Zig Zag Education

Biology AS / A Level Year 1 | OCR | H020/H420

Differentiated Homeworks

for AS / A Level Year 1 OCR Biology A

Update v1.1, May 2024

zigzageducation.co.uk POD 12210

Contents

Teacher's Introduction

This resource follows the OCR AS / A Level Year 1 specification, providing differentiated homework activities for all topics at this level. Each homework is designed to take approximately 40–60 minutes to complete and is differentiated, usually into three sections, with the activities for each section taking around 15–30 minutes to complete. Teachers may wish to assign specific sections to specific students, or assign an entire set, allowing the students to work through the questions at their own pace and see how far they can get. **The topic of mitosis, which is the first of the two types of cell division to be covered in the homeworks, has only two sections, while the 'Extend your thinking' section under meiosis provides students an opportunity to compare the two types of cell division.**

Each homework sheet begins with an overview of the specification content covered and what knowledge is to be consolidated during the homework.

The sections included in each activity are:

Content check. This section considers basic concepts and foundational knowledge for the topic. In some cases, this may incorporate a review of knowledge from GCSE which is essential for developing understanding at A Level. This activity should be accessible to ALL pupils and should be covered rather quickly by more-able pupils.

Essential skills and practice. This section is designed to consolidate the core concepts from the A Level specification. MOST students should be able to access this content, and perform well. In this AS / A Level Year 1 resource, few questions are designed to be exam-style, instead providing pupils with opportunities to practise the essential skills required in the exam.

Extend your thinking. This section involves higher-level thinking skills or may combine the current topic with knowledge from a previous topic, and as such may be more difficult but still accessible to many pupils. A few activities here are aimed only at the most able pupils; such activities may go slightly beyond the scope of the A Level specification, asking pupils to speculate or synthesise new information. Alternatively, they may introduce a situation from current affairs, asking pupils to apply their knowledge and evaluate something in the information provided.

EXTEND YOUR THINKING

15 minutes

Each section contains suggested timings that are indicated as shown (see left). It is suggested that teachers also ask pupils to write down how long they actually took to do each activity.

This can then be used by teachers as an indicator of which topics pupils are struggling with and where additional explanation or practice may be required. The estimated time could also be used as a guide to set a 'cap' on time spent to do the homework if there are concerns that pupils are spending too much time on homework (e.g. for EAL learners who may take significantly longer to read and understand instructions).

On the next page you will find an overview table, providing the names and contents of each homework. This table also provides a specification reference for each homework and highlights how the activities are distributed over the three sections of the AS / A Level Year 1 specification.

A set of accompanying teacher's notes and answers is provided for each homework; this can be found in the answers section at the end of the resource. Occasionally, this section includes additional notes and other information.

June 2023

Update v1.1, May 2024

Changes have been made to reflect the 2023 accessibility and clarity amendments to the specification.

The following questions (and associated answers) have been removed as they are no longer covered by the specification:

- *Homework 1 – Content check, question 1 m)-o)*
- *Homework 7 – Content check, question 4 D-E*
- *Homework 18 – Essential skills & practice, question 1 n)*
- *Homework 24 – Extend your thinking, question 2a) (i)*

The following questions have been amended for clarity in matching the specification:

- *Homework 1 – Content check, question 2: detail on resolution and magnification amended, and laser scanning confocal microscopes removed*
- *Homework 7 – 'What you will cover in this homework' updated to remove reagent strips*
- *Homework 25 – Content check, question 2: platelets added*
- *Homework 26 – Extend your thinking, question 2 answers clarified to state that examples are not necessary*
- *Homework 27 – Content check, question 2: terms updated to match those used on specification*
- *Homework 30 – Essential skills & practice, question 2c)-d): standard deviation and t-test formulae provided*

Specification Reference Table

	Topic	Specification section(s) covered
1	Microscopes	2.1.1 a–f
2	Cell Structure and Function	2.1.1 g–k
3	Introduction to Biomolecules	2.1.2 a & c
4	Carbohydrates and Biological Polymers	2.1.2 b–g
5	Lipids	2.1.2 b , c, h–j
6	Proteins	2.1.2 b, c, k–o
7	Biochemical Tests and Inorganic Ions	2.1.2 p–s
8	Nucleic Acids and ATP	2.1.3 a–d
9	DNA Replication	2.1.3 d–e
10	Protein Synthesis – Transcription	2.1.3 f
11	Protein Synthesis – Translation	2.1.3 g
12	Enzymes	2.1.4 a–c, e
13	Investigating the Rate of Enzyme Action	2.1.4 d, f
14	Cell Membranes	2.1.5 a–c
15	Transport Across Membranes	2.1.5 d–e
16	Mitosis	2.1.6 a–e
17	Meiosis	2.1.6 f–g
18	Stem Cells and Cell Differentiation	2.1.6 h–m
19	Exchange Surfaces	3.1.1 a–c
20	Gas Exchange	3.1.1 c–h
21	Circulatory System	3.1.2 a–j
22	Transpiration	3.1.3 a–e
23	Translocation	3.1.3 f
24	Pathogens	4.1.1 a–b
25	Non-specific Immunity	4.1.1 c–e
26	Specific Immunity and Medicine	4.1.1 f–n
27	Biodiversity	4.2.1 a–f
28	Conservation	4.2.1 g–i
29	Taxonomy	4.2.2 a–d
30	Adaptation and Evolution	4.2.2 e–i

1. MICROSCOPES

What you will cover in this homework:

- Observing and investigating cells and cell structure using microscopes
- The differences between optical light microscopes, transmission electron micr microscopes, and the confocal laser scanning microscope
- Measuring the size of an object or the magnitude of magnification, using the = size of image/size of real object, or an eye piece graticule and stage mi
- Defining magnification and resolution
- Preparing slides for examination under an optical light microscope, including

CONTENT CHECK

25 minutes

1. State the words or phrases which complete each gap below:

Many things in biology, including cells, their organelles, single-celled and _(a)_ mult be seen clearly with the naked eye. Even if they can be seen, they are far too small to well as being the first person to use the term '_(b)_', Robert Hooke devised his own li view of plant cells. With this he was able to see the cell walls of cork cells and to calcu microscopes are much more powerful and allow us to see other organelles such as _(e Many organelles can only be seen if certain _(f)_ are used to make them appear a dar Unfortunately, some organelles are too small or too thin to be seen under the light mi staining. The invention of _(g)_ microscopes has made it possible to view these orga microscopes have a much higher magnification and also _(h)_. A transmission electro objects as close as 0.2 nm, while a light microscope can only distinguish between obje how high the _(j)_ is, a chloroplast will only ever appear as a green oval under a light microscope will be able to 'see' the individual folds or cristae in the internal membran chloroplast structure, because its _(l)_ is so much higher.

2. Copy and complete the table below, using the given information.

Note: some pieces of information may be used more than once.

medium magnification **heavy metals** **higher resolution** **movem**
specimen mounted on a glass slide **colour images** **2D ima**
specimen suspended in a mounting medium within a chamber slide
various chemical stains **highest magnification** **lowest magnifi**
specimen must be placed in a vacuum

	TEM	SEM
Relative resolution		
Relative maximum magnification		
	heavy metals	

ESSENTIAL SKILLS & PRACTICE

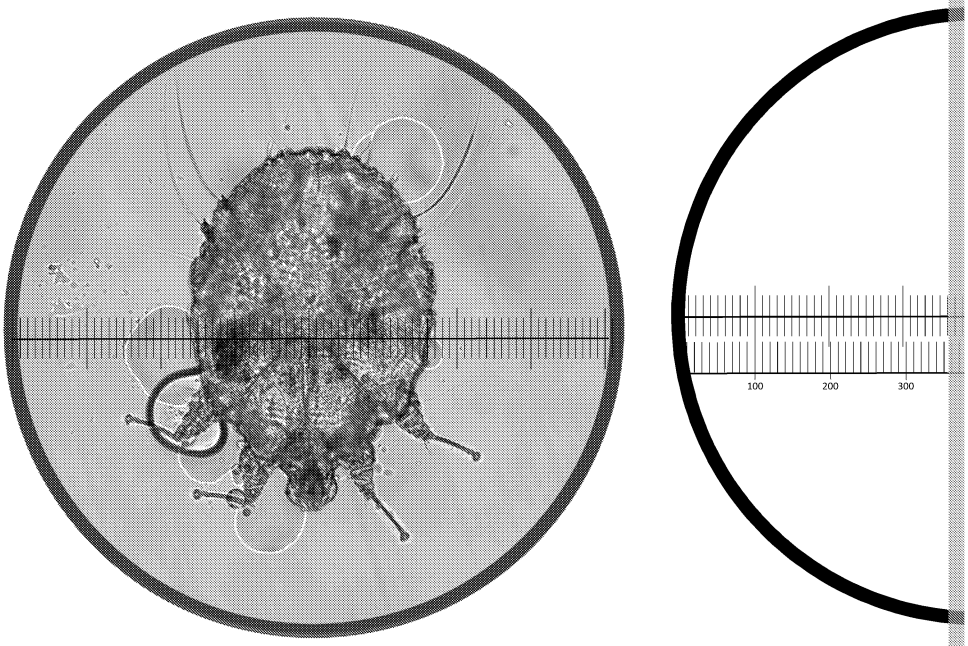
25 minutes

1. The image below shows a human scabies mite *Sarcopte scabiei* as seen unde
   The eyepiece graticule scale is also shown.

   In the second diagram, a stage micrometer with µm units is shown alongsid
   the same microscope and magnification.

   Make a scientific drawing of the scabies mite, and calculate its actual size us
   and stage micrometer.

   At what magnification is the scabies mite shown in the image?



2. Identify which type of microscope – transmission electron microscope (TEM)
   (SEM) or optical light microscope – would be the most suitable to use in eac

   Explain the reason for your choice.

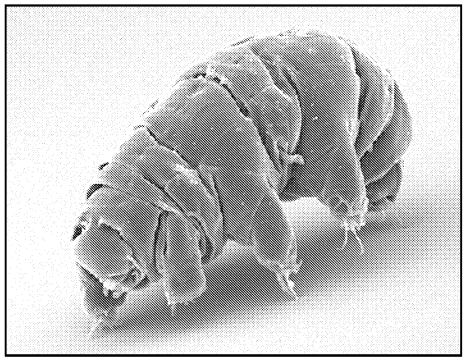
   A. Observing the movement mechanism used by ostracods (microscopic c
      lake water
   B. Analysing the surface of a possible food source for a small beetle (to ob
   C. Examining the detailed structure of the gonopods (modified legs) on a
      species to which it belongs
   D. Detailed observation of small organelles within a cell
   E. Observing the bioluminescence of bacteria in a sample of seawater
   F. Observing the internal structure of a chloroplast

3. Copy and complete the table to indicate which stains are suitable for highlig
a light microscope.

	Structure				
Stain	**DNA**	**Cell wall**	**Cytoplasm**	**Starch grains**	**Chromos during m**
Methylene blue					
Eosin					
Iodine					
Iodine in potassium iodide solution					
Haematoxylin					
Carbol fuchsin (an acid-fast dye)					

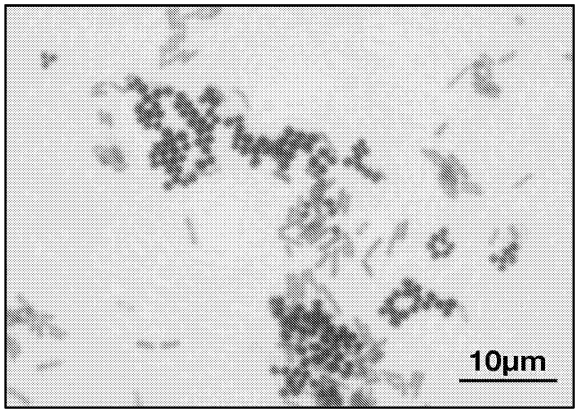
EXTEND YOUR THINKING

20 minutes



1. The image on the left shows a tard
which prefers to live in humid envi
   a) What type of microscope was
   Give at least one reason for y
   b) The image was taken at a mag
   the length of the actual tardig
   c) i. Why might the actual len
   from the value you have
   ii. Would you expect the ac
   shorter than the one you

2. The picture below shows differential staining of bacteria.



   a) What stain or stains
   b) What does it tell us
   shown in the image?
   c) What structure or m
   this differential stain
   d) Using the scale show
   approximate size of

3. For each of the situations below, choose the correct mix of stains for differe
mix of stains would allow you to perform the test described in the situation.

Stains: methylene blue and eosin haematoxylin and
carbol fuchsin and methylene blue eosin and i

   a) Blood smear taken for a complete blood count (determining the percent
   made up of each cell type)
   b) Testing a skin biopsy taken from a person suspected of having leprosy

2. CELL STRUCTURE AND FUN

What you will cover in this homework:

- Recognising various features of eukaryotic cells (knowing that some of these c
  - Plasma membrane
  - Nucleus (including the nucleolus and nuclear envelope)
  - Mitochondria
  - Golgi apparatus
  - Lysosomes (a type of Golgi vesicle that releases lysozymes)
  - Ribosomes
  - Rough and smooth endoplasmic reticulum (RER and SER)
  - Chloroplasts (in plants and algae)
  - Cell wall (in plants, algae, and fungi)
  - Cell vacuole (in plants)
  - Centrioles and cytoskeleton
  - Flagella
  - Cilia
- Linking the organelles involved in the production and secretion of proteins
- Comparing the similarities and differences between prokaryotic and eukary

CONTENT CHECK

20 minutes

1. Correctly match each organelle to its function.

	Organelle		Function
1	Nucleus	**A**	Production of proteins
2	Nucleolus	**B**	Modification and packaging of pr out of the cell
3	Cell surface membrane	**C**	Controls movement of molecules
4	Cell wall	**D**	Provide energy through generati
5	Lysosome	**E**	Where genetic information is sto
6	Golgi apparatus	**F**	Photosynthesis
7	SER	**G**	Storage of water in plants – helps cell's water potential
8	RER	**H**	Production, modification, and pa
9	Centriole	**I**	A major component of sperm cell
10	Cytoskeleton	**J**	Motile structures found on the ex movement of the cell, or of subst
11	Cell vacuole	**K**	Production and packaging of prot the cell
12	Mitochondria	**L**	To maintain shape and organism some algae
13	Chloroplast	**M**	Provides strength to the cell, assi within the cell, and allows the cel
14	Flagellum	**N**	Growth and organisation of spind
15	Cilia	**O**	Releases lysozymes to digest unw
16	Ribosome	**P**	A region of the nucleus in which r

2. Look up the following organisms. Can you find out which are prokaryotic, w are neither prokaryotic nor eukaryotic?

salmonella ascomycete herpes *M. tuberculosis* *E. co*
***Volvox* lycophyte microcystis nostoc nematode**

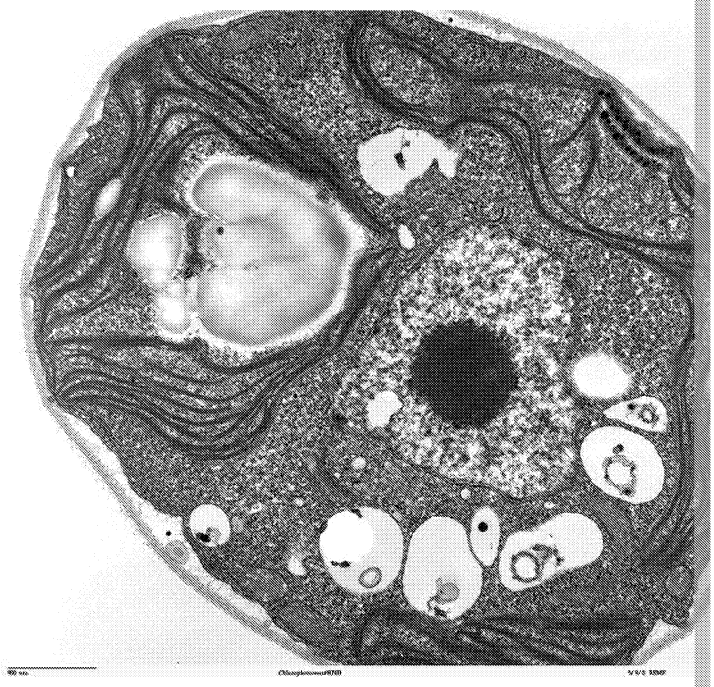
ESSENTIAL SKILLS & PRACTICE

20 minutes

1. For each of the cells shown, identify which cell components are present and

Cell component	Fungus	Plant	An
Nucleus			
Nucleolus			
Naked DNA			
Cell surface membrane			
Cell wall			
Mitochondria			
Chloroplasts			
Smooth endoplasmic reticulum			
Rough endoplasmic reticulum			
Golgi apparatus			
Flagellum			
Cilia			
Lysosome			
Ribosome			

2. The image below shows a TEM (transmission electron microscope) image of
eukaryotic single-celled algae. Make a scientific drawing of this organism in
Label at least four parts within this cell.



EXTEND YOUR THINKING

15 minutes

1. Consider structures A–F in relation to fungal cells. Match each of the letters

   A. cell wall **B.** nucleus **C.** mitochondria **D.** ribosome **E.** Golg

   1. Consists of RNA and protein
   2. Has extensive folding of the inner membrane and contains DNA
   3. An organelle with a single outer membrane
   4. Large organelle which may be singular or multiple within one cell cytop
   5. Not found in fungal cells
   6. Consists of (chitin)

2. Copy and complete the table. Identify which organelles possess each of the

	Nucleus	**Mitochondrion**	**Chlorop**
Double membrane bound			
Has folds in the internal membrane to increase surface area			
Involved in packaging of molecules to be exported from the cell			
Single outer membrane			
Not visible under an optical microscope			
Contains genetic material			
Oxygen diffuses into the organelle			
Only found in photosynthetic organisms			

3. Copy and complete the table below to compare and contrast the basic struc and eukaryotic cells. Provide simple details in your answers.

	Prokaryotes	
Ribosomes		
Genetic material		
Size		
Membrane-bound organelles		
Plasmids		
Flagella		
Cell wall		

3. INTRODUCTION TO BIOMOL

What you will cover in this homework:

- Hydrogen bonding and the properties of water
- The chemical elements of life

CONTENT CHECK

25 minutes

1. In order to understand the importance of water for biological organisms, th terms and concepts which must be fully understood. Research each of the t suitable definition in your own words. Make sure that your definition make

Cohesion **Adhesion** **Heat capacity** **Latent heat of vaporisation**

2. Match the properties of water to their importance in a biological context. C into your exercise book.

A. Water is a common metabolite…	1. Quite a lot of energy is needed for wate water evaporates from the surface of a amount of energy is carried away, prod
B. Water is a good solvent…	2. Water molecules are strongly attracted form thin columns (e.g. in phloem and x surface tension where it meets air, allow rest on its surface.
C. Water has a high heat capacity…	3. Many inorganic ions and small nutrient amino acids) exist in solution in cell cyto transported in water.
D. Water has a high latent heat of vaporisation…	4. Hydrolysis and condensation reactions a photosynthesis, and use of ATP as an en reactions, as well as in digestion and the biological monomers.
E. Water has strong adhesion and cohesion…	5. Large amounts of energy are required t water; water is the major component in in energy (temperature) are required to Organisms living in water also benefit fr environmental conditions.

3. All living things make use of the same key molecules: proteins, carbohydrate Looking at the formulae below, can you identify the six elements which are i

Glucose: $C_6H_{12}O_6$ Amino acid: R-CH(NH_2)-COOH (note that the 'R grou
Fatty acid: $CH_3(CH_2)nCOOH$ Adenine: $C_5H_5N_5$ Phospho

Use the formulae above and your prior knowledge of biological molecules t Name each of the six elements and indicate in which biological molecule(s) t

	Elements			
Molecule				
Carbohydrate				
Lipid				
Protein				
Nucleic acid				

ESSENTIAL SKILLS & PRACTICE

15 minutes

1. In each of these scenarios, identify which property/properties of water is/ar
   A. A pond skater resting on the surface of a pond
   B. A frog hibernating at the bottom of a pond during a cold winter
   C. Transpiration in a plant on a sunny day
   D. A man running a marathon on a hot day
   E. A dog goes for a swim in a large pond on a hot day

2. Explain the function of hydrogen bonding in the following properties of wat
   a) Water is a good solvent
   b) Water has high adhesion
   c) Water has a high surface tension

3. a) Use the information in the table below to create a pie chart showing:
      i. The respective amounts, by mass, of each element in the human b
      ii. The percentage of the human body made up of different elements atoms present

Element	O	C	H	N
% mass	65	18.5	10.0	3.2
% by number of atoms	24	12	62	1.1

   b) i. Which element shown in part a) is an important structural compon many other organisms, such as bacteria or fungi?
      ii. Why is this element important for humans?
      iii. Can you think of a distantly related group of organisms which may of this element? Suggest a type of organism and the reason why t the element.

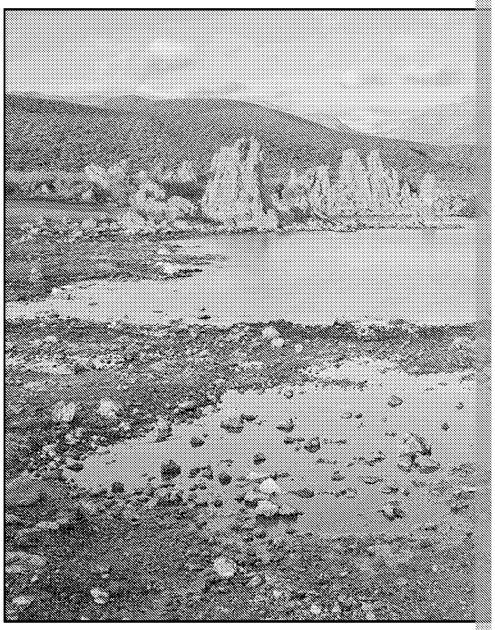
EXTEND YOUR THINKING

30 minutes

1. Water is an extremely important compound, which no known organism can last time you had a drink. Picture one molecule of water from this drink and taking through your body.

   Write a story about this water molecule. Note where the water molecule go action is connected to any of the important properties of water that you hav reactant or a product in a chemical reaction. If so, how do its atoms become become water again? Make sure there are at least 10 locations or actions in

2. Phosphorus is one of the six elements considered to be essential to all life. A species of bacteria has been found in Mono Lake, California, which is capable of living and growing in an arsenic-rich and phosphate-deprived environment. Wolfe-Simon et al. (2010) claimed that this species of bacteria, named GFAJ-1, is able to do this because it is able to use arsenic to build its DNA and other phosphorus-dependent molecules. Arsenic is highly toxic to most life on Earth, and many scientists have disputed the claims.



a) Using your knowledge of DNA, other biological molecules and chemistry scientist's claim is potentially true?

b) Carbon is a very important element for all known life. It is often referre many biological molecules. Some astrobiologists claim that on other pl readily available as it is here on Earth, non-carbon-based life may have e think is the main candidate for substitution of carbon in these non-carb Explain your answer.

3. The table below shows the relative amounts of various elements in a range o

	Human	Grass	Yea
Oxygen	65	57.0	72.1
Carbon	18.5	30.0	13.7
Hydrogen	10	6.6	9.8
Nitrogen	3.2	4.0	2.4
Phosphorus	1.0	1.0	1.1
Calcium	1.5	0.8	0.8
Sulfur	0.3	0.2	0.15
Potassium	0.4	1.0	1.4
Sodium	0.2	0.20	0.1
Magnesium	0.1	0.17	0.11

You should try to answer each of these questions using your own knowledge course, and from your life experiences), but if you get significantly stuck, you support you.

a) Why does the grass contain significantly more magnesium than the othe

b) Humans and beetles are both animals, but they have differences in their Identify two elements which show significant variation between these ty suggest why these differences occur?

4. CARBOHYDRATES AND BIOLOGICA

What you will cover in this homework:

- The biological polymers starch, glycogen and cellulose are large carbohydr
  monosaccharide glucose. Other monosaccharides include galactose and fruc
- There are different forms of glucose, including α-glucose and β-glucose
- Consider the relationship between structure and function for the polysaccha
  cellulose in their natural contexts
- Reducing sugars (usually monosaccharides) and non-reducing sugars (usually
  with a biochemical test using Benedict's solution
- Starch can also be detected using iodine solution

**This homework will cover some of the information you have learnt in class reg
looking at the concept of monomers and polymers in the contex**

CONTENT CHECK

20 minutes

1. At GCSE level you have already learnt about several carbohydrates, their use
   dietary sources. State the words or phrases which complete each gap belov

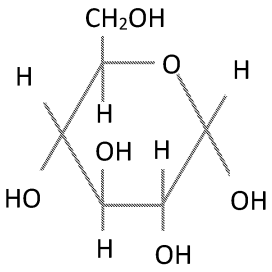
   Carbohydrates are made up of the elements carbon, _(a)_ and _(b)_. They are one o
   in the mammalian _(c)_, and are very important as they provide the body with its mai
   biological _(e)_ known as carbohydrates includes the simple sugar _(f)_, which is th
   molecules, _(h)_ (found in plants) and glycogen (found in _(i)_). Simple sugars lik
   examples include _(k)_, which is found in fruits, and _(l)_, which is combined with gl
   milk. The bond which joins two monosaccharides together in a disaccharide or _(n)_ i
   by a _(p)_ reaction in which a water molecule is released.

   The sugar _(q)_ is the primary molecule used in _(r)_ _(s)_. When we eat somethin
   pure starch, it is broken down by _(u)_ in our _(v)_ , and later in our intestines, to p
   This glucose is then absorbed into our blood, where it can be transported to the _(w)_
   respiration. The _(x)_ sugar deoxyribose is also an important component of DNA, wh
   used in RNA bases.

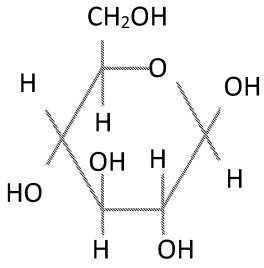
2. Glucose is an example of a reducing sugar. Name one other reducing sugar a
   of a non-reducing sugar.

3. The diagrams below show some of the carbohydrate molecules you need to
   a) Describe the difference between the structure of α-glucose and the stru
   b) For each of the disaccharides and polysaccharides identified below, list
      to make it. Recall or find out where each of these disaccharides and po

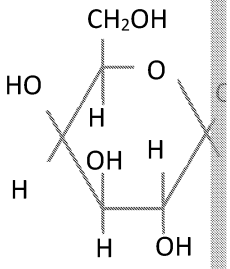
α-glucose



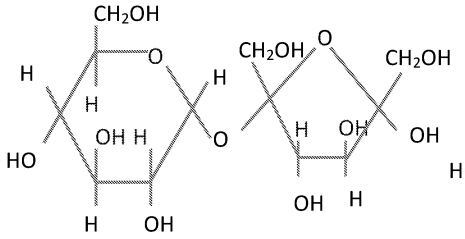
β-glucose



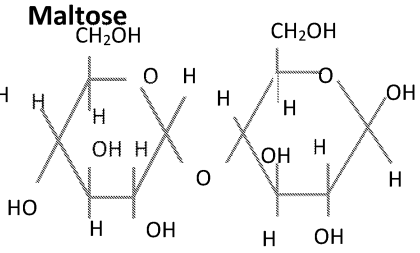
Galactose



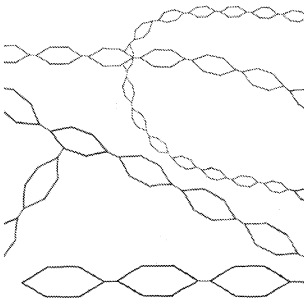
Sucrose



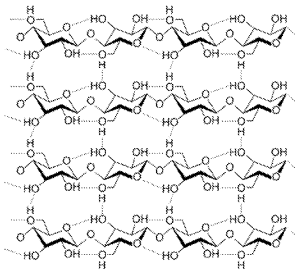
Maltose



Starch



Cellulose



ESSENTIAL SKILLS & PRACTICE

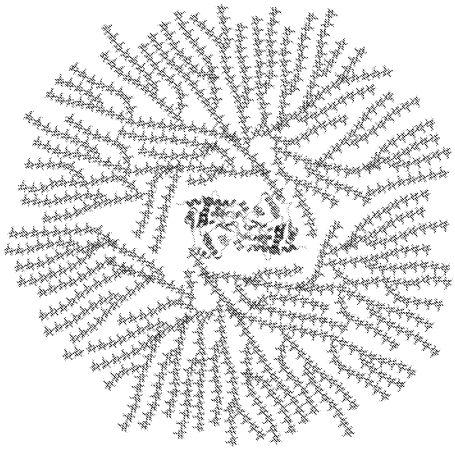
15 minutes

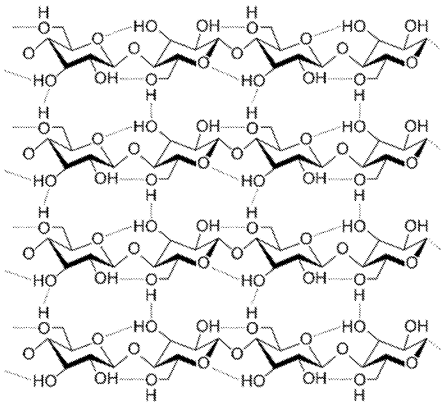
1. The diagrams below show the structure of each of the common polysaccha
glycogen. The main function of these molecules is also described alongside
explain **how** the structure of these molecules helps them to perform their v
exercise book, write the name of the molecule, draw a quick sketch showing
annotate your sketch and write a couple of sentences to explain how the st
linked to its function.

Glycogen: Glucose storage molecule used in animals – humans have glycogen stores in their liver

Cellulose: Structural material in plants – used for making cell walls

St





EXTEND YOUR THINKING

10 minutes

1. The diagram above shows the structure of starch as two different molecules
found within the starch granules of plants.
   a) What are the names of these two molecules?
   b) Compare and contrast these two molecules. Consider the structure an
   their respective prevalence in starch, and their reaction to iodine.

2. How does the structure of β-glucose help cellulose to form in flat sheets?

3. Is fructose a pentose sugar? Explain your answer.

5. LIPIDS

What you will cover in this homework:

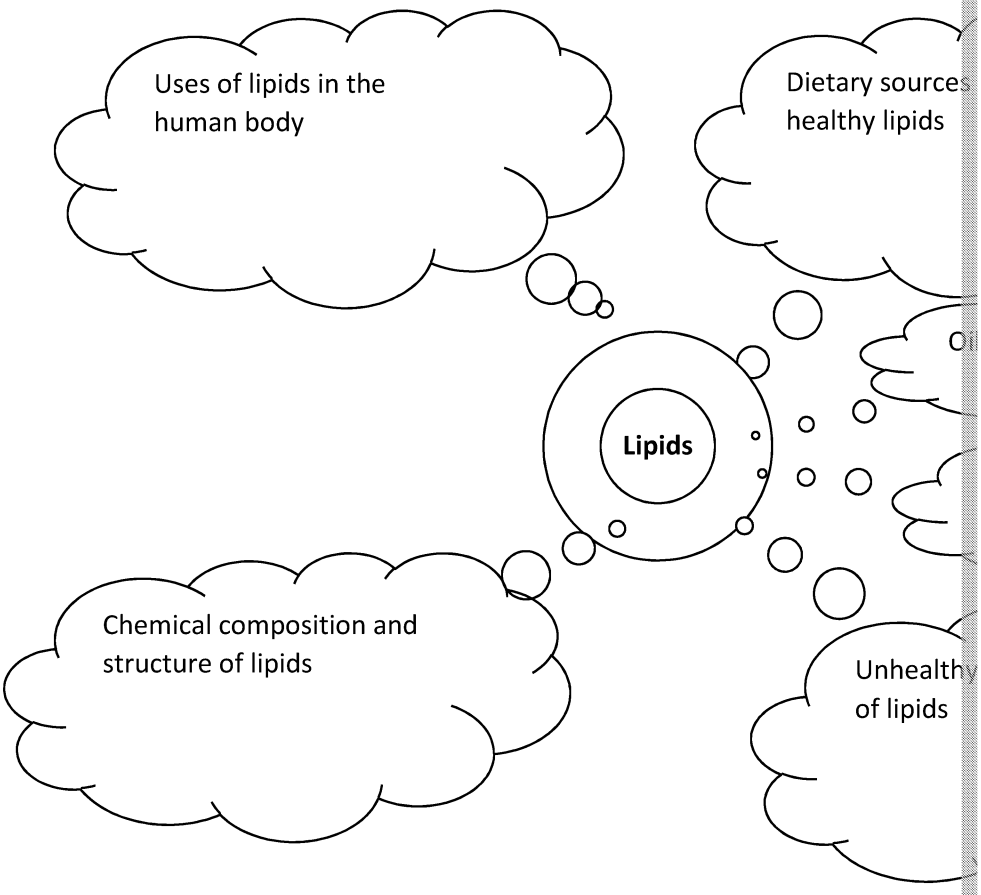
- Classification of lipids as triglycerides, phospholipids or cholesterol
- Recall the different properties of triglycerides, phospholipids and cholesterol differences are related to their different structures and functions
- Recall the general structure of a triglyceride, including glycerol and the three
- Define and use the terms saturated and unsaturated in relation to the R-group
- Describe the formation of an ester bond between a glycerol and a fatty acid

This homework will cover some of the information you have learnt in class continuing to consider the concept of monomers and polymers in the con

CONTENT CHECK

30 minutes

1. At GCSE level you have already learnt a little about lipids, their uses in the h sources. Copy and complete the mind map to show how much you remem extending the mind-map to show your new knowledge of lipids.



2. Copy and complete the table to show the main uses of the three major types human body.

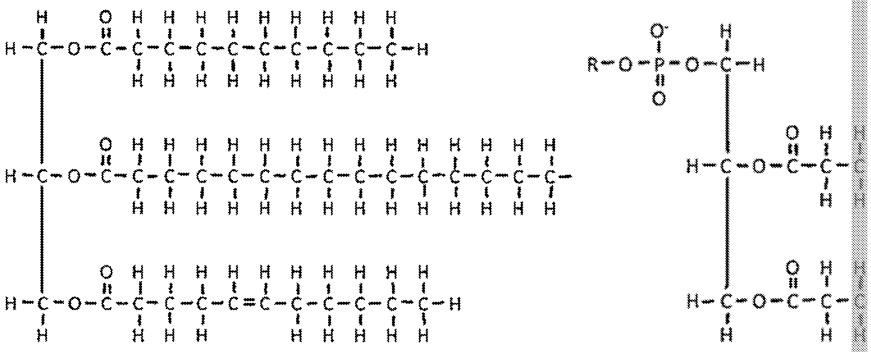
Lipid	Energy storage	Cell membrane structure
Triglyceride		
Phospholipid		
Cholesterol		

ESSENTIAL SKILLS & PRACTICE

25 minutes

1. Draw a diagram of a triglyceride and a phospholipid like the ones shown bel
molecules is a triglyceride, and which is a phospholipid, and then label your
features. Note that these labels may be used once, more than once or not a

unsaturated fatty acid *ester bond* *saturated fatty ac*
phosphate 'head' *fatty acid 'tails'*

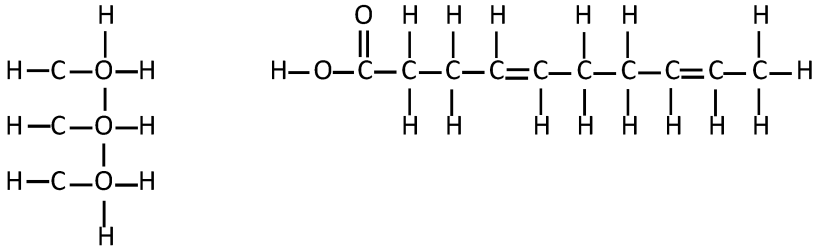


2. The monomers or simple molecules that are combined to form biological po
called condensation reactions, in which a water molecule is released for eac

a) Identify each of the molecules shown in the diagram below. Use 'mole
your answer.

b) Copy and complete the diagrams below to show the formation of the e
glycerol and fatty acid molecule through a condensation reaction.

molecule A ***molecule B***

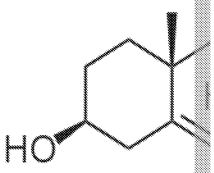


c) Draw the same molecule as it would appear after condensation with tw
sure your molecule includes at least one unsaturated fatty acid and on

3. The diagram shows a cholesterol molecule.

Find out the structure of an oestrogen molecule and draw it in a similar way to the diagram of cholesterol. Identify the differences between these two molecules.

[3]



EXTEND YOUR THINKING

15 minutes

1. The table below provides information on the structure and properties of pho
how these relate to their functions. Copy and complete the table:

Molecule	Structural feature	Property due to this structural feature
	Two fatty acid 'tails'	Affinity with other fats keeps molecules together
Triglyceride		
Phospholipid		Hydrophilic 'head' orients towards water and away from fat

2. Explain how the structure of cholesterol relates to its functions in the human

6. PROTEIN

What you will cover in this homework:

- Proteins are biological macromolecules, made up of many amino acids.
- Amino acids include an amine group and a carboxylic acid group on either e
  different for each of the 20 amino acids common to all living things.
- Dipeptides consist of two amino acids, while polypeptides include many.
- Describe the formation of a peptide bond between two amino acids.
- Provide examples for the range of functions performed by both globular an
  in other living things.
- Identify the primary, secondary, tertiary, and quaternary structure of a pro
  and its associated bonds (hydrogen, ionic, and disulfide bridges) to the pro

CONTENT CHECK

15 minutes

1. For each of the sentences below, half of the sentence is missing. Copy and c
   your exercise book or on a separate piece of paper.

   Proteins are very large molecules made up of...

   ... but they are also
   immune system funct
   metabolic reactions.

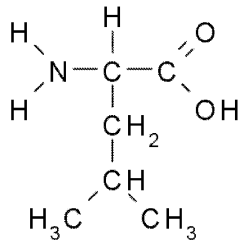
   We can get proteins from eating...

   ... condensation of tw

   Polypeptides are formed by the...

   ... may contain one or

2. Use the terms *R*-group, *Amine group*, and *Carboxylic acid*, to copy and label t
   an amino acid:



   Identify which part of this molecule differs among the 20 naturally occurring

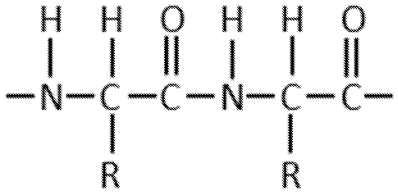
3. From the list of molecules below, identify which are globular proteins and w

   insulin keratin haemoglobin testosterone amylase col
   elastin DNA polymerase glucagon pepsin oe

ESSENTIAL SKILLS & PRACTICE

35 minutes

1. Copy and complete the diagram below to show the breaking of the peptide b
amino acids in a polypeptide molecule through a hydrolysis reaction:



2. Proteins have very specific structures related to their function within the bo
because of their unique structure. Use the passages below to copy and com
Some passages may need to be used more than once.

peptide bonds	**composite 3D structure made up of multiple polypeptide subunits**
α-helix, or β-pleated sheet	**3D structure**
ionic bonds and disulfide bridges	**sequence of amino acids**
strong covalent bond holding adjacent amino acids together	

Structure	Primary (1^{y} / 1°)	Secondary (2^{y} / 2°)	Tertiary
Description			
Type of bonding involved			
Role of bonding			

EXTEND YOUR THINKING

20 minutes

1. Keratin is the main protein which makes up human hair. However, hair is no
protein in the human body. This protein actually has a wide variety of uses a
other parts of the animal kingdom.

   Note that β-keratin may be referred to as *corneous beta-protein* or *keratin-a*
research. Also do not be confused with β-carotene – this is something very d

   a) Do some research to find out the key differences between α and β kera
   vertebrates (think birds, reptiles, mammals…)
   b) Link these differences to the functions of keratin in two contrasting situ

7. BIOCHEMICAL TESTS AND INOR

What you will cover in this homework:

- Recall and explain the use of Benedict's solution in the tests for reducing (usu
  non-reducing (usually disaccharides) sugars, iodine in testing for starch, Biure
  ethanol in testing for lipids.
- The use of quantitative methods for determining the concentration of biomole
- The use of chromatography in biological contexts.
- The importance of inorganic ions in biological contexts

CONTENT CHECK

25 minutes

1. Match each situation to the correct biochemical test.

A.	Determining the presence of reducing sugars in various foods	1.
B.	Determining the presence of starch in various foods	2.
C.	Determining the presence of lipids in various foods	3.
D.	Determining the presence of proteins or polypeptides in various foods	4.
E.	Determining the concentration of starch in a food sample	5.
F.	Isolating and identifying specific polypeptide sequences in a sample	6.
G.	Comparing the vitamin composition of different juice samples	7.

2. A student tested some food samples with Benedict's solution and iodine to
contained simple or complex carbohydrates. Her results are shown in the ta

	Food A	Food B	
Reagent added			**Result**
Iodine solution	Blue-black	Brown	
Benedict's solution	Light blue	Light blue	
Benedict's solution and dilute HCl	Brick red	Brick red	

a) Which food sample(s) contained starch but no sugars?
b) Which food sample(s) contained both starch and sugars?
c) Did any food samples contain sugars but no starch? If so, which one(s)?

3. Ions are molecules or atoms which carry an electrical charge due to having l
Organic molecules contain carbon and may have a long carbon backbone.

a) What is meant by the term *inorganic ions*? Describe in your own words.
b) Identify which of the molecules and chemical species below are **inorga**

H_2O Na^+ Ca^{2+} CH_4 Pu^{4+} OH^- H^+ Cs^+ NH^{4+}
K^+ PO_4^{3-} SO_4^{2-} H_2O_2 U^{4+} F^- Cl^- NO_3^-

4. The list of ions below indicates inorganic ions which are likely to be found w
human cell. Identify one or more ions from this list which match each of the

Copy your answers into your exercise book or onto lined paper by writing co
Note that the ions may be used once, more than once or not at all in your a

Na^+, Ca^{2+}, OH^-, H^+, K^+, PO_4^{3-}, Fe^{2+},

A. concentration significantly affects the pH of the cell
B. likely to be found in high concentrations only in certain cell types
C. important for the co-transport of glucose and amino acids
D. important structural component of nucleic acids, ATP and the cell mem
E. two ions important for maintaining the membrane potential of a cell, p
F. found in high concentrations in the stomach
G. important electrolyte in the body, can help to regulate osmotic potenti
across cell membranes
H. unlikely to be found in significant concentrations in most cells

ESSENTIAL SKILLS & PRACTICE

15 minutes

1. Some of the sentences below can be used to describe how to perform the t
are not in the correct order.

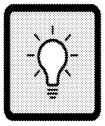
a) Choose which sentences are needed to describe the test for reducing s
respective letters in the correct order.
b) Do the same for the test for non-reducing sugar.
c) Do the same for the test for starch.

A. Repeat the test for reducing sugar. If the result changes from neg
then non-reducing sugars are present.
B. Leave to stand for at least three minutes.
C. Add a few drops of potassium iodide solution to your sample.
D. Place a small sample of the food substance into a test tube or boil
E. If negative, add a small amount of dilute hydrochloric acid to a ne
food substance and heat the mixture for a few minutes.
F. Add Benedict's solution (containing Cu^{2+}) to your food sample.
G. Place a small sample of the food substance into a test tube or spot
H. Observe the colour to determine the presence of reducing sugar: g
red < brown.
I. Add small amounts of solid sodium hydrogen carbonate until the r
J. Heat sample by placing test tube in a 'bath' of hot water.
K. Observe the colour to determine the presence of starch. A positiv

2. Plan an investigation to test the following five food substances for the prese

Substance A: Milk
Substance B: High fructose corn syrup
Substance C: Wholewheat biscuit
Substance D: Instant coffee powder (containing coffee, sugar and whitener)
Substance E: Custard powder

3. Do some research to find out which inorganic ion is important in the followi
   a) Maintaining the resting potential in most nerve cells
   b) Generation of an action potential
   c) Initiating contraction in skeletal muscle
   d) Source of nitrogen for the production of proteins in plants
   e) Central ligand in the chlorophyll molecule
   f) Central ion of the coordination complex in haem
   g) Co-transport of sucrose in plant phloem



EXTEND YOUR THINKING

30 minutes

1. The Biuret test can also be used for testing other biological samples, such as
   In these cases, it is not just the presence of protein which is important but a
   a) How can the basic method to determine the presence of protein in a sa
      an idea of the different concentrations of protein in different samples?
   b) Why might it be important to know the concentration of protein in blo
   c) What other tests might be done alongside the 'concentration' test? Ho

2. Can you explain the reasons for each of the following actions during the tes
   (What is the function of this action? What would happen if it wasn't done at
   a) Heating with dilute hydrochloric acid.
   b) Adding small amounts of solid sodium hydrogen carbonate until the mi
   c) Doing the test for reducing sugars twice, both before heating with hydr
      adding sodium hydrogen carbonate.

8. NUCLEIC ACIDS AND A

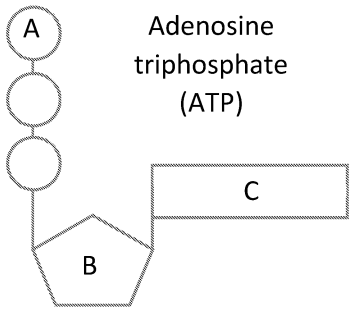
What you will cover in this homework:

- Nucleotides as the monomers of nucleic acids
- Types of RNA
- ADP and ATP as phosphorylated nucleotides
- The structure of DNA and RNA bases, and of ATP
- Base pairing in DNA and RNA and their overall structure

CONTENT CHECK

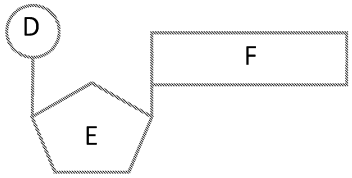
25 minutes

1. The diagrams below show the basic structure of three molecules: a single D
RNA nucleotide and an ATP molecule. Identify each of the structures indica



Adenosine triphosphate (ATP)

Deoxyribonucleic acid (DNA)



2. Copy and complete the table to show the components of DNA and RNA nuc

	Purines	Pyrimidines
DNA		
RNA		

3. There are three different types of RNA molecule found within cells, both pro
These three types have different functions and differ considerably in their s
functions of the three types are given below.

In your exercise book or on a separate piece of paper, draw a simplified dra
the structure of each type of RNA molecule, then match this to the correct n
shown below.

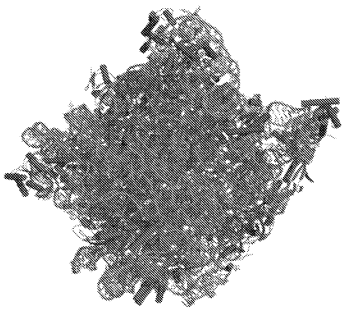
transfer RNA (tRNA)

messenger RNA (mRNA)

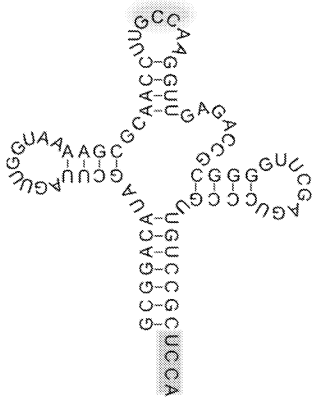
serves as a major structural component in ribosomes

a short chain of RNA complementary to a particular gene; transfers genetic informati from the nucleus to the cytoplasm of a eukaryotic cell

A:



B:

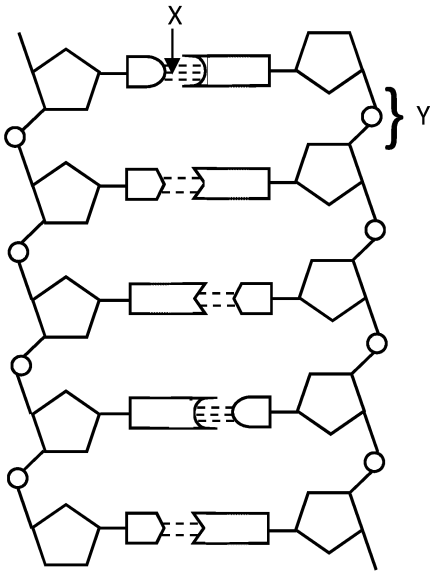


C:

ESSENTIAL SKILLS & PRACTICE

25 minutes

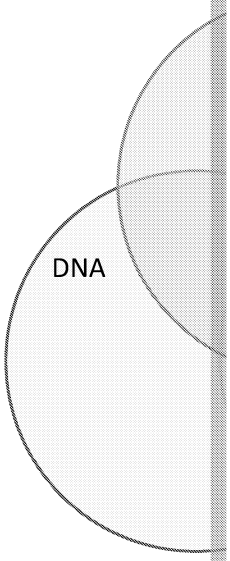
1. The following questions refer to the diagram below.



a) How many nucleotides are in
b) How many guanine bases are
c) How many adenine bases are
d) How many base pairs are in th
e) Name the bonds labelled X an
f) Name the enzyme involved in
What type of reaction joins nu

2. The molecules DNA, RNA and ATP have many similarities, but they also have many differences based on their different functions.

Use a Venn diagram like the one on the right to explore and identify the similarities and differences which exist among the three molecules. **[10]**



EXTEND YOUR THINKING

10 minutes

1. The structure of the three types of RNA is shown on p. 15 in question 3 of th

The rRNA is a very complex-looking molecule, which twists and turns on itse
short sections to hold a fold in its structure. It appears as a tangled mess.

tRNA has a characteristic shape, but two regions (highlighted in the diagram
important. These are the anticodon and the amino acid attachment site.

The mRNA is a straight chain of bases complementary to a section of DNA.

Consider and explain how these differences in the structure of the three mo
various functions.

9. DNA REPLICATION

What you will cover in this homework:

- How organisms achieve genetic continuity between cell generations
- Describing the process of DNA's semi-conservative replication and its constitu
  - unwinding of the double helix
  - complementary base pairing
  - the roles of DNA helicase and DNA polymerase

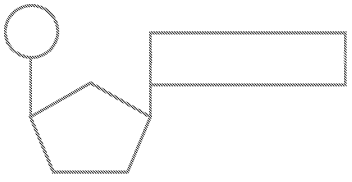
CONTENT CHECK

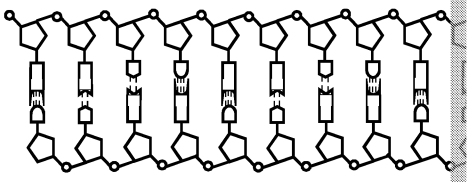
25 minutes

1. Match each of the key terms to the correct definition. Copy the definitions i or onto a blank sheet of paper.

1	3'	**A**	The enzyme which unwinds and separates double helix
2	5'	**B**	The nucleotide base which is able to form other base of interest
3	DNA helicase	**C**	The strand of parental DNA which is used t nucleotides in the daughter strand via com
4	DNA polymerase	**D**	When the DNA strand ends with the -OH g the deoxyribose sugar
5	Complementary base	**E**	Refers to the two strands of DNA in a mole opposite directions (i.e. the nucleotides a
6	Antiparallel	**F**	Refers to the fact that each daughter mole parental strand (50 %) and one new strand
7	DNA template strand	**G**	When the DNA strand ends with the phosp fifth carbon of the deoxyribose sugar
8	Semi-conservative	**H**	The enzyme which joins DNA nucleotides i forming the phosphodiester bond

2. a) The diagram on the left (below) shows a DNA nucleotide. Copy this diag and carbons of the ring of the deoxyribose sugar. Put a circle around th Identify which circle holds the 3' and 5' carbons.
   b) The diagram on the right (below) shows a section of DNA. Representing lines, identify the 3' and 5' ends of each strand. Draw an arrow alongsid the direction in which replication would occur for each strand.



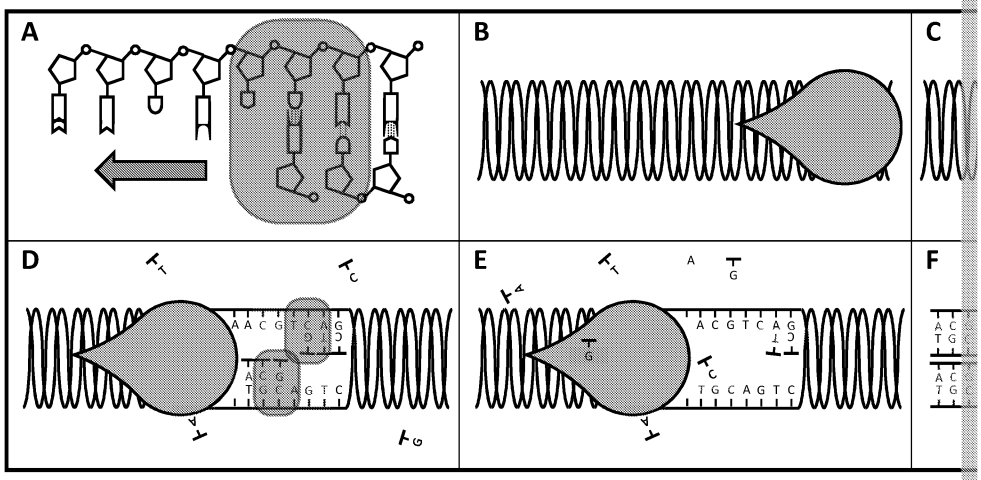


3. Explain what is meant by the term *semi-conservative* regarding the replicatio ensures genetic continuity between generations of cells. Draw a diagram to

ESSENTIAL SKILLS & PRACTICE

25 minutes

1. The diagrams below show the process of DNA replication. Order the diagra
is happening in each one.



2. The following sequence of DNA nucleotides is used as a template strand in D
   - Copy the sequence into your exercise book or onto blank paper.
   - Draw the other template strand of parental DNA.
   - Determine and draw the first six nucleotides to be added to each daug
   - Indicate the location of DNA polymerase and DNA helicase on your dia

3’ A T C G G A T T A T A G C C A T G C A T A G 5’

EXTEND YOUR THINKING

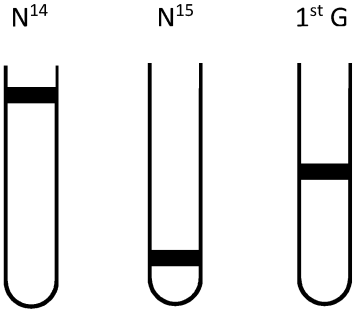
20 minutes

1. Shortly after Watson and Crick theorised the structure of DNA, three possible models were proposed for the replication of DNA. These included conservative replication in which one DNA molecule is entirely parental, and one is entirely new; semi-conservative in which each daughter DNA molecule contains one parental strand and one new strand; and dispersive in which each strand of DNA contains a combination of parental and new DNA. A diagram summarising these models is shown on the right.

   Two scientists, Meselson and Stahl, used isotopes of nitrogen N^{14} and N^{15} to label the DNA in bacteria and determine which of these models was true.

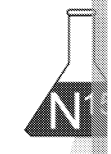
   a) Order the following steps to describe how this experiment was carried out:

      A. This ensured all of the DNA in the *E. coli* bacteria contained only th
      B. After one replication cycle (approximately 20 minutes), DNA was ex the bacteria.
      C. *E. coli* bacteria were cultured in a medium containing only heavy (generations.
      D. After another replication cycle another DNA sample was taken and the first.
      E. Some *E. coli* were then transferred to a medium containing norma
      F. The remaining bacteria were allowed to continue growing in the N
      G. This DNA was analysed using density gradient centrifugation to de the DNA molecules present in the sample.
      H. This process was repeated for a few more generations.

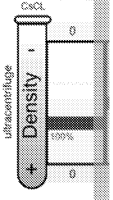


The centrifuge tubes shown on the left, ind DNA containing only N^{14}, DNA containing o generation of bacteria in Meselson and Sta

   b) Which two of the three proposed models of DNA replication are supported by this first result? [2]



The diagram on the right shows what was seen in Meselson and Stahl's experiment. These results clearly supported the semi-conservative replication model.



   c) Draw centrifuge tubes like the ones in the above diagram to show what you would expect to see for the first, second and third generations if the conservative or dispersive models had been true. [4]

[8]

10. PROTEIN SYNTHESIS – TRANS

What you will cover in this homework:

- Recalling the role and structure of mRNA, tRNA and rRNA
- The process of transcription of mRNA from DNA, including the role of RNA p

CONTENT CHECK

20 minutes

1. A student has written a summary of what they have learnt about RNA and t some mistakes.

   a) Identify at least five key terms used in the following passage, giving a d
   b) Identify each error in the passage below, stating how it could be rewor explaining your reasons.

   RNA is a similar molecule to DNA, but it is usually a much shorter ch single strand. An RNA sequence consists of four bases, which may b cytosine (C) or alanine (A). There are three major types of RNA mo functions. rRNA is the type of RNA which is combined with proteins The 'r' stands for ribosomal. mRNA, or messenger RNA, is a short, s which relates to a single gene on the DNA molecule. In all cells, this nucleus and must then move into the cytoplasm of the cell to be tra the cell's ribosomes. Transfer RNA (tRNA) is a molecule which help link the codons (a sequence of three bases) on the mRNA to a specif polypeptide to be formed in the correct sequence.

   During transcription, the DNA strand in the area of a particular ge expose the DNA bases. Complementary RNA bases can then bind wi according to the complementary base pairing – A to U, T to A, C to G then joins the individual RNA bases to form the mRNA molecule. In known as pre-mRNA and contains extra sections of 'nonsense' DNA w done in a process called splicing to produce the mRNA which is used i

ESSENTIAL SKILLS & PRACTICE

15 minutes

1. The DNA strand below is being transcribed.

molecule X

3'

A T T C G A T G C A T G C G T A C G A T G C A T G A C G C T A C G T

U A A G C U A C G U A C G

T A A G C T A C G T A C G C A T G C T A C G T A C T G C G A T G C A

   a) What is molecule X?
   b) Complete the transcription of the mRNA strand.

2. The following clues are in a crossword puzzle to do with genetics. What words could these clues be pointing to?

a) Sequence of three DNA bases [7]
b) All organisms have DNA [9]
c) Some information may be lost every time DNA is transcribed [10]
d) ACGU [3,5]
e) ACGT [3,5]
f) Made from RNA and proteins [8]
g) Coded by a triplet [5,4]
h) Non-coding sequence of DNA [6]
i) Coding sequence of DNA [4]
j) Carries genetic information from DNA to ribosomes [4]
k) Required to join mRNA nucleotides [3,10]
l) Production of mRNA from DNA [13]

EXTEND YOUR THINKING

20 minutes

1. Look at the list of features below. Identify which features match each type o and tRNA. For each feature explain how it is related to the function of the m

- singular, non-folding sequence of RNA
- complex folding with some helical sections
- short repeating A-T rich sequences on either end
- folded into three 'arms' with a short naked section at the end of the mo
- sequence of three bases (ACC) exposed at the 'top' of the molecule

11. PROTEIN SYNTHESIS – TRAN

What you will cover in this homework:

- The link between 'genes' and primary protein structure
- The roles of ribosomes and tRNA in the process of translation
- The process of translation of DNA or RNA sequences into an amino acid sequ

CONTENT CHECK

25 minutes

1. Match each of the key terms to the correct definition. Copy the definitions i onto a blank sheet of paper.

1.	genome	**A**	A molecule used to 'deliver' the DNA c
2.	gene	**B**	The process of using the 'instructions' o generate a complete polypeptide
3.	tRNA	**C**	The complete set of genes that an orga
4.	ribosome	**D**	A small organelle responsible for build
5.	transcription	**E**	Required for recycling RNA bases
6.	translation	**F**	A section of DNA which can be translat a protein or polypeptide
7.	ATP	**G**	The process of converting the DNA cod mRNA molecule
8.	mRNA	**H**	A complex molecule responsible for ma with a specific mRNA codon

2. State the words or phrases which complete each gap below.

The processes of DNA replication, transcription, and _____(a)_____ are sometimes They are the core processes involved in genetic transfer of information and share man these processes, the _____(b)_____ base-pairing between Cytosine and Guanine or Adenine and _____(c)_____, is important for accurately conserving the sequence the genetic code. However, mutations can occur during these processes with a base b _____(e)_____ base being used. Such mutations occur spontaneously and are alway of DNA, known as _____(g)_____ carry the information to construct a single comple the _____(h)_____ structure of a specific protein.

ESSENTIAL SKILLS & PRACTICE

20 minutes

1. Create a storyboard for the process of translation. Begin with a function of n polypeptide (primary protein structure). Include at least four story boxes in

2. The chart to the right provides all the code combinations for translating mRNA codons into amino acids.

   Use this chart to translate the following mRNA sequences:

   a) AUGGGCUCGAUU UACGCUAGCAUU GCGGCUAUGACAC [3]

   b) AUGGCAUUUGCA UGCUAUAUAGCA GUAGCAUCAGAU [3]

   c) AUGGUCAGAUGC AUGACAUAGCAU GACGCGCAUACG [3]

   [9]

First Base	U		C	
U	UUU	phe	UCU	ser
	UUC		UCC	
	UUA	leu	UCA	
	UUG		UCG	
C	CUU	leu	CCU	pro
	CUC		CCC	
	CUA		CCA	
	CUG		CCG	
A	AUU	ile	ACU	thr
	AUC		ACC	
	AUA		ACA	
	AUG	met (START CODON)	ACG	
G	GUU	val	GCU	ala
	GUC		GCC	
	GUA		GCA	
	GUG		GCG	

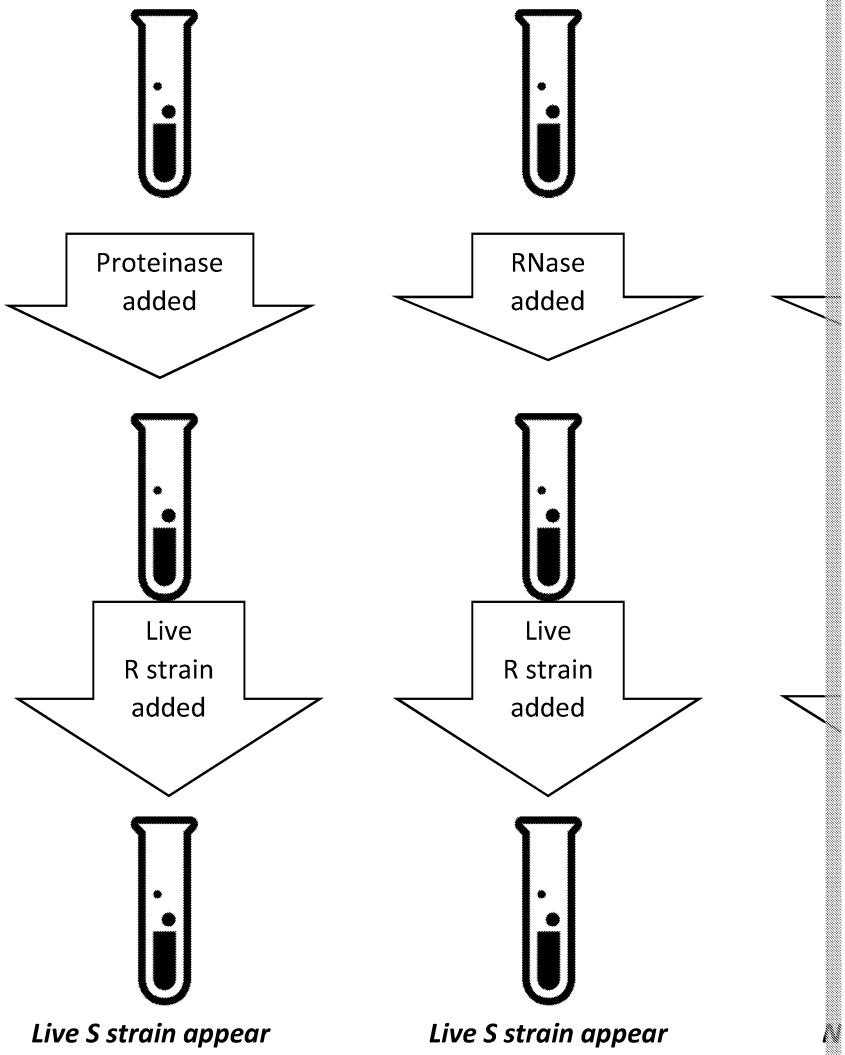
EXTEND YOUR THINKING

15 minutes

1. DNA was discovered in 1860 by Friedrich Miescher, but people did not know until much later. After Griffith's mouse experiment in 1928, people began to responsible for the transmission of information. Three scientists, Avery, Mac experiment to determine an answer to the question: What molecule is respo inheritable information – protein, DNA or RNA?

   Firstly, deadly S strain bacteria were cultured, centrifuged, heat-killed and ho The lipids and sugars from the resulting solution were then removed, before three test tubes.

   The diagram below shows how the experiment worked, and the outcomes.



   a) What was the function of the following?
      i. Culturing the bacteria
      ii. Heat-killing the bacteria
      iii. Homogenising the heat-killed bacteria
      iv. Adding the proteinase, RNase and DNase
      v. Adding live R strain bacteria
   b) What did the results of the experiment show? Explain your answer.

12. ENZYMES

What you will cover in this homework:

- Enzymes as biological catalysts
- Importance of enzymes in intracellular and extracellular processes
- Models of enzyme action
- Factors affecting the rate of enzyme catalysed reactions

CONTENT CHECK

25 minutes

1. Match the keywords to their definitions.

A	Enzyme
B	Substrate
C	Enzyme–substrate complex
D	Lock-and-key
E	Induced fit
F	Optimum
G	Denature
H	Competitive
I	Inhibitor
J	Coenzyme
K	Cofactor
L	Prosthetic group

1	The combination of enzyme an
2	A more advanced model of enz structure changes in response t
3	A molecule which uses the sam enzyme substrate
4	These organic molecules must b activating the enzyme or greatl
5	The 'best' level of a particular va this commonly refers to tempe
6	A molecule which prevents the as it should
7	A simple model of enzyme actio fits perfectly to a specific enzym
8	These inorganic compounds mu activate it or increase its catalyt
9	A protein whose specific structu activation energy of a specific r
10	These molecules bind with enzy ability. This includes both coen
11	The molecule(s) which is/are th catalysed reaction
12	When the enzyme's structure is

2. Using your knowledge of enzymes and proteins, state each word or phrase w passage below:

Enzymes are _(a)_ which function as biological _(b)_. This means that they lower the required for a chemical _(e)_ to occur. This is very important because high-energy co high _(f)_ or high _(g)_, cannot exist safely inside the human body or in other living very complex and specific _(i)_ structures; this is particularly true of the _(j)_ site, th with the substrate. As a result, enzymes are very _(l)_ to the molecules that they act

All enzymes have an _(m)_ temperature, at which they work best. Below this _(n)_ t the lower frequency of collisions between enzyme and substrate. A little above the _(to _(p)_ as first the hydrogen bonds break due to the high temperature, followed by t and _(r)_ bridges. This causes the enzyme to lose its _(s)_ _(t)_ and it can no long Different concentrations of H^+ ions have a similar effect on enzymes, and so all enzym which they can work effectively.

Inhibitors are molecules which prevent an enzyme from binding with its substrate and f They can be _(x)_ inhibitors which are often similar to the substrate and _(y)_ the act binding, or they can be _(A)_ inhibitors which bind to another site on the enzyme cau

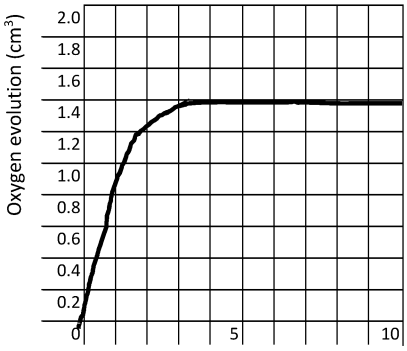
ESSENTIAL SKILLS & PRACTICE

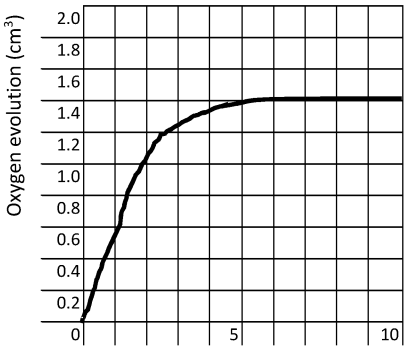
25 minutes

1. The graphs show the evolution of oxygen in an investigation into the rate of a which hydrogen peroxide, H_2O_2, is decomposed by catalase in liver. In the fi placed into 10 ml of 5 % H_2O_2. Sketch the graph into your exercise book, giv Then sketch the other two graphs, identifying which of the given conditions Draw a sketch graph for the other conditions shown below. Identify each o

higher temperature lower temperature extreme pH

higher substrate concentration lower substrate concentration





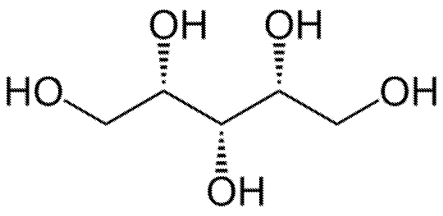
2. The lock-and-key model was both a model and an analogy for the mechanis with the enzyme likened to the 'lock' and the substrate being the 'key' spec fit hypothesis can be explained using the analogy of a sock and foot. Can yo analogy to explain the mechanism of enzyme action?

3. The following phrases are answers to questions relating to enzymes. What a Try to write a suitable question for each of the answers below:

Arctic cod	Denaturation
The rate increases and then suddenly drops	Hydrogen bonds holding the enzyme's 2° and 3° structures are broken
They denature at high temperatures	Enzyme–substrate complex

EXTEND YOUR THINKING

15 minutes



1. Xylitol is a specific isomer with the c used as a sugar substitute or low-ca derived from natural sugar. The dia structure of xylitol.

   a) Xylitol is chemically very similar t is significantly lower. Using you metabolism, suggest why.

   b) While xylitol is marketed as a low-calorie sweetener, the actual calorifi This is partly due to differences in the composition of the microbiota (a organisms) of the intestines. Suggest how the microbiota composition a of xylitol.

2. Choose information from the options below to write a short passage about e
Include the evidence which explains why enzyme theory has changed over t
'conformational selection' has been written for you as an example.

1858 1894 lock-and-key Fischer conformational s

multiple research which has shown that both the enzyme and substrate ar

1974 1998 2004 1990s enzymes are very specific, binding only

Koshland morphological changes in some highly flexible proteins ca

induced-fit hypothesis 1994 the enzyme changes shape to confor

Morphological changes in some highly flexible proteins cannot be explained b
several researchers proposed the conformational selection model, which a
to exist in multiple states, one of which matches the substrate.

13. INVESTIGATING THE RATE OF ENZ

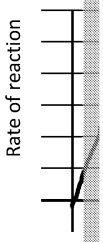
What you will cover in this homework:

- How to carry out an investigation into the effect of a specified variable on t enzyme-controlled reaction
- Select an appropriate format for the graphical presentation of results for a affecting the rate of an enzyme-controlled reaction
- Use a tangent to calculate the initial rate in an enzyme-controlled reaction

CONTENT CHECK

25 minutes

1. Consider that the substrate concentration in an experiment is gradually increased to see the effect on the rate of the reaction. A sketch graph showing the results of this initial experiment is shown on the right. You can see that after a certain substrate concentration there is no change in the rate of the reaction; this is known as the saturation point and happens because all the enzyme molecules are in use at any given moment.



Other conditions are then also changed, one by one. For each situation indi consider how the rate of reaction below the saturation point, and the maxi change under this new condition:

Factor changed	Effect on the rate of react below the saturation poi
Increased enzyme concentration	
Increase in temperature, below the optimum	
Presence of competitive inhibitor	
Presence of non-competitive inhibitor	
Extreme low pH	
Increase in temperature above the optimum	

2. A student is investigating the effect of enzyme concentration on the rate of s They measure the change in starch concentration by adding 0.1 ml of 0.002 % and testing its absorbance using a colorimeter at a wavelength of 610 nm. T student's calculations of the initial rate at different temperatures:

Temp (°C)	Initial starch conc. (%)
0	-0.0% / min
8	-0.0% / min
18	-0.3 % / min
28	-0.85 % / min
38	-2.5% / min

a) Identify three control variables which the student must keep the same f For each one, explain why it is important to control this variable, sugge describe how the student might control this variable.

b) Calculate the temperature coefficient (Q_{10}) for this concentration of am

ESSENTIAL SKILLS & PRACTICE

35 minutes

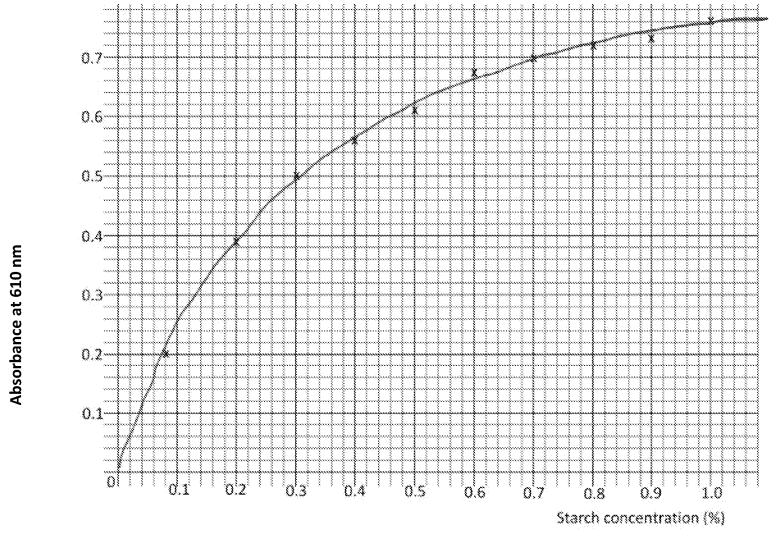
1. A student is investigating the effect of enzyme concentration on the rate of st
They measure the change in starch concentration by adding 0.1 ml of 0.002 %
testing its absorbance using a colorimeter at a wavelength of 610 nm. The ta

Amylase conc. (%)	Initial starch conc. (%)	Starch conc. after 60 s (%)	Starch conc. after 120 s (%)	Starch conc. after 180 s (%)
0	1	1	1	1
1	1	0.85	0.51	0.37
2	1	0.66	0.41	0.25
5	1	0.45	0.20	0.10
10	1	0.20	0.05	0.00

a) Present the data shown in the table above using a graph or graphs (cho
appropriate) to show how the rate of reaction varies under different en
b) Using your graph(s) identify one result which you think might be anoma
c) What could the student do to find out if this result is accurate?
d) What could the student have done differently to make all of their resul

2. a) For each of your graphs, use a tangent to help you calculate the initial r
b) How do the rates compare for the different concentrations?
c) Can you explain the results?

3. The student decided to replicate the results for the 1 % amylase concentrat
be an anomalous result. Their colorimeter readings are shown in the incom
The calibration curve for starch concentration at an absorbance of 610 nm i



a) Use the c
complete
b) Why do y
three rea
this expe
c) Draw a g

Initial starch conc. (%)	60 s		120 s		180 s		
	abs. 610 nm	Starch conc. (%)	abs. 610 nm	Starch conc. (%)	abs. 610 nm	Starch conc. (%)	ab 610
1	0.691		0.613		0.523		0.4
1	0.703		0.624		0.544		0.4
1	0.684		0.617		0.556		0.4
Avg.							

EXTEND YOUR THINKING

20 minutes

1. In order to know how much starch is in a sample solution, using a colorimete generate a calibration curve using the same concentration of iodine solution, starch. In the above example the starting starch concentration in each of the slowly decrease as the amylase acts, turning it into amylose and smaller suga solution, how can we make a calibration curve, suitable to use with the resul described above?

   Assume that in the investigation on rate of reaction, 2 ml of amylase solution solution as well as the 0.1 ml of iodine solution. Think about what concentra be made to make a suitable calibration curve, how you could make these dil the solutions should be prepared in order to get accurate results when using the starch concentration in the samples from the experiment.

14. CELL MEMBRANES

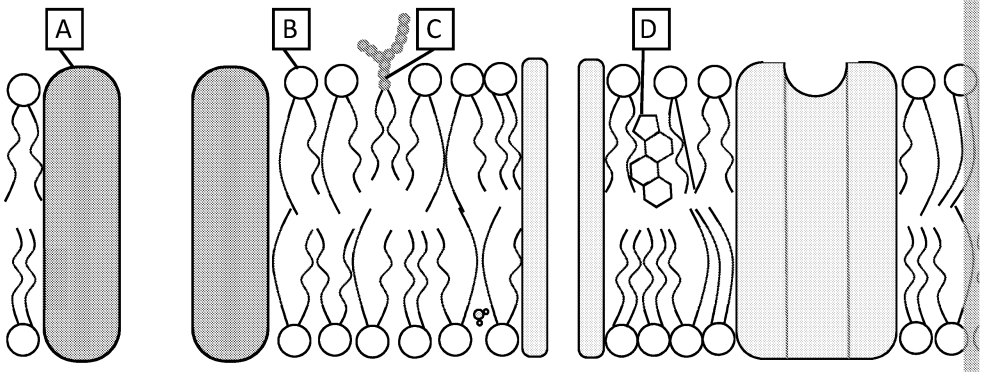
What you will cover in this homework:

- Similarities in the basic structure of cell membranes, including cell-surface me membranes and vesicles.
- The fluid-mosaic model of membrane structure, to include the presence, roles proteins, glycoproteins, glycolipids, and cholesterol.
- The factors affecting the permeability of the cell membrane

CONTENT CHECK

20 minutes

1. The diagram below shows a section from the cell surface membrane. This m the fluid mosaic model because it includes many molecules which are able t another like particles in a fluid.



   a) Identify each of the molecules labelled A–E.
   b) Of these five types of molecule, think about which you would expect to in the cell surface membrane. Put the molecules in order from most flu for your choices.

2. Describe each of the following components of the cell membrane and state
   a) Phospholipid
   b) Cholesterol
   c) Receptor protein
   d) Glycolipid

3. Copy and complete the following table to indicate which components of the in each of the main functions of the membrane.

	Phospholipid	Glycolipid	Intrinsic enzyme protein	Rece prot
Partially permeable barrier				
Site of chemical reactions				
Site of cell communication				

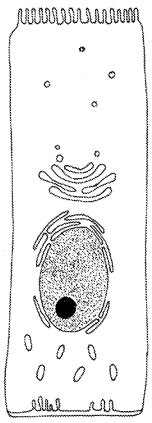
ESSENTIAL SKILLS & PRACTICE

30 minutes

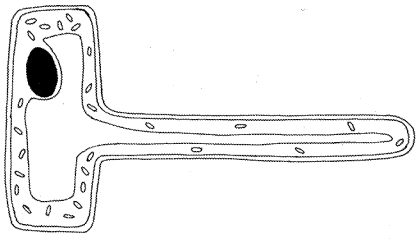
1. The cells shown below are all important for transport in biological organisms

   a) For each diagram:
   - name the type of cell shown
   - state which molecules or types of molecules it is responsible for tr
     where to where

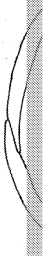
A



B



C –
sec



   b) State and explain two adaptations of the cell membrane which could in
      across the membrane. You may think about the situations given in a) t

2. State and explain how each of the following would affect the permeability o
   a) A higher proportion of saturated fatty acids
   b) The presence of a solvent such as ethanol
   c) Low temperature

EXTEND YOUR THINKING

10 minutes

1. Provide two examples of a reaction which occurs at a cell membrane. One e
   external membrane, i.e. the cell surface membrane. The other example sho
   membrane, i.e. the membrane of a cell organelle. For each example:
   - state/describe the reaction
   - identify the membrane involved
   - identify the membrane components involved in the reaction
   - identify the reactants and the products of the reaction
   - identify the importance of the reaction to the organism involved

15. TRANSPORT ACROSS MEM

What you will cover in this homework:

- The movement of molecules across membranes via passive and active proce
- Practical investigation of factors affecting the rate of diffusion or osmosis
- The effects of various water potentials on plant and animal cells

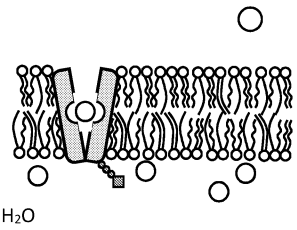
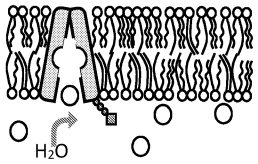
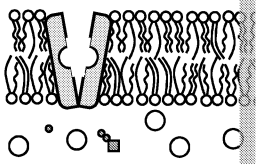
CONTENT CHECK

20 minutes

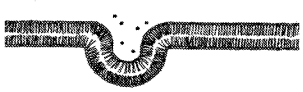
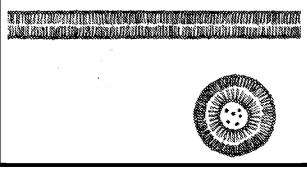
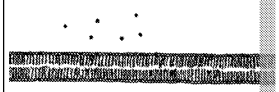
1. Copy and complete the table below to compare the different modes of tran

	Diffusion	Osmosis	Facilitat diffusio
Energy required			
Movement according to the concentration gradient			
Requires specific membrane proteins			
Many molecules can be moved simultaneously			
A very specific mode of transport; only occurs with one type of molecule			
Active or passive			

2. The diagrams below show the active transport of a substance into the cell. T order. Identify the correct order using the letters A–D, writing a short descr shown in each diagram.

A	B	C
		

3. The diagrams below show the process of exocytosis to move molecules out o order using the letters A–D, writing a short description to explain the situati

A	B	C
		

ESSENTIAL SKILLS & PRACTICE

15 minutes

1. For each type of molecule, under the conditions identified in the table, state transport across the cell membrane. Explain your choices.

	Molecule	
A	Water	Down th
B	Ions	Against th
C	Ions	Down th
D	Lipid-soluble vitamins	Down th
E	Water-soluble vitamins	Down th
F	Large soluble molecules (e.g. sugars)	Against th

2. A student uses cores of potato to investigate osmosis in different concentra cores are made using a core borer of 8 mm diameter. The student weighs t immersing the potato cores in salt solution. Their results are shown in the t

   a) Assume that each potato core was cut to a length of 2 cm. Calculate th each experiment.
   b) Identify three other variables which the student must take care to cont
   c) Copy and complete the results table.

Salt concentration (M)	Mass before immersion (g)	Mass after immersion (g)	Total change in mass (g)	C
0	0.63	0.84		
	0.65	0.83		
	0.67	0.79		
0.1	0.61	0.62		
	0.59	0.63		
	0.72	0.65		
0.2	0.64	0.59		
	0.68	0.62		
	0.69	0.61		
0.3	0.63	0.55		
	0.58	0.53		
	0.69	0.57		

   d) Draw a graph of the results. What do you notice?
   e) Using your knowledge of osmosis, explain the results of the investigati water potential, hypotonic, hypertonic, and isotonic.
   f) Using your graph, estimate the concentration of salt solution which is i the potato cells.

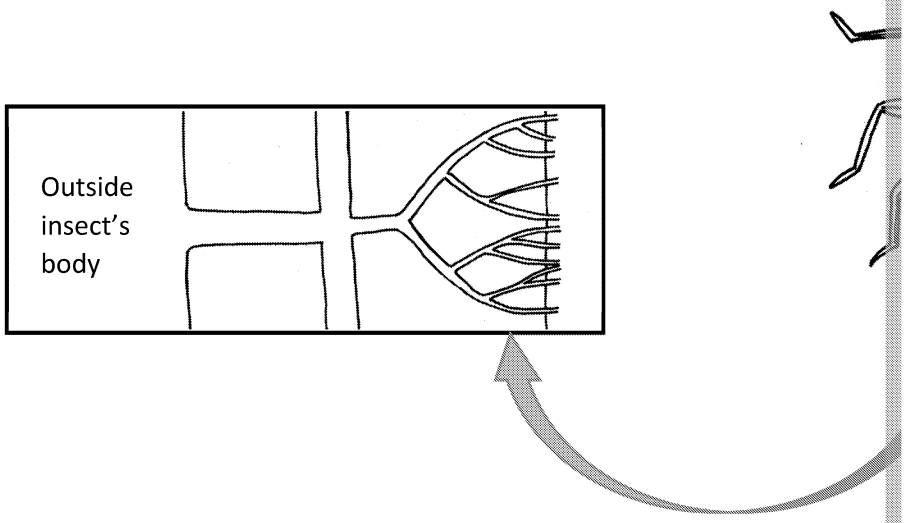
EXTEND YOUR THINKING

10 minutes

1. Compare and contrast the processes of facilitated diffusion and active trans

2. Root hair cells contain many mitochondria to supply the energy necessary fo and other substances from the soil into the cell. However, most mineral an passively. Can you explain these observations?

3. The diagram shows a cross section through the body of an insect, and a clos
tracheal system.



a) By what mode of transport does oxygen enter the insect's cells?
b) The insect does not have lungs or a mass transport system (like our blo
oxygen to its cells or to expel carbon dioxide from its body. Suggest wh
c) During the carboniferous period of Earth's history the oxygen concentra
around 35 % – much higher than it is today. At this time arthropods, in
be much larger than those we find today; for example, one dragonfly h
Giant spiders, millipedes and other arthropods are also known to have
of the modes of transport, and the way in which insects breathe (as ou
insects grew to be so large during this time but can no longer exist toda

16. MITOSIS

What you will cover in this homework:

- The cell cycle and its regulation by checkpoints
- The main stages of mitosis
- Recognition of the stages of mitosis in plant tissues examined under a ligh
- The importance of mitosis in life cycles, including growth, tissue repair and

CONTENT CHECK

15 minutes

1. State the words or phrases which complete each gap below:

All cells arise from other cells, via some means of cell _(a)_. Viruses are non-living cell in order to replicate. Prokaryotic cells usually divide by a process called binary has a number of important functions. These include _(c)_ reproduction, growth, tis or damaged _(d)_.

Eukaryotic cells usually divide by a process called _(e)_. Gametes (sex cells) are th alternative process of _(f)_. Mitosis is part of the _(g)_ _(h)_, which includes the cytokinesis. Mitosis, the division phase, consists of prophase, _(j)_, anaphase, and divisions', is the longest phase of the cell cycle; it consists of the stages of G_1, S and stands for _(n)_. This is when DNA _(o)_ occurs. _(p)_, meaning 'cell separation' the beginning of the next. In this phase the parent cell _(q)_ into two new daughte _(r)_ to the other and to the parent cell. The timing of the cell cycle is controlled b division can lead to _(t)_.

2. Match each phase of the cell cycle to the correct description. Copy the co book or on paper.

A. Interphase	
B. G_1 phase	
C. S phase	
D. G_2 phase	
E. Mitosis / Mitotic phase	
F. Prophase	
G. Metaphase	
H. Anaphase	
I. Telophase	
J. Cytokinesis	

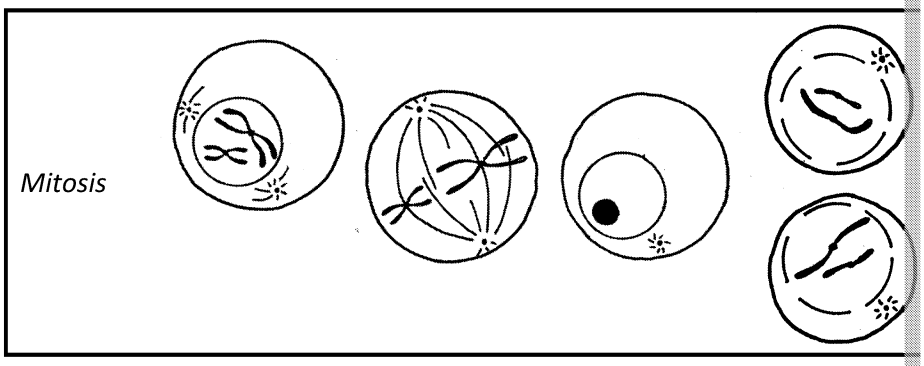
1.	Chromosomes are lined up along the e
2.	Spindle fibres have retracted to the ce envelope starts to form around each n
3.	The first growth phase. Occurring in th volume of the cell increases and organ
4.	The beginning of mitosis. Chromosom the nuclear envelope starts to dissolve
5.	The cell membrane pinches in the midd between the two daughter cells.
6.	The part of the cell cycle in which cell d encompassing all phases between prop
7.	The second growth phase, occurring at continues to gain volume, while cell co ready for the mitotic phase.
8.	The major phase of the cell cycle in wh cytoplasm, and replicates organelles an
9.	Replication of DNA occurs during this s
10.	The spindle fibres move back towards t two sister chromatids of each chromos

ESSENTIAL SKILLS & PRACTICE

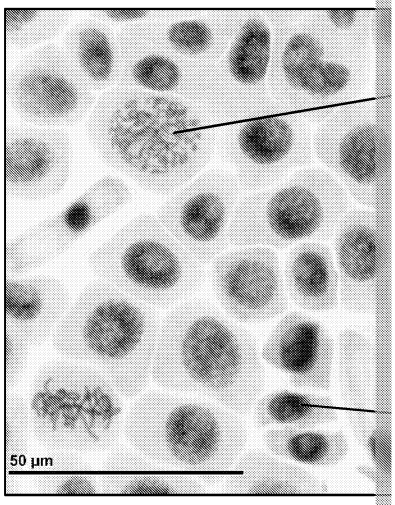
20 minutes

1. Decide the order in which the diagrams should be placed to describe the pro

   In your exercise book:
   - Copy the scientific drawings for the process with the diagrams drawn in
   - describe what is happening in each diagram
   - identify the phase of mitosis for each of the diagrams



2. The photomicrograph on the right shows a root meristem squash from an onion.



   a) Identify the stage of the cell cycle for each of the cells labelled A–E. [5]

   A mitotic index is a measure of the rate of cell division. It can be calculated from the number of cells undergoing mitosis in comparison to the total number of cells in the sample. It can be useful for researching the growth rates in various tissues, and for identifying certain diseases; for example, abnormal values can indicate a likelihood of cancer. Normally, human tissue samples yield values between 1 and 10 depending o tissue sample. Higher values would indicate tissue repair or cancerous cell g

   b) The tissue sample shown has a mitotic index value of 12. How does thi for human cells? Is it similar or different? Can you explain this observa

17. MEIOSIS

What you will cover in this homework:

- The significance of meiosis as a source of genetic variation in the life cycles
- The stages of the process of meiosis
- Non-disjunction during meiosis and associated genetic disorders

CONTENT CHECK

15 minutes

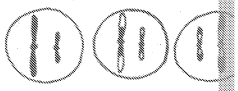
1. Match the key terms below with their correct definitions. Write the words w definitions in your notes or exercise book.

A. Haploid	1. When the sister chromatid during anaphase
B. Diploid	2. When sections of the homo during metaphase 1 of mei
C. Homologous chromosomes	3. Having half the number of c (only one copy of each chro
D. Chromatid	4. A replicated chromosome is joined by a centromere
E. Crossing over	5. Having two complete sets o
F. Non-disjunction	6. Chromosomes of a pair, wh of genes

2. The diagrams below depict the process of meiosis.

A 

B 

C 

E 

F 

G 

a) Use the letters A–G to put the diagrams in the correct order.
b) Identify which stage of meiosis is shown in each diagram A–G.
c) Describe what each diagram shows.

ESSENTIAL SKILLS & PRACTICE

15 minutes

1. For each of the sentences below, half of the sentence is missing. Copy and c
your exercise book or on a separate piece of paper.

... may lead to seri
Down's syndrome, o

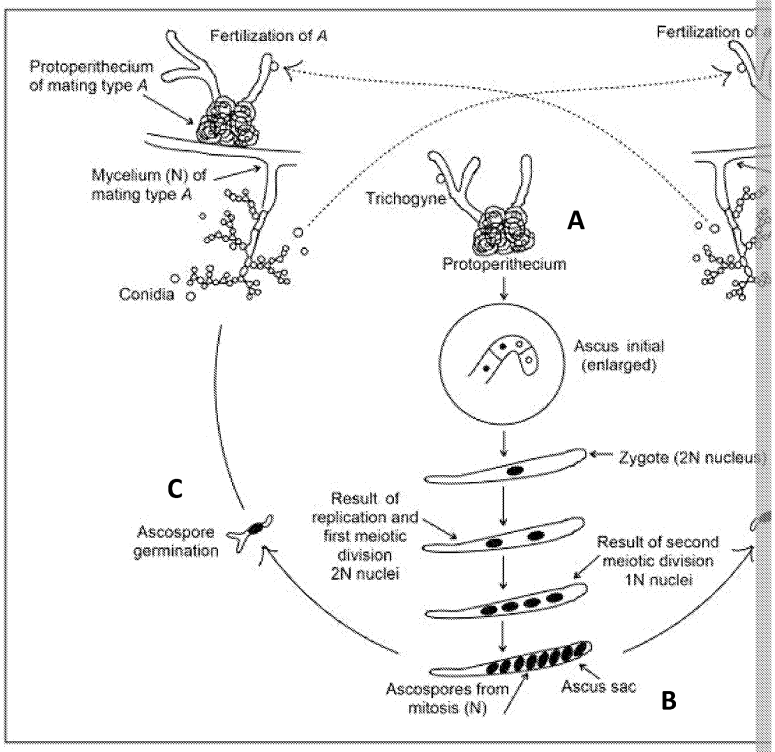
Crossing over during meiosis...

... ensures genetic v

Independent assortment of sister chromatids...

2. The diagram below shows the complex life cycle of a fungal species.

a) Determine whether the fungus is in a haploid or diploid state at each o
b) Between which two life stages does meiosis occur?



EXTEND YOUR THINKING

15 minutes

1. Create a mind map to compare and contrast mitosis and meiosis. Be sure to
importance of each process in a range of organisms.

18. STEM CELLS AND CELL DIFFERE

What you will cover in this homework:

- Specialisation of cells for particular functions
- Biological organisation of cells, tissues, organs and organ systems
- Differentiation of stem cells in adult plants and animals

CONTENT CHECK

20 minutes

1. Biological systems have various levels of organisation. Each of the following body, which is an example of an organism. Create a table to indicate which belongs to.

musculoskeletal system squamous epithelial cell biceps muscle tong neutrophil erythrocyte digestive system cartilage ciliated epi

2. Match the following specialised cells to their specific functions:

A. Sperm cell	1. To form a membrane or barrie transport can occur
B. Palisade cell	2. Works in synchronisation with muscle contraction
C. Squamous epithelial cell	3. To absorb sunlight energy for
D. Ciliated epithelial cell	4. Alters its shape to allow or dis out of the leaf
E. Root hair cell	5. To deliver genetic material in from the male's testis to the u fallopian tube of the female
F. Guard cell	6. Transport of sugars and other plant to other parts of the pla
G. Muscle cell	7. To move mucus or other thick of the body. Especially import
H. Phloem sieve tube	8. Absorption of minerals and wa

ESSENTIAL SKILLS & PRACTICE

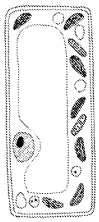
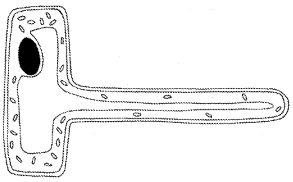
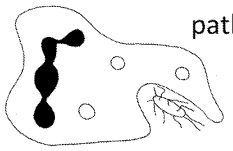
20 minutes

1. State the words or phrases which complete each gap below.

Stem cells are _(a)_ cells which are able to become different types of cell that are mo usually occurs after cell division in a process known as _(b)_. The very early embryo unspecialised stem cells similar to the original cell, the _(c)_. These cells undergo m rounds of differentiation to form the more complex _(d)_, and eventually a fully funct when its mother gives birth. In adult organisms _(e)_ cells are quite rare, but still ex bone _(g)_. Both erythrocytes and _(h)_ form from the differentiation of stem cells exist in the _(i)_ of plants, where they will differentiate into xylem vessels and phloe

Stem cells also have multiple uses in modern _(l)_. Developmental biology and stem recent years, with treatments for many _(m)_ and terminal diseases becoming theore potentially possible. Additionally, stem cells can already be used to replace or repair of whole functioning _(n)_ for transplant may be an option in the near future. Stem c _(o)_ medicine and treatments, as an organ created from your own cells will not be re

2. For each of the specialised cells below, identify two ways in which the cell h
specific function.

 Palisade mesophyll cell (found in the top layer of a leaf)	Root hair cell 	Neutrophil (white b cell which patho 

EXTEND YOUR THINKING

15 minutes

1. Create either a poster or a mind map to introduce other students (perhaps t in Years 7–9) to the concept of biological organisation. If you can, start with nutrients as your smallest level of organisation and go all the way up to an e each level and give examples and images to aid understanding.

19. EXCHANGE SURFACES

What you will cover in this homework:

- The importance of having a large surface area in biological contexts
- Calculating surface-area-to-volume ratios
- Common adaptations of exchange surfaces
- The components of the mammalian gaseous exchange system

CONTENT CHECK

25 minutes

1. The concept of having a high surface-area-to-volume ratio is a common the
transport of molecules from one region to another region is important for m

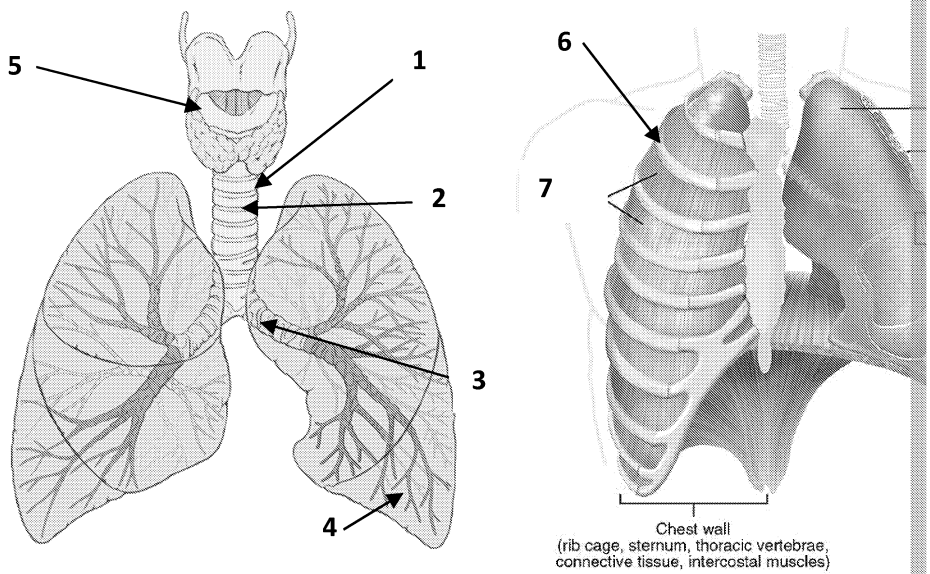
   a) For each of the organism categories listed, identify one situation in whi
across a membrane or barrier is important. Make sure you identify the
well as where the molecule is being transported from and to. One exa

Organism	Situation in which transport of
Mammal	Transport of oxygen from air in t
Fish	
Insect	
Plant	
Mycorrhizal fungus	

   b) For each of the situations listed, state how the large surface-area-to-vo
mentioning the adaptation and how this adaptation increases the surfa

Situation	How high surface are
Epithelial cell of the small intestine	
Root hair cell	
The leaf of a shade-tolerant plant	
An elephant's ears	

2. The diagram below shows the human gas exchange system. Identify the pa
feature, write a sentence describing its function in the gas exchange system

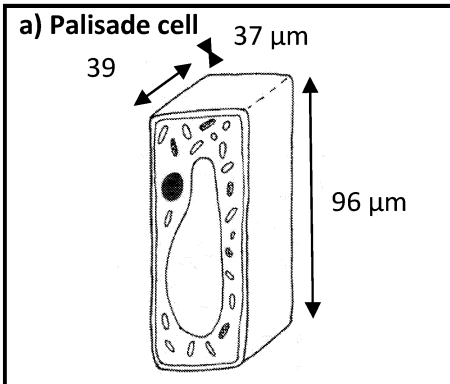


ESSENTIAL SKILLS & PRACTICE

20 minutes

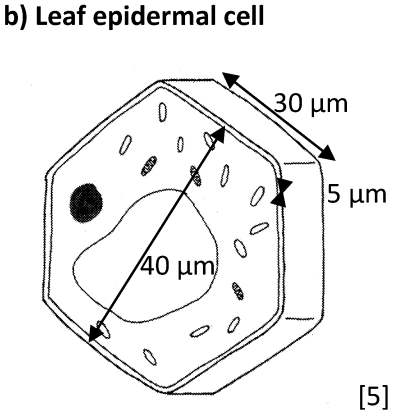
1. Use the measurements given in the diagrams below to estimate the surface ratio of the cells.

a) Palisade cell



[5]

b) Leaf epidermal cell



[5]

Note: *the area of a hexagon can be calculated using the formula:* $A = \frac{6}{2}ah$, *where a = the length of one side, and h = the distance between the centre of the hexagon*

2. A student is planning to investigate the effect of the surface-area-to-volume diffusion. They are given two 4 cm cubes of agar. From this the student mu SA : V ratios to use in their testing.

   a) Copy and complete the table below to indicate how the student should produce at least four different SA : V ratios.

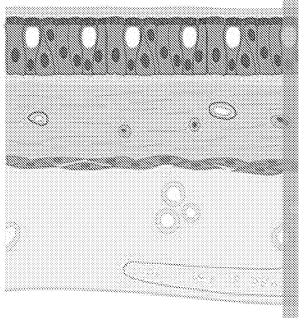
Agar diagram			8 ×
Total surface area (cm^2)			
Total volume (cm^3)			
SA : V (cm^2/cm^3)			

   b) Identify three control variables that the student should try to keep con describing how the variable could be controlled.

EXTEND YOUR THINKING

15 minutes

1. The diagram shows a cross section of the bronchial wall.



   a) Draw an enlarged diagram of a single goblet cell. Be sure to include any organelles you think should be in this cell. [4]
   b) Identify at least two specialised features of this cell and explain their importance for the cell's role in maintaining normal healthy function of the respiratory system. [5]
   c) The epithelial cells in this part of the lungs are quite different from those in the alveoli. Identify and explain two differences between the epithelial cells of the cells of the alveoli.
   d) State the identity of X. What is its function in the bronchus?

20. GAS EXCHANGE

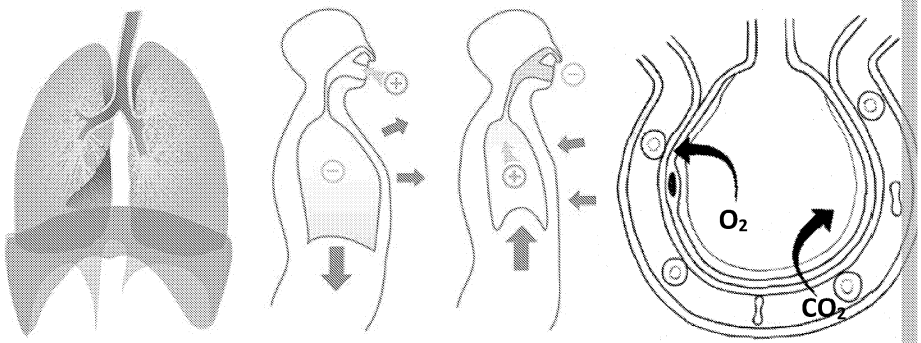
What you will cover in this homework:

- Ventilation in mammals, including the concepts of tidal volume, vital capacity
- Ventilation and gas exchange in bony fish
- Ventilation and gas exchange in insects

CONTENT CHECK

15 minutes

1. Order the diagrams below to show the mechanism of breathing and gas exc
   For each diagram describe what is happening.

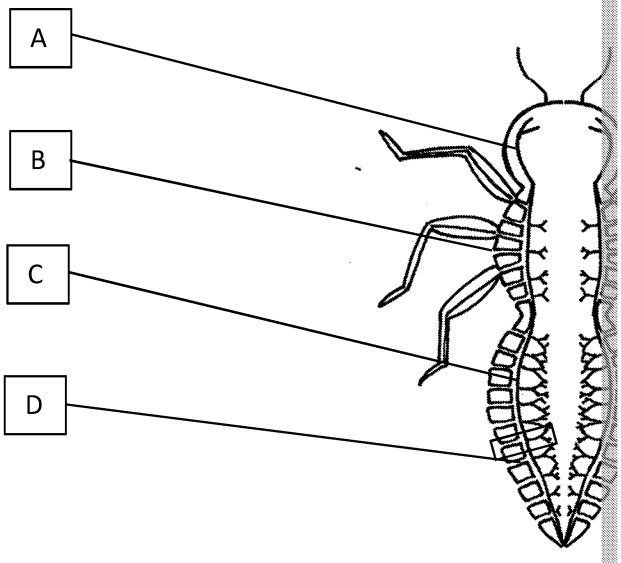


A **B** **C** **D**

2. a) State the words or phrases which complete each gap below:

Insects do not have a mass transport system or __(a)__ to ensure that their cell
respiration. Instead, they rely on _(b)_ to bring oxygen directly from the enviro
diffusion is allowed to occur directly between the outer surface of the insect and
likely to _(c)_ as water would diffuse just as readily as oxygen and carbon dioxi
have an impermeable _(e)_, made of chitin. Gas exchange between the air and
through a vast network of small _(f)_ tubules, known as __(g)__. These tubes
circular openings called _(h)_. There is also a large tube running the length of
tracheal trunk.

   b) Identify each of the structures labelled A–D on the diagram of the insec
   system below.

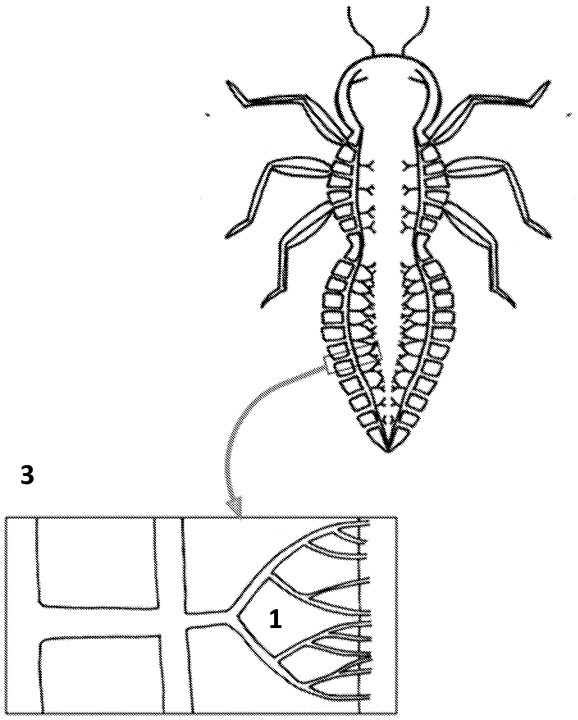


ESSENTIAL SKILLS & PRACTICE

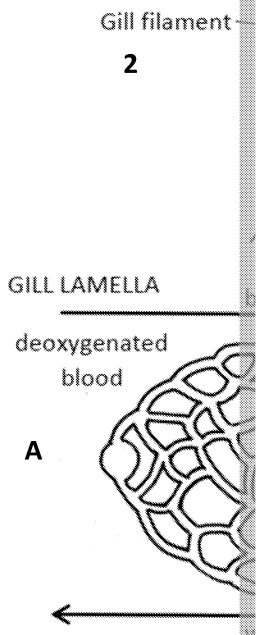
20 minutes

1. The diagrams below show gas exchange surfaces in a variety of organisms. T
diagrams identify some common features of gas exchange surfaces, while th
special adaptations.

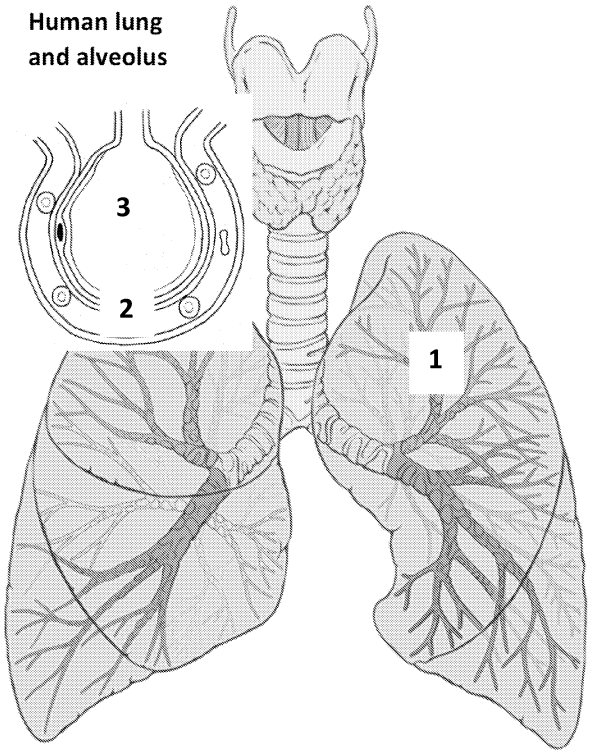
The tracheal system of insects



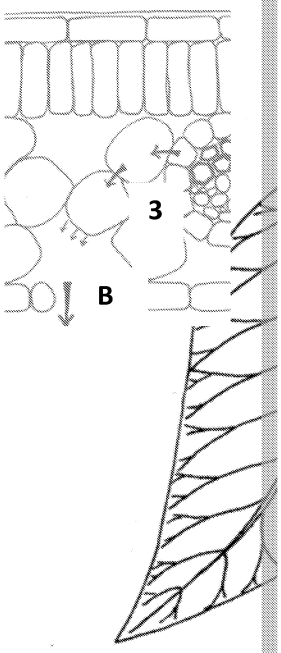
The gills of a fish



Human lung and alveolus



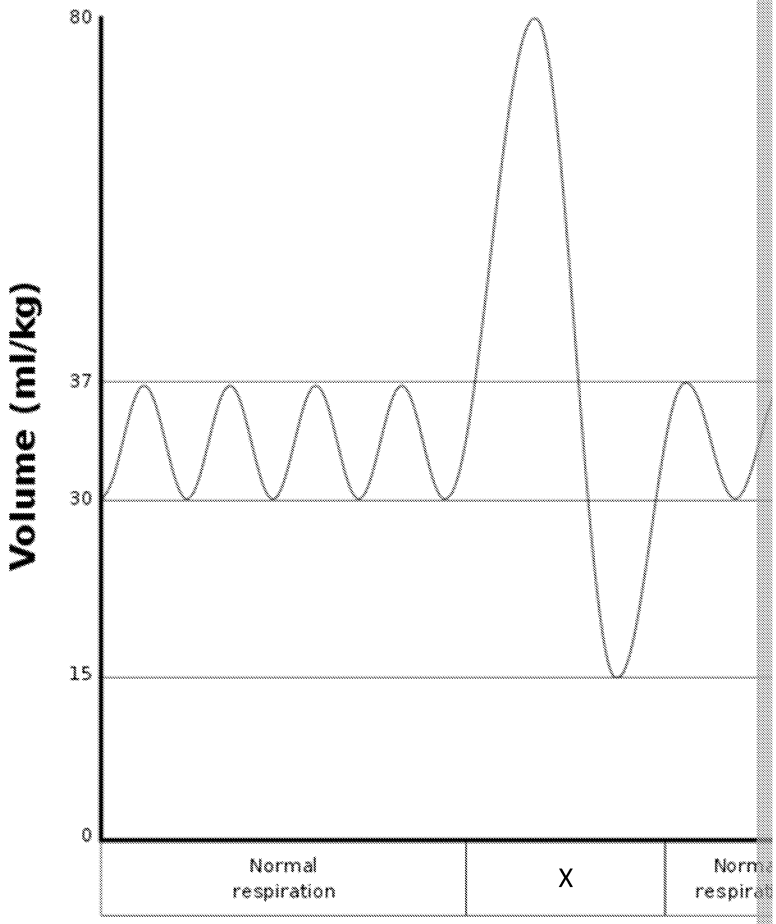
Leaf



a) Describe the common adaptations indicated by numbers 1–3.
b) Identify the specialist adaptations indicated by letters A and B.

2. a) Towards the end of the Palaeozoic era, atmospheric oxygen concentrat
today, at around 30–35 %. Insect 'gigantism' has been observed in the
Explain why insects and other arthropods were able to grow so large du
b) If insects did not have an impermeable exoskeleton, they would be able
skin just like frogs over-wintering in a pond. Why has this trait not evo

3. The graph below shows the readings from a spirometer.



a) What is a spirometer?
b) What is happening in section X of the graph?
c) In terms of A, B, C and D, identify:
   i. vital capacity
   ii. tidal volume
d) Assuming that the graph shows 1 minute, state the normal breathing ra
e) Describe two ways in which oxygen uptake is increased during exercise
f) Explain how regular exercise can gradually increase the ability of the lu

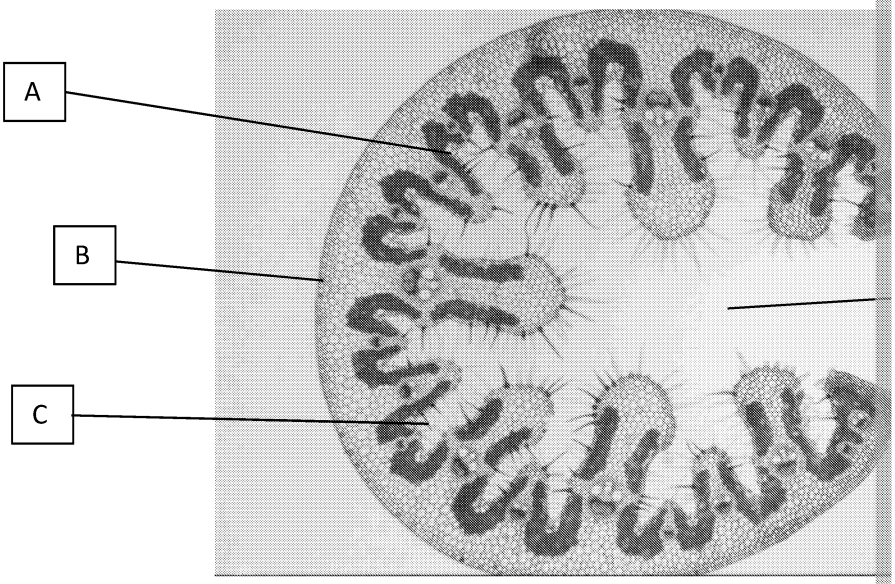
EXTEND YOUR THINKING

15 minutes

1. This unit focuses on gaseous exchange in animals. The ability to transfer yo unfamiliar contexts is a strong indicator that you have developed an in-dept Try to answer the following questions, considering this topic in the context o

   All plants have a trade-off between allowing sufficient gas exchange for resp while also not losing too much water. Most plants can achieve balance by h leaf surface (as much evaporation would occur here without such a protecti which live in environments where water is not easily obtainable must devel prevent drying out and death.

   The image below shows a cross section of marram grass as taken under a lig a xerophytic plant found on sand dunes in the temperate climate zone.



   a) Explain why marram grass needs to have xerophytic adaptations, despi across most of its range.

   b) i. Match each of the labels A–D to the following features of marram g
      1. Rolled leaf
      2. Stomata in 'sunken' pits
      3. Trichome – hairlike structure on the underside of the leaf surro
      4. Thick waxy cuticle

      ii. Each of these features is important for reducing water loss from th Using your knowledge of gaseous exchange, suggest how each fea to reduce water loss.

21. CIRCULATORY SYSTEM

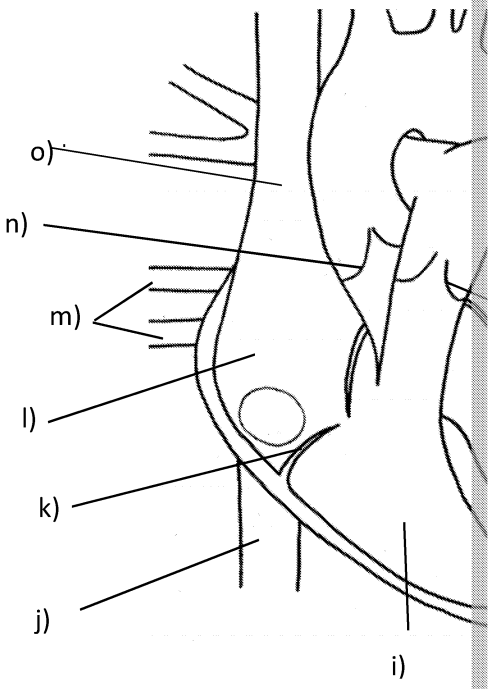
What you will cover in this homework:

- The need for transport systems in larger organisms
- The different types of circulatory system in a range of animals
- The structure and function of various components of the mammalian circulato
- The bodily fluids of blood, tissue fluid and lymph
- The cardiac cycle and its coordination
- Haemoglobin and the dissociation curve

CONTENT CHECK

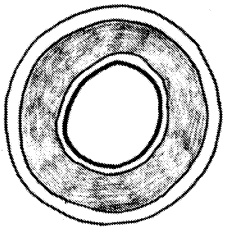
20 minutes

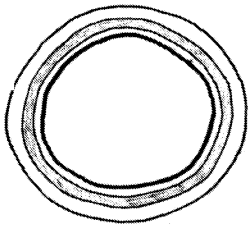
1. The diagram on the right shows the human heart. Identify the labels on the diagram; these include the names of the heart chambers, valves and the major blood vessels feeding into and out of the heart. **[15]**

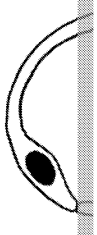


2. Certain molecules and cells are able to move into and out of the capillaries. **tissue fluid** and **lymph** are all connected and have many similarities. These f differences. Identify which of the following descriptions matches each of th
   a) Mostly water; contains small molecules such as nutrient monomers
   b) A little over 50 % water; contains many cells, mostly red blood cells, as hormones and plasma proteins
   c) Mostly water; contains lymphocytes, lipids and a few proteins
   d) Mainly water; may contain a few phagocytic white blood cells and prot important for exchange of molecules (e.g. oxygen, carbon dioxide, othe and out of cells

3. The diagrams below show the three different types of blood vessel.
   a) Identify each blood vessel.

   i. 

   ii. 

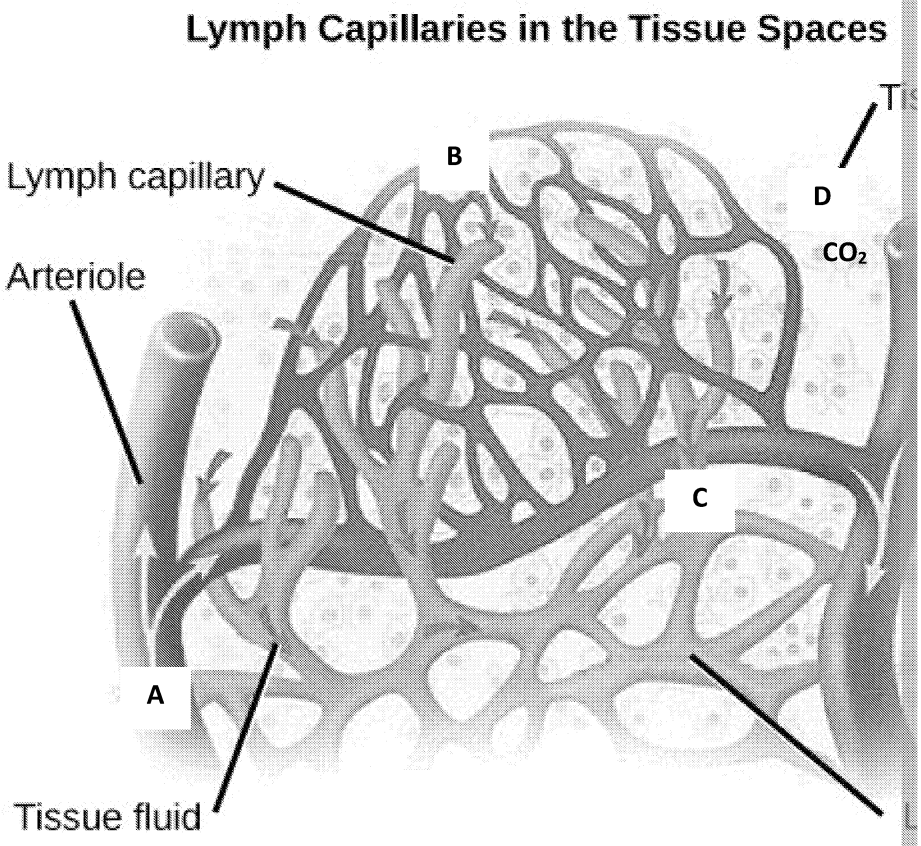
   iii. 

   b) Use the diagrams to help you describe the key differences in the struct

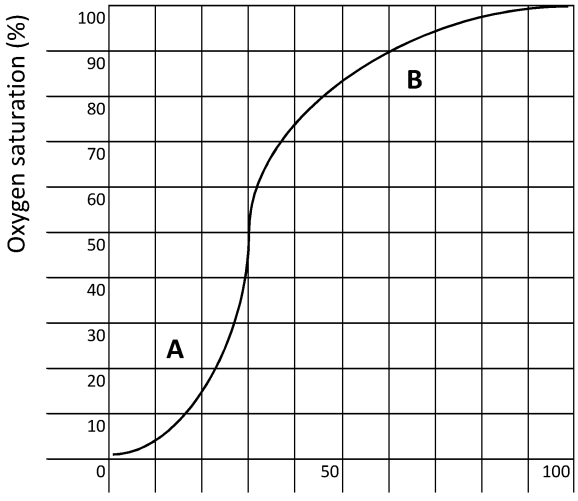
ESSENTIAL SKILLS & PRACTICE

20 minutes

1. The diagram below shows a capillary bed and the associated lymph vessels. Describe what is happening at points A, B, C and D.



2. The graph below shows the normal haemoglobin oxygen dissociation curve



a) Explain what is sh
A and B.

b) With reference to
oxygen is released
which are actively

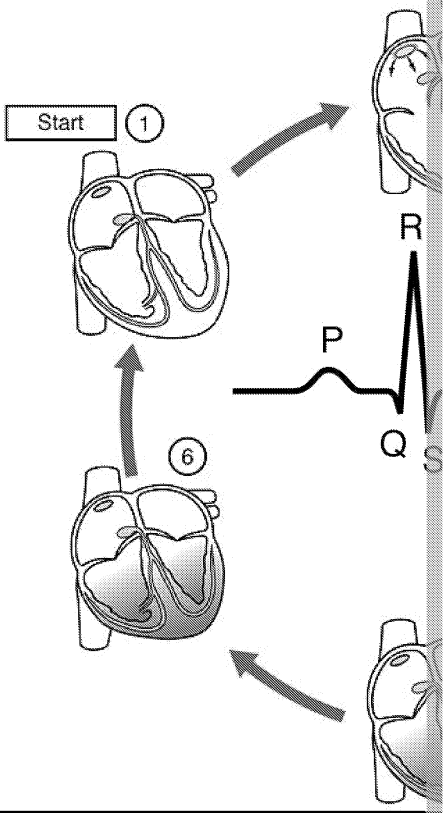
c) Sketch the graph
   i. To your sketch
   shows what y
   were high lev
   ii. Whale haem
   affinity for ox
   time betwee
   show what yo
   dissociation c

3. Copy and complete the table to indicate the type of circulatory system found

Animal/Group	Type of circulation		
	Closed	Open	Si
Human			
Mammal			
Bird			
Bony fish			
Insect			

4. The diagram on the right shows a complete cardiac cycle.

a) Copy and complete the table below to show the status of the valves and pressure changes associated with various stages in the cycle. [10]



Stage	Atrioventricular valves	Semilunar valves	Atrial pressure	
	closed	open		
3/R				
4/S	closed	closed		

b) What is the sinoatrial node, and what is its function in circulation?

c) How does the function of the sinoatrial node differ from the function o

EXTEND YOUR THINKING

15 minutes

1. Describe the initiation and coordination of a normal heartbeat. You should u your answer: Purkyne tissue, myogenic, sinoatrial node, and atrioventricula
2. Compare and contrast the circulatory system of a mammal and a fish. Expla differences for mammalian organisms.

22. TRANSPIRATION

What you will cover in this homework:

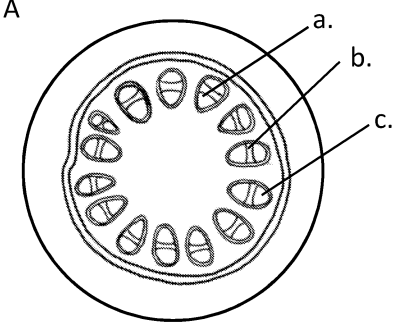
- The structure and function of xylem and phloem
- The process of transpiration and transport of water in a plant
- Investigating the rate of transpiration

CONTENT CHECK

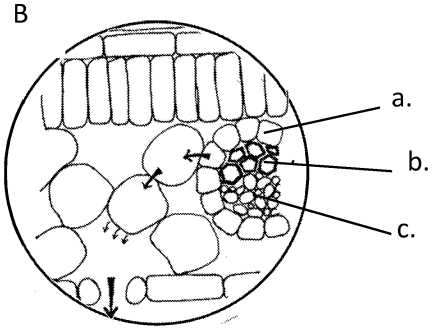
20 minutes

1. a) Identify which part of the plant is shown in each of the diagrams A–C.
   b) For each diagram, identify the correct location (a, b or c) for the xylem transporting water and dissolved minerals up the plant.

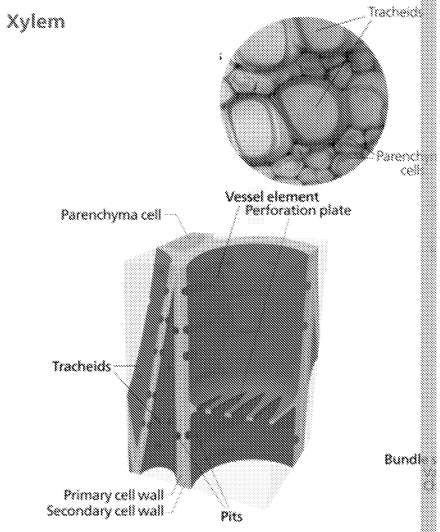
A



B



2. The cells of the xylem and phloem are highly adapted to their function. The diagrams to the right depict these two structural features of plant anatomy.
   a) Identify two features of xylem vessels shown on the left-hand diagram, explaining how each feature helps these cells to carry out their function. [4]
   b) State and explain a feature of xylem which helps it to carry out its function, but which is not shown on the diagram. [2]
   [6]



3. State the words or phrases which complete each gap below.

Transpiration is the _(a)_ of water from the air spaces of a leaf via the _(b)_. These open to allow _(c)_ _(d)_ to diffuse into the leaf for photosynthesis. At the same time, oxygen produced in the process of _(e)_ and water vapour _(f)_ the leaf via diffusion. As water leaves the plant, more water is drawn up the xyl transpiration stream due to the _(g)_ of water molecules. Several factors affect the r measured experimentally using a piece of lab equipment known as a _(h)_.

ESSENTIAL SKILLS & PRACTICE

20 minutes

1. The leaf of a plant has two main methods for reducing water loss. These are important to keep the plant cells turgid and healthy.

   a) Identify and describe these two mechanisms. [4]
   b) One of these two methods is a permanent barrier to water loss, while the other can be controlled (being either 'open' or 'closed' depending on conditions inside and outside the plant).
      i. Why is it necessary to allow the loss of water from the leaf? [1]
      ii. Under what conditions is this feature 'closed'? [1]
      iii. State and explain the effect this has on the rate of photosynthesis. [2]

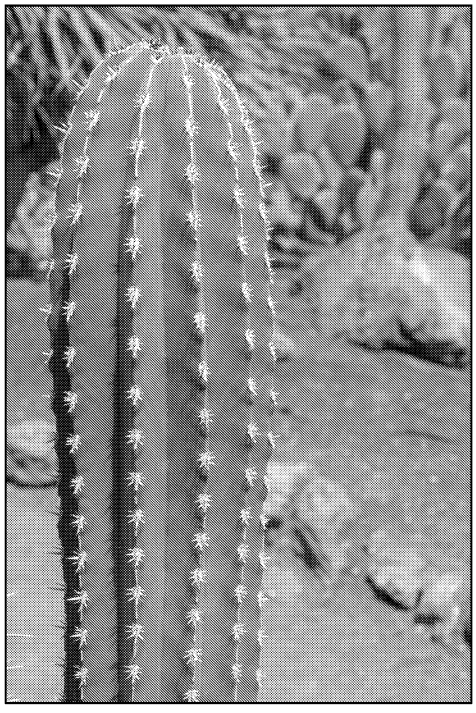
   [8]

2. In the roots of the plant, there are two pathways that water can take to reach the xylem vessels in the vascular bundle.

   a) Name these two pathways. [2]
   b) Copy and complete the table below, which compares these two pathways. [6]

Water passes into the root hair cell, through the cell cytoplasm and plasmodesmata	
via osmosis	
	more rapid
	blocked by the Casparian strip

[8]



EXTEND YOUR THINKIN

20 minutes

1. The cactus is a common example o water conditions.

   a) What is the name given to plan
   b) Identify two adaptations of the in a low-water environment. E how it helps the cactus to surv
   c) Some of these adaptations are of trees which typically live at areas which receive quite high why pine trees may need adap water loss.

2. Think about how transpiration occ

   Identify **four** factors which affect t For each one, explain the impact o rate of transpiration.

23. TRANSLOCATION

What you will cover in this homework:

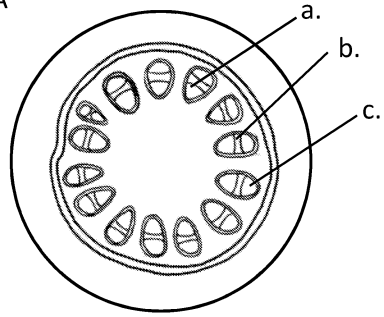
- The structure and function of xylem and phloem
- The mass flow hypothesis and experiments used to investigate the movemen

CONTENT CHECK

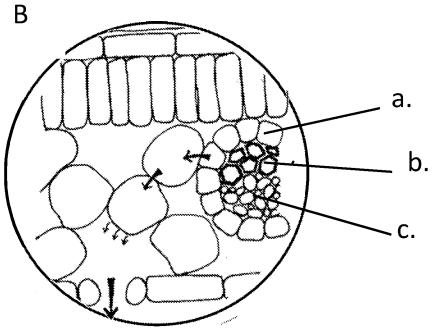
15 minutes

1. For each of the diagrams A–C, identify the correct location (a, b or c) for the
for translocation.

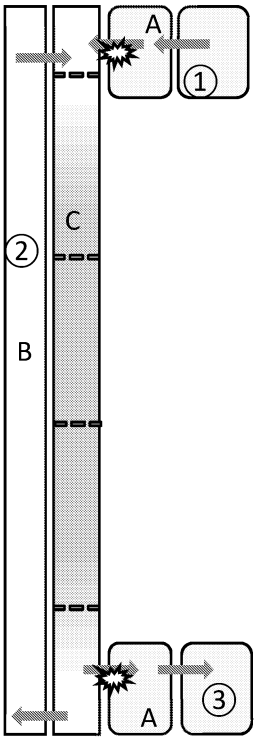
A



B



2. The diagram below depicts the mass flow hypothesis model of translocatio



a) i. Identify the cells labelled A.
ii. Identify the structure labelled B.
iii. Identify the structure labelled C.

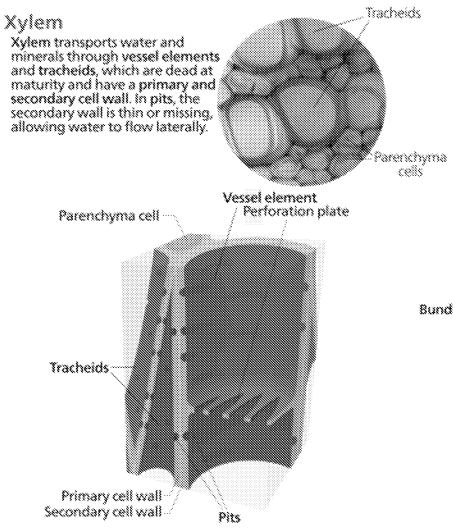
b) State the names of the processes occurring at

c) i. The process at ① occurs at a location kn
Give a definition of the word *source* in th
ii. Give an example of a source in a plant.
iii. The process at ③ occurs at a location kn
Give a definition of the word *sink* in this
iv. Give two examples of a sink in a plant.

ESSENTIAL SKILLS & PRACTICE

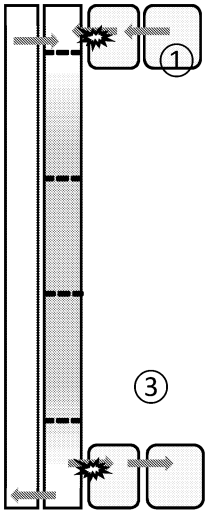
15 minutes

1. The cells of the xylem and phloem are highly adapted to their function. The diagrams to the right depict these two structural features of plant anatomy.



   a) Which of the two cell types is most important for translocation? [1]
   b) Identify two features of phloem sieve tubes shown on the right-hand diagram, explaining how each feature helps these cells to carry out their function. [4]

[5]



2. The diagram to the left depicts the mass flow hypothesis

   a) Describe in detail the process occurring at ①.
   b) Describe in detail the process occurring at ③.
   c) What generates the force to move the nutrients fro
   d) Are the substances inside the phloem and xylem alw directions? Explain your answer.

EXTEND YOUR THINKING

20 minutes

1. Copy and complete the table below to indicate what we have learnt about t the experiments mentioned. Make sure that you provide a brief description what observations or evidence it provides, and your interpretation of what t not yet studied these experiments in class, you can do some research online copy information from the Internet. Select the relevant information and ad

Experiment	Observation	What does it tell u evidence suppo
Aphid experiment Description:		
Bark ringing Description:		
Radioactive carbon tracking Description:		

24. PATHOGENS

What you will cover in this homework:

- Recognise viruses as acellular particles not sharing many of the characteristic
- The key features of viral particle structure
- Classification of disease-causing agents as viruses, bacteria, funguses, or pro

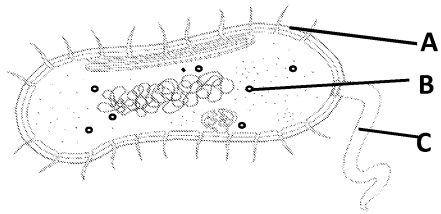
CONTENT CHECK

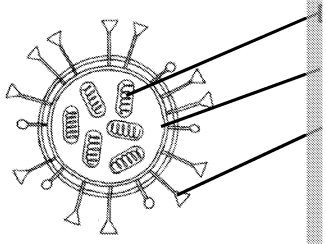
20 minutes

1. Look up the following organisms. Can you find out which are prokaryotic, w
are neither prokaryotic nor eukaryotic?

Salmonella ***Clavibacter spp.*** **ascomycete herpes** ***M. tuberculosis*** ***E. c***
Volvox **lycophyte microcystis influenza nostoc**
Neisseria meningitidis **euglena** ***Microsporum***

2. Identify each of the structures labelled A–F. Briefly describe the function of





3. Ring rot, tobacco mosaic virus, late blight and black sigatoka disease are all
species. Copy and complete the table below, linking the information of crop
and treatment.

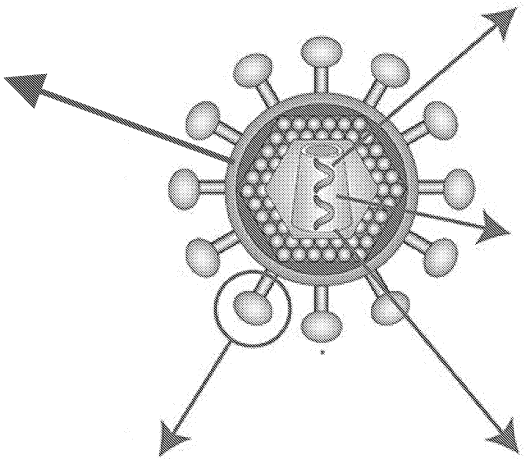
Pathogen	Type of pathogen	Crop	Countries/re most affect
Ring rot			
Tobacco mosaic virus			Very widespread (especially) in regions (where survive outside host for long
Late blight		Potatoes, tomatoes	
Black sigatoka	Fungus		

4. Copy and complete the viral fact file below.

HIV virus

Viral family:
Vector:
Mode of transmission:
Examples of transmission route:

Mother to child (_____, _____ and _



ESSENTIAL SKILLS & PRACTICE

30 minutes

1. Copy and complete the table below to compare and contrast the basic struct cells and eukaryotic cells. Provide simple details in your answers.

	Viruses	Prokaryotes
Ribosomes		70 S / smaller
Genetic material		
Size	Very small (approx. 5–300 nm)	
Membrane-bound organelles		None
Plasmids		
Flagella	None	
Cell wall		Murein
Capsid		

2. Malaria is a vector-borne protozoal (animal-like protist) disease which is qui
quite common in tropical climates.

   a) i. Distinguish between the terms *microorganism* and *pathogen*.
      ii. In the statement above, explain why malaria is described as a 'dise
   b) Explain the meaning of the term *vector*.
   c) This disease is spread by mosquitoes. How does this explain the preval
   climates? (Hint: there are two reasons.)
   d) Protozoa are 'animal-like' protists. Using this fact, explain why malaria

EXTEND YOUR THINKING

25 minutes

1. You may already have learnt at GCSE that all known organisms have eight ch
These are:
Movement – the ability to move
Respiration – perform a chemical process to release energy from food
Senses – the ability to detect changes in their internal and external environ
Control – the ability to alter their internal environment to maintain constan
Growth – increase in size and complexity
Reproduction – produce more of their own species through either sexual or
Excretion – remove toxins and the waste products of metabolism
Nutrition – require a source of nutrients for respiration and other metaboli

   For each of these characteristics, decide whether or not viruses display the c
answer. You may want to organise your answers as a table.

2. COVID-19 is a highly communicable or contagious disease.

   a) State the meaning of the term *communicable*.
   b) Explain how social factors can affect the rate of transmission of commu
   c) Discuss the use of *social distancing* to reduce transmission rates of COV

25. NON-SPECIFIC IMMUN

What you will cover in this homework:

- Plant defences
- Non-specific defences in animals
- Cells involved in non-specific immunity

CONTENT CHECK

20 minutes

1. Most organisms have multiple ways to protect themselves against disease-c
defence mechanisms below. For each of the defences identified in the table
plants or animals, and describe how it is able to defend against pathogens.

Defence	Plant/Animal	How does
Tannins		
Waxy cuticle		
Casparian strip		
Stomach acid		
Sticky resin		
Tears		
Mucus		
Commensal microorganisms		
Ciliated epithelial cells		
Callose		

2. Copy and complete the passage below.

Non-specific immunity forms our body's first, second and third lines of _(a)_ against
than specific immunity, which takes time to be 'switched on'. The first line of defence
'always on'. These defences are usually _(c)_ means of preventing pathogens from
physical barrier is the skin, but another very important element of our primary defence
many tracts that have an opening to the _(f)_ world. Every time we breathe in, we ar
along with the much-needed oxygen. These become _(h)_ in the mucus lining our tr
can then be moved back out of the body through expulsion mechanisms such as _(j)_
tears and the acid in our stomach also form a _(l)_ defence which is able to stop man

The second line of defence takes over if any pathogens get past the first lines of defe
This includes inflammation, the help of commensal _(m)_, and blood clotting. When
mast cells react by releasing _(n)_. This cell-signalling molecule causes _(o)_, bring
and plasma proteins to the site of the injury. The excess blood supply also causes th
characteristic of inflammation. The heat can make it difficult for pathogens to _(q)_ a
from the blood begin _(r)_ any pathogen they find. The phagocytes then digest the
nutrient components. Meanwhile, blood-clotting by _(s)_ and, later, scab formation f
underlying skin begins to _(u)_.

ESSENTIAL SKILLS & PRACTICE

20 minutes

1. The human body has many ways of defending itself. Some of these method
wide range of pathogens, while others are specific to a particular pathogen.

   a) i. Identify which of the following are examples of non-specific immu
   specific immune response.

   the skin inflammation agglutination histamine phagoc

   ii. For two of the non-specific immunity examples you have identified,
   preventing disease.

   b) Describe some advantages and disadvantages of non-specific immunity.

2. Produce a flow diagram to show the primary and secondary defences of no
Try to include all these words in your answer, as well as any others you can t
the function of each feature of the immune system.

inflammation skin tears mucous membranes phagoc
stomach acid chemical physical/mechanical microbiom

EXTEND YOUR THINKING

20 minutes

1. A wildlife rescuer has just been bitten on the hand by a polecat which could
other pathogens in its saliva.

   a) Describe in detail the non-specific responses which will occur at the site
   b) A day after the incident the entire hand of the wildlife rescuer is so swo
   move his fingers and it hurts to try to clench his fist. The hand also feels
   Explain these observations.
   c) The wildlife rescuer goes to the local doctor's surgery for his wound to b
   removes a large amount of pus from the man's hand.
      i. What is pus?
      ii. Why do you think there is so much pus in the man's hand just one
   d) If the polecat was carrying rabies, will the rescuer's non-specific immun
   against this pathogen? Explain your answer.

26. SPECIFIC IMMUNITY AND M

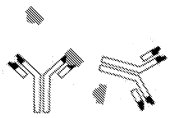
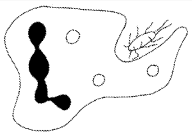
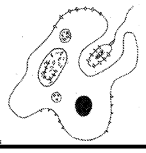
What you will cover in this homework:

- The specific immune response and immunity
- The roles of T lymphocytes, antigen-presenting cells, helper T cells, cytotoxic the cellular response
- The roles of B lymphocytes, the antigen–antibody complex, plasma cells and response and long-term immunity
- The use of vaccines and the associated ethical issues

CONTENT CHECK

20-25 minutes

1. Copy and complete the table below to include the main roles for each of the of the immune system. ***Note:*** *not all immune cells have a common abbrevia*

Diagram	Name and abbreviation	Key
	Cytotoxic T cell T_C	
		
		Generate a faster and bigger infection by the same patho
		
	Helper T cell T_H	
		Produce and secrete large qu
	T lymphocyte (T-cell) T	
	B lymphocyte (B-cell) B	
		

2. Distinguish between the terms *active* immunity and *passive* immunity. Prov

ESSENTIAL SKILLS & PRACTICE

30 minutes

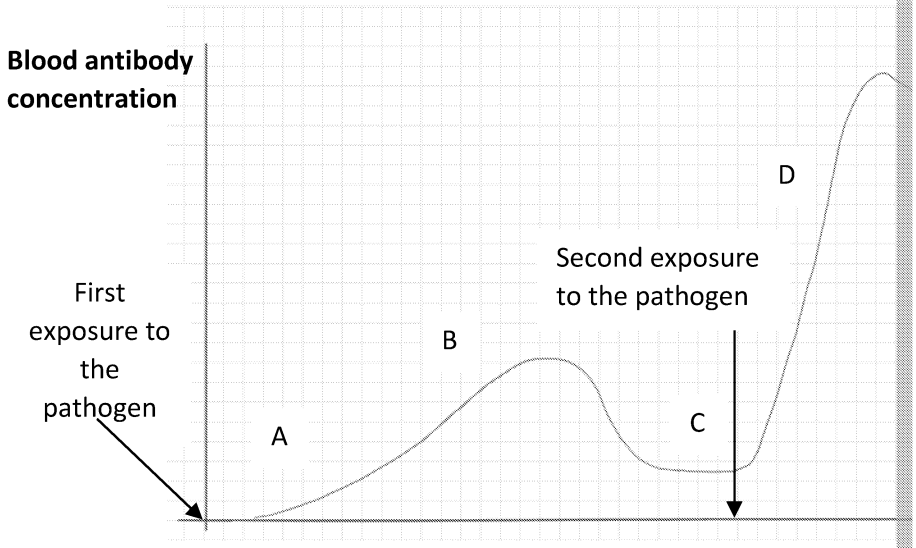
1. Write a clue for each word in the crossword puzzle in relation to cell recogn

	1. P	H	2. A	G	O	C	Y	3. T	O	S	I	S	
	A		G					O					5. E
6. A	N	T	I	G	E	N			X			7. P	
N		H		L					I			R	
T		O		U			8. M	O	N	O	C	L	O	N
I		G		T								T	
B		E		I								E	
O		N		N								I	
D				A				10. R	E	C	O	G	N	I
11. Y	E	A	S	T										
				12. I	M	M	U	N	E					
				O										
14. I	M	M	U	N	I	T	Y					15. V	I	R

2. Vaccines are an important element in national health policies in many count

   a) Which category of disease-causing microbes is most commonly preven
   Explain why.
   b) State two potentially fatal diseases which are now prevented via natio

3. Copy the sketch graph below.

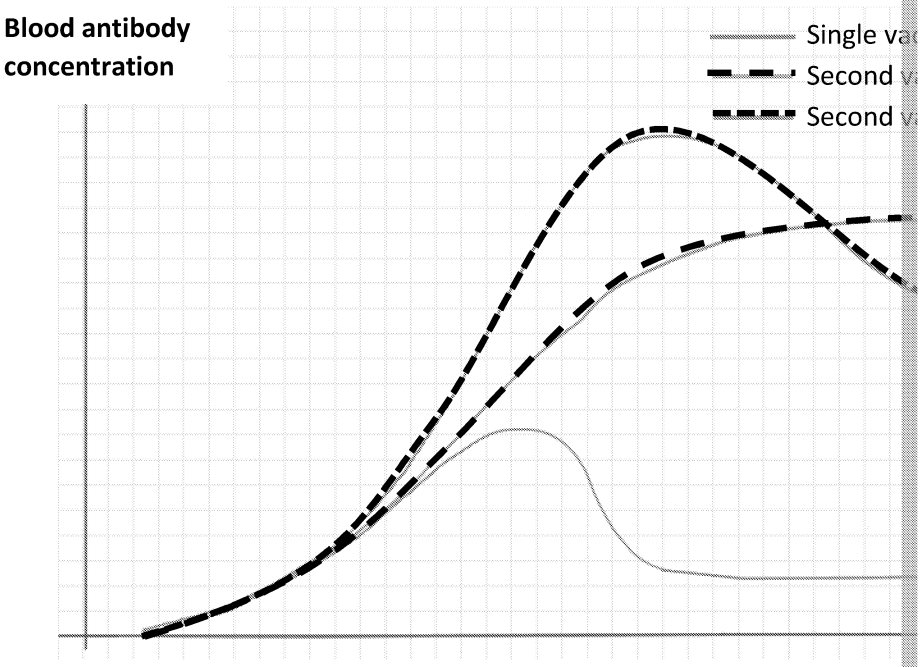


   a) Use the graph to describe the key differences between the primary and
   b) Describe what is happening in the immune system at points A–D.
   c) Which type of response would be demonstrated by someone who has
   Explain why.

EXTEND YOUR THINKING

30 minutes

1. Look at the sketch graph below.



a) Describe what the graph shows.
b) What is the minimum number of vaccine doses which should be admin
c) What are the optimum conditions for vaccine delivery?
d) Sometimes it is inconvenient to go to the clinic for your booster shot o
supposed to go. In this situation many people decide to go a few days
when they have more time. Is this a good idea? Explain your answer in
e) i. State and explain two ethical issues with the **development** of vacc
ii. State and explain a different ethical issue with the general use of v
iii. State and explain an ethical issues with the use of vaccines to cont
disease such as COVID-19.

2. Make a mind map to elaborate on the benefits and risks of using antibiotics
bacterial infection.

3. a) Describe in detail the role of antibodies in defending the body from dis
b) Explain why an organ transplant recipient must take immunosuppressa
life following the organ transplant.
c) How is stem cell research revolutionising this field of medicine?

27. BIODIVERSITY

What you will cover in this homework:

- Biodiversity from the largest to smallest scales
- Collection of biodiversity data
- Species richness and biodiversity indices (including calculation of a specific i
- Impacts of various farming techniques on local biodiversity

CONTENT CHECK

15 minutes

1. Match each situation to a suitable sampling method.

1.	Percentage cover quadrat sampling	**A**	A method of catching insects and sma forest floor
2.	Quadrat counts	**B**	This might be used to collect data on t a transitional environment, e.g. from t the shoreline
3.	Line transect	**C**	Equipment used to collect tree-dwelli
4.	Sweep net	**D**	A method for estimating the populatio
5.	Fogging and white sheet / drop net	**E**	Used to sample plant diversity when i individual plants, e.g. with moss or gr to get an estimate of the percentage o
6.	Pitfall traps	**F**	A method of catching flying insects ac
7.	Light trap	**G**	A piece of equipment used for catchin from the ground
8.	Mark–release–recapture	**H**	Might be used to gather data for calcu based on the plant species in a habita

2. The word *biodiversity* simply means variation in biology. As a scientific conc with the levels of variety which can be observed in biological systems. Each biodiversity which occur at different levels of biological organisation.

   a) Match each biodiversity type to its description.

   species evenness **<u>species biodiversity</u>** **<u>habitat biodiversity</u>** **g**
   species richness index of diversity **<u>global biodiv</u>**

   A: The level of variation in the gene pool of a particular species or po
   B: A measure of the number of different species in a community, or t particular taxonomic group in a particular area
   C: The variety of life on a planet-wide scale, usually in reference to th this can also include genetic diversity on a global scale and even ge
   D: The variety of different habitats available in a given ecosystem or a
   E: A measure of species diversity which takes into account both the s evenness (the proportion of the total community belonging to eac
   F: The variety of species in a given community, or within a particular t particular area
   G: A measure of how evenly the members of the community are distr different species

   b) Place the four levels of biodiversity (bold and underlined) above in orde

3. a) Put these habitats in order of least diversity to greatest diversity:
   - a 2000-acre sugar cane farm
   - regular cattle pasture
   - a tropical rainforest
   - an apple orchard
   - a mangrove forest
   - temperate woodland
   - an alpine meadow with cattle grazing

   b) Explain your reasons for the habitats that you have identified as having *greatest diversity*.

ESSENTIAL SKILLS & PRACTICE

25 minutes

1. The table below provides information about the estimated numbers of vario large palm oil plantation and those found in an equal area of rainforest.

   a) Use this data to calculate an index of diversity for each habitat.

Palm oil plantation		Rainforest	
Species	**n**	**Species**	**n**
Zebra dove	5	Great hornbill	2
Greater racket-tailed drongo	2	Oriental pied hornbill	2
Red-billed blue magpie	2	Red-whiskered bulbul	2
Greater coucal	4	Thick-billed green pigeon	4
Tree sparrow	8	Red jungle fowl	5
Common myna	14	Silver pheasant	3
White-vented myna	4	Chestnut-headed tesia	2
		Streaked bulbul	2
		White-throated bulbul	2
		Grey-chested jungle flycatcher	3
		Brown-chested jungle flycatcher	2
		Golden-fronted leafbird	2
		Scarlet-breasted flowerpecker	3
		Yellow-vented flowerpecker	4
		Little spider hunter	7
		Purple-naped sunbird	2

   b) What is the species richness of birds in the two habitats?
   c) Would you expect other taxonomic groups to give similar results? Expla
   d) Explain why the rainforest has higher species richness and a higher inde
   e) The great hornbill is a large frugivorous bird, which is considered as an and a healthy ecosystem. Can you suggest why?

2. State three processes or techniques of modern farming which reduce biodiv For each one, explain how biodiversity is affected.
   Remember: - this could be to do with genetic or species diversity
   - one action could have multiple consequences

EXTEND YOUR THINKING

25 minutes

1. Why is it better to use an index of biodiversity than a simple measure of spe

2. When calculating an index of biodiversity, the data used in the calculation sho
taxonomic group, e.g. insects, frogs or birds. Suggest two possible reasons fo

3. Imagine you have inherited a farm from a distant relative who recently died
you are an ecologist interested in conservation and biodiversity, you plan to
restore local biodiversity. Think about how you can achieve the highest dive
You can present your answer as an annotated map of your farm, or in prose
state at least five methods you will use / things you will do, and explain how
increase biodiversity.

4. Over the last few lessons you have been focusing on the various ways of me
how it is affected by various human activities.

   a) Why is biodiversity such an important aspect of ecology? Explain your a
   b) What can we gain from measuring biodiversity and/or genetic diversity?

28. CONSERVATION

What you will cover in this homework:

- The importance of conserving biodiversity
- *In situ* and ex *situ* conservation methods
- Conservation treaties

CONTENT CHECK

15 minutes

1. The following list states some of the reasons for protecting biodiversity. Use reasons as ecological, economic or aesthetic (this includes the idea of conse for future generations).

   Note that some of these may fit into more than one category and there may answer. However, there are wrong answers. Make sure that you can justify teacher if asked.

   preservation of genes that may be lost due to disease or

   preserving ecosystems or landscapes as they a

   human mental health is connected to time in nature increas

   protect keystone species protect undiscovered sourc

   reduce soil depletion protect against global warming an

   source of undiscovered beneficial genes (such as disease r

   reduce the risk of disease, including novel zoono

2. State the words or phrases which complete the gaps below.

   Conservation is a field of biology responsible for protecting _(a)_. It can be carried o methods. *In situ* conservation occurs in the habitat of the species of interest. This ca areas such as marine conservation zones, wildlife reserves and national parks. There a the waters around England. Each one protects one or more _(c)_ or species that hav threatened. *In situ* conservation can also include legislation which protects certain sp hunting during certain _(d)_, so as to have the least impact on the species of interes

   The other type of conservation includes the development of gene or seed _(e)_, as w captive breeding or plant culture projects occurring in _(f)_ and botanical gardens. I down to a single population of only 18 individuals, but thousands of ferrets bred in a been used to _(g)_ the wild population, which has now stabilised at just over 200 ad provide long-term storage of genes that may become _(h)_ from the living populatio

   There are also a number of international and local conservation agreements which pro These include the Convention on International Trade in Endangered Species (CITES), w live animals, and animal _(i)_, such as rhino horn and pangolin scales. Meanwhile th Conservation of Nature (IUCN) monitors the _(j)_ status, along with threats and other through a coalition of government and civil society organisations.

ESSENTIAL SKILLS & PRACTICE

20 minutes

1. The table below identifies some of the well-known organisations and agreem
Some of these are international, while others are national bodies operating c
Copy and complete the table to provide basic information about each one.

Organisation/ agreement	Full name	How is it used in conserv
CITES	Convention in International Trade in Endangered Species	
CBD		
CSS		
IUCN	International Union for the Conservation of Nature	
RSBP		
WWT		Protects endangered wetland species, through the mainten an area of around 20 km^2 and birds. Also involved in resea It was involved in a breeding Hawaiian goose from extinct
Ramsar Convention		

2. The Asian elephant is sometimes referred to as a keystone species of the So
ecosystem. Using the information in the fact file, discuss whether this desig

Asian elephant (*Elephas maximus*)

Thailand is home to around 3000–4000 wild elephants, most of which can be found in and around Thailand's largest national parks. Each elephant in a herd needs around 100 km^2 to find enough food to stay healthy. This means that each herd of elephants needs a large area of rainforest to survive. An even larger area of forest is required to maintain a viable population. Currently around 30 % of Thailand's rainforest hosts elephants.

Elephants contribute to creating a heterogeneous environment which supports a wide variety of species by breaking small trees or branches of various sizes; this opens up small gaps in the canopy and encourages new plant growth. They are also key seed dispersers as they eat large amounts of vegetation, including fruits, and travel very far distances each day. Due to their large size, the presence of elephants in the rainforest also supports rapid nutrient cycling and provides fertiliser for young plants.

EXTEND YOUR THINKING

30-40 minutes

1. Using your knowledge of conservation, and additional sources you find onli
and *ex situ* methods which could be used to improve the conservation statu
   - *Make sure you give both the common name and the binomial name of y*
   - *Give a citation and reference for any information you find online.*
   - *Try to use only academic sources: the IUCN website and Google Scholar w*
   - *Write no more than 1000 words.*
   - *Your teacher may want you to use a particular style for citations and re APA and Harvard. You can find guidance for these very easily online.*

29. TAXONOMY

What you will cover in this homework:

- Defining species and naming conventions
- Phylogenetic classification systems, including the hierarchy of domain, kingdo genus and species
- Improvements in classification of organisms

CONTENT CHECK

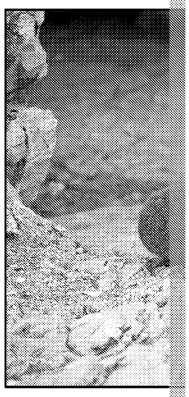
15 minutes

1. 'Do Kangaroos Play Cricket Or Football Generally Speaking?' is an acronym to order of the hierarchy of classification. What taxa are represented by the le

2. According to scientific naming conventions, decide whether each of the follo same species or different species. For each one, also identify the lowest leve share. The first two have been done for you as an example.

   a) Kaibab squirrel (*Sciurus aberti kaibabensis)* and Abert's squirrel *(Sciurus*
   These two squirrels are different subspecies, but the same species
   b) Cliff chipmunk (*Tamius dorsalis*) and least chipmunk (*Tamius minimus*)
   These two chipmunks are different species, but are of the same gen
   c) Eastern cottontail rabbit (*Sylvilagus floridanus*) and European rabbit (*O*
   d) Western lowland gorilla *(Gorilla gorilla gorilla)* and Western gorilla *(Go*
   e) Modern humans (*Homo sapiens*) and Flores man (*Homo floresiensis*)
   f) African forest elephant (*Loxodonta cyclotis*) and Asian elephant (*Elepha*
   g) Eurasian brown bear (*Ursus arctos arctos*) and the grizzly bear (*Ursus a*

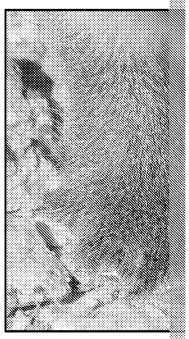
3. The rock hyrax is an animal which was very difficult for scientists to classify based on morphology. It looks very much like a rabbit with short ears but has very different teeth and small hooves on its feet!



   Hyraxes also have small tusks which grow from their incisors, and nipples close to their armpits, as do elephants and manatees.

   a) Why would it be difficult for scientists to believe that the closest living relative to the hyrax is the elephant? [2]
   b) What morphological evidence is there that hyraxes are most closely related to elephants? [3]
   c) What recent innovations in biology have made it easier to prove that elephants are the hyrax's closest living relatives? How can these innovations be used to prove the relationship between the species? [3]

   [8]



ESSENTIAL SKILLS & PRACTICE

20 minutes

1. For each of the situations described below, decide whether the 'parents' are
different species. Explain your answer.

   a) A liger and a tigon are both formed by a cross between a lion and a tige
only occurred in zoos using IVF fertility treatments, often producing offs
problems which only live a few years and are unable to reproduce.

   b) As the Arctic ice sheet shrinks, polar bears are being forced further and
Meanwhile, brown bears have been moving north as the warming clima
range. An increasing number of 'pizzly' bears – polar–grizzly bear hybri
and Alaska. At least one of these hybrids – now kept in a museum – has
grizzly bear DNA and 25 % polar bear DNA, indicating that it is a second

   c) A male zebra finch raised by a Bengalese finch foster mother is unable t
zebra finches when it becomes an adult because it has 'learned' the look
foster mother.

   d) Wolves are able to mate with domestic dogs, producing fertile offspring
third-generation wolf–dog hybrids. Hybrids which are tamed and kept b
so it is unknown whether these hybrids can continue to breed generatio
health impacts.

   e) In 2001, Eden Ostrich Farm in Cumbria had a surprise birth from its Shet
foal's unusually large ears, spikey mane and stripy legs, staff of the farm
foal must be the male zebra which had been housed with the mare duri
and female zebra are known to not be able to produce offspring.

2. The diagrams below show two different interpretations of human evolution
evidence of human evolution. You may also research some additional infor
to help you answer some of the questions.

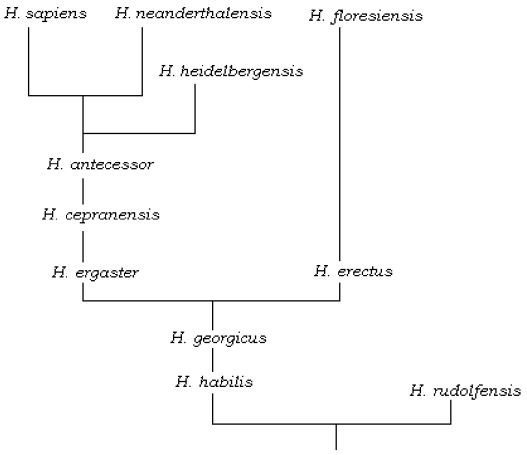
a) Some scientists believe that *Homo sapiens* evolved from *Homo erectus*
such as *Homo heidelbergensis,* as suggested in the second diagram. Giv
support this idea.

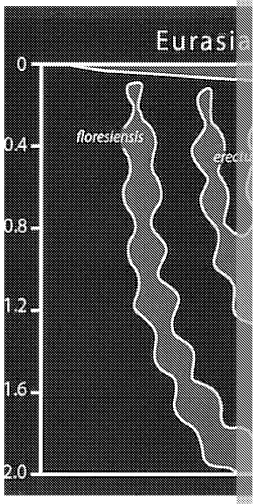
b) Other scientists believe that *Homo erectus* DID NOT evolve into *Homo s*
share a common ancestor. Give two pieces of evidence which support t

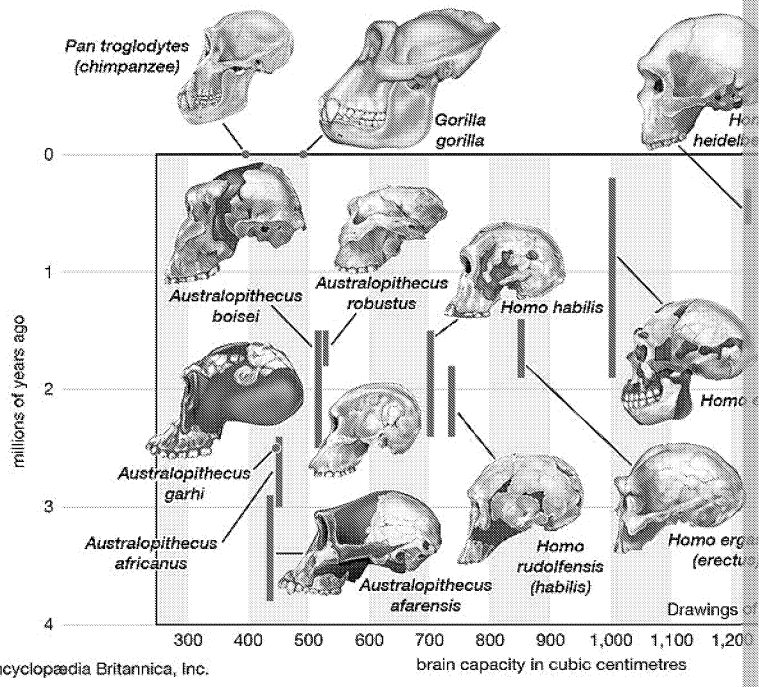
c) i. What evidence is missing which would allow us to determine whet
from *Homo erectus*?

ii. How would this piece of evidence help us to make a decision?

iii. Discuss the chance of this evidence being found.







EXTEND YOUR THINKING

15 minutes

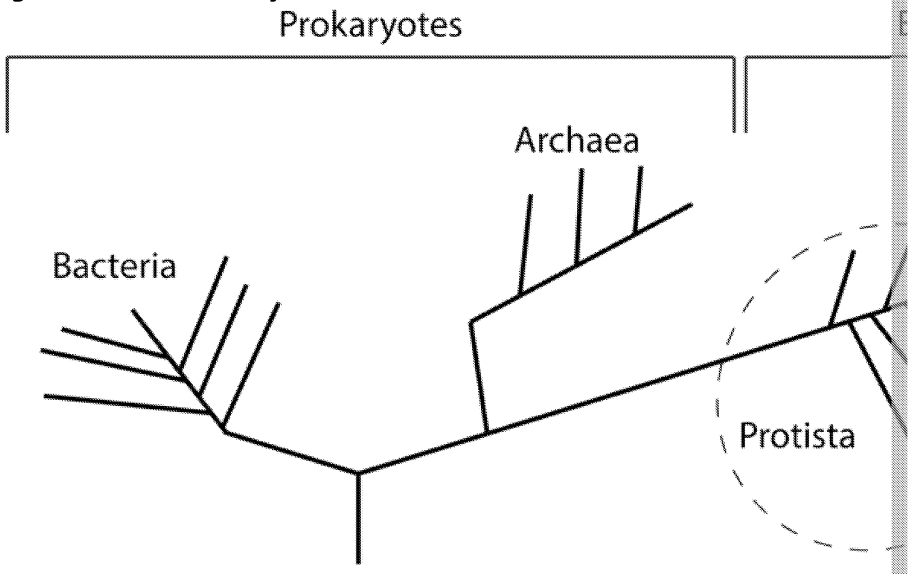
1. The table below shows the traditional classification system based on the 'fiv
kingdoms model had clear criteria for classifying newly discovered organism
unicellular, or being photosynthetic or not.

However, modern DNA technology has shown that this system has some fla
phylogenetic tree based on DNA evidence of modern species in all domains.

Table 1: The five kingdoms

Kingdom	Bacteria	Protista	Plantae	
Criteria for classification	Single-celled Prokaryotic	Single-celled Eukaryotic	Multicellular Eukaryotic Photosynthetic	Mu Euk He
Examples of inclusion	All bacteria and archaea	Algae Some slime moulds Amoeba Yeast Protozoa (e.g. plasmodium)	Plants Seaweed	Ver Ech (st rel Mu zoo

Figure 1: Modern classification based on DNA evidence



a) Look at Table 1 and Figure 1. Identity three 'errors' in the five kingdom
new genetic evidence.

b) Which kingdom from the original model is the most difficult to reclassif
genetic evidence?

c) i. What does the five kingdom model suggest about the relatedness
ii. What does the phylogenetic tree suggest about the relatedness of
iii. Why are yeast cells often used as a superior alternative to bacteria
medicinal drugs?

d) Discuss why the kingdoms of 'bacteria' and 'protista' are rarely used to
'animalia', 'plantae' and 'fungi' have persisted in literature.

30. ADAPTATION AND EVOLU

What you will cover in this homework:

- Evidence for evolution
- Interspecific and intraspecific variation (including examples of continuous an
- Statistical analysis of variation
- Adaptation to environment
- The mechanism of natural selection under different selection pressures
- The human significance of evolution in other kingdoms

CONTENT CHECK

20 minutes

1. All living things demonstrate variation. Variations between species (for exa chimpanzees and humans) are referred to as interspecific variation, while di example, the different possibilities for eye colour among humans) are refer

   The list below identifies some observable differences that may be seen in ra

   - straight or lop (floppy) ears
   - having only three legs
   - ear length
   - fur colour
   - tumorous growths starting
   - a scar
   - body mass
   - fur length

   a) For each one, decide whether it is caused by genetics, the environment Provide an explanation for your answer.
   b) For each of the genetically controlled characteristics, identify whether it variation or discontinuous variation.

2. Decide whether each of the following statements is true or false. If false, ex should be corrected.

   a) Adaptations which lead to natural selection are always anatomical.
   b) Natural selection results in species that are better adapted to their env
   c) Mutations always occur randomly.
   d) Every random mutation creates a new allele with a new phenotype for a
   e) New alleles may be harmful or beneficial, or have no impact on survival
   f) A new allele which is beneficial in one population must be beneficial in a

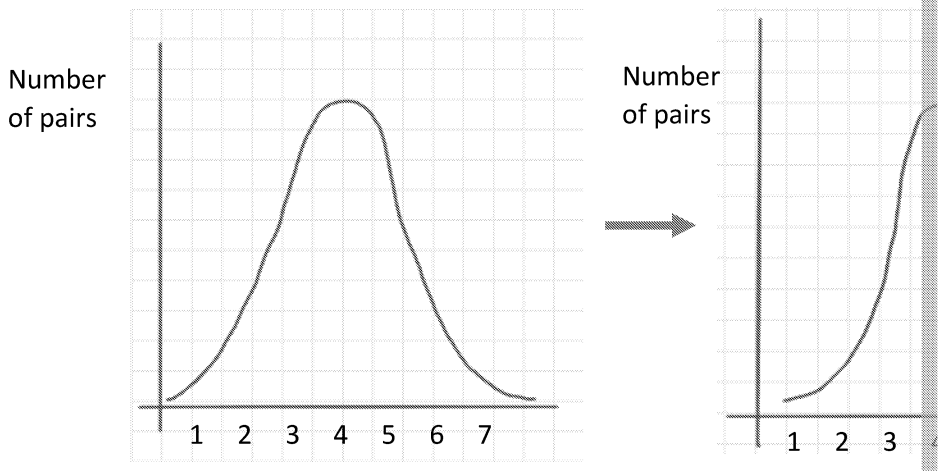
3. Identify which type of selection pressure (stabilising, directional or disruptive following situations. Explain your answer.

   a) A population of mice in the Mediterranean has variation in the shade of pale sandy brown to dark brown (almost black). A summer drought caus disappear from the area, so that sandy soil and dark volcanic rocks dom
   b) A small population of rats find themselves stranded on an island with a travelling there on several pieces of driftwood in a storm.
   c) The diet of a particular species of finch consists only of grass seeds.

ESSENTIAL SKILLS & PRACTICE

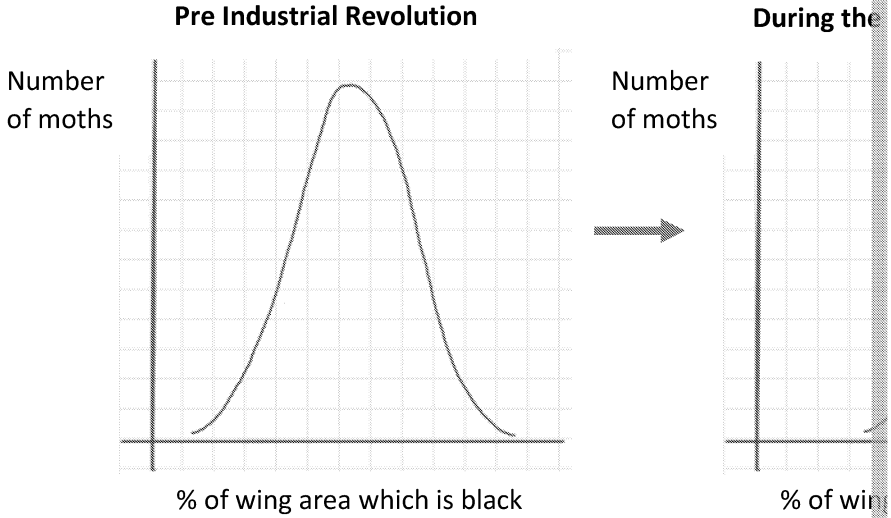
25 minutes

1. Natural selection does not always lead to change in a species. Usually, if the
lead to a type of selection known as stabilising selection. In contrast, if the e
if a population finds itself in a new environment, then directional selection m
Look at the following examples of natural selection, and answer the associat



a) i. What type of selection is demonstrated by this situation?
ii. What happens to birds at the lower end of the normal distribution?
at passing on their genes?
iii. What happens to the birds at the higher end of the normal distribu
unsuccessful at passing on their genes?

b) During the Industrial Revolution there was so much soot and smog in th
that everything became covered in a thin layer of black carbon. The gra
of wing colour in a species of moth called the peppered moth. These m
camouflage against white-grey lichen which grows on tree trunks.



i. What type of selection is demonstrated by this situation?
ii. What happened to moths at the white end of the normal distribut
unsuccessful at passing on their genes?
iii. What happened to the moths at the black end of the normal distri
successful at passing on their genes?
iv. The Clean Air Act (1956) led to a dramatic reduction in the air pollu
smog and soot clearing from the area. What would you expect to h
distribution over the next few decades? Draw a sketch graph and e

2. You have decided to study the effects of human encroachment on wild anim
red fox as a model species. You have collected the following data from two
population of foxes living in their natural and historical habitat, Eurasian de
a population of foxes living in and around London.

a) Do you think the sample of 20 foxes is adequate for representing the w
Explain your answer.

b) Suggest a method which could be used for randomly sampling the foxe

c) State the values which complete the table by calculating the mean and
the urban foxes.

$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

The forest foxes (natural habitat)						
Individual	**Shoulder height (cm)**	**Hind foot length (cm)**	**Body length (cm)**	**Mass (g)**	**Individual**	**Shoulder height (cm)**
01	36	13.5	62	7812	01	
02	37	13.8	64	8288	02	
03	40	14.8	70	9800	03	
04	42	15.5	74	10 878	04	
05	39	14.5	68	9282	05	
06	39	14.5	68	9282	06	
07	47	17.2	84	13 818	07	
08	45	16.5	80	12 600	08	
09	44	16.2	78	12 012	09	
10	48	17.5	86	14 448	10	
11	37	13.8	64	8288	11	
12	38	14.2	66	8778	12	
13	44	16.2	78	12 012	13	
14	47	17.2	84	13 818	14	
15	49	17.8	88	15 092	15	
16	42	15.5	74	10 878	16	
17	41	15.2	72	10 332	17	
18	40	14.8	70	9800	18	
19	36	13.5	73	7812	19	
20	38	14.2	77	8778	20	
Mean average	41.5	15.3	74.0	10 690	**Mean average**	
Standard deviation	4.1	1.4	7.7	2310	**Standard deviation**	

d) i. Which characteristic appears to show the biggest difference betwe
Explain your answer.

ii. Use a t-test to determine if this difference is significant.

$$t = \frac{|\overline{x_A} - \overline{x_B}|}{\sqrt{\frac{s_A^2}{n_A} + \frac{s_B^2}{n_B}}}$$

iii. Try to explain your findings, thinking about the environments in w

EXTEND YOUR THINKING

20 minutes

1. Natural selection leads to the development of adaptations which help a spec

   a) Make a table like the one below and complete it by giving at least one a the table. You may do some research to find the answers.

Environmental condition	Example of a structural adaptation	Example of a physiological adaptation
Extreme cold		
Extreme heat / arid environment		Fat storage as a metabolic source water
High altitude		
Marine environment		

   b) Some insects have adapted to widespread use of pesticides, becoming Discuss the implications of this for the human food supply.

2. a) Give an example of stabilising selection that has not been mentioned in Explain why stabilising selection occurs.
   b) Give an example of directional selection that has not been mentioned in Explain why directional selection occurs in this situation.
   c) Amanda and Jeff are discussing the evolution of giraffes. Amanda think Africa are a good example of directional selection because they must ha of the trees. Jeff says that this can't be because giraffes have not chan appeared in Africa thousands of years ago; therefore, it must be stabili is correct – Amanda or Jeff? Discuss your reasoning.

Answers

1. Microscopes

Content check

1. a) microscopic, b) cells, c) magnify, d) size, e) chloroplasts, f) stains, g) electron, h) r
magnification, k) detail, l) resolution (12)
2. *1 mark to be awarded for each correctly completed table cell.*

	TEM	SEM
Relative resolution	higher resolution	
Relative maximum magnification	highest magnification	medium magnification
Staining	heavy metals	heavy metals
Mounting	specimen must be placed in a vacuum	specimen must be placed i a vacuum
Colour of image	black-and-white images	black-and-white images
Movement	no movement	no movement
Type of image	2D image	3D image

Essential skills & practice

1. Actual size calculation: 600 µm = 61 eyepiece units; therefore, **1 eyepiece unit = 9.8**
Width of mite = 34 eyepiece units (allow 33–35)
34 × 9.8 = 333.2 µm ≈ **330 µm or 0.33 mm** (3)
magnification = size of image / size of real object
= 33 / 0.33 = 100 × (2)
2. *Award 1 mark for correct selection of microscope, 1 mark for each accompanying ex*
   A. Optical light microscope: in order to observe the movement of the organisms t possible with electron microscopes as viewing occurs in a vacuum
   B. SEM: the surface of the object must be viewed in detail (high resolution requi
   C. SEM: the surface of the object must be viewed in detail; it is not necessary for t
   D. TEM: transmission electron microscopy is necessary to see inside the cell
   E. Optical light microscope: Electron microscopes can only produce a black-and-w be observed
   F. TEM: transmission electron microscopy is necessary to see inside the organell
3. *Award 1 mark for each correct row, maximum 6 marks.*

	Structure				
Stain	**DNA**	**Cell wall**	**Cytoplasm**	**Starch grains**	**Chromo during**
Methylene blue	✓	×	✓	×	✓
Eosin	×	×	✓	×	×
Iodine	×	×	×	✓	×
Iodine in potassium iodide solution	×	✓	×	✓	×
Haematoxylin	✓	×	×	×	✓
Carbol fuchsin (an acid-fast dye)	×	×	×	×	×

Extend your thinking

1. a) SEM – 3D image / high resolution
   b) size of real object = size of image / magnification
   43 mm / 100 = 0.43 mm
   c) i. The tardigrade is shown at an angle – not perfectly lengthwise / 3D imag
   Therefore, orientation affects the measurement of the length (1)
   ii. Therefore, the actual length might be a little longer than the one calculat

2. a) Gram stain / crystal violet and safranin
   b) There are at least two different types of bacteria in the sample; one bacteria t
   is gram-positive / the long thin bacteria are gram-negative, while the round ba
   c) Cell wall; gram-positive bacteria have a thick layer of peptidoglycan in their ce
   the gram stain
   d) *Answers may be made more accurate by measuring a string of bacteria.*

3. a) Methylene blue and eosin; the cell nuclei appear blue-violet under the methyl
   types of leukocyte to be more easily distinguished; the eosin makes the red bl
   appear a slightly different colour
   b) Carbol fuchsin and methylene blue; leprosy is caused by *Mycobacterium lepra*
   appear pink in the biopsy sample and contrast against the blue tissue cells sur

2. Cell Structure and Function

Content check

1. 1 = E, 2 = P, 3 = C, 4 = L, 5 = O, 6 = B, 7 = H, 8 = K, 9 = N, 10 = M, 11 = G, 12 = D, 13 = F,
2. **Prokaryotic:** salmonella, *M. tuberculosis*, *E. coli*, spirochete, nostoc, microcystis (6)
   Eukaryotic: ascomycete (fungus), *Volvox* (green algae), lycophyte (primitive fern), n
   (photosynthetic protoctist) – *common names given as additional information, not r*
   Neither: herpes (1)
   Additional notes and explanation: ascomycete is a group of fungi, Volvox is a genus o
   are primitive fern-like plants, nematodes are roundworms and may be soil-dwelling o
   photosynthetic protoctist which have a secondary endosymbiosis with a green algae.
   neither prokaryote nor eukaryote.

Essential skills & practice

1. *Award 2 marks for each column with 0–1 errors, 1 mark if 2–3 errors, 0 marks if > 3 e*

Cell component	Fungus	Plant	Anim
Nucleus	✓	✓	✓
Nucleolus	✓	✓	✓
Naked DNA	×	×	×
Cell wall	✓ chitin	✓ cellulose	×
Mitochondria	✓	✓	✓
Chloroplasts	×	✓	×
Smooth endoplasmic reticulum	✓	✓	✓
Rough endoplasmic reticulum	✓	✓	✓
Golgi apparatus	✓	✓	✓
Vacuole	×	✓	×
Lysosome	× / rarely	× / rarely	✓
Ribosome	✓	✓	✓
Flagella	×	×	rare
Cilia	×	×	someti

2. • Smooth, clear continuous lines, preferably drawn using a sharp pencil (1)
   • Suitable size (1)
   • Appropriate amount of detail (1)
   • No shading (completely black nucleus acceptable) (1)
   • 1 mark for each correctly identified cell structure (4)

Extend your thinking

1. A = 6, B = 4, C = 2, D = 1, E = 3, F = 5
2. *Award 2 marks for each correct column. Deduct 1 mark for each error within a colu*

	Nucleus	Mitochondrion	Chloroplast	G
Double membrane bound	✓	✓	✓	
Has folds in the internal membrane to increase surface area	×	✓	✓	
Involved in packaging of molecules to be exported from the cell	×	×	×	
Single outer membrane	×	×	×	
Not visible under an optical microscope	×	×	×	
Contains genetic material	✓	✓	✓	
Oxygen diffuses into the organelle	×	✓	×	
Only found in photosynthetic organisms	×	×	✓	

3. *Award 1 mark for each correctly completed box.*

	Prokaryotes	
Ribosomes	70 S / smaller	
Genetic material	Single circular loop of DNA, not associated with protein	Several linear chr
Size	Small (approx. 0.2–2.0 µm)	Large (a
Membrane-bound organelles	None	Many (e.g. R
Plasmids	Usually present	
Flagella	Common	
Cell wall	Murein	Plants (cellulose)

3. Introduction to Biomolecules

Content check

1. **Cohesion:** the attractive force between adjacent water molecules which generates a
   important for capillary action
   Adhesion: the attractive force between water molecules and an adjacent surface – s
   'tube' of water in capillary action in plants
   Heat capacity: the amount of energy required to raise the temperature of a certain
   Latent heat of vaporisation: the energy required to cause a specific mass of a subst
   Metabolite: a molecule used or created in a biological chemical reaction
   1 mark per definition. Must be written in students' own words to be awarded the m
2. A. Water is a common metabolite… 4. Hydrolysis and condensation reactions are i
   photosynthesis, and use of ATP as an energy source in metabolic reactions, as well a
   polymerisation of biological monomers.
   B. Water is a good solvent… 3. Many inorganic ions and small nutrient molecules (e.
   solution in cell cytoplasm and can be easily transported in water.
   C. Water has a high heat capacity… 5. Large amounts of energy are required to rais
   the major component in cell cytoplasm so large changes in energy (temperature) ar
   temperature. Organisms living in water also benefit from more stable environment
   D. Water has a high latent heat of vaporisation… 1. Quite a lot of energy is needed
   when water evaporates from the surface of an organism a relatively large amount o
   cooling effect.
   E. Water has strong adhesion and cohesion… 2. Water molecules are strongly attra
   form thin columns (e.g. in phloem and xylem vessels in plants) and has surface tens
   small or light organisms to rest on its surface.
   1 mark for each correct pairing

3. Carbon (C), hydrogen (H), oxygen (O), nitrogen (N), sulfur (S) and phosphorus (P). *S*
name and symbol for each element. Note that they may be in a different order from
Deduct 1 mark for each error.
Award 1 mark for each correct row.

	Elements				
Molecule	Carbon	Hydrogen	Oxygen	Nitrogen	
Carbohydrate	✓	✓	✓	×	
Lipid	✓	✓	✓	×	
Protein	✓	✓	✓	✓	S so
Nucleic acid	✓	✓	✓	✓	

Essential skills & practice

1. Students should be awarded 2 marks for each suitable description up to a maximum
   - identification of which property of water is important (1)
   - explanation of how this property helps the organism in the given context (1)

   A. The **surface tension** of the water stops the pond skater from sinking.

   B. Water is at its **densest at 4 °C** – this means that water at the bottom of the po the bottom of the pond remains liquid throughout the winter, and the frog wi – oxygen dissolved in the pond water allows the frog to stay alive (to respire a

   C. Transpiration in plants is only possible because the **cohesion** between water m to remain intact all the way from the plant's roots to its leaves inside the xyle **heat** of vaporisation – transpiration also allows the plant to lose heat and mai hot day; water is a **good solvent** – on a sunny day the plant will do more photo which must be transported to other parts of the plant; these sugars are dissol phloem.

   D. Water's **high latent heat of vaporisation** allows the marathon runner to regul heat from the evaporation of sweat; water is a **good solvent** – nutrients and o blood, and minerals and nutrients are dissolved in the cytoplasm of his cells, a muscle contraction to occur.

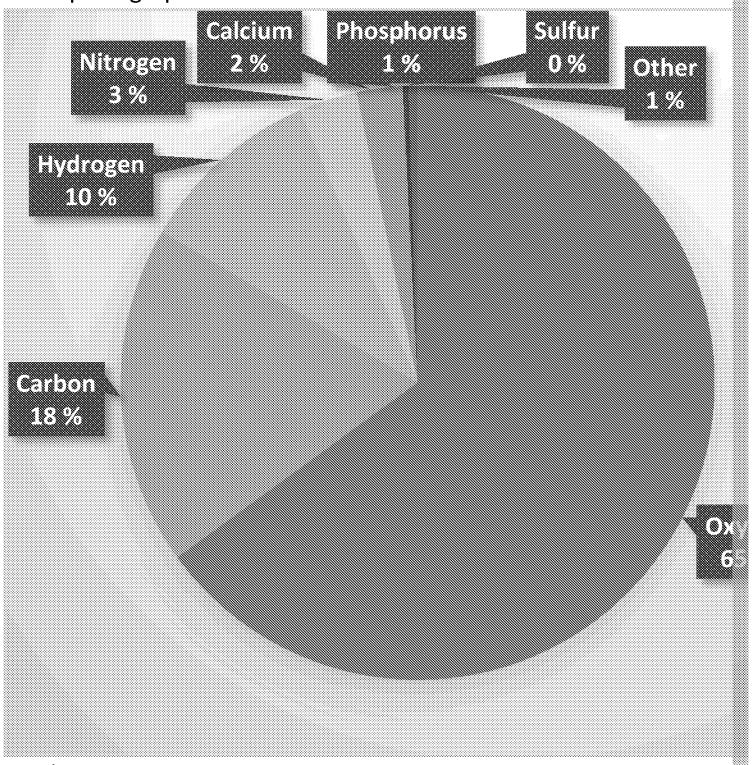
   E. Even on a hot day the temperature of water in a large body of water does not **high heat capacity**; the water is a much lower temperature than the air on the heat of the day by going for a swim; when the dog leaves the water, water's **h** means that heat is carried away from the dog as the water evaporates from its and, therefore, loses heat much more slowly than a person as its tongue – use a relatively small area.)

2. a) Hydrogen bonding occurs between the hydrogens of the water molecule and t molecules to easily surround and separate each solute molecule

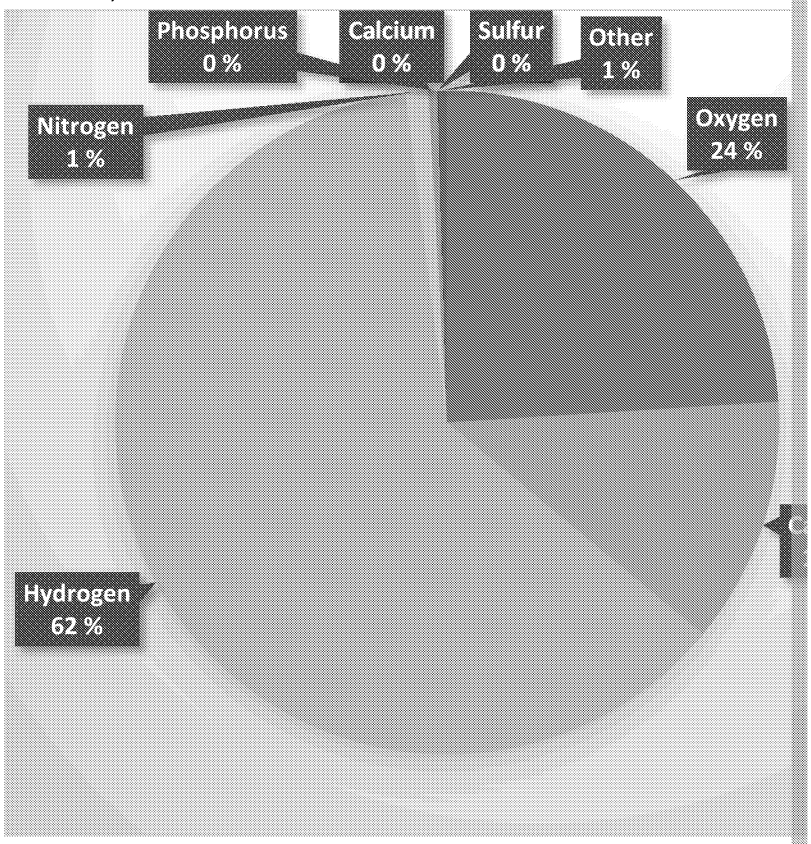
   b) Water molecules easily bond to other materials via hydrogen bonding; this pr properties of water

   c) Water's high surface tension comes from the high cohesion between water m due to the fact that each water molecule is able to form a hydrogen bond with

3. a) i. Award 1 mark for:
- Correctly constructed pie chart (i.e. all angles correct)
- Correctly labelled segments or legend
- Descriptive graph title



ii. Mark as a) i.



b) i. Calcium

ii. Calcium is a major component of bone structure

iii. Several answers are acceptable, e.g. seashells, molluscs, squid; the expect have a calcareous exoskeleton – without calcium the shells will be weaken damaged. Some students may refer to coral and coral bleaching, which re polyps. The mark should be given for the explanation.

Extend your thinking

1. Answers will vary significantly, and all sensible answers should be accepted, awardi
to a maximum of 10 marks.
The following ideas are likely to appear in students' responses:
   - water molecule exists in a mixture (e.g. tea, coffee, juice, mineral water), bein
ions / other molecules in the solution (*important solvent)*
   - water molecule is used in the hydrolysis of a biological polymer (e.g. starch or a
system, and becomes part of the monomer molecules *(molecules should be sp
through in the story) (important metabolite)*
   - water molecule is absorbed in the large intestine and passes into the blood, w
(important solvent)
   - diffuses / moves via osmosis / passive transport from the blood in a capillary i
also acts as a solvent. *(important solvent)*
   - glucose is respired, releasing water into the cell cytoplasm. The high proportio
body to maintain a steady temperature as large amounts of energy are require
specific heat capacity)
   - water is used in hydrolysis of biological polymers within the cell, e.g. recycling of RN
   - water moves via diffusion / osmosis / passive transport from the cell cytoplasm
blood in a capillary
2. a) Phosphorus is a key structural component of DNA, RNA, ATP and phospholipid
required for the mark); phosphorus is in the same group of the periodic table a
have similar chemical properties; arsenic would be able to form the same bon
molecules identified
Note for teachers: as arsenic is a heavier element, these molecules would then
   b) Silicon; like carbon, this element is able to form four bonds and would be equa
suitable for the evolution of life
*Note for teachers: some students may be aware that smaller elements are gene
elements are generally rarer in the universe, based on the theory of how elemen*
3. a) Magnesium is an essential structural component of chlorophyll; grass is a plan
for photosynthesis
   b) Calcium; humans have a calciferous endoskeleton which requires calcium to g
Nitrogen/sulfur; the beetle larvae may contain less protein in relation to other b
Sodium; the nervous system of the beetle is smaller and less extensive than th
not required as much for neuron firing (2)

4. Carbohydrates and Biological Polymers

Content check

1. a) hydrogen, b) oxygen [a) and b) can be either way round], c) diet, d) energy, e) mo
h) starch, i) animals, j) monosaccharides, k) fructose, l) galactose, m) disaccharide, n
p) condensation (16)
q) glucose, r) cellular, s) respiration, t) rice, u) enzymes, v) mouth, w) cells, x) pentos

2. Reducing sugar: fructose/galactose, maltose or lactose; Non-reducing sugar: sucros
3. a) The 'OH' group and 'H' on carbon 1 are reversed in α-glucose and β-glucose (o
   b) Sucrose: α-glucose + fructose (table sugar, found in many plants); Maltose: glu
as a product of the breakdown of starch); Lactose: glucose + galactose (milk);
Starch: α-glucose (plant storage of glucose);
Cellulose: β-glucose (plant cell walls);
Glycogen: α-glucose (animal storage of glucose)
1 mark should be awarded for the correct composition, 1 mark for the location

Essential skills & practice

1. **Starch:** combination of many glucose molecules into long chains, makes the molecu
storage; being insoluble stops the molecule from being mobile within the plant; bra
easily accessible for respiration as glucose is more easily removed (max. 3)
Cellulose: hydrogen bonds between sheets; strengthens structure providing suppor
Glycogen: combination of many glucose molecules into long chains, makes the mol
of storage; being insoluble stops the molecule from being mobile within the body; h
molecule more easily accessible for respiration as glucose is more easily removed (m

Extend your thinking

1. a) Amylose and amylopectin
   b) Amylose is a straight chain molecule / simple helix / amylose is unbranched, w
   In amylose, adjacent glucose molecules are linked only by α 1–4 glycosidic bon
   α 1–6 glycosidic bonds
   Amylose is less soluble in water than amylopectin (students may note that am
   with hot water)
   Amylose turns blue-black when iodine is added, but amylopectin does not
   Amylose makes up about 20 % of starch, while amylopectin makes up about 8
   Award 1 mark for each comparison statement.

2. Orientation of the 'OH' group on β-glucose means that alternate glucose molecules
   allowing the chains to form in 'straight lines' rather than helices (1)
   The alternation of the orientation of the glucose molecules allows hydrogen bonds t
   This increases the strength of the structure (1)
3. A pentose sugar contains five carbons; while fructose has a pentagonal rather than
   it contains six carbons and is, therefore, a hexose sugar

5. Lipids

Content check

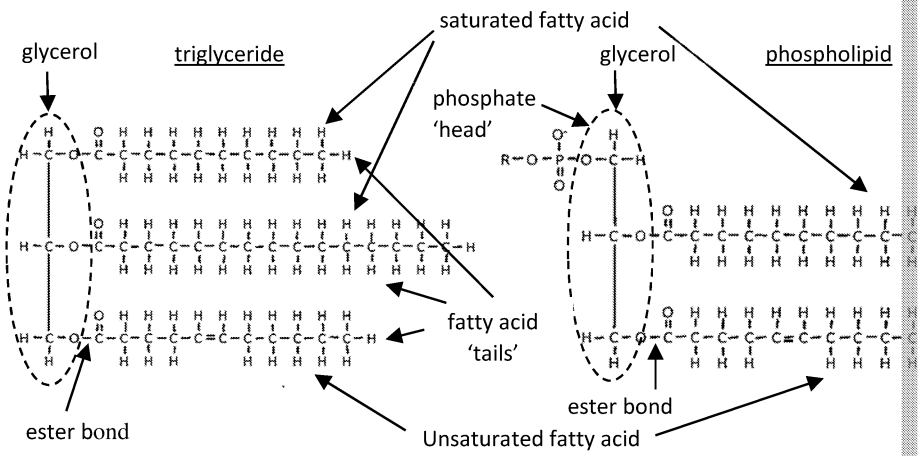
1. **Mind map:** This is an open-ended activity, but expected answers include:
   - Uses of lipids in the human body … long term store of energy; building block o
     insulation of nerves (myelin sheath); making hormones (cholesterol)
   - Chemical composition and structure of lipids – C, H and O; glycerol and three f
     unsaturated or saturated
   - Dietary sources of healthy lipids – oily fish, nuts, avocado
   - Unhealthy dietary sources of lipids – fast food (e.g. burgers and French fries), c
     cakes, chocolate, meat with high fat content
   - Oils – lipids which are typically liquid at room temperature; usually come from o
     grapeseed oil, soybean oil); contain more unsaturated and polyunsaturated fat
   - Fats – lipids which are typically solid at room temperature; tend to come from a
     bacon fat); contain more saturated fatty acids / fewer unsaturated fatty acids
   - Recent learning:
     - types of lipids – phospholipids (structural components in cell membranes;
       acids, and a phosphate 'head') – triglycerides (found in food; one molecu
     - emulsion test for lipids
     - saturated fatty acids (all single bonds) and unsaturated fatty acids (doubl

   As this is an open-ended revision activity, it is recommended that pupils are awarde
   within each bubble
2. *Award 1 mark for each correct row.*

Lipid	Energy storage	Cell membrane structure	Horm
Triglyceride	✓	×	
Phospholipid	×	✓	
Cholesterol	×	✓	

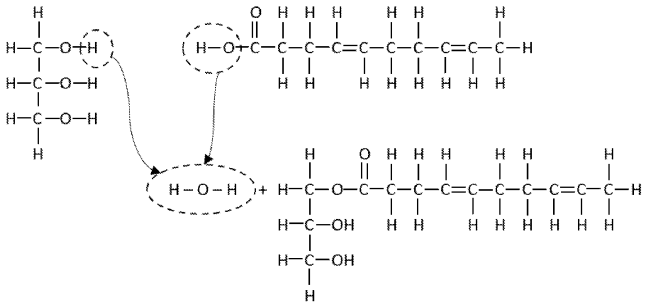
Essential skills & practice

1. *Award 1 mark for each correct label*



2. a) molecule A = glycerol; molecule B = (polyunsaturated) fatty acid

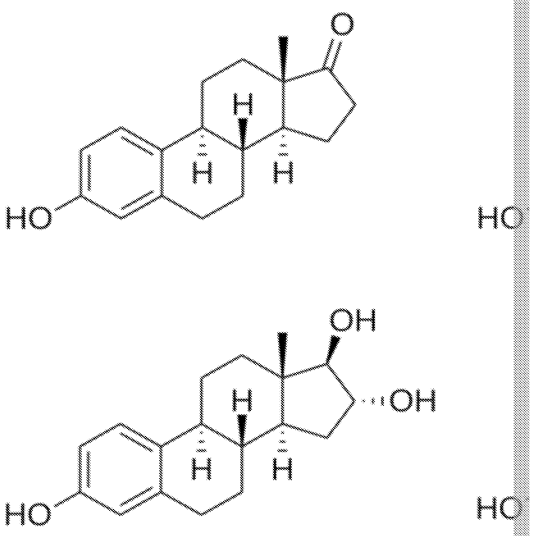
b)



Award ***1 mark*** fo
correctly identi
atoms involved
reaction. Award
mark for correc
drawing the co
ester bond.

c) The part of the molecule drawn in part b) is unchanged
All three fatty acids are correctly attached to the glycerol molecule with an est
One or both of the additional fatty acids is/are saturated
There are no errors in the number of bonds between the atoms

3. Note that students may have different variations of the oestrogen molecule. The image (right) shows four common structures. The key differences for students to identify are:
   - three double bonds in the first ring structure
   - no double bond in the second ring structure
   - no 'tail' **[3]**



Extend your thinking

1. *This is an open-ended task. Award 1 mark for each box containing a correct idea, ev*

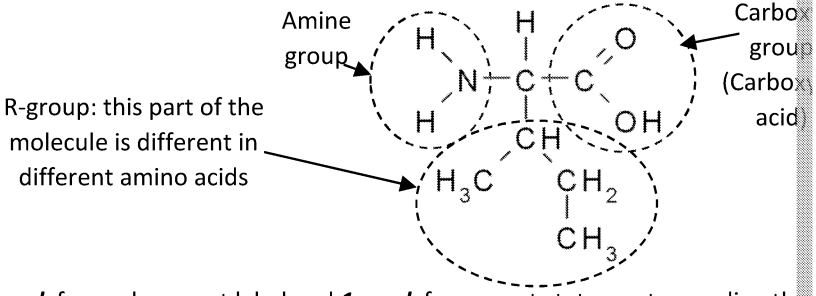
Molecule	Structural feature	Property due to this structural feature	How this relates
Phospholipid	Two fatty acid 'tails'	Affinity with other fats keeps molecules together	Keeps the cel allowing fluid
Triglyceride	Large and non-polar	Hydrophobic and insoluble in water	Good for storage m
Phospholipid	Polar phosphate 'head'	Hydrophilic 'head' orients towards water and away from fat	Ensures all molec group outward 'sphere' which

2. *Award 1 mark for the function (bold) and 1 mark for the explanation.*
Ring structures of cholesterol **improve membrane stability** by 'bonding' with adjace cell membranes (2)
The short, wide shape of the molecule in comparison to the phospholipids also caus of molecules in the cell membrane, **improving membrane fluidity** (2)
Cholesterol's similarity to many lipid-based hormones and vitamins also makes it a **of these molecules** in the body (2)

6. Proteins

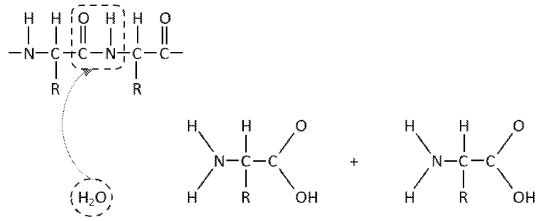
Content check

1. Answers may vary – accept as long as the statements given are true.
(Proteins are very large molecules made up of)… hundreds or thousands of amino a
Our body needs proteins for growth and repair,… (but they are also very effective f various metabolic reactions.)
(We can get proteins from eating)… fish, meat, eggs, dairy products, beans and puls
Dipeptides are formed by… (condensation of two amino acids.)
(Polypeptides are formed by the)… condensation of many amino acids.
A functional protein… (may contain one or several polypeptides.)
Answers may vary. Award ***1 mark*** for each correct sentence.
2. The R-group is the only part of the molecule which differs among the 20 naturally o



Award ***1 mark*** for each correct label and ***1 mark*** for correct statement regarding th
3. Globular proteins: insulin, haemoglobin, amylase, DNA polymerase, glucagon, peps
Fibrous proteins: keratin, collagen, elastin
Testosterone and oestrogen are steroid-based (lipid-based) hormones and are not p
Deduct 1 mark for each error.

Essential skills & practice

1. 

Award ***1 mark*** for correctl in the reaction.

Award ***1 mark*** for correctl amino acids.

2.

Structure	Primary (1^{y} / 1^{o})	Secondary (2^{y} / 2^{o})	Tertiary (3^{y} / 3^{o})
Description	sequence of amino acids	α-helix, or β-pleated sheet	3D structure
Type of bonding involved	peptide bonds	hydrogen bonds	ionic bonds and disulfide bridges
Role of bonding	strong covalent bond holding adjacent amino acids together	maintains the helix or sheet structure	create and maintain forming strong bonds diffe

Award ***1 mark*** for each correct box.

Extend your thinking

1. a) α-keratin is made up of α-helices; which are joined adjacently by S–S cross links are long, strong and flexible; they are commonly found in hair and skin (4)
β-keratin is made up of β-pleated sheets; which form H bonds between them in rigid than α-keratin; and is found in higher amounts in hard structures such as t reptiles and birds (4)

b) *Students are expected to choose an example rich in α-keratin, such as hair or sk such as rhino horn, nails, scales, feathers (shafts) or a bird's beak. Award 1 mar examples.* (1)
Explanations should include the idea that <u>β-keratin increases rigidity</u> *(1) which is students should specify why the increased rigidity is beneficial (1)*
Students should identify why the flexibility provided by α-keratin is beneficial in

7. Biochemical Tests & Inorganic Ions

Content check

1. A = 4; B = 6; C = 1; D = 5; E = 3; F = 2; G = 7
2. a) D only
b) A only
c) B and C (both answers must be correct for the mark)

3. a) For definition: *Any suitable and accurate description should be accepted. Pupils should include:*
- idea that inorganic molecules do not contain carbon; (1)
- ions carry an electrical charge (due to losing or gaining electrons) (1)

b) Correct answer: Na^{+}, Ca^{2+}, OH^{-}, H^{+}, NH^{4+}, K^{+}, PO_4^{3-}, SO_4^{2-}, Cl^{-}, NO_3^{-}
Award full marks if all correct. Deduct 1 mark for each error as specified below.
Not ions: H_2O, CH_4, H_2O_2
Organic: CH_4; $COOH^{-}$ sometimes considered organic and therefore allowed in ei and should not be considered as important for biological organisms
Pu^{4+}, Cs^{+}, U^{4+}, F^{-}, CN^{-} should not be considered as important for biological organisms and would be damaging inside cells. Pu^{4+}, and U^{4+} are relatively rare and unstable

4. A. OH^{-}, H^{+}; B. Ca^{2+}, K^{+}, Fe^{2+}; C. Na^{+}; D. PO_4^{3-}; E. Na^{+}, K^{+}; F. H^{+}; G. Na^{+}; H. Fe^{2+}

Essential skills & practice

1. a) Reducing sugars: D, F, J, B, H
   award 1 mark if 1–2 errors in the order, 0 marks if 3 or more errors
   b) Non-reducing sugars: D, F, J, B, H, E, I, A
   award 1 mark if 1–2 errors in the order, 0 marks if 3 or more errors
   c) Starch: G, C, K
   all must be correct for the mark
2. Procedure should include the following steps:
   1. Place a small amount of each substance in separate test tubes (pupils may give
   2. Dissolve any solid substances in a small amount of distilled water (again pupils
   amounts are suggested the volume given here should match the volume given
   3. EITHER add a few drops of sodium hydroxide, shake gently, and then add a few
   OR add a few drops of Biuret reagent and shake gently
   4. Observe any colour change in the solution (from the colour of the biuret reage
   5. If the solution turns purple protein is present. If the solution looks pale blue th

   Award ***1 mark*** for each correct step
3. a) Sodium (Na^+) and potassium (K^+)
   b) Sodium (Na^+)
   c) Calcium (Ca^{2+})
   d) Ammonium (NH_4^+) or nitrate (NO_3^-)
   e) Magnesium (Mg^{2+})
   f) Iron (Fe^{2+})
   g) Proton/hydrogen (H^+)

Extend Your Thinking

1. a) It is expected that the following ideas are included:
   - Idea that the purpleness/darkness is dependent on the amount of protei
   - Weaker pupils may simply note that a negative result is pale blue, a weak
   positive is violet/purple.
   - There could be recognition that there should be some kind of compariso
   - Perhaps a food known to contain high levels of protein (e.g. egg white) is
   concentration (e.g. 100% egg white, 50% egg white, 25% egg white or 10
   white) and this is used for comparison of other substances.
   - Colorimetry can be used to compare the absorbance of the samples with

   If the pupil does some research or has extensive prior knowledge, the followin
   - Testing absorbance at a wavelength of 540nm
   - Standardised solution is required to compare against (i.e. colour generate
   protein, not just an arbitrary scale for comparison)

   It is suggested to use a more subjective grading for this open-ended question:
   Poor – vague answer**: 1–2 marks**
   Good answer – containing elements of the expected answer: **3–5 marks**
   Excellent answer - Including the concept of a standardized solution and colorim
   How many marks are awarded within each band should depend on the level o
   provided in the answer.

   b) To help diagnose various medical conditions
   c) Amino acid chromatography, to identify specific proteins

2. a) Hydrolysis of the bonds between the two monosaccharides (reducing sugar) in a
   b) Neutralise the solution (1)
   adding until it 'stops fizzing' ensures the sodium hydrogen carbonate is slightly
   been neutralized (1)
   c) There is no direct test for non-reducing sugars (1)
   the test for reducing sugars should be done first to determine the presence of
   if there is a negative or very weak result, the test for non-reducing sugars shou
   this involves separating the monosaccharides and re-testing for the presence o
   if the result changes from negative to positive, (or from a weak positive to a st
   sugars were present in the original sample (1)

8. Nucleic Acids and ATP

Content check

1. A = phosphate; B = ribose; C = adenine; D = phosphate; E = deoxyribose; F = organic
   guanine or thymine; G = phosphate; H = ribose; I = organic base / adenine, cytosine,
2. *Award 1 mark for each correctly filled cell.*

	Purines	Pyrimidines
DNA	Adenine and Guanine	Thymine and Cytosine
RNA	Adenine and Guanine	Uracil and Cytosine

3. A: ribosomal RNA; serves as a major structural component in ribosomes
   This is probably the hardest molecule for pupils to sketch, but also the least importa
   do so in an exam situation, but they should be able to recognise this molecule and th
   Anything roughly resembling the diagram on the worksheet should be accepted. Tea
   the ribosome consists of both rRNA and protein but is largely RNA. All three compo
   must be correct to gain the marks. (2)
   B: transfer RNA (tRNA); carries an amino acid to the ribosome
   The diagram drawn by pupils should include the amino acid connection site and the
   characteristic shape of the molecule, but does not need to include all bases and othe
   All three components (name, structure and function) must be correct to gain the ma
   C: messenger RNA (mRNA); a short chain of RNA complementary to a particular gen
   from the nucleus to the cytoplasm of a eukaryotic cell
   The diagram drawn by pupils should show a long chain of bases, which may or may no
   diagram as shown on the worksheet. Make sure pupils are aware that an mRNA is co
   DNA. All three components (name, structure and function) must be correct to gain th

Essential skills & practice

1. a) 10
   b) 2
   c) 3
   d) 5
   e) X = hydrogen bond; Y = phosphodiester bond
   f) DNA polymerase, condensation reaction

2. **DNA only:** double helix, long chains, deoxyribose, base may be thymine, store of ge
   RNA only: relatively short chain, base may be uracil, 'carrier' of genetic information
   ATP only: single nucleotides, three phosphate groups, organic base is always adeni
   release energy
   DNA and RNA: polynucleotides – many nucleotides are joined together in a long ch
   or guanine, contain genetic information
   RNA and ATP: contains ribose
   All molecules: include phosphate, pentose sugar and organic base
   Award marks for any correctly matched feature

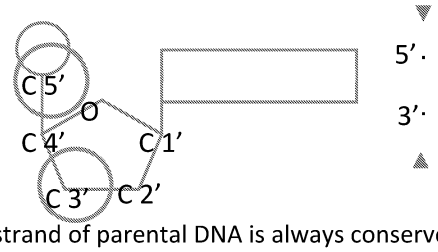
Extend your thinking

1. *Note: Some of the ideas covered in this activity will not yet have been taught at A Le*
   have been exposed to the ideas at GCSE, especially if following a separate science cu
   them through their own self-study.
   Possible answers include the following ideas:
   - rRNA combines with protein to form the ribosome. Its complex folding and in
     hold a specific shape which can 'fit' with the protein elements of the ribosome,
     tRNA and amino acids during protein synthesis.
   - The anticodon of the tRNA is at the extreme end of the molecule and is specifi
     ensuring that amino acids are joined in the correct sequence during protein sy
     site is equally unique and remains as a single chain so that hydrogen bonds ca
     amino acid.
   - The mRNA does not fold like other RNA molecules but remains as a single chai
     molecule to leave the nucleus through special pores in its surface, and for the
     the ribosome during protein synthesis.
     Award marks for any correct and relevant ideas up to a maximum of 3 marks p

9. DNA Replication

Content check

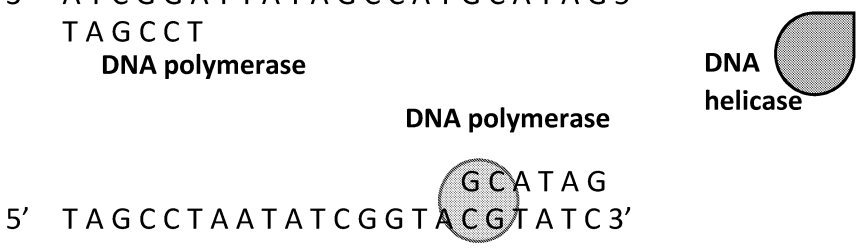
1. 1 = D, 2 = G, 3 = A, 4 = H, 5 = B, 6 = E, 7 = C, 8 = F
2. *Note: While knowledge of 3' and 5' is not explicitly mentioned in the 2017 specification, specimen papers. This concept should be included in teaching the role of DNA polymer Sound understanding of this concept will also help pupils significantly in understanding*
   a) Carbons and oxygen positioned correctly (1)
   Fifth carbon labelled somewhere on the 'branch' between the pentose ring an the phosphate group connects to the 'branch' (1)
   Third carbon correctly labelled (1)
   b) 5' and 3' ends of both strands correctly labelled (1)
   Direction of DNA replication correctly identified according to 5' and 3' ends (1)



3. One strand of parental DNA is always conserved (in each new daughter strand) (1)
   (Helps to ensure genetic continuity as the) parent DNA is used as a continuous temp daughter strand) (1)

Essential skills & practice

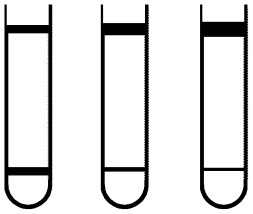
1. The correct order and expected descriptions are:
   1 = B: DNA helicase binds with / attaches to the DNA molecule
   2 = C: DNA helicase begins to unwind the alpha helix and separate the two strands o bonds between the complementary bases
   3 = E: Free DNA nucleotides begin to bind to their complementary bases on the DNA
   4 = D: DNA polymerase binds / attaches to each strand of DNA and begins to join the reaction, forming the phosphodiester bond
   5 = A: DNA polymerase only works in the 5' ⇨ 3' direction
   6 = F: Two identical DNA daughter molecules are created
   Ordering: Deduct 1 mark for each error (2)
   Descriptions: Award marks for any suitable description, 1 mark for each diagram (6)
2. • DNA polymerase should be shown at the 3' end of each daughter strand of DN added in the 5' ⇦ 3' direction (1)
   • DNA helicase can be drawn at either end of the diagram but not over the repli
   • The 5' and 3' indicators should be drawn on the bottom template strand to sho strands of the parental DNA molecule are antiparallel (1)

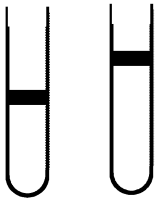


Extend your thinking

1. a) C, A, E, B, G, F, D, H (2) – deduct 1 mark for each error
   b) Both the semi-conservative and dispersive models are supported by this result (as both models predict daughter DNA molecules containing 50 % parental/old a
   c) Results confirming conservative replication:
   • bands located correctly (1)
   • appropriate width of band (1)

Results confirming di
• bands located co
• appropriate wid





10. Protein Synthesis – Transcription

Content check

1. a) *The mark should be awarded only if the definition is adequate and correct for t*
The chosen words are likely to come from the following:
RNA – ribonucleic acid; a nucleic acid macromolecule in which each nucleotide
nitrogen-containing base and a ribose sugar
DNA – deoxyribose nucleic acid; a nucleic acid macromolecule in which each n
group, a nitrogen-containing base and a deoxyribose sugar, usually formed into
nucleic acid – a macromolecule made up of nucleotides, each of which is made
nitrogen-containing base and a pentose sugar
rRNA – ribosomal RNA; a molecule which forms part of the ribosome
mRNA – messenger RNA; a molecule which is made during transcription from a
tRNA – transfer RNA; a molecule used in translation
translation – the process of converting the mRNA code/sequence to a sequenc
polypeptide – a long chain of amino acids
transcription – the process of converting a DNA sequence into a complementa
complementary base pairing – the system of matching base pairs (A to T/U, and
replication, transcription and translation
splicing – 'cutting' and 'sticking' the pre-mRNA made in transcription into the m
b) only a single strand – some sections of tRNA and rRNA are folded back to form
thymine – RNA has uracil but not thymine
all cells – only eukaryotes have a nucleus
DNA polymerase – this should be RNA polymerase as it is RNA bases being join
different enzyme
prokaryotes – splicing occurs in eukaryotes not prokaryotes; the mRNA produc
prokaryotes is already ready for translation
Award 1 mark for identifying the error correctly, 1 mark for a correct explanati

Essential skills & practice

1. a) RNA polymerase
b) *Deduct 1 mark if T is used in the RNA strand. Allow up to two errors per mark.*

2. a) Triplet (1)
b) Universal (1)
c) Degenerate (1)
d) RNA bases (1)
e) DNA bases (1)
f) Ribosome (1)
g) Amino acid (1)
h) Intron (1)

Extend your thinking

1.
- singular, non-folding sequence of RNA (mRNA: unfolded strand is easier to fit t
be read by the ribosome) (2)
- complex folding with some helical sections (rRNA: makes the molecule comple
'fit' with other rRNA and protein sub-molecules of the ribosome) (2)
- short repeating A-T rich sequences on either end (mRNA: helps the ribosome t
the mRNA) (2)
- folded into three 'arms' with a short naked section at the end of the molecule (
amino acid acceptor which allows a single amino acid to bind with the molecu
- sequence of three bases (ACC) exposed at the 'top' of the molecule (tRNA: nak
temporarily bind with its complementary codon on the mRNA) (2)

1 mark for correctly identifying the RNA molecule, 1 mark for the explanation.

11. Protein Synthesis – Translation

Content check

1. 1 = C; 2 = F; 3 = H; 4 = D; 5 = G; 6 = B; 7 = E; 8 = A
2. a) translation, b) complementary, c) Uracil, d) information, e) incorrect, f) random, g)

Essential skills & practice

1. *Students should be given up to 2 marks for each box in their storyboard. Award 1 m*
accuracy and detail.
Basic ideas include:
1. mRNA leaves the nuclear envelope and travels to the ribosome
2. First tRNA brings the first amino acid to the ribosome / translation begins

3. New tRNAs bring more amino acids to the ribosome, matching with the mRNA
sequence of amino acids
4. The completed polypeptide is released from the ribosome, and the last tRNA a
the ribosome

2. a) Met-Gly-Ser-Ile-Tyr-Ala-Ser-Ile-Ala-Ala-Met-Thr *Deduct 1 mark for each error.*
b) Met-Ala-Phe-Ala-Cys-Tyr-Ile-Ala-Val-Ala-Ser-Asp *Deduct 1 mark for each error.*
c) Met-Val-Arg-Cys-Met-Thr-STOP *Deduct 1 mark for each error. Max. 1 mark if*

Extend your thinking

1. a) i. Ensure enough genetic material to give a strong result / result would be e
ii. The deadly S strain bacteria needed to be dead for the experiment to sho
all test tubes would produce the same result
iii. Break up the cells to release the constituent parts
iv. Removes one molecule from the mix
v. Live bacteria would use the transmission molecule to transform into S str
otherwise all test tubes would show the same result
b) The test tube which the DNAase was added to did not produce any new S strai
was the molecule responsible for transmitting genetic information

12. Enzymes

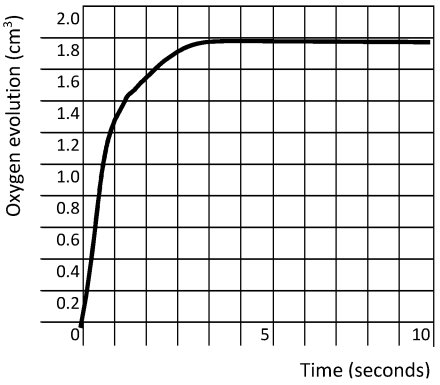
Content check

1. A = 9; B = 11; C = 1; D = 7; E = 2; F = 5; G = 12; H = 3; I = 6; J = 4; K = 10; L = 8
2. a) proteins, b) catalysts, c) activation, d) energy, e) reaction, f) temperature, g) pres
round], h) organisms, i) tertiary, j) active, k) binds, l) specific (12)
m) optimum, n) temperature, o) optimum, p) denature, q) covalent, r) disulfide, s) t
v) pH (10)
w) substrate, x) competitive, y) occupy, z) substrate, A) non-competitive, B) lose/ch

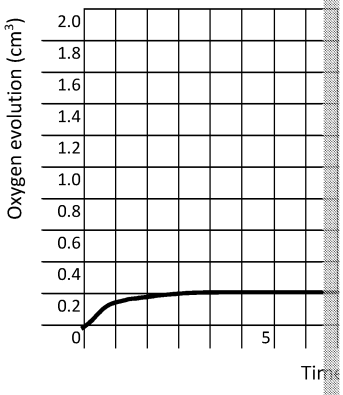
Essential skills & practice

1. Graph A – lower temperature (slower rate, but reaction stops at the same level) (1)
Graph B – lower substrate concentration (slower rate, reaction stops at a lower leve

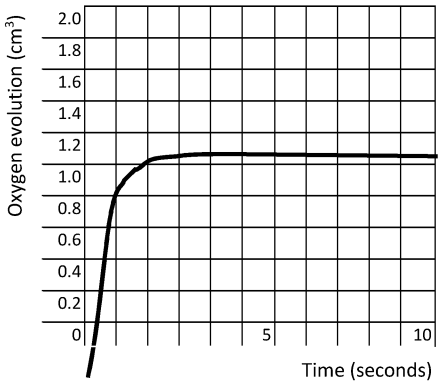
Increased substrate concentration – *increased rate of reaction and increase in the end point as more substrate is available for the reaction.*



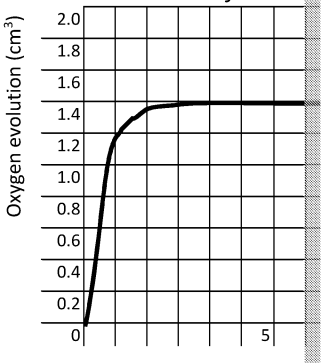
Extreme pH – *a flat line at 0 as the enzyme is likely to b inactive at extreme*



Increased temperature – *rate of reaction increases due to increased frequency of collisions, but end point does not change as the amount of substrate is the same.*



Higher enzyme concentra *increases due to incre collisions, but end point d amount of substr*



For each situation:

- correct graph (1)
- correct explanation (1)

2.
- Sock is designed to fit a foot (1)
- but exists in a different shape until it 'combines' with the foot (1)
  (similar to the way that the shape of an enzyme changes when it binds to the s
- Induced fit explains that while the enzyme and substrate are complementary, t
  to the substrate (and vice versa) (1)
- Sock is the enzyme, and the foot is the substrate (1)

Wording will vary

3. *As this is an open-ended activity, responses will vary. Possible questions (top row fir*
   - Name an organism which possesses enzymes which work well below 0 °C.
   - What is the name given to the loss of an enzyme's 3D structure?
   - Which type of enzyme inhibitor can attach to the active site?
   - What happens to the rate of an enzyme-controlled reaction as temperature is g
   - What happens within an enzyme as it starts to denature? / What happens to a
     higher than the optimum?
   - How do enzymes increase the rate of reactions inside living organisms?
   - How are the enzymes of thermophilic bacteria, which live above 75 °C, differe
     the enzymes used in biological laundry detergent different from other enzyme
   - What is the name of the combined structure made up of the enzyme and its su
   - Why does denaturation prevent an enzyme from working?

   Any correct question should be awarded a mark

Extend your thinking

Suggestions may include:

1. a) Enzymes in the human digestive tract are not able to metabolise xylitol into mo
      recognised and absorbed by the wall of the small intestine. Enzymes in humar
      cells are unable to metabolise/respire xylitol as it contains different bonds / do
      sites which are specific to glucose or other sugars. *Award a mark for any corre*
   b) Certain bacteria (or yeasts) may possess enzymes which are able to break/met
      compounds which can be more easily absorbed by the small intestine. The rat
      in a particular person will, therefore, affect how many calories they are able to
      Award a mark for any correct response

2. *Note: This activity includes some information from the conformational selection mo*
   specification, but pupils are not actually expected to use this information; it is prese
   given information together.
   The complete passage should include the following ideas, in the order shown, thoug
   be different:

   In **1894, Fischer** proposed the **lock-and-key** model of enzyme action to explain the
   binding only to certain substrate molecules.
   - correct date, name, theory and description (4)

   However, this model could not explain **multiple research which has shown that bo**
   dynamic (changing) molecules.
   - correct explanation of how this fact fits the changing theories (1)

   In **1958, Koshland** proposed the **induced-fit hypothesis** which explains that **the enz**
   the substrate when binding,
   - correct date, name, theory and description (4)

   but morphological changes in some highly flexible proteins cannot be explained by t
   researchers proposed the conformational selection model, which allows for the pro
   states, one of which matches the substrate.
   - information provided in the question (0)

13. Investigating the Rate of Enzyme Action

Content check

1. *Each correctly filled box in the table should be awarded 1 mark.*

Factor changed	Effect on the rate of reaction below the saturation point
Increased enzyme concentration	increased (steeper gradient)
Increase in temperature, below the optimum	increased (steeper gradient)
Presence of competitive inhibitor	decreased (shallower gradient)
Presence of non-competitive inhibitor	decreased (shallower gradient)
Extreme low pH	decreased (maybe no reaction)
Increase in temperature above the optimum	decreased (maybe no reaction)

Additional notes:

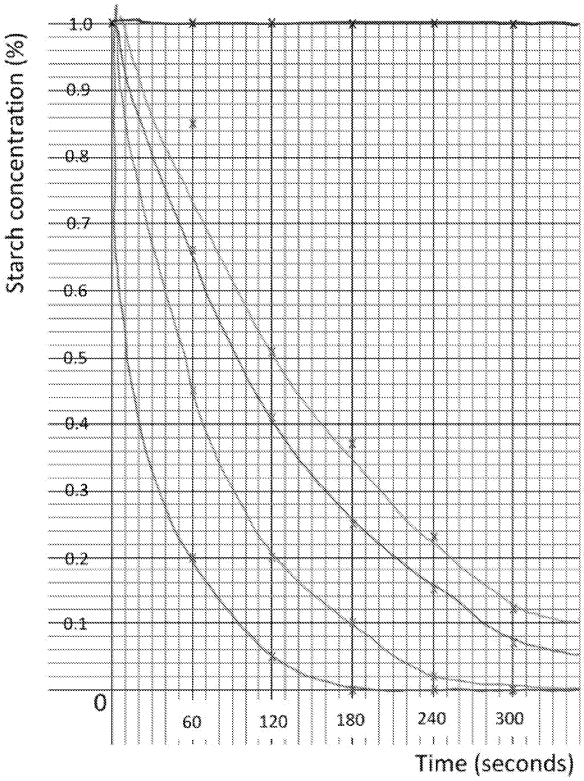
Competitive inhibitor: The inhibitor 'competes' with the substrate for the enzymes' a
number of enzymes available to the substrate at lower concentrations. The greater t
the lower the concentration of substrate, the greater the effect will be. However, be
substrate molecules exist in the solution that they 'outcompete' the inhibitor such th
maximum rate of reaction seen at high substrate concentrations.
Non-competitive inhibitor: As non-competitive inhibitors do not 'compete' for the ac
concentration does not have any effect, but the inhibitor prevents the enzyme from f
effectively lowers the enzyme concentration.

2. a) *1 mark should be awarded for each suitable variable, 1 mark for each explanat*
given variables.
Possible variables and explanations include, but are not limited to:
   - **starch concentration** would affect the total amount of starch available – a
reaction – and should be controlled
   - **volume of starch solution** would affect the total amount of starch availab
the reaction and should be controlled, any value below 10 ml should be c
equipment appropriate to the chosen value should be given as the metho
for values < 5 ml, 10 ml measuring cylinder for larger values.
   - **volume of amylase solution** should also be controlled to keep the total vo
also affect the probability of collisions between enzyme and substrate an
value below 10 ml should be considered as suitable, measuring equipme
should be given as the method to control, e.g. syringe or pipette for valu
for larger values.
   - **amylase concentration** would affect the amount of amylase available to t
rate of the reaction. This must be controlled. Suitable values are 1–10 %
   - other variables such as **pH**, **method of mixing components**, **vessel for mi**
cuvette, etc.) may be considered and should be accepted as long as an ap
explanation is given.

   b) Equation stated $Q_{10} = R_2 / R_1$ (1)
Students must take either 28 °C and 38 °C, or 18 °C and 28 °C, as the values of r
temperature change.
Either: 2.5 / 0.85 = 2.94 OR 0.85 / 0.3 = 2.83 (1)

Essential skills & practice

1. a) *Graphs should be drawn with time on the x-axis and starch concentration on th line for each amylase concentration. Pupils may draw separate graphs for each preferable to have all lines drawn on the same graph for ease of comparison. G not by using a computer. A sample answer is shown below:*



- both axes correctly l
- axes given an appro
- graph drawn at a sui
- points plotted accur
- smooth curve drawn
- anomaly correctly o

b) 60 s for 1 % amylase solution appears to be anomalous

c) Repeat this measurement; if different from the first measurement at least one check which result is the more accurate

d) Should have taken at least three repeats for all data points so that an average c reliable data obtained)

2. a) *Note that pupils are likely to have drawn a slightly different tangent and will have chosen different points from which to calculate the gradient. Their tangents will also have been drawn based on a different hand-drawn curve and may vary significantly.*
The values below were chosen due to the fact that the tangent intercepted the grid lines at these points, as shown right.
The final gradients calculated by the students should be ± 10 % from the values shown to be accepted, and their working should be shown.
For 1 % amylase concentration:
0.58 – 1.00 / 80 – 0 = -0.0053 % s^{-1} or -0.32 % min^{-1}
For 2 % amylase concentration:
0.46 – 1.00 / 80 – 0 = -0.0068 % s^{-1} or -0.41 % min^{-1}
For 5 % amylase concentration:
0.56 – 1.00 / 30 – 0 = -0.015 % s^{-1} or -0.88 % min^{-1}
For 10 % amylase concentration:
0.2 – 1.00 / 20 – 0 = -0.04 % s^{-1} or -2.4 % min^{-1}

- correctly drawn tangents (1)
- correct gradient calculations (1)
- answer for 1 % amylase within the range -0.0058 to -0.0048 % s^{-1} or -0.35 to -0.29 % min^{-1} (1)
- answer for 2 % amylase within the range -0.0075 to -0.0061 % s^{-1} or -0.45 % to -0.37 min^{-1} (1)
- answer for 5 % amylase within the range -0.017 to -0.013 % s^{-1} or -0.97 % to -0.79 min^{-1} (1)
- answer for 10 % amylase within the range -0.044 to -0.036 % s^{-1} or -2.64 % to -2.16 min^{-1} (1)

b) Th in co

c) Hi m ac th le

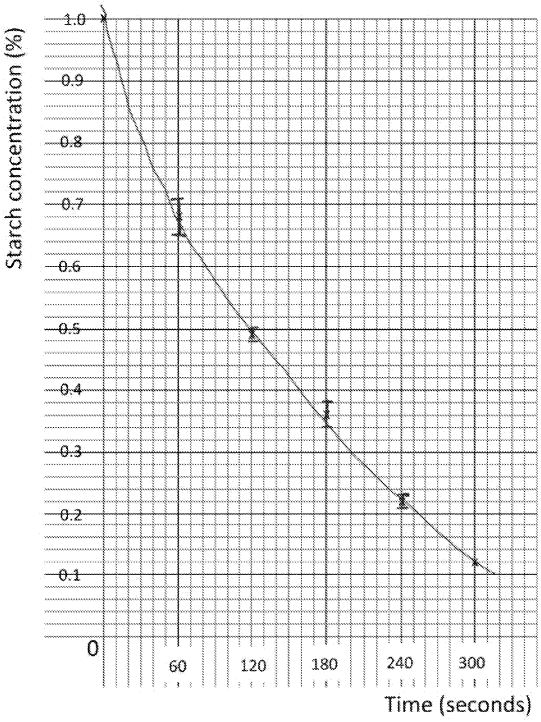
3. a) Total: Each correctly calculated average starch concentration (i.e. for each tim

Alternatively, the pupils may decide to take an average of the absorbance valu average into a starch concentration value. However, this prevents the pupil fr deviation for the starch concentration.

Initial starch conc. (%)		60 s		120 s		180 s		240 s	
		abs. 610 nm	Starch conc. (%)	abs. 610 nm	Starch conc. (%)	abs. 610 nm	Starch conc. (%)	abs. 610 nm	Sta co (%
	1	0.691		0.613		0.523		0.401	
	1	0.703		0.624		0.544		0.432	
	1	0.684		0.617		0.556		0.423	
Avg.	1	0.693 (±0.008)	0.68	0.618 (±0.005)	0.49	0.541 (± 0.014)	0.36	0.419 (± 0.013)	0.2

b) Improves reliability of the results / minimum of three repeats allows for an av experimenter to identify an anomalous result

c) *A sample graph is shown below. Note that error bars may or may not be prese*



- both axes correctly la
- axes given an approp
- graph drawn at a suita
- points plotted accura
- appropriate (passes t smooth curve drawn

Extend your thinking

1. At least four values between 0 and 1 % should be given (1)
Four or more given values evenly spaced (1)
A good suggestion would be 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9 and 1 %, or 0.2,
Values above 1 % should be excluded as these values would not be relevant to the
Recognition that different concentrations can be made by mixing the 1 % starch sol different ratios (1)
e.g. the 0.2 % concentration could be made by adding 2 ml of 1 % starch solution to 0.4 ml of 1 % starch solution to 1.6 ml of distilled water
Recognition that these standard solutions must be mixed with iodine and amylase i investigation in order to produce a calibration curve which will give accurate values *e.g. 2 ml starch solution, 2 ml distilled water and 0.1 ml iodine solution (at the same main investigation)*
Pupils may note that the absorbance should be checked with different concentratio to ensure that the amylase does not affect the absorbance at the 610 nm wavelen

14. Cell Membranes

Content check

1. a) A = protein; B = phospholipid; C = glycolipid; D = cholesterol; E = glycoprotein
   b) B/C, E, D, A. *The placement of cholesterol (D) in this order should be flexible as have limited knowledge. Placing from third to fifth place is suggested. Pupils' e following ideas:*
   The phospholipids and glycolipids are relatively small molecules and will, there the membrane;
   the glycoprotein is bigger and less mobile;
   while the membrane protein is very big and difficult to be moved by the jostlin
   cholesterol is bound/attracted to adjacent phospholipids so is expected to be le
   be aware that the effect and function of cholesterol in the membrane is differe temperatures it maintains fluidity by increasing the space between phospholip stability due to its effect on neighbouring molecules).
   Allow 1 mark for each correct idea, up to a maximum of 4

2. a) Phospholipids have a hydrophobic tail and a hydrophilic head, which causes th membranes automatically arranging with their heads facing outwards; they ar the membrane
   b) Cholesterol is a lipid made up of four carbon 'rings'; it increases both membra
   c) Receptor proteins are intrinsic membrane proteins which 'respond' to specific space; they are involved in intercellular communication
   d) Glycolipids have a carbohydrate 'head' and two fatty acid tails; they help to ma are involved in cell recognition

3. *Award 1 mark for each correct column.*

	Phospholipid	Glycolipid	Intrinsic enzyme protein	Receptor p
Partially permeable barrier	✓	×	×	✓
Site of chemical reactions	×	×	✓	×
Site of cell communication	×	✓	×	✓

Essential skills & practice

1. a) A = columnar epithelial cell (of the small intestine) (1)
   nutrient molecules (1) are transported from the lumen of the small intestine in blood or lymph (1)
   B = root hair cell (plant) (1)
   mineral ions and water (1) are transported from the soil into the cell / from the ce
   C = epithelial cell of the capillary wall (1)
   oxygen and nutrients; are transported from the lumen of the capillary (the blo into adjacent body cell (2) OR
   carbon dioxide and other waste products of metabolism; are transported from cell / out of the cell into the blood (2)
   b) *Any sensible answer should be accepted. Possible answers include:*
      - increased surface area (by microvilli, cell elongation, or cell flattening)
      - increased number of transport proteins or pores (depending on the mole
      - increased fluidity, especially if non-polar molecules or small polar molecu
      - increased number of mitochondria to provide ATP for active transport

2. *Award 1 mark for stating the effect on permeability and 1 mark for the explanation.*
   a) Decreased permeability; saturated fatty acids have higher melting points and hi acids; they allow the phospholipids to pack closer together in the membrane, de
   b) Increased permeability; solvents such as ethanol create gaps in the membrane as membrane can dissolve in the solvent; this allows molecules to pass through the

c) Decreased permeability; low temperature means the molecules of the membr simple diffusion and osmosis more difficult / low temperature generally slows t movement of molecules, meaning that passage of molecules via transport pro slowly / less frequently

Extend your thinking

1. *As this is an open-ended activity, there are no specific answers.*
   Award marks for:
   - state/describe the reaction (1), e.g. absorption of B12 by epithelial cells in the
   - identify the membrane involved (1), e.g. cell surface membrane / mitochondri
   - identify the membrane components involved in the reaction (1), i.e. specific e
   - identify the reactants of the reaction (1)
   - identify the products of the reaction (1)
   - identify the importance of the reaction to the organism involved (1)

   Total marks for two examples.

15. Active Transport and Co-transport

Content check

1. *Award 2 marks for each column, with 1 mark deducted for two errors within the col*

	Diffusion	Osmosis	Facilitated diffusion	
Energy required	×	×	×	
Movement according to the concentration gradient	down	down	down	
Requires specialised membrane proteins	×	×	✓	
Many molecules can be moved simultaneously	×	×	×	
A very specific mode of transport; only occurs with one type of molecule	×	✓	×	
Active or passive	passive	passive	passive	

2. Order: D, A, B, C (1)
   D. The substance being transported has a higher concentration on the inside of t cell. The molecule enters a specific transport protein.
   A. Hydrolysis of ATP activates the specific transport protein.
   B. This changes the shape of the transport protein, releasing the molecule on the
   C. ADP and P^+ are released from the transport protein, returning the protein to it
3. Order: B, D, A, C (1)
   B. The molecule to be transported has been packaged into a vesicle
   D. The vesicle reaches the cell surface membrane and its phospholipids begin to m
   A. The vesicle membrane completely merges with the cell surface membrane
   C. The molecules are released into the extracellular space (4)

Essential skills & practice

1. Water, down the concentration gradient: Osmosis (1)
   The cell membrane is partially permeable and allows small molecules like water to p bigger molecules and charged ions are unable to pass without a transport protein. I water will move down the gradient across the membrane via osmosis. (2)
   Ions, against the concentration gradient: Active transport / Co-transport (1)
   Due to their electrical charge and the hydrophobic nature of the phospholipid fatty a through the cell membrane. A membrane protein is required. If moving against the transport or co-transport is needed. (2)
   Ions, down the concentration gradient: Facilitated diffusion (1)
   As movement is down the concentration gradient, energy is not needed. However, a the membrane (see above), simple diffusion is not possible; a specific protein is nee via facilitated diffusion. (2)

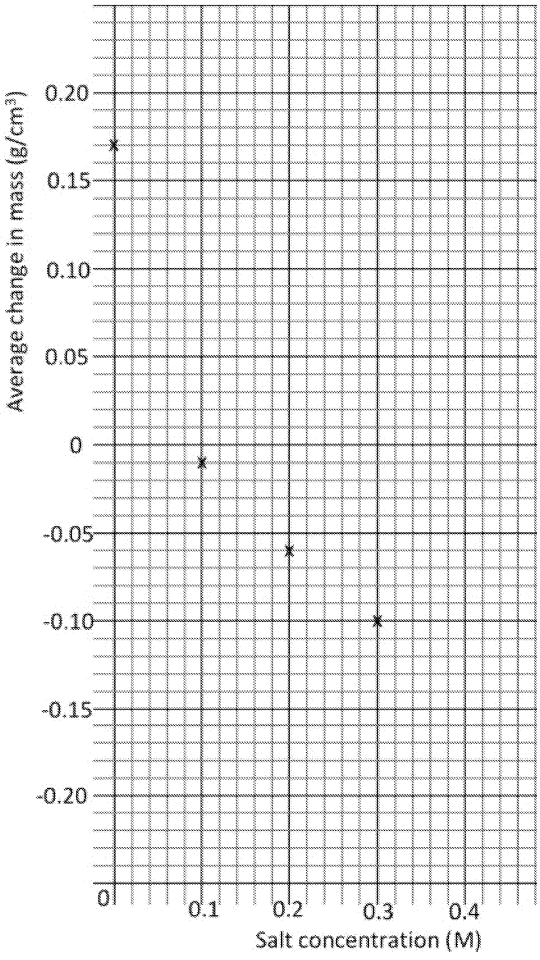
Lipid-soluble vitamins, down the concentration gradient: Diffusion (1)
Most lipid-soluble vitamins are relatively small and, due to the lipid-based nature o
through relatively easily. Therefore, if transport is down a concentration gradient s
Water-soluble vitamins, down the concentration gradient: Facilitated diffusion (1)
Due to the hydrophobic nature of the fatty acid tails of the phospholipids that make
molecules are not normally able to pass through the membrane easily. Therefore, a
transport would occur via facilitated diffusion. (2)
Large soluble molecules (e.g. sugars), against the concentration gradient: Active tra
Due to their large size and the hydrophobic nature of the phospholipid fatty acid ta
cannot easily pass through the cell membrane. A membrane protein is required. If
gradient, active transport or co-transport is needed. (Movement of sugars usually o

2. a) Volume of cylinder = $\pi r^2 h$ (1)
   = $\pi \times 0.16 \times 2 = 1.01\ cm^3$ (1)
   b) Suggestions for control variables could include: temperature, time of immersio

   c)

Salt concentration (M)	Mass before immersion (g)	Mass after immersion (g)	Total change in mass (g)	Cha mass
0	0.63	0.84	0.21	0
	0.65	0.83	0.18	0
	0.67	0.79	0.12	0
0.1	0.61	0.62	0.01	0
	0.59	0.63	0.04	0
	0.72	0.65	-0.07	-0
0.2	0.64	0.59	-0.05	-0
	0.68	0.62	-0.06	-0
	0.69	0.61	-0.08	-0
0.3	0.63	0.55	-0.08	-0
	0.58	0.49	-0.09	-0
	0.69	0.57	-0.12	-0

   d)



The potato in the 0 M
while all others have

e) The result for 0 M salt solution shows that water enters the potato cells from the
has a higher water potential than the cytoplasm of the potato cells. It can be sa
The 0.1 M solution is close to isotonic as there is very little change in the mass
of the cell cytoplasm and the water potential of the salt solution are very simil
The results for 0.2 M and 0.3 M salt solution show that water leaves the potato
salt solution, which has a lower water potential.

f) If using a best-fit curve it is likely that pupils will give values around 0.08 M sal
If using a best-fit line a value of around 0.16–0.18 will be given

Extend your thinking

1. - Both active transport and facilitated diffusion require a specialised membrane
   - Both active transport and facilitated diffusion typically involve the movement o
specific direction across the membrane
   - In facilitated diffusion the molecule moves down / follows its concentration gra
the molecule is moved against its concentration gradient
   - Active transport requires ATP to supply energy, while facilitated diffusion does
2. Normally, transpiration of water from the leaves maintains a constant 'pull' of wate
away from the roots.
This maintains a concentration gradient for the passive absorption of minerals into
root hair cells remain low).
Some minerals exist in very low concentrations in the soil, such that maintenance o
for passive transport is not possible.
Adverse conditions may also lower the rate of transpiration and reduce the concen
between the soil and the root hair cell.
Under these conditions active transport is required to uptake the necessary minerals an
3. a) Diffusion
   b) The insect is small enough for its highly branched tracheal system to produce a
short enough diffusion distance for oxygen and carbon dioxide to diffuse betwe
without the need for a transport system.
   c) The higher oxygen concentration in the carboniferous period increased the co
atmosphere and the cells inside the insect's body;
thus, oxygen could diffuse more quickly and more efficiently into the branching t
Today's oxygen concentration of around 20 % is insufficient (to support such la
as it would take too long for oxygen to diffuse the distances required and get in
continue respiring at a steady rate.

16. Mitosis

Content check

1. a) division, b) host, c) asexual, d) cells (4)
e) mitosis, f) meiosis, g) cell h) cycle, i) mitosis (accept *division*), j) metaphase, k) telop
n) synthesis, o) replication, p) cytokinesis, q) divides (accept *separates* or *cleaves*), r) iden
2. A = 8; B = 3; C = 9; D = 7; E = 6; F = 4; G = 1; H = 10; I = 2; J = 5

Essential skills & practice

1. Correct ordering – *deduct 1 mark for each error* (2)
Picture 3 (interphase: chromosomes uncondensed and invisible; nuclear envelope i
Picture 1 (early prophase: centrioles begin to move to the poles; spindle fibres begi
intact) (1)
Picture 5 (late prophase: spindle fibres have attached to the centromeres; nuclear e
Picture 2 (metaphase: chromosomes are lined up at the cell's equator / on the meta
Picture 6 (anaphase: sister chromatids have moved to opposite poles of the cell) (1)
Picture 4 (cytokinesis: the cell membrane has 'pinched off' into two new cells, each
parent cell; the nuclear envelope is reforming around each new nucleus) (1)
2. a) A = prophase; B = metaphase; C = cytokinesis; D = anaphase; E = interphase
   b) The mitotic index value is a little higher than the normal range for human cells
This is a tissue sample from a plant not a human; it should be expected that th
It is from a growing region of the plant; therefore, a higher than normal rate o

17. Genetic Diversity

Content check

1. A = 3; B = 5; C = 6; D = 4; E = 2; F = 1
2. a) A, D, E, B, G, F, C *Deduct 1 mark for each error.*
   b) A = prophase 1; D = metaphase 1; E = anaphase 1; B = telophase 1; G = metaph
   C = telophase 2
   c) A = DNA forms into chromosomes; the spindle begins to form (1)
   D = the spindle fibres arrange the chromosomes in tetrads along the metapha
   E = the homologous chromosomes are separated and moved to opposite ends
   B = the cell membrane pinches off, dividing the cell into two (1)
   G = the chromosomes line up on the metaphase plate (1)
   F = sister chromatids are separated and moved to opposite ends of the cell (1)
   C = the cell membrane pinches off forming four new daughter cells, each with
   as the parent cell (1)

Essential skills & practice

1. Non-disjunction during meiosis… (may lead to serious genetic disorders, such as Dow
   (Crossing over during meiosis…) increases the genetic variation among daughter ce
   the alleles for each gene.
   Random fertilisation between gametes… (ensures genetic variation among siblings.
   (Independent assortment of sister chromatids…) ensures that every daughter cell is
2. a) A = diploid; B = haploid; C = haploid; D = haploid
   b) A and B

Extend your thinking

1. *This is a very open-ended question. Students should be awarded for any sensible su*
   1–4 marks: *Basic information about the two methods of cell division. Likely to inclu*
   For mitosis:
   - Produces daughter cells genetically identical to each other and to the parent c
   - Maintains chromosome number i.e. 2n in most cases
   - Part of the cell cycle
   - Uses: growth, repair, asexual reproduction

   For meiosis:
   - Produces daughter cells genetically dissimilar to one another and to the paren
   - Halves the chromosome number, i.e. n
   - Essential for sexual reproduction in order to maintain chromosome number fr
   - Generates genetic variation among gametes

   5–8 marks: *Greater level of detail given, e.g. for generation of genetic variation som*
   - random assortment of chromatids during anaphase
   - crossing over between homologous chromosomes

   students may mention the various methods of asexual reproduction in plants, anima

   9–12 marks: *Student's own evaluation is given in respect of the significance of vario*
   type of cell division; this is logical and shows good understanding of the topic
   Students may mention:
   - *random fertilisation of gametes producing further genetic variation*
   - *the importance of genetic variation for the long-term survival of a species*
   - *the impacts on non-disjunction during meiosis*
   - *the importance of mitosis in growth & development from the zygote to the adu*
   - *the importance of mitosis for replacing dead & damage cells, including in tissu*

18. Stem Cells and Differentiation

Content check

1. *Award 1 mark for each correctly placed item.*

Level of organisation	Cell	Tissue	Orga
Examples	Squamous epithelial cell Neutrophil Erythrocyte	Smooth muscle Cartilage Ciliated epithelium Cardiac muscle	Biceps m Tongu Hear

Students may alternatively have a table as below:

Part of the human body	*Level of organisation*
Musculoskeletal system	*Organ system*
Squamous epithelial cell	*Cell*
Biceps muscle	*Organ*
Tongue	*Organ*
Heart	*Organ*
Smooth muscle	*Tissue*
Neutrophil	*Cell*
Erythrocyte	*Cell*
Digestive system	*Organ system*
Cartilage	*Tissue*
Ciliated epithelium	*Tissue*
Cardiac muscle	*Tissue*

2. A = 5; B = 3; C = 1; D = 7; E = 8; F = 4; G = 2; H = 6

Essential skills and practice

1. a) unspecialised, b) differentiation, c) zygote, d) foetus, e) stem, f) tissues, g) marrow
   j) sieve, k) tubes (11)
   l) medicine, m) chronic, n) organs, o) personalised (4)
2. *Award 1 mark for each correct statement to a maximum 2 marks per cell.*
   Palisade mesophyll cell: columnar shape allows many cells to pack together tightly, actively photosynthesise; many chloroplasts, increasing the possible rate of photosy the sugars made in photosynthesis (2)
   Root hair cell: elongated shape increases surface-area-to-volume ratio, increasing th large vacuole for temporary storage of water and minerals – allows the plant to con mitochondria to supply the energy for active transport of mineral ions (2)
   Neutrophil: flexible shape allowing it to engulf pathogens and other foreign bodies, pathogens; lobed nucleus increases flexibility and 'space' available for engulfing and
   Sperm cell: long flagellum for swimming; many mitochondria to provide the energy maximise efficiency (acrosome provides enzymes for digesting the protective cover

Extend your thinking

1. *This is an open-ended activity. Students' answers are expected to vary considerably. should not differ. The order of organisation of* ***cells > tissues > organs > organ syste*** *correct. Expansion of this to include the starting point of biological molecules and th to be: biological molecules > cell organelles > cells > tissues > organs > organ systems > ecosystem. If this order is correct, with suitable definitions given for each level of o Deduct 1 mark for each error in the order. If the student has omitted the definitions, A further 9 marks are available for providing suitable examples and/or images for ea*

19. Exchange Surfaces

Content check

1. a) Expected possible answers are given below. Any correct answer should be acc
where transport is to and from should be identified to be awarded both marks.

Fish	Oxygen is transported from the water across the g
Insect	Diffusion of oxygen occurs from the tracheal system of t diffusion of CO_2 and H_2O occurs from the cells of the
Plant	Carbon dioxide diffuses from the air inside the air spaces oxygen diffuse out of the mesophyll cells into
Mycorrhizal fungus	Minerals are transported from the soil into the hyp transported from the fungal hyphae into the root cells from the root of the plant into the

b) Expected answers are given below. The keywords relating to the adaptation a
Students should be encouraged to use these terms. 1 mark should be awarded
a further 1 mark for the explanation.

Epithelial cell of the small intestine	'Finger-like' **microvilli**; greatly increase the cell surfac of the small intestine, without increasi
Root hair cell	An **elongated** shape; greatly increases the surface increased slightly or not
The leaf of a shade-tolerant plant	Shade-tolerant plants have extremely **large leaves**; m volume ratio which exists in most leaves due to t
An elephant's ears	An elephant has **very large thin ears**; the large size ar surface-area-to-volume ratio, which helps the elepha from its body to the enviro

2. *Award 1 mark for each correct label <u>with</u> a correct function description.*
1 = trachea: **allows air into and out of the lungs from the nose and/or mouth**
2 = cartilaginous rings: **support the structure of the trachea and bronchi, preventin**
3 = bronchus: **allows air from the trachea into and out of each lung**
4 = bronchiole: **allows air to reach each of the thousands of alveoli throughout the**
5 = larynx: **produces sound and protects trachea from food blockage**
6 = ribs: **protect the lungs from damage; provide attachment for intercostal muscles**
7 = intercostal muscles: **help the ribcage to move up and out on inhaling, and in ar**
8 = diaphragm: **muscle which contracts, expanding the chest cavity for inhalation, cavity during exhalation**

Essential skills & practice

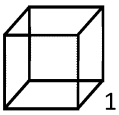
1. a) Area of the upper and lower surface of the cell = 37 × 39 = 1443 μm² (1) or 140
Two sides = 96 × 37 = 3552 μm²; other two sides = 96 × 39 = 3744 μm² (1) or 37
Total surface area = (1443 × 2) + (3552 × 2) + (3744 × 2) = 17 478 μm² (1) or 17
Volume = 37 × 39 × 96 = 138 528 μm³ (1) or 140 000 μm²
SA : V = 17 478 / 138 528 = 0.0126 μm²/μm³ or 0.013 μm²/μm³ (1)

b) *Students are expected to have used a formula for finding the area of a hexago of one side, and h is the length between the middle of one side and the centre o may be used.*
Area of the upper and lower surface of the cell = $\frac{6}{2}$ × 30 × 20 = 1800 μm² (1)
Area of each side = 30 × 5 = 150 μm² (1)
Total surface area = (1800 × 2) + (150 × 6) = 4500 μm² (1)
Volume = 1800 × 5 = 9000 μm³ (1)
SA : V = 4500 / 9000 = 0.5 μm²/μm³ (1)

c) *It is expected that students will assume the cell to be approximately circular in likely to use the formula: $A = \pi r^2$. Likewise 2 πr is likely to be used to find an ap the cell.*
Area of the upper and lower surface of the cell = π200² = 125 663 μm² (1)
Area of the sides = 2 × π × 200 × 15 = 18 850 μm² (1)
Total surface area = (125 663 × 2) + 18 850 = 270 176 μm² (1)
Volume = 125 663 × 15 = 1 884 945 μm³ (1)
SA : V = 270 176 / 1 884 945 = 0.14 μm²/μm³ (1)

2. *Note: Students may not choose the sizes given in the example below.*
Four or more sizes have been selected (1)
Given sizes cover a suitable range and are well spaced within that range (1)
Total volume × 3 does not exceed 128 cm³ (allowing for three repetitions from the a

Surface area calculations are accurate according to the diagrams. 1 mark per calcul
SA : V calculations are accurate. 1 mark per calculation. (4)

Agar diagram	512 ×  0.25 cm^3	64 ×  0.5 cm^3	8 ×  1 c
Total surface area (cm^2)	$0.25^2 \times 6 \times 512 =$ 192	$0.5^2 \times 6 \times 64 = 96$	$6 \times 8 = 48$
Total volume (cm^3)	8	8	8
SA : V (cm^2/cm^3)	24	12	6

b) Expected answers are:
- Temperature: could be controlled using a water bath; temperature can b doing all experiments in the same location in as short a time as possible; i at least be measured to ensure it does not affect results
- Solution concentration: the solution of the molecule diffusing into the ag ensure all experiments use the same concentration
- Volume of solution: use a suitably sized measuring cylinder or pipette to e is used in all experiments
- Shape and size of reaction vessel: all experiments should be done using t (e.g. boiling tube, 100 ml beaker, 250 ml beaker)

1 mark should be given for identifying the variable, 1 mark for describing how

Extend your thinking

1. a) Diagram should be:
- drawn to a suitable size (height approximately 10–15 cm) (1)
- drawn with a sharp pencil, with smooth, clear lines (1)
- the nucleus, rough endoplasmic reticulum, Golgi apparatus, secretory ve and appropriately labelled *(if all present, award 2 marks; if 1–3 features a than 3 features are missing, award 0 marks)* (2)

b) The mucus produced by these cells is essential for maintaining normal healthy it traps and removes pathogens (1)
Large amount of RER; is important as it is responsible for producing the mucins/p
Large amount of Golgi apparatus; is important as it is responsible for preparin ready for secretion from the cell (1)
The secretory vesicles make up a large proportion of the cells' volume; as they into the respiratory tract (1)
Microvilli; increase the surface area of the apical end of the cell, allowing a hig

c) Bronchial epithelial cells are tall and 'vertically' asymmetrical (1)
Ciliated; as their main role is to move the mucus up the respiratory tract towa
Alveolar epithelial cells are flattened; to reduce diffusion distance for gas excha
Non-ciliated, with minimal organelles; as their only role is to allow diffusion of g lungs/blood (1)

d) X = cartilage (1)
This structure keeps the bronchus or bronchiole passage open to allow air to flo easily (1)

20. Gas Exchange

Content check

1. B: Diaphragm contracts, moving down; ribcage moves up and out (1)
E: Space inside the chest cavity increases; air is sucked into the lungs (1)
D: Oxygen from inhaled air diffuses across the alveoli into the blood, while carbo into the air inside the alveoli (1)
C: Diaphragm relaxes, moving up; ribcage moves in and down (1)
A: Space inside the chest cavity decreases; air is forced out of the lungs (1)
2. a) a) lungs; b) diffusion; c) desiccate/dehydrate; d) loss; e) exoskeleton; f) branch
b) A = tracheole; B = spiracle; C = tracheal trunk; D = trachea

Essential skills & practice

1. a) 1 = branching of tubes to increase surface area
   2 = thin/flat surface to increase surface area
   3 = short diffusion distance
   b) *Award 1 mark for identification of the adaptation, 1 mark for the explanation.*
   A Countercurrent mechanism: necessary due to the low oxygen concentrati
   diffusion gradient across the length of the lamina (2)
   B Stomata: allow the plant to control loss of water via diffusion under dry e

2. a) Higher concentrations of atmospheric oxygen increased the concentration gra
   insect cells) (1)
   Oxygen would have diffused into the insect tracheal system and insect cells m
   This made it possible for insects to evolve larger morphology as there was still
   at the ends of the longer tracheoles (1)
   b) A terrestrial insect without an impermeable exoskeleton would lose water via
   preventing this loss of water has a much greater evolutionary advantage than
   which would occur due to having a permeable cuticle (1)

3. a) Equipment used to measure the rate and depth of breathing
   b) A single forced deep breath
   c) i. A–D
   ii. B–C
   d) 8 (allow 9)
   e) Increased rate; increased depth
   f) It is thought that regular exercise can gradually increase your vital capacity; th
   potential to take up oxygen as your maximum oxygen uptake is dependent on
   breathing rate

Extend your thinking

1. a) The sand which the marram grass lives in does not retain water well, so most
   the plant is able to uptake very much (1); coastal regions are also subject to re
   day, meaning that water would evaporate from the surface of the leaf and be
   environment than in still air (1)
   b) i. 1 = D; 2 = A; 3 = C; 4 = B
   ii. 1. Rolled leaf: the leaf is rolled up to keep the thick waxy cuticle of the
   the under surface of the leaf on the inside; the rolling of the leaf cre
   which maintains a high humidity and reduces the water potential gr
   2. Stomata pits: the stomata are found at the bottom of 'folds' in the l
   trap air, maintaining a high humidity close to the stomata; this reduc
   reduces further transpiration of water from the plant (1)
   3. Hairs/trichomes: these help to trap the air, maintaining high humidi
   4. Thick waxy cuticle on upper/outer surface: wax is largely impermea
   on the outer surface of the leaf (1)

21. Circulatory System

Content check

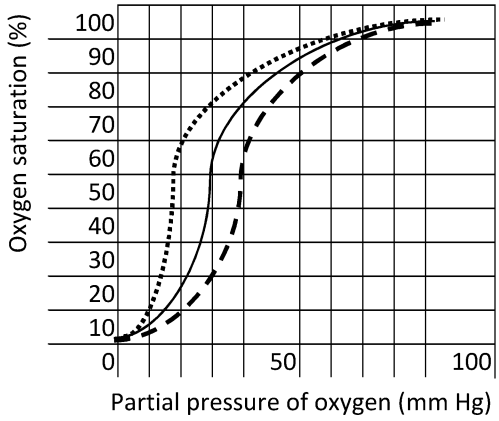
1. a) Aorta
   b) Pulmonary artery
   c) Left pulmonary veins
   d) Left atrium
   e) Pulmonary valve
   f) Bicuspid valve
   g) Left ventricle
   h) Septum
   i) Right ventricle
   j) (Inferior) vena cava
   k)
   l)
   m)
   n)
   o)
2. a) Blood plasma
   b) Blood
   c) Lymph
   d) Tissue fluid
3. a) i. Artery
   ii. Vein
   iii. Capillary

b) Veins have a large lumen, while the lumen of an artery is comparatively small (t
only just big enough for a single red blood cell) (1)
Arteries have a very thick muscular wall, while the wall of a vein is comparativ
Arteries have a very elastic wall, while the wall of a vein is comparatively less e
at all due to being only one cell thick) (1)
Veins have valves to prevent backflow of blood, while arteries and capillaries d
Reference to blood pressure should be ignored as this is to do with function rat

Essential skills & practice

1. A = oxygenated blood moves into the capillary bed from an arteriole (1)
B = blood plasma, containing nutrients, moves from the blood into the interstitial sp
diffuses out of the blood (max. 1)
C = tissue fluid moves into the lymph vessel (1)
D = carbon dioxide and other waste products move from the tissue cells / tissue fluid

2. a) A = in a low-oxygen environment (e.g. deoxygenated blood) the haemoglobin
more likely to release oxygen than bind with it (1)
B = in a high-oxygen environment (e.g. in the alveolar capillaries) the haemoglo
may reach 100 % saturation (1)
b) Cells which are actively respiring are taking in oxygen and releasing carbon dio
Reduced oxygen concentration lowers the concentration of oxygen in the envi
haemoglobin's maximum saturation of oxygen
Increased carbon dioxide concentration also lowers the haemoglobin's oxyger
the haemoglobin
c) i. Dashed line
ii. Dotted line



3. *1 mark for each correct row.*

Animal/Group	Type of circulation		
	Closed	Open	Si
Human	✓	×	
Mammal	✓	×	
Bird	✓	×	
Bony fish	✓	×	
Insect	×	✓	

4. a) *1 mark for each gap.*

Stage	Atrioventricular valves	Semilunar valves	Atrial pressure	
2/Q	closed	open	increases slightly	inc
3/R	open	closed	high	
4/S	closed	closed	increases slightly	

b) The sinoatrial node is a bundle/group/collection of cells in the wall of the (righ
of the heartbeat (1)
c) The sinoatrial node initiates a wave of depolarisation (1), while the atrioventri
tissue which propagates the wave of depolarisation (1)

Extend your thinking

1. Regular heartbeat is myogenic, meaning that it occurs automatically without nervo
   When the heart beats, a group of cells in the right atrium called the sinoatrial node
   depolarisation; (1)
   This causes the atria to contract; (1)
   Depolarisation is blocked from reaching the ventricles and travels to the atrioventri
   This stimulates the atrioventricular node to pass the signal/stimulus/depolarisation
   This causes a slight delay which ensures that the atria contract before the ventricles
   The bundle of His splits into two conductive fibres called Purkyne tissue; (1)
   which carry the depolarisation and ensure that the ventricles contract from the bot
   Contraction of the ventricles forces blood out of the heart into the pulmonary arter
2. Both fish and mammals have a closed circulatory system; (1)
   Mammals have a double circulation, while fish have only a single circulation; (1)
   The double circulation of mammals separates the oxygenated and deoxygenated bl
   This ensures that the body always receives oxygenated blood, and improves body e

22. Transpiration

Content check

1. a) A = stem; B = leaf; C = root
   b) A = a); B = b); C = b)

2. a) Tracheids – provide interlocking structure which increases strength for structu
   Pits – have a thinner wall which allows for easy movement of water and make
   cells possible (2)
   Lack of organelles / cytoplasm – unhindered movement of substances (2)
   Perforation plate – large gaps minimising resistance to flow of substances (2)
   b) Lignified walls – strengthen the xylem, improving structural support for the pla

3. a) evaporation; b) stomata; c) carbon; d) dioxide; e) photosynthesis; f) leave; g) coh

Essential skills & practice

1. a) Waxy cuticle on the upper surface of the leaf; (1) makes it difficult for water to
   (which gets hotter, due to the Sun) (1)
   Stomata (on the underside of the leaf); (1) can be closed to prevent water loss
   b) i. Maintains transpiration pull / allows photosynthesis to occur / stomata must
   the leaf for photosynthesis
   ii. When there is little water in the soil, the stomata must close to prevent the
   iii. When the stomata are closed, water and carbon dioxide are not being brou
   that photosynthesis cannot happen; (1) if only some stomata are closed, the ra
   not stop. (1)

2. a) Apoplast (1) and symplast (1)
   b)

Symplast	
water passes into the root hair cell, through the cell cytoplasm and plasmodesmata	water trave in
via osmosis	
slower	
nothing blocks this pathway	blocke

Extend your thinking

1. a) xerophyte/xerophytic
   b) Thick waxy cuticle (surrounding the entire plant); reduces/prevents water loss
   Leaves reduced to spines; most water loss from plants occurs at the leaves, so
   water; the spines also serve to prevent herbivores from 'stealing' the water st
   Thick stem; stores water, allowing the plant to survive through drought condit
   Award 1 mark for each adaptation, 1 mark for the associated explanation.
   c) Pine trees are coniferous / do not drop their leaves in the winter; (1) the high a
   environments where pine trees live usually have cold winters, which may drop
   precipitation is high / there is lots of rainfall, if the ground is frozen the roots of
   having adaptations to prevent water loss is beneficial as the pines may not be a
   winter. (1)

2. **Temperature:** increasing temperature increases the rate of transpiration; however,
   may close all stomata to prevent desiccation
   Humidity: increasing humidity reduces the rate of transpiration as the water poten
   evaporation of water from the leaves will be slow
   Concentration of CO_2: higher concentrations of CO_2 increase the rate of photosynth
   potential in the leaf cells, drawing more water up the xylem
   Light intensity: increasing light intensity increases the rate of photosynthesis and, t
   however, if the light intensity is too high, the plant may close its stomata to preven
   Award 1 mark for each factor, 1 mark for the associated explanation.

23. Translocation

Content check

1. A = b); B = c); C = a)
2. a) i. A = companion cell
      ii. B = xylem vessel
      iii. C = phloem sieve tube element
   b) ① = active loading; ② = mass flow; ③ = unloading
   c) i. The source is the plant tissue or organ where the assimilates (e.g. sucros
      assimilates are produced or being stored
      ii. Leaf
      iii. The sink is the plant tissue or organ where the assimilates (e.g. sucrose) a
      assimilates will be used or stored for future use
      iv. Roots and shoots / growing regions

Essential skills & practice

1. a) phloem (sieve tubes)
   b) Lack of organelles – minimises resistance to the movement of substances (2)
   Sieve plate – allows easy movement of substances from one sieve tube eleme
   Adjacent to companion cell – allows access to cellular functions without its ow

2. a) The companion cell provides ATP for the active transport of glucose into the p
   This greatly lowers the water potential of the sieve tube element; water also
   via osmosis;
   This raises the hydrostatic pressure in the sieve tube;
   b) The companion cells provide ATP to actively transport sucrose out of the sieve
   This allows the movement of sucrose to happen more quickly; as the concentr
   cell might become quite high
   As the water potential of the sieve tube rises, water starts to leave the sieve t
   hydrostatic pressure
   c) Hydrostatic pressure
   d) No – the liquid in the phloem vessels always moves from roots to leaves, but
   either direction; sometimes the source is a storage root, while the sink is a gro

Extend your thinking

1. *Award 1 mark for each description, 1 mark for each observation, and 2 marks for ea*

Experiment	Observation	What d (Think about whether or n flow
Aphid experiment Aphids are used to collect liquid from phloem tubes.	When an aphid's body is removed, liquid continues to leak from the stylet (mouthpart) inserted in the phloem.	Supports mass flow hypothe pressure inside the phloem
Bark ringing In a bark ringing experiment, a circular ring of bark is removed from a tree. This removes the phloem tissue but not the xylem.	A 'bulge' forms above the ring and the lower part of the tree slowly dies.	Supports the mass flow hyp essential for the transport o
Radioactive carbon tracking The plant is put in an environment containing radio-tagged CO_2 which can be tracked as it moves through the plant in glucose.	Substances move quickly (much more quickly than in simple diffusion) in the phloem.	Supports the mass flow hyp responsible for the moveme
	Substances can move in opposite directions in the plant.	Against the mass flow hypot substances in a phloem siev direction at the same rate. H explained by the fact that p in each stem, and, therefore, different sieve tubes in diffe The same substance can als the same time and travel at

24. Pathogens

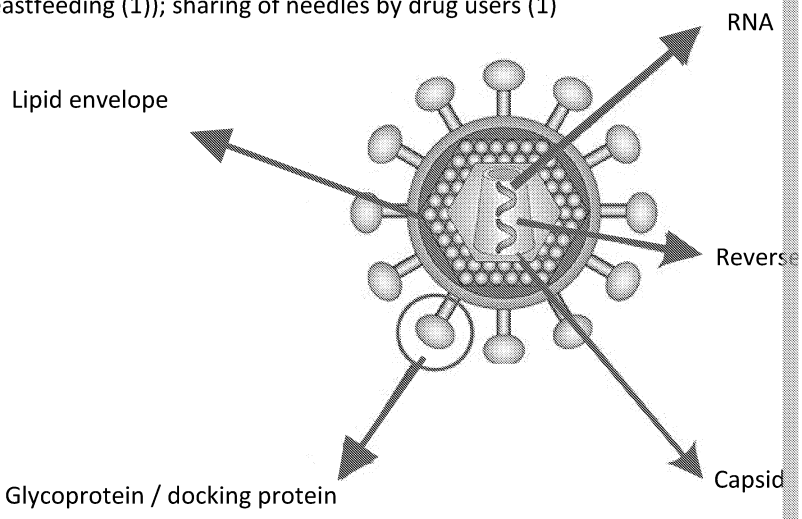
Content check

1. **Prokaryotic:** salmonella, *M. tuberculosis*, *E. coli*, spirochete, nostoc, microcystis, Clavi
   Eukaryotic: ascomycete (fungus), *Volvox* (green algae), lycophyte (primitive fern), n
   (photosynthetic protoctist), *Plasmodium*, Microsporum spp.,
   – common names given as additional information, not required in student's answer
   Neither: herpes, influenza (2)
   Additional notes and explanation: bacteria which causes ring rot, ascomycete is a g
   among the green algae, lycophytes are primitive fern-like plants, nematodes are rou
   or parasitic, euglena are a photosynthetic protoctist which have a secondary endosy
   Neisseria meningitidis is the bacterium which commonly causes meningitis, Microsp
   of fungi in the genus Microsporum which commonly cause ring worm or athlete's fo
   diseases and, therefore, are neither prokaryote nor eukaryote.
2. A = capsule; sometimes referred to as the slime capsule, this feature provides prote
   phagocytosis (2)
   B = plasmid; a small circular piece of DNA which can be 'swapped' with other bacte
   for maintaining genetic variation in the population (2)
   C = flagellum; 'tail-like' structure which provides mobility / allows the bacterium to
   substrate (2)
   D = genetic material (accept RNA or DNA); provides instructions for building the viru
   E = (protein) capsid; protects the genetic material from the environmental conditio
   may or may not be favourable) (2)
   F = attachment protein (antigen); allows the virus to 'recognise' the correct host ce
   host cell membrane (2)

3. One mark for each cell completed correctly

Pathogen	Type of pathogen	Crop	Countries/region affected
Ring rot	Bacteria	Potatoes, tomatoes	Mainly USA, Medite Middle East and Sou Northern hemisp subtropical t temperate regi
Tobacco mosaic virus	Virus	Tobacco, tomato, pepper, cucumbers, ornamental flowers	Very widespread (especially) in cold (where it can survive of the host for lo
Late blight	Oomycete (protoctist)	Potatoes, tomatoes	Wet temperate regi Europe, Northern Southern Canad
Black sigatoka	Fungus	Bananas	Widespread in tr regions, particularly America and South

4. Viral family: retrovirus (1)
Vector: none (1)
Mode of transmission: intimate contact / exchange of bodily fluids (1)
Examples of transmission route: e.g. blood donation (1); sexual intercourse (1); mot (1) and breastfeeding (1)); sharing of needles by drug users (1)



Essential skills & practice

1. *Award 1 mark for each correctly completed box.*

	Viruses	Prokaryotes
Ribosomes	None	70 S / smaller
Genetic material	(Double stranded or single stranded) RNA or DNA	Single circular loop of DNA not associated with protei
Size	Very small (approx. 5–300 nm)	Small (approx. 0.2–2.0 µm)
Membrane-bound organelles	None	None
Plasmids	None	Usually present
Flagella	None	Common
Cell wall	None	Murein
Capsid	Present	No

2. a) i. Microorganisms can be any organisms not visible to the naked eye, includi
small fungi, and protists; (1) while 'pathogens' refers only to organisms w
includes viruses, which are technically not organisms as they are non-livi
ii. Malaria is the word used to refer to someone exhibiting the symptoms o
by a different name / by the pathogen *Plasmodium spp.* (1)
OR
Malaria is a disease caused by a pathogen; (1) the pathogen which cause
different name / is called *Plasmodium* (1)

b) An agent / another organism, which carries/transmits the pathogen from host t

c) Tropical regions have high levels of rainfall; (1) mosquitoes require pools of wa
offspring; therefore, tropical regions have greater populations of mosquitoes t
Tropical regions are warm; (1) insects, including mosquitoes, have higher rates
warmer temperatures; they are more likely to act as vectors in warm condition

d) Most antibiotics are designed to affect prokaryotes; (1) protists are eukaryotes
most antibiotics; (1) a drug / an antibiotic designed to adversely affect eukaryo
dangerous to human cells; (1) therefore, it is difficult to find drugs which are a
not cause adverse effects in the human host (1)

Extend your thinking

1. For movement and reproduction, 'no', 'yes', 'partially' or words to that effect should
characteristics are debatable. However, the accompanying explanation must match
Award 1 mark for each characteristic.

Movement	Partially	Only mechanical or passive (e.g. in wind, water or bloo
Respiration	×	Viruses do not have any metabolism including respirati cell's energy
Senses	×	Viruses do not have any sensory proteins or other mea
Control	×	Viruses have no internal environment to control
Growth	×	Viruses remain the same size, and do not change in co
Reproduction	Partially	Virus particles replicate using the host cell's organelles host cell
Excretion	×	As viruses do not have any metabolism they have no w
Nutrition	×	Without a metabolism and using their host cell to repli any nutrients

2. a) A disease which can be transmitted from host to host / an infectious or transm

b) Close proximity of hosts increases the rate of transmission; (1) this can be caus
crowded living conditions; or combined use of buildings by large numbers of p

c) *Due to its open-ended nature, answers are likely to vary considerably. Expecte*
- Regular handwashing and use of alcohol gel limits the deposition and up
in communal buildings
- No sharing of objects
- Disinfecting of surfaces (tables, banisters, sinks, etc.) at regular and frequ
- Use of disposable gloves when entering busy buildings or handing out ob
(e.g. in supermarkets)
- All designed to reduce the effects of the combined use of buildings by lar
- Wearing of face masks / use of screens
- Keeping > 1 m away from other people
- Aimed to reduce the likelihood of transmission via droplets in the breath
creating barriers between them [max. 6

*As this is a discussion question, students are expected to identify some advantag
methods, or comment on their likely usefulness. Marks should be awarded for a*

25. Non-specific Immunity

Content check

1. *Award 1 mark for each correct row*

Defence	Plant/Animal	How does
Tannins	Plant	Chemical defence / serves as an pathogen m
Waxy cuticle	Plant	Physical
Casparian strip	Plant	Physical barrier – impermeable to wa the apoplast pathway must pass thro
Stomach acid	Animal	Extreme pH denatures the protei
Sticky resin	Plant	Traps and immobi
Tears	Animal	Tears contain lysozymes,
Mucus	Animal	Traps pathogens and allows them secretions (ph
Commensal microorganisms	Both	Compete with pathogenic microorgan to grow and reproduce (in animals us be yeasts and sy
Ciliated epithelial cells	Animal	Cilia move mucus
Callose	Plant	Blocks the phloem sieve tubes, preve

2. a) defence; b) rapid; c) physical; d) entering; e) mucous; f) outside; g) pathogen; h)
k) lysozymes; l) chemical; (12)
m) microorganisms; n) histamine; o) dilation; p) swelling; q) grow; r) engulfing; s) pl

Essential skills & practice

1. a) i. Specific immunity: agglutination, memory cells (1)
Non-specific immunity: the skin, inflammation, histamine, phagocytosis (
ii. The skin: provides a physical barrier to prevent entry of pathogens (1)
Inflammation: generation of heat in the region of inflammation makes it
while the high number of phagocytes gives a high chance that the invadi
causing infection (1)
Histamine: initiates inflammation and triggers an immune response (1)
Phagocytosis: phagocytes engulf pathogens and digest them, preventing t
infection (1)

b) Expected answers include:
Advantages: rapid/immediate, all-round defence, several lines of defence, mo
Disadvantages: may not fully eradicate a pathogen
Award 1 mark for any correct/plausible advantage, 1 mark for any correct/pla

2. Award 2 marks for correct identification of primary defences, including:
- physical barriers: skin, mucous membranes, tears (1)
- *award an additional mark for* blood clotting (1)
- chemical barriers: lysozymes in tears, stomach acid (1)

Secondary defences:
- mast cells release histamine (1)
- inflammation brings high numbers of phagocytes, (1) and
- causes heat, which reduces bacterial reproduction (1)
- phagocytosis (1)
- natural killer cells 'kill' any infected cells (1)

Award a further mark for logical organisation of the flow diagram (1)

Extend your thinking

1. a) Mast cells identify a pathogen or other foreign object in the polecat's saliva (1
Mast cells release histamine, causing blood vessels to dilate (1)
The rush of blood to the area causes inflammation (1)
Phagocytes brought in with the rush of blood consume pathogens and foreign
also remove damaged cells (1)
Platelets in the blood exposed to the air begin to clot, forming a temporary ba
As the blood clot dries out it will form a scab (1)

b) The high number of pathogens in the polecat's saliva / the depth of the wound
continue to find foreign objects, and continue to release histamine (1)
The swelling will get worse until the number of pathogens is reduced and fore
Heat in the hand slows the replication of bacteria (from the polecat's saliva) (1)

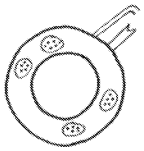
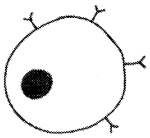
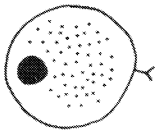
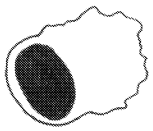
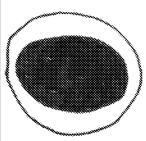
c) i. Dead tissue cells, dead phagocytes, and bacteria *(at least two componen*
ii. Due to the high number of pathogens in the polecat's saliva / due to the
pathogens entered the man's body; (1) therefore, many tissue cells were
have reached their limit of phagocytosis and have died (1)

d) Phagocytes will recognise the virus particles as foreign and remove them via p
Other actions of the non-specific immune response will have little impact on a
Phagocytes are most effective against viruses after agglutination, which involve
immune response (1)
Natural killer cells will not be effective against a virus until after it has infected
If there is a low number of virus particles in the polecat's saliva, the phagocyte
before an infection occurs (1)
Non-specific immunity is generally not very effective against viral pathogens (1)

26. Specific Immunity

Content check

1. *Award 1 mark for each correctly filled box.*
Note: diagrams shown here are examples only, students' diagrams may vary depend
Use text for additional marking guidance.

Diagram	Name and abbreviation	
 Diagram should show 'docking protein/tube' and vesicles containing signal proteins	Cytotoxic T cell T_C	Instruct
n/a	Antibodies Ab	Neutralis complex phagocyt binding t
 Diagram should show external antibodies	Memory cells B_M and T_M	Generate subsequ
n/a	Phagocyte	Engulf an
 Diagram should show cytokines and receptor (these may or may not be labelled)	Helper T cell T_H	Activate
 Award mark if nucleus approximately 50% cell size & jagged/uneven surface (due to high number of antibodies within)	Plasma cell	Produce specific a
 Award mark if large nucleus shown. Undifferentiated cells look similar externally	T lymphocyte (T cell) T	Various r different
	B lymphocyte (B cell) B	Various r different
	Antigen-presenting cell	Presents pathoge

2. Active immunity occurs when cells of the immune system recognise the presence o
creating antibodies to combat the infection; this occurs when someone is infected b
this can occur when someone is vaccinated against a disease
Award 1 mark for the definition, 1 mark for the given example
In contrast, passive immunity involves only antibodies;
Artificially produced antibodies may be given to a patient by a doctor / natural pass
receives antibodies from its mother's breast milk
Award 1 mark for the definition, 1 mark for the given example

Essential skills & practice

1. *Possible answers are shown below. Wording of pupils' answers will vary significant*
earn the marks. Award 1 mark for each correct clue.

Across	**Down**
1. Phagocytosis: pathogen engulfed	1. Pathogen: a m causing disea
5. Blood: where most immune cells are found and transported	2. Agglutination antigens via t antibody com
6. Antigen: a cell-surface protein or glycoprotein specific to the cell type which allows cell recognition	3. Toxin: a chem fatal to the bo
8. Monoclonal: a specific type of antibody produced via cloning of a specific white blood cell	4. ELISA: enzym common labo presence of a
10. Recognition: identification of a cell by the immune system	6. Antibody: pro cells / lympho antigen–antib specific antige
11. Yeast: a family of unicellular fungi which may be pathogenic (e.g. candida) or useful (e.g. in making bread)	7. Protein: type o antigens and a
12. Immune: the organ system responsible for protecting the body from disease	9. Disease: patho
13. Cell: a 'unit' of life, recognised by a unique antigen	
14. Immunity: resistance to disease	
15. Virus: a type of pathogen	

2. a) Virus(es) (1)
Viruses are incurable / cannot be cured through antibiotics or other medicines;
priority for vaccine development (1)
b) Expected answers include but are not limited to: TB, COVID-19, rabies, typhoid
potentially fatal and for which a vaccination schedule exists should be awarded
standard vaccination schedules in different countries can be very different. Stu
another country may, therefore, give very different answers. 1 mark per disea

3. a) The primary immune response has a long lag before antibodies are produced (1
The amount of antibodies produced during the primary response is less (1)
Allow reverse argument
b) A = naive B cell binds with virus, engulfs, and activates presenting antigens on
B = antibody production (1)
C = memory B cells remain in blood after infection (1)
D = memory cells trigger rapid production of antibodies on second exposure (1)
c) Secondary. The viral particles in the vaccine expose the immune system to the
primary response.

Extend your thinking

1. a) Shows changes in antibody concentration in the blood following vaccination
First dose of vaccine causes a slow rise in antibody concentration
If second dose given, antibody concentration continues to rise
If no second dose given, antibody concentration drops to a low level
Residual antibody concentration after two doses is much higher than after one
Second dose at 14 days provides highest antibody concentration following vac

b) Two – one dose does not provide significant lasting immunity

c) A second vaccine should be given 14 days after the first vaccine; if the second d
'immune memory' is reduced

d) *Students' answers will vary. Award 1 mark per any valid point, up to a maximu*
include:
People should be careful about doing this; sometimes the exact date of the va
on the strength of the immune memory
Good idea if vaccine received close to recommended date / < 1–2 days should h
Weigh up the benefits of not going on the recommended day vs the risk of redu
suboptimal timing
Depends on vaccine; people should seek advice from a doctor if they're not su
their appointment

e) i. Use of animals in testing; against animal rights / unfair use of animals
Use of humans in testing; may cause unexpected side effects / risks not k
Use of humans in testing phase; people may actually get sick from the va
1 mark for each issue, 1 mark for the explanation

ii. Animal products used in production; some think unethical / not suitable fo
allergic reaction
People who refuse a vaccine are still protected by herd immunity; many th
1 mark for each issue, 1 mark for the explanation

iii. Some people are unable to take the vaccine due to likely allergy; unfair tha
Government may decide who gets vaccinated first; could be unfair for tho
Unforeseen side effects due to minimal/rushed testing; poses risk to those
1 mark for each issue, 1 mark for the explanation. Issue and explanation s

2. **Expected ideas include:**
Benefits – effective against a range of bacterial pathogens; simple to use; cheap to p
Risk – <u>antibiotic resistance</u> – e.g. MRSA – *Staphylococcus* infection that is difficult to
antibiotics; may have evolved due to overuse of antibiotics in treating non-life-threa
<u>Affects all bacteria in the body, including beneficial ones</u> – e.g. *Clostridium difficile* –
following antibiotic treatment
Award marks for each major 'branch' of the mind map: basic ideas (1); moderate det
expected answers given) (3); excellent detail (all or almost all expected answers give
Examples shown are not necessary for the marks, as they are not covered by the spec

3. a) *1 mark should be awarded for each distinct point which is correct. Ideas are lik*
Antibodies allow the cells of the immune system to recognise cells which do no
damaged (e.g. has become cancerous) it will not show the correct antigens and
part of the body and will be killed; pathogenic organisms have their own specif
system to recognise them; once the immune system has been exposed to a pat
numbers of antibodies to form complexes with the pathogen's antigens; the pa
rendering it harmless; or the antigen-body complex can lead to agglutination; a
remove via phagocytosis.

b) A tissue / an organ from another person, even a close relative, will not have all
of its cells; if recognised by the immune system as 'foreign', the cells will be kil
drugs weakens the immune system; so that an organ / a tissue which shares so
from a close relative with a good tissue match) will not be attacked.

c) Stem cell research is developing our ability to culture both tissues and organs; a
patient's own stem cells could be used without a chance of rejection; this negat
immunosuppressant drugs and also makes it much easier to provide transplant
patients would not need to wait for a suitable donor to die before gaining a tra
ethical considerations surrounding the use of transplanted organs.

27. Biodiversity

Content check

1. 1 = E; 2 = H; 3 = B; 4 = G; 5 = C; 6 = A; 7 = F; 8 = D.
2. a) A = genetic diversity; B = species richness; C = global biodiversity; D = habitat b
   F = species diversity; G = species evenness
   b) genetic diversity < species diversity < habitat biodiversity < global biodiversity

3. a) Expected order is: a 2000-acre sugar cane farm, an apple orchard, regular catt
   cattle grazing, a mangrove forest, temperate woodland, a tropical rainforest
   A switch between the alpine meadow and mangrove forest should be allowed a
   distinguish. Students should be able to recognise that the alpine meadow will h
   species than the regular cattle pasture, and that the pasture is likely to have hi
   due to not requiring the use of pesticides, fertilisers and herbicides.
   b) Least diversity: a 2000-acre sugar cane farm – large area of monoculture crop d
   habitat, thus the area will only be suitable for a small number of species. Mor
   high levels of chemicals such as fertilisers and pesticides, which will further red
   Greatest diversity: a tropical rainforest – a natural habitat with high variation in
   nutrient cycling, making the raw materials for life easily available. Little to no h
   Allow up to 2 marks for each answer, with 1 mark awarded for each clear logic

Essential skills & practice

1. a) **Palm oil plantation**

Species	n	n/N	$(n/N)^2$
Zebra dove	5	0.128	0.016
Greater racket-tailed drongo	2	0.051	0.003
Red-billed blue magpie	2	0.051	0.003
Greater coucal	4	0.103	0.011
Tree sparrow	8	0.205	0.042
Common myna	14	0.359	0.129
White-vented myna	4	0.103	0.011
Sum	N = **39**	$\Sigma(n/N)^2$ = **0.215**	
D = 1 - 0.215 = 0.785			

Rainforest

Species	n	n/N	$(n/N)^2$
Great hornbill	2	0.043	0.002
Oriental pied hornbill	2	0.043	0.002
Red-whiskered bulbul	2	0.043	0.002
Thick-billed green pigeon	4	0.087	0.008
Red jungle fowl	4	0.087	0.008
Silver pheasant	3	0.065	0.004
Chestnut-headed tesia	2	0.043	0.002
Streaked bulbul	2	0.043	0.002
White-throated bulbul	2	0.043	0.002
Grey-chested jungle flycatcher	3	0.065	0.004
Brown-chested jungle flycatcher	2	0.043	0.002
Golden-fronted leafbird	2	0.043	0.002
Scarlet-breasted flowerpecker	3	0.063	0.004
Yellow-vented flowerpecker	4	0.087	0.008
Little spider hunter	7	0.152	0.023
Purple-naped sunbird	2	0.043	0.002
Sum	N = **46**	$\Sigma(n/N)^2$ = **0.077**	
D = 1 – 0.077 = 0.923			

For each habitat calculation, award 1 mark for completing the 'n/N' column co
the '$(n/N)^2$' column correctly; award 1 mark for correct substitution of these v
1 mark for a correct final answer.

   b) Palm oil plantation: 7; Rainforest: 16

c) Yes. Regardless of the taxonomic group, the greater variation in the rainforest conditions for a greater variety of species.

d) The greater variation in the rainforest habitat provides suitable conditions for a increasing species richness (1). The variation in the habitat also ensures that n in relation to others, meaning that evenness is also likely to remain higher in th groups (1). In the palm oil plantation, humans have altered the environment to plant species, palm oil, minimising variation in the environmental conditions, w species but make it difficult for others to survive (1); this reduces both species r

e) As it is a large bird, the great hornbill needs a large amount of food to stay alive (many different fruiting trees in its habitat in order to have food all year round (1) many different species to be able to feed means that it will only be found in prim degraded) rainforest with high biodiversity (1); this makes it a good indicator as w biodiversity (1); the great plant diversity required by the hornbill will also provide animal species, reinforcing the connection between the presence of great hornbi

2. **Expected answers include:**
Use of pesticides – many species killed, particularly crop pests and their predators (in which may not be directly killed by the pesticides but suffer from losing their food su
Use of fertilisers – causes an imbalance and loss of biodiversity in the soil communit microorganisms cannot survive the sudden change in soil chemistry
Use of herbicides – all plants except crops are killed, reducing the variety at the base cascading loss of species diversity. Insects and soil microbes may also be directly af
Ploughing/tilling – compacting of the ground due to heavy machinery and action of t fungi and soil microbes; repeated ploughing prevents communities of soil microbes f low to no biodiversity. This has knock-on effects to the wild plant life and insect and
Replacement of hedgerows with fences, or removal of hedgerows to make bigger fie microhabitat within farmland; without them, many birds and small mammals cannot they cannot continue to survive in the area. Many butterflies and other insects may of food / for reproduction.
Loss of crop rotation and increase in monoculture – reduction of variation at the bas tillage and increased proportion of the year when land is bare mean that very few sp food and lack of shelter for wild species in all levels of the food web
Animals kept caged or indoors year round instead of on pasture – cattle and other gr heterogeneity by selectively grazing (cutting vegetation to a range of different heigh
Award 1 mark for each appropriate and correct suggestion, up to a maximum of 3 m not exhaustive.)
Award 1 mark for each valid point in the student's explanation, up to a maximum of

Extend your thinking

1. A diversity index **takes into account species evenness as well as species richness**, an accurate idea of species and genetic biodiversity in an area than species richness alo
2. *Possible answers include the following:*
Species from different taxonomic groups are likely to have very different population c differences, e.g. you would not expect the population of elephants and the populatio similar due to the massive difference in their size and food requirements. Therefore, to be inaccurate if it includes data from multiple taxonomic groups as the evenness is
It is not feasible to collect data from all or multiple taxonomic groups in an area bec be too high – there would be too many species to count/estimate in a suitable amou
It is not feasible to collect data from all or multiple taxonomic groups in an area bec sample different groups (e.g. birds, insects, water insects, reptiles) is very different. taxonomic groups would, therefore, be too high.
Award 1 mark for each correct suggestion, 1 mark for the associated explanation.
3. *This is obviously quite an open-ended activity, and students will have very varied ans suggestion, and up to 2 marks for the explanation.*
Likely ideas include:
   - Measures to increase habitat heterogeneity *(distinctly separate methods can b making a pond / wetland area and allowing cattle grazing would both achieve h are distinct actions so should be awarded 2 marks*)
   - Minimising disruption to natural processes (e.g. no ploughing)
   - Planting particular wild flowers to attract certain species of butterfly
   - Putting up shelters for various native wildlife, e.g. log piles, hedgehog houses, bird
   - Planting trees or shrubs which are beneficial to wildlife, e.g. oak trees or fruit t

4. a) *Students' answers will vary. Any valid point should be awarded a mark.*
Some possible answers include:
- Without genetic diversity a species may not be able to adapt and evolve t
- Without species diversity in a habitat, the food web loses resilience / is le
- e.g. a natural disaster / e.g. rapid population decline of a particular speci
- Without habitat heterogeneity many species will no longer be able to live
- Biodiversity on all scales increases the health and resilience of the ecosys
- Soil biodiversity affects the health of soil, which in turn affects the health toxins) of the food that we eat

b) *Students' answers will vary. Any valid point should be awarded a mark.*
Some possible answers include:
- Measuring biodiversity and genetic diversity helps us to predict potential
- Measuring biodiversity and genetic diversity allows us to make reasoned conservation efforts and funding

28. Conservation

Content check

1. *Award 1 mark for each correctly categorised reason. Note that some reasons can fi either position.*

Ecological	*Economic*
• preservation of genes that may be lost due to disease or artificial selection • increase ecosystem resilience • protect keystone species • protect against global warming and natural disasters • reduce the risk of disease, including novel zoonotic diseases	• preservation of genes that may be lo disease or artificial selection • protect undiscovered sources of me • reduce soil depletion • protect against global warming and natural disasters • source of undiscovered beneficial ge as disease resistance for crops) • reduce the risk of disease, including zoonotic diseases

2. a) biodiversity; b) *ex*; c) habitat; d) seasons; (4)
e) banks; f) zoos; g) supplement; h) lost; (4)
i) parts; j) population (2)

Essential skills & practice

1. *Award 1 mark for each correct answer in the 'full name' column. Students' answers 1 mark for a short/basic response, 2 marks for more detail.*

Organisation/ agreement	Full name	How is it used in conserva
CITES	Convention in International Trade in Endangered Species	International agreement between controls trade of listed species acr both live and dead specimens, wh cosmetics o
CBD	Rio Convention on Biological Diversity	An agreement between (190) g development methods; this means a use up natural resources, thus pres
CSS	Countryside Stewardship Scheme	Provides financial incentives for la the natural environment on thei *of 'enhan*
IUCN	International Union for the Conservation of Nature	A coalition of over 1400 mem comprehensive research / monitors over 140,0
RSPB	Royal Society for the Protection of Birds	Works to protect species and ha reserves, education, and inf
WWT	Wildfowl and Wetlands Trust	Protects endangered
Ramsar Convention		Treaty between (172) governments; cooperation involving the conservatio

2. Students are expected to recognise:
In support of the statement that elephants are a keystone species:
- Generation of a heterogeneous environment
- Seed dispersal
- Supporting nutrient cycling and fertilising the soil

Against the statement:
- Elephants are not present in all rainforest national parks; therefore, maybe th… functioning of the ecosystem, and not a keystone species.

Extend Your Thinking

1. *This activity should be marked according to the rubric below:*

Criterion	Excellent (5)	Very good (4)	Good (3)	S…
Academic language and use of scientific conventions	*Any species mentioned is identified by its binomial name. Answer is consistently written in third-person narrative, with an appropriate level of formality.*	*Any species mentioned is identified by its binomial name. Answer is mostly written in third-person narrative, with an appropriate level of formality.*	*Any species mentioned is identified by its binomial name. A good attempt is made to write the answer in third-person narrative, with an appropriate level of formality, but with several errors.*	*The … ider… com… The … writ… cor… only… use…*
Discussion of *in situ* conservation methods	*At least one* in situ *conservation method is given, with a thorough discussion of **BOTH** the possible benefits and drawbacks of this method.*	*At least one* in situ *conservation method is given, with some discussion of **BOTH** the possible benefits and drawbacks of this method.*	*At least one* in situ *conservation method is given, but discussion covers only the possible benefits **OR** drawbacks of the method.*	*Mer… in s… with… disc… pote… dra…*
Discussion of *ex situ* conservation methods	*At least one* ex situ *conservation method is given, with a thorough discussion of **BOTH** the possible benefits and drawbacks of this method.*	*At least one* ex situ *conservation method is given, with some discussion of **BOTH** the possible benefits and drawbacks of this method.*	*At least one* ex situ *conservation method is given, but discussion covers only the possible benefits **OR** drawbacks of the method.*	*Mer… ex s… with… disc… pote… dra…*
Use of academic sources	*Three or more appropriate academic sources are used, correctly cited, and referenced.*	*Fewer than three appropriate academic sources are used, correctly cited, and referenced.*	*A good number of sources are used, cited, and referenced, but may not be appropriately academic, or there may be some errors in citation and referencing.*	*At l… is u… Cita… refe… mul…*
Organisation of writing	*The answer is around 750–1000 words. Writing is well organised with a clear introduction and conclusion, and well-developed paragraphs.*	*The answer may not be more than 750 words. Writing is well organised with an introduction, a conclusion, and appropriate paragraphs.*	*The answer is fewer than 750 words. Writing is organised but may be missing an introduction, a conclusion, or appropriate paragraphing.*	*The … tha… No … org… par… use…*

29. Taxonomy

Content check

1. D = Domain; K = Kingdom; P = Phylum; C = Class; O = Order, F = Family; G = Genus; S
   Award 2 marks if all correct, deduct 1 mark for two errors.
2. b) Different species; same genus / both members of the *Tamius* genus
   c) Different species; different genus, (probably) same family / both members of t
   d) Same species; different subspecies
   e) Different species; same genus / both members of the *Homo* genus
   f) Different species; different genus, (probably) same family / both members of t
   g) Same species, different subspecies

3. a) Very small and furry, unlike elephants; more closely resemble rodents and othe
   and guinea pigs; no trunk
   b) Tusks grow from incisors similar to elephants (1)
   Positioning of nipples is unusual and similar to elephants and manatees (which
   another) (1)
   Feet are elephant-like in that they have thick pads on the bottom and small ho
   each digit (1)
   c) DNA / RNA / amino acid sequencing (1)
   Direct measurement of the DNA similarities/differences (1)
   Provides more reliable evidence of relationships (1)
   than relying on morphological evidence, which is an indirect assessment of DN
   convergent evolution) (1)

Essential skills & practice

1. a) Different species: the two do not breed voluntarily and offspring are infertile
   b) Same species: evidence of a second-generation hybrid means that the first-ge
   the two populations of bears are able to reproduce successfully
   c) Different species: mate recognition is well formed in both species, ensuring tha
   would not occur
   d) Same species: successful reproduction is possible between wolves and dogs
   e) Different species: the offspring is infertile

2. a) *H. heidelbergensis* and *H. erectus* disappear from the fossil record around the s
   H. sapiens appear (1)
   There is a clear trend in cranial capacity from *H. erectus* through *H. heidelberg*
   There is a clear trend in skull shape from *H. erectus* through *H. heidelbergensis*
   If additional research has been done, students may mention trends in height o
   mentioned, H. Heidelbergensis should not be included as they were known to b
   b) Most recent *H. erectus* were found in Asia/Eurasia, not in Africa where the ear
   Skull shape of *H. erectus* and *H. sapiens* is too different (1)
   c) i. DNA
   ii. Direct measurement of genetic change / changes in DNA could be 'tracke
   shared by these species
   iii. It is very unlikely that this evidence can be found (1)
   Too much time has passed and DNA is likely to be heavily degraded, if it e
   DNA would need to be found for all populations in question, making it eve
   useable sample is highly unlikely) (1)
   Small chance of finding DNA in the tooth of a very well preserved skull / f

Extend your thinking

1. a) *There are many points that students could make. Any valid observations shoul*
   Some expected answers include:
   Plants, animals and fungi evolved from protists and should be in the same (no
   Yeast is a single celled fungi but appears in 'Protista' not 'Fungi'
   Seaweed are multicellular algae and should be in the same kingdom, but are s
   All slime moulds should be in the same kingdom
   Bacteria are not a single kingdom
   Animalia, Plantae and Fungi appear to be more closely related than the differe
   bacteria are placed in one kingdom while plants, animals and fungi are separa

b) Protista

c) i. That these three taxa are distantly related to an equal degree

ii. That these three taxa are quite closely related (1)
with Fungi and Animalia being more closely related to each other than to

iii. Yeast cells share much more DNA and cellular machinery with humans th

d) *Expected ideas include*:

- The kingdom of 'Bacteria' has been replaced with the domains of eubact
between these two taxa is significant and important
- Protista is not a valid kingdom as the DNA evidence shows that animals, p
protists, and some 'protists' are actually within these taxa (e.g. green alg
- Animalia, Plantae, and Fungi are still valid taxa as each one forms a single
Each distinct point should be awarded a mark.

30. Adaptation and Natural Selection

Content check

1. a)
- straight or lop (floppy) ears: genetic – discontinuous variation with only t
- having only three legs: environmental – genetic mutation is unlikely as de
symmetrical, and removal of a whole limb is quite a drastic change to occ
is most likely to have lost a leg in an accident)

*Note: If students are curious to know more, evidence of similar mutations in fro
with high levels of mutagenic chemical pollutants can be shown to them in class.
extra legs than fewer legs, but fewer legs can occur. Either way this is the resul
with the limb development during metamorphosis and can be likened to similar
the foetus in the womb of placental mammals. As such, this still falls under 'en
genetics have changed, the effect is localised to cells in the early limb bud, eithe
the limb, or causing splitting of the limb bud, resulting in multiple limbs. The ch
caused by the presence of a particular chemical in the environment or exposure*

- ear length: genetic (rabbits are born to have long ears or short ears) – tho
environmental component from nutrient availability
- fur colour: genetic – there are a few distinct possibilities, but rabbits will
duration of their lives. ACCEPT 'both' – the base fur colour is determined
muted/bleached by exposure to the Sun.
- tumorous growths starting on the face and spreading: *students may or may
myxomatosis; however, they should recognise that this is caused by a disease
Even if students suggest cancer it should be recognised that this has an enviro
the rabbit has inherited from birth.* Environmental – caused by exposure to a
- a scar: environmental – caused by an accident
- body mass: both – size of rabbit will have a genetic basis with certain bre
others limited to quite small sizes; food availability and quality will also a
- fur length: genetic – some rabbits have short (1 inch) fur, some have long
on their genetics. Amount of fur may have a small dietary (environmenta

Both source of variation and description must be given for the mark.

b) Examples of discontinuous variation are: straight or floppy ears, length of ears
Examples of continuous variation are: body mass, fur length (note: it is accept
discontinuous as each breed typically has either long or short hair – however,
two fur lengths possible, and hybrid rabbits usually produce fur of an interme

2. a) False, anatomical ⇨ anatomical, physiological or behavioural

b) True

c) True

d) False, every or new phenotype ⇨ some / may create – a random mutation occ
the DNA will not create a new allele

e) True

f) False, must be beneficial in all populations of the species ⇨ may not be benef
as this depends on the environmental conditions

3. a) Disruptive: the medium-coloured mice will have nowhere to hide and are likel
reproducing (selection against the mean)

b) Directional: the smaller rats in the population are more likely to find sufficient
more likely to live longer and reproduce more (selection against the upper ext

c) Stabilising: as the finches eat only one type of seed, those with beaks at the sm
find it difficult to eat enough seeds to survive (selection for the mean / against

Essential skills & practice

1. a) i. Stabilising
   ii. Pairs of birds which lay only 0–1 eggs in a clutch run the risk of not being ab… best they will produce one chick in each mating season which will be less th…
   ii. Birds which lay 6–7 eggs are unlikely to be able to find enough food for a… are undernourished and it's possible that none survive to adulthood.
   b) i. Directional
   ii. Moths at the 'white' end of the distribution find it difficult to find camou… environment; they are more likely to be eaten by predators and less likel…
   iii. Moths at the 'black' end of the distribution are camouflaged easily in the … they easily avoid predators, live longer and produce more offspring.
   iv. *The student's sketch graph should show the opposite of the graphs in the …* the environment reduce, the tree bark returns to the pre-industrial state … white from lichen. Moths in the middle of the distribution will be best ca… will shift back towards the left.

2. a) *Any answer with a valid explanation should be accepted.*
   b) Humane traps set up in random locations throughout the habitat (1)
   Humane traps set up in a systematic manner throughout the habitat (1)
   Any named systematic method should also be accepted. (1)
   c) *1 mark for each mean and standard deviation calculation.*

Mean average	41.5	15.3	74.0	10 690	**Mean average**	
Standard deviation	4.1	1.4	7.7	2310	**Standard deviation**	

   d) i. Body length appears to show the largest difference
   For other characteristics the standard deviations overlap, suggesting the …
   ii. Process of the answer may vary depending on the equation used for t-tes…
   The sample answer uses this equation:

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}}}$$

   = (74.0 – 64.4) / √ (7.7^2 / 20 + 6.5^2 / 20)
   = 9.6 / √ (59.29 / 20 + 42.25 / 20)
   = 9.6 / √ (2.96 + 2.11); = 9.6 / √ 5.07; = 9.6 /
   d.f. = 20 + 20 – 2 = 38; t (P < 0.05) = 2.024; a…
   there is a significant difference. *Students ma… value is above 3.566, the difference is signif…*
   Award 1 mark for a correct d.f.; 1 mark for the t-value; 1 mark for corre… values into the equation; 1 mark for the final calculation; 1 mark for the …
   iii. *Any sensible suggestion and logical argument should be accepted. Allow … for the explanation. Example answer:*
   The urban foxes are significantly smaller than the forest foxes; this could … urban environment, such as under houses or in a heap of rubble; as it is e… they are more likely to survive / will live longer, and have a better chance …

Extend your thinking

1. *a) Award 1 mark for each sensible suggestion. The table below provides some ex…*

Environmental condition	Example of a structural adaptation	Example of a physiological adaptation
Extreme cold	Thick and/or long fur; short ears; short/fluffy tail (Arctic fox, polar bear, musk ox, woolly mammoth)	Thermogenesis of brown fat; 'anti-freeze' in the Arctic cod and wood frog
Extreme heat / arid environment	Thin, short or no fur; big ears with a good blood supply (African elephant, fennec fox, bat-eared fox)	Fat storage as a metabolic source of water
High altitude	Alpine plants are usually very short/small, with tiny brightly coloured flowers to conserve energy and offer protection from wind	Change in haemoglobin of birds which fly at high altitudes (note: increased haemoglobin / red blood cells may be inherited in some high-altitude populations)

Environmental condition	Example of a structural adaptation	Example of a physiologica adaptation
Marine environment	Loss of fur on marine mammals; change of legs to fins/flippers (or wings to flippers)	Change to the haemoglobi of marine mammals to allo them to stay under wate for longer (extend time between breaths)

b) *Students' answers will vary. Award any sensible suggestion up to a maximum answers include:*
The crops of farmers who rely on pesticides will/may be decimated; this coul food supply; new pesticides may need to be developed to maintain effective requires money – there are, therefore, economic implications
Birds and other small animals which eat the insects may ingest high levels of have knock-on effects elsewhere in the food chain / could also affect organic predators to keep pest numbers down
On the other hand, organic farms which rely on the natural predators of crop may be more successful than in normal years

2. a) *Students' answers will vary. Award 1 mark for:*
- *description of a suitable situation in which stabilising selection would oc*
- *explanation of why extreme values at one end of the distribution would*
- *explanation of why extreme values at the other end of the distribution w*
- *statement explaining how this leads to stabilising selection occurring (i.e successful in survival and reproduction)*

b) *Students' answers will vary. Award 1 mark for:*
- *description of a suitable situation in which directional selection would oc values at one end of the distribution would not be successful*
- *explanation of why extreme values at the other end of the distribution w*
- *statement explaining how this leads to directional selection occurring (i.e reproduction among individuals of one extreme slowly shifts the mean o*

c) *Students' answers will vary. Either point of view is acceptable, but the studen person / type of selection. Award 1 mark for:*
- There is natural variation in the length of giraffes' necks

If directional selection chosen:
- Giraffes with short necks are unable to reach enough leaves and starve t to reproduce
- Giraffes with the longest necks have an advantage over other giraffes as
- As a result, they live longer and produce more offspring
- This leads to directional selection as the mean neck length in the popula to generation

If stabilising selection is chosen:
- Giraffes with short necks are unable to reach enough leaves and starve t to reproduce
- Giraffes with very long necks waste energy becoming so tall, as the giraf already reach all the leaves on all the trees
- As a result, the giraffes with normal neck length live longest and produc
- This leads to stabilising selection as the giraffes at both extremes are les mean neck length is selected for