

Exam-style questions and sample answers have been written by the authors. In examinations, the way marks are awarded may be different.

> Workbook answers

Chapter 1

Exercise 1.1

- 1 a Carbon, hydrogen, oxygen
- b Carbon
- c Nitrogen

Exercise 1.2

- 1 a Hydrogen bonds
- b When sweat evaporates, heat energy from the body is used to break the hydrogen bonds between the water molecules. As the water is converted from liquid to vapour, the body cools down.

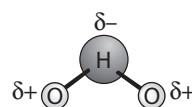
c

Cohesive properties	Adhesive properties
force that allows water molecules to stick together	force that allows water molecules to cling to surrounding materials
allows insects such as the pond skater to walk on water as they do not break the surface tension beneath them	adhesion of water molecules to xylem vessels allows water to be drawn up from the roots to the leaves

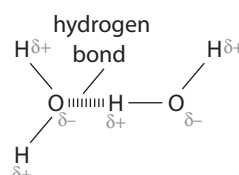
d

Metabolite	Solubility
Glucose	Soluble
Amino acids	Soluble
Cholesterol	Insoluble
Lipids	Insoluble
Sodium chloride	Soluble

- 2 a Any similar image to that shown below.



- b Any similar image to that shown below.

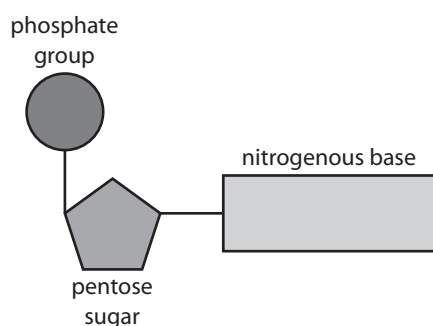


- 3 a Transparency of water
- b Photosynthesis
- 4 a To cut breathing holes in the ice
- b Thick layers of fat under their skin provide thermal insulation
- c Its streamlined shape allow it to move faster in water when catching prey
- 5 a Asteroids and comets that have fallen to Earth
- b The range of distance a planet can be from the Sun which is not so hot as to boil the water on it, or too cold to freeze all water on its surface. Planets in this zone could have water that would remain liquid.

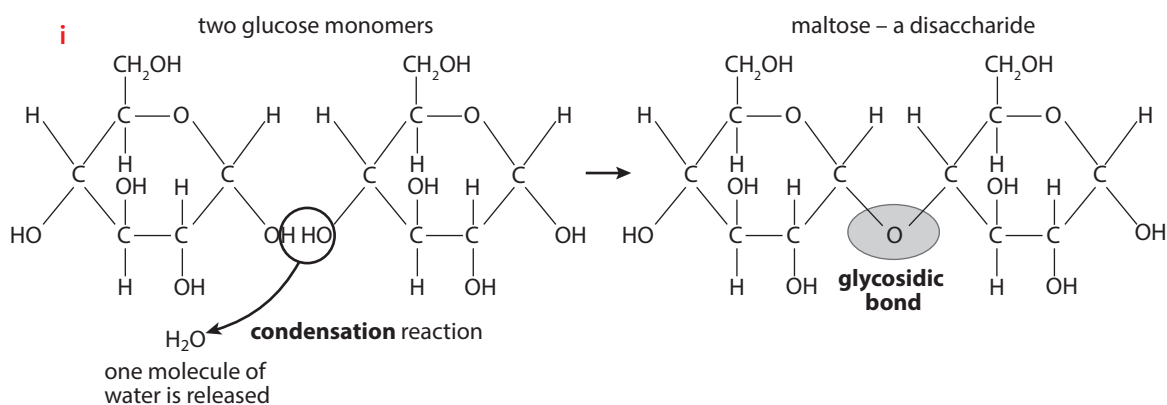
Exercise 1.3

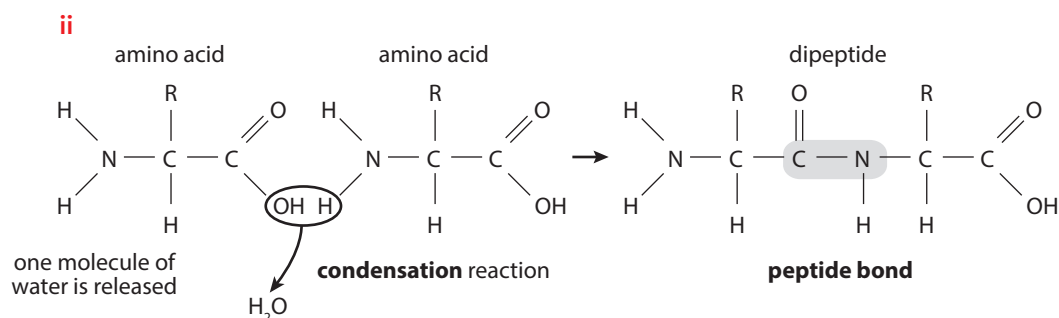
- 1 a Covalent bonds
- b 4
- c i Carbon, hydrogen, oxygen
- ii Carbon, hydrogen, oxygen, nitrogen
- iii Carbon, hydrogen, oxygen
- iv Carbon, hydrogen, oxygen, nitrogen, phosphorous

- 2 a Carbohydrate
b Lipid
c Carbohydrate
d Nucleic acid
e Carbohydrate
f Protein
g Protein
- 3 a monosaccharides / glucose / any other named monosaccharide
b Amino acids
c nucleotides
d Glycerol and fatty acids
- 4 a i (Two from:) glucose, fructose, ribose, deoxyribose, galactose
ii (Two from:) sucrose, lactose, maltose
iii (Two from:) starch, glycogen, cellulose, chitin
b Cellulose is in plant cell walls, starch is used as a glucose store in plants, carbohydrates are stored as glycogen in animals.
c Two glucose molecules are joined together in a condensation reaction, after the removal of H–O–H, which forms a molecule of water.
- 5 a Diagram of similar to that shown.



- b Polynucleotide/nucleic acid
- 6 a Water
b Diagrams similar to those shown here.





c Ester bond

d Hydrolysis

7 Anabolic reactions build molecules and catabolic reactions break down molecules.

8 Adenosine triphosphate (ATP)

9 a i Carboxyl group

ii Amine group

iii Phosphate group

b Amino acid

c DNA / RNA / Nucleic acid / nucleotide / ATP

d Phosphorous and oxygen

Exercise 1.4

1 a glucose is used in respiration to provide energy in the form of ATP; glucose is used to form larger structural and energy storage molecules

b (two from) lactose, maltose, sucrose

2 a i False, amylopectin is a branched molecule.

ii True

iii True

b Amylose

c The molecule is compact and linear (amylopectin would be more branched).

3 a Amylose **d** Cellulose

b Amylopectin **e** Glycogen

c Chitin

4

	Cellulose	Amylose	Amylopectin	Glycogen
Single unit of glucose	beta	alpha	alpha	alpha
Bonds formed	1-4	1-4	1-4 and 1-6	1-4 and 1-6
Branched	no	no	yes	yes

Exercise 1.5

1 a High energy content, less dense than water, non-polar and insoluble, provide excellent insulation.

b Osmosis

c Lipids are less dense than water.

d Whales and seals use the thermal insulation of lipids to stay warm in very cold environments

2 a
$$\text{BMI} = \frac{\text{mass (kg)}}{\text{height (cm/m)}^2}$$

b Saturated and *trans* fats; accept any named examples, such as butter, chocolates, cookies, fries, cakes, ice creams.

c Accept any named examples, such as avocados, almonds, nuts, named vegetables, fish, olive oils.

d Student answer should include a balanced review of the theory. It is likely that an increase in saturated fatty acids will lead to an increase in CHD as saturated fatty acids raise cholesterol levels in the blood. However, there is no evidence presented to show that the increase in CHD is definitely caused by the intake of saturated fatty acids. The increase in CHD might be due to other factors related to population X.

- 3 Answers must refer to both carbohydrates and lipids.

Carbohydrates	Lipids
Readily available and easier to digest	Cannot be digested as easily
Store less energy per gram	Stores more energy per gram
Soluble and easier to transport	Insoluble in water

- 4 Kidneys

- 5 They are non-polar.

Exercise 1.6

- 1 In order: condensation, polypeptide, covalently
- 2 a Peptide bonds
b Hydrogen bonds
c Accept any of the following: ionic bonds, disulfide bridges, hydrogen bonds
- 3 a i Insulin
ii Antibody / immunoglobulin
iii Hemoglobin
iv Catalase
b i Collagen
ii Keratin
iii Silk
c Globular proteins are rounded in shape and are soluble
Fibrous proteins are long and narrow in shape, are insoluble, and often have a structural function
- 4 a $20^3 = 8000$
b $20^6 = 64\,000\,000$
- 5 a The specific sequence of particular amino acids, joined together.
b Peptide bonds
c Alpha helices have a helix shape, but beta sheets are pleated and look like folded paper (any description of the difference between them is acceptable; award marks for a correctly named example).

- d i R group
ii Hydrogen bonds, disulfide bonds, ionic bonds; accept hydrophobic interactions between non-polar side chains if mentioned.
- e i Three
ii Four
iii Four
iv Six
- 6 a Conjugated protein
b The heme group which allows the molecule to bind oxygen

Exercise 1.7

- 1 a Deoxyribonucleic acid and ribonucleic acid.
b Table/answer should contain the following:

DNA	RNA
Contains deoxyribose	Contains ribose
Bases are A, T, G, C	Bases are A, U, G, C
Double-stranded molecule	Single-stranded molecule
Very long strands	Relatively shorter strands

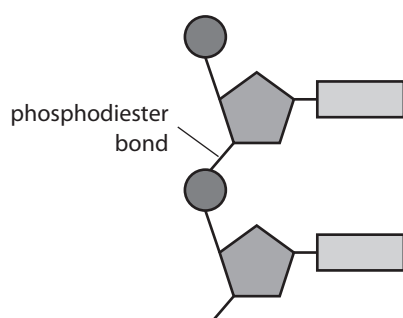
- c Both sets of base pairs are joined by hydrogen bonds but T and A are joined by two hydrogen bonds, compared to the three hydrogen bonds that join G and C.
- 2 • DNA helicase moves along the double helix, unwinding and unzipping the two strands by breaking the weak hydrogen bonds between complementary bases.
• DNA polymerase moves along the two strands, adding complementary nucleotides to each of the templates. G joins with C, and T joins with A.
• The newly formed DNA molecules will twist to produce two genetically identical double helices of DNA.
- 3 Diagram to show antiparallel strands with three nucleotides on each strand. Diagram should contain a labelled nucleotide (including deoxyribose sugar, phosphate group and nitrogenous base, represented by pentagons for the sugar, circles for the phosphate group,

and rectangles for the bases). Nucleotides should be joined by a covalent bond and bases by hydrogen bond.

- 4 Any three from: Rosalind Franklin, James Watson, Francis Crick, Maurice Wilkin
- 5 a Protein/polypeptide
b Nucleosome
c The antiparallel nature of the double helix, bonded by complementary base pairing.
- 6 a Alfred Hershey and Martha Chase
b They discovered that DNA and not protein is the genetic material
c Each daughter molecule is formed containing one original strand from the parent and one newly synthesised strand.

Exam-style questions

- 1 A [1]
2 B [1]
3 D [1]
4 D [1]
5 B [1]
6 B [1]
7 C [1]
8 a Diagram should look similar to the one shown here. [1]



Circles, pentagons and rectangles should be used for the phosphate groups, pentose sugars and bases. [1]

The phosphate group should be joined to the other nucleotide at the third carbon (C3) position. [1]

- b Phosphate group (circle) [1]
pentose sugar (pentagon) [1]
base (rectangle) [1]
all correctly labelled.
- c Correct bond labelled (sugar of one nucleotide joined to phosphate group of the next) [1]
Correctly labelled as a phosphodiester bond [1]
- 9 a Carbon [1]
hydrogen [1]
oxygen [1]
Because they are all found in the main biological molecules [1]
(proteins, lipids, carbohydrates and nucleic acids) [1]
b Nitrogen [1]
because it is found in all proteins and nucleic acids [1]
- 10 a Must contain at least one similarity and one difference for maximum marks. Both are linear. Both contain carbon, hydrogen and oxygen. Both contain a carboxylic acid group. An amino acid contains nitrogen, whereas a fatty acid does not. [3]
b Glucose is a hexagonal structure whereas ribose is a pentagon. Both are ring structures. Both are monosaccharides. Both contain carbon, hydrogen and oxygen. Both contain oxygen in the ring. [3]
- 11 Monosaccharides join together to form polysaccharides such as glycogen. [1]
Glycosidic bonds are formed between glucose molecules. [1]
Condensation reaction. [1]

12 [maximum 3 marks]

Carbon has four electrons in its outer shell. [1]

It can make four single covalent bonds, like the central carbon in an amino acid. [1]

It can make double bonds with carbon or oxygen; C = O is found in fatty acids and amino acids. [1]

It can bond with other carbon atoms and various other elements including hydrogen, oxygen and nitrogen. [1]

13 [maximum 3 marks]

Thermal properties of water [1]

Water has a high specific heat capacity / resists a change in temperature [1]

Animals can maintain a constant internal temp [1]

Example of homeostasis [1]

14 a A non-protein group that forms part of or combines with a protein. [1]

b [maximum 2 marks]

Four polypeptide chains / Quaternary structure [2]

Each polypeptide has a heme group [1]

Heme group is prosthetic / contains iron atom [1]

c Iron ions bind to oxygen [1]

Iron allows hemoglobin to transport oxygen in the bloodstream [1]

15 Condensation reactions form bonds whereas hydrolysis reactions break bonds. [1]

Condensation reactions produce water whereas hydrolysis reactions require the addition of water. [1]

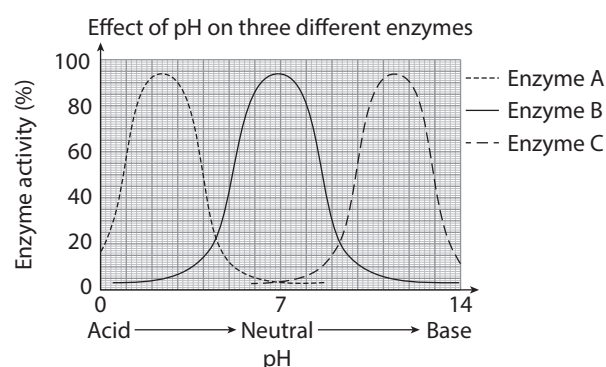
Condensation reactions convert monomers to polymers whereas hydrolysis reactions convert polymers to monomers. [1]

Chapter 2

Exercise 2.1

- 1 **a** Large complex molecules are broken down into small simple ones.
- b** Simple molecules are joined to form larger, more complex ones.
- c**
 - i** Anabolic
 - ii** Catabolic
 - iii** Catabolic
 - iv** Anabolic
 - v** Anabolic
- 2 **a** X is the substrate, Y is the enzyme and Z is the enzyme–substrate (ES) complex.
- b** Substrate will bind to the enzyme's active site to form the ES complex. A catabolic reaction takes place and the substrate is converted into two products, which are released from the active site. The enzyme remains unchanged and so can be reused.
- c** Straight label line drawn to the active site of the enzyme, which is the top of shape Y.
- d** Protein that is a biological catalyst and speeds up reactions, whilst remaining unchanged itself.
- 3 **a** 40 °C, as it creates the greatest enzyme activity.
- b** High temperatures break the bonds holding the tertiary structure together. The enzyme's active site loses its 3D shape and can no longer bind to the substrate.
- c** Independent variable is pH, dependent variable is time to test negative with iodine. Possible controlled variables are: volume of starch solution, volume of amylase, concentration of starch solution, concentration of amylase, concentration of iodine, temperature.
- d** pH 7 but accept any answer between pH 6 and 8.
- e** Maltose
- f** Stomach enzymes (pH 2) / pepsin

- 4 **a** Time taken
- b** Volume of oxygen produced
- c** Accept realistic and relevant suggestions such as using an oxygen probe or a gas syringe. Reject inaccurate methods such as counting bubbles.
- d** Graph has correctly labelled axes with units (time (s) on *x*-axis, volume of oxygen collected (cm³) on *y*-axis), points correctly plotted and joined together by a line.
- e** The overall trend is a curve. Between 30 and 150 seconds the trend in oxygen production is almost linear with a directly proportional increase, showing a constant rate of reaction. After 150 seconds, the volume of oxygen produced significantly decreases as the rate of reaction declines. By 180 seconds the volume of oxygen produced has reached a plateau at approximately 24 cm³. At this point the rate of reaction is zero, as no further product is being formed.
- 5 **a** Student graph should look similar to the one below, with three curves on one graph of similar shape and plotting. Axes and curves should be suitably distinguished, and labelled as A, B and C.



- b**
 - i** Enzyme A, as it has an optimum pH around pH2-3
 - ii** Enzyme B, as blood has a neutral pH, and so enzyme B would work optimally in that environment. Both Enzyme A and C would be denatured at pH 7.
 - iii** 12

- 6 a i** Krebs cycle / Calvin cycle / other valid metabolic pathway
- ii** The minimum energy required for a reaction to happen.
- iii** The *y*-axis should be labelled as 'energy' and the *x*-axis can be 'time' or 'progress of reaction'. Accept any similar suggestions; units not required. Legend should show that the solid line is reaction without an enzyme and dotted line is reaction with an enzyme
- iv** Lowered the activation energy by approximately 50%.

7 a

	Competitive inhibitor	Non-competitive inhibitor
Compare the shape of the inhibitor to the shape of the substrate	Similar	Different
Where does the inhibitor bind?	Active site	Allosteric site
Duration of inhibition	Temporary	Permanent
Effect of inhibitor on the active site	No Effect	Altered shape
Does increasing the substrate concentration lessen the effect of the inhibitor?	Yes	No
Can maximum rate of reaction be reached?	Yes	No

- b** Inhibitor should be labelled as competitive (left-hand part of Figure 2.6) or non-competitive (right-hand part of Figure 2.6) and answer should briefly outline that it is binding at, or away from, the active site.

- c i** Competitive
- ii** Non-competitive
- iii** As substrate concentration increases, it is possible for the substrates to increase their presence and overcome a competitive inhibitor to reach the maximum rate. However, a noncompetitive inhibitor permanently affects the active site, making a number of enzymes inoperable. The Maximum reaction rate can therefore not be achieved.
- d i** Enzyme that causes browning is denatured by the high temperature.
- ii** Enzyme responsible for browning is denatured by the change in pH
- e** Penicillin
- f** Carbon monoxide
- g** Fomepizole
- h** It prevents the accumulation of excess product which is wasteful, or could even be toxic.

Exercise 2.2

- 1 a** The controlled release of energy by breaking down organic compounds to produce ATP.
- b** Glucose + oxygen → carbon dioxide + water + energy;

$$\text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2 \rightarrow 6\text{CO}_2 + 6\text{H}_2\text{O} + 36\text{ATP}$$
- 2 a** Glucose is broken down to two pyruvate molecules and 2 ATP are produced
- b** Pyruvate enters the mitochondria and is converted to acetyl-CoA
- 3 a** Cytoplasm
- b i** The matrix
- ii** Inner mitochondrial membrane
- c** Accept synthesis of molecules, active transport, endo and exocytosis, cell division, any other relevant answer
- 4 a** Production of beer, wine, bread, ethanol or any other correctly named example.

- b** Lactate or lactic acid
- c** Ethanol and carbon dioxide
- d** Aerobic respiration produces 36 ATPs but anaerobic respiration produces only three ATP molecules.
- 5 a** Tube B is a control so that any change in the manometer can be attributed to the consumption of oxygen.
- b** The pressure in Tube A is reduced as the organism consumes oxygen and this causes the liquid to move from an area of higher pressure towards the area of lower pressure.
- c** The investigation uses a live organism that may be argued is not ethical; it cannot be guaranteed that the insect may not be harmed in any way.
- d** Use of an organism such as germinating seeds or yeast that does not feel pain.
- 6 a** A reaction in which reduction and oxidation occur simultaneously
- b**
- | Oxidation | Reduction |
|-------------------|-------------------|
| loss of electrons | gain of electrons |
| loss of hydrogen | gain of hydrogen |
| gain of oxygen | loss of oxygen |
- c i** (Aerobic) respiration
- ii** Oxidised
- iii** Hydrogen atoms, and therefore electrons, are removed from glucose (and added to the hydrogen acceptors NAD⁺ and FAD).
- iv** The glucose is oxidised but other parts of the reaction are reduced as they accept the hydrogen.
- d i** Adenosine triphosphate (ATP)
- ii** Glycolysis, link reaction, Krebs cycle, electron transfer chain
- e i** Cytoplasm
- ii** Anaerobic
- iii** Phosphorylation
- iv** Lysis
- v** The energy to add the Pi comes from an oxidation reaction. The triose bisphosphate is oxidised and at the same time NAD⁺ is reduced to NADH + H⁺.
- vi** ATP formation
- vii** Any sensible answer that creates a mnemonic for PLOA.
- viii** 2 × NADH, 2 × pyruvate
- ix** 2 × ATP were required at the start of the pathway but 4 × ATP were produced. Therefore 4 – 2 is 2 ATP.
- 7 a** The matrix contains enzymes for the link reaction and the Krebs cycle; inner membrane is folded to form cristae to increase surface area for reactions; 70S ribosomes make proteins and enzymes required for respiration; ATPase enzyme joins ADP and Pi to form ATP; space between inner and outer membranes enables a high concentration of protons to accumulate; outer membrane keeps the mitochondrion content separate from the cytoplasm.
- b** Link reaction and Krebs cycle.
- c i** Decarboxylation
- ii** Kreb's cycle
- iii** Coenzyme A
- iv** Citrate
- v** Dehydrogenation
- vi** ATP
- vii** Link, pyruvate, carbon, decarboxylation, hydrogen, Krebs cycle, citrate, dehydrogenated, carbon dioxide, ATP, NADH, FADH₂
- d i** During the following: link reaction, conversion of citrate to 5-carbon acid and 4-carbon acid.
- ii** During oxidation, hydrogen is removed from of the carbon chain and donated to NAD⁺ or FAD. This occurs at 4 points.
- iii** 8, 2, 2, 6

- 8 a** Both NADH and FADH₂ are reduced electron carriers. They bring electrons and hydrogen produced during glycolysis, the link reaction and the Krebs's cycle to the electron transport chain

NADH offloads its electrons and hydrogen at the first carrier in the chain, reforming NAD⁺. Its electrons each result in the formation of 3 ATP.

FADH₂ offloads its electrons and hydrogen at the second carrier in the chain, reforming FAD. Its electrons each result in the formation of 2 ATP.

- b** Folded to increase the surface area, so that more electron transport chains can be present along the membrane.
- c** Oxidative phosphorylation
- d i** Inner membrane
- ii** Creates a potential difference across the membrane/creates a concentration gradient for facilitated diffusion.
- iii** Linking the movement of protons across a membrane to ATP synthesis
- iv** ATP synthase

Exercise 2.3

- 1 a** carbon dioxide + water → glucose + oxygen
- b** $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$
- c** Location of respiration is mitochondria, whereas location for photosynthesis is chloroplast.

Reactants for respiration are glucose and oxygen whereas reactants for photosynthesis are carbon dioxide and water.

Products of respiration are carbon dioxide and water whereas products of photosynthesis are glucose and oxygen.

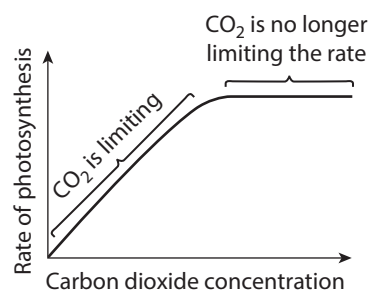
- 2 a** Factor that affects the rate of reaction when available in lower quantities.

- b i** As the light intensity increases, the rate of photosynthesis increases. At high light intensity, the rate plateaus.

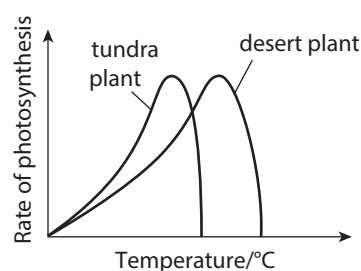
- ii** Rate of photosynthesis can only increase up to a point and then it cannot go any faster, no matter how much light is provided. The rate of photosynthesis plateaus when another factor (temperature/carbon dioxide concentration) is limiting the rate.

As there is a finite number of chloroplasts, only so much light can be absorbed by a leaf. Above the light saturation point (LSP), excess light cannot be involved in photosynthesis.

- iii** Any graph similar to below. Curve should increase rapidly before levelling off at a certain point. Axes should be labelled as shown.



- c i** Graph should look similar to below. Rate increases for both curves to the optimum temperature (peaks) before decreasing. The optimum temperature of the tundra plant should be lower than that of the desert plant.



- ii** Above the optimum temperature the enzymes involved in photosynthesis (rubisco) are denatured.

3 a Chloroplasts

- b i** The thylakoid membrane
ii The stroma

c Agree: the light-independent reaction does not directly require sunlight

Disagree: the light independent reactions can only take place with the products of the light-dependent reaction, so therefore both reactions do require sunlight.

4 a Chlorophyll molecules in photosystem II become activated by photons of light and pass their excited electrons to an electron acceptor protein at the start of the electron transport chain.

b Takes them from water as the water is split into electrons, protons and an oxygen atom.

c The splitting of water using light energy.

d Photosystem I

e i Photophosphorylation

ii Both pump protons across a membrane to create a concentration gradient.

Both involve the enzyme ATP synthase and ATP production.

Protons accumulate in the thylakoid space in chloroplasts, whereas they accumulate in the intermembrane space of the mitochondria.

f $\text{NADPH} + \text{H}^+$

5 a Non-cyclic photophosphorylation

b Cyclic photophosphorylation

6 a Carbon fixation involves taking inorganic carbon (in the form of CO_2 during photosynthesis) and incorporating it into an organic molecule (part of a living organism).

b Rubisco is the enzyme that catalyses carbon fixation in plants. It combines inorganic carbon dioxide and ribulose biphosphate (RuBP) to form the organic molecule glycerate 3-phosphate (GP). Rubisco is actually called RuBP carboxylase but is often known as Rubisco.

7

Function	Structure
Provide large surface area for light-dependent reactions to take place	Thylakoid membrane
Provides a rapid proton gradient/pump for chemiosmosis	Thylakoid space
Location of the Rubisco, and the Calvin cycle	Stroma
Synthesis of proteins required within the chloroplast	70S ribosomes

8 a Hydrogen / H

b ATP synthase, which is located within the thylakoid membranes

Exam-style questions

- | | | |
|-----------|---|-----|
| 1 | B | [1] |
| 2 | D | [1] |
| 3 | B | [1] |
| 4 | C | [1] |
| 5 | A | [1] |
| 6 | B | [1] |
| 7 | D | [1] |
| 8 | C | [1] |
| 9 | D | [1] |
| 10 | B | [1] |
| 11 | A | [1] |
| 12 | A | [1] |
| 13 | D | [1] |
| 14 | B | [1] |
| 15 | D | [1] |
| 16 | B | [1] |
| 17 | D | [1] |
| 18 | B | [1] |
| 19 | A | [1] |
| 20 | A | [1] |

- 21 C [1]
 22 C [1]
 23 D [1]
 24 A [1]
 25 a Temperature [1]
 pH [1]
 substrate concentration [1]
 b Rate increases as temperature increases [1]
 peaks at the optimum temperature (37 °C for most enzymes in the body) [1]
 but then rate decreases after the optimum temperature as the enzymes become denatured [1]
 c Stomach [1]
 26 a Biological catalyst, globular protein [1]
 binds to substrate [1]
 speeds up chemical reactions [1]
 b Substrate approaches active site [1]
 causes a conformational change in the enzyme to fit substrate more closely [1]
 suggests that more than one similarly shaped substrate can bind to the same enzyme [1]
 c Diagrams should show enzyme and substrate, substrate same shape as the active site of the enzyme [1]
 substrate enters the active site, forming enzyme–substrate complex [1]
 reaction occurs, enzyme releases new products [1]
 enzyme remains the same shape after the reaction and is free to continue with more reactions with other substrates [1]
 27 a Carbon dioxide produced [1]
 causing bread to rise [1]
 b Lactic acid/lactate [1]
 c Animals ingest food that contains glucose [1]
 plants make their own glucose during photosynthesis [1]

- 28 a [1] for each comparison/difference shown in the table [maximum 2 marks].

	Mitochondria	Chloroplasts
Proton origin	NADH + H ⁺	Water molecules
Proton accumulation	Intermembrane spaces	Thylakoid spaces

- b Light-dependent reaction happens in light, light-independent reaction does not need light [1]
 light-dependent reaction happens in thylakoids, light-independent reaction happens in the stroma [1]
 light dependent reactions require NADP and ADP whereas the light independent reactions require ATP and NADPH [1]
 light dependent reactions produce oxygen whereas light independent reactions produce glucose [1]
 c The chlorophyll molecules in a photosystem become activated [1]
 by photons of light [1]
 excited electrons are passed to the primary electron acceptor [1]
 d i Diagram includes the following labelled structures:
 outer and inner membranes [1]
 stroma [1]
 grana [1]
 thylakoid [1]
 70S ribosomes [1]
 ii Stroma contains enzymes required for the Calvin cycle [1]
 grana increases surface area to allow more reactions to take place [1]
 thylakoid space is smaller to allow proton accumulation [1]
 70S ribosomes produce proteins for use inside the chloroplast [1]
 Thylakoids contain photosystems required for the light dependent reactions [1]

Chapter 3

Exercise 3.1

- 1 a Table/answer should contain the following:

DNA	RNA
Contains deoxyribose	Contains ribose
Bases are A, T, G, C	Bases are A, U, G and C
Double-stranded molecule	Single-stranded molecule
Very long strands	Relatively short strands

- b Both sets of base pairs are joined by hydrogen bonds, but T and A are joined by two hydrogen bonds, compared to the three hydrogen bonds that join G and C.
- c Both parental DNA strands are used as a template. Each new DNA molecule consists of one original template strand, and one newly formed strand. Accept an answer in the form of a labelled diagram.
- 2 a Polymerase chain reaction
- b *Taq* DNA polymerase
- c 256
- d Denaturation: heating the sample to separate the strands.

Annealing: addition of primers to the 5' end of each strand.

Extension: *Taq* polymerase adds complementary DNA nucleotides to duplicate each strand.

- e Quicker to identify pathogens and allows treatments to be provided more quickly to patients.
- f Size and charge of the fragments.
- 3 i Accept any of the following: blood (WBC), hair follicles, semen, saliva, skin.
- ii DNA has a negative charge due to the phosphate groups, so is attracted to the positive anode in a gel electrophoresis tank. Shorter fragments travel further along the gel, and larger fragments travel a shorter distance because they are impeded by the agarose gel particles.

- iii Suspect 2
- iv Because the banding pattern of the crime scene exactly matches that of the suspect.
- v Identification of human remains; paternity testing; profiling of diseases. Accept any other reasonable suggestion.

4

	Replication of leading strand	Replication of lagging strand
DNA is used as a template	YES	YES
DNA is created 5' to 3'	YES	YES
Replication is continuous	YES	NO
Replication occurs away from the replication fork	NO	YES
Okazaki fragments are involved	NO	YES
Only 1 RNA primer is required	YES	NO

- b i Unwinds the DNA strands and separates them by breaking the hydrogen bonds.
- ii Adds a short RNA primer.
- iii Replaces the RNA primer with DNA.
- iv Attaches complementary DNA nucleotides in a 5' to 3' direction. Proofreads the DNA.
- c The DNA strands run parallel to each other but in opposite directions: one strand is 3' to 5', the other is 5' to 3'.

Exercise 3.2

- 1 a RNA polymerase
- b Coding / antisense strand
- c Uracil (U)

- d** $4 \times 4 \times 4 = 64$ different combinations.
- 2 a** CAG GGA TCT AAC
b GCT GGA GTG TTG
c GGG CGA CCT CAC
- 3 a** Ribosome
b The triplet of mRNA bases that corresponds with a specific amino acid or stop signal during translation.
c The stop codon tells the ribosome that it must separate from the mRNA as the polypeptide is now complete.
- 4 a i** Initiation
ii Elongation
iii Termination
b i The strand transcribed by RNA polymerase.
ii The DNA strand that is not used as a template during transcription
iii DNA sequence that codes for a polypeptide.
iv The removal of introns and the joining together of exons.
c i Promoter
ii Nucleosome
iii DNA methylation

5 20

	Transcription	Translation
In which direction does it occur?	5' to 3'	5' to 3'
What is used as a template?	DNA	mRNA
What is the main product	an mRNA strand	a polypeptide
Where in the cell does it occur?	In the nucleus	In the cytoplasm / ribosome

- 7 a** D (initiation), B (elongation), A (translocation), C (termination)
b E (exit), P (peptidyl) and A (aminoacyl)
c Small subunit and a larger subunit.
d Polysome
- 8 a** A region of non-coding DNA at each end of every eukaryotic chromosome that is responsible for capping end sequences.
b They will shorten.
- 9 a** The polypeptides must be modified to reach their functional state.
b Disulfide bridge

Exercise 3.3

- 1 a i** substitution
ii insertion
iii inversion
iv deletion
- 2** Makes the genetic code more resistant to genetic changes as a base substitution might not impact on the final expression of the intended protein.

	Normal	Mutated
DNA template	CTC	CAC
mRNA	GAG	GUG
Amino acid	Glutamic Acid	Valine
Shape of red blood cells	Biconcave disc	Sickle / crescent shaped

- 4** Benign is when the tumour is restricted to that particular area of the body but malignant is when the cancer spreads to other parts of the body.
- 5** A mutagen is a substance that has the ability to alter the DNA sequence whereas a carcinogen is a particular type of mutagen that results in cancer.
- 6 a** 52% (accept 51%–54%)
b 28% (accept 26%–29%)
c % change = $\frac{[(\text{final value} - \text{original value}) / \text{original value}] \times 100}{100}$; $\frac{[(28 - 52) / 52] \times 100}{100}$; -46.2% (accept -43% to -50%).

- d** Overall decrease in number of male smokers, aged 20–24 between 1974 and 2012
- e** Answer will have more detail, will include the percentage decrease (if not already), will mention the two mini-increases in 2001 and 2011, as well as the gradual increase between 1990 and 1998 (or any other extra detail from the graph as identified).
- 7 a** Both trendlines show a decrease over time. Both trendlines show little fluctuation / are relatively smooth.
Both trendlines start to plateau around 2006.
Values for men are always slightly higher than values for women
- b** Causes for decrease in both males and females could be caused by smoking bans, or health campaigns.
As the wage gap between males and females has reduced, more similar values as cigarettes become equally affordable to both sexes.
- 8 a** Reduces number of carcinogens consumed, reduces number of people smoking tobacco cigarettes.
- b** Food and Drug Administration, Centers for Disease Control and Prevention
- c** Student answer should offer a considered and balanced view that includes more than one argument or factor. Students' own opinion should be clearly stated and be supported by appropriate evidence from the article.
- 9** Student answer should weigh up the strengths (such as being safer, healthier) and the limitations (such as lack of evidence, lack of data, restriction of choice for humans, harsh penalties, human rights or other sensible answers).
- 10** DNA polymerase (III)

Exercise 3.4

- 1 a i** Methylation prevents the DNA from being transcribed and translated, so the protein it codes for is no longer produced.
- ii** Diet, illnesses, the ageing process, chemicals, smoking, alcohol, drugs, medicines; accept any other correct answer if not listed here.

iii Methyl group, CH₃

b i Nature is the genes passed on through inheritance, nurture is the adaptation due to environment.

ii Student answer must outline both effects on the phenotype (observable characteristics), summarising that both have a role to play. The genetic code determines what genes a person has; but the environment influences which genes are turned on/are expressed.

2 a i 63% (allow $\pm 5\%$)

ii 37% (allow $\pm 5\%$)

iii 29% (allow $\pm 5\%$)

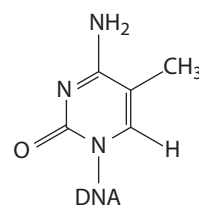
iv 17% (allow $\pm 5\%$)

b That a genetic factor contributes towards the onset of condition.

c Height is highly influenced by genetics but not completely; some environmental factors (such as diet) also contribute to final height.

d The identical twins may have different DNA methylation patterns and may be influenced by environmental factors at different times.

3 The CH₃ group annotated correctly.



Exam-style questions

- 1** B [1]
- 2** C [1]
- 3** B [1]
- 4** D [1]
- 5** B [1]
- 6** C [1]
- 7** A [1]
- 8** C [1]
- 9** D [1]

- 10 C [1]
 11 A [1]
 12 A [1]
 13 B [1]
 14 D [1]
 15 D [1]
 16 A [1]
 17 B [1]
 18 D [1]
 19 C [1]
 20 A [1]
 21 B [1]
 22 B [1]
 23 D [1]
 24 A [1]
 25 A [1]
 26 B [1]
 27 D [1]
 28 D [1]
 29 C [1]
 30 A [1]
 31 C [1]
 32 Any [3]
 from the following:
 DNA replication is essential in order to produce two genetically identical daughter cells (mitosis).
 Occurs during S phase of interphase.
 Once identical copies have been made, during cell division one copy of each identical pair is separated into each daughter cell.
 If DNA replication is not completed successfully, cell division could result in cells with the incorrect amount of DNA. These cells are typically destroyed via apoptosis.
- 33 [1]
 Gene mutations can arise if there are errors during DNA replication of interphase (S phase).
 The sequence of nucleotides could be altered.
 Failure of complementary base pairing during semi-conservative replication.
 Chromosome mutations can occur if there is a failure to separate chromatids during anaphase.
 Daughter cells could have the incorrect number of chromosomes.
- 34 Any [4]
 from the following:
 Autosomal dominant diseases are passed from parent to children via gametes.
 If the genetic disease does not cause death of the child, they may survive to reproduce, and pass it to future generations.
 If the genetic disease is only apparent later in life (e.g. Huntington's) then it may well have already been passed to offspring.
 Not all genetic diseases are screened for, and it is the parent's choice to do so.
 Some parents choose to maintain pregnancies even if they know there is a high chance of having a child with a genetic disease.
- 35 a Any [5]
 of the following [maximum 1 mark per point]:
 DNA sample [1]
 obtained from hair/semen/tissue/blood [1]
 DNA quantity amplified [1]
 by PCR [1]
 DNA cut into fragments [1]
 using restriction enzymes [1]
 DNA fragments separated [1]
 by size in gel electrophoresis [1]
 Number of repeats varies from one person to another, creating a pattern of bands unique to each individual [1]

- b** Any [6] of the following [maximum 1 mark per point]:

Used in forensic science	[1]
for comparing DNA at crime scenes to suspects	[1]
Used in paternity testing	[1]
to match parents' DNA to their offspring	[1]
Immigration cases	[1]
to determine whether person is entitled to residency	[1]
Genetic screening	[1]
to find out likelihood of given phenotype	[1]
Medical diagnosis	[1]
to identify known sequences of viruses or bacteria	[1]
Any other use	[1]
with explanation	[1]

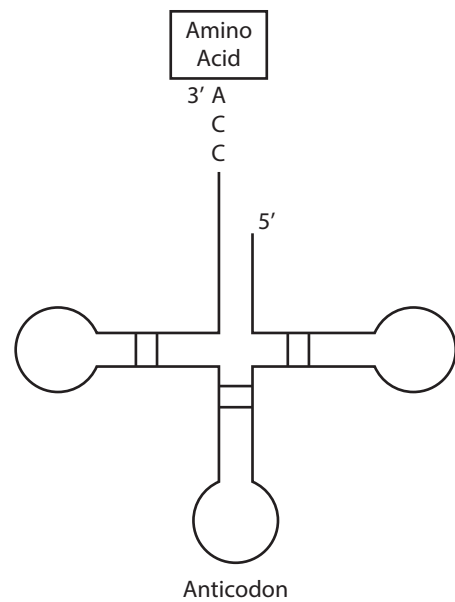
- 36** Helicase unwinds and unzips the DNA template. [5]
 DNA Primase add an RNA primer
 DNA Polymerase III adds DNA nucleotides
 DNA Polymerase I replaces RNA primers for DNA
 DNA ligase joins okazaki fragments together

- 37** Replication of the leading strand is continuous whereas replication of the lagging strand is discontinuous. [2]

Replication of the leading strand is towards the replication fork whereas replication of the lagging strand is away from the replication fork.

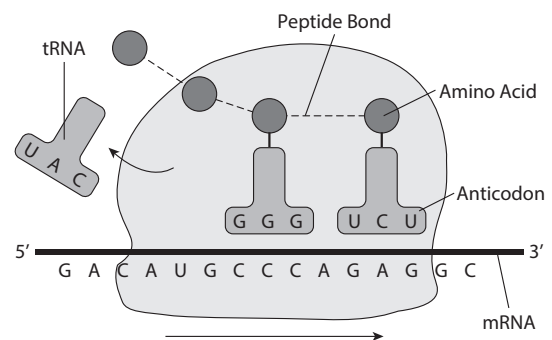
Replication of the leading strand requires a single RNA primer whereas replication of the lagging strand requires a number of RNA primers.

38



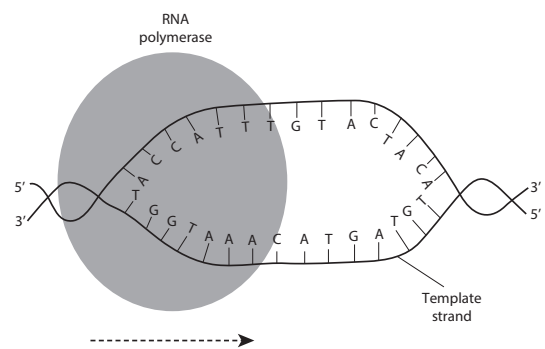
[5]

39



[6]

40



[2]

c mRNA: ACCAUUUGUACUACA [2]

41 a 1 = transcription, 2 = translation

b a = DNA, b = mRNA, c = polypeptide

42 Claimant 3 has no bands in common, so should not inherit.

Claimant 1 has a couple of bands in common, but is not likely to be a close relative.

Claimant 2 has over half of their bands in common, so is most likely to be a closer relative. They should inherit. **[2]**

43 a -3.33% (must be negative) **[1]**

b Part of the DNA sequence contains non coding regions at the beginning which indicate a binding site for RNA Polymerase. These bases are not transcribed. **[1]**

c -41.38% **[1]**

d Introns are removed. **[1]**

Chapter 4

Exercise 4.1

1 a In this order:

Prokaryotic	Eukaryotic
One single chromosome of DNA	Multiple chromosomes of DNA
Chromosome is circular	Chromosomes are linear
DNA not associated with proteins (naked)	DNA associated with histone proteins
Located free floating in the cytoplasm (nucleoid)	Located within the nucleus

- b i Diploid
 ii Haploid
 iii Homologous
 iv Somatic cell
 v Karyogram
 vi Karyotype
- c i Female (XX), male (XY)
 ii Down syndrome is present as there are 3 copies of chromosome 21. The biological sex is female as the last pair are two X chromosomes.
 iii Male
- 2 a i Section of DNA that carries the instruction for one protein / characteristic
 ii A different version of the same gene.
 iii The physical characteristic of an organism.

Exercise 4.2

- 1 a Genotype
 b Dominant allele
 c Recessive allele

- d Codominance
 e Homozygous
 f Heterozygous
 g Carrier

- 2 a Missing values are 1:1, 2:1, 3:1
 b Second filial generation, the offspring of a cross between two individuals of the F₁ generation.

- 3 a i Brown, white
 ii Bb, bb
 iii B, b and b, b

iv

	b	b
B	Bb	Bb
b	bb	bb

- v 50%, 1 : 1, 1 in 2

- b i smooth, smooth
 ii Aa, Aa
 iii A, a, A, a

iv

	A	a
A	AA	Aa
a	Aa	aa

- v 75%, 3 : 1, 3 in 4

- c i carrier, carrier
 ii Ff, Ff
 iii F, f, F, f

iv

	F	f
F	FF	Ff
f	Ff	ff

- v 25%, 1 in 4, 1 : 4
 vi 25%, 1 in 4, 1 : 4
 vii 50%, 1 in 2, 1 : 2

viii

	F	F
F	FF	FF
f	Ff	Ff

0%, the offspring will not suffer from cystic fibrosis.

4 a i A

ii A

iii B

iv B

v AB

vi O

b i Blood group A, blood group B

ii $I^A i$ and $I^B i$

iii I^A, i, I^B, i

iv

	I^B	i
I^A	$I^A I^B$	$I^A i$
i	$I^B i$	ii

v 1 : 1 : 1 : 1 for AB : A : B : O blood groups.

5 a Linked genes are found on the same chromosome, usually close together. The closer they are together, the more likely that they will be inherited together.

b XY

c 23 pairs or 46 chromosomes.

6

Genotype	Gametes
BBRR	All BR
bbRR	All bR
BbRR	BR and bR
Bbrr	Br and br

7 a i All GgTt, all tall with green seeds

ii ggTT and ggTt

iii GGtt and GgTt

b i Parental phenotypes: tall plant, green seeds

Parental genotypes: TtGg

Gametes: TG tG Tg tg

F₁ Punnett:

	TG	tG	Tg	tg
TG	TTGG	TtGG	TTGg	TtGg
tG	TtGG	ttGG	TtGg	ttGg
Tg	TTGg	TtGg	TTgg	Ttgg
tg	TtGg	ttGg	Ttgg	ttgg

ii Tall plants with green seeds: 9

Tall plants with yellow seeds: 3

Short plants with green seeds: 3

Short plants with yellow seeds: 1

c i

Parental phenotypes:	tall plant, green seeds	short plant, green seeds
Parental genotypes:	TtGg	ttGg
Gametes:	TG tG Tg tg	tG tg

F₁ Punnett:

	TG	tG	Tg	tg
tG	TtGG	ttGG	TtGg	ttGg
tg	TtGg	ttGg	Ttgg	ttgg

ii Tall plants with green seeds: 3

Tall plants with yellow seeds: 1

Short plants with green seeds: 3

Short plants with yellow seeds: 1

d This statement is false as linked genes do not follow Mendel's laws of random assortment. Therefore, they are not inherited independently and it is possible that there can be a range of different ratios.

e All of the genes that have their loci on a particular chromosome.

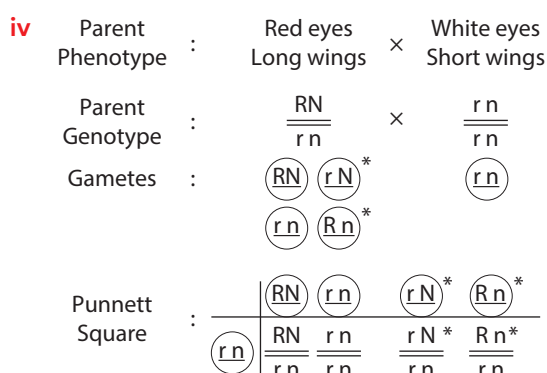
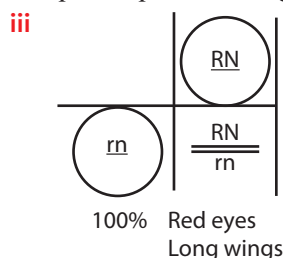
8 a Organism that has a different combination of alleles than either of its parents.

b Possible genotypes are RrTt and rrrt

9 a $\frac{A}{a} \frac{B}{b}$

b i $\frac{R}{R} \frac{N}{N}$ and $\frac{r}{r} \frac{n}{n}$

ii The homozygous dominant parent produces RN gametes, and the homozygous recessive parent produces rn gametes



* = recombinant

10 a

Continuous variation	Discontinuous variation
<ul style="list-style-type: none"> Measurable data Can produce any value between two extremes Examples include: Height, mass, skin colour, foot length 	<ul style="list-style-type: none"> Categorical data Can only take certain values Examples include: handedness, hair colour, eye colour, blood type

b Continuous variation tends to be affected by environmental factors.

c The x-axis should be height, y-axis the frequency, the curve should show a normal distribution as shown by a bell curve.

11 a Discrete/discontinuous

b $\chi^2 = \sum \frac{(O - E)^2}{E}$

c There is no significant difference between the observed genotypes in the offspring and the expected genotypes in a Punnett square.

d i

	O	E	O-E	(O-E) ²	(O-E) ² / E
Smooth	5474	5493	-19	361	0.066
Wrinkled	1850	1831	19	361	0.197

ii 0.262

iii $2 - 1 = 1$

iv We DO accept the null hypothesis as the chi-squared value is less than the critical value.

e i

	Expected ratio	Observed (O)	Expected (E)	O – E	(O – E) ²	(O – E) ² /E
Black fur	4	89	60	29	841	14.02
White fur	3	40	45	–5	25	0.56
Grey fur	9	111	135	–24	576	4.27
Total	16	240	240			18.85

 ii $3 - 1 = 2$

iii The null hypothesis should be rejected because the chi-squared value is far greater than the critical value (5.991). The data collected do not fit the expected ratios.

f i

	Expected ratio	Observed (O)	Expected (E)	O – E	(O – E) ²	(O – E) ² /E
Tall, hairy	9	278	280	–2	4	0.014
Tall, smooth	3	97	93	4	16	0.17
Short, hairy	3	92	93	–1	1	0.01
Short, smooth	1	30	31	–1	1	0.03
TOTAL		497	497			0.224

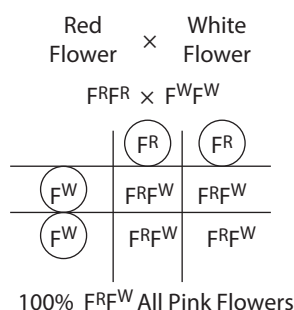
 ii $4 - 1 = 3$

iii The null hypothesis should not be rejected because the chi-squared value is far less than the critical value (7.815). The data collected do fit the expected ratio.

iv Mendelian ratios are being followed, the genes are not linked.

12 a Incomplete dominance

b



13 Co-dominance

14 Temperature: can affect some organisms that lay eggs at certain temperatures (e.g. reptiles).

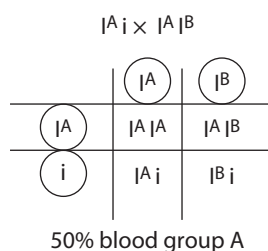
Location: the sex of some species is determined by the location at which their eggs settle (e.g limpets).

15 PKU is autosomal recessive and so the child must inherit a recessive allele from each parent to have the condition.

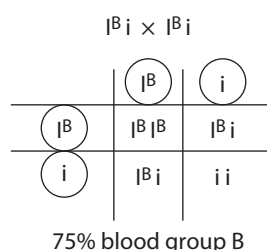
16 a There are more than 2 alleles for blood group (I^A , I^B , i) so it is an example of multiple alleles.

 The alleles I^A and I^B are expressed in the phenotype blood group AB, so it is an example of codominance

b Man × Women
Blood group A Blood group AB



c Women × Man
Blood group B Blood group B



Exam-style questions

- 1 D [1]
- 2 A [1]
- 3 A [1]
- 4 B [1]
- 5 C [1]
- 6 D [1]
- 7 B [1]
- 8 B [1]
- 9 A [1]
- 10 A [1]
- 11 C [1]
- 12 B [1]
- 13 B [1]
- 14 D [1]
- 15 A karyogram is a diagram or photograph of the chromosomes from an organism whereas a karyotype is the number and type of sex chromosomes present in the nucleus e.g 46, XX [1]

- 16 a** [1] for any of the following [maximum 5 marks]:
- Caused by non-disjunction
 - During meiosis
 - Chromosomes fail to separate
 - Gametes have an extra chromosome
 - Some individuals have 47 chromosomes
 - Known as trisomy 21
 - More likely in mothers who are over 35 years old.

- b i** There is an extra copy of chromosome 21. [1]
- ii** X and Y chromosomes present. Male. [1]

c [1] for any of the following [maximum 6 marks]:

- Gene mutation.
- Altered DNA code.
- Changes in the polypeptide chain.
- Glutamic acid replaced by valine.
- Hemoglobin is abnormally shaped.
- Red blood cell is sickle shaped.
- Cannot transport as much oxygen.
- Carriers are resistant to malaria.

- 17 a** BBll and bbLL [1]
- b** Bll [1]
- and bL [1]
- c** BbLl 100% [1]
- d** [1] for each correct row completed.

	BL	Bl	bL	bl
BL	BBLL	BbLL	BbLL	BbLl
Bl	BbLL	BBll	BbLl	Bbll
bL	BbLL	BbLl	bbLL	bbLl
bl	BbLl	Bbll	bbLl	bbll

- e** long, black fur: 9 [1]
- long, brown fur: 3 [1]
- short, black fur: 3 [1]
- short, brown fur: 1 [1]

18 Any [4] from the following:

Genetic variation in offspring is created through meiosis.

Independent assortment and crossing over.

Every egg and sperm is genetically different, and they are produced in large numbers.

Sexual reproduction combines one of many million sperm with one of thousands of eggs.

Evolution is change in heritable characteristics of a population over time.

Evolution requires variation within a population (otherwise clones would be produced).

Genetic variety within offspring allows for survival of the fittest/natural selection.

Variety within a population increases resilience to environmental change and likelihood of surviving the outbreak of disease.

19 Parent genotypes

[1]

Gametes

[1]

Offspring genotypes

[1]

Woman	$X^A X^a$	×	Man	$X^A Y$
	X^A		X^a	
X^A	$X^A X^A$		$X^A X^a$	
Y	$X^A Y$		$X^a Y$	

20 a L = Long fur R = Red eyes
l = Short fur r = Black eyes

$$\frac{LR}{lr} \times \frac{lR}{lR}$$

b

	LR	lr	Lr^*	lR^*
LR	$\frac{LR}{lR}$	$\frac{lR}{lR}$	$\frac{Lr^*}{lR}$	$\frac{lR^*}{lR}$
lr	$\frac{LR}{lr}$	$\frac{lR}{lr}$	$\frac{Lr^*}{lr}$	$\frac{lR^*}{lr}$

21 a Recessive, as II-1 and II-2 can produce affected offspring

b i aa

ii Aa

c 100%

22 i

	Floppy ears blotchy coat		×	Upright ears smooth coat	
	FfBb			ffbb	
	<div>FB</div>	<div>Fb</div>		<div>fB</div>	<div>fb</div>
<div>fb</div>	FfBb	FfBb		ffBb	ffbb
	1	:	1	:	1
	Floppy blotchy	:	Floppy smooth	:	Upright blotchy
					Upright smooth

ii There is no difference between the observed and expected values. Mendelian ratios are being followed; the genes are not linked.

iii There is a significant difference between the observed and expected ratios. Mendelian ratios are not being followed; the genes are linked.

iv

	O	E	O-E	(O-E) ²	(O-E) ² /E
Floppy ears, Blotchy coat	23	14	9	81	5.79
Floppy ears, smooth coat	24	14	10	100	7.14
Upright ears, blotchy coat	5	14	-9	81	5.79
Upright ears, smooth coat	4	14	-10	100	7.14

v 25.86

vi $4 - 1 = 3$

vii Critical value at 5% is 7.815

viii Because the chi squared value is above the critical value, the null hypothesis is rejected. Mendelian ratios are not being followed. The genes are on the same chromosome (linked).

Chapter 5

Exercise 5.1

- 1
 - a A property of a complex system, but which the individual components do not have.
 - b The boiled broth destroyed all microorganisms and when no other microorganisms could enter, the broth remained unchanged. However, once the neck was broken and microorganisms could enter, they reproduced. This showed that cells only come from pre-existing cells.
 - c There would have been growth in the flask before the neck was snapped off.
- 2 Cells are the smallest units of life; All cells come from pre-existing cells; Living organisms are composed of one or more cells
- 3
 - a The experiment reacted together inorganic gases thought to be present in early Earth's atmosphere, and it produced organic amino acids. This provided evidence for the potential production of the first proteins, which are a key component of cells.
 - b Electrical sparks were used to imitate lightning.
- 4
 - a ATP, an energy source that can be used by cells
 - b Iron and sulfur
- 5
 - a RNA has the ability to self-replicate and also act as an enzyme
 - b Active site
- 6
 - a An aggregate created through the self assembly of amphipathic molecules; the hydrophobic ends face inwards and the hydrophilic ends face outwards.
 - b Hydrophobic molecules do not attract water and have non-polar groups or tails, whereas hydrophilic molecules attract water and have polar groups or heads.
 - c Structures formed from the aggregation of abiotic components, but which have some similarities to living cells.
- 7
 - a Approximately 4-5 billion years
 - b Anaerobic
 - c Thermophilic as thermal vents are very hot. Autotrophic as there were no other organisms to take nutrition from. Would not have used light as a source of energy as the deep ocean is very dark.
 - d The use of a genetic code. LUCA is the ancestor of all living things, and genes are passed from one generation to the next.

Exercise 5.2

1

Structure	Description	Eukaryotic or prokaryotic cell?
Nucleus	Present, surrounded by nuclear envelope	Eukaryotic
Mitochondria	Never present	Prokaryotic
Endoplasmic reticulum	Usually present	Eukaryotic
Ribosomes	80S	Eukaryotic
Chromosomes	Long strands of DNA, associated with histones	Eukaryotic
plasmid	Present in some, providing resistance to antibiotics	Prokaryotic
Cell wall	present	Prokaryotic
Pili	Allow exchange of genetic material	Prokaryotic

- b i** Mitochondrion
- ii** Active transport across membranes, endo and exocytosis, protein production, replication
- c i** Plasma membrane: controls movement of molecules in and out of cell.
- ii** Cytoplasm: holds organelles and site of some reactions.
- iii** Centrioles: organises spindle microtubules in cell division.
- iv** Mitochondria: site of cellular/aerobic respiration.
- v** Chloroplast: site of photosynthesis.
- vi** Vacuole: helps in osmotic balance of cell and storage of substances.
- vii** 80S ribosomes: site of protein synthesis.
- viii** Nucleus: contains the genetic material, controls the cell activities.
- ix** Rough endoplasmic reticulum: transports proteins.
- x** Golgi apparatus: processes and packages proteins.
- xi** Lysosomes: digest microbes and unwanted organelle parts.
- xii** Cell wall: protects cell and maintains shape of cell.

d Vacuole, cell wall, chloroplasts.

2 Allow any of the following: homeostasis, metabolism, nutrition, movement, excretion, growth, response to stimuli and reproduction.

3 a Cell differentiation

b A group of similar cells working together to perform the same function.

4 a Magnification = measured size/actual size

b Magnification = $24\,850\,000\ \mu\text{m}/7100\ \mu\text{m}$; magnification = $\times 3500$

c Proteins, peptides and antibodies

d Phosphorescent stains are used so that different parts of the same cell can be distinguished easily.

e Electrons have shorter wavelengths and can distinguish between objects closer together, giving images a high resolution.

f

	Light microscope	Transmission electron microscope	Scanning electron microscope
	uses light to produce images	uses electron beams to produce images	uses electron beams to produce images
Maximum magnification	$\times 2000$	up to $\times 1\,000\,000$	$\times 200\,000$
Stain used	coloured dyes	heavy metals	carbon or gold coating

5

Xylem	Phloem
composed of a column of dead cells	composed of a column of living cells
thickened with lignin	associated with companion cells
transports water and minerals from roots to leaves	transports sugars, amino acids and plant growth regulators to all parts of the plant

- 6 a Mitochondrion and chloroplast
- b Both mitochondria and chloroplasts have double membranes; they have their own DNA; they can self replicate; they contain 70S ribosomes; they are the same size as a typical prokaryotic cell.
- c Mitochondria are the site of aerobic respiration and ATP production; Chloroplasts are the site of photosynthesis
- 7 Multicellular organisms have many different cell types so can become more complex; they can perform more functions; they can have a longer life span.
- 8 a Through the expression of some genes and not others
- b Temperature, nutrient availability, salinity
- c Stem cells

Exercise 5.3

- 1 They do not have cells, have no metabolism and can only replicate inside a host cell.
- 2 Prokaryotic cells are larger than viruses.
- 3 Hand hygiene, face masks, personal protective equipment (PPE), safe injection procedures, washing and sanitising contaminated surfaces.
- 4 DNA or RNA surrounded by a protein coat called a capsid.
- 5 The phage attaches onto the surface of the bacterial cell and injects its genetic material into the cell cytoplasm
- 6 T helper cells
- 7 AIDS (acquired immunodeficiency syndrome)
- 8 A disease that can pass from animals to humans.
- 9 Inhalation of viral particles when an infected person coughs or sneezes; direct contact of viral particles from a contaminated surface.
- 10 a Virus is absorbed into the bacterium; virus uses the host enzymes to replicate inside the cell; assembled viruses burst out of the host cell, killing the host cell in the process.
- b Virus attaches to receptors on the host cell surface; viral envelope fuses with the cell plasma membrane, and viral RNA and enzymes pass into the host cell; host cell produces and assembles new viruses; viruses bud off from the host cell membrane.

Virus	Size	Genetic material	Envelope	Host
Poliovirus	30 nm	Single-stranded RNA	No	Humans are the only natural host
Influenza	90 nm	Single-stranded RNA	Yes	Mammals: each species has its own specific virus
Herpes simplex	150 nm	Double-stranded DNA	Yes	Primarily human cells but can infect a range of different species
HIV	100 nm	Single-stranded RNA	Yes	Humans, other types of immunodeficiency viruses infect other species
Coronavirus	100 nm	Single-stranded RNA	Yes	Humans, bats, rats, cattle and birds
Lambda phage	225 nm tall	Double-stranded DNA	No	<i>E.coli</i> bacteria

- 12** *Chlamydia* sp. evolved from a free-living ancestor that had its own metabolism but can now only reproduce inside a host cell. The regressive hypothesis suggests that viruses were once free-living but developed a symbiotic relationship with their hosts and eventually lost genes for independent life.
- 13** Virus first hypothesis.
- 14** a By recombination of genetic material; through mutation in their DNA or RNA sequences
- b Genetic recombination
- c Genetic mutation and lack of proofreading by RNA polymerase which allows mutation to remain.
- 15** With such a high mutation rate, resistant viruses eventually develop which survive treatment, reproduce and create a resistant population.

Exam-style questions

- 1 C
- 2 B
- 3 D
- 4 C
- 5 C
- 6 C
- 7 C
- 8 D
- 9 B
- 10 A
- 11 C
- 12 D
- 13 A
- 14 B
- 15 C
- 16 B
- 17 A
- 18 A

- 19** Any six from the following:

Elements can create various numbers of covalent bonds, which increases variety of molecules that can be made.

Carbon can have single, double or triple bonds.

The main elements in biological molecules are carbon, hydrogen, oxygen, nitrogen.

Additional elements in some biological molecules are iron, magnesium, phosphorous and sulfur.

Although the main unit of a molecule can be the same, there are variable regions, such as the R group in amino acids (20 different ones), and the variable nucleotide bases (four different ones).

The structures created when joining thousands of slightly different monomers can be hugely different, e.g. the vast number of different polypeptides created with 20 different amino acids.

The bonding between the same molecules can result in varied structures, e.g. the different structures of amylose, amylopectin cellulose and glycogen.

Once molecules are created, the ways in which they fold is entirely dependent upon their constituent monomers, e.g. secondary and tertiary structures in proteins.

Through the incorporation of metal ions, molecules can be given a new functionality, e.g. the Fe^{2+} in hemoglobin, the Mg ion at the centre of every chlorophyll.

- 20** Any six from the following:

Cell structures can identify whether a cell is prokaryotic or eukaryotic:

e.g. prokaryotic cells have 70S ribosomes/a nucleoid/pili;

e.g. eukaryotic cells have 80S ribosomes/nucleus/many membrane bound organelles.

Eukaryotic cells can be classified as animal, plant, fungi or protist.

Animal cells do not have chloroplasts/do not have cell walls.

Fungal cells do not have chloroplasts and have cell walls made from chitin.

Plant cells have chloroplasts, cell walls made of cellulose and large permanent vacuoles.

Protists are single celled organisms that typically have both plant and animal like features.

[6]

- 21 a** Apical meristem
- b** Lignin
- 22** DNA replicates [1]
 separates into two different areas of the cytoplasm [1]
 that then divides into two [1]
 binary fission [1]
- 23 a** A parasite lives on or inside a living host [1]
 Viruses can enter host cells and use their metabolism to replicate. [1]
 e.g HIV fuses with the T cell plasma membrane and enters the cells [1]
- b** A pathogen causes disease. [1]
 Viruses can invade the body and cause damage to its cells. [1]
 e.g. HIV enters and causes the destruction of T lymphocytes. [1]
 e.g HIV infection can lead to AIDS [1]
- c** A vector carries genetic material but is unaffected by it. [1]
- Some viruses, e.g. bacteriophages will infect cells by injecting their genetic material directly into the host cell. Medical research is currently being carried out on using viral vectors to carry and deliver genes to target cells as part of gene therapy [1]
- 24** Both have cell walls; [3]
 Both have nuclei enclosed by an envelope;
 Both have a plasma membrane;
 Both have mitochondria;
 Plants have chloroplasts whilst fungi do not;
 Plant cell walls are made of cellulose whereas fungal cell walls are made of chitin.

Chapter 6

Exercise 6.1

1	Davson and Danielli	Evidence from electron microscopy helped to develop the 'lipo-protein sandwich' model, which showed a phospholipid bilayer between two layers of protein
	Singer and Nicolson	Evidence from fluorescent tagging and freeze fracturing revealed proteins inside the membrane. Their model, the 'fluid mosaic model' included integral proteins throughout the membrane

2 Fluid because the phospholipids can float into position anywhere in the membrane.

Mosaic as the surface is made up of many separate phosphate heads.

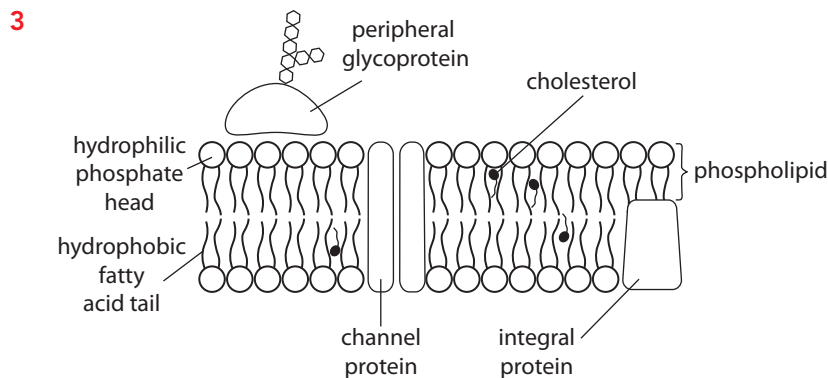


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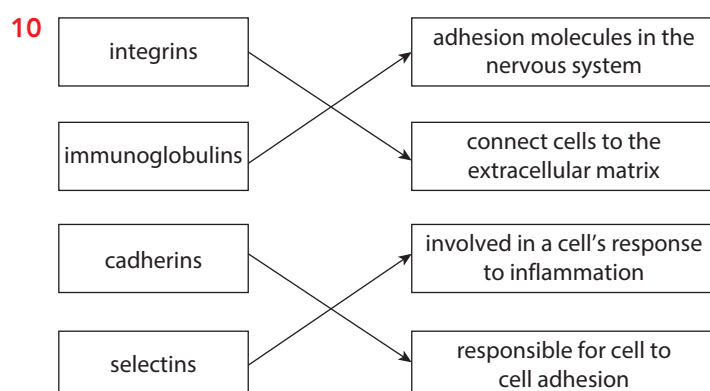
- Integral protein should be within the membrane.
- Peripheral protein should be on the surface of the membrane.
- Cholesterol should be in noticeable spaces between fatty acid tails.

4 Phosphate heads are hydrophilic, so face outwards and associate with water both inside and outside of the cell.

Fatty acid tails are hydrophobic, so face inwards and associate with each other.

5	Clathrin coated vesicles	system of membranes covered in ribosomes	modification of proteins
	Golgi apparatus	rounded organelle containing digestive enzymes	transport of molecules within the cell
	Rough endoplasmic reticulum	small vesicles coated with protein	breaks down worn out organelles and destroys pathogens
	Lysosomes	series of flattened membranes	synthesis and storage of proteins

- 6 a Both
b Chloroplast
c Neither
d Both
e Both
f Mitochondria
g Mitochondria
h Neither
- 7 Ribosomes present in the cytoplasm make proteins which typically remain within the cell whereas ribosomes located on the RER are typically for secretion.
- 8 a Separation allows for the mRNA transcript produced within the nucleus to be modified (intron removal) before being accessed by ribosomes in the cytoplasm for translation.
b Within compartments, enzymes and substrates can be concentrated, increasing the likelihood of successful collisions and overall reaction rate.
c Lysosomes contain digestive enzymes, which if released into the cell could damage the cell contents.
- 9 a Saturated fatty acids do not have any C=C bonds whereas unsaturated fatty acids have one or more C=C bond.
b The double bonds (C=C) within an unsaturated fatty acids chain create bends/kinks in the molecule
c Saturated fatty acids have a higher melting point. They are straighter chains which allow for tighter packing. This creates a more rigid and therefore less fluid structure.

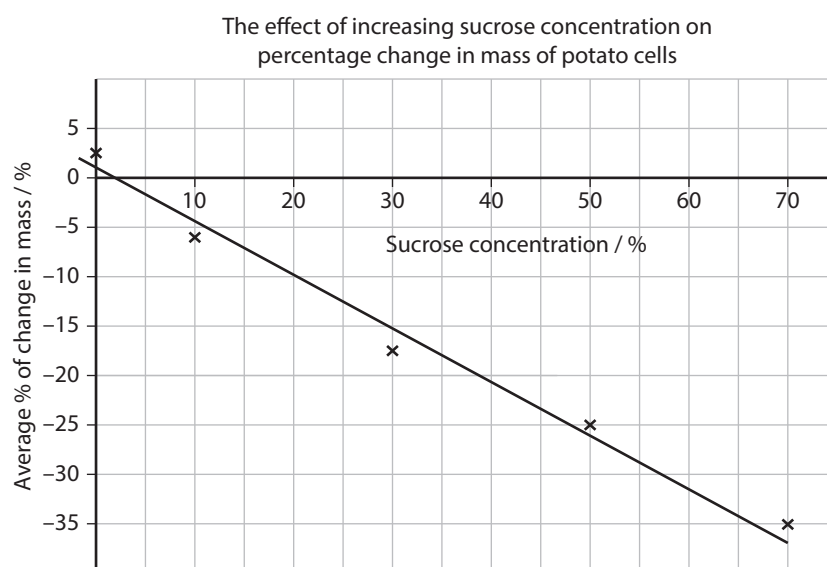


Exercise 6.2

1

Feature of transport	Simple diffusion	Facilitated diffusion	Osmosis	Active transport
a Molecules move down their concentration gradient	✓	✓	✓	✗
b Energy is required	✗	✗	✗	✓
c Transport of large or charged molecules	✗	✓	✗	✗
d Involves the movement of water molecules	✗	✗	✓	✗
e Requires a membrane protein	✗	✓	✗	✓

- 2 a Simple diffusion
b Osmosis
c Active transport
d Facilitated diffusion
e Active transport
f Active transport
g Active transport
h Osmosis
i Facilitated diffusion
- 3 Graph A shows active transport as there is continual movement of molecules into the cell as it is continually pumped across the membrane.
Graph B shows simple diffusion as once there is an equal concentration on either side of the membrane, there will be no further increase in net movement into the cell.
- 4 a 10%, 30%, 50%, 70%
b 0%
c Graph should include: Descriptive title, *y*-axis heading, *x*-axis heading, points plotted correctly, straight line of best fit.



- d Allow between 1 and 5%, but will correlate to the *x*-axis intercept point value.
- e i When put into a hypotonic solution, there was a greater concentration of water molecules in the potato than in the solution. Potato cells absorbed water by osmosis, causing the cells increase in mass.
ii When put into a hypertonic solution, there was a greater concentration of sugar in the solution than in the potato. Potato cells lost water by osmosis, causing the cells decrease in mass.
iii In an isotonic solution, there was the same concentration of sucrose in the solution as in the potato. Water would move into and out of the potato cells, but there would be no net direction of movement. The potato chip would not change in mass.
- 5 Similarities: Both are types of endocytosis
Differences: Phagocytosis is the intake of entire cells whereas pinocytosis is the intake of tiny droplets of liquid.

Exercise 6.3

- 1 **a** Similarity: Both take up water by osmosis.
Differences: animal cells are likely to burst due to not having a cell wall whereas plant cells swell and become turgid.
- 2 **a** A solution that contains a greater concentration of solute. The sucrose solution is hypertonic to the leaf cells.
b A solution that contains a lesser concentration of solute. The leaf cells are hypotonic to the carrot cells.
c A solution that is the same concentration as the cells put into it. The carrot cells and sucrose solution are isotonic.
- 3 **a** Pure water has a water potential value of zero. The cell's water potential must be lower than zero, so have a negative value.
b The water potential value becomes more negative
c In setup A, arrow should show water will move into the cell from the surroundings. In setup B, arrow should show water will move into the cell from the surrounding solution.
In setup C, arrow should show water will move out of the cell into the solution.
d Setup C
e Water will move into a cell by osmosis if its water potential in the cell is more negative than that of the surroundings

Exercise 6.4

- 1 As cells grow, both their surface area and volume (increase), but not at the same rate. The volume grows at a (faster) rate than the surface area. Therefore, as a cell becomes larger its surface area to volume ratio (decreases). This means that there will become a point at which the surface area is insufficient for the volume. The demands of (oxygen) supply will no longer be met, or removal of waste products becomes inefficient, leading to a toxic level within the cell. To prevent this from happening, a cell will increase its surface area to volume ratio by (dividing). This is why cells do not become very large.
- 2

epithelial cells of the small intestine	very long length but extremely narrow
neuron	biconcave disc shape
red blood cell	long thin protrusion
root hair cell	millions of microvilli
- 3 Mitogens cause the cell to divide, which increases the surface area to volume ratio.

Exercise 6.5

- 1 **a** G1 as it occurs before S (which is when the DNA is replicated)
b Doubles
c Organelles are replicated, which take up space.
- 2 **a** Cyclin D
b Cyclin B

- c** Only when cyclin levels peak (E, A and B) can there be progression to the next stage of the cell cycle.

After initiating progression, cyclins are quickly broken down.

Different cyclins control progression into S, G₂ and mitosis.

- 3 a** A = anaphase, B = prophase,
C = telophase, D = metaphase,
E = cytokinesis, F = Interphase

- b** F B D A C E

- 4 a** Anaphase

- b** Nucleosome

- c** Mitotic index = $14/45 = 0.31$

- 5 a i** Anaphase 1

- ii** Metaphase 1

- iii** Prophase 1

- iv** Telophase 1

- v** Prophase 1

- vi** Anaphase 2

- vii** Telophase 2

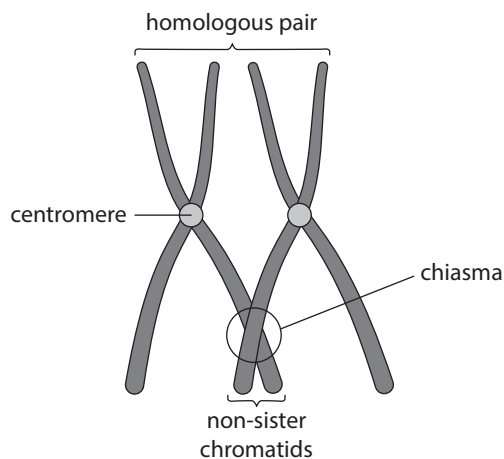
- b i** Meiosis 1

- ii** Independent assortment occurs.

- iii** To make haploid gametes, and to make genetically different cells.

- iv** Ends of non-sister chromatids are exchanged.

- v**



- vi** Law of independent assortment

- 6 a** Trisomy

- b** Down syndrome

- c** Heart defects, vision problems, hearing loss, greater chance of infections.

- 7 a** Diploid cells have chromosomes that can be paired whereas haploid cells have chromosomes that cannot be paired.

- b** The cell cycle includes interphase, mitosis and cytokinesis whereas mitosis is the division of the nucleus.

8	Feature	Mitosis	Meiosis
	Does interphase occur at the start?	Yes	Yes
	Which cells can undergo the process?	Somatic body cells	Ovary and testis cells
	What type of cells are produced?	Diploid body cells	Haploid gametes
	Number of divisions	1	2
	Does independent assortment occur?	No	Yes
	Does crossing over occur?	No	Yes
	Number of daughter cells produced	2	4
	Ploidy of daughter cells	2n	n
	Are daughter cells genetically identical?	Yes	No

- 9 a The law of segregation: individuals possess two alleles for each gene and a parent passes one of each pair to their offspring.

The law of independent assortment: alleles of different genes are sorted into gametes independently of one another.

b Anaphase 1

c Metaphase 1

- 10 a Mitotic index = Number of cells undergoing PMAT / Total number of cells

b $68 / 150 = 0.45$

c A higher than normal rate of cellular division could be an indicator of cancer.

Exam-style questions

1 C

2 C

3 D

4 A

5 B

6 A

7 C

8 B

9 A

10 D

11 A

12 C

13 C

14 A

15 B

16 A

17 C

18 A

19 B

20 B

21 D

22 C

23 A

24 B

25 A

26 A

27 B

28 C

29 D

30 B

31 B

32 The phosphate heads are hydrophilic;

The heads face outwards and associate with water;

The fatty acid tails are hydrophobic;

The tails face inwards and associate with one another;

A bilayer structure is formed.

[1]

[1]

[3]

33 [1] for each of the following [maximum of 8 marks]:

Chromosomes supercoil; (in prophase)

Chromosome line at the equator; (in metaphase)

Sister chromatids are separated; (in anaphase)

Chromosomes decondense; (in telophase)

34 a Amniocentesis and chorionic villus sampling

b The failure of homologous pairs to separate during anaphase 1, or failure of sister chromatids to separate at anaphase 2.

35 [1] mark per row [maximum 3 marks].

Facilitated diffusion	Active transport
Transports substances down their concentration gradient	Transports substances against their concentration gradient
Does not require ATP	Does require ATP
Both require a membrane protein	

36 I = 70S ribosome

II = Matrix

III = Intermembrane space

37 [1] mark per row [maximum 4 marks].

Endocytosis	Exocytosis
Transports substances into the cell	Transports substances out of the cell
Cell membrane decreases in size	Cell membrane increases in size
Vesicles move away from the membrane	Vesicles move toward the membrane
Vesicles pinch off the membrane	Vesicles fuse with the membrane
Both involve active transport/require ATP	
Both involve bulk transport	

38 The sodium potassium pump is a protein found in the membranes of nerve cells;

Sodium ions are pumped out of the neurone and potassium ions are pumped into the neurone;

3 sodiums pumped out for every 2 potassium pumped in;

Requires ATP energy;

Maintains the resting membrane potential.

39 There is higher water potential in the cell than in the surrounding solution;

Water will move out of the cell;

by osmosis;

The cell will become crenated.

40 In both, DNA supercoils;

In both, the nuclear membrane breaks down;

Crossing over occurs during meiosis I but not in mitosis;

Homologous chromosomes pair up in meiosis I but not in mitosis.

41 a 0.1% (± 0.02)

b [1] Similarity: Both trends increase with increasing age of the mother; Similarity: Both trends follow the same pattern/shape.

[1] Difference: The risk of having a child with trisomy 18 is always higher than the risk of having a child with trisomy 13.

c [2] marks for an argument for or against the statement.

Agree: As maternal age increases, risk for all three lines increases.

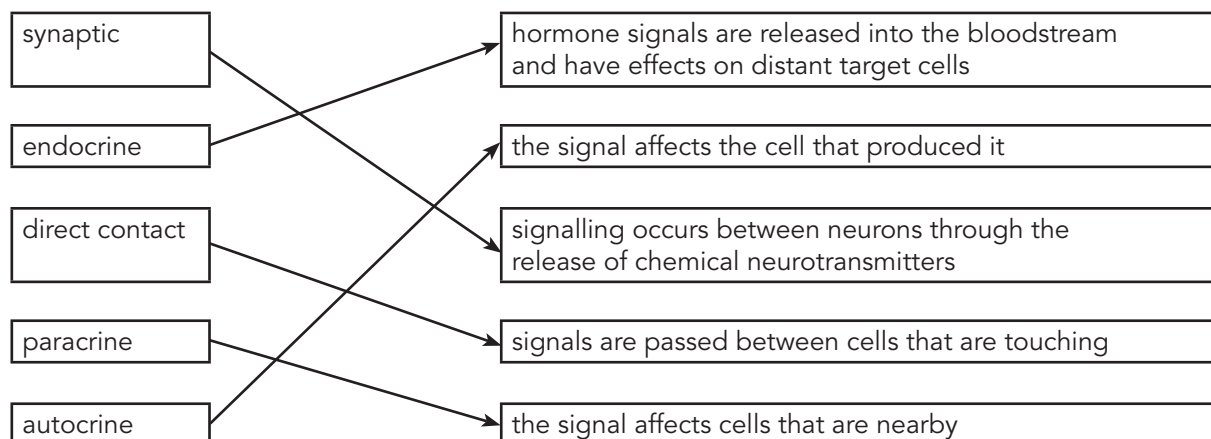
Disagree: Only three abnormalities are shown.

Disagree: No idea how many mothers and their babies were surveyed.

Disagree: Other factors could be influencing the increase.

Chapter 7

Exercise 7.1



Example	Type of signalling
Insulin is produced by cells of the pancreas. It is released into the bloodstream and binds to the receptors on liver and muscle cells	Endocrine
When an action potential reaches the end of a neuron, the signal is converted from electrical to chemical through the release of neurotransmitter into the cleft. It diffuses across the cleft and binds to receptors on the membrane of the next neuron	Synaptic
Testosterone produced by Leydig cells of the testes cause nearby cells to increase sperm production	Paracrine
During the production of an immune response, Helper T cells attach to the receptors on the surface of B cells. A signal is then sent from the T cell that activates the B cell	Direct contact
During the inflammatory response, Macrophages produce a molecule called interleukin-1. Macrophages also have IL-1 receptors on their surface, so are signalled by the molecules that they themselves produce	Autocrine
During embryonic development, cells can instruct nearby cells what cell type to differentiate into	Paracrine
Plasmodesmata are microscopic channels between adjacent plant cells. They allow signal molecules to pass between neighbours	Direct contact

- 3 a hormone
 b neurotransmitter
 c cytokine
 d ions
- 4 a A type of cell signalling used by bacteria is *quorum sensing*. It allows bacteria to be aware of the density of their *population*. When they are in sufficiently *high* numbers, the bacteria alter their *gene expression* as a group, in order to produce an effect that will *increase* their chance of survival.
- b If sufficient numbers of bacteria bioluminesce, they may be able to make enough light to attract fish to eat them. The bacteria would then have access to the nutrient rich digestive tract of the fish.

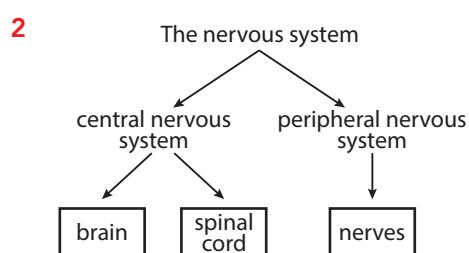
- c** Some human pathogens form biofilms in order to resist the body's immune system.
Some bacteria which form plaque on teeth create a biofilm which is difficult to remove from the tooth surface.

- 5 a** Negative feedback
b Positive feedback
c Negative feedback
d Positive feedback

Exercise 7.2

1

Type of neuron	Cell body	Carries signals from	Carries signals to
Sensory	Positioned at the centre of the neuron	Receptors	Central nervous system
Relay	Makes up the majority of the neuron	Sensory neuron	Motor neuron
Motor	Located at one end of the neuron	Central nervous system	Effector



- 3 a** Reflexes are faster and so they reduce the amount of damage to the body by acting more quickly.
b Answer:
i Unconscious
ii Unconscious
iii Conscious
iv Conscious
v Unconscious
vi Unconscious
vii Unconscious

4

6	Once the signal is sent, excess neurotransmitter (such as acetylcholine) is broken down to prevent continued signalling
5	Sodium ions enter the post-synaptic neuron, creating an action potential
3	Vesicles of neurotransmitter move towards and fuse with the presynaptic membrane
4	Neurotransmitter diffuses across the gap and binds to receptors on the post-synaptic membrane
2	An action potential reaches the presynaptic membrane

- 5 a The resting potential, when no signal is occurring. The sodium–potassium pump pumps three sodium ions (Na^+) out of the membrane for every 2 potassium ions (K^+) in. Creates a potential difference across the membrane of -70 mV .
- b Sodium channels shut and potassium channels open.
- c Hyperpolarisation, it ensures a signal passes along the neuron in one direction.
- d Depolarisation. Sodium gated channels are open, so sodium ions diffuse into the axon, increasing the membrane potential.
- e Repolarisation. Potassium gated channels are open, so potassium diffuses out of the membrane, decreasing the membrane potential.
- 6 An action potential is the **reversal** and restoration of the potential **difference** across the membrane of a **neuron** that is conducting a signal.
- 7 a Between sensory neuron and relay neuron/ between relay neuron and motor neuron.
- b Presynaptic neuron must be depolarised by an action potential, migration and fusion of presynaptic vesicles with the membrane.
- c Sends a chemical signal across a synapse.
- d Choline and an acetyl group
- e Acetylcholinesterase
- 8 a This would not be effective as it would mimic serotonin, increase binding to the post-synaptic receptors, and increase signalling.
- b This would be effective as serotonin could no longer bind, reducing signalling.
- c This would be effective as it would reduce the amount of serotonin in the synapse, and reduce receptor binding.
- d This would not be effective as sodium entry would cause signal transmission.
- e This would be effective as serotonin would not be released into the synaptic cleft.
- f This would be effective as it would decrease the membrane potential, making it harder to start a signal in the second neuron.
- 9 a Nicotine, cocaine, amphetamines
- b Benzodiazepines, alcohol and tetrahydrocannabinol
- c Dopamine signalling in the brain causes feelings of increased energy, confidence and wellbeing/euphoria.
- d Cocaine acts upon dopamine synapses, blocking dopamine uptake transporters that results in dopamine remaining in the synapse. The post-synaptic neuron becomes continuously excited/ continual signalling, resulting in a feeling of euphoria.
- e Depression/paranoia
- 10 a Neonicotinoid pesticides have been linked to a decline in bee population/kill bees.
- b Reducing the number of bees could reduce pollination of crops, thereby affecting harvests and human food supplies. Any other valid suggestion.
- 11 a Saltatory conduction
- b Nodes of Ranvier
- c Schwann cell
- d Myelin
- e Increases the speed
- 12 a Skin surface / base of hair follicles
- b Pinching / cutting / heat / chemicals
- c Protein channels open and positively charged ions enter the nerve ending. This depolarises the nerve ending and creates an action potential.

Exercise 7.3

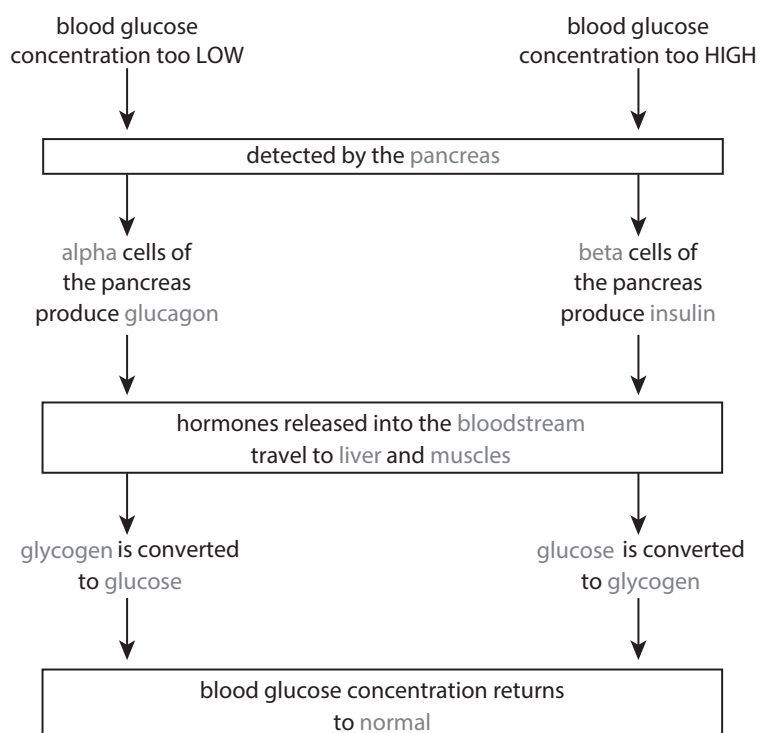
- 1 a A chemical messenger produced by an endocrine gland that is released into the bloodstream and affects distant target cells throughout the body.
- b Receptors are found on the surface of cells as peptide hormones are hydrophilic/lipophobic.
- c Tyrosine derivative, steroid hormone

- d** When the level of a substance exceeds narrow limits, corrective mechanisms act to return the value back within those limits. An example would be when blood sugar levels rise above a normal level, insulin acts so that blood sugar levels are lowered/vice versa.
- e** They would have leaner muscle and move faster than their competitors who would have to rely on natural ability alone.
- f**
- i** Epinephrine/adrenaline
 - ii** Glucagon
 - iii** Antidiuretic hormone (ADH)
 - iv** Testosterone
- g** Testosterone

2

Type of signalling	Statement/Description
Hormonal	Can have widespread effects throughout the body
Nervous	Rapid signalling
Hormonal	Long duration of effect
Nervous	Transported along neurons as a wave of depolarisation
Hormonal	Chemical signals
Nervous	Involves the movement of sodium and potassium ions across membranes

3



- 4 a** High blood glucose levels/glucose present in urine/frequent urination/tiredness or fatigue/weight loss
- b** Kidney disease/retinal damage/high blood pressure/stroke or heart attack
- 5 a** Auxins cause elongation of plant cells.
- b** In the apex of the shoot, in the embryos of seeds, in apical meristems.

- c** It is possible for auxins to activate or inhibit genes in order to promote a rapid response, or to inhibit a response.
- d** They dissolve and are moved through the phloem to where they need to be.
- 6 a** The growth of a plant towards light.
- b** Positive phototropism and negative geotropism.
- c** Phototropin receptors on the light side of a shoot are phosphorylated. Auxins become more concentrated on the shaded side of the shoot. It causes cells on that side to grow longer, causing the stem to bend.
- d** So that roots grow downwards into the soil, enabling the roots to collect minerals and water that are needed for growth.
- 7** When a ligand binds to a G protein coupled receptor, a conformational change in the *G* protein results in the activation of the *enzyme* adenylyl cyclase. Adenylyl cyclase converts ATP to cyclic AMP (cAMP). cAMP acts as a *secondary* messenger inside the cell which leads to an alteration in gene expression.
- When a *ligand* binds to a tyrosine kinase receptor, the tyrosine residues are *phosphorylated*. This triggers a phosphorylation cascade inside the cell which can result in the *activation* of enzymes or transcription factors.
- 8 a** abscisic acid
- b** ethylene
- c** auxin
- d** cytokinin
- 9 a** Structure B
- b** Structure A
- c** Structure C
- d** The second messenger creates a transcription factor. The transcription factor binds to DNA and causes the transcription (D) of the gene coding for the particular enzyme.
- e** A peptide as it cannot pass through the plasma membrane and must bind to receptors on the cell surface membrane, e.g. adrenalin / insulin

- 10** The hormone represented is a steroid hormone.
E.g. progesterone / testosterone / estradiol
- The hormone is able to pass through the plasma membrane so must be lipid based (like a steroid). Protein hormones bind to the surface of a cell.
- 11** Image D is correct as auxin has accumulated on the shaded side of the shoot, causing cells to elongate on that side. This results in the shoot bending towards the light.

Exam-style questions

- 1** C
- 2** A
- 3** A
- 4** A
- 5** D
- 6** B
- 7** C
- 8** A
- 9** B
- 10** B
- 11** B
- 12** A
- 13** B
- 14** B
- 15** D
- 16** D
- 17** D
- 18** B
- 19** D
- 20** A
- 21** C
- 22** C
- 23** A
- 24** B
- 25** A
- 26** D

- 27 A**
- 28 B**
- 29 A**
- 30** Similar structure to nicotine.
Nicotinoids bind to ACh receptors and block them.
Muscle contraction can no longer occur/paralysis in insects.
- 31** Award 1 mark for any similarity between both geotropism and phototropism, and 1 mark for each difference [maximum 3 marks].
Similarities: Both are growth responses in plants.
Both are created by the plant growth regulator, auxin.
Differences: Geotropism is in response to gravity whereas phototropism is in response to light.
Roots show positive geotropism whereas they show negative phototropism.
Shoots show positive phototropism whereas they show negative geotropism.
- 32 a** Chemical messenger [1]
secreted by glands or cells [1]
into the blood [1]
- b** Named hormone [1]
with a description of how that hormone affects the body [1]
e.g. insulin being released from the pancreas, for conversion and absorption of glucose.
- c** Any [6] from:
Alpha cells produce glucagon [1]
glucagon promotes conversion of glycogen to glucose [1]
which raises blood sugar levels [1]
when blood sugar levels are too low [1]
Beta cells in the pancreas produce insulin [1]
which promotes glucose storage and absorption [1]
- when blood glucose levels are too high [1]
to lower the blood sugar level [1]
- 33 a** For each [1]
the two types must be compared, not simply described.
- | Type I | Type II |
|---|--|
| Usually develops in young people/children | Onset during adulthood |
| Not able to produce insulin in the body | Cannot respond to insulin |
| Requires daily injections | Controlled by change in diet and lifestyle |
| Target cells sensitive to insulin | Target cells not responsive to insulin |
| Caused by genetics | Caused by lifestyle |
- b** Student may agree because: poor diet [1]
lack of exercise [1]
has been linked to the onset of type II diabetes.
Disagreement because: not everyone with a bad diet gets diabetes [1]
some people might be genetically predisposed [1]
Accept any other reasoned argument for [1] mark.
- 34** Animal hormones are produced by endocrine glands whereas plant growth regulators are produced by most plant cells.
Animal hormones may target cells far from the site of production whereas plant growth regulators target nearby cells.
There are two main types of animal hormone whereas there are five main types of plant growth regulator.
Animal hormones are transported in the bloodstream whereas plant growth regulators are transported in the phloem/diffuse to nearby cells.

Chapter 8

Exercise 8.1

1 cell

single, most basic unit of which organisms consist

a skin cell, a mucosal cell, a ciliated cell

tissue

a group of similar cells working together to perform a particular function

muscle, mucosa, tendon

organ

a group of different tissues working

the heart, the liver, the lungs

organ system

a group of different organs working together to perform one or more functions

circulatory, respiratory, digestive, nervous

- 2 Stem cells are *undifferentiated* and retain the capacity to divide. Once they express a particular set of *genes*, they will change into a particular cell type, and therefore have a particular function (they become *specialised*). Once differentiated, the process *cannot* be reversed.

Stem cells are located in various tissues, where they can be used to proliferate and continually replace themselves, or to differentiate into certain cell types. Their ability to differentiate into a variety of cell types (their *potency*) varies:

- The only true totipotent cells (which can differentiate into any cell type) is a zygote.
- Embryonic stem cells are pluripotent, meaning they can differentiate into most cell types of the body. Embryonic stem cells can be removed from a blastocyst. A use of embryonic stem cells is in the treatment of Stargardt's disease.

Adult stem cells found in bone marrow and hair follicles are multipotent meaning they can differentiate into a small set of related cells. Those from bone marrow can produce various types of blood cell and so are used in the treatment of leukemia. Stem cells from hair follicles can generate all cell types of the skin.

Exercise 8.2

- 1 Unicellular organisms do not require a *circulatory* system as they can rely on *diffusion* to provide sufficient *oxygen* and nutrients, and to remove waste products efficiently. Diffusion alone is not sufficient to provide for all cells in a *multicellular* organism, and so they need a circulatory system to bring nutrient-filled *blood* within close proximity to every cell in the body.

2 a i C

ii A

iii V

iv C

v V

vi C

vii A

- b Arteries subdivide into smaller arterioles, which then branch into capillary networks.

Capillaries join to form larger venules, which then join up to form veins.

- c Three from:

The thicker outer layer (collagen and elastic fibres) prevents tearing under high pressure.

Having a smaller lumen creates higher blood pressure.

Having thicker elastic layers allows the artery to stretch as the heart beats, and recoil back to its original size in order to maintain the pressure.

The inner lining of epithelial cells reduces friction.

3 a

Blood component	Primary role(s)
Red blood cell/ erythrocyte	Transport of oxygen
White blood cell/ leukocyte	Defence against disease/ immunity
Platelet/ thrombocyte	Blood clotting
Plasma	Transport of substances/ energy (nutrients, CO ₂ , heat, hormones)

b Provides more space for the hemoglobin, so can carry more oxygen.

c To prevent infection by pathogens; to minimise blood loss.

d Hemoglobin

e Lymphocytes: production of antibodies
Phagocytes: engulf and digest microbes

f Reduced diffusion distance/flexible to squeeze along capillaries/larger surface area to volume ratio.

4 a Various methods exist to provide organisms with the materials they require, and to remove metabolic *waste*. Unlike our *double* circulatory system, fish have a *single* circulatory system. Organisms like arthropods have an *open* circulatory system with no blood vessels, and simple organisms like *sponges* and *hydra* do not require a circulatory system at all.

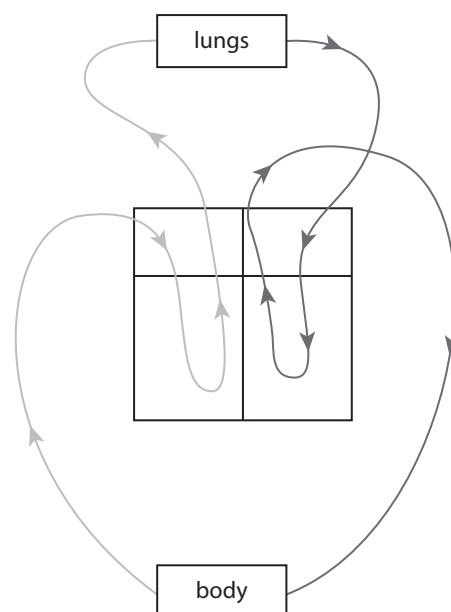
b A = capillaries, B = artery, E = vein

c B would have more oxygen than E; E would contain more carbon dioxide than B.

d Oxygen, glucose, nutrients

e Carbon dioxide, urea

f



g Within one full circuit, the blood passes through the heart twice.

h Pulmonary system sends deoxygenated blood to the lungs, and oxygenated blood from the lungs to the heart.

The systemic circulation sends oxygenated blood away from the heart (to the rest of the body), and deoxygenated blood from cells in the body back to the heart.

5 a A = right and left atria

B = right and left ventricles

C = pulmonary artery

D = aorta

E = vena cava

F = septum

G = atrio-ventricular valves

- b** 1 Sinoatrial node produces electrical signal across the walls of the atria.
- 2 Atrial systole occurs.
- 3 The signal is passed to the AV node. It then travels down the septum and around the ventricles via Purkinje fibres.
- 4 Ventricular systole occurs.
- c** Atrioventricular node. Septum
- d** Contraction
- e** Sinoatrial node. Right atrium
- f** Medulla oblongata
- g** Epinephrine/adrenaline

6 a Heart attack

b Number of beats per minute. Normal range in an adult is 60–100.

c

Factor	Consideration	Increase OR decrease heart rate?
Increased age	Heart muscles struggle to pump as well in older people	Decrease
Increased body size	Larger area needs to be covered	Increase
Increased Temperature	Vasodilation occurs	Decrease
Increased potassium ions	Potassium ions can decrease action potentials	Decrease
Increased eating	Blood required to be pumped to the stomach	Increase
Drugs (caffeine/nicotine)	Caffeine and nicotine are stimulants	Increase
Drugs (alcohol, barbiturates)	Alcohol and barbiturates are depressants	Decrease

7 a Sphygmomanometer

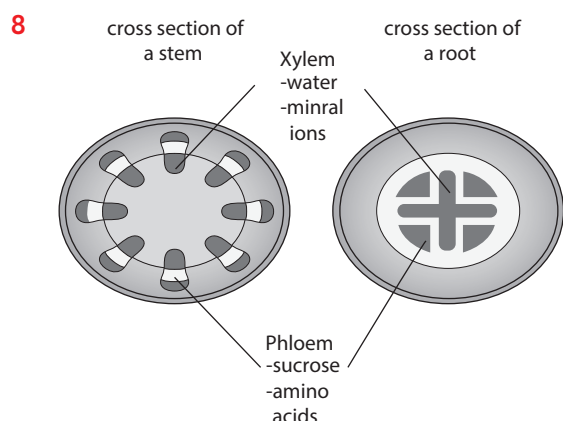
b Systolic: the pressure put upon the arteries as the heart contracts.

c Diastolic: the pressure put upon the arteries when heart muscles are relaxed.

d Patient A

e Patient C (51 bpm)

f Repeat a number of times and determine an average value (or identify and discount significant outliers).



9 a Lignin

b Cohesion is due to hydrogen bonding between water molecules, whereas adhesion is due to hydrogen bonding that occurs between water molecules and molecules in the walls of the xylem.

c As water is lost from the leaves, more water is pulled up the stem as the molecules are bonded together (by hydrogen bonding) As a result, root cells lose water and become hypertonic to the water in the soil More water is drawn into the roots (by osmosis) from the soil to replace that lost.

d i Osmosis

ii Capillary action

iii Evaporation

iv Diffusion

10 a As the humidity increases, the rate of transpiration decreases.

b There is more water in the air when it is more humid, so therefore the diffusion gradient is less, causing less water to move out of the leaf.

c Increasing light intensity increases the rate of transpiration.

Increasing temperature increases the rate of transpiration.

Increasing wind speed increases the rate of transpiration.

11 a i Mass flow: Dissolved ions move into the plant, as it absorbs water

ii Facilitated diffusion: ions from the soil water are transported into root hairs, down their concentration gradient with the aid of membrane proteins

iii Active transport: Where the concentration of a mineral is lower in the soil water than in plant cells, active transport is needed to take it up. Root hair cells contain mitochondria to provide ATP required to pump ions across the membrane.

b. Calcium is needed for cell wall formation
Magnesium is needed for the production of chlorophyll

Iron is required as a co-factor for numerous enzymes

12

Label	Identity, with 2 reasons
A	Xylem: it is a continuous tube with no cross divisions, the direction of movement is upwards
B	Cambium: it is positioned between two different types of vessel in a stem, it is not transport vessel tissue
C	Phloem: it contains cells with sieve plates, the direction of movement is both up and down, there are companion cells to provide energy and nutrients

13

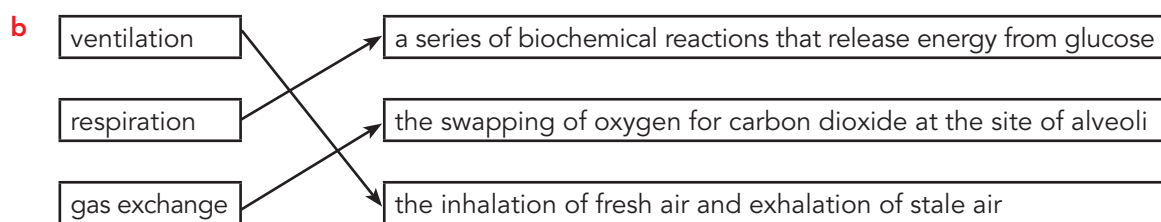
Attribute	Xylem	Phloem
Composed of living or dead cells?	Dead	Living
2 materials transported	Water / mineral ions / hormones	Sucrose / amino acids
Direction of transport	Upwards	Upwards and downwards
What moves substances along	Transpiration stream	Hydrostatic pressure

Exercise 8.3

- 1
 - a A large surface area to provide maximum area for exchange
 - b A steep concentration gradient so substances will diffuse to where they are required
 - c Moist as most substances diffuse faster when they are dissolved
 - d A short diffusion distance is created by being thin
- 2
 - a Higher glucose concentration / nutrients in intestines than blood
 - b Higher oxygen concentration in alveoli than bloodstream; higher carbon dioxide in blood than alveoli

3

Feature	How rate of gas exchange is maximised
Surface area	Huge surface area to increase rate of diffusion
Wall of alveoli	Very thin; short diffusion distance, one cell in thickness
Blood supply	Capillaries surround each alveolus to maintain concentration gradients of oxygen and carbon dioxide
Moisture lining	Moisture allows gases to dissolve, which increases diffusion rate



- c trachea → bronchus → bronchiole → alveolus
- 4
 - a The aim is to reduce the number of people who die from smoking related illness.
 - b Approximately 4000
 - c Any three from:
 Increase taxation on tobacco products.
 Media campaigns to warn people of the consequences of long-term usage.
 Ban advertising of tobacco products on TV.
 Ban smoking in public places.
 - d Less oxygen would be able to bind to hemoglobin; less oxygen will be transported around the body/to cells; amount of respiration the body can do is reduced; less energy is available so people get tired/fatigued more quickly.
 - e
 - i Two from: asbestos, passive smoking, air pollution
 - ii Carcinogen
- 5
 - a Reduces surface area and, therefore, reduces rate of diffusion of gases in the lungs; causing less oxygen to be taken in and less carbon dioxide being removed from the body.
 - b Shortness of breath, fatigue, gasping
 - c
 - i Ribcage moves upwards. and outwards
 - ii Diaphragm contracts and flattens

- iii Volume of the thorax increases
- iv Air pressure decreases
- v Air rushes into the lungs
- d Inspired air has a higher percentage of oxygen than expired air.
Inspired air has a lower percentage of carbon dioxide than expired air.
Both inspired and expired air have the same amount of nitrogen.

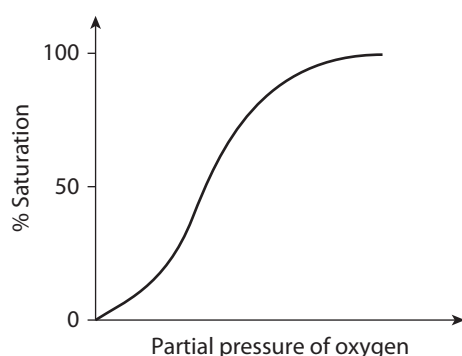
6 a Quaternary

b 4

c 4

d Iron

e



- 7 a The oxygen dissociation curve shifts to the right as CO_2 increases.
- b High carbon dioxide concentration will occur in respiring tissues. Respiring tissues require oxygen, so need more oxygen to be released into the tissues.
- c i Vigorous exercise produces *carbon dioxide*.
ii CO_2 dissolves in blood to produce *carbonic acid*.
iii pH of the blood *decreases*.
iv Chemoreceptors in the *aorta* and carotid arteries detect the change in pH.
v Signals are sent from the *medulla oblongata* in the brain to the diaphragm and intercostal muscles of the respiratory system.
vi Breathing rate *increases*.
- d Spirometer.
- e Increased heart rate allows oxygen to be transported more quickly around the body Increased ventilation rate increases the amount of oxygen that can diffuse into the blood Increased number of erythrocytes means more oxygen can be carried in circulation.
- f Fetal hemoglobin has a higher affinity for oxygen than maternal hemoglobin, allowing the fetus to constantly gain oxygen from maternal blood.

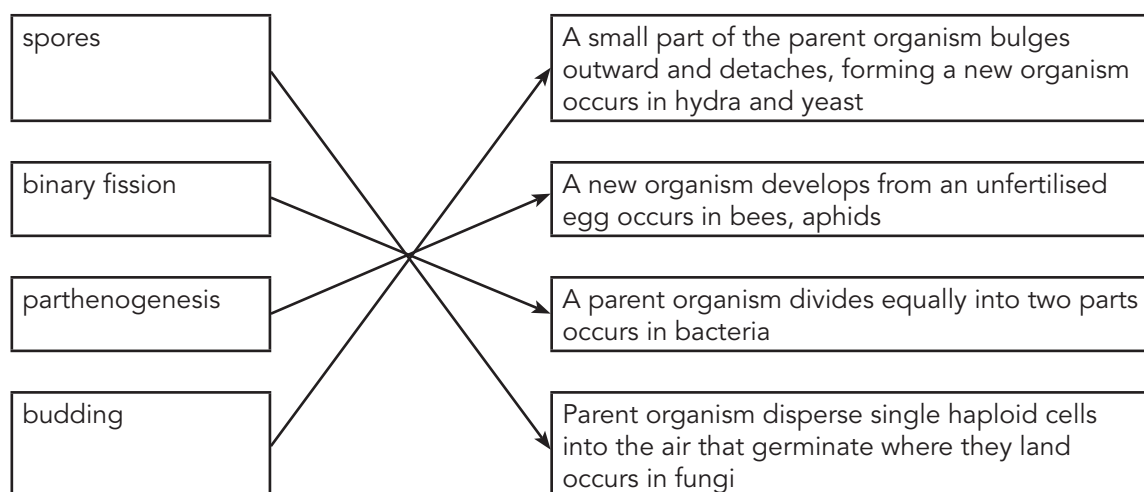
8 a

Description	Structure(s) of a leaf
Provides a waterproof surface	Waxy cuticle
Is the site of gas exchange	Spongy mesophyll
Is a transparent layer of cells	Upper epidermis
Contains chloroplasts	Guard cells, palisade mesophyll, spongy mesophyll
Layer of cells that contains the most guard cells	Lower epidermis
Is the main site of photosynthesis	Palisade mesophyll
Transports water and minerals	Xylem
Transports glucose, hormones and amino acids	Phloem

- b** Long, large surface area, short diffusion distance, thin walls
- c i** Stomata
- ii** Potassium ions are pumped into guard cells. Water follows by osmosis. The guard cells swell and become turgid. Because the walls between guard cells are reinforced, an opening is created between them.
- d** Hot temperature, windy, low humidity, high light intensity

Exercise 8.4

1



- 2 a A ovary
B uterus
C cervix
D vagina
E oviduct/fallopian tube

b

Structure	Function
Uterus	Where the fetus grows and develops
Ovary	Produces haploid gametes (oocytes)
Vagina	Tube into which the penis deposits semen
Fallopian Tube/ Oviduct	Transports the egg from ovary to uterus
Cervix	Narrow opening to the uterus

- c A sperm duct
B urethra
C testis
D scrotum
E penis

d

Structure	Function
Penis	Deposits semen into the vagina
Sperm duct	Tube that carries sperm from testis to penis
Scrotum	Holds the testes outside the main body cavity
Bladder	Stores urine
Urethra	Tube through which urine or semen can exit the body
Testis	Produces haploid gametes (sperm)

- 3 a Oviduct/fallopian tube
b i Acrosome releases its content of enzymes, which digest through the outer layers of follicle cells surrounding the egg, to let the sperm through.

- ii Cortical granules are released from the egg by exocytosis and this digests sperm cell receptor proteins so that no further sperm can bind. Prevents polyspermy (entry of multiple sperm into one egg.) Zona pellucida hardens to prevent further sperm entry.

- c The nuclei of the two haploid gametes (sperm cell and egg cell) fuse to form a zygote, which then divides by mitosis into a blastocyst. The uterus blastocyst implants into the lining of the uterus where it continues to divide into an embryo.

- 4 a Three from: Woman may have blocked fallopian tubes; man may not produce enough sperm; men with erectile dysfunction; same sex couple; any other valid reason.

b

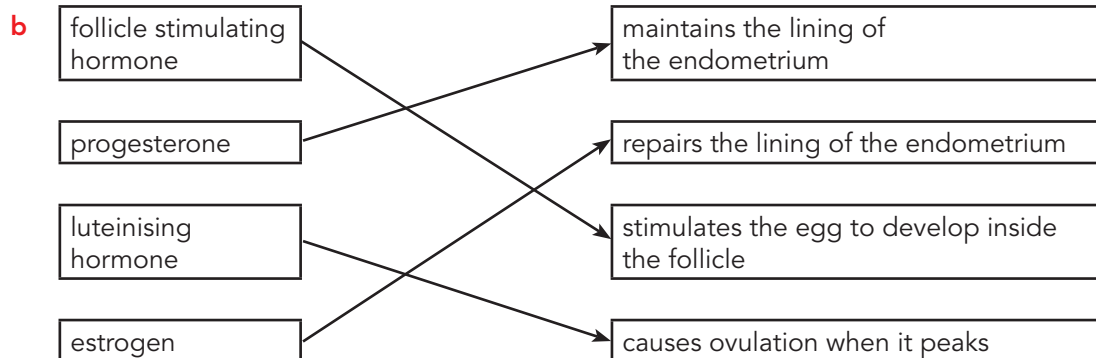
Pros	Cons
allows infertile couples to have children	some embryos are destroyed
embryos can be screened for genetic diseases	IVF can be dangerous to mothers if it results in multiple births
any unused embryos can be used for stem cell research	IVF is against some religious beliefs/unnatural
	gives false hope to potential parents as not always successful
	selects for the wealthy as it is an expensive treatment

Accept any other valid argument for or against.

- c i FSH
ii harvested / removed
iii fertilization
iv blastocyst / embryo
v uterus
vi pregnancy

5 a

1	Menstruation
2	FSH increases
3	Estrogen increases to a peak
4	LH surge occurs on day 14
5	Ovulation occurs
6	Formation of the corpus luteum
7	Progesterone levels increase
8	The corpus luteum breaks down
9	Progesterone levels fall



c Inhibition

d It prevents any more eggs from maturing and ovulating during pregnancy, in order to prevent additional pregnancies.

6 a The endometrium lining

b Blood vessels in the uterus lining provide the developing embryo with the nutrients and oxygen that it needs.

c Human chorionic gonadotropin (HCG)

d i HCG produced by the growing fetus stimulates the corpus luteum to grow and secrete estrogen and progesterone, which maintain the lining.

ii The fully grown placenta takes over, producing the estrogen and progesterone that maintains the lining. (The corpus luteum breaks down.)

7 a Exchange of materials to keep the fetus alive and healthy.

Production of estrogen and progesterone once the corpus luteum breaks down after the first trimester.

b

From mother to fetus
oxygen
glucose
minerals and vitamins
water
hormones
drugs

From fetus to mother
carbon dioxide
urea
hormones (HCG)
water

- c Signals from the *fetus* prevent further production of progesterone, triggering the secretion of *oxytocin*, which is produced by the posterior lobe of the *pituitary gland*. Estrogen levels rise and induce the development of oxytocin receptors on muscles of the *uterine wall*. Uterine contractions are initiated by the secretion of *prostaglandins* from the endometrium. Oxytocin stimulates the myometrium to contract. The *contractions* become progressively stronger as more oxytocin is released until the baby is pushed from the uterus, during *labour*. This is an example of *positive feedback*.

d Prolactin

8 A Primary follicle

B Primary oocyte

C 1st polar body

D Secondary oocyte

E Secondary oocyte

F 2nd Polar body

G Ovum

9 A Primary spermatocyte

B Secondary spermatocyte

C spermatid

D Spermatazoa

10 a By wind, water, mammals (e.g. bats/rodents)

b List and explain three characteristics that plants use to attract pollinators

Feature	How this attracts pollinators
Colourful flowers /petals	Pollinators attracted by the colours of the petals
Patterned flowers	Pollinators attracted by the patterns and guided towards the pollen
Attractive scent	Mimics pheromones of insects and attracts them to the plant

 c i Large and colourful flowers **Insect**

 ii Nectaries **Insect**

 iii Feathery stigmas **Wind**

 iv Stigma hanging outside the flower **Wind**

 v Small sticky pollen **Insect**

d Male pollen and female ovule nuclei fuse to form a zygote.

11 a A anther

B filament

C style

D stigma

E petal

F sepal

G ovary

b

Part of flower	Function
Petal	Colourful to attract pollinators
Stigma	Pollen landing site
Style	The pollen tube grows through this from stigma to ovary
Ovary	Contains the ovules and site of fertilisation
Sepal	Protects the flower
Filament	Supports the anther
Anther	Contains the pollen

12 a A cotyledon

B testa

C embryo shoot

D embryo root

E micropyle

- b** Stores food reserves (starch). The energy released through the respiration of the starch store can be used for germination.
- c** To protect the seeds from the harsh environments that they might be in.
- d** Hole through which water is absorbed for germination.
- e** Wind, water, animals, explosion

Exercise 8.5

- 1 a** In the bloodstream

- b i** B
- ii** C
- iii** A

- c** A = pituitary gland
B = adrenal gland
C = pancreas
D = ovary
E = testis

d

Hormone	Where produced	Function
Progesterone	Ovaries	Maintains the endometrium
Estrogen	Ovaries	Female secondary sexual characteristics
Testosterone	Testes	Male secondary sexual characteristics
Epinephrine	Adrenal gland	Increases heartrate
Antidiuretic hormone (ADH)	Pituitary gland	Controls water content of the blood
Insulin	Pancreas	Decreases blood glucose
Glucagon	Pancreas	Increases blood glucose
Oxytocin	Pituitary gland	Causes uterine contraction

- 2 1** Receptors detect a change.
2 The brain receives and processes information.

- 3** Signals are sent to effectors.
- 4** Corrective mechanisms are employed.
- 5** Value returns back within normal limits.

- 3 a i** Thermoregulation
ii Endotherm(ic)
iii Hypothalamus of the brain
iv Shivering, vasoconstriction, hairs stand up (goosebumps)
v Sweating, vasodilation, hairs lie flat
vi Negative feedback
- b i** Gular fluttering to dissipate heat from the throat. egret, behavioural
ii Avoid having an insulating layer over their entire body by storing fat in one particular place. camel, physiological
iii Have large, thin ears with a very good blood supply to lose heat by radiation. elephant, physiological
iv Pant to lose heat through evaporation from the tongue. dog, physiological
v Live in burrows to avoid the heat of the sun during the day. jerboa, behavioural
vi Grow an extra layer of fur known as a 'winter coat' to insulate from the cold. polar bear, physiological
vii Have a thick layer of fat called blubber that is used for insulation. whales, physiological
- 4 a** $(314\,000\,000/108\,000\,000) \times 100 = 291\%$.
b Insulin is made by the beta cells of the pancreas, glucagon is produced by the alpha cells of the pancreas.
c Blood glucose concentration decreases as insulin stimulates the uptake of glucose from the blood and into cells of the liver and muscles.
d Blood glucose concentration increase as glycogen in the liver and muscles is broken down to release glucose into the blood.

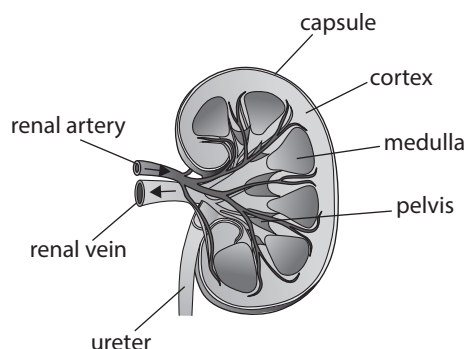
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Scenario	Effect on blood pressure	Explanation
Increasing heart rate	Increases	Blood is pumped at an increasing frequency, so increases the blood pressure
Increasing the diameter of blood vessels (vasodilation)	Decreases	Same volume of blood passes through wider tubes, so pressure decreases
Dehydration	Decreases	Blood volume decreases, so blood pressure decreases
Epinephrine is administered	Increases	Heart rate is increased and vasoconstriction occurs
Sudden blood loss (accident)	Decreases	Blood volume decreases, so blood pressure decreases
ADH is released into the bloodstream	Increases	Collecting duct reabsorbs more water into the bloodstream. Blood volume increases, so blood pressure increases
Aldosterone is released into the bloodstream	Increases	Aldosterone causes uptake of sodium ions into the blood at the site of the kidneys, which are followed by water by osmosis. Blood volume and blood pressure rise

6 a Excretion

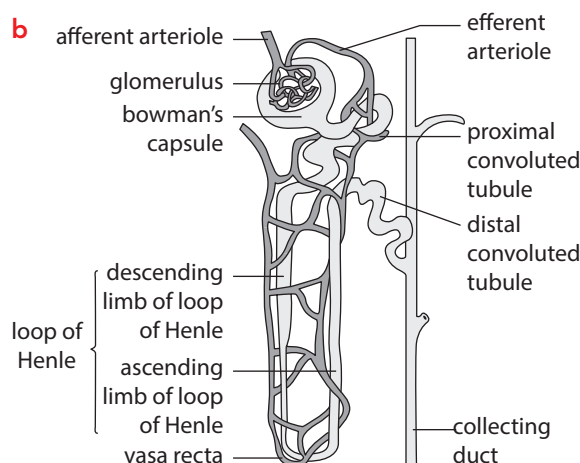
b Regulation of water and salt content of the blood, maintains pH balance, retains substances that the body needs (glucose, proteins, amino acids).

c



7 a

Structure	Function
Bowman's capsule	Cup-shaped structure surrounding the glomerulus that collects the filtrate
Glomerulus	Network of capillaries where ultrafiltration takes place
Loop of Henle	Tube shaped like a hairpin (or loop); has a descending limb and an ascending limb; water and salt are reabsorbed here
Collecting duct	End of the nephron where final adjustments of water are made. Carries urine to the renal pelvis
Proximal convoluted tubule	First twisted section of the nephron that has many mitochondria for the active reabsorption of glucose
Distal convoluted tubule	Second twisted section of the nephron, where ions are exchanged between the filtrate and blood
Efferent arteriole	Brings blood from the renal artery to the glomerulus
Afferent arteriole	Narrowed blood vessel that restricts blood flow to generate high pressure in the glomerulus
Vasa recta	Network of capillaries that surrounds the loop of Henle



8 a Osmoregulation

b Antidiuretic hormone (ADH)

- c 1 Hypothalamus detects the blood concentration is too high (too little water in the blood).
- 2 Pituitary gland releases ADH.
- 3 ADH travels in the bloodstream to the kidney.
- 4 Kidney responds by creating more aquaporins at the collecting duct.
- 5 Water is reabsorbed from the collecting duct, back into the blood.
- 6 Blood concentration decreases back to normal.

9 a Dialysis

- b i Urea must leave the blood, by diffusing through the membrane.
 - ii Glucose must remain in the blood.
 - iii Only excess water should leave the blood, by passing through the membrane.
 - c i Transplantation
 - ii Because we each have 2 kidneys, and can live with only one.
 - iii Transplantation is more convenient, gives a better life for the patient, more independence for the patient.
- However, the body might reject the kidney and this can cause further complications. Viruses and other pathogens could be transmitted.
Accept any other sensible suggestion.

d Accept any of the following:

Renal artery contains more urea than the renal vein.

Renal artery contains more oxygen than the renal vein.

Renal artery contains more salt than the renal vein.

Renal artery contains more water than the renal vein.

Renal artery contains more hormones than the renal vein.

10 a Antidiuretic hormone (ADH)

b Decreases the solute concentration as ADH causes water to enter the blood.

c More ADH is released from the pituitary gland into the bloodstream.
ADH binds to receptors on the collecting duct.

More aquaporins form at the collecting duct.

More water is taken from the collecting duct into the blood.

Production of a low volume of concentrated urine.

d Osmoregulation

11 a Dehydration

b If the blood becomes hypotonic to the cells, the cells will uptake water by osmosis, and burst.

Exam-style questions

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

- 11 D
- 12 A
- 13 D
- 14 C
- 15 C
- 16 B
- 17 A
- 18 C
- 19 B
- 20 A
- 21 C
- 22 D
- 23 B
- 24 D
- 25 C
- 26 B
- 27 A
- 28 A
- 29 C
- 30 D
- 31 D
- 32 D
- 33 A
- 34 A
- 35 D
- 36 C
- 37 a Plasma; erythrocytes/RBC; leucocytes/WBC/lymphocytes/phagocytes; platelets
- b Lymphocytes produce antibodies to fight against pathogens.
- Phagocytes engulf and digest bacteria/phagocytosis.
- 38 a Any from the following [maximum 4 marks].
- Blood enters atria from veins/vena cava and pulmonary vein.
- Atria pump blood into ventricles.
- Ventricles have a thicker wall of muscle.
- Ventricles pump blood out of the heart through arteries/aorta and pulmonary artery.
- Left ventricle pumps blood to the body.
- Right ventricle pumps blood to the lungs.
- b i Diagram should include any of the following correctly labelled for [1], [maximum 3 marks].
- Thick wall (collagen)
- Thick layer of elastic fibres/muscle
- Narrow lumen
- No valves
- Smooth endothelium lining inside the lumen
- ii Any of the following [1] [maximum 3 marks].
- Thin walls/layer of elastic fibres and muscle: as only carrying blood at low pressure.
- Wide lumen: to create lower blood pressure.
- Valves: required to prevent backflow.
- Smooth endothelium inside the lumen: reduces friction.
- c Each correctly drawn and labelled [1] [maximum 6 marks]:
- Right and left atria
- Right and left ventricles (right wall thinner than the left wall)
- AV valves between the atria and ventricles
- Aorta and pulmonary artery
- Vena cava and pulmonary vein
- Semilunar valves within main artery
- 39 Allocate [1] for each of the following, correctly reasoned:
- Water splits the testa.
- Oxygen required for respiration.
- Warm temperature to optimise conditions for enzymes.

- 40 a** Any [1] for each of the following [maximum 4 marks]. Must contain at least one similarity and one difference.

Sperm are produced in millions each day; oocytes are released once per month.

Sperm production starts during puberty; oocyte production begins before birth.

Sperm are produced throughout adult life/ until death, whereas oocyte release ends when a woman reaches the menopause.

Sperm are produced by testes whereas oocytes are produced by ovaries.

Both are produced by meiosis.

Both have a haploid number of chromosomes (23).

- b** Any [1] for each of the following, drawn and labelled correctly [maximum 3 marks]:

Head containing acrosome.

Haploid nucleus in the head.

Tail that is at least three times the length of the head.

Mitochondria in the midpiece.

- c** Stimulates the corpus luteum [1]
to secrete progesterone and estrogen [1]

- d** [maximum 6 marks] from:

Capillaries [1] allow exchange of material with mother; such as oxygen, nutrients, antibodies; and remove waste products; such as carbon dioxide and urea; placenta connected by umbilical cord to developing baby; two umbilical veins and one umbilical artery;

After 12 weeks placenta takes over the role of hormone secretion; secretes progesterone and estrogen.

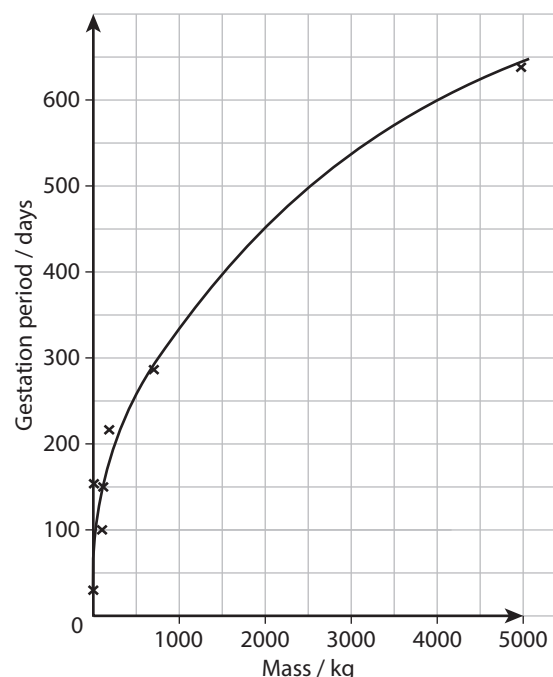
- 41** [maximum 3 marks] from:

Increased carbon dioxide concentration/ decrease in blood pH.

Caused where the cells are respiring heavily.

Shift to the right indicates that hemoglobin releases oxygen more readily/lower affinity for oxygen.

- 42 a**



Award [1] for each of:

Axes correct way round.

Axes labelled, with units.

Appropriate scales.

Points plotted correctly.

Line of best fit (curve or straight line).

- b** $(490/150) \times 100 = 327\%$ increase

- c** This will depend upon a student's line of best fit. Will be in the region of 350–450 days.

- d** Agree as the line of best shows a positive trend.

Agree as the heaviest organism has the longest gestation/lightest organism has the shortest gestation.

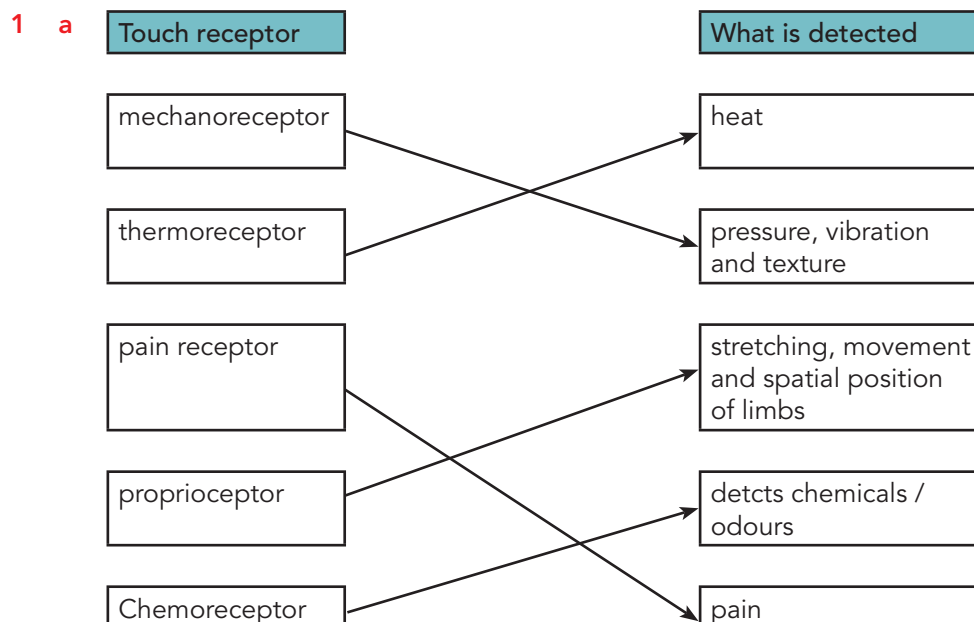
Disagree as we do not know how many organisms of each species were sampled.

Disagree because there are no error bars to show reliability of data.

Disagree because some organisms with very similar gestation periods have different masses (goat and sheep).

Chapter 9

Exercise 9.1



b Damage due to cuts/burns without being aware. Infection likely as pain would not bring your attention to the damage.

c Photoreceptors in the (retina of the *eyes* / *medulla of the brain*) **transduce** light energy to (*chemical* / *electrical*) nerve impulses. Vertebrate photoreceptors send signals along the optic nerve to the (*brain* / *muscles*) where information is co-ordinated.

Chemoreceptors transduce (*light* / *chemical*) energy into electrical nerve impulses. Vertebrates have chemoreceptors in the lining of their (*eyes* / *nose*) and mouth that bind to specific molecules, causing action potentials to be produced. Invertebrates have chemoreceptors on their (*antennae*, *palps and legs* / *wings and abdomen*) that bind to scent molecules and activate (*sensory* / *motor*) neurons. Olfactory receptors are a particular type of chemoreceptors that can detect (*coloured* / *oderant*) molecules.

d Rats are used to detect explosives; dogs are used to detect drugs; pigs are used to locate truffles under the ground (accept any other valid example).

e Animals with a better sense of smell often have an increased density of olfactory chemoreceptors.

2 a The chef drops the pan after recoiling in pain.

b Thermoreceptor/pain receptor.

c i Photoreceptor

ii Chemoreceptor

iii Mechanoreceptor

iv Chemoreceptor (olfactory)

3 A Light

B Sensory neurone

C Brain and spinal cord

D Motor neurone

E Muscle

4 a Reflexes are faster and so they reduce the amount of damage to the body by acting more quickly.

- b i** Unconscious
- ii** Unconscious
- iii** Conscious
- iv** Conscious
- v** Unconscious
- vi** Unconscious
- vii** Unconscious

5

Voluntary actions	Involuntary actions
Walking	Peristalsis
Balance	Breathing
Speech	Digestion

- 6 a** A receptor
- B sensory neurone
- C motor end plate / effector
- D motor neurone
- E interneurone / relay neurone

- b i** receptors
- ii** sensory
- iii** relay / inter
- iv** motor
- v** effector
- vi** contraction
- vii** away

- 7 a A** Relay neurone / interneurone
- B** Motor neurone

- b** Synapse
- c** Arrow should be from left to right
- d** Structure D is carrying the signal away from the Cell body, so it is an axon
- e** The muscle will contract / a movement will be caused to occur.

- 8 i** Smooth
- ii** Cardiac
- iii** Skeletal
- iv** Skeletal

Exercise 9.2

- 1 a** (positive) Phototropism
- b** Auxin
- c** To maximise the amount of light absorption for photosynthesis
- d** Growing downward allows roots to access water and minerals in the soil. It also anchors the plant into the soil.
- e** The mimosa plant's leaves droop in response to touch, which allows them to avoid damage by heavy rain.

The venus fly trap has hinged leaves that snap shut when sensitive hairs are stimulated. This allows the plant to gain an additional source of nutrition.

2 a

	Exoskeleton	Endoskeleton
Internal or external?	external	internal
Position of muscles?	muscles on the inside	muscle on the outside
Function?	protection	support, protection of internal organs
Example organisms?	invertebrates, e.g. insects	vertebrates

- b i** Joint
- ii** Skeleton
- iii** Ligament
- iv** Tendon
- v** Muscle

- c** The biceps and triceps have opposing actions.

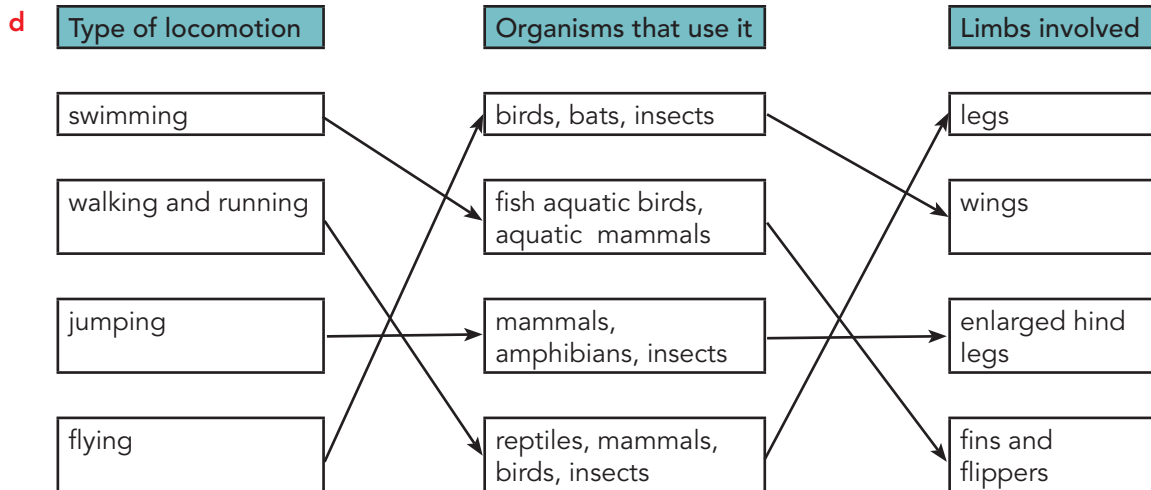
The biceps muscle contracts whilst the triceps relaxes.

As the biceps shortens, it pulls on the radius, decreasing the angle between the upper and lower arm

- d** Deduce the features being compared, and add them to the table.

Feature	Hip joint	Elbow joint
Type of joint	Synovial, ball-and-socket	Synovial, hinge
Bones involved	Femur and pelvis	Ulna, radius, humerus
Type of movement	Rotation	Flexion and extension

- 3** Contraction of flexor muscles and relaxation of extensor cause flexing of the tibia, and storage of potential energy. When the extensor muscles contract and flexor relax, it causes the tibia to extend. This produces a powerful force that propels the grasshopper high and far into the air.
- 4 a** Calcium ions are required to reveal the binding sites on actin (troponin and tropomyosin). Without it, myosin heads cannot form cross bridges with actin.
- b** The distance between Z lines
- c** Actin filaments
- d i** The H zone will decrease.
- ii** The A band will remain the same.
- iii** Distance between Z lines will decrease
- iv** The sarcomere length will decrease.
- e** Dark bands are areas containing myosin;
Light bands contain actin only
- f** The upper image is relaxed, because there is a greater distance between Z lines.
- 5 i** *Calcium* ions bind to actin.
- ii** *Troponin* and tropomyosin undergo a conformational change to expose the myosin binding sites.
- iii** Myosin heads bind to *actin* by forming cross bridges.
- iv** Myosin heads pull the actin closer to the Z lines. This is called the *power stroke*.
- v** *ATP* binds to the myosin heads. Energy released is used to *break* the cross bridges with actin and myosin heads bend into the cocked position.
- vi** *ADP* and *Pi* is released.
- 6 a** Frog
- b** Chameleon
- c** Lion
- d** Heron
- 7 a** To find food, escape predators, find mates, avoid danger (or any other valid suggestion)
- b** wings, arms, fins, tails, legs
- c i** Propulsion
- ii** Stability
- iii** Support



- e**
- i** To attract a mate/to reproduce
 - ii** To find food/resources (during the European winter)
 - iii** To escape being killed/avoid a predator
 - iv** Finding a suitable habitat/to reproduce
- f** Dolphins have a streamlined shape, and flippers and a flattened tail to provide propulsion when swimming.

18 A

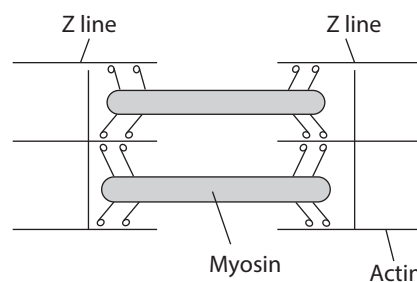
19 B

20 C

21 B

22 D

23



Allow [3] for correct drawing and labelling of Actin, Myosin and Z lines

Allow [1] for contracted state, as shown by very little distance between Z lines and Myosin

- 24** Allow [1] (max 6 marks) for any of the following points:

Calcium ions bind to actin.

Troponin and tropomyosin undergo a conformational change to expose the myosin binding sites on actin.

Myosin heads bind to actin by forming cross bridges.

Myosin heads pull the actin closer to the Z lines. This is called the power stroke

ATP binds to the myosin heads.

Exam-style questions

1 B

2 A

3 C

4 D

5 A

6 D

7 D

8 B

9 D

10 C

11 B

12 D

13 B

14 C

15 A

16 B

17 C

Energy released from ATP is used to break the cross bridges with actin.

Myosin heads bend into the cocked position.

ADP and Pi is released.

- 25** Dendrites carry impulses to the cell body [1] whereas axons carry impulses away from the cell body [1]

- 26** Movement involves a change in position whereas locomotion involves a change in location [1]

Plant stems show movement by bending towards the light whereas woodlice can show locomotion by walking across a petri dish. [1]

- 27** Yes, many reflex actions travel to the spinal cord and not to the brain in order to make responses quicker. An example would be the withdrawal of a foot from a hot bath. [1]

Does not support, sometimes signals do go to the brain, as it is closer than the spinal cord. An example would be the pupil response to light. [1]

- 28** Allow [1] (to a maximum of 3 marks) for any of the following:

Enteric nervous system;

Peristalsis;

Smooth muscle;

Involuntary muscle contraction;

Longitudinal and circular muscles;

Contraction behind food pushes it along the intestines.

- 29** Allow [1] (to a maximum of 3 marks) for any of the following:

To see a predator, the stimulus (light) is detected by photoreceptors;

Signal is transduced into a nervous impulse/electrical signal;

travels to the central nervous system along sensory neurons;

CNS sends signal along motor neurons to muscles in the head and throat;

Response is to make an alarm call to warn other monkeys.

- 30 a** The longer is the snake, the less frogs it eats.

- b** Allow [1] (to a maximum of 3 marks) for any of the following. Must include both sides of the argument for maximum marks.

Yes, because as a snake grows, it eats less frogs suggesting it has learned from past experience.

Yes, because young snakes eat most frogs, suggesting they do not know instinctively that they are poisonous.

No, because the number of snakes of each length sampled is unknown.

No, because larger snakes may be choosing to eat larger prey instead.

No, because the skeletons may belong to a different species of frog.

Chapter 10

Exercise 10.1

1 a Disease-causing organism or virus.

b

Bacterium	Fungus	Protoctist	Virus
cholera	thrush	Chagas disease	COVID-19
tuberculosis	athlete's foot	malaria	influenza
syphilis	ringworm	giardiasis	rubella

2 a Air travel and more regular movement between countries.

b Reduce human-to-human transmission: minimise sexual transmission between carriers, safe burial of the dead, isolate known infected people, prevent direct contact with affected people.

Introduce measures to further contain the outbreak: keep the healthy and the sick apart, improved hygiene, regular hand washing and cleaning of surfaces.

3 a i The skin is a (~~chemical~~/physical) barrier as it is made of a strong substance called keratin.

ii The outer layer of skin is (~~alive~~/dead), so it is removed along with the pathogens present whenever we wash.

iii The skin's sebaceous glands act as a chemical barrier as it produces sebum that has (~~antibacterial~~/antiviral) properties.

iv Sweat is slightly (~~alkaline~~/acidic), which inhibits bacterial growth.

b i Mucous membranes are found in various places in the body including the respiratory, urinary and (~~reproductive~~/excretory) tracts.

ii Mucus acts as a physical barrier as it is (~~dry~~/sticky), so traps the pathogens.

iii Mucus acts as a chemical barrier as it produces the enzyme (~~lysozyme~~/amylase), which kills bacteria.

4 a Prevents blood loss.

Prevents pathogen entry to the body.

b 1 Clotting factors are released by damaged platelets.

2 Conversion of prothrombin to thrombin.

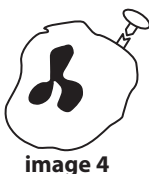



3 Conversion of soluble fibrinogen into insoluble fibrin.

4 Fibrin mesh traps blood cells.

5 A soft clot is produced that hardens into a scab as it is exposed to air.

c Enzyme (and therefore a protein)

5 a and b

Description	Image	Process
1 Bacteria become attached to the phagocyte		Recognition of a 'non-self' entity
2 Bacteria becomes engulfed by the phagocyte		Endocytosis encloses bacterium into a vesicle inside the phagocyte
3 Hydrolytic enzymes destroy the bacterium		Digestion breaks down the bacterium
4 Waste products leave the phagocyte		Excretion releases substances out of the phagocyte

6 a Antibody

b Antigen

c Antibody

d Antibody

e Antigen

f Antibody

7 a Human immunodeficiency virus

b Take an HIV blood test

c Helper T cells/T lymphocytes

d Reverse transcriptase

 e Unprotected sexual intercourse/**vaginal secretions and semen**, transfusion of infected blood, transmission from mother to child via breast feeding, across the placenta during pregnancy, using infected needles.

 f $(36\,000\,000/100) \times 40 = 14.4$ million people

g AIDS stands for Acquired Immune Deficiency Syndrome. Once your immune system is compromised by having very few T cells, infections by bacteria, viruses and fungi are not fought off and they cause secondary infections. Symptoms of these infections are termed AIDS. It is these infections that can kill a patient.

8 a i There was a positive correlation between the penicillin administration and the recovery of the mice.

ii Penicillin could be used to treat bacterial infections.

b Student should suggest not, and that stricter controls would prohibit such experiments that kill mice, and certainly such tests on humans would not be done today.

c Statement is completely incorrect because antibiotics are not effective against viruses.

d Cell wall production, binary fission/cell division, protein production/translation, metabolic pathways.

- e Antibiotics target aspects of a bacterium that are not present in a virus, e.g. cell wall/metabolic processes.
- f Random mutation or being passed a plasmid carrying the resistance gene from another bacterium.
- g Try a different antibiotic or try a higher dosage of antibiotic.
- h Meticillin-resistant *Staphylococcus aureus*.

It is a type of bacterium that is resistant to one or more antibiotics. Others (including the bacteria causing tuberculosis and gonorrhoea) have been discovered that are resistant to every antibiotic used to treat them.

The concern is that specific bacterial infections will become untreatable.

- i The soil, as it contains thousands of different strains of bacteria that may well produce antibiotics to compete with one another.

9

Initial bacterial infection results in many thousands of bacteria dividing, which cause a patient to show symptoms of a disease. Due to rapid division rate, one bacterium gains antibiotic resistance via mutation

Patient takes antibiotic, which kills the non-resistant bacteria

Only resistant bacteria remain. These then divide, creating a population of resistant bacteria. They create symptoms in the patient

Patient takes the same antibiotic again, which is now ineffective. Patient now has to take a different antibiotic

- 10 a Humans, birds, bats and lizards

- b Suitable receptors on plasma membranes may be present/absent.

The temperature of the host organism may not be suitable.

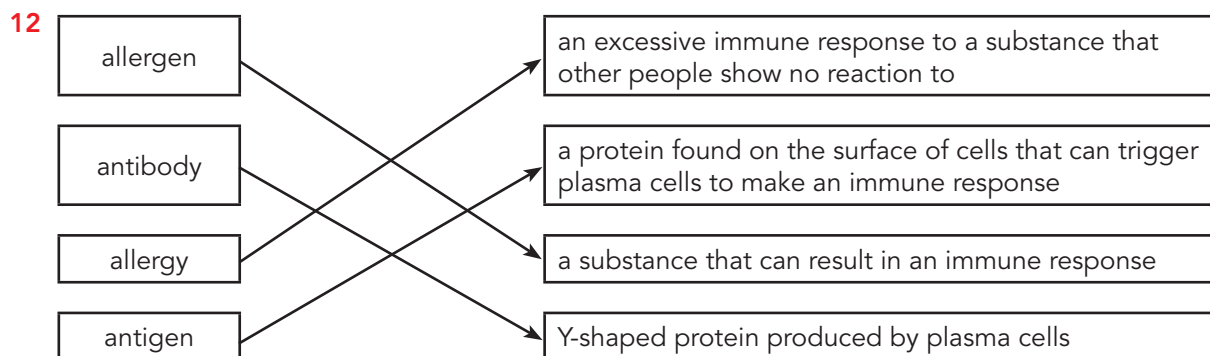
- c The bacteria that cause the disease cannot survive at the higher temperature of a birds' body.

d

Disease	Type of pathogen	Method of transmission to humans	Species which can be infected
Influenza	Virus	Inhalation of infected air	Various
Rabies	Virus	Being bitten with infected saliva	Human, bats, fox, skunk, bat
Anthrax	Bacteria	Direct contact	Human, deer, goat, cattle
Japanese encephalitis	Virus	Injection via infected mosquitos	Human, pigs, birds

- 11 Most of the currently emerging diseases that can be passed from animals to humans are caused by (*viruses/bacteria*). They are particularly dangerous if they also have the ability to (*transpose/transmit*) between humans, as it would allow the disease to spread throughout human populations. With increased (*international travel/online communication*), pandemics can spread very rapidly.

The (*receptors/DNA*) on the surface of viruses have a very (*high/low*) mutation rate that results in the continual emergence of new strains and variants. Occasionally, mutations result in viral strains that can be transmitted (*between/inside*) different species. Examples of this include COVID-19 and (*tuberculosis/H5NI*).



13 a Blood group AB

b Blood group O

c Blood group AB

d Blood group O

e Blood group A

f Blood group B

14 The patient's blood plasma will contain anti-B antibodies. These will bind to the surface of the donated blood cells and cause clotting.

15 a Antigen

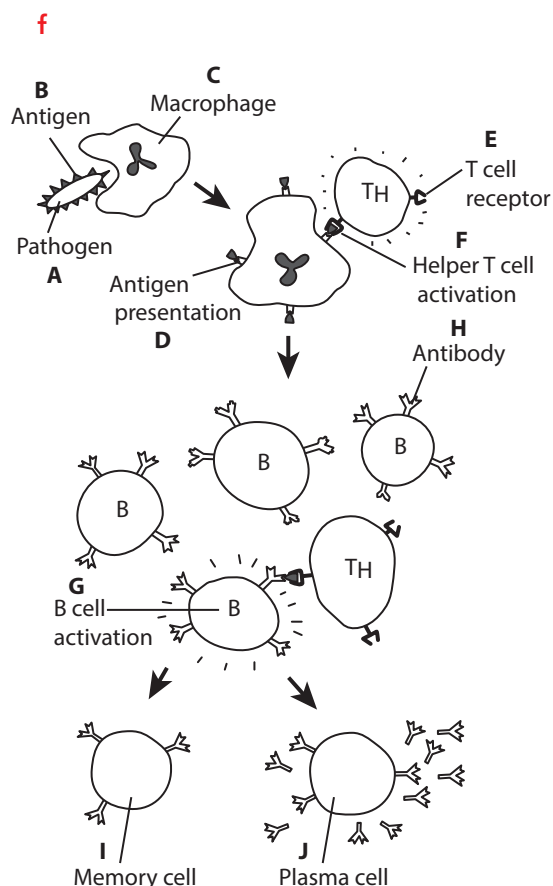
b Cell mediated involves the production of specialised T cells whereas the humoral response involves antibodies being produced by B lymphocytes/B cells.

c

Antibodies are secreted into the bloodstream
Antigen presentation on the surface of macrophages
Clonal selection of B cells
Antibodies cause the destruction of specific antigen and to anything they are attached
Activated helper T cells bind to specific B cells
Helper T cell recognises antigen on the surface of a macrophage and binds to it
Pathogen invades the human body
Helper T-cell activation

d Memory cells remain in the blood stream so that a large and rapid antibody response can be created if the same pathogen invades again.

e When a phagocytic cell engulfs and digests a pathogen, it displays some of the pathogen's proteins on its surface.



- 16 a** A disease-causing organism or virus.
- b** Immunity
- c** Vaccination
- d** Vaccines contain weak, or dead, versions of a (*phagocyte/pathogen*) that are introduced into the body. Antigens in the vaccine stimulate the immune response and the formation of (*pathogens/memory cells*). If (*the same/different*) pathogens invade later on, the response is (*slow/rapid*) enough to prevent serious symptoms of the disease.
- e** They must be tested on animals before being used on humans.
- f** An antibody is a protein produced by lymphocytes to fight against an antigen. An antigen is the protein on the surface of pathogens that stimulates an immune response.

17 a

Feature	Innate	Adaptive
Involves the production of antibodies		✓
Takes a few days to become fully active		✓
Involves phagocytosis	✓	
Body's first line of defense	✓	
Involves the action of B and T lymphocytes		✓
Involves the protection by skin and mucous membranes	✓	

Exam-style questions

- 1** D
- 2** D
- 3** A
- 4** C
- 5** C
- 6** B
- 7** B
- 8** B
- 9** C
- 10** D
- 11** A
- 12** B
- 13** D
- 14** B
- 15** C
- 16** B
- 17** C

- 18** A
- 19** D
- 20** D
- 21** B
- 22** D
- 23** Resistance to the onset of a disease [1]
after infection by the pathogen that causes the disease [1]
- 24** Allow [1] for each [maximum 8 marks]:
Vaccine is a modified or weakened version of the pathogen/toxin produced by the pathogen.
Must contain antigens from the pathogen.
Vaccine injected / ingested.
Antigens stimulate an immune response.
Macrophages present antigen to T cells, resulting in T-cell activation.
Activated T cells can cause activation of specific B cell.
Activated B cells clone themselves.
Some clones develop into memory cells.
Memory cells remain in circulation for a number of years
If infected again, by the same pathogen, much greater production of antibodies / much faster.
Person considered to have immunity when they can be infected with the pathogen but show no symptoms of the disease
Booster shot may be required to maintain immunity after a period of time.
- 25** Pro vaccination: any [2] from:
Provides immunity to disease.
Limits spread of disease.
Diseases such as smallpox can be eradicated.
Protects vulnerable groups of people.
Reduces stress on health providers and the costs.
Provides protection without needing to experience the symptoms of the disease.
- Against vaccination: any [2] from:
May produce some side effects (pain/irritation/bruising).
It may produce an allergic response in some people.
Immunity is not guaranteed.
- 26 a** Allow [1] for each [maximum 3 marks]:
Initial spike in 1917.
The number of deaths decreased until 1957.
From the 1957–1969 the numbers plateau at a value of around 2000 deaths.
From 1970 onwards, the disease is at, or almost at, zero deaths.
Must include some reference to years and values for maximum marks
- b** 1937 = 22 500
1957 = 2500
 $(20\,000/22\,500) \times 100$ [1]
89% decrease (allow 85–95%) [1]
- c i** Sharp decrease.
- ii** Allow [1] for each [maximum 4 marks]:
A weak or dead version of the TB bacterium is introduced into a body.
Antigens in the vaccine stimulate the immune response.
Memory cells are produced.
If the live pathogen enters the body later on, a large number of TB-specific antibodies is rapidly produced.
Infection is killed before symptoms of the disease develop.

- d** Answer must include at least one supportive and one non-supportive argument, with reasoning.

Supportive: award [1]

The steepest decrease in deaths occurs at the same time the BCG vaccine was introduced on a wider scale, (1950s) suggesting it was successful in combatting the disease.

Non-supportive: award [1] for any of the following:

The number of deaths was already declining, so it is hard to conclude that the sharper decrease is in fact due to vaccination.

Number of deaths of people who were vaccinated is unknown, so the effect on deaths cannot be concluded.

From 1957 to 1969, the number of deaths remains relatively constant, even though the number of vaccinated people is likely to have increased.

Chapter 11

Exercise 11.1

- 1 Devised by (~~Aristotle~~/Carl Linnaeus), the binomial naming system names each species in (~~Latin~~/Greek) to ensure an organisms' name is universal across the globe. Binomial names consist of the (~~genus followed by species/species followed by genus~~) The (~~genus/species~~) is always capitalised, and the (~~genus/species~~) is always lower case. If typed, the binomial name must be in (*italics*/**bold**) and if written it should be (underlined/^{superscript})

- 2 a Animalia/animals
Plantae/plants
Fungi
Protists/protocists

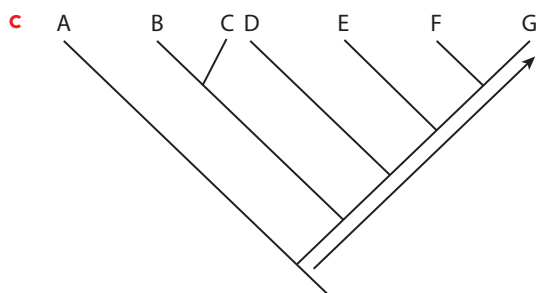
b

Archaea	Eubacteria	Eukarya
halophiles	cyanobacteria	red algae
methanogens	<i>E. coli</i>	yeast
thermoacidophiles	<i>Lactobacillus</i>	daffodil
		octopus
		dinoflagellate
		<i>Paramecium</i>

- 3 a Extreme temperature (*Thermoproteus*)
Extreme salt conditions (halophiles)
- b Archaea.
- c More similar to Eukarya.
Discovered due to comparison between DNA sequences/amino acid sequences/molecular biology/cell ultrastructure.
- d Incorrect statement.
Viruses are not considered to be living/they do not possess all features attributed to a living organism, e.g. they cannot reproduce without a host cell to live in.
- 4 a *A = quince, B = alba, C = byronia, D = dipetala, E = chinensis, F = yulania.*
- b A Ladybird
B Long-horn beetle
C Stag beetle
D Cicada
- c Key uses visible external features such as number of body parts, number of segments, presence of wings and presence of antennae to arrive at the three separate organisms.
Key uses series of either/or choices.
Either type of key is acceptable.

- 5 a A group of organisms consisting of a common ancestor and all of its descendants.
b DNA nucleotide (base) sequence or amino acid sequence.
c A branching tree diagram that shows the most likely evolutionary relationships between a number of different species.
d DNA and proteins
- 6 a Node
b A common ancestor
c Arrow should be vertical, pointing upwards.
d C and E as they have a more recent common ancestor/fewer nodes to reach a common ancestor.
- 7 a The three domains of life (Archaea, Eubacteria, Eukarya)
b Time
c They became extinct.
d A has eight species, B has ten species, C has 13 species.

- 8 a Organism A
b F and G



Allow other positioning as long as direction left to right is clear.

- d These proteins are present in the majority of species.
- 9 a The more branch points between species, the more distant their relationship.

Cladograms are drawn to scale so that the length of the branch is proportional to the time since the split from a common ancestor occurred.

- b Crocodiles.
c Vertebrae, bony skeleton, four limbs
d Sharks
- 10 a A study of the physical features of organisms
b $(4800/5000) \times 100 = -96\%$
c DNA sequencing methods have only recently been developed, allowing for comparison between DNA base sequences.

Exercise 11.2

- 1 a They die through lack of food, predation or other named consequence, and their genes are not passed to the next generation.
b Mechanism for evolution in which favourable heritable characteristics increase within a population. Also known as survival of the fittest.
c Finches with various beak sizes will have initially populated the islands. However only those with beaks suited to the food source available would have survived. Only the finches with small beaks would have survived on island with small seeds, and only finches with large beaks would have survived on islands producing large nuts. Over many generations, the islands would each only have finches with beaks suited to the seed type available.
d They reproduce at a very rapid rate, meaning many generations can be produced in very little time.

This increases the likelihood of random mutation which will increase the rate of evolution.

- 2 a By camouflaging itself against the lichen growing on trees.
b Industrial Revolution or an increase in factories and coal-burning homes that produce pollution. Killed the lichen and darkened the tree bark.
c Melanic (dark) and peppered (light) varieties.
d Dark melanic moths. It was able to camouflage itself from prey, unlike the lighter type that was now more visible against the darker trees. Selective predation occurred.

- 3 a** Random mutations are likely to occur when cells divide. The chance of a mutation occurring that will provide resistance to an antibiotic is greater. Evolution by natural selection can therefore happen very quickly and a whole population of resistant bacteria can form.
- b** Antibiotic-resistant bacteria (that are not killed by the body's immune system) survive, and will reproduce by binary fission, creating clones, each carrying the gene for antibiotic resistance. Resistant bacteria numbers then increase exponentially.
- 4 a** This is an example of rodenticide resistance. Rats becoming resistant to the poison warfarin. Rat populations can then increase rapidly, eating entire stores of grain. This could lead to hunger and starvation in some human populations.
- b** This is an example of herbicide resistance. Weeds are becoming resistant to the weedkiller glyphosate. Growth of weeds in crop fields can greatly reduce crop yield.
- c** This is an example of insecticide resistance. The Colorado potato beetle is resistant to all known insecticides, which results in the devastation of entire potato harvests.

5 a Evolution

b

Species	Traits bred for
Cows	Milk production, meat production, flat backs to make it easier to give birth, longer legs for easier milking
Sheep	Wool production, milk production
Horses	Speed, colouration, size, strength
Dogs	Agility, obedience, aggression, size

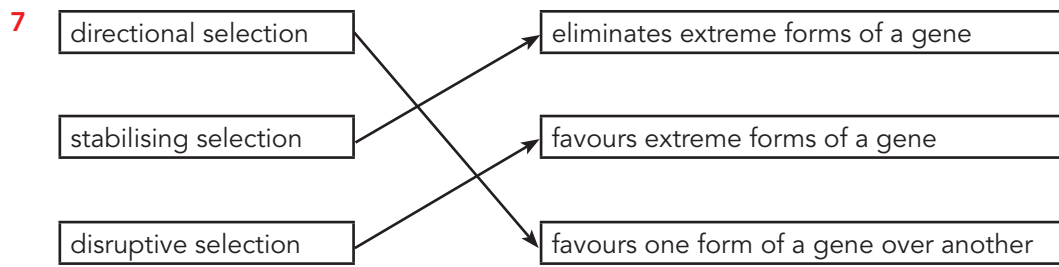
- c** If all organisms are bred to be very similar, there will be a loss of genetic diversity/reduced gene pool. Some traits that are selected for due to aesthetics, could be unhealthy for organisms, and reduce their chances of survival, e.g. flat faces of some breeds of dog creates breathing problems. Inbreeding in pedigree dogs can result in numerous health issues such as deafness in dalmatians, hip dysplasia in labradors, heart disease in bulldogs.

- d i** Yield
- ii** Disease, pests
- iii** Harvest
- iv** Taste, smell

- 6 a** The sum of all of the genes and their alleles found in a population of a species.
- b** The greater range of genes means it is more likely to adapt to any changes in environmental conditions and survive.
- c** Immigration from another population of the same species can introduce new alleles.
- d** Mutations, meiosis, sexual reproduction

e

Scenario	Effect on the gene pool size
Selective breeding for a particular trait	Reduction
Immigration of organisms from a different population	Increase
Hunting season	Reduction
Emigration of organisms from the population	Reduction
A natural disaster	Reduction
Random mutation	Increase
International zoos continually exchange animals to reduce inbreeding	Increase



- 8 i During the Industrial Revolution, lighter peppered moths became more noticeable to predators: Directional
- ii In a population of mice, colours can range from black, to brown to white. In winter, mice can camouflage either against the ice, or against the black lava rocks: Disruptive
- iii When a population of bacteria is exposed to antibiotics, only those carrying resistance genes will survive: Directional
- iv In animals, very small babies do not typically survive and very large babies cannot fit through the birth canal: Stabilising
- v In Galápagos finches, largest beaks are favoured for cracking nuts, and smallest beaks for eating seeds: Disruptive
- vi Arctic hares can be brown or white. In winter, camouflage is key to survival in their snow-covered environment: Directional

- 9 a Genetic drift
- b Sexual selection
- c Genetic drift
- d Sexual selection
- e Genetic drift
- f Sexual selection
- g Genetic drift
- h Genetic drift

- 10 a $p + q = 1$
 p = the allele frequency of the dominant trait
 q = the allele frequency of the recessive trait
 $p^2 + 2pq + q^2 = 1$
 p^2 = proportion of the population that are homozygous dominant
 q^2 = proportion of the population that are homozygous recessive
 $2pq$ = proportion of the population that are heterozygous
- b If 85% have brown eyes, then the percentage showing the recessive allele is 15%. Therefore q^2 is 0.15
- i $q = \text{square root of } 0.15 = 0.39$
- ii $p = 1 - q$, so $1 - 0.39 = 0.61$
- iii $2pq = 2 \times 0.39 \times 0.61 = 0.47 = 47\%$

c Frequency of the dominant allele (p) = 0.8

i $q = 1 - p = 0.2$

ii $p^2 = 0.8 \times 0.8 = 0.64$

iii $q^2 = 0.2 \times 0.2 = 0.04$

iv $2pq = 2 \times 0.8 \times 0.2 = 0.32$

d The frequency of the dominant allele is 0.9 (p).

The frequency of the recessive allele is 0.1 (q).

AA = proportion of the population that are homozygous dominant

$p^2 = 0.9 \times 0.9$

$= 0.81 = 81\%$

Aa = proportion of the population that are heterozygous

$2pq = 2 \times 0.9 \times 0.1$

$= 0.18 = 18\%$

aa = proportion of the population that are homozygous recessive

$q^2 = 0.1 \times 0.1$

$= 0.01 = 1\%$

e proportion of the population that are homozygous recessive (q^2) = $9/800 = 0.01$

q = square root of $0.01 = 0.1$.

$p = 1 - q$

$1 - 0.1 = 0.9$.

f Any of the following:

Mutation does not occur.

No natural selection.

The population is large

All members of the population breed.

Mating is random.

Mating produces the same number of offspring.

No immigration or emigration.

11 a Those produced through techniques in which the genetic material has been altered in a way that would not occur naturally.

b To become resistant to disease.

To become resistant to pests.

To become resistant to pesticides.

To increase yield/size.

To improve taste/smell.

c If cross-breeding happens, resistance genes could be passed to weeds.

Reducing the gene pool of plant species would reduce their environmental resilience/resistance to disease.

d A species of rice that has been modified to contain a high level of beta-carotene, which is used to produce vitamin A. It can be used to enrich the diet of people in developing countries, and prevent the effects of vitamin A deficiency (night blindness).

Exercise 11.3

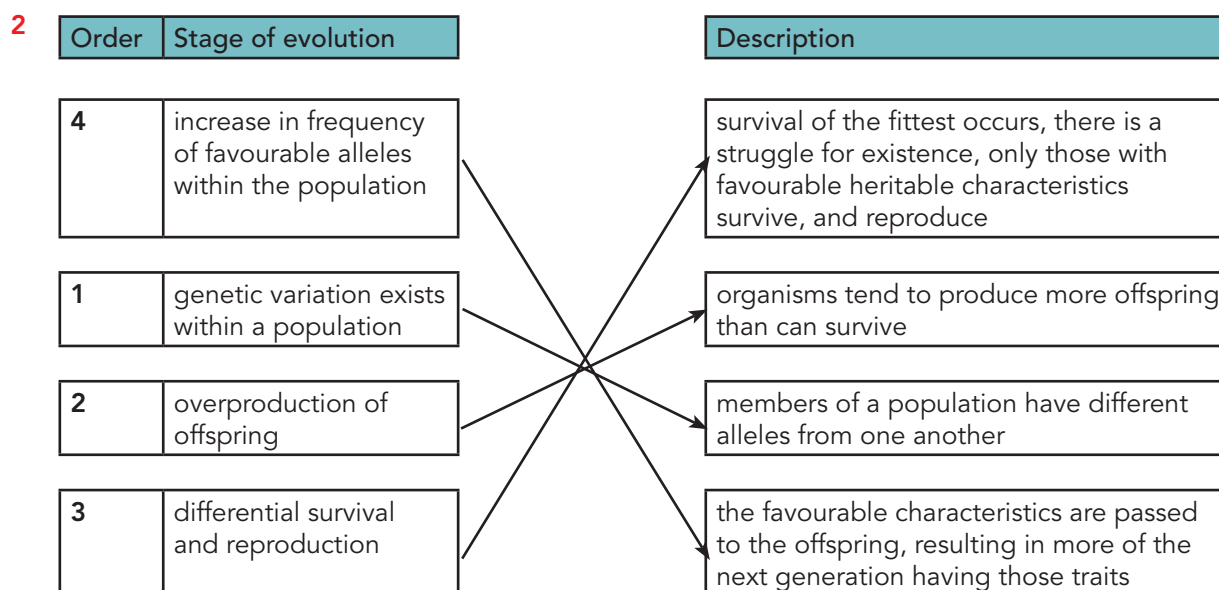
1 a Characteristics of an organism that can be inherited from parents (on genes/chromosomes).

b It increases the chances of survival, and the production of offspring.

c They increase in frequency within a population.

d Evolution takes many, many generations and so cannot occur in the lifespan of one organism. Only a population of a species can evolve, not a single organism.

e Blowhole, flippers and streamlined bodies



3

Selection pressure	Characteristics selected for
Antibiotics are applied to a Petri dish of growing bacteria	antibiotic resistance
A factory dumps chemical waste onto a nearby field of plants	tolerance to pollution
When fishing for King crab in the Gulf of Alaska, fishermen put bait into cages with large holes	smaller size
Tuberculosis is discovered in a badger found dead on the side of a field	immunity to tuberculosis
In winter, the black lava rocks in the mountainous environment of the snowshoe hare become covered in snow	light coloured/white fur

- 4 a**
- i** Yes
 - ii** No: not old enough
 - iii** Yes
 - iv** Yes
 - v** No: not old enough, and not found in rock
 - vi** Yes
- b** (Relatively) very few fossils have been discovered.
- The process of fossilisation requires specific criteria, which are very uncommon. Death needs to have been immediately followed by coverage in oil/quicksand.
- The organism must not have been eaten by predators or scavengers, and the remains must not have been decomposed.
- c** Palaeontologist
- d** Hemoglobin is found in nearly all species of vertebrate animal, so is good for comparison.
- Mutations arise in DNA at a relatively regular rate. The number of differences present between the DNA sequences would therefore correlate to how many years since they shared a common ancestor.

- 5 a i Geographic isolation, which is likely to result in (allopatric) speciation.
- ii Group of similar organisms that can produce fertile offspring.
- iii Number of individuals of the same species living in the same area at the same time.
- iv They would not attempt to breed/they would not be able to produce fertile offspring.
- b i Finches
- ii When an initial population is separated across an archipelago, it acts as a geographical (*barrier/separator*). The birds (~~can~~/cannot) move from island to island as they cannot fly that far, so reproduction does not occur (~~within~~/between) islands. As the environments are (*different/identical*) on each island, different selection pressures exist for each (~~organism~~/population). Over (*many/few*) generations, allele frequencies change differently on each island, resulting in (*distinctly different/very similar*) populations.
- 6 a Organism created by mating members of two different species.
- b The inability to produce offspring.
- c Parents of hybrid organisms often have different (and odd) numbers of chromosomes compared to either of the parents.
- d Zebra and donkey
- e Hybrids are infertile, so they cannot reproduce.
- 7 a Punctuated equilibrium
- b Gradualism
- c Punctuated equilibrium
- d Gradualism
- e Punctuated equilibrium
- f Gradualism
- g Punctuated equilibrium
- h Gradualism

8

Example	Type of barrier
A tsunami creates a wide river through the centre of an organism's territory	Geographic
Male birds that sing the wrong song during mating season will not attract a female	Behavioural
A species of tree releases millions of pollen grains into the wind, but the stigmas (female parts that receive the pollen) of the same species do not develop until 2 weeks later	Temporal
Male fireflies signal to female counterparts by flashing their lights in specific patterns. Females only respond to flashes indicating males of the same species	Behavioural
A hurricane blows hundreds of frogs from the mainland across a range of nearby islands	Geographic
Cicadas are insects that can have very long life cycles. Sexually mature adults of <i>Magicicada tredecim</i> emerge to mate every 13 years, whereas <i>Magicicada septendecim</i> emerge every 17 years	Temporal
A huge tree falls in a rainforest, killing 25% of a colony of ants and separating the survivors into two groups	Geographic
In North America, the western spotted skunk breeds in September and eastern spotted skunks breed in March	Temporal

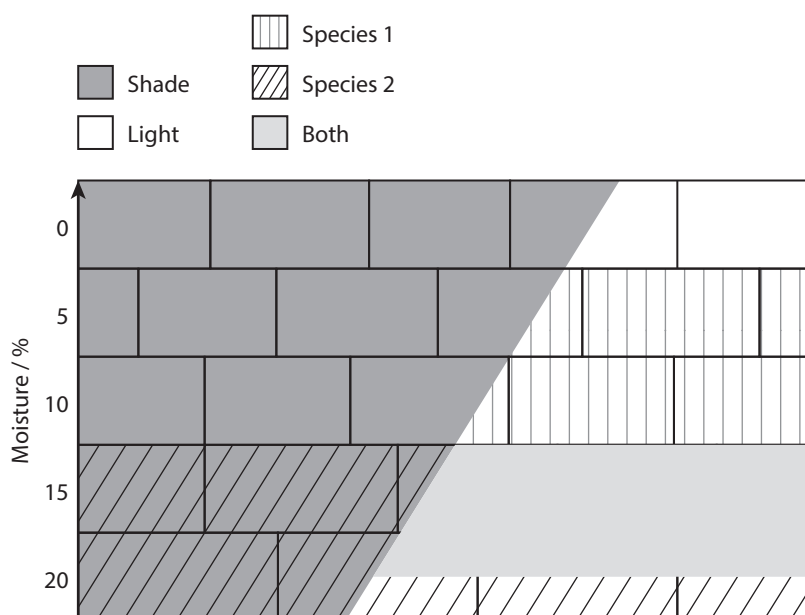
Exercise 11.4

1 a

Abiotic factors	Biotic factors
soil pH temperature	number of predators
water climate soil type	population size
light intensity	parasites
salinity food availability	mates
territory	
breeding sites	

- b** Water, light intensity, soil pH
- c** Water, temperature, food availability
- d** Tree/drey
 - Garden/woodland/forest habitat
 - Acorns/nuts/seeds as a food source
 - Herbivore
 - Predation by foxes, dogs, cats and birds of prey
 - Competition with other birds for nuts
 - Little tolerance for very hot and dry conditions
 - Temperature tolerance range of 0–40 °C

- 2 a** Mutualistic. The coral polyp provides protection and carbon dioxide whilst the zooxanthellae provides oxygen, glucose and amino acids.
- b** Water of the correct pH/
salinity/ temperature
- Light for the zooxanthellae to photosynthesise
- Oxygen for the polyp to respire
- Carbon dioxide for the zooxanthellae to photosynthesise
- c i** Decreased light availability for zooxanthellae
- ii** Increased temperature outside the coral's tolerance levels
- iii** Ocean acidification lowers the pH of the water to outside the coral's tolerance level
- 3 a** Quadrat
- b** Transect
- c** Transect
- d** Quadrat
- e** Transect
- 4 a** No two species can occupy the same exact same niche as they would compete for exactly the same limited resources.
- b i** The fundamental niche is the (~~actual~~/potential) mode of existence of a species.
- ii** The realised niche is the (actual/~~potential~~) mode of existence of a species.
- iii** The realised niche is typically (~~larger~~/smaller) than the fundamental niche.
- c** The actual mode of existence is smaller due to human intervention, and competition with other species.
- d i** Image should be similar to that shown below.
- ii** overlap should be shown similar to diagram below. Competition for resources will occur. Only one species will be able to grow.
- iii** The area of overlap will be taken over by Species 2. This means that the realised niche of Species 1 will be smaller than its fundamental niche.



iv Human interaction (could cause damage to the wall)

Temperature

Competing species (e.g. moss also grows on walls)

Availability of nutrients

Predators (typically invertebrates)

5 a Similar anatomical structures in the same relative positions that originate from a common ancestor.

b The shaded bones are the same bone and have the same relative position.

Human, dog and bird have elongated bones, whereas the whale bone is much shorter.

All linked to digits at one end.

c Adaptive radiation/evolution, accept divergent radiation/evolution

d Convergent evolution

e

Analogous structures	Homologous structures
A result of convergent evolution	A result of divergent evolution
Different in structure	Similar in structure
Similar in function	Different in function
Originate from unrelated ancestors	Originate from a common ancestor

f i Convergent

v Divergent

ii Convergent

vi Convergent

iii Convergent

vii Divergent

iv Convergent

viii Convergent

6 a A measure of variation at the genetic, species and ecosystem level

b The Simpson's diversity index

c The number of different species and the abundance of each species

d

High biodiversity	Low biodiversity
A tropical rainforest	Monoculture farmland, e.g. field of wheat
The Great Barrier Reef	The mown lawn in a city centre park
A woodland with a high Simpson's Diversity index	A cleared building development site with a low Simpson's Diversity index
A healthy freshwater stream	A desert
	A heavily polluted lake

7 Emperor penguin:

Tolerant to living on ice and very cold waters of the Antarctic.

Temperature tolerance as low as -60°C due to cooperative behaviour.

Feed on fish and squid.

Males can tolerate a period of starvation for up to 2 months.

Adaptations give them the ability to dive deeper than other birds, and stay underwater for up to 20 minutes.

Marram grass:

Tolerant to very dry conditions.

Xerophytic adaptations include deep roots, sunken stomata and waxy leaves.

Tolerant to growing in free moving sand.

8 a A plant that adapts to survive in environments where there is little water, such as the desert.

b Has special leaves that are able to trap moisture from the air and therefore get more water into the plant than would be expected.

c Answer can include ideas such as:

long roots to extract water from deep underground.

Tiny leaves/spines so that loss of water through transpiration is minimised.

Succulent stems to conserve water.

Stomata only open at night when it is cooler to reduce transpiration.

Waxy cuticles on leaves minimise water loss by evaporation.

9 a i Behavioural

ii Physiological

iii Behavioural

iv Physiological

v Behavioural

vi Structural

vii Physiological

viii Structural

ix Structural

b By staying in caves and burrowing, they avoid the midday heat.

By only hunting at night they keep cool and minimise water loss through sweating.

c Both animals look to protect themselves by minimising sunlight on them.

Both animals search for a microclimate that is cooler during summer.

The wood rat protects itself by creating its own microclimate, whereas the falcon does so by using the natural microclimates available to it.

10 a Examples are water lilies and hornwort H.

b Leaves have a thick waxy cuticle X.

c Often have very small, reduced leaves X.

d Can have small feathery roots H.

e Often have long and highly branched roots X.

f Some have stomata only on the upper surface of leaves H.

g Examples are marram grass and cacti X.

11 a Mangrove trees grow aerial roots called pneumatophores which grow up, out of the water and absorb oxygen from the air.

b Roots can pump out salt / salt is excreted onto the surface of leaves / salt is transported to sacrificial leaves, which then fall from the plant.

Exam-style questions

1 B

2 B

3 C

4 B

5 A

6 D

7 C

8 B

9 B

10 A

11 A

12 C

13 B

14 B

15 C

16 B

17 D

18 C

19 C

20 C

21 B

22 D

23 C

24 D

25 a Homologous structures evolved from common ancestor, analogous have not [both parts of the statement needed for 1 mark].

b Reference to both types of evolution required. [1] for each direct comparison.

Convergent evolution	Divergent evolution
Unrelated ancestor	Common ancestor
Structures have similar functions	Structures have different functions
Structurally different	Structurally similar
Species become more similar over time	Species become more different over time

Allow [1] for a correctly named example of each

c Allow [1] for each of the following, to a maximum of 3 marks:

Following a mass extinction event/ scenario when many niches become available. [1]

Natural selection causes adaptation in a species to different niches. [1]

Resulting in many species from one common ancestor species. [1]

Speciation occurs [1]

e.g Darwin's finches / other relevant example [1]

26 a Amphibians

b Bony ribs, clavicle and scapula

c Lampreys

d Land vertebrates

27 Allow [1] for each of the following (maximum 6 marks)

Graphs should each show bell shaped curves, with Y axis labelled 'Frequency'

Directional graph favours one form of an allele over another.

Stabilising graph eliminates extremes.

Disruptive graph favours extremes

Correct example of each type of selection given / described [3]

28 a From 1983–1990 the percentage of patients remained at zero [1]

From 1991–1999 the value shows a significant increase from 5–25% [1]

From 1999 onwards there seems to be a plateau forming [1]

b Allow [1] for each of the following (maximum 4 marks)

Antibiotics used to treat bacterial infections.

Some bacteria contain a gene that is resistant to the antibiotic.

Antibiotics kill the bacteria without this gene.

The resistant bacteria survive and reproduce.

Natural selection favours the bacteria with the resistant gene.

Over a period of time, the resistant bacteria will grow and the antibiotic will no longer be effective.

- c** Allow [1] for each of the following (maximum 3 marks):

Bacterial generation times are very short, allowing resistant bacteria to divide rapidly.

Hospitals treat many ill people within close proximity, so bacteria could exchange plasmids carrying resistance genes

Overuse of antibiotics creates a selective pressure for resistant bacteria

Hospitals contain people with weak immune systems, which means resistant bacteria are more likely to survive

- 29** Allow [1] for each of the following (maximum 5 marks):

Variation within a population

Moths can be peppered or dark

Overproduction of offspring

Moths produce more offspring than can survive.

Industrial revolution killed the tree lichen and exposed the dark bark.

Survival of the fittest/natural selection

Darker moths were better camouflaged, so they were not eaten by predators.

Differential survival and reproduction

Dark survivors reproduced, passing allele for dark colouration to their offspring.

Frequency of allele for dark colouration increased

Proportion of dark moths in the population increased.

- 30** Allow [1] for each of the following (maximum 4 marks):

Two names: genus and species.

Devised by Carl Linnaeus.

Genus is capitalised, species is lower case.

Latin, for universal understanding.

If written, must be underlined.

- 31** The fundamental niche is the potential mode of existence of a species given its adaptations [1]

whereas the realised niche is the actual mode of existence of a species resulting from its adaptations and competition with other species [1]

- 32 a** Frequency of dominant allele = p
500 show the recessive allele.
 $500/1200 = 0.42 = q^2$
 $q = \text{square root of } 0.42 = 0.65$
 $p = (1 - q) = (1 - 0.65) = 0.35$ [1]

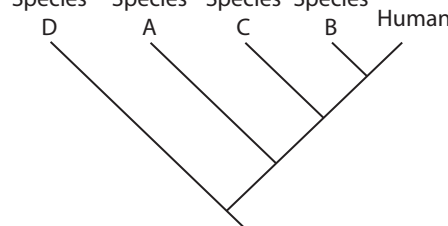
- b** First determine $2pq$
 $2 \times 0.35 \times 0.65 = 0.455$
45.5% of 1200 rabbits = 546 [1]

- 33 a** Base sequencing of a gene as the same amino acid can be coded for by a number of different triplets (genetic code is degenerate). [2]

- b** [3]

Organism	Differences from human
Human	–
Species A	5
Species B	1
Species C	3
Species D	9

- c** [4]



Chapter 12

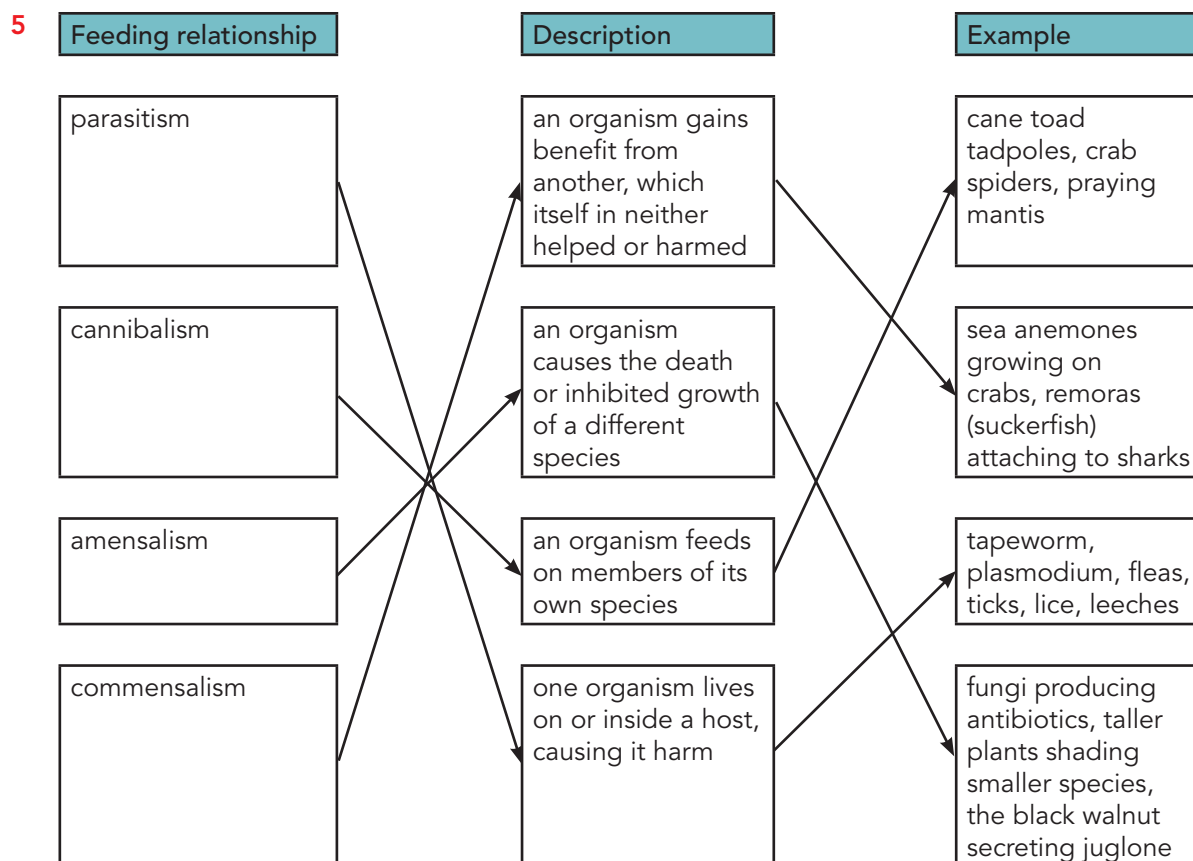
Exercise 12.1

- 1 A autotroph
B heterotroph
C photoautotroph
D consumer
E detritivore / saprotroph
F detritivore / saprotroph

2 a		Detritivore	Saprotroph
	Heterotroph or autotroph?	Heterotroph	Heterotroph
	Internal or external digestion?	Internal	External
	Are nutrients obtained from dead organisms and detritus?	Yes	Yes
	Are digestive enzymes secreted onto surrounding food?	No	Yes
	Does the organism have a physical mouth?	Yes	No
	Are bacteria and fungi good examples?	No	Yes
	Are beetles, worms and crabs good examples?	Yes	No

- b Euglena/Venus fly trap/any other valid answer. Reasoning should include an aspect that makes it an autotroph and an aspect that makes it a heterotroph.
- c Consumers: eat organisms that are living or recently killed, whereas the other heterotrophs feed on dead, decomposing matter.
Examples can include any correct named predator/herbivore, etc.
- 3 a Very dark/no available light
Underground caves/very deep in the ocean, soil
- b Hydrogen sulfide or ammonia

Generalists		Specialists	
Features	Examples	Features	Examples
eat a variety of foods and thrive in a variety of habitats	raccoons squirrels mice	have a limited diet and habitat requirements	koalas giant pandas Canada lynx
tolerant to environmental disturbance		sensitive to environmental disturbance	



- 6**
- a** Autotrophy
 - b** Chemolithoheterotrophy
 - c** Chemoorganoheterotrophy
- 7**
- a** Cusps on molars for grinding, thick enamel to prevent breakage, canines to tear flesh.
 - b** Aphids have a very thin tube-like stylet which pierce stems and drink from phloem vessels.
 - c** Dental pad rather than incisors, Flat molars with rough surfaces for grinding.
 - d** Excellent eyesight, sharp claws for catching prey. Hooked beak for tearing flesh.
 - e** Fangs to inject venom and toxins which quickly immobilize prey.
 - f** Greater absorbance of far red light, broader leaves to capture maximal sunlight, movement of leaves to capture light throughout the day

Exercise 12.2

- 1**
- a** Active transport, cell division, growth, synthesis of nucleic acids.
 - b** Respiration / metabolism
 - c** Autotrophs obtain their energy from sunlight / chemicals whereas saprotrophs obtain their energy from the digestion of dead, decaying animal and plant material.
- 2**
- a** Maize
 - b** Food chains show the movement of energy via feeding, and nothing 'eats' the Sun.
 - c** The maize makes its own organic compounds (food) by photosynthesis.

- d Heterotrophic
- e The direction of the energy flow
- f Grass (*producer*) → locust (*primary consumer*) → scorpion (*secondary consumer*) → baboon (*tertiary consumer*) → leopard (*top / quaternary consumer*)

- 3 a i Oak tree
- ii Mouse, rabbit, goat
- iii Any correct food chain (must begin with oak tree), must contain arrows to show energy flow.
- iv Organisms in the food chain should be labelled: producer, primary consumer, secondary consumer, tertiary consumer.

b Seaweed → crab → squid → penguin → killer whale

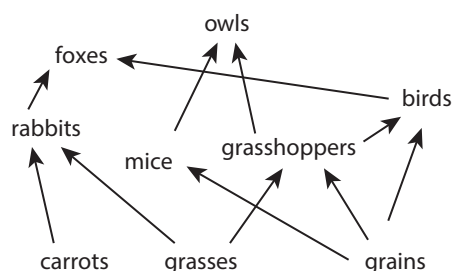
c Decrease/decline.

d Increase in squid population means that more crabs need to be consumed to meet energy needs and so population of crabs would decrease.

e Yes: Decrease in seals would mean fewer food sources for the whale to eat, resulting in a decline in numbers.

No: Decrease in seals would mean less competition with penguins for squid. The penguin population would increase meaning more food for killer whales. Their number would therefore increase.

- 4 a Any similar food web to the one shown below.

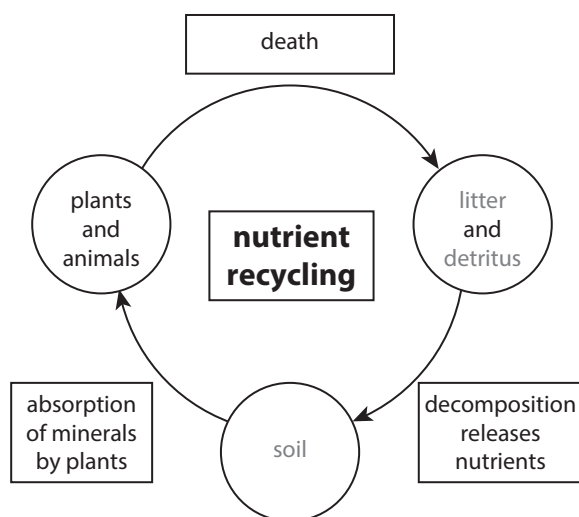


- b Any correct food chain beginning with one of the producers (carrots, grasses and grains)

Food chains	Food webs
a single line of organisms connected by feeding	numerous interconnected food chains
suggests organisms only have one source of food	suggests organisms have multiple sources of food
one arrow to and from each organism (except for the producer and last consumer)	multiple arrows between organisms
show feeding relationships between few organisms	show feeding relationships between many organisms
show the flow of energy between organisms of an entire community	show the flow of energy between organisms of an entire community

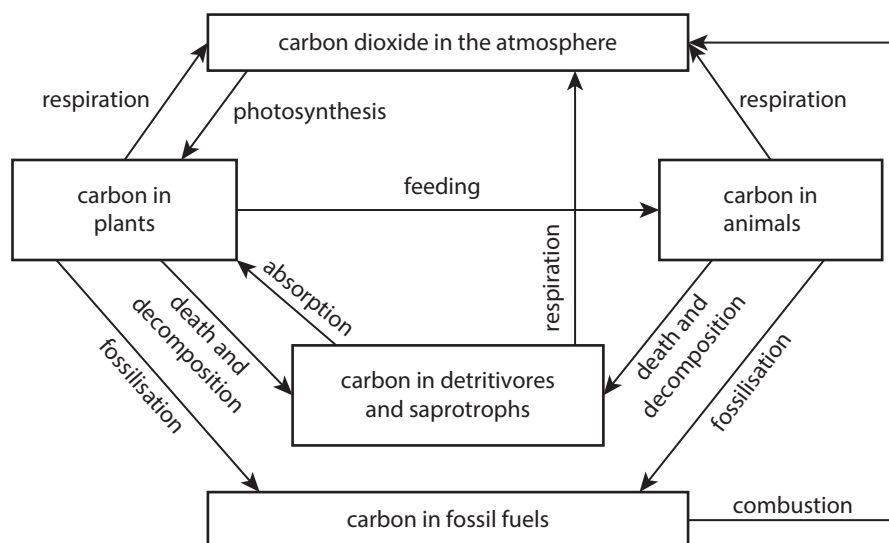
- d Secondary consumer
- e Organisms have more than one source of food
- f Birds

- 5 a Sunflower
b Frog
c 10% of $100\text{ J} = 10\text{ J}$
d Lost as heat, not all biomass eaten, some biomass excreted in urine and feces, energy transferred to the surroundings as heat through respiration.
e 1 J
f Quaternary consumer
g Any sensible suggestion, such as $\text{kJ m}^{-2}\text{ year}^{-1}$
h Heat
- 6 a Energy is transferred between trophic levels. Width of the bar represents amount of energy, so the bars reduce in width as you progress upwards.
b Percentage lost = $(\text{change}/\text{original}) \times 100$
 $= (1483 - 163.1) / 1483 \times 100$
 $= 89\%$ lost;
 $100 - 89 = 11\%$ passed on.
c $4000 - (1200 + 1800) = 1000\text{ J}$
d Pyramid should consist of 3 bars of equal height, labelled upwards as producer, primary consumer and secondary consumer. Width of bars should be relative to energy values e.g 120 mm (producer), 10 mm (primary consumer), 1 mm (secondary consumer)
e Light energy \rightarrow chemical energy
f Photosynthesis
- 7 a



- b Bacteria and fungi
c Rabbit dies, decays, is decomposed and nutrients are released into soil. Nutrients are taken up by the roots of a plant that is then eaten by the cow and incorporated into the tissues of the cow.
d i DNA/RNA/nucleic acid/phospholipid/ATP
ii Amino acid/protein/DNA/RNA
e The Sun

8 a


 b i CH_4

ii Methanogenic archaeans

iii Anaerobic / waterlogged / anoxic and acidic pH

iv It has a greater ability to trap long wave radiation / heat

v Carbon dioxide

vi It takes thousands of years to form, and is harvested faster than it can be produced.

vii Coal, oil, natural gas

viii Combustion / burning / oxidation

c i As time passes, the concentration of atmospheric carbon dioxide increases.

ii More combustion of fossil fuels, more cars and houses, increased deforestation, increased human population and respiration, any other sensible answer.

iii In spring, plants have fewer leaves in spring, less photosynthesis and more respiration so more carbon dioxide released into the air.

In summer, plants have more leaves in summer, more photosynthesis, so more carbon dioxide taken into plants from the atmosphere.

9

Flow of energy	Flow of nutrients
Originates from the Sun	Originates from the Earth
Flow is linear	Flow is cyclic
Source is infinite	Source is finite
Cannot be recycled, ultimately transferred as heat	Can be recycled by saprotrophs and decomposers

- 10 a** Nodes
- b** Ties have number values, or are drawn with different widths, wider representing greater energy flow.
- c i** 0.3 as the total value supplied to Species B must add up to 1.0 (representing 100% energy)
- ii** Species E and D as they do not receive energy from any other organisms.
- iii** Species F, as it only has one source of energy (totally dependent upon species E).
- iv** Species D, as it provides a greater proportion of energy.

Exercise 12.3

- 1 a** A group of organisms that can interbreed to produce fertile offspring.
- b** Interspecific
- c** Predation
- 2 a i** Number/group of organisms of the same species, living in an area at the same time.
- ii** A group of populations that live and interact in an area.
- iii** A community and the abiotic environment.
- iv** Non-living factors, such as pH, soil type, oxygen levels.
- v** The position of the organism within a food chain.
- b** Species, population, community, ecosystem
- c i** Ecosystem
- ii** Population
- iii** Community
- iv** Habitat
- v** Abiotic factor
- 3 a** They benefit from the activity of each other.
- b** Protection is provided and carbon dioxide is provided for photosynthesis.
- c** Carbon dioxide + water → glucose + oxygen;
 $6\text{CO}_2 + 6\text{H}_2\text{O} \rightarrow \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$
- d** Glucose
- e** Relationship between a fungus and an alga.
 Fungus absorbs water and minerals from the surroundings and provides protection.
 Alga photosynthesises and produces glucose for the fungus.

f

Example	Most likely relationship
Cat and mouse	Predation
Two oak trees	Intraspecific competition
Dogs and fleas	Parasitism
Cows and horses	Interspecific competition
Clown fish and sea anemone	Mutualism
Pigs and tapeworms	Parasitism
Lynx and hare	Predation
Barnacles and whales	Commensalism
Birds feeding from the teeth of crocodiles	Mutualism
Bacteria and penicillin-producing fungus	Amensalism

4 a i Random quadrat sampling

ii Lincoln index

iii Chi-squared test

b Total number of daisies in the ten quadrats: 721

 Average number of daisies per quadrat: $721/10 = 72.1$

 Total number of quadrats that could fit into the area = $(10 \times 2) \times (20 \times 2) = 800$

 Estimated population size for total area: $72.1 \times 800 = 57\,680$

 c i Population size $P = (M \times N)/R$; $= (200 \times 200)/60 = 667$ birds in this population.

 ii Population size $P = (M \times N)/R$; $= (485 \times 71)/28 = 1230$ frogs in the population.

iii The marking can sometimes make the organism more visible to predators and prey.

The marking can sometimes come off.

The method does not account for migration.

 5 a Null hypothesis (H_0): there is no association between the two species.

b The null hypothesis is rejected.

c i

	<i>X. parietina</i> present	<i>X. parietina</i> absent
<i>P. adscendens</i> present	26	39
<i>P. adscendens</i> absent	14	21

ii

	O	E	$(O - E)^2$	$(O - E)^2/E$
<i>P. adscendens</i> present, <i>X. parietina</i> present	25	26	1	0.038
<i>P. adscendens</i> present, <i>X. parietina</i> absent	40	39	1	0.026
<i>P. adscendens</i> absent, <i>X. parietina</i> present	15	14	1	0.071
<i>P. adscendens</i> absent, <i>X. parietina</i> absent	20	21	1	0.048

- iii Chi-squared value = 0.183
- iv Degrees of freedom = $1 \times 1 = 1$
- v Critical value at 5% = 3.84
- vi As the chi-squared value is less than the critical value, accept H_0 . There is no association between the two types of lichen.

- 6 a They can spray acid into the eyes and mouths of potential predators to deter them.
- b By stowing away with humans, travelling in their cars/ships (accept any other similar answer that uses humans as the 'carrier').
- 7 a Release hydrochloric acid to burn and irritate potential predators.
- b Produce ink to confuse predators/change colour to camouflage.
- c Spray 100 °C hydrogen peroxide to defend against predators.
- d Covered in armoured scales to prevent damage.
- e Covered in thorns to prevent herbivory.
- f Produce a stinging chemical to defend against herbivores.
- g Covered in needles to deter animals.
- 8 a Intraspecific mutualism
- b Interspecific mutualism
Bees gain sugary nectar, flowers gain pollination
- c Intraspecific mutualism
- d Interspecific mutualism
Plant gains minerals and water, mycorrhizae gain sugars
- e Interspecific mutualism
Crocodiles gain clean teeth, plovers gain food material.
- 9 a i Protection from extreme cold
- ii Flocking confuses predators by making it harder to focus on one prey organism.
- iii Help with rearing of young
- b Increased competition for resources (food, mates, water)
- Increased risk of spread of disease
- Risk of attracting predators

10	Factors affecting plants		Factors affecting animals	
	Density dependent	Density independent	Density dependent	Density independent
	Water availability	Light intensity	Water availability	Natural disaster
	Soil mineral content	pH of the soil	Mates	Temperature
	Available space	Temperature	Available space	
	Disease	Natural disaster	Prey	
			Disease	

- 11 a Lag phase
- b Log/exponential phase

- c Increased competition for resources such as light and nutrients, competition for space, increase in herbivory, increase in disease
 - d Stationary phase.
 - e Carrying capacity
- 12 a The chemical inhibition of one species by another
- b i Release chemicals that prevent the seeds of other species of plant from germinating.
 - ii Produce antibiotics that kills bacteria.

Exercise 12.4

- 1 a Light and heat
- b Matter (allow air/oxygen/carbon dioxide/water)
- c Type of soil, type of plant, pH of soil, intensity of light, volume of water, any other suitable response.
- d Use of oxygen and carbon dioxide sensors (or other sensible suggestion).
- e i Use of pH data sensor/probe (or similar suggestion).
- ii pH will increase/become more alkaline as photosynthesis occurs at a high rate. This means more carbon dioxide is absorbed by the plants from the water.
- 2 a Tropical rainforest and temperate rainforest.
- b Between -5 and -15 °C, less than 100 cm mean annual precipitation.
- c Thorn forest, thorn scrub and desert.
- d Solar radiation / latitude / altitude.

3 a

Primary succession	Secondary succession
Begins from an area of bare rock	Begins with a cleared area of land
Occurs after glacial retreat or when volcanic islands form in the ocean	Occurs after deforestation, forest fire or abandoned farmland
Takes a longer period of time	Takes a shorter period of time

b

Description
Bacteria, lichen and mosses colonise bare rock
Shallow soil forms as pioneer species die
Grasses and small shrubs begin to grow
As plants die and decompose, soil deepens
Trees begin to grow and replace low growing shrubs as they are outcompeted for light and minerals
A climax community of tall trees forms

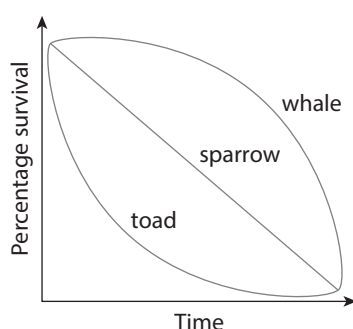
- 4 a A large store of carbon.
- b Fossil fuels, soil, plants, atmosphere, oceans.
- c The flow of carbon from one pool to another. The net difference between the carbon removal and carbon addition.
- d Any three from: soil respiration, photosynthesis, plant respiration, ocean uptake, ocean loss, litterfall.

- e** Yes: humans cause a number of fluxes including burning fossil fuels and deforestation.
 No: not all fluxes are due to human activity such as volcanoes, ocean uptake and loss.
 No: the fluxes caused by humans have very low values, so are unlikely to affect the carbon cycle a lot.
- 5 a** Yes, because it has more data to compare over a longer period of time to show the impact of human activity.
 No, as MLO is in a very remote location, so affects by human activities may not be easily detected.
 No, as relying on the data from one observatory is not very reliable.
 No, because the data still only go back to the 1950s; it would be more reliable to have data going back hundreds of years to see if humans really are responsible for the climate change.
- b** Plants photosynthesise more in the summer and take in the carbon dioxide from the atmosphere to produce sugar for growth; in the winter, there is less growth and less photosynthesis as plants have fewer leaves. Respiration produces carbon dioxide and less is removed from the atmosphere.
- c** El Niño caused deforestation and forest fires, changing the landscape so that more carbon dioxide was released into the atmosphere by combustion, and less carbon dioxide was removed by plant and tree growth.
- d** Percentage change = (change / original value) × 100
 $(100/320) \times 100 = 31.25\%$.
- e** Reduces number of trees and plants that can take in carbon dioxide from the atmosphere; this leads to an overall increase in carbon dioxide concentrations in the atmosphere.
- f i** There was a decrease in the amount of fossil fuels burnt due to reduced use of transportation.
ii The carbon dioxide already present in the atmosphere did not break down, and the value of 'reduction' was not significant enough to be noticed against the amount produced naturally during respiration in plants, animals and soils.
- 6 a** sustainable fishing maintains a balance between fishing and species reproduction to ensure the survival of all species
- b** permit fishing only when species are not reproducing; limit numbers of fish caught; restrict catch of small individuals so that they live to reproduce;
- c** replant the same number of trees as are harvested; use selective logging and thinning of trees so that entire areas are not cleared.

7

r-strategists	K-strategists
reproduce rapidly	reproduce slowly
little parental care for offspring	invest a large amount of time into caring for offspring
mice, bacteria, grass, fish	gorillas, elephants, whales
more likely to survive environmental change	less tolerant to environmental change
short lifespan	long lifespan
produce many offspring at once, few of which live to adulthood	produce few offspring, most of which live to adulthood
pioneer species during succession	part of the climax community during succession

8 a



- b** A whale is a K-strategist. Very few whales die during infancy due to the high amount of parental care. The majority achieve their full lifespan.

A sparrow is an intermediate species that has an equal chance of dying at any age during its lifespan.

A toad is an r-strategist. The majority die at a young age due to being produced in large numbers with very little parental care. Those that survive tend to live for the duration of their lifespan.

Exercise 12.5

- 1 a i** A species with a disproportionate impact on an ecosystem and which strongly affects community structure.
- ii** Prey, such as the deer, would grow in population; eventually they would compete with each other for food, water and shelter. Resources would decline and population numbers would fall.
- b i** The mussel population increased.
- ii** The absence of the natural predator, the sea star, meant that more mussels would survive to reproduce, causing their numbers to increase.
- iii** Other species declined as the mussels grew in such large numbers and competed for resources.
- c i** Hunting
- ii** The otters' prey (sea urchins) grew in number and size. They consumed the kelp forests, which could no longer provide shelter to fish populations. Biodiversity declined massively.

- 2 a** A time in the Earth's history when very large numbers of species died out simultaneously, or within a very short time span.
- b** Five
- c** Volcanic eruption, drought, ice age, impact of meteorite to the Earth's surface
- d** Increased human population, resulting in pollution, habitat loss and climate change

- 3 a i** The giant moa
- ii** Human settlers hunted and killed them for food.

- b** The Caribbean monk seal
- c** The golden toad
- d** Deforestation / planting of tree plantations for rubber and palm oil

- 4 a** Macroplastic is large and highly visible such as bottles and bags, microplastic is the microscopic pieces formed by the breakdown from the macroplastic.

- b** Bioaccumulation is when organisms accumulate toxins in their bodies within one trophic level, whereas biomagnification is when the concentration of the chemicals accumulate to a level greater than the trophic level before them.

- 5 a** Species that is not native to an area.
- b** The introduced species may outcompete the local species for resources.

The alien species may become a predator of the local species.

The alien species may not have any natural predators in the new ecosystem, meaning their numbers could quickly increase, and resources would become depleted.

- c** For biological control of a pest.
- d** This was in the pre-DDT days when many chemicals and pesticides were quite destructive to the crops.

The use of the toads would also have been expected to be less expensive in the long term compared to using pesticides each year.

- e** The cane toads did not have any natural predators and so would survive and keep breeding. They produce a very large number of eggs. They are toxic at every stage of their life cycle.

Although tadpoles are restricted to water, toads are able to travel to new habitats.

- f** Produces a deadly toxin in glands on their head, which prevent them from being eaten.

6 a Russia

- b** Carried on the underside of boats and cargo ships.

- c** They are out competing endemic mussel species.

They are thought to be the cause of avian botulism disease, which has killed a huge number of water birds in the lakes.

- 7** Japanese knotweed was introduced to gardens due to its attractive flowers. It became invasive. It grows rapidly and outcompetes and eliminates native species. Biodiversity is reduced as a result.

- 8 a** The natural or artificial addition of nutrients into waterways, which leads to anoxic conditions and death of aquatic organisms.
- b** Nitrates and phosphates
- c** Run-off of manure from animal farmland. Leaching of artificial fertiliser from agricultural farms.
- d** Biological oxygen demand. Increases during eutrophication.

e	Nitrates and phosphates enter waterways
	Excessive growth of aquatic plants
	Surface of water covered by plant life, reducing light penetration
	Plants below the surface die, as they do not receive sufficient light
	Bacteria decompose the dead plant material, using up the oxygen in the water
	Oxygen levels in the water decrease
	Aquatic animals die

- 9 a** A means of conservation that aims to protect natural systems and wilderness areas, restoring them to the levels of diversity that existed before human interruption.

- b** Renewing land that has been damaged or degraded by agriculture or industry.

- c** The point beyond which an ecosystem becomes unstable and can no longer recover

Exercise 12.6

- 1 a**
- | |
|---|
| Short-wavelength radiation from the Sun reaches the Earth's surface |
| Short-wave radiation is absorbed by the Earth but is re-emitted as longer wavelength heat energy (infrared radiation) |
| Long-wavelength radiation (light) is absorbed by greenhouse gases |
| Greenhouse gases re-emit the absorbed light back towards the Earth |
| This causes the overall temperature of the Earth to increase |
- b** Ice cores collected in Greenland and Antarctica contain bubbles of the ancient atmosphere. The content of these bubbles were analysed.
- 2 a i** The ice will melt and animal populations such as penguins, polar bears and walrus could be lost. Sea level rising could cause flooding of lowland areas, and make seas too deep for sunlight to reach reef ecosystems.
- ii** The permafrost will thaw, releasing large amounts of methane and carbon dioxide. These gases will contribute to further global warming.
- iii** Upwelling may be prevented, so nutrient rich water does not come to the surface. Primary productivity will decline, resulting in reduced energy flow through marine ecosystems.
- iv** Corals will expel their algae, resulting in coral bleaching. Entire reef ecosystems may die.

- b i** As the global temperature rises, the ice which would typically reflect solar radiation is lost. Solar radiation is then absorbed by the oceans and land, which further increases the global temperature. **15 C**
- ii** The increase in a factor causes it to further increase. An increase in global temperature melts the ice which results in a further increase in global temperature. **16 B**
- 3 a** Oak tree leaves and caterpillars are appearing earlier in the spring. This food source is then not available to the chicks of great tits. **17 D**
- b** The mouse eared chickweed is a small plant which grows well in snow-covered soil. As winters are warmer, snow melts and the chickweed is outcompeted by taller plants which would not normally be able to grow at that time of year. **18 D**
- c** Migrating reindeer feed on snow covered lichen in winter. Warmer temperatures and increased rainfall result in lichens being trapped in ice which the reindeer cannot access. **19 D**
- 20 B**
- 21 A**
- 22 D**
- 23 B**
- 24 B**
- 25 B**
- 26 B**
- 27 C**
- 28 C**
- 29 D**
- 30 D**
- 31 D**
- 32 A**
- 33 A**
- 34 C**
- 35 D**
- 36 C**
- 37 A**
- 38 B**
- 39 B**
- 40 D**
- 41 A**
- 42 D**
- 43 D**
- 44 C**
- 45 B**
- 46 A**

Exam-style questions

- 1 D**
- 2 D**
- 3 A**
- 4 A**
- 5 A**
- 6 C**
- 7 D**
- 8 B**
- 9 A**
- 10 B**
- 11 B**
- 12 A**
- 13 C**
- 14 A**
- 15 C**
- 16 B**
- 17 D**
- 18 D**
- 19 D**
- 20 B**
- 21 A**
- 22 D**
- 23 B**
- 24 B**
- 25 B**
- 26 B**
- 27 C**
- 28 C**
- 29 D**
- 30 D**
- 31 D**
- 32 A**
- 33 A**
- 34 C**
- 35 D**
- 36 C**
- 37 A**
- 38 B**
- 39 B**
- 40 D**
- 41 A**
- 42 D**
- 43 D**
- 44 C**
- 45 B**
- 46 A**

- 47 a** Limiting factor
b Community
c Population
d Species
e Ecosystem
f Keystone species
g Competition
h Herbivory
i Mutualism
j Commensalism

- 48 a** Any sensible food chain beginning with named producer [1]

arrows show correct flow of energy along the chain [1]

Trophic Levels are named in correct order as: producer, primary consumer, secondary consumer, tertiary consumer. [1]

- b** Explanation shows that energy decreases by 80–90% at each level and after four or five organisms there is not enough energy available to continue the food chain any further. [1]

- c** Pyramid shows same number of trophic levels labelled as producer, primary consumer, secondary consumer and tertiary consumer. [1]

The pyramid bars should decrease in width at each successive level. [1]

Decrease at each level should be around 80–90%. [1]

- d** Accept any answer between 10 and 20%.

- e** Any three from:

Energy lost in urine/feces [1]

organism not fully consumed [1]

heat/lost in respiration [1]

incomplete digestion/not all of the organism is assimilated [1]

- 49** [1] for each of the following [maximum 3 marks]:

Species are interdependent on each other.

Loss of one species will affect other species.

Overpopulation of some species will cause imbalance.

This could affect abiotic factors, such as soil fertility.

Other populations might be affected.

- 50** Sewage increases the concentration of nitrates and phosphates in the river. [1]

Eutrophication will occur. [1]

Aerobic micro-organisms will feed on sewage / dead organic matter. [1]

Biological oxygen demand will increase. [1]

- 51** Answer must include at least one similarity and one difference.

Allow [1] for any of the following direct comparisons (maximum 6 marks)

In-situ	Ex-situ
Both aim to increase numbers of a particular species / prevent extinction	
Organisms remain in their native habitat	Organisms are moved to an artificial environment
Animals more likely to exhibit normal breeding behaviours	Animals less likely to show normal mating behaviours, artificial insemination may need to be used
Animals are free to roam very large areas of land e.g. nature reserves	Animals are confined within a much smaller area e.g. in a zoo
Animals have little human interaction	Animals are fed daily by humans and are closely cared for by keepers and vets
Protection from poachers may be required	Animals are closely monitored with a high level of security. Poaching is not a concern
Fencing and land management may be required, but overall less expensive	Buildings and artificial habitats are constructed, which is very costly

52 Answer must include both sides of the argument.

Allow [1] for each of the following (maximum 3 marks)

No, because:

- visitors are more likely to cause damage to the native habitats
- visitors are more likely to disturb animals and stress may alter their natural mating behaviour

Yes, because:

- separate walkways can be created for visitors to minimize disruption
- visitor access can have positive outcomes such as public awareness and improved knowledge of wildlife which may increase support and funding
- entry fees will provide the necessary funding for the continued maintenance of the reserve

53 Loss of land habitats [1]

Roads that are necessary to transport materials fragment the surrounding habitats [1]

Heavy metal leakage into surrounding soils [1]

54 Allow [1] for each of the following (maximum 3 marks):

EDGE = Evolutionarily Distinct and Globally Endangered

Research and conservation organisation

Work to conserve the most endangered species

Train conservationists to protect the most at-risk species

Distinctive species have very few closely related species.

55 Tawny owls in Finland are predominantly grey in order to camouflage against snow. [1]

Global warming has resulted in less snow [1]

There is now a shift in the colour of owls to being dark brown, as that colour is now more advantageous [1]

56 Allow [1] for each of the following (maximum 6 marks)

A mesocosm is a small scale self-sustaining enclosed environment;

Sealed to prevent matter from entering or leaving;

Energy (light / heat) can enter and leave;

A mesocosm may include the following:

a transparent boundary to allow light to enter for photosynthesis;

a source of decomposers (soil / compost) to recycle nutrients;

respiring organism to provide CO₂ to producers;

a plant to provide oxygen to respiring organisms;

grit / stones to prevent waterlogging;

(A closed mesocosm should not include invertebrate animals as they are unlikely to survive)

57 Answer must include at least 1 similarity and one difference

Allow[1] for each direct comparison or similarity (maximum 3 marks)

Chemoautotroph	photoautotrophs
Oxidation reactions are the energy source	Light is the energy source
e.g iron oxidising bacteria (or other correct example)	e.g plant / algae (or other correct example)
Both produce their own organic molecules	
Both produce ATP energy	

58 Allow [1] for each of the following (maximum 6 marks):

Exponential growth (log) phase;

Abundant resources;

No disease / competition leads to a rapid increase in numbers;

Transition phase;

Density dependent factors cause the rate of increase to slow;

Large numbers lead to intraspecific competition for resources / outbreak of disease / increased risk of predation; Stationary phase;

Carrying capacity is the maximum number of organisms in a population that can be sustained in a given area;

Correctly labelled diagram of a sigmoid growth curve.

59 [1] for the following [maximum 3 marks]:

Named example, such as DDT.

Define biomagnification as the accumulation of chemicals along the food chain.

Chemicals are stored in the organisms and passed up the trophic levels.

Chemicals become more concentrated at higher trophic levels.

60 a Answer must include correct units.

Greenhouse gas	Chemical formula	Pre-1950 concentrations	2010 concentrations	Increase
Carbon dioxide	CO ₂	278 ppm	365 ppm	87 ppm
Methane	CH ₄	700 ppb	1745 ppb	1045 ppb
Nitrous oxide	N ₂ O	270 ppb	314 ppb	44 ppb
Hydrofluorocarbons	HFC-23	0	14 ppt	14 ppt
Perfluorocarbons	CF ₄	0	80 ppt	80 ppt
Sulfur hexafluoride	SF ₆	0	4.2 ppt	4.2 ppt

b $1045/700 \times 100 = 149\%$

c Answer must include at least one similarity, and one difference.

Allow [1] for each of the following (maximum 3 marks):

Carbon dioxide, methane and nitrous oxide were present both prior to 1950 and in 2010 whereas hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride was only present in 2010.

All gases increased in concentration over time.

Carbon dioxide had by far the largest concentration both before 1950 and in 2010.

The concentrations of hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride, all increased, but by tiny amounts.

d Carbon dioxide, methane and nitrous oxides already existed naturally before industrialisation. The others are all made by humans after 1950.

61 a Both sides of the argument required; yes, because it was causing bird populations to decline due to biomagnification. No, because the link to bird numbers was not proven; no, because there was a rise in malaria after its use was stopped.

b Slow/slight increase from 1971 to 1991 [1]

Dramatic increase from 1991 to 2000 [1]

Peak in 2000 [1]

Sharp decrease after 2000 [1]

c Re-introduction of DDT due to such high malarial rates.