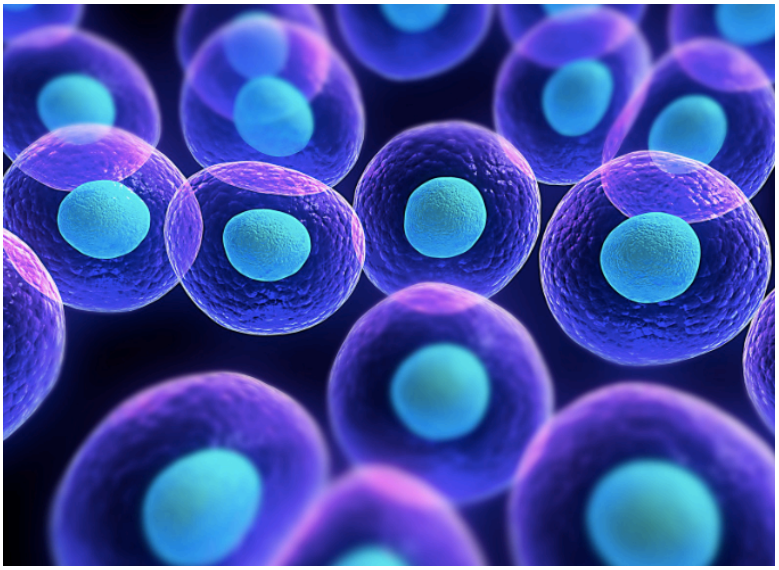
AQA Separate Science

1. Cell Biology Revision Booklet



Name: _____

Class: _____

Teacher: _____

4.1 Cell Biology

4.1.1 Cell structure

- 4.1.1.1 Eukaryotes and Prokaryotes
- 4.1.1.2 Animal and plant cells
- 4.1.1.3 Cell Specialisation
- 4.1.1.4 Cell Differentiation
- 4.1.1.5 Microscopy
- 4.1.1.6 Culturing microorganisms

4.1.2 Cell division

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4.1 Cell Biology Pupil Checklist

4.1.1 Cell Structure	
4.1.1.1 Eukaryotes and Prokaryotes	**Review**
Identify that plant and animal cells (eukaryotic cells) have a cell membrane, cytoplasm and genetic material enclosed in a nucleus.	☺ 😐 ☹
Understand that bacterial cells (prokaryotic cells) are much smaller in comparison than plant and animal cells.	☺ 😐 ☹
Identify that bacterial cells have cytoplasm and a cell membrane surrounded by a cell wall and that the genetic material is not enclosed in a nucleus. It is a single DNA loop and there may be one or more small rings of DNA called plasmids.	☺ 😐 ☹
Demonstrate an understanding of the scale and size of cells and be able to make order of magnitude calculations, including the use of standard form.	☺ 😐 ☹
4.1.1.2 Animal and plant cells	**Review**
Explain how the main sub-cellular structures, including the nucleus, cell membranes, mitochondria, chloroplasts in plant cells and plasmids in bacterial cells are related to their functions.	☺ 😐 ☹
Identify that most animal cells have the following parts: • a nucleus • cytoplasm • a cell membrane • mitochondria • ribosomes. and be able to identify them on a diagram	☺ 😐 ☹
Identify that in addition to the parts found in animal cells, plant cells often have: • chloroplasts • a permanent vacuole filled with cell sap. Be able to identify them on a diagram.	☺ 😐 ☹
Understand that plant and algal cells also have a cell wall made of cellulose, which strengthens the cell.	☺ 😐 ☹
4.1.1.3 Cell Specialisation	**Review**
Explain how the structure of different types of cell relate to their function in a tissue, an organ or organ system, or the whole organism	☺ 😐 ☹
Give examples of specialised cells	☺ 😐 ☹
4.1.1.4 Cell differentiation	**Review**
Explain the importance of cell differentiation.	☺ 😐 ☹
Understand that as an organism develops, cells differentiate to form different types of cells.	☺ 😐 ☹
Understand that most types of animal cell differentiate at an early stage.	☺ 😐 ☹
Understand that many types of plant cells retain the ability to differentiate throughout life.	☺ 😐 ☹
Understand that in mature animals, cell division is mainly restricted to repair and replacement. As a cell differentiates it acquires different sub-cellular structures to enable it to carry out a certain function. It has become a specialised cell.	☺ 😐 ☹
4.1.1.5 Microscopy	**Review**
Understand how microscopy techniques have developed over time	☺ 😐 ☹
Explain how electron microscopy has increased understanding of sub-cellular structures.	☺ 😐 ☹

Identify that an electron microscope has much higher magnification and resolving power than a light microscope.	☺ 😐 ☹
Explain why electron microscopes can be used to study cells in much finer detail and identify the advantages of this.	☺ 😐 ☹
Carry out calculations involving magnification, real size and image size using the formula: magnification = size of image/ size of real object	☺ 😐 ☹
Express answers in standard form if appropriate.	☺ 😐 ☹

4.1.1 Cell Structure	
4.1.1.6 Culturing microorganisms	**Review**
Identify that bacteria multiply by simple cell division (binary fission) as often as once every 20 minutes if they have enough nutrients and a suitable temperature.	☺ 😐 ☹
Identify that bacteria can be grown in a nutrient broth solution or as colonies on an agar gel plate.	☺ 😐 ☹
Understand why uncontaminated cultures of microorganisms are required for investigating the action of disinfectants and antibiotics.	☺ 😐 ☹
Describe how to prepare an uncontaminated culture using aseptic technique.	☺ 😐 ☹
Explain why petri dishes and culture media must be sterilised before use	☺ 😐 ☹
Explain why inoculating loops used to transfer microorganisms to the media must be sterilised by passing them through a flame	☺ 😐 ☹
Explain why the lid of the Petri dish should be secured with adhesive tape and stored upside down	☺ 😐 ☹
Explain why in school laboratories, cultures should generally be incubated at 25°C.	☺ 😐 ☹
Calculate cross-sectional areas of colonies or clear areas around colonies using πr2.	☺ 😐 ☹
Calculate the number of bacteria in a population after a certain time if given the mean division time.	☺ 😐 ☹
(HT only) Express an answer in standard form.	☺ 😐 ☹

4.1.2 Cell division	
4.1.2.1 Chromosomes	**Review**
Identify that the nucleus of a cell contains chromosomes made of DNA molecules. Each chromosome carries a large number of genes.	☺ 😐 ☹
Identify that in body cells the chromosomes are normally found in pairs.	☺ 😐 ☹
4.1.2.2 Mitosis and the cell cycle	**Review**
Recall that cells divide in a series of stages called the cell cycle.	☺ 😐 ☹
Describe the stages of the cell cycle, including mitosis.	
Recall that during the cell cycle the genetic material is doubled and then divided into two identical cells. Before a cell can divide it needs to grow and increase the number of sub-cellular structures such as ribosomes and mitochondria.	☺ 😐 ☹
Recall that the DNA replicates to form two copies of each chromosome.	☺ 😐 ☹

Recall that in mitosis one set of chromosomes is pulled to each end of the cell and the nucleus divides. Finally the cytoplasm and cell membranes divide to form two identical cells.	☺ 😐 ☹
Understand the three overall stages of the cell cycle	☺ 😐 ☹
Understand that cell division by mitosis is important in the growth and development of multicellular organisms.	☺ 😐 ☹
Recognise and describe situations in given contexts where mitosis is occurring.	☺ 😐 ☹
4.1.2.3 Stem Cells	**Review**
Recall that a stem cell is an undifferentiated cell of an organism which is capable of giving rise to many more cells of the same type, and from which certain other cells can arise from differentiation.	☺ 😐 ☹
Describe the function of stem cells in embryos, in adult animals and in the meristems in plants.	☺ 😐 ☹
Recall that stem cells from human embryos can be cloned and made to differentiate into most different types of human cells.	☺ 😐 ☹
Recall that stem cells from adult bone marrow can form many types of cells including blood cells.	☺ 😐 ☹
Recall that meristem tissue in plants can differentiate into any type of plant cell, throughout the life of the plant.	☺ 😐 ☹
Recall that treatment with stem cells may be able to help conditions such as diabetes and paralysis.	☺ 😐 ☹
Understand that in therapeutic cloning an embryo is produced with the same genes as the patient. Stem cells from the embryo are not rejected by the patient's body so they may be used for medical treatment.	☺ 😐 ☹
Understand that the use of stem cells has potential risks such as transfer of viral infection, and some people have ethical or religious objections.	☺ 😐 ☹
Recall that stem cells from meristems in plants can be used to produce clones of plants quickly and economically.	☺ 😐 ☹
Recall that plant clones can be beneficial; • Rare species can be cloned to protect from extinction. • Crop plants with special features such as disease resistance can be cloned to produce large numbers of identical plants for farmers.	☺ 😐 ☹

4.1.3 Transport in cells	
4.1.3.1 Diffusion	**Review**
Recall that substances may move into and out of cells across the cell membranes via diffusion.	☺ 😐 ☹
Recall that diffusion is the spreading out of the particles of any substance in solution, or particles of a gas, resulting in a net movement from an area of higher concentration to an area of lower concentration.	☺ 😐 ☹
Recall that some of the substances transported in and out of cells by diffusion are oxygen and carbon dioxide in gas exchange, and of the waste product urea from cells into the blood plasma for excretion in the kidney.	☺ 😐 ☹
Explain how different factors affect the rate of diffusion.	☺ 😐 ☹
Recall that the factors which affect the rate of diffusion are: • the difference in concentrations (concentration gradient) • the temperature	☺ 😐 ☹

• the surface area of the membrane.	
Recall that a single-celled organism has a relatively large surface area to volume ratio. This allows sufficient transport of molecules into and out of the cell to meet the needs of the organism.	☺ 😐 ☹
Calculate and compare surface area to volume ratios.	☺ 😐 ☹
Explain the need for exchange surfaces and a transport system in multicellular organisms in terms of surface area to volume ratio.	☺ 😐 ☹
Explain how the small intestine and lungs in mammals, gills in fish, and the roots and leaves in plants, are adapted for exchanging materials.	☺ 😐 ☹
Recall that in multicellular organisms, surfaces and organ systems are specialised for exchanging materials. This is to allow sufficient molecules to be transported into and out of cells for the organism's needs.	☺ 😐 ☹
Recall that the effectiveness of an exchange surface is increased by: • having a large surface area • a membrane that is thin, to provide a short diffusion path • (in animals) having an efficient blood supply • (in animals, for gaseous exchange) being ventilated.	☺ 😐 ☹
4.1.3.2 Osmosis	**Review**
Recall that water may move across cell membranes via osmosis.	☺ 😐 ☹
Recall that osmosis is the diffusion of water from a dilute solution to a concentrated solution through a partially permeable membrane.	☺ 😐 ☹
Be able to use simple compound measures of rate of water uptake	☺ 😐 ☹
Use percentages	☺ 😐 ☹
Calculate percentage gain and loss of mass of plant tissue	☺ 😐 ☹
Be able to plot, draw and interpret appropriate graphs.	☺ 😐 ☹
4.1.3.3 Active Transport	**Review**
Recall that active transport moves substances from a more dilute solution to a more concentrated solution (against a concentration gradient). This requires energy from respiration.	☺ 😐 ☹
Understand that active transport allows mineral ions to be absorbed into plant root hairs from very dilute solutions in the soil. Plants require ions for healthy growth.	☺ 😐 ☹
Understand that active transport also allows sugar molecules to be absorbed from lower concentrations in the gut into the blood which has a higher sugar concentration. Sugar molecules are used for cell respiration.	☺ 😐 ☹
Describe how substances are transported into and out of cells by diffusion, osmosis and active transport	☺ 😐 ☹
Explain the differences diffusion, osmosis and active transport.	☺ 😐 ☹

Cell Biology Knowledge

4.1.1 Cell Structure

4.1.1.1 Eukaryotes and Prokaryotes

Prokaryotes

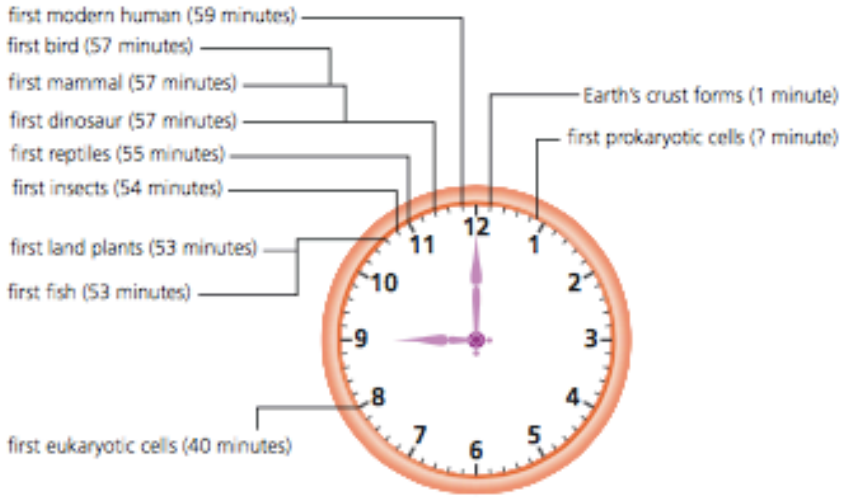
All bacterial cells are **prokaryotic**, which means that all bacteria are **prokaryotes**. Evolutionary evidence suggests that prokaryotes evolved much earlier than eukaryotic cells.

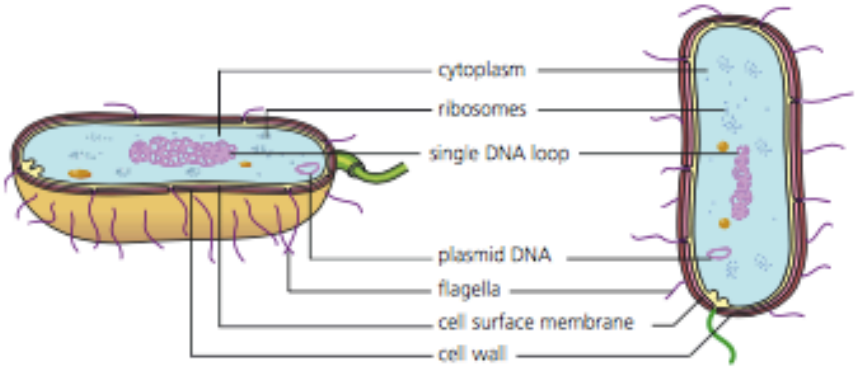
Prokaryotes:

- are single celled
- do not have a nucleus containing their genetic material (DNA)
- are smaller than eukaryotic cells.

Individual bacterial cells are usually between 1 µm and 10 µm in length. One thousand micrometres (µm) make up one millimetre (mm). This means that between 100 and 1000 bacteria will fit in a straight line in 1 mm. Groups of bacterial cells, called colonies, are shown in Figure 1.2. Many, but not all, scientists think that prokaryotes evolved before eukaryotes and so are missing some cell components that eukaryotic cells possess. These scientists think that prokaryotes first appeared about 3.5 billion years ago, which is only one billion years after the Earth's crust formed.

If the last 4.6 billion years were scaled down into an hour, Figure 1.3 shows when the first prokaryotic and eukaryotic organisms are likely to have evolved. Humans have actually only been present for the last few seconds of the last minute, so not long at all!





▲ Figure 1.4 A bacterial cell as seen with a microscope (magnified ×20000) and as three- and two-dimensional diagrams.

Eukaryotes

All animal and plant cells are **eukaryotic**, which makes all plants and animals **eukaryotes**. Figure 1.1 shows examples of the huge diversity we can see in eukaryotic life on Earth.

You can see from Figure 1.1 that many eukaryotic cells belong to more complex organisms. Often such organisms are made from more than one cell and so we call them multicellular. It is difficult to determine when eukaryotic cells first appeared on Earth, but many scientists think that it happened about two billion years ago. We are still not sure how exactly eukaryotic cells first appeared on Earth.

Component	Structure and function
Cytoplasm	This fluid is found in all cells. It is mainly water and it holds other components such as ribosomes. Here most of the chemical reactions in the cell happen (such as the making of proteins in ribosomes).
Cell wall	Like those of plants and fungi, bacterial cells have a cell wall to provide support. However, unlike plant cell walls this is not made of cellulose. The cell membrane is found on the inside surface of the cell wall.
Single DNA loop (not in chromosomes)	DNA in prokaryotes is not arranged in complex **chromosomes** like in eukaryotic cells. It is not held within a nucleus.
Plasmid DNA	These are small, circular sections of DNA that can move from one cell to another. They provide genetic variation for bacteria.
Flagellum	This is a whip-like structure that helps many prokaryotes to move by rotating or flicking (like a whip).
Cell-surface membrane	This controls what substances go in and out of a cell. It also has internal extensions that have enzymes attached to them. **Respiration** occurs in these enzymes. Prokaryotic cells do not have **mitochondria**, which is where respiration occurs in eukaryotic cells.
Ribosome	Proteins are made from amino acids in ribosomes, which are present in the cytoplasm.

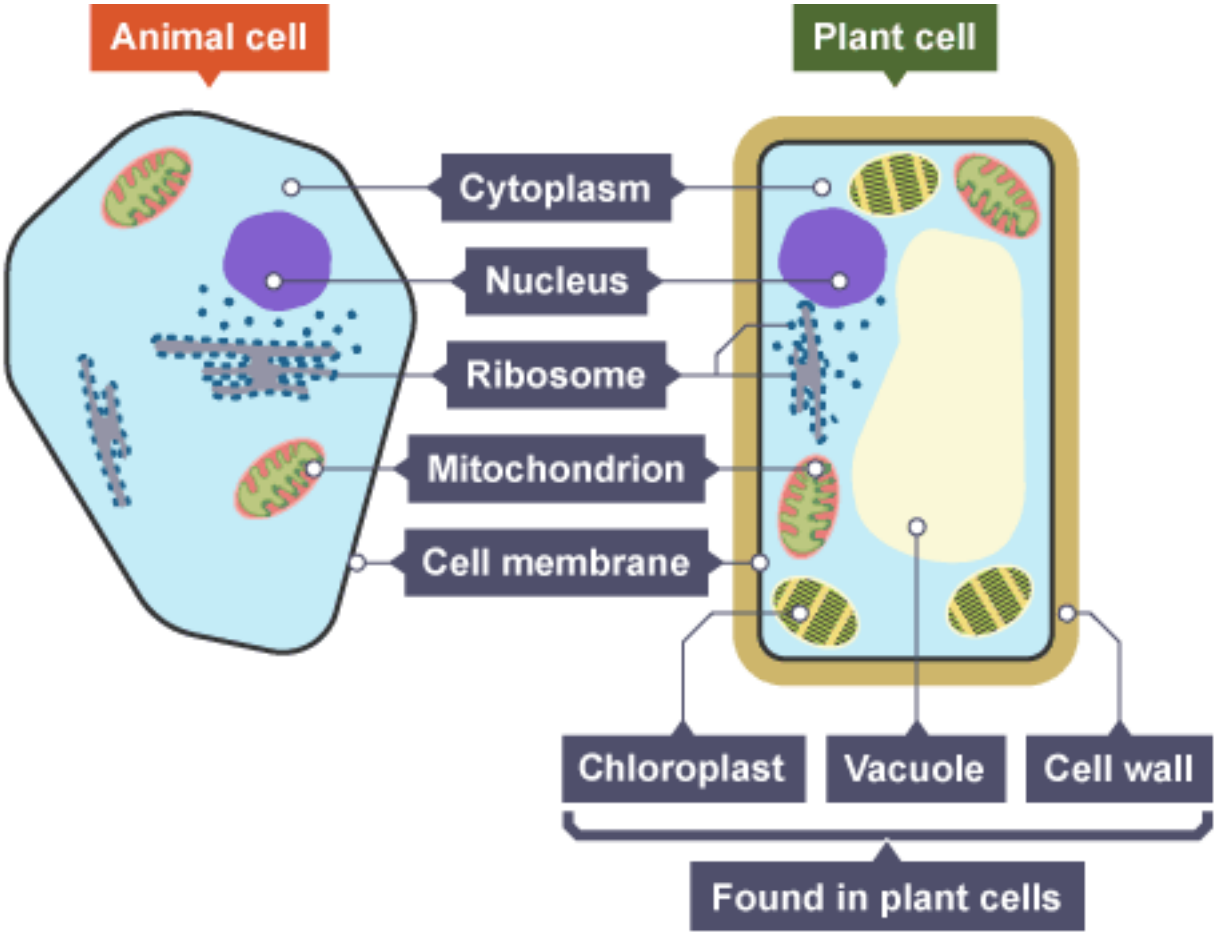
4.1.1.2 Animal and Plant cells

Function of cells which animal and plant cells have in common

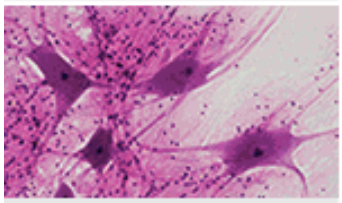
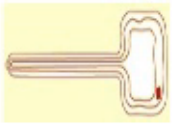
part	function
nucleus	contains genetic material, which controls the activities of the cell
cytoplasm	most chemical processes take place here, controlled by enzymes
cell membrane	controls the movement of substances into and out of the cell
mitochondria	most energy is released by respiration here
ribosomes	protein synthesis happens here

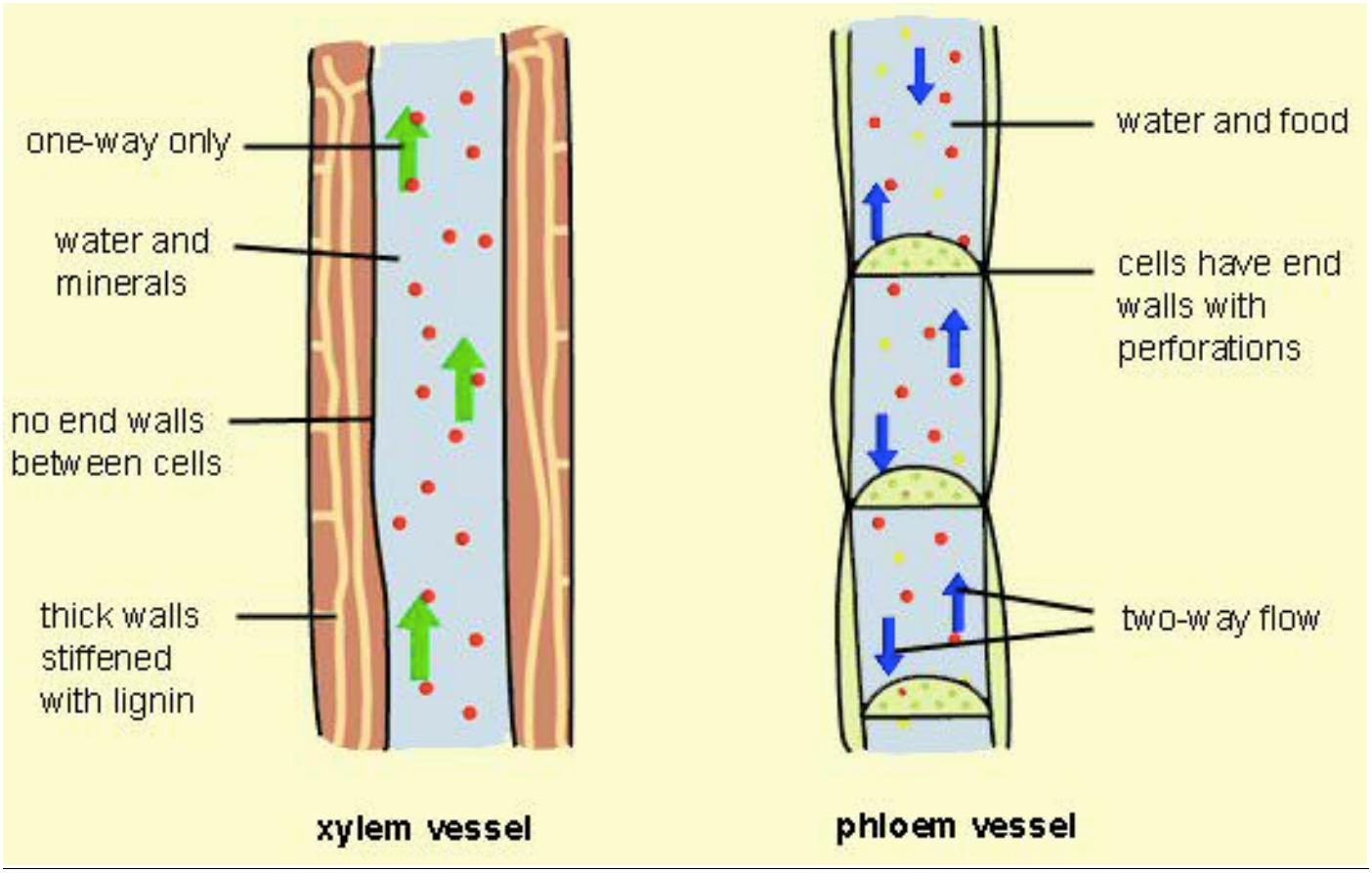
Extra parts of plant cells

part	function
cell wall	strengthens the cell
chloroplasts	contain chlorophyll, which absorbs light energy for photosynthesis
permanent vacuole	filled with cell sap to help keep the cell *turgid*



4.1.1.3 Cell Specialisation

	**Nerve cells**	To carry nerve impulses to different parts of the body	• Long • Connections at each end • Can carry electrical signals
root hair cell		Absorbs water and mineral ions from the soil.	Long 'finger-like' process with very thin wall, which gives a large surface area.
sperm cell		Fertilises an egg cell (female gamete).	The head contains genetic information and an enzyme to help penetrate the egg cell membrane. The middle section is packed with mitochondria for energy. The tail moves the sperm to the egg.



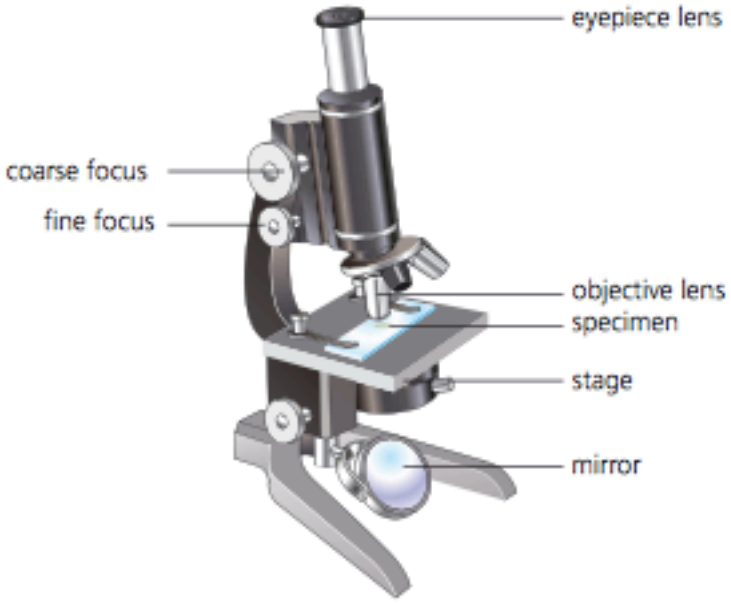
Many cells are **specialised**. They have structures that are adapted for their function. For example, muscle cells bring parts of the body closer together. They contain protein fibres that can **contract** when energy is available, making the cells shorter.

4.1.1.4 Cell differentiation

Differentiation

Differentiation is the process of cells becoming specialised. Most types of animal cells differentiate at an early stage. They become specialised for a particular function and cannot change into different types of cells. In mature animals, cell division is mainly restricted to replacement and repair. On the other hand, many plant cells keep the ability to differentiate.

4.1.1.5 Microscopy



Light microscopes

The parts of a light microscope and their functions are shown in Table 1.2.

Table 1.2 The functions of the parts of a light microscope.

Part	Function
Eyepiece lens	You will look through this lens to see your sample. This is often ×10.
Objective lens	Usually there are three to choose from (often ×5, ×10 and ×25). The smallest will be the easiest to focus, so select this first. When you have focused this lens try a different one with a greater magnification.
Stage	This holds the sample securely, often using two metal clips.
Specimen	This is usually placed in a drop of water or stain on a microscope slide under a very thin glass cover slip.
Mirror	This reflects the light up through the sample, and then the objective and eyepiece lenses into your eyes.
Course focus	This quickly and easily moves the stage up and down to focus on the sample.
Fine focus	This sensitively and slowly moves the stage up and down to allow you to make your image very sharp.

The total magnification of the image you are looking at is calculated by:

$$\text{total magnification} = \frac{\text{magnification of eyepiece lens}}{} \times \frac{\text{magnification of objective lens}}{}$$

Electron microscopes

Electron microscopes use **electrons** in place of rays of light to make an image (Figure 1.19). The wavelength of electrons can be up to 100 000 times smaller than that of visible light. This means that electron microscopes can take images at significantly higher magnifications. The first electron microscope was made by German scientists Ernst Ruska (1906–1988) and Max Knoll (1897–1969) in 1931. This was a transmission electron microscope (TEM). Several years later, in 1937, German scientist Manfred von Ardenne (1907–1997) invented a second type called a scanning electron microscope (SEM).

Transmission electron microscopes fire a large beam of electrons though a very thin slice of the specimen. All electrons are fired at the same time. Not all of the electrons pass though the specimen. The image is made from only those electrons that do.

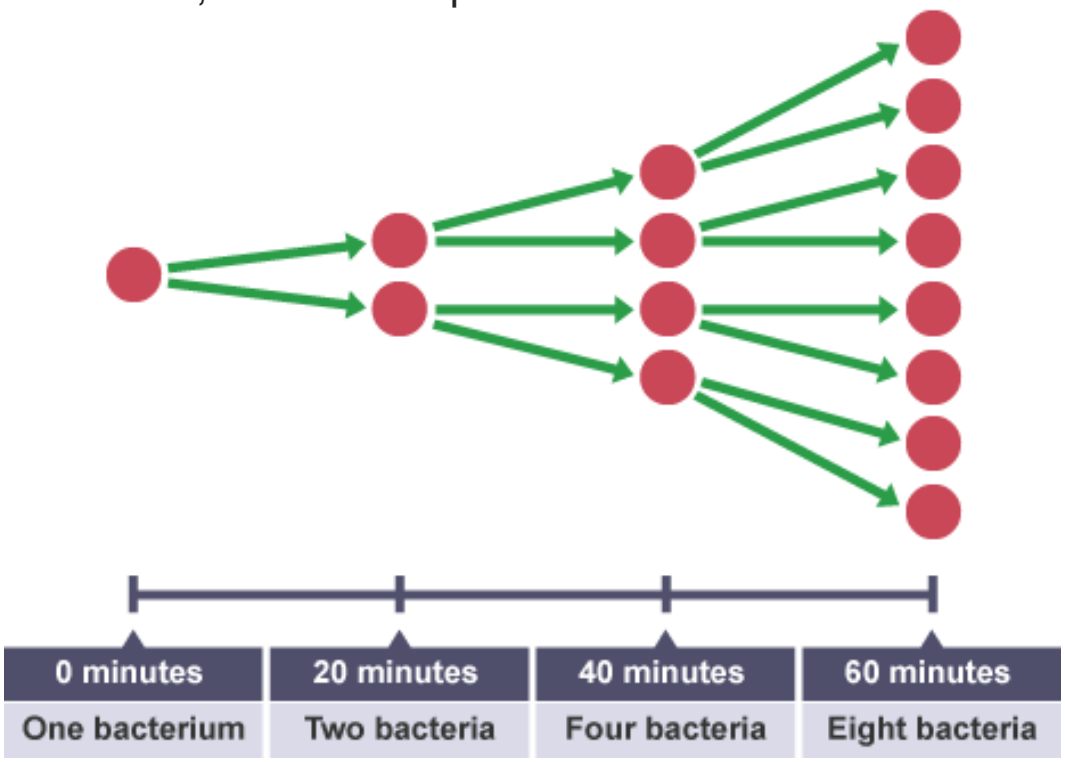
Scanning electron microscopes also use a beam of electrons. This beam is much smaller and scans across the whole image but not all at the same time. Electrons scatter from the surface of the sample and are detected to make an image.

As a consequence of their different methods of working, the images that these two microscopes take are very different from each other. Images from transmission electron microscopes are flat and are usually taken in cross-section through a specimen. That is, they are frequently used to look at a section through a cell. Scanning electron microscopes don't need thin samples so can be used to take images that look more three-dimensional. All electron microscope images are black and white. On occasions scientists colour these images to make them look more striking (Figure 1.20).

The **resolution** of microscopes is defined as the shortest distance between two parts of a specimen that can be seen as two distinctly separate points. As a result of the wavelength of light the maximum resolution of light microscopes is 200 nm. (There are one million nanometres (nm) in a millimetre.) The wavelength of electrons is shorter than that of light, and so much closer points can be resolved. An electron microscope can resolve points up to 2000 times closer than a light microscope, at a separation of just 0.1 nm.

Bacterial growth

Bacteria can replicate approximately every 20 minutes by **binary fission**, which is a simple form of **cell division**. This level of replication will depend on the availability of nutrients and other suitable conditions, such as temperature.



There are many ways to grow, or **culture**, bacteria, eg:

- nutrient broth solution
- **colonies** on an agar plate

Nutrient broth solution, or culture medium, allows a liquid or gel to provide all the nutrients needed for bacteria to grow successfully. These must include carbohydrates for energy, nitrogen for **protein synthesis**, plus other minerals.

Agar plates are created by pouring hot molten agar into sterile **petri dishes**, which is then allowed to set. Bacteria can be spread onto the plates, and allowed to form individual colonies of the specific bacterium.

Uncontaminated cultures

If a specific bacterium is going to be cultured, other contaminating bacteria would compete for nutrients in the broth or agar. Some bacteria could also be harmful, such as **pathogens**, and would complicate the results of experiments when testing the efficiency of antibiotics or other anti-microbial compounds.

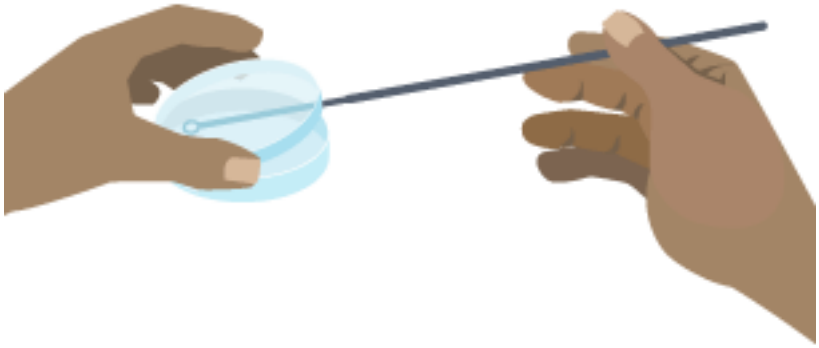
It is therefore important that any petri dish or agar used is sterilised before

use, and that aseptic techniques are used to inoculate the plates.

Use of aseptic techniques to avoid contamination

An inoculating loop can be used to transfer bacteria. It is sterilised by heating it to red hot in a Bunsen flame, before and after use.

To inoculate the agar, lift the lid of the Petri dish and tilt. Do not fully remove or place on the desk as the lid prevents micro-organisms from the air contaminating the culture, and vice versa.



Following inoculation, the lid of the Petri dish should be secured in place by strips of adhesive tape for safety reasons. The dish should be labelled and dated.

Inoculated agar plates are incubated at 25°C in school laboratories for no more than 24–48 hours. This encourages growth of the culture without growing human pathogens which thrive at body temperature (37°C).

For safety reasons, plates and equipment should be sterilised after use.

Colonies of bacteria

Bacteria are micro-organisms, and individual cells cannot be seen without a microscope. However, when grown on agar in a Petri dish, each individual cell divides multiple times to form a visible colony.

If we count the number of individual colonies of bacteria on the plates, it is possible to estimate the numbers of individual bacteria in the original sample.

In order to make an accurate calculation of the numbers of bacteria in a sample, the original sample will need to be diluted - this is known as a serial dilution. Only when the sample is sufficiently dilute that it produces clear individual colonies can a calculation be made.

How to calculate the number of bacteria in a population

Example

The mean division time for bacteria population A is 20 minutes. If the observation begins with one bacterium, calculate how many bacteria will be present after six hours.

In order to answer this, you can split the calculations into two sections.

Part 1 – Calculate how many times the bacteria divide in six hours

In this example, the bacteria divide every 20 minutes, and will therefore divide three times every hour, $\frac{60}{20} = 3$.

If the bacteria grow for six hours, each bacterium will divide 3 times per hour × 6 hours = 18 times.

Part 2 – Calculate the number of bacteria in the population

Every time the bacteria reproduce, the number doubles. To calculate the number of bacteria at the end of the growth period, you can use this equation.

$$\textit{Bacteria at the beginning of the growth period} \times 2^{\textit{number of divisions}}$$

Number of bacteria at the beginning = 1

Number of divisions = 18

$1 \times 2^{18} = 1 \times 262{,}144 = 262{,}144$ bacteria

For a higher mark, you could express answers in standard form.

For example, the above answer of 262,144 bacteria can also be written as 2.62×10^5 bacteria.

4.1.1 Cell Structure PPQ's

Low demand

PPQ 1

(c) The **figure** shows a sperm cell.

Describe how a sperm cell is adapted to carry out its function.

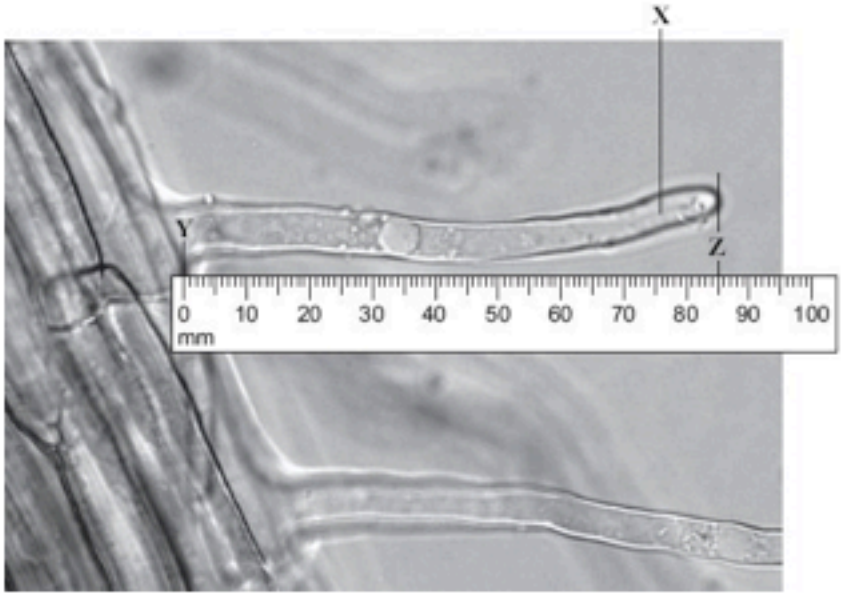
.....

.....

(1)

PPQ 2

Q2. The photograph shows part of the surface of a plant root. This part of the root is covered with hundreds of structures like the one labelled **X**.



(b) (i) Use the scale to measure the length **Y–Z** on the photograph.

On the photograph, length **Y–Z** = ... mm.

(1)

(ii) The photograph shows the root magnified 100 times.

Calculate the actual length **Y–Z**.

.....

.....

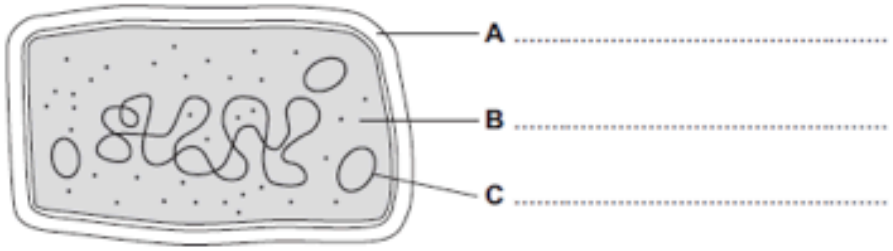
.....

Actual length **Y–Z** = ...mm.

(2)

PPQ 3

Q4.(a) The diagram shows the structure of a bacterial cell.



(i) On the diagram use words from the box to label structures **A**, **B** and **C**.

cell membrane	**cell wall**	**chloroplast**	**cytoplasm**	**plasmid**

(3)

(ii) Give **one** difference between the structure of the bacterial cell and an animal cell.

.....

(1)

(iii) Name **one** structure that is found in a plant cell but is **not** found in a bacterial or an animal cell.

.....

(1)

PPQ 4

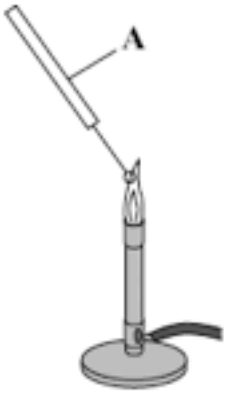
(a) It is important to prevent contamination when growing microorganisms.

The diagram shows the transfer and culturing of microorganisms.

Stage V

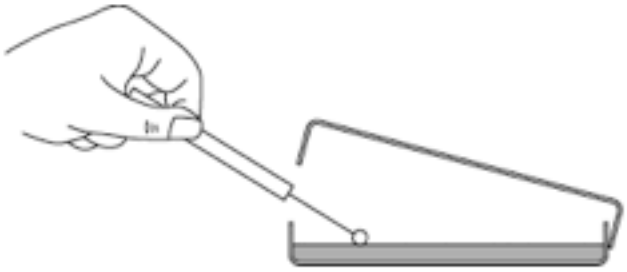
A Petri dish with agar is heated to 150 °C for 50 minutes, then cooled

Stage W



Stage X

Stage Y



Stage Z

Petri dish kept at 25 °C for 48 hours

(i) Name the apparatus labelled **A** in stage **W**.

Draw a ring around **one** answer.

inoculating loop **pipette** **thermometer**

(1)

(ii) Give the letters of the **two** stages from **V**, **W**, **X**, **Y** and **Z**, which are carried out to kill microorganisms.

Stages ☐ and ☐

(2)

(iii) Give the letter of the stage, **V**, **W**, **X**, **Y** or **Z**, where incubation takes place.

Stage ☐

(1)

(b) A culture medium used for growing microorganisms contains various nutrients.

Which nutrient is the main source of energy for the microorganisms?

Draw a ring around **one** answer.

carbohydrates **mineral ions** **vitamins**

(1)

(Total 5 marks)

PPQ 5

The following are precautions taken when preparing a streak of bacteria on an agar jelly plate.

Give a reason for each.

(i) The inoculating loop is heated in a hot bunsen flame.

REASON:

_____

_____

(1)

(ii) The loop is allowed to cool before putting it into the bacterial culture.

REASON:

_____

_____

(1)

(iii) The lid of the petri dish is only partly opened.

REASON:

_____

_____

(1)

(iv) The petri dish is sealed with sticky tape.

REASON:

_____

_____

(1)
(Total 4 marks)

Standard demand

PPQ 6

(b) Phloem is involved in a process called translocation.

(i) What is translocation?

.....

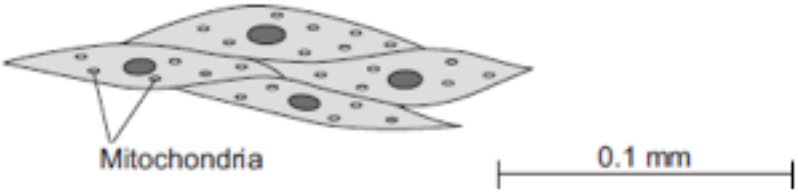
.....

.....

(1)

PPQ 7

Q4. The image below shows some muscle cells from the wall of the stomach, as seen through a light microscope.



(b) **Figure above** is highly magnified.

The scale bar in **Figure above** represents 0.1 mm.

Use a ruler to measure the length of the scale bar and then calculate the magnification of **Figure above**.

.....

.....

.....

.....

Magnification = ... times

(2)

PPQ 8

(ii) Explain why translocation is important to plants.

.....

.....

.....

.....

(2)

High demand

PPQ 9

(d) A scientist observed a cell using an electron microscope.

The size of the image was 25 mm.

The magnification was × 100 000

Calculate the real size of the cell.

Use the equation:

$$\text{magnification} = \frac{\text{image size}}{\text{real size}}$$

Give your answer in micrometres.

.....

.....

.....

Real size = ... micrometres

(3)

PPQ 10

Q7. The photograph shows a red blood cell in part of a blood clot. The fibres labelled **X** are produced in the early stages of the clotting process.

(b) The average diameter of a real red blood cell is 0.008 millimetres.
On the photograph, the diameter of the red blood cell is 100 millimetres.

Use the formula to calculate the magnification of the photograph.

Diameter on photograph = Real diameter × Magnification

.....

.....

.....

Magnification = ...

(2)

4.1.1 Cell Structure PPQ Answers

Low demand

PPQ MS1

(c) has a tail so it can swim (to an egg)

accept has many mitochondria to release energy to swim

1

PPQ MS2

(b) (i) 85

if incorrect unit added = 0

1

(ii) 0.85

ignore working or lack of working
*accept correct answer from candidate's (i) for **2** marks*

$\frac{85}{100}$ *with no answer or wrong answer gains **1** mark*

accept ecf

2

PPQ MS3

M4.(a) (i) **A** – (cell) wall

1

B – cytoplasm

1

C – plasmid

1

(ii) bacterium cell has cell wall / no nucleus / no mitochondria / plasmids present

accept its DNA / genetic material is not enclosed / it has no nuclear membrane
it = bacterium cell
accept converse for animal cell
ignore flagella

1

(iii) any **one** from:

- chloroplast
  ignore chlorophyll
- (permanent) vacuole

1

PPQ MS4

Q1.

(a) (i) inoculating loop

1

(ii) V

1

W

either order

1

(iii) Z

1

(b) carbohydrates

1

[5]

PPQ MS5

Q2.

(i) the loop is sterilised

accept to kill anything on the loop

or

to kill any bacteria on it;

do not credit to clean the loop

1

(ii) if hot it would kill bacteria picked up (from culture);

accept 'microorganisms' or 'microbes'

accept entry of contaminated air but reject entry of air unqualified

1

(iii) to prevent entry (from the air) of unwanted bacteria or bacterial spores or fungal spores;

accept so can't breath on it

accept 'microorganisms' or 'microbes'

1

(iv) so that the (petri) dish is not opened (after bacteria are cultured)

or to reduce evaporation

or drying of the agar,

accept 'microorganisms' or 'microbes'

accept to prevent anything relevant getting in/out

reject references to spillage

1

[4]

Standard demand

PPQ MS6

(b) (i) movement of (dissolved) sugar

allow additional substances, eg amino acids / correct named sugar (allow sucrose / glucose)

allow nutrients / substances / food molecules if sufficiently qualified

ignore food alone

1

PPQ MS7

(b) (Long tail) moves the sperm / allows the sperm to swim

1

towards the egg

allow correct reference to other named parts of the female reproductive system

1

(Mitochondria) release energy (for movement / swimming)

allow supply / produce / provide

1

in respiration

1

PPQ MS8

(ii) sugars are made in the leaves

1

so they need to be moved to other parts of the plant for respiration / growth / storage

1

High demand

PPQ MS9

(d) real size = 25 / 100 000

1

0.00025

1

(conversion to) 0.25 (µm)

*allow 0.25 (µm) with no working shown for **3** marks*

1

PPQ MS10 (b) 12500

if correct answer, ignore working / lack of working

$\frac{100}{0.008}$ *for **1** mark*

ignore any units

2

4.1.2 Cell division

4.1.2.1 Chromosomes

Chromosomes are made from DNA. Genes are short sections of DNA. Genetically identical cells are produced by a type of cell division called mitosis. In sexual reproduction, a male gamete fuses with a female gamete to produce a new cell. This is called fertilisation. Gametes are produced by a type of cell division called meiosis. They contain a single set of chromosomes, whereas body cells contain two sets of chromosomes.

DNA, genes and chromosomes

DNA

DNA (deoxyribose nucleic acid) molecules are large and complex. They carry the genetic code that determines the characteristics of a living thing.

Except for identical twins, each person's DNA is unique. This is why people can be identified using DNA fingerprinting. DNA can be cut up and separated, forming a sort of 'bar code' that is different from one person to the next.

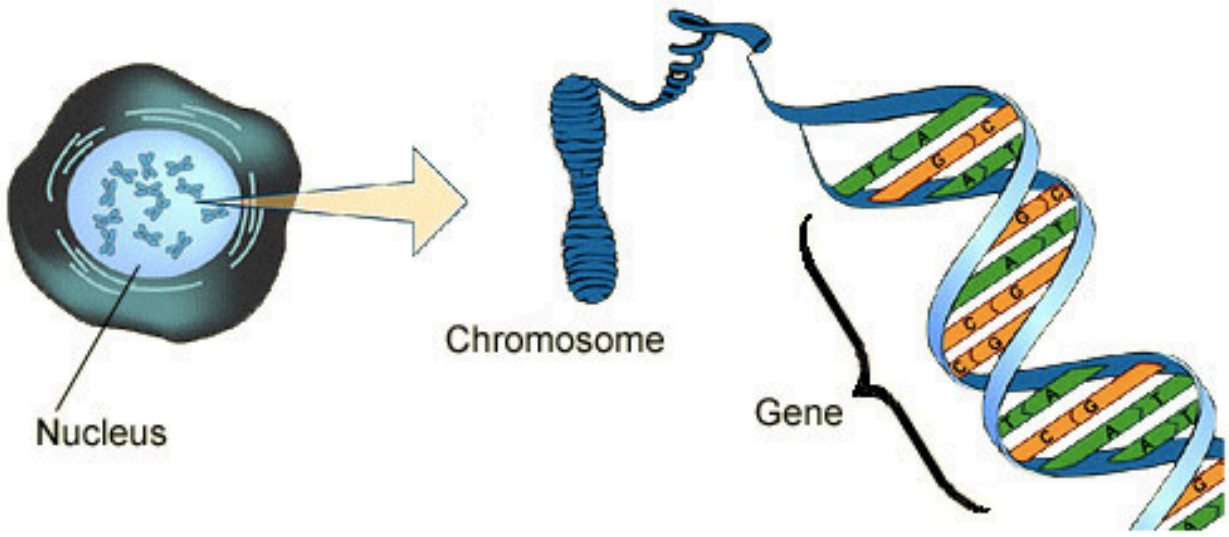
Genes

A *gene* is a short section of DNA. Each gene codes for a specific protein by specifying the order in which amino acids must be joined together.

Chromosomes

The cell's nucleus contains *chromosomes* made from long DNA molecules.

The diagram shows the relationship between the cell, its nucleus, chromosomes in the nucleus, and genes.

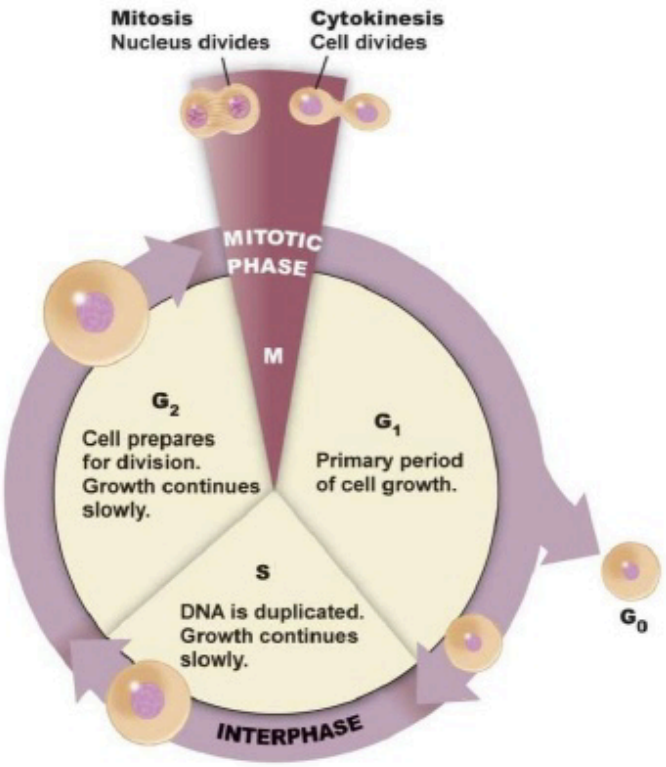


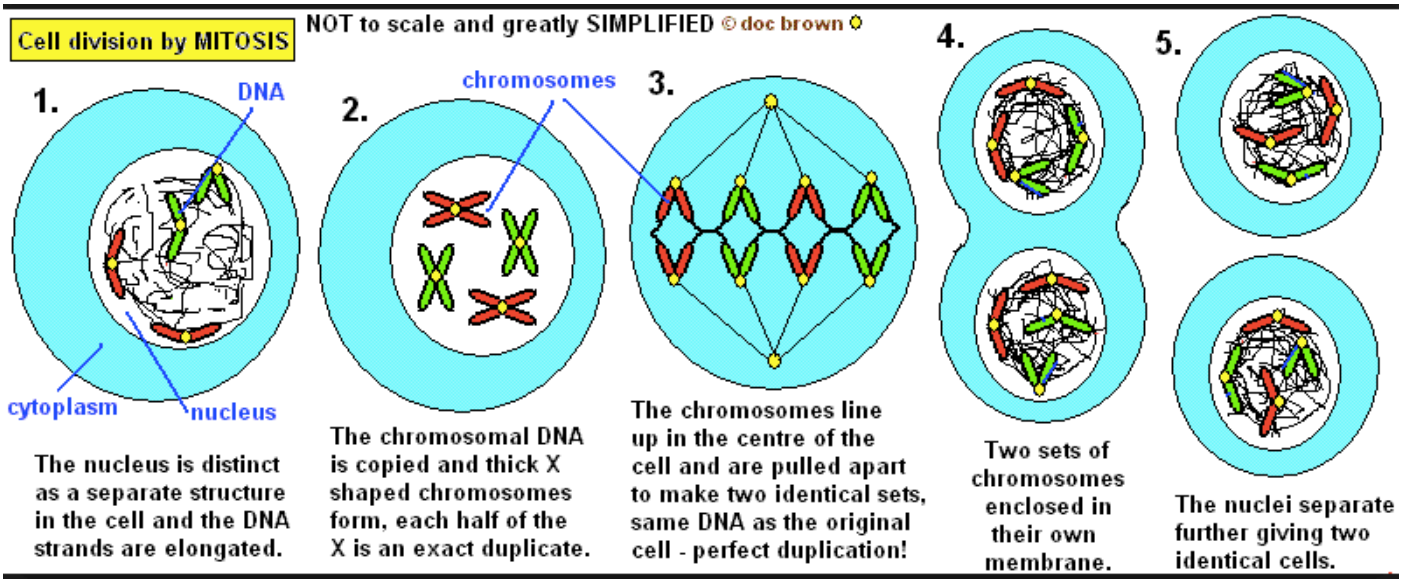
Nucleus, chromosome and gene

4.1.2.2 Mitosis and the cell cycle

Cell Cycle: Interphase

- G_1- primary growth phase
  - Makes more cytoplasm and organelles
  - Most of the growing
- S- synthesis
  - DNA is replicated
- G2- secondary growth phase
  - Prepares for mitosis





4.1.2.3 Stem cells

Differentiation

Most types of animal cells **differentiate** at an early stage - they become specialised for a particular function and cannot change into different types of cell. In mature animals, cell division is mainly restricted to replacement and repair. However, many plant cells keep the ability to differentiate.

Stem cells

There are two types of stem cells:

- **adult stem cells** - these are unspecialised cells that can develop into many (but not all) types of cells
- **embryonic stem cells** - these are unspecialised cells that can develop into any type of cell.

During the development of an *embryo*, most of the cells become **specialised** (cells with modifications to structure according to the task they have to perform). They cannot later change to become a different type of cell.

But embryos contain a special type of cell called **stem cells**. These embryonic stem cells can grow into any type of cell found in the body so they are not specialised. Stem cells can be removed from human embryos that are a few days old, for example, from unused embryos left over from fertility treatment.

Stem cells have the potential to be used in new treatments for conditions such as Parkinson's disease and paralysis. There are social and ethical issues concerning the use of human embryonic stem cells in medical research and treatments.

Meristems

Plants cells are different to animal cells in another way. Unspecialised stem cells in plants are grouped together in structures called **meristems**. Cells produced by meristems ensure that plants continue to grow in height and width throughout their life. Animals stop growing in size once they become adults.

Plant meristems divide to produce cells that increase the height of the plant, length of the roots and girth of the stem. They also produce cells that develop into leaves and flowers.

Therapeutic cloning

If you were to receive medical treatment with cells grown from stem cells, your body's immune system would recognise the cells as **foreign**, and they would be rejected and die. But this would not happen if you received cells with the same genes as your own.

This could be done by cloning one of your cells to produce an *embryo*, then taking stem cells from this. This is called therapeutic cloning. Here are the steps involved:

1. *nucleus* taken out of a human egg cell
2. nucleus from a patient's cell put into the egg cell
3. egg cell stimulated to develop into an embryo
4. stem cells taken from the embryo
5. stem cells grown in a container of warm nutrients
6. stem cells treated to develop into required cell types.

Advantages and disadvantages

Cloning allows growers to mass produce plants that may be difficult to grow from seed. All the plants are genetically identical, which is useful because you can be sure of their characteristics. On the other hand, the lack of genetic variation means that if the plants become exposed to disease or to changes in environmental conditions, all of them will be affected.

4.1.2 Cell division PPQ's

Low demand PPQ 1

1(b) Many types of cell can divide to form new cells.

Some cells in human skin can divide to make new skin cells.

Why do human skin cells need to divide?

.....

.....

(1)

PPQ 2

2(c) Stem cells from a recently destroyed embryo can be grown in special solutions.

Some facts about stem cells are given below.

- Stem cells from an embryo can grow into any type of tissue.
- Stem cells may grow out of control, to form cancers.
- Large numbers of stem cells can be grown in the laboratory.
- Stem cells may be used in medical research or to treat some human diseases.
- Patients treated with stem cells need to take drugs for the rest of their life to prevent rejection.
- Collecting and growing stem cells is expensive.

Use **only** the information above to answer these questions.

(i) Give **two** advantages of using stem cells.

1 .....

.....

2 .....

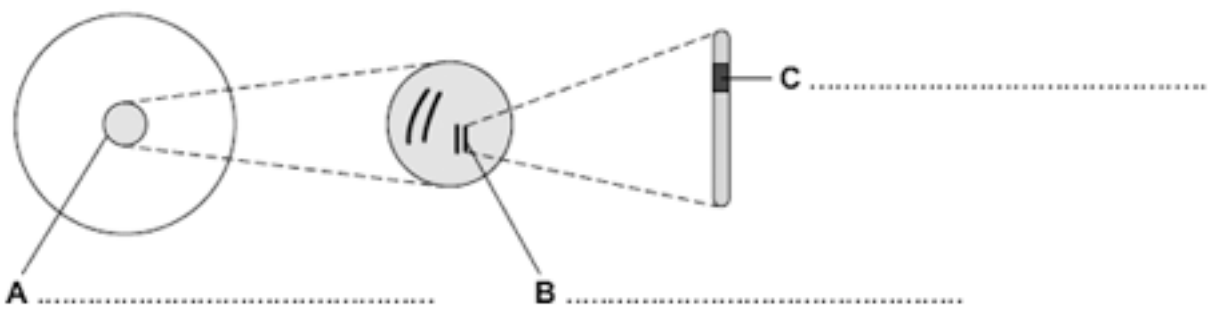
.....

(2)

PPQ 3

Q3. **Diagram 1** shows an animal cell and some of the structures inside the cell.

Diagram 1



(a) Use words from the box to label structures **A**, **B** and **C**, on **Diagram 1**.

Characteristic	Chromosome	Gamete	Gene	Nucleus

Standard demand

PPQ 4

4(b) Stem cells can be taken from human embryos.

In therapeutic cloning, an embryo is produced that has the same genes as the patient.

(i) Name **one** source of human stem cells, other than human embryos.

.....

(1)

(ii) Stem cells from embryos can be transplanted into patients for medical treatment.

Give **one** advantage of using stem cells from embryos, compared with cells from the source you named in part (i).

(1)

.....

.....

PPQ 5

5(c) (i) How many pairs of chromosomes are there in a human body cell?

.....

(1)

(ii) How many chromosomes are there in a human egg cell?

.....

(1)

(d) Chromosomes contain genes. From what substance are genes made?

.....

(1)

(e) In the process of mitosis, how do the number of chromosomes in the daughter cells compare to that in the original cell?

.....

(1)

High demand PPQ 6

6(c) For a baby to grow, its cells must develop in a number of ways.

Explain how each of the following is part of the growth process of a baby.

(i) Cell enlargement

.....

(1)

(ii) The process of cell division by mitosis

.....

.....

.....

.....

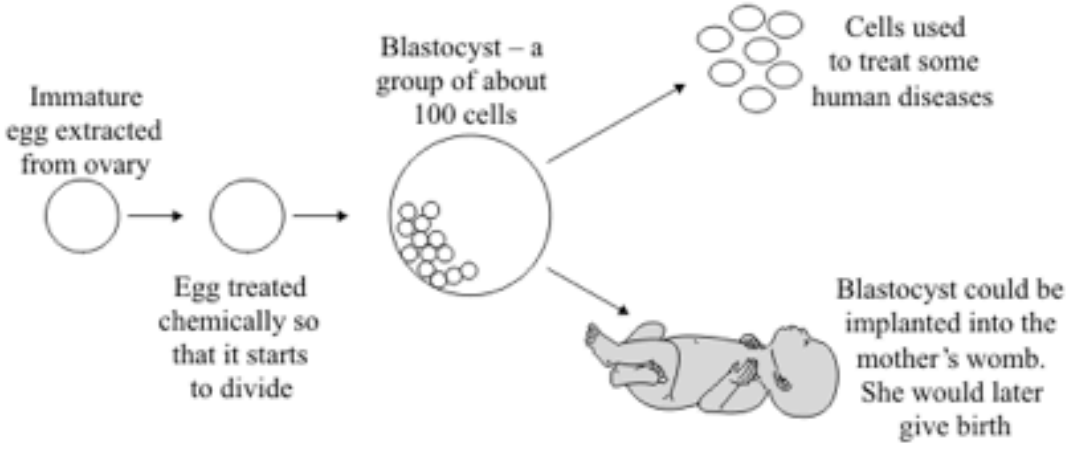
.....

.....

(3)

PPQ 7 4 marks

Q7. The diagram shows how an immature egg could be used either to produce cells to treat some human diseases or to produce a baby.



Scientists may be allowed to use this technique to produce cells to treat some human diseases, but not to produce babies.

Using information from the diagram, suggest an explanation for this.

.....

.....

.....

.....

.....

.....

.....

PPQ 8

Q8. Read the information about stem cells.

Stem cells are used to treat some human diseases.

Stem cells can be collected from early embryos. These stem cells have not begun to differentiate, so they could be used to produce any kind of cell, tissue or organ. The use of embryonic stem cells to treat human diseases is new and, for some diseases, trials on patients are happening now.

Stem cells can also be collected from adult bone marrow. The operation is simple but may be painful. Stem cells in bone marrow mainly differentiate to form blood cells. These stem cells have been used successfully for many years to treat some kinds of blood disease. Recently there have been trials of other types of stem cell from bone marrow. These stem cells are used to treat diseases such as heart disease.

Evaluate the use of stem cells from embryos or from adult bone marrow for treating human diseases.

You should give a conclusion to your evaluation.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(5)
(Total 5 marks)

4.1.2 Cell division PPQ Answers

Low demand

PPQ MS1

(b) for repair / growth **or** to replace cells

ignore new cells / skin

1

PPQ MS2

(c) (i) any **two** from:

- can grow into any type of tissue / named tissue
- used in medical research
- used to treat human diseases
- large numbers can be grown

2

PPQ MS3

M3. (a) A – nucleus

1

B – chromosome

1

C – gene

1

Standard demand

PPQ MS4

(b) (i) (adult) bone marrow

accept (umbilical) cord blood, skin, amniotic fluid / membrane

1

(ii) cells will not be rejected by the patient's body (if they have been produced by therapeutic cloning)

allow easier to obtain linked to embryo stem cells

or

(embryo stem cells) can develop into many different types of cells

allow doesn't need an operation linked to bone marrow

or

(embryo stem cells) not yet differentiated / specialised or undifferentiated

accept embryo cells are pluripotent

1

PPQ MS5

(c) (i) 23

1

(ii) 23

credit the same as the one above to be marked consequential

1

(d) DNA

do not accept nucleic acid

1

(e) same

1

High demand
PPQ MS6

M6.

(c) (i) any **one** from

(cells which are bigger) take up more space

(cells) have to get bigger **or** mature to divide

1

(ii) chromosomes duplicate **or**
make exact copies of self

accept forms pairs of chromatids

1

nuclei divide

accept chromatids ***or***
chromosomes separate

1

identical (daughter) cells formed

accept for example, skin cells make more skin cells ***or*** *cells are clones*

1

PPQ MS7

M7. any **four** from:

- cells used to treat diseases do not go on to produce a baby
- produces identical cells for research
- cells would not be rejected
- allow cells can form different types of cells
- (immature) egg contains only genetic information / DNA / genes / chromosomes from mother **or** there is only one parent
- asexual / no mixing of genetic material / no sperm involved / no fertilisation **or** chemical causes development
- baby is a clone
- reference to ethical / moral / religious issues

  allow ethically wrong
  ***NB** cloning is illegal gains **2** marks*
  ignore unnatural
- risk of damage to the baby

  in correct context

[4]

PPQ MS8

M8. Marks should **not** be awarded for simply copying the information provided
A mark may be awarded for a comparison between treatments if the answer only involves copied information

any **four** from:

*For all **4** marks to be awarded, there must be at least 1 pro and 1 con*

embryo stem cells – examples of

pros

- can treat a wide variety / lots of diseases / problems
- many available / plentiful
- using them better than wasting them
- painless

cons

- (possible) harm / death to embryo
- (relatively) untested / unreliable / may not work
  allow long term effects not known
  ***or** may be more risky*
- embryo can't be 'asked' / 'embryo rights' idea

adult bone marrow stem cells – examples of

pros

- no ethical issues (in collection) **or** permission given
- quick recovery
- (relatively) safe
  allow does not kill (donor) / low risk
- well tried / tested / know they work

cons

- operation hazards eg infection
- few types of cell / tissue produced **or** few diseases / problems treated
- painful so may deter donors

4

Conclusion to evaluation:

A reasoned conclusion from the evidence

1

4.1 Cell Biology Knowledge
4.1.3 Cell transport
4.1.3.1 Diffusion

Diffusion is the movement of a substance from a region of higher concentrationto a region of lower concentration. Diffusion is the movement of gas or solute molecules from a region of higher concentration to a region of lower concentration until they are equal.

Diffusion is important to organisms because it is the process by which useful molecules enter the body cells and waste products are removed.

E.g.

The intestines

Digested food molecules (amino acids, glucose) move down a concentration gradient from the intestine to the blood. Waste products such as carbon dioxide or urea travel by diffusion from body cells into the bloodstream.

The lungs

Oxygen moves from high concentration (in the air sac) to a lower concentration (in the blood). Carbon dioxide moves from high concentration (in the blood) to a lower concentration (in the air sac).

Urea is a waste product that is removed from cells into the blood plasma for excretion by the kidney.

Factors that Affect Rate of Diffusion

Diffusion occurs in fluids (liquids and gases). It does not happen in solids because solids have fixed points and they are held together by the force of attraction which prevents them from moving freely. In liquids and gases however, their molecules are constantly moving randomly and spread through any available space until they are evenly distributed.

Diffusion in gases is faster than in liquids. This is because there is almost no force of attraction in gas molecules and this makes gas molecules free to move in every direction.

These are the factors that affect rate of Diffusion;

1. **The size of the molecule:** The smaller the molecule such as gas, the faster the rate of diffusion while the larger the molecules (liquid) the slower the rate of diffusion
2. **Concentration gradient**: The greater the concentration difference, the faster the rate of diffusion.
3. **Temperature**: The higher the temperature, the faster the rate of diffusion
4. **State of matter**: Diffusion in gas molecules is faster than the diffusion in liquids.

5. surface area. The larger the surface area the faster the rate of diffusion.

A simple, **unicellular** **organism** (consisting of one cell) can rely on **diffusion** to move substances into and out of the cell. Its **surface area** is **large** compared to its **volume**, so nutrients and other substances can pass quickly through the membrane and around its 'body'.

However, the surface area of a **multicellular** organism, such as a plant or animal, is **small** compared to its volume. As a result, multicellular organisms need **specialised exchange surfaces** (such as lungs or gills) and **transport systems**.

Common features of exchange surfaces:

- thin - for a short diffusion distance
- large area - achieved by being long and thin, flat, or folded
- moist - so that substances can be dissolved for diffusion to happen

Common features of transport systems:

- tubes or 'vessels' that carry materials from one part of the organism to another
- close contact with cells, such as those of exchange surfaces

The **circulatory system** in humans has a pump, the heart. However, the transport systems in plants - the xylem and phloem - do not have pumps.

4.1.3.2 Osmosis

Osmosis is a type of diffusion that involves the random movement of water *molecules*. It is the movement of water across a *partially-permeable* membrane, from an area of high water concentration to an area of low water concentration.

Partially-permeable

A partially-permeable membrane is a membrane that allows small particles such as water molecules through it, but not larger particles such as sugar molecules and ions from salts.

Water concentration

A dilute solution has a high water concentration, while a concentrated solution has a low water concentration. For example, when salt is dissolved in water:

- A little dissolved salt produces a dilute solution with a high water concentration
- A lot of dissolved salt produces a concentrated solution with a low water concentration.

4.1.3.3 Active transport

Active transport is the movement of dissolved molecules into or out of a cell through the cell membrane, from a region of lower concentration to a region of higher concentration. The particles move against the **concentration gradient**, using energy released during **respiration**.

Sometimes dissolved molecules are at a higher concentration inside the cell than outside, but, because the organism needs these molecules, they still have to be absorbed. **Carrier proteins** pick up specific molecules and take them through the cell membrane against the concentration gradient.

Examples of active transport include:

- uptake of **glucose** by epithelial cells in the **villi** of the small intestine
- uptake of ions from soil water by root hair cells in plants

Active transport vs diffusion and osmosis

	Diffusion	Osmosis	Active transport
Down a concentration gradient	✓	✓	✗
Against a concentration gradient	✗	✗	✓
Energy needed	✗	✗	✓
Substance moved	Dissolved solutes	Water	Dissolved solutes
Notes	Gases and dissolved gases also diffuse	Partially permeable membrane needed	Carrier protein needed

4.1.3 Cell transport PPQ's

Low demand

PPQ 1

1b (iii) Inside the lungs, oxygen is absorbed from the air into the blood.

Give **two** adaptations of the lungs that help the rapid absorption of oxygen into the blood.

1 .....

.....

2 .....

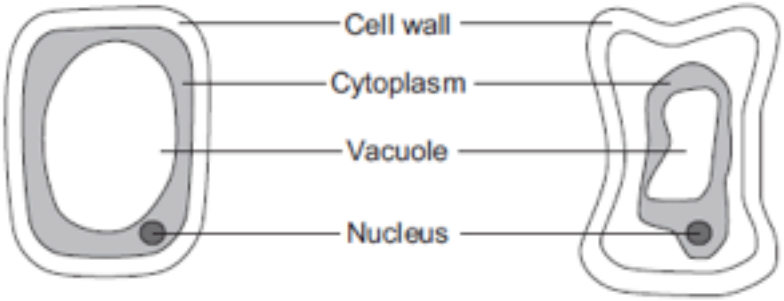
.....

(2)

PPQ 2

(b) Students put plant cells into two different strengths of sugar solutions, **A** and **B**.

The diagram below shows what the cells looked like after 1 hour.



Cell in sugar solution **A** (after 1 hour)

Cell in sugar solution **B** (after 1 hour)

2b(i) Describe **two** ways in which the cell in sugar solution **B** is different from the cell in sugar solution **A**.

1 .....

.....

2 .....

.....

(2)

PPQ 3

3(b) Gases *diffuse* between the leaf and the surrounding air.

(i) What is *diffusion*?

.....

.....

.....

.....

(2)

Standard demand

PPQ 4

4c(ii) Explain why active transport is necessary in root hair cells.

.....

.....

.....

.....

.....

.....

(2)

PPQ 5

Q6. Plant roots absorb water from the soil by osmosis.

(a) What is osmosis?

.....

.....

.....

.....

.....

.....

(3)

PPQ 6

Q5.In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.

Diffusion is an important process in animals and plants.

The movement of many substances into and out of cells occurs by diffusion.

Describe why diffusion is important to animals and plants.

In your answer you should refer to:

- animals
- plants
- examples of the diffusion of named substances.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total 6 marks)

High demand PPQ 7

Q7. Plants need nitrate ions in order to make proteins.

A plant is growing in soil flooded with water.

Explain why the plant cannot absorb enough nitrate ions.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total 5 marks)

PPQ 8
4 marks

Read the following information about how the small intestine absorbs sugars.

- The blood absorbs glucose and some other sugars, like xylose, from the small intestine.
- Glucose molecules are the same size as xylose molecules, but glucose is absorbed more quickly than xylose.
- Experiments with pieces of intestine show that the uptake of oxygen by the intestine is
  50 % higher in the presence of glucose than in the absence of glucose. Xylose does not have this effect on the uptake of oxygen.
- The cells lining the small intestine have many mitochondria.

Explain how this information provides evidence that glucose is absorbed by the small intestine using *active transport*.

.....

.....

.....

.....

.....

.....

.....

.....

.....

4.1.3 Cell transport PPQ's Answers

Low demand

PPQ MS1

(iii) any **two** from:

- (have many) alveoli
  allow air sacs
- large surface / area
- thin (exchange) surface **or** short diffusion pathway
  accept only one / two cell(s) thick
- good blood supply / many capillaries
  allow (kept) ventilated or maintained concentration gradient.

2

PPQ MS2

(b) (i) any **two** from:

allow correct answers in terms of A

- vacuole is small(er)
- cytoplasm has shrunk
  allow cytoplasm is smaller
- gap between cytoplasm and cell wall
- cell wall curves inwards
  allow cell B is flaccid or cell A is turgid
- the (cell) membrane has moved away from the wall

PPQ MS3

(b) (i) movement / spreading out of particles / molecules / ions / atoms
ignore names of substances / 'gases'

1

from high to low concentration
accept down concentration gradient
ignore 'along' / 'across' gradient
ignore 'with' gradient

1

PPQ MS4

(ii) for movement of minerals / ions
Do not accept 'water'

1

against their concentration gradient

1

PPQ MS5

M6.(a) any **three** from:

- (water through a) partially permeable
  accept 'semi permeable' / selectively permeable

- membrane
- from dilute to (more) concentrated solution
  allow 'from a high concentration of water to a lower concentration (of water)'
  allow 'from high water potential to low water potential'
  allow 'down a concentration gradient of water'
  *do **not** accept 'along a concentration gradient of water'*
- (it's a) passive (process)
  allow requires no energy

3

PPQ MS6

M5 Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response. Examiners should also apply a 'best-fit' approach to the marking.

0 marks
No relevant content.

Level 1 (1 – 2 marks)
An example is given of a named substance
or
a process
or
there is an idea of why diffusion is important eg definition.

Level 2 (3 – 4 marks)
At least one example of a substance is given
and
correctly linked to a process in either animals or plants.

Level 3 (5 – 6 marks)
There is a description of a process occurring in either animals or plants that is correctly linked to a substance
and
a process occurring in the other type of organism that is correctly linked to a substance.

examples of points made in the response

Importance of diffusion:

- to take in substances for use in cell processes
- products from cell processes removed

Examples of processes and substances:

- for gas exchange / respiration: O_2 in / CO_2 out
- for gas exchange / photosynthesis: CO_2 in / O_2 out
- food molecules absorbed: glucose, amino acids, etc
- water absorption in the large intestine
- water lost from leaves / transpiration
- water absorption by roots
- mineral ions absorbed by roots

extra information

Description of processes might include:

- *movement of particles / molecules / ions*
- *through a partially permeable membrane*
- *(movement of substance) down a concentration gradient*
- *osmosis: turgor / support / stomatal movements*

[6]

PPQ MS7

M7. (nitrate) ions are absorbed by active transport

1

(active transport) is the movement of ions against the concentration gradient

allow (active transport) is the movement of ions from a dilute to a more concentrated solution

1

(active transport) requires energy from respiration

1

(respiration) requires oxygen

1

no / little oxygen / air in water-logged soil

1

[5]

PPQ MS8

M8. active transport needs energy **or** diffusion is not energy-dependent

1

any **three** from:

- (energy from) aerobic respiration
- more respiration with O_2 **or** more energy release with O_2
- (aerobic) respiration / energy release occurs in mitochondria

  *do **not** allow anaerobic*
- xylose / other sugars absorbed by diffusion / not by active transport

  allow active transport is selective / specific

  or active transport can distinguish glucose and xylose

3