

Write your name here

Surname

StemUp Model Solution

Other names

**Pearson Edexcel
Level 3 GCE**

Centre Number

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Candidate Number

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Biology B

Advanced

**Paper 3: General and Practical Principles
in Biology**

Monday 18 June 2018 – Morning

Time: 2 hours 30 minutes

Paper Reference

9BI0/03

You must have:

Calculator, HB pencil, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Show your working in any calculation questions and include units in your answer where appropriate.
- Answer the questions in the spaces provided
– *there may be more space than you need.*
- You may use a scientific calculator.
- In question(s) marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically showing how the points that you make are related or follow on from each other where appropriate.

Information

- The total mark for this paper is 120.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ►

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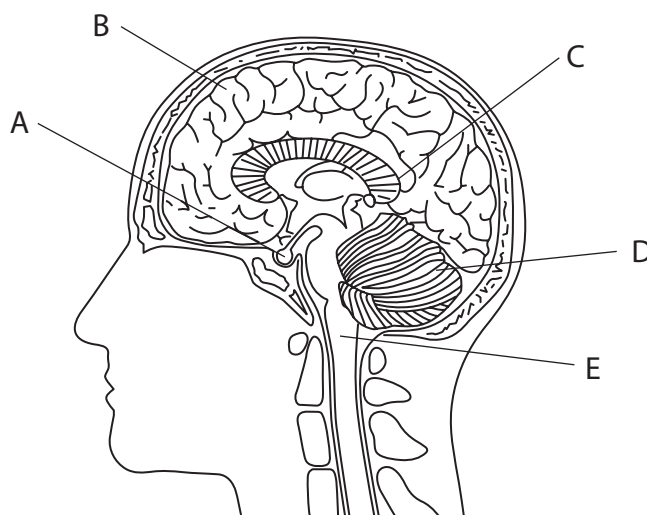

Pearson

Answer ALL questions.

Write your answers in the spaces provided.

- 1** The human brain controls many functions.

The diagram shows a section through a human brain with parts labelled A to E.



- (a) Which letter labels the part of the brain that controls heart rate?

(1)

E

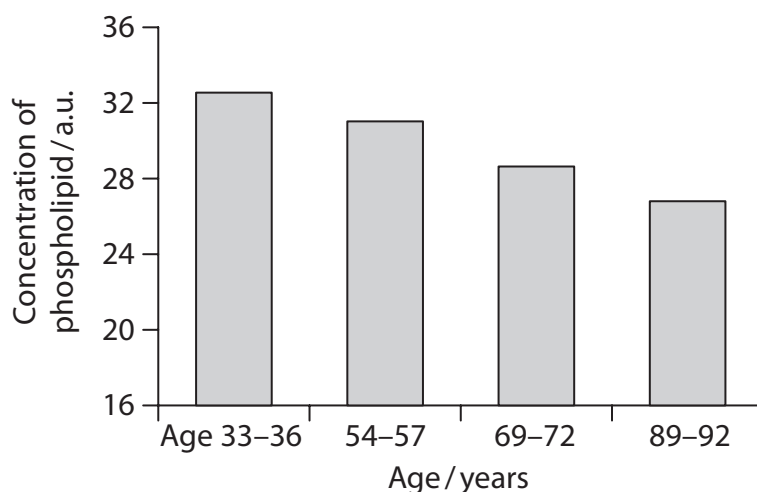
- (b) The human brain consists of 100 billion neurones.

The function of these neurones is affected by many factors.

The concentration of phospholipid in neurones from one part of the brain was measured.

This was carried out in people from different age ranges.

The graph shows the results.



Explain how age might affect the structure of a neurone and the speed of transmission of an impulse.

(3)

With increasing age the concentration of phospholipid in the neurones decreases (from about 32.5 a.u. at 33 to 36 years to about 27 a.u. at 89 to 92 years).

This suggests there is reduced myelin sheath (fewer Schwann cells), as the myelin sheath is made of phospholipid membranes, so the axon is less well insulated.

This affects saltatory conduction, as the impulse can no longer jump between the nodes of Ranvier, so it slows the transmission of the impulse.

Changes to the axon membrane also affect the ion channels and ion movement, so the action potential is affected.

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P 5 2 2 8 6 R A 0 3 3 6

(c) Poisons can also affect the function of neurones in the brain.

The photograph shows a pufferfish, a traditional food delicacy in Japan.



Pufferfish have to be carefully prepared by a chef to remove a poison called tetrodotoxin. This poison causes muscle paralysis.

Neurones were placed in a solution containing tetrodotoxin and in a control solution.

The neurones were stimulated and the potential difference across the axon membrane was measured.

The table shows the results.

Solution	Potential difference after stimulation / mV
tetrodotoxin	-70
control	+40

Analyse the data to explain the effect of tetrodotoxin on the neurone.

(4)

With tetrodotoxin the potential difference stays at -70 mV after stimulation, so the neurone remains at resting potential, whereas the control reaches +40 mV (an action potential).

This is because tetrodotoxin blocks the voltage-gated sodium ion channels, so they stay closed and do not open.

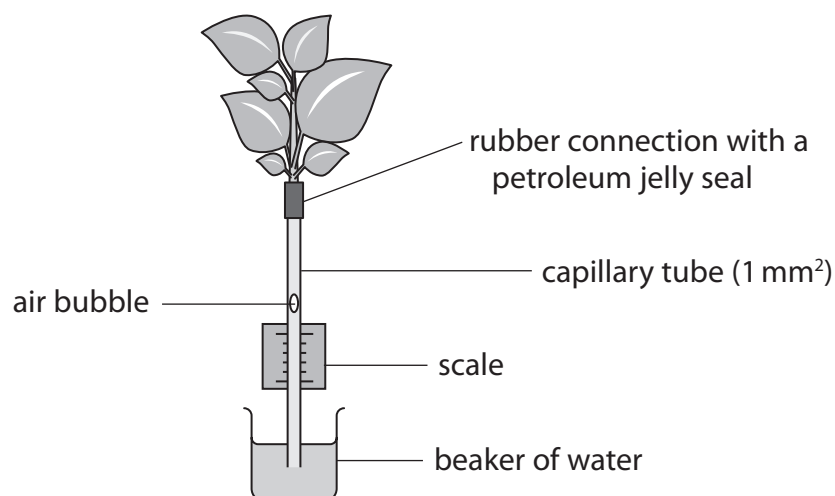
Therefore there is no movement of sodium ions into the axon across the membrane, which prevents depolarisation, so no action potential is produced (causing paralysis).

(Total for Question 1 = 8 marks)



- 2 A student investigated the effect of moving air on transpiration in a leafy shoot.

The diagram shows the potometer used by the student.



- (a) In this investigation, a leafy shoot was cut from a plant.

The leafy shoot was then put under water and the stem inserted into the rubber connection.

Explain how this procedure should be modified to produce accurate readings.

(2)

The shoot should be cut under water, not in air, and the stem inserted into the rubber connection while under water, to prevent air getting into the xylem and blocking it, maintaining the water column (cohesion).

The leaves must then be dried before readings are taken, because wet leaves reduce diffusion (evaporation) of water vapour.

- (b) During the investigation, the air bubble moved off the scale very quickly.

Explain how this potometer could be modified to obtain repeat readings.

(2)

Attach a reservoir (syringe) of water with a three-way tap to the capillary tube, so that water can be pushed in to return the air bubble to the start of the scale (reset the bubble) for each repeat.



- (c) The student measured the distance in millimetres that the air bubble moved during a five-minute period in moving air and in still air.
- (i) Explain how the student could convert these readings into a transpiration rate using the units $\text{mm}^3 \text{cm}^{-2} \text{min}^{-1}$.

(3)

Multiply the distance moved by the bubble (mm) by the cross-sectional area of the capillary tube (1 mm^2), i.e. $\pi r^2 \times d$, to give the volume of water taken up in mm^3 .

Divide this volume by the total surface area of the leaves in cm^2 (e.g. found by drawing round the leaves on graph paper and counting squares).

Divide by 5, the time in minutes, to give the rate in $\text{mm}^3 \text{cm}^{-2} \text{min}^{-1}$.

- (ii) The table shows the mean results and standard deviations of this investigation.

Mean rate of transpiration / $\text{mm}^3 \text{cm}^{-2} \text{min}^{-1}$	
In moving air	In still air
3.2 ± 0.3	0.8 ± 0.2

Explain the results of this investigation.

(2)

Moving air removes water molecules (water vapour) from around the leaf, which increases the water potential gradient (concentration gradient) between the air spaces in the leaf and the air, so water vapour diffuses out through the stomata faster.

The difference is significant because the SDs do not overlap (2.9 to 3.5 compared with 0.6 to 1.0).

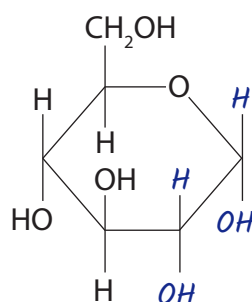
(Total for Question 2 = 9 marks)



3 Glucose and fructose are monosaccharides.

(a) Complete the diagram to show the structure of alpha glucose.

(1)



(b) The makers of sweet tasting drinks use the enzyme glucose isomerase to convert glucose into fructose.

Fructose is a monosaccharide that tastes much sweeter than glucose.

(i) Explain a possible health benefit of converting glucose into fructose for use in sweet tasting drinks.

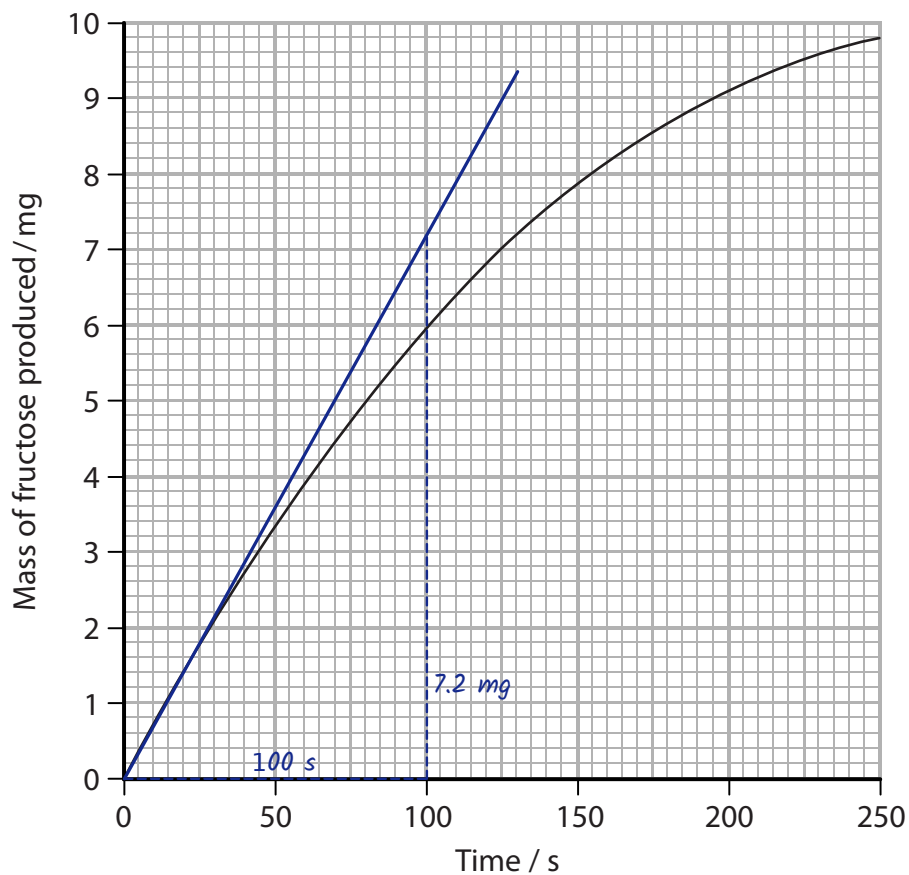
(2)

*Fructose tastes much sweeter, so less sugar is needed for the same sweet effect,
therefore there is less energy (calorie) intake,
therefore there is less risk of obesity and type 2 diabetes (and tooth decay).*



(ii) A student investigated the activity of glucose isomerase.

The graph shows the results of this investigation.



Determine the initial rate of the reaction.

(1)

gradient of tangent at $t = 0$

$$= 7.2 \text{ mg} \div 100 \text{ s} = 0.072$$

Answer 0.072 mg s⁻¹

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(iii) Cofactors are non-protein molecules that help enzymes to function.

Magnesium ions act as cofactors for some enzymes.

Devise an experiment to investigate the effect of magnesium ions on the initial rate of this reaction.

(5)

Set up two sets of tubes, one containing glucose isomerase with magnesium ions (e.g. 1 cm³ of magnesium chloride solution) and one without magnesium ions (an equal volume of distilled water added instead).

Use the same volume and concentration of glucose isomerase enzyme in each tube, e.g. 1 cm³ of 1% enzyme solution.

Use excess glucose (substrate), the same volume and concentration in each tube, e.g. 10 cm³ of 10% glucose.

Control the temperature using a thermostatically controlled water bath (e.g. 30 °C) and control the pH using a buffer solution (e.g. pH 7), equilibrating the solutions before mixing.

Measure the mass of fructose produced at regular intervals (e.g. every 25 s), plot a graph of mass of fructose against time and draw a tangent at $t = 0$ to find the initial rate.

Repeat each at least three times to calculate a mean and standard deviation and to recognise anomalies, then compare the initial rates with and without magnesium ions.

(Total for Question 3 = 9 marks)



4 Photosynthetic pigments are found in plant leaves.

(a) Describe how you could use chromatography to separate these pigments.

(3)

Grind the leaves with a solvent and draw a pencil line (start line) near the bottom of the chromatography paper. Add the pigment extract to the start line as a small spot using a capillary tube.

Dry the spot and repeat several times to concentrate the spot.

Place the paper in a named solvent, e.g. propanone (or petroleum ether), so that the start line and spot are above the solvent level.

Leave until the solvent front reaches near the top, then remove and mark the solvent front; the pigments separate as different spots (R_f values).

(b) A scientist investigated the effect of lead pollution by cars on the chlorophyll content of plant leaves.

Quadrat sampling was used to collect leaves from a plant species.

Leaf samples were collected from an area with little car traffic and from an area with heavy car traffic.

The leaf samples were tested for lead content and chlorophyll content.

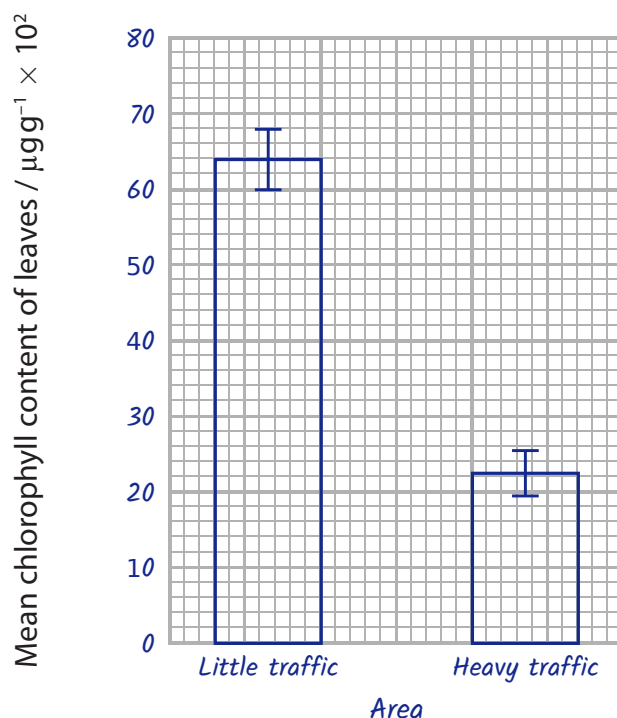
The table shows the results of this investigation.

Area	Mean lead content of leaves / $\mu\text{g g}^{-1}$	Mean chlorophyll content of leaves / $\mu\text{g g}^{-1} \times 10^2$
Little traffic	1.28 ± 0.64	64.00 ± 4.00
Heavy traffic	3.11 ± 0.31	22.50 ± 3.00



- (i) Plot a graph to show the data for mean chlorophyll content.

(2)



- (ii) Explain how the quadrat sampling should have been carried out.

(3)

The quadrats should be placed at random in each area, to remove bias, e.g. by laying out two tape measures at right angles and using a random number generator to give coordinates.

In both areas, sampling should be done at the same distance from the road (traffic), e.g. along a transect placed parallel to the road, and enough quadrats should be used to obtain a running mean, so that the data are valid and representative.



(iii) The scientist concluded that lead pollution from cars reduces the photosynthesis of plants.

Criticise the validity of this conclusion.

(2)

The data show that heavy traffic (more lead) is associated with reduced chlorophyll content, from 64.00 to 22.50 $\mu\text{g g}^{-1} \times 10^2$.

However, the conclusion is not valid because photosynthesis was not measured, and the lead may be from other sources; other factors such as light intensity, Mg^{2+} or other pollutants may be responsible. Only one species of plant was investigated.

(Total for Question 4 = 10 marks)

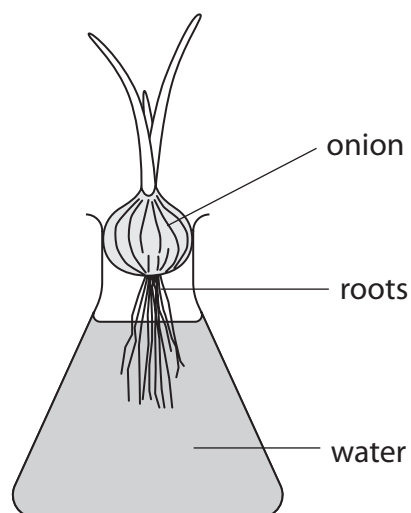


- 5 A student read that some plants do not grow well in waterlogged soil.

The student formed the following hypothesis:

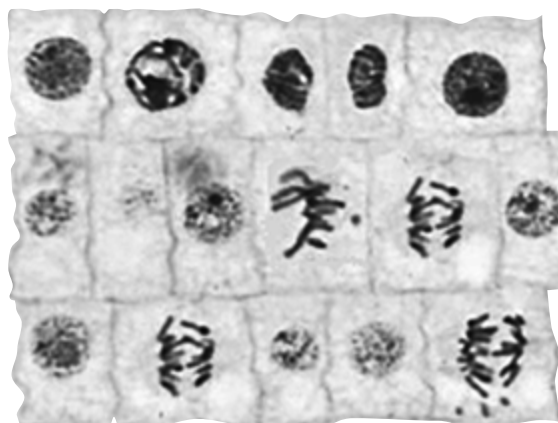
Adding water to soil inhibits mitosis in root cells.

To test this hypothesis, the student grew onion roots in the apparatus shown.



The tips of the onion roots were removed and observed for stages of mitosis.

The photomicrograph shows a preparation from one onion root tip.



- (a) Calculate the percentage of cells in this photomicrograph in anaphase.

(2)

$$\text{cells in anaphase} = 3, \text{ total cells} = 16$$

$$3 \div 16 = 0.1875$$

$$0.1875 \times 100 = 18.75$$

Answer 18.8 %



(b) Describe how to prepare a microscope slide of root tissue to show stages of mitosis.

(4)

Cut the root tip (e.g. 5 mm) and place it in warm hydrochloric acid (e.g. 1 mol dm⁻³ at 60 °C for 5 minutes) to separate the cells.

Remove the acid by rinsing the root tip in (cold) water.

Add a named stain such as acetic orcein (or toluidine blue) to stain the chromosomes.

Place the tip on a microscope slide and macerate (tease apart) with a mounted needle.

Add a coverslip and squash gently (press with the thumb through filter paper) to spread the cells into a single layer.

(c) Devise a method the student should use to investigate the effect of waterlogged soil on mitosis in root cells.

(4)

Grow onion roots in waterlogged soil and in non-waterlogged soil (or use a range of water contents of the soil).

Use the same variety of onion, with bulbs of the same age and size.

Control the temperature, light, soil type, mineral ion concentration and pH of the soil.

Leave the onions to grow for the same stated time, e.g. 7 days.

Take cells from the same part of each root tip, e.g. cut 2 mm from the tip, prepare squashes, count the cells in each stage of mitosis and calculate the mitotic index.



(d) Waterlogged soil lacks oxygen.

Explain why a lack of oxygen in waterlogged soil could reduce the growth of a plant.

(4)

Aerobic respiration is inhibited and anaerobic respiration occurs in the root cells, therefore the electron transport chain and oxidative phosphorylation are inhibited (only glycolysis occurs and ethanol is produced), so there is less ATP synthesis.

So less active transport of mineral ions (e.g. nitrate) occurs into the root hair cells, and there is less protein synthesis and less spindle fibre contraction in mitosis, so the plant grows less.

(Total for Question 5 = 14 marks)

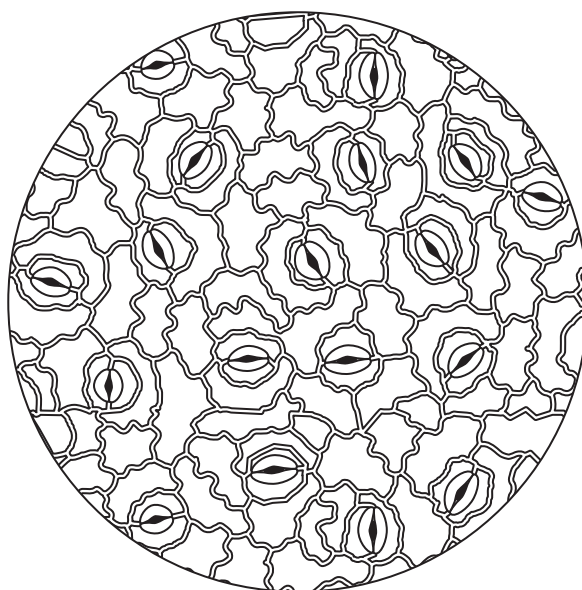


- 6 A student investigated the effect of light intensity on the development of stomata in coffee plant leaves.

The following method was used:

- young coffee seedlings were separated into two groups
- one group was grown in bright light and the other group was grown in dim light
- leaves were selected from each group and their surfaces were painted with nail varnish
- the nail varnish was allowed to dry and then peeled off the leaf surface
- each nail varnish peel was observed using a light microscope.

The diagram shows an example of the field of view seen by the student when using the high power lens.



- (a) Describe how a microscope should be used to observe the stomata using the high power lens.

(3)

Locate the specimen (stomata) using the low power objective lens first, with the slide on the stage under the clips.

Focus using the low power (then medium power) objective lens with the coarse focus before turning to the high power objective lens.

Only use the fine focus with the high power lens.



- (b) The diameter of the field of view is 0.4 mm.

Calculate the number of stomata per mm^2 on the leaf surface.

The area of a circle is πr^2 , where π is 3.142.

(2)

$$\text{number of stomata in field of view} = 18$$

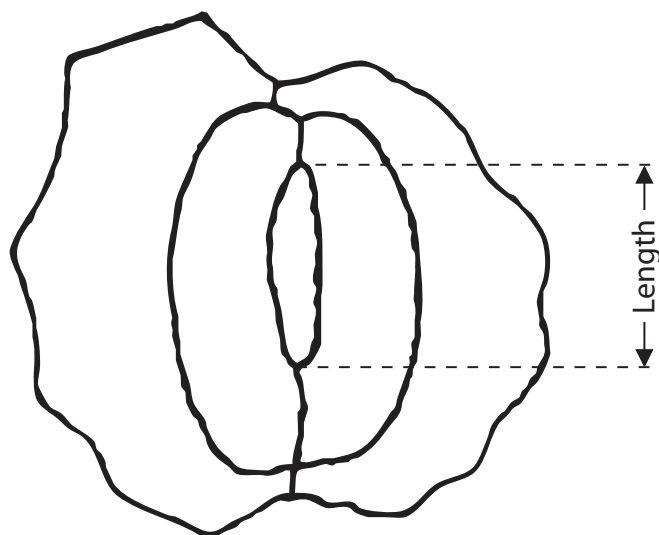
$$r = 0.4 \div 2 = 0.2 \text{ mm}$$

$$\text{area} = 3.142 \times 0.2^2 = 0.126 \text{ mm}^2$$

$$18 \div 0.126 = 143$$

Answer 143 mm^{-2}

- (c) The diagram shows one of the stomata drawn by the student.



The actual length of this stoma is $20 \mu\text{m}$.

Calculate the magnification of this drawing.

(2)

$$\text{length on drawing} = 27 \text{ mm} = 27\,000 \mu\text{m}$$

$$\text{magnification} = \text{image} \div \text{actual}$$

$$= 27\,000 \div 20$$

Answer $\times 1350$



(d) The results of this investigation are shown in the table.

Leaf sample	Number of stomata mm^{-2}	
	Leaves in bright light	Leaves in dim light
1	184	143
2	190	138
3	182	140
4	185	132
5	192	136
Mean ($\bar{x}$) and SD	186.6 ± 4.2	137.8

(i) Calculate the SD for the leaves in dim light.

Use the formula

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

$$x - \bar{x} : 5.2, 0.2, 2.2, -5.8, -1.8$$

$$(x - \bar{x})^2 : 27.04, 0.04, 4.84, 33.64, 3.24$$

$$\sum(x - \bar{x})^2 = 68.8$$

$$68.8 \div (5 - 1) = 17.2$$

$$SD = \sqrt{17.2} = 4.15$$

Answer 4.1



- (ii) Describe how these nail varnish peel samples should be taken to allow a valid comparison between the mean numbers of stomata.

(2)

*Take the leaves from the same height (same age) on the stem in each plant,
and take each peel from the same stated position on the leaf (e.g. halfway between
the midrib and the edge) and from the same surface of the leaf (lower surface).*

- (iii) Analyse the data to explain how fewer stomata might affect the growth of coffee plants.

(3)

*Leaves in dim light have fewer stomata (mean 137.8 compared with 186.6 per mm²),
so less carbon dioxide is absorbed (diffuses in).*

Therefore less GP (GALP) and glucose is made in the Calvin cycle, so reduced growth.

*There is also less transpiration, so less water and fewer mineral ions (e.g. nitrate and
magnesium) are taken up,*

therefore less amino acids, protein, chlorophyll and DNA are made, reducing growth.

(Total for Question 6 = 14 marks)



7 Malaria is caused by *Plasmodium*, a pathogenic microorganism.

Vaccination is one of many methods being used to control malaria.

In a study, the effectiveness of a vaccine for malaria was tested.

The following method was used:

- samples of *Plasmodium* were exposed to radiation and used to make a vaccine
- two groups of people, A and B, were given different doses of the vaccine
- a third group of people, C, was used as a control
- one month after vaccination, all three groups of people were exposed to mosquitoes known to contain live *Plasmodium*
- the number of people in each group with malaria was recorded.

The results are shown in the table.

Group	Treatment with the vaccine	Number of people in each group	Number of people with malaria
A	low dose	17	16
B	high dose	6	0
C	control	12	11

(a) (i) Explain why the samples of *Plasmodium* were exposed to radiation.

(2)

To kill (attenuate, inactivate) the Plasmodium, preventing its reproduction, therefore there is less risk of infection (developing malaria) from the vaccine, while the antigens are still present.

(ii) State the control treatment that was given to people in group C.

(1)

Vaccinate with saline (a placebo) containing no Plasmodium.



(iii) It was claimed that this vaccine was 100% effective.

Analyse the data to criticise the validity of this claim.

(3)

The vaccine was effective for group B (high dose) because zero people were infected, but not effective for group A (low dose) as 16 out of 17 people were infected.

The group A (low dose) result is similar to the control group C (11 out of 12 infected).

The sample size of group B was small, only 6 people, and how the people were selected is unknown, so there is no information about gender, age, health or prior infection.

(iv) Describe how vaccination enabled the people in group B to have active artificial immunity against malaria.

(5)

Antigens from the Plasmodium in the vaccine are engulfed by macrophages, which become antigen presenting cells (APCs), displaying the antigen on MHC proteins.

The APC binds to a T helper cell with complementary CD4 receptors, activating it.

The activated T helper cells release cytokines, which stimulate B cells with complementary antibodies to divide (clone).

The B cells differentiate into plasma cells, which release antibodies specific to the Plasmodium antigen.

T memory cells and B memory cells are also produced, so on exposure to live Plasmodium a faster and larger secondary response occurs.



(b) Anti-malarial drugs can be used to protect people from malaria.

These drugs are not always effective because *Plasmodium* develop resistance.

Explain how drug-resistant *Plasmodium* may evolve.

(3)

Random (chance) mutations occur in the DNA of some Plasmodium, producing a new allele.

This allele codes for proteins (enzymes) that make the drug ineffective, e.g. by breaking it down.

The drug is the selection pressure: Plasmodium without the allele are killed, while the resistant organisms survive and reproduce,

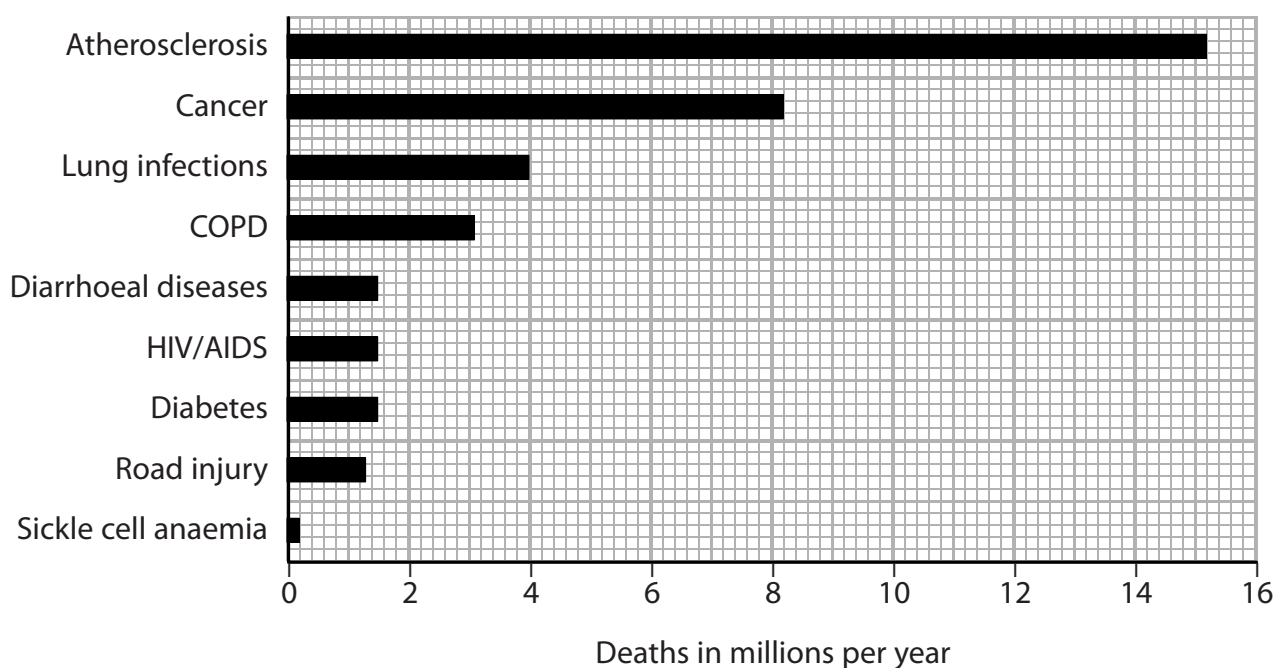
therefore the resistant organisms pass on the allele, so the frequency of the resistance allele increases in the population.

(Total for Question 7 = 14 marks)



8 There are many disorders that affect the health of people.

The graph shows the number of people in the world who die each year from different health disorders.



(a) The graph shows that atherosclerosis kills more people than any of the other disorders.

This is mainly due to its development in the coronary arteries.

(i) State the number of deaths caused by atherosclerosis.

Give your answer in standard form.

(1)

Answer 1.52×10^7



(ii) Describe how atherosclerosis develops in the coronary arteries.

(3)

Damage to the endothelium of the coronary artery is caused by high blood pressure, toxins or smoking.

An inflammatory response occurs, with the arrival of macrophages (white blood cells) at the damaged area.

Deposits of cholesterol and calcium build up under the endothelium, leading to the formation of an atheroma (plaque), which narrows the lumen of the artery.

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*(b) Some health disorders, such as sickle cell anaemia, have a genetic basis.

People who are at risk of these disorders can be identified using genetic tests.

Hospital managers need to predict the future cost of treating people with health disorders.

It has been claimed that the Hardy-Weinberg equation ($p + q = 1$ or $p^2 + 2pq + q^2 = 1$) could be used to predict the number of people who would need treatment for health disorders.

Discuss the validity of this claim.

(9)

The Hardy-Weinberg equation can only predict the number of people with genetic disorders caused by a single gene, such as sickle cell anaemia or cystic fibrosis. Many of the health disorders in the graph are not genetic but are caused by lifestyle or by pathogens, e.g. atherosclerosis is linked to smoking, diet and lack of exercise, COPD to smoking, and HIV/AIDS and lung infections to infection. So for most disorders the equation could not be used at all.

In the equation, $p + q = 1$ refers to allele frequencies, where p is the frequency of the dominant allele and q the frequency of the recessive allele. $p^2 + 2pq + q^2 = 1$ refers to genotype frequencies: p^2 is homozygous dominant, $2pq$ is heterozygous (carriers) and q^2 is homozygous recessive, i.e. the people with sickle cell anaemia who would need treatment.

However, the equation assumes that the allele and genotype frequencies remain constant from one generation to the next. This is only true if there is no selection and mating is random, there is no mutation, no migration into or out of the population, and the population is large so there is no genetic drift.

These assumptions are not valid for human populations. People do not mate randomly, there is migration between countries, which brings in new alleles (e.g. the sickle cell allele is more common in people from areas with malaria), and there is selection, e.g. heterozygotes are protected against malaria while treatment allows people with disorders to survive and reproduce. New mutations also arise. Different countries also have



different population sizes, and small populations show genetic drift.

In addition, the frequency of q must first be found, which requires genetic testing.

Genetic testing is expensive, some people are unwilling to have a genetic test, and it is not possible to test for all alleles. The environment can also affect gene expression, so not everyone with a genotype will develop the disorder or need the same treatment.

In conclusion, the claim is only partly valid: the Hardy-Weinberg equation could give an estimate of the number of people with a single-gene genetic disorder such as sickle cell anaemia, but because its assumptions are not met and most health disorders are caused by lifestyle, it could not accurately predict the future number of people needing treatment or the cost of treating them.

(Total for Question 8 = 13 marks)



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9 Last year, eight million Christmas trees were bought in the UK.

There are many Christmas tree farms that supply these trees.

The photograph shows young Christmas trees growing on a farm.



Christmas tree farmers remove the other plants (weeds) in order to increase tree growth.

A farmer investigated two methods of removing weeds:

- removing weeds by hand
- spraying herbicides that inhibit weed growth.

The table shows the mean height of Christmas trees using each method, over a five-year period.

Year	Mean height of trees / cm	
	Removing by hand	Using herbicide
0	20	20
1	50	60
2	70	100
3	90	130
4	110	160
5	130	200

- (a) (i) Calculate the difference between the mean rate of growth of these trees over the five years.

(2)

by hand: $(130 - 20) \div 5 = 110 \div 5 = 22 \text{ cm year}^{-1}$

herbicide: $(200 - 20) \div 5 = 180 \div 5 = 36 \text{ cm year}^{-1}$

$36 - 22 = 14$

Answer 14 cm year⁻¹



- (ii) Analyse the data to explain the difference in the mean height of the trees at the end of the five-year period.

(2)

The trees treated with herbicide were 70 cm taller after 5 years (200 cm compared with 130 cm), because the herbicide is more effective at removing weeds: it kills all the weeds, whereas removing by hand lets them grow again.

Therefore there is less competition for light, water and mineral ions, so the trees grow more.

- (iii) Explain two biotic variables that need to be controlled to allow a valid comparison of the effect of each method on tree growth.

(2)

The same species (variety) of tree must be used, because different species of tree grow at different rates.

Animals such as herbivores and insect pests (and disease) must be controlled, as they feed on the trees and affect growth; also the same spacing of trees, to control intraspecific competition.



(b) A student read that some herbicides work by inhibiting electron transport in photosynthesis.

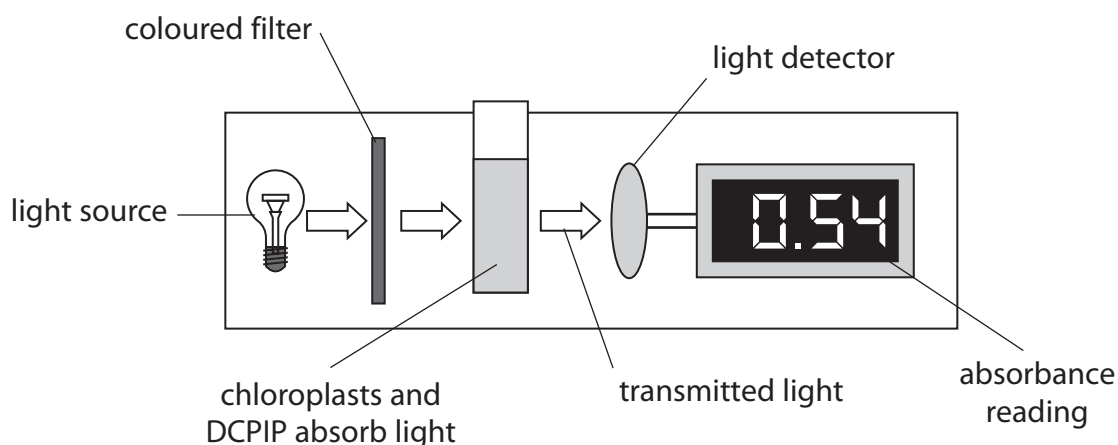
The student investigated this using the indicator DCPIP.

This indicator changes from blue to colourless when it is reduced.

The student used the following method:

- chloroplasts were suspended in two tubes, each containing a solution of DCPIP
- herbicide was added to one of the tubes and no herbicide was added to the other tube
- both tubes were exposed to light
- a colorimeter was used to measure the absorbance in each tube at five minute intervals for 20 minutes.

The diagram shows details of the workings of the colorimeter used by the student.



As DCPIP changes from blue to colourless, the absorbance of light decreases.

(i) Explain how the student used this method to collect valid data.

(4)

Use the same light intensity for both tubes, e.g. measured with a light meter.

Use a red filter in the colorimeter, as blue DCPIP absorbs red light.

Use a control tube containing water (or chloroplasts without DCPIP) to calibrate the colorimeter to zero absorbance, and use tubes with clean sides and no scratches, holding them by the opaque side.

Use the same concentration and volume of chloroplasts and DCPIP in each tube.

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The table shows the results.

Time / min	Absorbance / a.u.	
	With herbicide	Without herbicide
0	0.53	0.54
5	0.54	0.31
10	0.54	0.24
15	0.54	0.20
20	0.53	0.16

(ii) Analyse the data to explain the effect of this herbicide on the growth of weeds.

(4)

Without herbicide the absorbance falls from 0.54 to 0.16 a.u. as DCPIP is reduced (decolourised), but with herbicide it stays at 0.53 to 0.54 a.u., so DCPIP is not reduced and stays blue.

This is because no electrons are available, as the herbicide reduces electron transport in the light-dependent reactions.

Therefore less reduced NADP is made, and less ATP is made by photophosphorylation, so the Calvin cycle (light-independent stage) is affected, so less GALP and glucose is made and the weeds do not grow.

(Total for Question 9 = 14 marks)



10 Antibiotics can affect bacteria.

The table describes the mode of action of four antibiotics.

Antibiotic	Mode of action
benzylpenicillin	disrupts peptidoglycan structure
streptomycin	binds to 70S ribosomes
ciprofloxacin	inhibits enzymes involved in prokaryotic DNA replication
rifamycin	inhibits prokaryotic RNA polymerase

- (a) (i) Name the antibiotic that affects Gram positive bacteria only.

(1)

Benzylpenicillin

- (ii) Give one reason why these antibiotics will not affect human cells.

(1)

Human cells are eukaryotic; they lack a cell wall (peptidoglycan) and have different (80S) ribosomes and enzymes.

- (b) Explain how rifamycin prevents the growth of bacteria.

(3)

Rifamycin binds to the RNA polymerase enzyme, changing the shape of its active site, therefore transcription (mRNA synthesis) is prevented, so no proteins (enzymes) can be made, so the bacteria cannot grow.



(c) Mutations in the DNA of bacteria can enable them to be resistant to antibiotics.

- (i) A single bacterium can produce 2×10^{10} new cells per day by cell division.

The mean mutation rate in one day is 1 in 10 million new cells produced.

Calculate the mean number of bacteria with mutations that could be produced in one day from a single bacterium.

(2)

$$\begin{aligned} & 2 \times 10^{10} \times (1 \div 10\,000\,000) \\ &= 20\,000\,000\,000 \div 10\,000\,000 \\ &= 2000 \end{aligned}$$

Answer 2×10^3

- (ii) Explain how bacteria may become resistant to streptomycin if a mutation changes the primary structure of a protein.

(3)

A change in the primary structure changes the amino acid sequence, so there are different R groups, which form different hydrogen bonds, ionic bonds and disulphide bonds.

Therefore the secondary and tertiary structure of the protein is different, therefore the ribosome (70S) has a different shape, therefore streptomycin cannot bind to the ribosome, so protein synthesis continues.



(d) A student compared the effectiveness of these four antibiotics on the growth of bacteria.

Devise a method that the student could use to obtain valid results.

(5)

Use the same species of bacteria for all the antibiotics, e.g. E. coli, spread evenly on agar plates (culture medium) from the same broth culture.

Use described aseptic technique, e.g. flame the loop and the neck of the bottle in a Bunsen burner flame, swab the bench with disinfectant and lift the lid of the Petri dish only slightly.

Place filter paper discs soaked in the same concentration and volume of each antibiotic on the agar, with a control disc soaked in sterile water.

Incubate the plates at 25 °C (between 20 °C and 25 °C) for 48 hours.

Measure the diameter of the zone of inhibition around each disc and calculate the area.

Repeat at least three times for each antibiotic, calculate means and compare them.

(Total for Question 10 = 15 marks)

TOTAL FOR PAPER = 120 MARKS



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