

Answers

1 Chemical elements and biological compounds

Now test yourself

- 1 Cohesion forces allows the transport of water columns up the xylem. Cohesion forces also give water its high surface tension.
- 2 The high latent heat of water means that it provides a cooling effect when evaporating, for example in sweating.
- 3 High specific heat capacity
- 4 Water dissolves a wide variety of different solutes.
- 5 Two molecules of alpha glucose
- 6 Glycogen
- 7 So that they do not dissolve in water and damage the structure they form.
- 8 Chitin is a mucopolysaccharide that contains acetylamine side chains, which are not found in other polysaccharides.
- 9 Glycerol and fatty acids
- 10 A triglyceride consists of one glycerol molecule bonded to three fatty acids. A phospholipid consists of one glycerol molecule bonded to two fatty acids and a phosphate group.
- 11 Lipids store twice as much energy as the same mass of carbohydrates; this makes them efficient stores of energy.
- 12 A saturated fatty acid has no carbon-to-carbon double bonds in the hydrocarbon chain. An unsaturated fatty acid does have carbon-to-carbon double bonds within the hydrocarbon chain.
- 13 20
- 14 The primary structure is the sequence of amino acids in a polypeptide. In the secondary structure the polypeptides coil to form an alpha helix or a beta pleated sheet.
- 15 Sulfur is a component of some amino R groups and means that disulfide bridges can form between the sulfur-containing R groups.
- 16 Haemoglobin has a quaternary structure.

2 Cell structure and organisation

Now test yourself

- 1 Aerobic respiration
- 2 The folds of the cristae increase the surface area on which ATP synthesis can occur.
- 3 There are ribosomes on the surface of the rough endoplasmic reticulum.
- 4 Chlorophyll

- 5 The 70S ribosomes in prokaryotes are smaller than the 80S ribosomes in eukaryotes.
- 6 Viruses consist of a nucleic acid and a protein coat.
- 7 Tissues are made up of cells with a similar structure and the same function. Organs are groups of tissues that carry out a particular function.
- 8 Any two from roots, leaves, stems or flowers.

Practice questions

1 magnification = $\frac{\text{image size}}{\text{actual size}}$

Convert both measurements to mm:

$$12 \text{ cm} = 120 \text{ mm}$$

$$500 \mu\text{m} = 0.5 \text{ mm}$$

$$\text{magnification} = \frac{120}{0.5}$$

$$\text{magnification} = 240\times$$

- 2 100 eyepiece divisions = 10 divisions on the stage micrometer $\times 0.1 \text{ mm}$

$$100 \text{ eyepiece divisions} = 1 \text{ mm}$$

$$1 \text{ eyepiece division} = \frac{1}{100} = 0.01 \text{ mm}$$

As this value is in mm, multiply it by 1000 to find the length of 1 eyepiece division in μm .

$$1 \text{ eyepiece division} = 0.01 \times 1000 = 10 \mu\text{m}$$

$$\text{plant tissue sample} = 75 \times 10 = 750 \mu\text{m}$$

3 Cell membranes and transport

Now test yourself

- 1 Phospholipid tails are hydrophobic, so they are repelled by the water inside and outside the cell.
- 2 Intrinsic proteins lie across both the layers of the membrane, while extrinsic proteins are either in one layer of the membrane or on the surface of the membrane.
- 3 Cholesterol helps to increase the rigidity of the membrane.
- 4 Glycoproteins are proteins with a carbohydrate chain attached, while glycolipids are lipids with a carbohydrate chain attached.
- 5 Diffusion occurs through the phospholipid bilayer, while facilitated diffusion occurs through a carrier or channel protein.
- 6 Large substances are taken into the cell by endocytosis, while exocytosis takes them out of the cell.
- 7 The pressure potential is generated by the cytoplasm pushing on the cell wall.
- 8 Water leaves the cell by osmosis and it becomes plasmolysed.

Practice questions

- The line crosses the x-axis at 0.25 mol dm^{-3} , so this is the concentration where there will be no change in mass.
- $$\Psi = \Psi_s + \Psi_p$$

$$\Psi_s = \Psi - \Psi_p$$

$$= -238 - 75 \text{ kPa}$$

$$= -313 \text{ kPa}$$
- The solute potential is between -200 kPa and -300 kPa because the point of incipient plasmolysis (50% of cells plasmolysed) is between these two values. At incipient plasmolysis the water potential of the cell is equal to the solute potential of the surrounding solution.
- To improve the reliability of the results.
 - Phospholipids are soluble in organic solvents. Increasing the concentration of organic solvents will dissolve the phospholipid bilayer, making the cell more permeable to betalain, meaning more will diffuse out of the cell, thus decreasing the mean transmission.

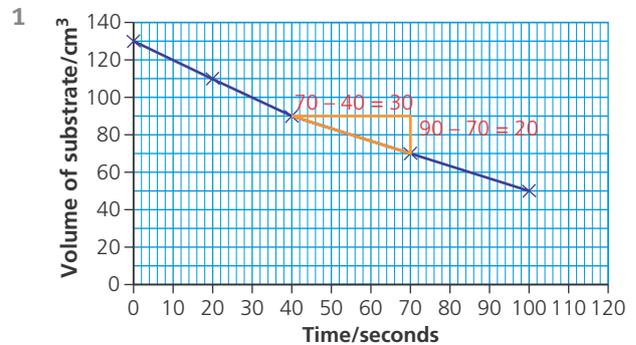
4 Biological reactions and enzymes

Now test yourself

- Enzymes provide a route for a reaction to occur at a lower activation energy.
- According to the lock-and-key theory the substrate is an exact complementary shape to the enzyme's active site. According to the induced-fit theory the enzyme's active site changes shape to fit around the substrate.
- The rate of reaction is fastest at the start of the reaction.
- A control experiment is important because it shows that it is the enzyme's action which is causing the change in the dependent variable.
- The enzyme and substrate have low kinetic energy and therefore there are fewer successful collisions between active sites and substrates, and fewer enzyme-substrate complexes are formed per unit time.
- Small changes from the optimum pH cause enzymes to become inactive.
- The presence of more substrate molecules increases the chance of successful collisions between active site and substrate.
- The substrate must always be in excess.
- The competitive inhibitor enters the active site and blocks the substrate from entering, preventing the formation of an enzyme-substrate complex and therefore preventing products forming.
- A non-competitive inhibitor does not bind to the active site, so does not need to be a complementary shape.

- Any two advantages from: the enzymes are more stable at higher temperatures and a wider range of pH; the enzymes can be easily added or removed to control the reaction and be easily recovered for reuse; a mixture of enzymes with different optimum pH values and temperatures can be successfully used together.

Practice questions



$$70 - 40 = 30 \text{ seconds}$$

$$90 - 70 = 20 \text{ cm}^3$$

$$\frac{20}{30} = 0.67 \text{ cm}^3 \text{ second}^{-1}$$

5 Nucleic acids and their functions

Now test yourself

- The purine bases are adenine and guanine.
- Ribose and phosphate
- mRNA, rRNA, tRNA
- Any two from: a DNA nucleotide has one phosphate molecule, while ATP has three phosphate molecules; DNA contains the pentose sugar deoxyribose, while ATP contains the pentose sugar ribose; DNA can contain one of four nitrogenous bases while ATP always contains adenine.
- Both DNA strands act as a template.
- ^{15}N and ^{14}N
- The molecules produced by DNA replication are made up of one newly formed strand and one original strand.
- It catalyses the addition of complementary DNA nucleotides to form a strand of DNA.
- A gene
- In the nucleus
- The template strand
- RNA polymerase
- It catalyses the formation of a peptide bond between amino acids.
- At the ribosome
- A specific amino acid attaches to the tRNA molecule; this requires ATP.
- There are two binding sites.

6 Genetic information

Now test yourself

- The chromatids are joined by the centromere.
- A pair of chromosomes comprising one maternal and one paternal chromosome.
- A diploid cell has the full number of chromosomes and a haploid cell has only one chromosome from each homologous pair.
- To the poles of the cell
- At the equator of the cell
- The splitting of the cell into two cells.
- Anaphase
- Mitosis produces two genetically identical diploid cells. Meiosis produces four genetically different haploid cells.
- Two
- Homologous chromosomes pair up to form a bivalent.
- Crossing over

Practice questions

- number of cells = $86 + 32 + 14 + 6 + 19 = 157$
 mitotic index = $\frac{32 + 14 + 6 + 19}{157} = \frac{71}{157} = 0.45$
 - Interphase is the longest stage of the cell cycle and each cell spends more time in interphase than undergoing mitosis as a whole. You can see this as the total number of cells in all four stages of mitosis is still less than the number of cells in interphase. The fastest stage of mitosis is anaphase because the lowest number of cells are in it. The longest stage of mitosis is prophase, because it has the most cells in it after interphase.

7 Organisms are related through evolutionary history

Now test yourself

- Protocista, Plantae, Fungi, Animalia
- Bacteria, Archaea, Eukarya/eukaryotes
- kingdom, phylum, class, order, family, genus, species
- Animalia and Plantae
- They are adapted to carry out the same function (swimming) but have not evolved from a common ancestor.
- The pentadactyl limb is a homologous feature.
- Measuring the proportion of DNA shared between organisms and comparing the amino acid sequences of proteins.
- Biodiversity decreases as you move from the equator to the poles.

- Biodiversity is the number of species found within a specified geographic region, and the number of individuals of each species in a given environment.
- A species with a high degree of variation in the DNA base sequences has a higher genetic biodiversity.
- Natural selection

Practice questions

Species	Number (n)	$n - 1$	$n(n - 1)$
<i>Paraponera clavata</i>	56	55	3080
<i>Titanus giganteus</i>	7	6	42
<i>Eciton burchellii</i>	39	38	1482
<i>Dynastes hercules</i>	5	4	20

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

$$\sum n(n-1) = 3080 + 42 + 1482 + 20 = 4624$$

$$N = 56 + 7 + 39 + 5 = 107$$

$$N(N-1) = 107(107-1) = 107(106) = 11342$$

$$D = 1 - \frac{4624}{11342} = 1 - 0.41 = 0.59$$

This answer shows a moderate level of biodiversity, due to this sample being dominated by *Paraponera clavata* and *Eciton burchellii*.

8 Adaptations for gas exchange

Now test yourself

- The respiratory surface of the amoeba is the plasma membrane of the cell.
- A flatworm has a thin body, meaning the diffusion pathway for oxygen into its body is short.
- The earthworm has a circulatory system that oxygen diffuses into and is then carried all around the body.
- Contraction of the insect's body speeds up the movement of air through the spiracles.
- Ventilation moves the respiratory medium over the respiratory surface, maintaining a concentration gradient.
- Countercurrent flow maintains the concentration gradient for oxygen, so diffusion of oxygen into the blood from the water occurs across the whole length of the gill.
- The surfactant reduces the surface tension in the alveoli and prevents them from collapsing during exhalation.

- 8 The volume of the pleural cavity increases and the pressure decreases.
- 9 Malate lowers the water potential in the guard cells. This causes water to move in by osmosis, making the guard cells turgid.
- 10 Spongy mesophyll
- 11 When the guard cells become turgid the outer wall bends more than the inner wall; this causes the stomata to open.
- 12 Xylem tissue carries water, and water is a reactant in photosynthesis.

Practice questions

- 1 Cube A:

$$\text{area of one side} = 30 \times 30 = 900 \text{ mm}^2$$

$$\text{total surface area} = 900 \times 6 = 5400 \text{ mm}^2$$

$$\text{volume} = 30 \times 30 \times 30 = 27000 \text{ mm}^3$$

Therefore, the surface area-to-volume ratio of cube A is 5400:27000.

Divide both sides by 5400 (the largest common factor):

$$\text{surface area-to-volume ratio} = 1:5$$

Cube B:

$$\text{area of one side} = 60 \times 60 = 3600 \text{ mm}^2$$

$$\text{total surface area} = 3600 \times 6 = 21600 \text{ mm}^2$$

$$\text{volume} = 60 \times 60 \times 60 = 216000 \text{ mm}^3$$

Therefore, the surface area-to-volume ratio of cube B is 21600:216000.

Divide both sides by 21600 (largest common factor):

$$\text{surface area to volume ratio} = 1:10$$

Cube A would take the least time to become red, as it has the larger surface area-to-volume ratio.

- 2 radius = $\frac{0.4}{2} = 0.2 \text{ m}$

$$\text{surface area of a cylinder} = 2\pi rh + 2\pi r^2$$

$$\text{surface area of moray eel} = (2 \times 3.14 \times 0.2 \times 1.2) + (2 \times 3.14 \times 0.2^2)$$

$$= 1.5072 + 0.2512$$

$$= 1.7584 \text{ m}^2$$

$$\text{volume of a cylinder} = \pi r^2 h$$

$$\text{volume of moray eel} = 3.14 \times 0.2^2 \times 1.2$$

$$= 0.15072 \text{ m}^3$$

$$\text{surface area:volume} = 1.76:0.15$$

- 3 mean number of stomata = $\frac{7 + 11 + 9}{3}$

$$= \frac{27}{3}$$

$$= 9$$

$$\text{radius of field of view} = \frac{0.6}{2} = 0.3 \text{ mm}$$

$$\text{area of field of view} = \pi r^2 = 3.14 \times 0.3^2$$

$$= 0.28 \text{ mm}^2$$

mean number of stomata per mm^2 = mean number of stomata per field of view/area of field of view in mm^2

$$= \frac{9}{0.28}$$

$$= 32 \text{ stomata per mm}^2 \text{ (to the nearest whole stoma)}$$

9 Adaptations for transport

Now test yourself

- In a closed circulatory system the blood is always carried in vessels or in the heart. In an open system the blood is not always in vessels but bathes the tissues directly.
- In a single circulatory system the blood only flows through the heart once per circuit around the body. In a double circulatory system there is a pulmonary and systemic circulatory system, and the blood flows through the heart twice per circuit around the body.
- Arteries have a thicker muscle and elastic tissue layer (tunica media) than veins.
- The rise and fall in pressure in the arteries is due to ventricular systole and diastole.
- The septum
- The tricuspid valve prevents backflow of blood from the right ventricle to the right atrium.
- The bundle of His carries the wave of depolarisation from the atrioventricular node down to the base of the ventricles.
- The QRS complex represents depolarisation of the ventricles, resulting in ventricular systole.
- The foetal curve is shifted to the left so that the foetal haemoglobin can absorb oxygen from the mother's haemoglobin at all partial pressures of oxygen.
- At the arterial end of the capillary the hydrostatic pressure is greater than the osmotic pressure.
- As negatively charged hydrogencarbonate ions diffuse out of the red blood cells, negatively charged chloride ions diffuse into the red blood cells.
- A high carbon dioxide concentration causes the oxyhaemoglobin to become unstable and have a lower affinity for oxygen (oxygen dissociation curve is shifted to the right). This means that the oxyhaemoglobin dissociates more readily, unloading oxygen.
- Apoplast, symplast and vacuolar
- High humidity reduces the rate of transpiration.
- Xerophytes are adapted for low-water environments.
- The aphid mouthparts (the stylets) are able to penetrate the phloem vessel and extract the sap without getting blocked.

Practice questions

- time between peaks of QRS complex = $0.64 - 0.04 = 0.6$ seconds
heart rate = $\frac{60}{0.6} = 100$ beats per minute
- radius = 2.5 mm
volume of a cylinder = $\pi r^2 h$

$$\begin{aligned} \text{volume of capillary} &= 3.14 \times 2.5^2 \times 56 \\ &= 1099 \text{ mm}^3 \\ \text{rate} &= \frac{1099 \text{ mm}^3 / 60 \text{ min}}{48 \text{ mm}^2} \\ &= \frac{18.32 \text{ mm}^3 \text{ min}^{-1}}{48 \text{ mm}^2} \\ &= 0.38 \text{ mm}^3 \text{ min}^{-1} \text{ cm}^{-2} \end{aligned}$$

- 3 An increase in temperature would increase the rate of transpiration.

10 Adaptations for nutrition

Now test yourself

- Plants are autotrophic because they produce complex organic molecules in photosynthesis.
- Chemoautotrophs
- Saprotrophic nutrition
- Holozoic nutrition involves the ingestion and internal digestion of food.
- The *Hydra*'s gut is unspecialised and only has one opening, while more complex organisms have a specialised gut with two openings.
- The chemical digestion of lipids begins in the duodenum.
- An endopeptidase hydrolyses peptide bonds between specific amino acids within the polypeptide chain, while an exopeptidase hydrolyses the terminal (end) peptide bonds of peptides.
- The ileum has a large surface for absorption due to being long, and having villi and microvilli. The ileum has a large number of capillaries, lacteals and lymphatic capillaries to transport the products of digestion.
- Diastema
- Carnassials are specialised molars that cut flesh and crush bone.
- Regurgitating food allows ruminants to 'chew the cud', thus increasing the surface area for cellulose digestion.
- Ectoparasites live on an organism.