SAMPLE TEXTBOOK ANSWERS

Chapter 6 Cells at work – cell metabolism

The following are sample answers only. Other answers to the same questions may also be correct.

Science inquiry

Activity 6.1 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 of 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.

Review questions

1 Explain what is meant by the terms 'metabolism', 'catabolism' and 'anabolism'.

Answer: Metabolism comprises the sum of all chemical reactions that take place in a cell or an organism.

Catabolism refers to reactions where large molecules are broken down into smaller molecules. Catabolic reactions release energy.

Anabolism refers to reactions where small molecules are built up into larger molecules. Anabolic reactions require energy.

2 a Why are enzymes necessary in living organisms?

Answer: Enzymes allow chemical reactions to take place at normal body temperature; without them, reactions would proceed too slowly to be effective.

b What is meant by the statement that enzymes are specific?

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

c List the factors that affect enzyme activity.

Answer: Temperature; enzyme concentration; substrate concentration; pH; presence of co-factors and co-enzymes.

3 What is 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.

4 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? Explain.

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

c Why is it necessary for cells to respire?

Answer: Cells need to respire to release energy for all of the cell's activities, such as movement, production and secretion of new substances.

5 a Explain the role of ATP and ADP in cellular respiration.

Answer: ATP stores energy within a chemical bond between a phosphate group and ADP. ADP can be reused to store more energy.

b What part do ATP and ADP play in the synthesis of organic molecules?

Answer: The breakdown of ATP to ADP provides the energy for the formation of chemical bonds between small molecules to build larger molecules.

c Using a diagram, summarise the energy relationship between ATP and ADP.

Answer: Students should draw a simplified version of the diagram from the text:

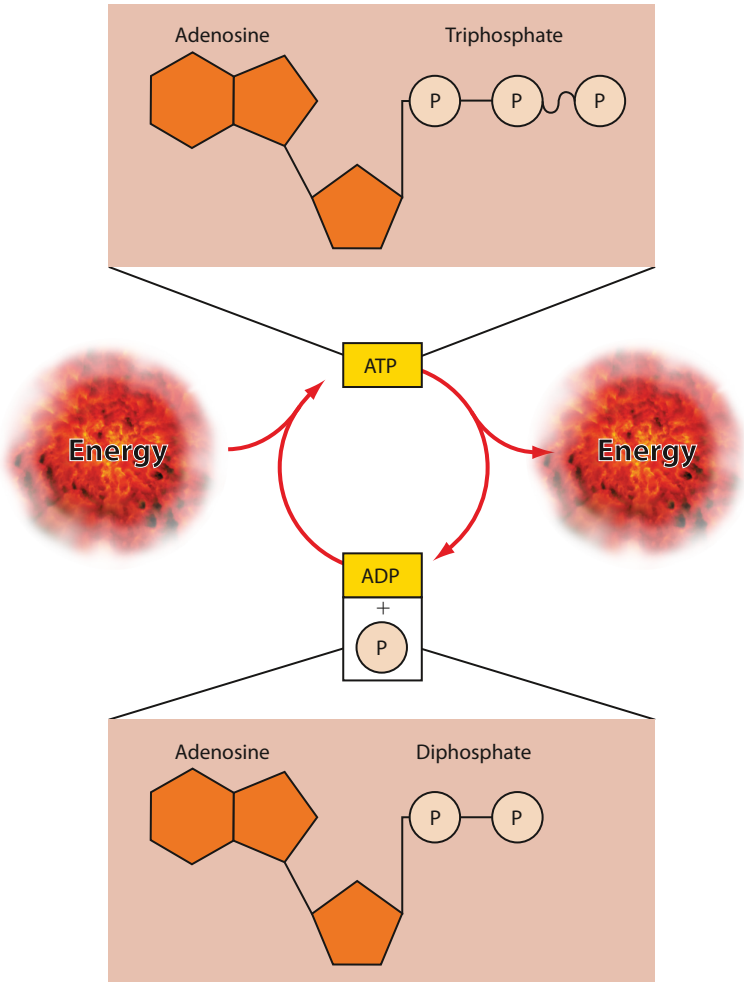

Figure 6.5 ATP stores energy; the energy is released when ATP breaks down to ADP.

6 What is the difference between aerobic and anaerobic respiration in terms of:

a the 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 the 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 the 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.

7 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.

8 List the processes for which cells need energy. Indicate whether each process is common to all cells or whether the process would occur only in particular cells.

Answer:

- Building complex molecules: all cells
- Cell division and growth: most cells
- Movement of cell organelles: all cells
- Movement of whole cell: some cells
- Maintaining cell organisation: all cells
- Active transport: all cells
- Transmission of nerve impulses: nerve cells only.

9 What is synthesis? Why do reactions involving synthesis require matter and energy?

Answer: Synthesis is the combination of small molecules to make larger molecules; for example, amino acids joining to form proteins, or glucose molecules joining to make glycogen. Matter, in the form of small molecules, is required to be joined, and energy is needed to form the chemical bonds between the small molecules.

10 Draw up a table showing the six types of nutrients and the role of each in cellular metabolism.

Answer:

Nutrient	Role in cell metabolism
Water	Dissolves substances; chemical reactions occur in water; water takes part in some reactions
Carbohydrates	Provide energy for reactions
Lipids	An important energy source
Proteins	Enzymes are proteins that catalyse all reactions and control metabolism; energy source when carbohydrates and lipids are not available; proteins also make up much of the structural material in the cell
Minerals	May be part of enzymes; function as co-factors; may be part of substances such as ATP (phosphates)
Vitamins	Act as co-enzymes for chemical reactions

Apply your knowledge

1 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.

2 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

3 Which of the following would yield the greatest amount of ATP if completely broken down in cellular respiration – a gram of carbohydrate, lipid or protein? (Use references if necessary.)

Answer: Lipid (The yield is approximately 37 kJ/g, while carbohydrates and proteins yield approximately 17 kJ/g.)

4 For each of the following processes state whether the chemical reactions are anabolic or catabolic reactions.

a Protein synthesis

Answer: Anabolic

b Aerobic respiration

Answer: Catabolic

c Anaerobic respiration

Answer: Catabolic

d Formation of glucose from lactic acid

Answer: Anabolic

e Formation of glycogen

Answer: Anabolic

5 Adolf Hitler and a number of high-ranking Nazi leaders committed suicide by taking cyanide. Find out what effect cyanide has on cells. Why is cyanide a lethal poison?

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.

6 Vitamin C is essential for the production of collagen in the body. A deficiency of Vitamin C leads to scurvy, a disease that causes loss of teeth and easy bruising, especially around the joints. What role would Vitamin C play in the production of collagen?

Answer: Vitamin C acts as a co-enzyme in the reaction that synthesises collagen, a type of protein, from amino acids. Without it, production of collagen cannot occur. Collagen, an important component in fibrous tissue, is the most abundant protein in the body.

7 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.

8 Figure 6.11 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?

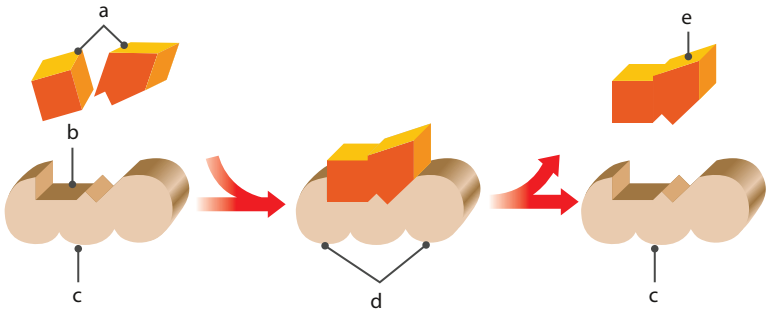

Figure 6.11 A model for enzyme action

Answer:

Enzyme = c

Substrate = a

Active site = b

Enzyme–substrate complex = d

Product = e