Answer: The control variables are the concentrations of the reagents (milk, trypsin and pH buffer solution). These are controlled by making each one in bulk and taking samples from the same solution.

5 Why are all the test tubes left in the water baths for 10 minutes before the trypsin and milk are added together?

Answer: Conditioning the reagents ensures they are at the required temperature prior to adding them together. Starting at an incorrect temperature may affect the results, for example at 0°C there would be expected little to no activity, but if either reagent is warmer to start with the reaction may occur too quickly.

6 What are the advantages of taking an average of test samples as opposed to just one?

Answer: Taking an average allows for errors in any one test. This procedure in particular has a subjective end-point, so taking averages narrows down the expected result from a relatively wide range.

7 Why did the milk become clearer in this investigation?

Answer: Proteins are too large to be soluble, so as the trypsin starts to break them down, they become small enough to dissolve and ‘disappear’.

8 You used a buffer solution in this investigation. What are buffer solutions used for?

Answer: To keep the pH constant.

9 What is the optimal temperature for trypsin activity?

Answer: 40–50°C

Activity 3.2 Investigating aerobic and anaerobic respiration during exercise

1 The world record for the 100 m sprint is less than 10 seconds. In a 100 m race, what proportion of a sprinter's energy would come from anaerobic respiration?

Answer: At least 85% – probably close to 100%

2 In a marathon race, what proportion of a runner's energy would come from anaerobic respiration?

Answer: Approximately 1%

3 At what duration of maximum effort would half an athlete's energy come from aerobic and half from anaerobic respiration? Can you suggest some sports in which maximum effort would come in bursts of that duration?

Answer: It would take approximately 2 minutes. Sports include swimming, running certain distances, boxing and wrestling (2-minute rounds).

4 Name some sports or activities in which most of the energy would come from anaerobic respiration.

Answer: Football, rugby, netball, skateboarding, surfing, and any sport involving brief bursts of intense activity

5 Name some sports or activities in which most of the energy would come from aerobic respiration.

Answer: Long-distance running and swimming, hiking, climbing, water polo, horse riding and other endurance sports

6 Some observers noted that a sprinter who had just run 400 m in 50 seconds was breathing much more heavily than a runner who had just completed a marathon in 2.5 hours. Suggest why this would be so.

Answer: A sprinter would gain energy from anaerobic respiration. Lactic acid that is produced during anaerobic respiration must be converted to glucose and then to glycogen in the liver. This process requires oxygen, so the body incurs an 'oxygen debt' when cells are anaerobically respiring. Once the exercise ceases, breathing is heavy so that the oxygen debt can be repaid. The marathon runner does not need recovery oxygen because most of the energy would be produced via aerobic respiration.

Chapter 3 review questions

Recall

1 Write the full names for ATP and ADP.

Answer: ATP: Adenosine triphosphate; ADP: Adenosine diphosphate

2 Describe the difference between breathing and cellular respiration.

Answer: Breathing is the taking in of air via the airways – it is a physical action. Respiration is a chemical reaction that supplies energy in every living cell.

3 What compounds are synthesised from:

a glucose?

Answer: Complex carbohydrates, particularly glycogen

b amino acids?

Answer: Proteins

c fatty acids and glycerol?

Answer: Lipids, phospholipids and steroids

4 State the function of enzymes in the body.

Answer: Enzymes are biological catalysts that are able to speed up chemical reactions in the body by lowering the activation energy. They are not consumed in the reaction.

Explain

5 Compare and contrast metabolism, catabolism and anabolism.

Answer:

Compare: All are used to name the chemical reactions that occur in the cells. All have inputs and produce waste products.

Contrast: Catabolism: reactions where large molecules are broken down into smaller ones, releasing energy.

Anabolism: reactions where small molecules are combined to form larger ones, requiring energy.

Metabolism: refers to the balance between energy release and energy use.

6 a Write a chemical equation that summarises cellular respiration.

Answer: $C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$

b Is the summary an accurate picture of what happens in cellular respiration? Justify your answer.

Answer: No. It is not an accurate picture, because more than 20 chemical reactions occur within the mitochondria or cytoplasm during cellular respiration.

7 Explain the difference between aerobic and anaerobic respiration in terms of the:

a quantity of energy released

Answer: In aerobic respiration, one molecule of glucose can release enough energy to form up to 38 ATP molecules from ADP. In anaerobic respiration, one molecule of glucose can release enough energy to form two ATP molecules from ADP.

b reactions involved

Answer: Aerobic respiration requires oxygen and involves a series of reactions: glycolysis, the Krebs cycle and the electron transport system. Anaerobic respiration requires no oxygen and involves only glycolysis, and then the conversion of pyruvic acid to lactic acid.

c location of the chemical reactions within the cell.

Answer: Aerobic reactions occur in the mitochondria of the cell. Anaerobic reactions occur in the cytoplasm of the cell.

8 Explain what is meant by 'oxygen debt' or 'recovery oxygen'. How is an oxygen debt 'repaid'?

Answer: Lactic acid that is produced during anaerobic respiration must be converted to glucose and then to glycogen in the liver. This process requires oxygen so the body incurs an 'oxygen debt' when cells are respiring anaerobically and building up lactic acid, usually during intense physical exercise. Once the exercise ceases, breathing is heavy so that the oxygen debt can be repaid. This extra oxygen that is required to convert lactic acid to glucose and glycogen is called recovery oxygen.

9 Explain why enzymes are substrate specific.

Answer: Enzymes will only combine with one particular substrate and thus will only catalyse one specific reaction.

10 Explain why increasing the substrate concentration has no impact on the rate of the reaction beyond a certain point.

Answer: Enzymes can become saturated. Once all active sites are occupied the concentration of substrate does not have an impact on the rate of the reaction. As such, a plateau can be seen if measuring rate of reaction against substrate concentration.

Apply

11 'Cellular respiration is vital for cellular functioning.' Explain this statement.

Answer: Cellular functioning is how efficiently the cell is working. Many cell functions are active processes requiring ATP. Cellular respiration produces ATP, so without the reaction, there would not be enough energy for normal cellular functioning.

12 Use a diagram to summarise the relationship between ATP and ADP.

Answer: Students should draw a simplified version of Figure 3.17 on page 71 of the student book.

13 The law of conservation of energy states that energy can be neither created nor destroyed. If this is so, why do we need to continually take energy into the body in the form of food?

Answer: Energy cannot be created or destroyed, but it can be transferred and transformed, or converted. Energy is constantly being converted by the body to synthesise new products necessary for life activities, such as growth and repair, reproduction and movement. A large amount of energy is also converted to heat, which is a form of energy that living cells cannot use.

14 For each of the following processes, state whether the chemical reactions are anabolic or catabolic reactions:

a protein synthesis

Answer: Anabolic

b anaerobic respiration

Answer: Catabolic

c formation of glycogen

Answer: Anabolic

d aerobic respiration

Answer: Catabolic

e formation of glucose from lactic acid.

Answer: Anabolic

15 The figure below is a model showing how an enzyme is involved in a chemical reaction. Which letter corresponds to the enzyme, substrate, active site, enzyme–substrate complex and product?

Answer:

a Substrate

b Active site

c Enzyme

d Enzyme-substrate complex

e Product

Extend

16 ACE inhibitors are medications that slow the activity of angiotensin-converting enzyme (ACE). Angiotensin is an enzyme that causes blood vessels to constrict. A person prescribed an ACE inhibitor would produce less angiotensin than usual. Suggest what medical condition/s ACE inhibitors could be used to control. Explain the reason for your suggestions.

Answer: ACE inhibitors would be used to control high blood pressure (hypertension). Slowing the activity of angiotensin-converting enzyme would reduce the amount of angiotensin produced, which in turn would reduce the amount of constriction of blood vessels, thereby reducing blood pressure.

17 Adolf Hitler and a number of high-ranking Nazi leaders committed suicide by taking cyanide. The cyanide ion travels to the mitochondria where it acts as an enzyme inhibitor for cytochrome C oxidase, an enzyme involved in the electron transport system. Explain why cyanide poisoning is fatal.

Answer: Cyanide prevents the cells from using oxygen. Cyanide inhibits the enzyme cytochrome C oxidase, which is part of the electron transport chain. Tissues that rely heavily on aerobic respiration, such as cardiac muscle and nerve cells, are most affected by cyanide.