

PEARSON EDEXCEL A-LEVEL BIOLOGY A • 9BN0

BIOLOGY



EXAM QUESTION PACK

TOPIC 3: VOICE OF THE GENOME

SCORE

/485

PERCENTAGE

%

STEMUP

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Q1.

Mineral ions are required for plant growth.

(i) Nitrate ions are required for the synthesis of

(1)

☐ **A** amino acids

☐ **B** cellulose

☐ **C** starch

☐ **D** sucrose

(ii) Phosphate ions are required for the synthesis of

(1)

☐ **A** cellulose

☐ **B** chlorophyll

☐ **C** nucleic acids

☐ **D** sucrose

(iii) Magnesium ions are present in the structure of

(1)

☐ **A** amino acids

☐ **B** cellulose

☐ **C** chlorophyll

☐ **D** starch

(Total for question = 3 marks)

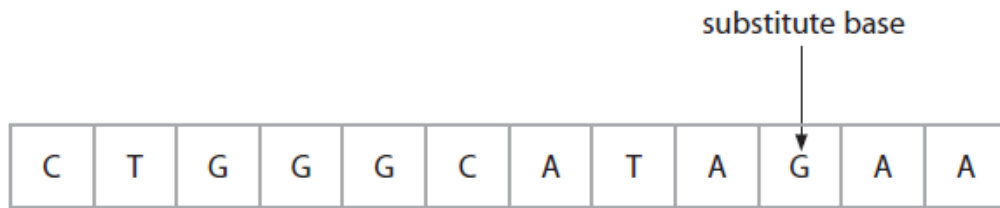
Q2.

Thalassaemia is a recessive genetic disorder that affects the production of haemoglobin. It is caused by a gene mutation.

Scientists are developing methods to repair gene mutations such as the one that causes

thalassaemia.

One of the most common mutations causing thalassaemia is the substitution of one adenine base with guanine. The diagram shows the location of the mutation in part of the DNA strand coding for four amino acids.



Explain why this mutation affects the function of the haemoglobin molecule.

(3)

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(Total for question = 3 marks)

Q3.

The consistency of the mucus is determined by the movement of water, by osmosis, from the cells lining the bronchi.

Explain how the partial permeability of the surface membrane of the cells lining the bronchi allows osmosis to take place.

(2)

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Q4.

All cells have a cell surface membrane.

Cell surface membranes regulate the movement of substances into and out of cells.

(i) Which of the following describes the movement of water by osmosis?

(1)

☐ A	against a solute concentration gradient	through a fully permeable membrane
☐ B	against a solute concentration gradient	through a partially permeable membrane
☐ C	down a solute concentration gradient	through a fully permeable membrane
☐ D	down a solute concentration gradient	through a partially permeable membrane

(ii) The concentration of potassium ions inside an animal cell is many times higher than the concentration of potassium ions in the extracellular fluid.

Which mechanism is responsible for the uptake of potassium ions by this animal cell?

(1)

- ☐ A active transport
- ☐ B exocytosis
- ☐ C osmosis
- ☐ D passive diffusion

(iii) Glucose enters cells by facilitated diffusion.

Which part of the cell surface membrane allows facilitated diffusion of glucose?

(1)

- ☐ A cholesterol
- ☐ B glycolipid
- ☐ C phospholipid

(Total for question = 3 marks)

Q5.

Peat bogs are formed over millions of years from the remains of plants and animals.

Waterlogging and acidic conditions prevent the decomposition of plants and animals in peat bogs.

The photograph shows peat being cut from a peat bog.



(Source: © Reimar/Shutterstock)

(i) State how the age of the layers in a peat bog can be determined.

(1)

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(ii) Explain why the conditions in peat bogs prevent decomposition.

(3)

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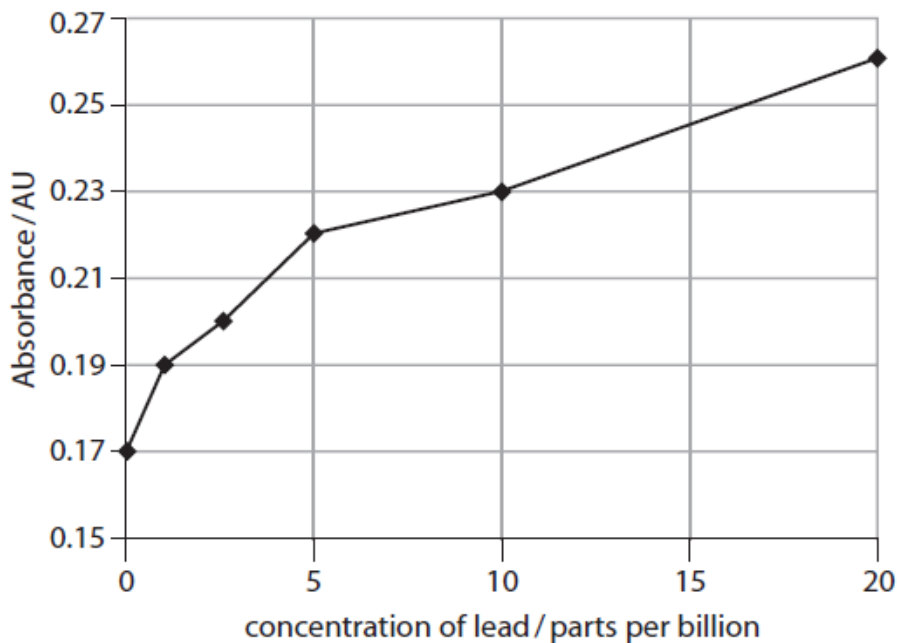
(Total for question = 4 marks)

Q6.

Lead is a toxic metal that can affect the structure of proteins. Lead affects protein in a similar way to changing pH.

Beetroot vacuoles contain a pigment. The absorbance of a solution is proportional to the concentration of the pigment in the solution.

The graph shows the results of a scientific investigation to study the effect of increasing lead concentration on the permeability of the membranes of beetroot cells.



(a) State the name of the membrane that surrounds the vacuole in beetroot cells.

(1)

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(b) Calculate the difference in percentage increase in absorbance between the lead concentration of 0-10 parts per billion and 10-20 parts per billion.

(3)

Answer %

(c) (i) Explain the effect of lead on membrane permeability in beetroot cells.

(2)

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(ii) Devise an investigation to determine whether pH has a similar effect to lead on the permeability of the membranes of beetroot cells.

(4)

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(Total for question = 10 marks)

Q7.

Porphyria is a life-threatening genetic disease. It is caused by a mutation in the gene coding for an enzyme involved in the production of haem.

In people with porphyria, haem cannot be produced.

Explain why this mutation may prevent the enzyme involved in the production of haem from functioning correctly.

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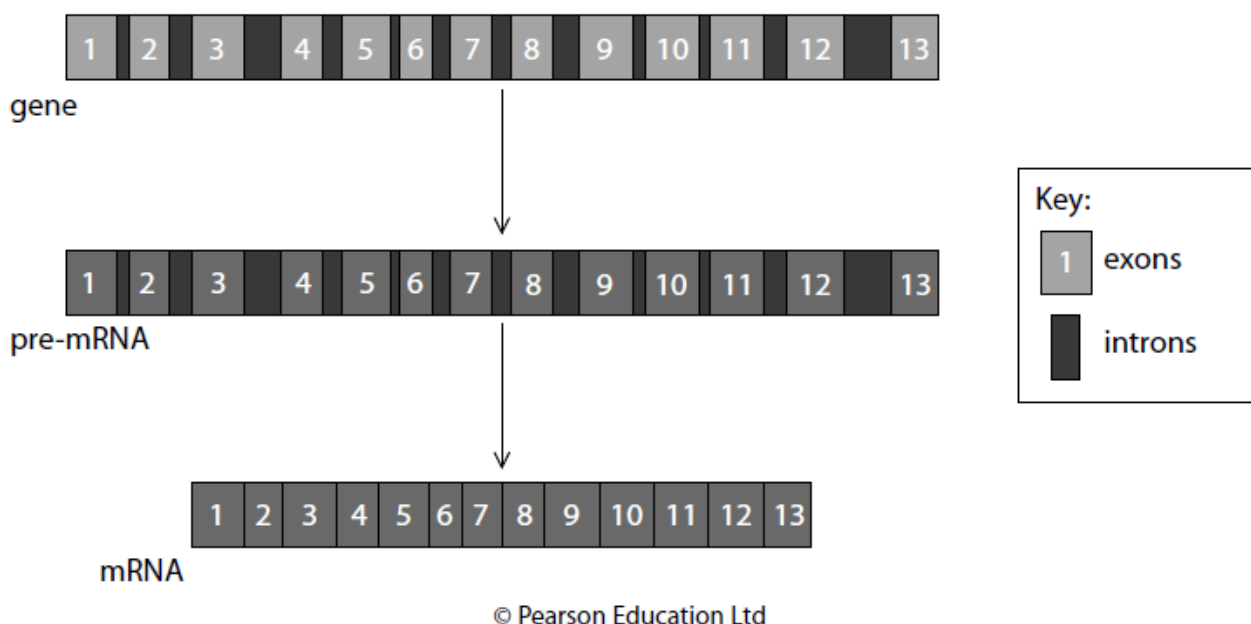
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(Total for question = 4 marks)

Q8.

A central idea in biology is that DNA codes for the synthesis of proteins from amino acids. The instructions for making proteins are in the form of mRNA.

The diagram shows two stages in the production of mRNA.



(a) Explain how this molecule of mRNA is produced.

(4)

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(Total for question = 4 marks)

Q9.

The scientific article you have studied is adapted from 'How Performance-Enhancing Drugs Work.'

Use the information from the article and your own knowledge to answer the following questions.

(a) (i) The population of the UK is 63 182 000 of which 49 182 000 are adults (paragraph 13).

Calculate the number of adults who have asthma.

(2)

Answer

(ii) People with asthma sometimes have difficulty breathing (paragraph 13).

Explain how beta-2 agonists may help to relieve their symptoms.

(2)

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(iii) Explain how beta-2 agonists can increase the heart rate (paragraph 13).

(4)

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(b) Explain how human growth hormone (HGH) is able to stimulate cells to secrete IGF-1 (paragraphs 20 and 21).

(4)

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(c) Explain why it is difficult to identify athletes who are using banned substances such as HGH (paragraphs 17, 20 and 22).

(2)

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(d) Explain one benefit of using substances developed from perfluorocarbons (PFCs) to treat patients with breathing difficulties (paragraphs 30 and 31).

(2)

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(e) Local anaesthetics mask pain by binding to protein channels in the membranes of neurones (paragraph 38).

Explain how binding to protein channels will prevent pain being sensed by the pain centre of the brain.

(4)

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(f) Explain why diuretics are a prescribed drug for high blood pressure (paragraph 43).

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(g) A test for the T/E ratio can help to identify athletes who have injected testosterone into their body (paragraph 45).

Explain the limitation of this test.

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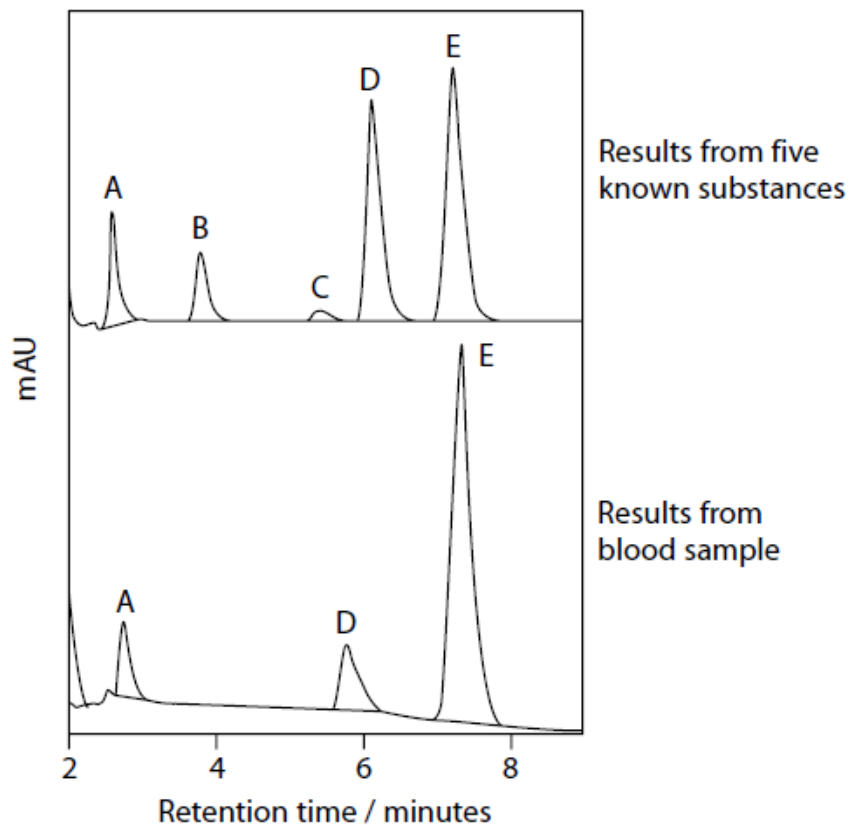
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(h) Gas chromatography (GC) can be used to detect athletes who have taken banned drugs (paragraph 48).

The chromatogram shows the GC results for five known banned substances, A, B, C, D and E.



Explain why the peak for drug E is different from the peak for drug A (paragraph 48).

(2)

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(i) Explain how the blood passport may result in more effective monitoring of athletes (paragraph 51).

(2)

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(j) Comment on the ethical viewpoints for and against the use of performance-enhancing drugs by athletes.

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(Total for question = 33 marks)

Q10.

Answer the questions with a cross in the boxes you think are correct ☐. If you change

your mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☒.

In the lungs, oxygen moves from the alveoli into red blood cells.

(i) How many times does an oxygen molecule cross a cell surface membrane to move from the centre of an alveolus to the centre of a red blood cell?

(1)

☐ **A** 2

☐ **B** 3

☐ **C** 4

☐ **D** 5

(ii) Oxygen enters the red blood cell by

(1)

☐ **A** active transport

☐ **B** diffusion

☐ **C** facilitated diffusion

☐ **D** osmosis

(Total for question = 2 marks)

Q11.

Penicillin is an antibiotic. It was discovered in 1928. Since then many antibiotics have been identified and are widely used in the treatment of bacterial infections.

Scientists have recently discovered a new class of antibiotics that bind to ribosomes.

(i) Explain why these antibiotics could affect the production of proteins in bacteria.

(3)

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(ii) These new antibiotics attach to a site on the ribosome not affected by any known antibiotics.

Deduce why these new antibiotics might be used to treat bacteria that are resistant to other antibiotics.

(2)

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* (iii) Scientists have isolated these new antibiotics and tested their effectiveness against bacteria that are resistant to other types of antibiotic.

Devise a laboratory procedure to compare the effectiveness of penicillin with one of the new antibiotics.

(6)

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[illegible]

(Total for question = 11 marks)

Q12.

(i) Many of the proteins synthesised become extracellular enzymes.

Describe what happens to these proteins following the process of translation until they are released from the cell.

(3)

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(ii) Cells in people with these diseases produce incorrectly folded enzyme molecules.

Explain why enzymes that are incorrectly folded cannot carry out their function.

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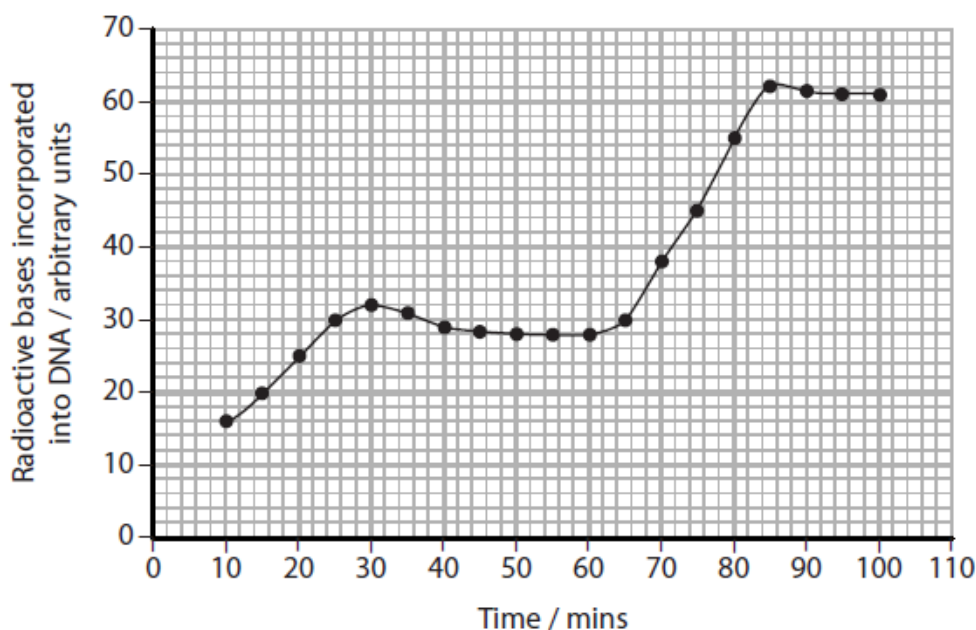
(Total for question = 6 marks)

Q13.

DNA synthesis in bacterial cell cultures has been investigated.

In an experiment, a mixture of radioactive bases was added to a culture of dividing bacteria.

The results are shown in the graph.



(i) Calculate the fastest rate of uptake of bases by these bacteria.

(2)

Answer

(ii) Deduce how many times the bacteria in the culture have divided during this experiment.

(2)

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(iii) Explain why the experiment would be improved if all the bases were provided but only the thymine was radioactive.

(2)

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(Total for question = 6 marks)

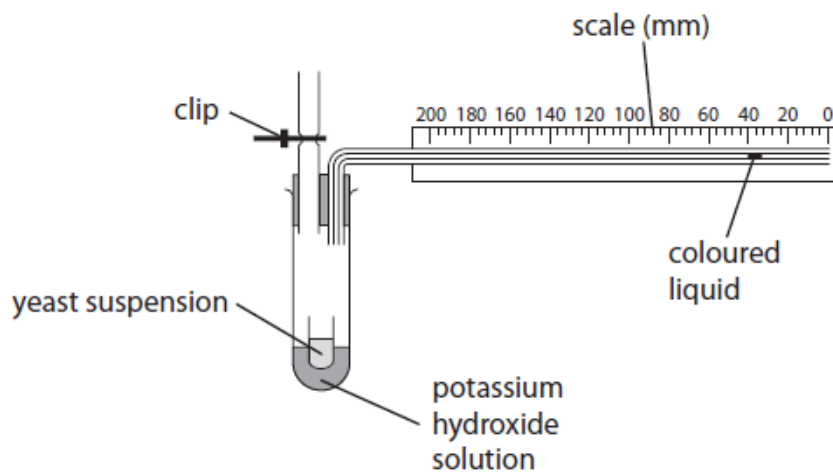
Q14.

Yeast is a single-celled organism that can respire aerobically.

Mitochondria are the sites of aerobic respiration in yeast cells.

It has been stated that if the temperature of yeast is raised by 10 °C, the rate of respiration will double.

The diagram shows some apparatus that can be used to measure the rate of respiration in yeast.



Devise an investigation using this apparatus to determine whether an increase of 10 °C doubles the rate of respiration in yeast.

(4)

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(Total for question = 4 marks)

Q15.

All cells have a cell surface membrane.

Some epithelial cells in the lungs secrete mucus. If the mucus is too 'sticky', it cannot be easily removed from the lungs.

Other epithelial cells in the lungs contain CFTR proteins in their cell surface membranes.

(i) Describe the role of the CFTR protein in ensuring that the mucus produced in the lungs has the right consistency.

(3)

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(ii) The table shows part of the gene that codes for the CFTR protein and the corresponding amino acid sequence. Each amino acid is represented by a single letter.

Part of the CFTR gene	ATTAAAGAAAATATCATCTTTGGTGTTCCTAT										
Amino acid sequence	I	K	E	N	I	I	F	G	V	S	Y

Explain how the information in the table demonstrates the nature of the genetic code.

(3)

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(Total for question = 6 marks)

Q16.

There are a number of reactions that regularly occur in cells.

* Another reaction that regularly occurs in cells is phosphorylation.

Phosphorylation plays a significant role in a wide range of cellular processes. Over a quarter of a million scientific articles have been written on this subject.

Using your knowledge of biology, discuss the roles of phosphorylation in cells.

(9)

[illegible]

Q17.

Trypsin is an enzyme found in many groups of living organisms.

Trypsin specifically acts on a polypeptide to form amino acids.

State the type of chemical reaction catalysed by trypsin.

(1)

(Total for question = 1 mark)

Q18.

Enzymes control biochemical pathways.

Phosphofructokinase is an enzyme involved in controlling the rate of glycolysis.

State what is meant by the term enzyme.

(2)

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(Total for question = 2 marks)

Q19.

Collagen is a fibrous protein.

Explain how the structure of collagen is related to its function.

(4)

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Q20.

In birds and mammals, gas exchange takes place between the blood in the capillaries and the air in the alveoli.

There are three layers between the blood and the air in the alveoli: the capillary wall, a layer of extracellular matrix and the alveolar wall. This is called the blood-gas barrier.

The extracellular matrix contains collagen.

(i) Describe the structure of collagen.

(3)

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(ii) Give a function for collagen in the blood-gas barrier.

(1)

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(Total for question = 4 marks)

Q21.

Hereditary spherocytosis is a condition that affects red blood cells.

This inherited condition is caused by a gene mutation that affects the shape of the cell surface membrane.

Describe the structure of the cell surface membrane.

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(Total for question = 3 marks)

Q22.

Global warming can affect abiotic factors that determine the distribution of organisms.

The presence of sodium chloride in soil is an abiotic factor that affects the germination of seeds.

The effects of sodium chloride solution and gibberellin on the germination of rice seeds have been investigated.

Gibberellin regulates developmental processes in plants.

Gibberellins can activate the gene for amylase in rice seeds.

Amylase is an enzyme that hydrolyses starch in the rice seeds.

Devise an investigation to demonstrate the effect of gibberellin on amylase activity in rice seeds treated with sodium chloride.

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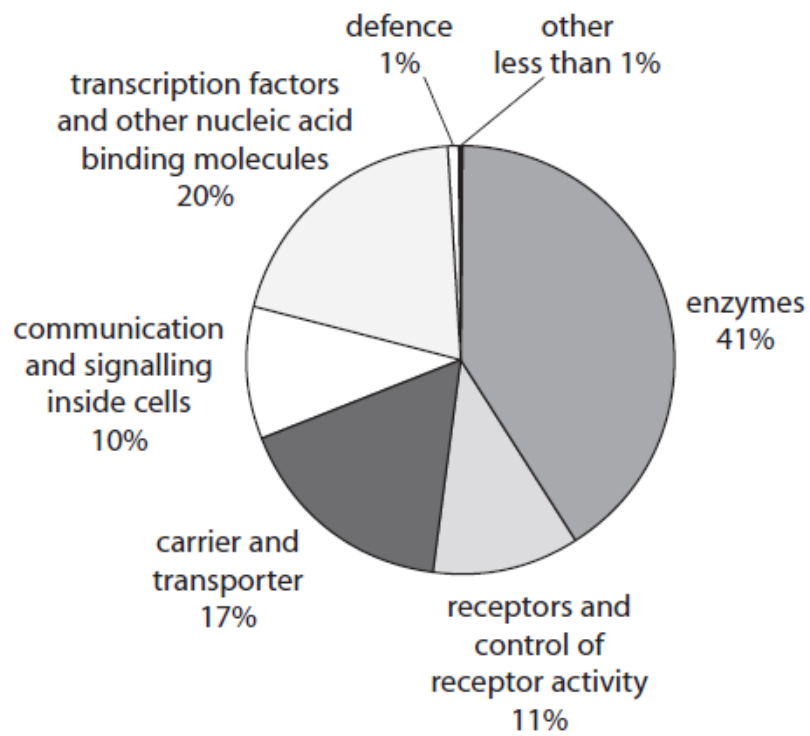
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(Total for question = 4 marks)

Q23.

* The human genome codes for approximately 20 000 different proteins.

The pie chart shows the proportion of proteins carrying out different functions.



The 20 amino acids used to make proteins can be classified according to the properties of their side chains (R groups).

Table 1 shows the number of amino acids with these properties.

Property of the side chain group	Number of amino acids with the property
Non-polar	9
Polar, uncharged	6
Negatively charged	3
Positively charged	2

Table 1

Table 2 shows three amino acids, used to synthesise proteins, that have unique properties.

Amino acid	Comment on structure
Cysteine	The side chain contains a thiol group (-S-H) that is chemically reactive.
Glycine	The side chain is a hydrogen atom which is much smaller than any other side chain. This allows tight coiling of polypeptide chains.
Proline	The side chain forms a peptide bond with the nitrogen in the amino group. This makes a polypeptide chain more rigid.

Table 2

Discuss the importance of the amino acid side chain to the structure, function and location of proteins.

(9)

(Total for question = 9 marks)

Q24.

The inheritance of coat colour in mice has been investigated.

Some scientists crossed mice that had yellow coats. The offspring had either yellow coats or non-yellow coats.

(i) Explain how the scientists knew which allele for coat colour was recessive.

(2)

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(ii) The crosses led to a total of 1599 offspring being produced.

Predict the number of yellow and non-yellow offspring produced.

(2)

Offspring with a yellow coat	Offspring with a non-yellow coat

(iii) The table shows the actual number of offspring with each coat colour.

Offspring with a yellow coat	Offspring with a non-yellow coat
1064	535

Explain why there are differences between the predicted and actual numbers of these mice.

(3)

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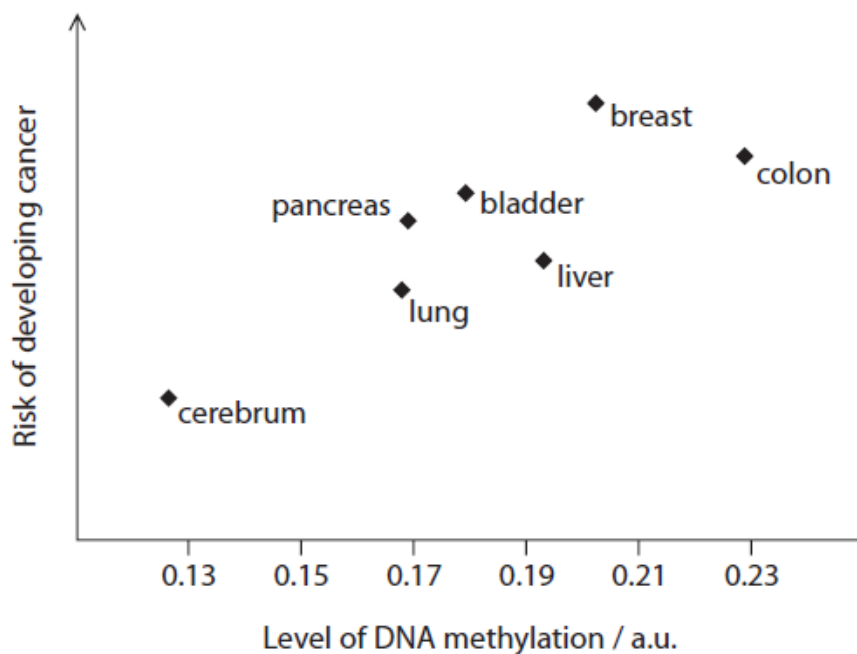
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(Total for question = 7 marks)

Q25.

There is a link between the methylation of certain regions of DNA and the risk of developing cancer.

The graph shows the relationship between the level of methylation of these regions of DNA and the risk of developing cancer in different parts of the body by the age of 70.



(i) Draw a line of best fit on the graph to identify any correlation between the independent variable and the dependent variable.

(1)

(ii) An investigation studied the effect of age on the mean level of DNA methylation.

In this investigation, the null hypothesis was rejected at the 5% significance level.

Explain what is meant by the phrase: the null hypothesis was rejected at the 5% significance level for this investigation.

(2)

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*(iii) Scientists have found that a high level of succinate leads to the inhibition of an enzyme called TET.

The function of TET is to remove methyl groups from DNA.

Explain how a mutation in the gene for succinate dehydrogenase can increase the risk of developing cancer.

(6)

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(Total for question = 9 marks)

Mark Scheme

Q1.

Question Number	Answer	Mark
(i)	The only correct answer is –A <i>amino acids</i> B is incorrect because nitrates are not found in cellulose C is incorrect because nitrates are not found in starch D is incorrect because nitrates are not found in sucrose	Computer (1)

Question Number	Answer	Mark
(ii)	The only correct answer is –C <i>nucleic acids</i> A is incorrect because phosphate is not found in cellulose B is incorrect because phosphate is not found in chlorophyll D is incorrect because phosphate is not found in sucrose	Computer (1)

Question Number	Answer	Mark
(iii)	The only correct answer is – C <i>chlorophyll</i> A is incorrect because magnesium is not found in amino acids B is incorrect because magnesium is not found in cellulose D is incorrect because magnesium is not found in starch	Computer (1)

Q2.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following • (because) { one triplet is affected / a different triplet code is produced } (1) • (the mutation) could change one of the amino acids (1) • this would {change the bonds formed between the R groups / cause a change in the tertiary structure}(1) • the haemoglobin would no longer be able to bind to oxygen (1)	ALLOW produce a stop codon IGNORE reference to secondary or quaternary structure	(3)

Q3.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: - partially permeable membrane is a barrier to some solutes but not water (1) - enables a concentration gradient of { solutes / water } (1)		(2)

Q4.

Question Number	Answer	Mark		
(i)	The only correct answer is B - <table><tr><td>against a solute concentration gradient</td><td>through a partially permeable membrane</td></tr></table> A is not correct because in osmosis water moves against a solute concentration gradient - through a partially permeable membrane C is not correct because in osmosis water moves against a solute concentration gradient - through a partially permeable membrane D is not correct because in osmosis water moves against a solute concentration gradient - through a partially permeable membrane	against a solute concentration gradient	through a partially permeable membrane	1
against a solute concentration gradient	through a partially permeable membrane			

Question Number	Answer	Mark
(ii)	The only correct answer is A – Active transport B is not correct because exocytosis s an export process C is not correct because osmosis describes the movement of water (solvent) molecules D is not correct because passive diffusion take place down a concentration gradient	1

Question Number	Answer	Mark
(iii)	The only correct answer is D – Protein A is not correct because carrier molecules or channel used for facilitated diffusion are proteins B is not correct because carrier molecules or channel used for facilitated diffusion are proteins C is not correct because carrier molecules or channel used for facilitated diffusion are proteins	1

Q5.

Question Number	Answer	Additional guidance	Mark
(i)	• using carbon (14) dating	ALLOW the deeper the layer in the peat, the older it is	graduate (1)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to three of the following • conditions are anaerobic (1) • therefore less (aerobic) respiration by decomposers (1) • acidic conditions {inhibit /denature} enzymes (1) • therefore (enzymes) cannot {digest / break down} organic material (1)	ALLOW (waterlogging) reduces the oxygen content ALLOW microorganisms / named decomposers ALLOW decomposers respiring anaerobically ALLOW description of denaturing eg change in shape of active site ALLOW break down plants / animals /peat	Expert (3)

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Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	Tonoplast		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)	• selection of correct points from the graph (1) • calculation of percentage (1) • difference in percentage (1)	0.17 AU , 0.23 AU , 0.26 AU <u>Example of calculation:</u> $35.3\% \div 13.0\%$ $= 22.3\%$ Allow full marks for correct answer with no working	(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(i)	An explanation that makes reference to the following: • interferes with { tertiary / 3-D } shape of the channel proteins (1) • therefore causes channel proteins to		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)(ii)	An answer that makes reference to four of the following: • solutions with a range of pH values (1) • pieces of beetroot of same surface area (1) • control of other named relevant variables (1) • measurement of absorbance of solution using colorimeter (1) • repeats at each pH value to calculate mean (1)	e.g. temperature / volume of solution / time left in solution /	(4)

Q7.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to four of the following • a mutation will lead to a change in the sequence of bases (in the DNA) (1) • (therefore a mutation) may lead to {a different amino acid /change in the sequence of amino acids} (1) • so different R groups would change the tertiary structure of the enzyme (1) • therefore the (shape of the) active site is changed (1) • therefore substrate does not fit active site of enzyme / substrate-enzyme complexes cannot form (1)	ALLOW change to triplet code (of DNA) ALLOW reference to STOP codon being produced	Expert (4)

Q8.

Question Number	Acceptable Answer	Additional guidance	Mark
	An explanation that makes reference to four of the following: • DNA unzips and one strand acts as a template (1) • ribonucleotides pair up with complementary bases (1) • RNA polymerase joins ribonucleotides together to form pre-mRNA (1) • the mRNA has fewer bases than pre-mRNA / gene (1) • as a result of removal of introns / mRNA made up of exons only (1)		(4)

Q9.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(i)	49 182 000 x 0.05 (1) 2 459 100 (1)	Correct answer gains full marks	(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(ii)	An explanation that makes reference to the following: • can dilate bronchioles /airways (1) • therefore allowing more oxygen into lungs /alveoli (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(a)(iii)	An explanation that makes reference to the following: • sympathetic neurotransmitters are released at the SAN (1) • therefore if beta-2 agonists are present the SAN will increase its rate of stimulation (1) • so impulses will spread faster and more often over the atria (1) • therefore the heart muscle will contract more often which increases the heart rate (1)		(4)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	An explanation that makes reference to four of the following: • HGH binds to receptor in cell surface membrane (1) • activation of messenger molecule in cytoplasm (1) • reference to protein kinase cascade (1) • transcription factor produced (1) • gene for IGF-1 switched on (1)		(4)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	An explanation that makes reference to the following: • occur naturally / would have some present in body (1) • therefore difficult to detect additional HGH (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(d)	An explanation that makes reference to the following: - no need for blood transfusion (1) plus any one from: - therefore no risk of rejection / agglutination/ delay in {tissue/blood} typing (1) - they supply the oxygen requirements for the body (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(e)	An explanation that makes reference to four of the following: - reference to {sodium ion channels / voltage gated sodium ion channels} (1) - binding blocks movement of sodium ions into neurone (1) - membrane is not depolarised (1) - action potential is not generated (1) - no impulses conducted to brain (1)	Accept more sophisticated answers that refer to the effect on calcium ion movement	(4)

Question Number	Acceptable Answer	Additional guidance	Mark
(f)	An explanation that makes reference to two of the following: (they) increase the removal of {water/salts} from blood (1) (removal of water) lowers blood volume and therefore pressure (1) (removal of salt) lowers uptake of water into blood (by osmosis from tissue fluid) and therefore blood pressure (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(g)	An explanation that makes reference to the following: - normal ratio is 1:1 (1) - taking testosterone and epitestosterone in equal measures maintains this ratio (1) - therefore it is not possible to detect cheats (1)		(3)

Question Number	Acceptable Answer	Additional guidance	Mark
(h)	An explanation that makes reference to the following: • drug E has been retained in the gas phase longer (1) • because it has {greater solubility / smaller mass} (1)	Accept more sophisticated answers related to charge	(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(i)	An explanation that makes reference to two of the following: • longitudinal monitoring / to be followed over time (1) • therefore can identify individual differences in naturally occurring drug concentrations (1) • therefore can see pattern or link to competition / injury / look for changes (1)		(2)

Question Number	Acceptable Answer	Additional guidance	Mark
(j)	An answer that makes reference to the following: • the absolutist's view would be that they should never be used (1) plus any one from: • because of the damage to the body by the side effects (1) • athletes should compete using their innate {anatomical / physiological} abilities / fair competition should be promoted (1) and • the rationalist's view would be that their use is acceptable if there is a justifiable outcome (1) Plus any one from: • because it is a personal choice (1) • because it could help to overcome the inequalities in {training / medical support} (1)		(4)

Q10.

Question Number	Answer	Mark
(i)	The only correct answer is D - 5 A is not correct because oxygen has to travel across both sides of a cell in the alveolus wall plus both sides of the capillary wall cell as well as across the cell surface membrane of a red blood cell. This summates to 5, not 2. B is not correct because oxygen has to travel across both sides of a cell in the alveolus wall plus both sides of the capillary wall cell as well as across the cell surface membrane of a red blood cell. This summates to 5, not 3. C is not correct because oxygen has to travel across both sides of a cell in the alveolus wall plus both sides of the capillary wall cell as well as across the cell surface membrane of a red blood cell. This summates to 5, not 4.	(1)

Question Number	Answer	Mark
(ii)	The only correct answer is B (diffusion) A is not correct because oxygen does not enter a red blood cell by active transport C is not correct because oxygen does not enter a red blood cell through facilitated diffusion D is not correct because oxygen does not enter a red blood cell through osmosis	(1)

Q11.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to three of the following • ribosome shape is altered (1) • mRNA is prevented from binding (to the ribosome) / causing change in tRNA binding (1) • therefore translation cannot occur (1) • { protein / polypeptide } is not synthesised (1)	ALLOW translation is affected / reduced / altered ALLOW faulty protein produced	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to two of the following • bacteria have not been exposed to new antibiotics before /bacteria do not have mechanisms to make them resistant to the new antibiotics (1) • bacteria have developed resistance (to other antibiotics) by { evolving / natural selection } (1) • therefore there has been {no advantage to possessing amutation to bypass the new antibiotic / no mutation present to give resistance } (1)		(2)

Question Number	Answer	Mark
(iii)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the genericmark scheme. The indicative content below is not prescriptive and candidates are not required to include all thematerial which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content • prepare agar plates with bacterial cultures / bacterial lawn / seeded with bacteria –use bacteria that are resistant to other antibiotics • prepare solutions of new antibiotic and penicillin • place onto paper discs / into wells in the agar / prepare mast rings • control time and temperature of incubation • same concentration and volume of both antibiotics • measure the area of inhibition • repeat for effective antibiotics • description of serial dilution of each antibiotic • range of dilutions on each plate-one antibiotic per plate • statistical test to determine which is the most effective • repeat with different strains of resistant bacteria	(6)

Level	Marks		Additional Guidance
0	0	No awardable content	
1	1-2	An explanation of how the investigation should be modified may be attempted but with limited analysis, interpretation and/or evaluation of the scientific information. Generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Preparation of agar plates Method of adding antibiotic Use of new antibiotic and penicillin Measure zone of inhibition
2	3-4	An explanation of how the investigation should be modified will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Incubated for stated time 24-72 hours Incubated at stated temperature 25-37°C Method of culturing bacteria on agar plates/preparing a lawn Repeats to calculate the mean Larger zone of inhibition-more effective antibiotic
3	5-6	An explanation of how the investigation should be modified is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured.	Strain of bacteria known to be resistant to penicillin/other antibiotics Same volume/concentration of both antibiotics Several strains of resistant bacteria tested with new antibiotic Preparation of serial dilutions for both antibiotics Range of concentrations give minimum effective dose Named statistical test eg T-test

Q12.

Question Number	Answer	Additional guidance	Mark
(i)	A description that makes reference to three of the following - the proteins are folded in the rough endoplasmic reticulum (RER) (1) - the proteins are {packaged into/transported in} vesicles (1) - the protein is modified in the Golgi apparatus (1) - exocytosis (1)	ALLOW processed/description of modification ALLOW description of exocytosis	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to the following • (if the protein is not folded correctly) the {tertiary structure / 3D shape} would be different(1) • therefore the active site of the enzyme would not { fit / bind with } the substrate / it would not be able to form an enzyme substrate complex (1) • therefore it would not be able to catalyse the reaction (1)	ALLOW not complementary	(3)

Q13.

Question Number	Answer	Additional Guidance	Mark
(i)	• correct values taken from the graph (1) • correct answer with units (1)	<u>Example of calculation</u> 55 – 45 (= 10) = 2 au min⁻¹ ALLOW an answer between 1.6 au and 2 au per minute or 0.0267 to 0.0333 au per second Correct answer with units, with no working gains full marks Correct answer with no units, gains one mark only	2

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following: • DNA contents doubles twice / two stages of DNA synthesis (1) • therefore two divisions (1)	ALLOW two increases in uptake of bases ALLOW twice	2

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to two of the following: - because thymine is found only in DNA (1) - other radioactive bases taken up by all nucleic acids (1) - only DNA would be measured (1)	ALLOW RNA does not contain thymine ALLOW other bases taken up by RNA ALLOW no need to separate DNA from RNA	2

Q14.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to four of the following: - selection of two temperatures that are not above the optimum temperature (1) - named variable kept constant (1) - record the distance travelled by the coloured liquid in a set time (1) - description of how to calculate rates (1) - data collected during the initial rate of reaction / before a factor (other than temperature) becomes limiting (1)	ALLOW: below a temperature that causes enzyme denaturing or not above optimum temp ALLOW any two temperatures between 10 and 40°C e.g. pH of solution, {sucrose/glucose} concentration, yeast {concentration / volume} ALLOW time taken for coloured liquid to travel a set distance e.g. by dividing distance travelled by time	(4)

Q15.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to three of the following: - chloride ions leave cells (through the CFTR channel protein) (1) - sodium ions leave the cells (following the chloride ions) (1) - increasing the solute concentration in the mucus (1) - water moves out of the cells by osmosis (into the mucus) (1)	NOT active transport of chloride ions ALLOW chloride ions move into the mucus ALLOW NaCl, Na⁺ or Cl⁻ instead of solute ALLOW description of osmosis	3

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: (triplet code) is shown by three bases coding for an amino acid (1) - non-overlapping code e.g. ATT codes for amino acid I and then AAA code for amino acid K (1) - degenerate code as both ATT and ATC code for amino acid I (1)		3

Q16.

Question Number	Indicative content	
	Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Candidates are expected to offer a range of appropriate examples to support a comment on the roles of phosphorylation in Biology. • Description of phosphorylation as an addition of phosphate. • Examples of phosphorylation in respiration to include glycolysis, oxidative phosphorylation, substrate level phosphorylation. • Examples of phosphorylation in photosynthesis to include RuBP, GP, NADP, non-cyclic photophosphorylation. • Role of phosphorylation of ADP to store energy. • Phosphorylation of lipids to make phospholipids and their roles in membranes. • Addition of phosphates to help form the DNA backbone / involved in phosphodiester bonds. • Appreciation of the consequences of phosphorylation such as activation of molecule for further reactions.	
Level	Mark	Descriptor
	0	No rewardable material
1	1-3	Demonstrates isolated elements of biological knowledge and understanding. Provides little or no references to a range of

Level	Mark	Descriptor
		scientific idea, processes, techniques and procedures. Scientific arguments may be attempted, but fails to link biological concepts and/or ideas in order to support decision/conclusion. Limited attempt to address the question.
2	4-6	Demonstrates adequate biological knowledge and understanding with selection of some biological facts/concepts to support an argument or decision/conclusion being made. Scientific reasoning occasionally supported through the linkage of a range of scientific ideas, processes, techniques and procedures. Scientific argument is partially developed. Attempts to synthesise and integrate relevant knowledge with linkages to biological concepts and/or ideas, leading to a notional scientific argument or decision/conclusion.
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts to support an argument or decision/conclusion being made. Scientific reasoning supported throughout by sustained linkage of a range of scientific ideas, processes, techniques and procedures. Scientific argument is well developed and logical. Demonstrating throughout the skills of synthesising and integrating relevant knowledge with consistent linkages to biological concepts and/or ideas, leading to nuanced and balanced scientific argument or decision/conclusion based on evidence.

Q17.

Question Number	Answer	Additional Guidance	Mark
	hydrolysis		(1)

Q18.

Question Number	Answer	Additional guidance	Mark
	An answer the makes reference to two of the following: • {biological / protein} catalyst (1) • lowers the activation energy (for a reaction) (1) • increasing the rate of reaction (1)		(2)

Q19.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to four of the following: • three { polypeptide / collagen } chains tightly coiled around each other (1) • due to every third amino acid { being glycine / having a small R group } (1) • chains are held together by { hydrogen bonding / covalent cross links } (1) • flexible without stretching (due to triple helix) (1) • chains of collagen associate together to form fibrils (1) • (fibrils) have a high tensile strength (and function to support tissues) (1)		(4)

Q20.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to three of the following: - primary structure described as a repeating amino acid sequence (1) - three polypeptide chains (1) - chains coiled around each other (1) - cross-linking between the chains (1)	ALLOW {proline / glycine / hydroxyproline} rich polypeptide chains IGNORE alpha helix ALLOW {covalent / hydrogen / disulphide} bonding between chains	3

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to one of the following: - to provide {strength / flexibility} (1) - holds walls of capillaries and alveoli close together (1)	ALLOW to support alveoli IGNORE to support capillaries	1

Q21.

Question Number	Answer	Additional guidance	Mark
	A description that makes reference to three of the following - cell membrane is (mainly) phospholipids and protein (1) - phospholipids form a bilayer (1) - proteins float in the phospholipids / change position / fluidmosaic model (1) - proteins may span the bilayer or be located in only onelayer (1)	ALLOW proteins embedded in the phospholipid bilayer ALLOW proteins may be intrinsic / extrinsic IGNORE function of proteins such as carrier/ channel	(3)

Q22.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to four of the following: - seeds treated with sodium chloride and with sodium chloride and gibberellin (1) - description of how an abiotic factor can be controlled (1) - extract amylase from the seeds (1) - description of assay (1) - description of how quantitative results will be obtained to enable comparison (1)	ALLOW with sodium chloride and different concentrations of gibberellin e.g. use a water bath to control the temperature ALLOW method of standardising quantity of amylase e.g. same volume of {amylase extract / seed extract} / same {mass / number / type / size} of seed e.g. iodine starch test or Benedict's test to measure reducing sugars e.g. length of time to remove starch or use of a colorimeter ALLOW a description of how gibberellin might affect the result e.g. 'if gibberellin increases amylase activity time for iodine solution to go colourless will be shorter'	(4)

Q23.

Question number	
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content Information • there are 20 000 different proteins • these proteins carry out different functions • there are a {large number of / 20} different {R groups / amino acids} • most R groups are non-polar, some are polar a few have a charge Linkage to structure • R groups determine {3D shape / structure} of proteins • {large number of / 20 R groups} • many combinations of amino acids required to give wide variety of protein structures • R groups can form bonds to stabilise 3D structure (e.g. cysteine) • role of R-groups in structure of haemoglobin • role of R-groups in structure of collagen • location of cysteine allows formation of disulfide bonds Linkage to function • R groups variety of protein shapes are required to allow proteins to carry out wide range of functions • examples of functions that require specific structure e.g. antibodies specific to an antigen / enzymes specific for a substrate / receptors e.g. neurotransmitters and (acetylcholine) and ion-gated channels • polar / ionic R groups increase solubility • non-polar R groups will be on outside of insoluble proteins / structural proteins / collagen / proteins inserted into membranes • role of R-groups in function of haemoglobin • role of R-groups in function of collagen Linkage to location • polar R groups will be in aqueous environment / non-polar regions in a non-aqueous environment

	• polar / ionic R groups soluble in {plasma/ tissue fluid / cytoplasm} / line the inside of ion channels / found on the outside of soluble proteins such as hormones / transport proteins / immunoglobulins / cytokines • role of R-groups in location of haemoglobin • role of R-groups in location of collagen
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Level	Marks		
0	0	No awardable content	
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.	Selection of some information from the table – little or no linkage Linkage to one aspect – 2 marks Two linkages for same aspect – 3 marks
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.	Linkage between R groups and two aspects from structure, function and location One comment on each - 4 marks An additional comment - 5 marks An additional 2 comments – 6 marks
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.	Linkage between R groups and all three aspects (structure, function and location) One comment on each - 7 marks

		The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	An additional comment - 8 marks An additional 2 comments – 9 marks
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Q24.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following: - the parents were {heterozygous / had a dominant and a recessive allele} as the offspring had both yellow and nonyellow coats (1) (because the parents had yellow coats) the recessive allele was for non-yellow coat (1)	ALLOW parents were carriers	(2) Exp

Question Number	Answer	Additional Guidance	Mark				
(ii)	<table><tr><td>offspring with a yellow coat</td><td>offspring with a non-yellow coat</td></tr><tr><td>1199.25</td><td>399.75</td></tr></table> 1 mark for each predicted number	offspring with a yellow coat	offspring with a non-yellow coat	1199.25	399.75	ALLOW 1199 for 1199.25 ALLOW 400 for 399.75	(2) Clerical
offspring with a yellow coat	offspring with a non-yellow coat						
1199.25	399.75						

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following :		(3) Exp
	- ratio is 2 : 1 rather than 3 : 1 (1) - random fertilisation (1) - due to no homozygous dominant individuals surviving / homozygous dominant is lethal (1)	ALLOW description of random fertilisation	

Q25.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that includes: a line that shows a positive correlation with lung, liver and colon points below the line and breast, bladder and pancreas above the line		(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: - there is a correlation between age and level of DNA methylation (1) - as there is only a 5% likelihood of these results being produced by chance (1)	ALLOW converse, e.g. 95% probability that DNA methylation increases with age ALLOW as the calculated value is greater than the critical value at $p=0.05$	(2)

Question Number	Indicative content
* (iii)	Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant. Give examples of relevant biological knowledge and understanding: - mutation is a change in the { base sequence in DNA / gene } / different amino acid sequence / primary structure of the enzyme succinate dehydrogenase - succinate dehydrogenase { less / non- } functional - succinate therefore accumulates - accumulation of succinate inhibits TET - therefore methyl groups not removed / increased methylation of DNA - affects transcription of a gene / therefore alters amount of product formed - greater methylation of DNA is associated with increased risk of cancer

			Additional Guidance
Level 0	Marks	No awardable content	
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Only one point of basic information referred to: e.g. mutation results in more succinate, or high succinate and inhibition of TET, or less TET and more methylation of DNA
Level 2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Link between high levels of succinate and inhibition of TET
Level 3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Links made to include all of these points: mutation leads to higher levels of succinate, which inhibits TET, therefore increasing DNA methylation, which increases risk of cancer Logical explanation of the reasons why a mutation in the enzyme succinate dehydrogenase can increase risk of developing cancer

Q1.

At the start of fertilisation, many sperm cells will surround the ovum.

Fertilisation begins with the acrosome reaction.

(i) Which of the following describes the acrosome reaction?

(1)

- ☐ **A** the ovum releases enzymes that digest the egg cell membrane
- ☐ **B** the ovum releases enzymes that digest the zona pellucida
- ☐ **C** the sperm cell releases enzymes that digest the egg cell membrane
- ☐ **D** the sperm cell releases enzymes that digest the zona pellucida

(ii) Which of the following statements describes the genetic content of a sperm cell?

(1)

	Each sperm cell will contain	Different sperm cells will contain
☐ A	one copy of each gene	different alleles of some genes
☐ B	one copy of each gene	the same alleles for all genes
☐ C	two copies of each gene	different alleles of some genes
☐ D	two copies of each gene	the same alleles for all genes

(Total for question = 2 marks)

Q2.

Yeast is a single-celled organism that can respire aerobically.

Mitochondria are the sites of aerobic respiration in yeast cells.

(i) Name two molecules needed for aerobic respiration that can move into the mitochondria.

(2)

1

2

(ii) The outer mitochondrial membrane is not permeable to hydrogen ions (H⁺).

Explain the importance of this feature of the membrane.

(4)

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(Total for question = 6 marks)

Q3.

The scientific article you have studied is adapted from *Scientific American*.

Use the information from the scientific article and your own knowledge to answer the following question.

"Why is aging, smoking or radiation exposure associated with cancer?" (paragraph 8).

Explain why "These things cause mutations".

(3)

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(Total for question = 3 marks)

Q4.

(i) Muscle contains actin and myosin protein fibres.

Which of the following describes the primary structure of a protein?

(1)

- ☐ **A** amino acids joined by hydrogen bonds
- ☐ **B** amino acids joined by ester bonds
- ☐ **C** amino acids joined by peptide bonds
- ☐ **D** amino acids joined by phosphodiester bonds

(ii) Describe the structure of an amino acid.

(3)

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Q5.

Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

Moving a limb involves the interaction of muscles, tendons and ligaments.

Tendons and ligaments are important structures in elbow and knee joints.

(i) Which of the following identifies the structures that join bones to bones in an elbow joint?

(1)

- ☐ **A** ligaments only
- ☐ **B** ligaments and tendons
- ☐ **C** tendons only
- ☐ **D** neither ligaments nor tendons

(ii) One type of joint injury is a torn ligament. This may be treated by adding a piece of tendon to the ligament. This is because after a period of time, the tendon tissue changes and responds in the same way as a ligament.

Which of the rows in the table correctly describe the changes in this piece of tendon?

(1)

Row	Piece of tendon shows a change in its	The change is
1	genotype	an anatomical adaptation
2	genotype	a physiological adaptation
3	phenotype	an anatomical adaptation
4	phenotype	a physiological adaptation

- ☐ **A** row 1 only
- ☐ **B** row 3 only
- ☐ **C** rows 1 and 2
- ☐ **D** rows 3 and 4

*(iii) The photograph shows athletes competing in the modern triathlon.



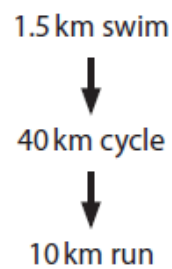
© Gonzalo Arroyo Moreno / Stringer

The modern triathlon involves three sports: swimming, cycling and running.

An investigation was carried out to compare the level of demand on the body of these three sports during a triathlon.

The investigation involved 12 athletes who were all males of the same age.

Each athlete carried out the triathlon as shown in the flow diagram. There was no rest period between each sport.



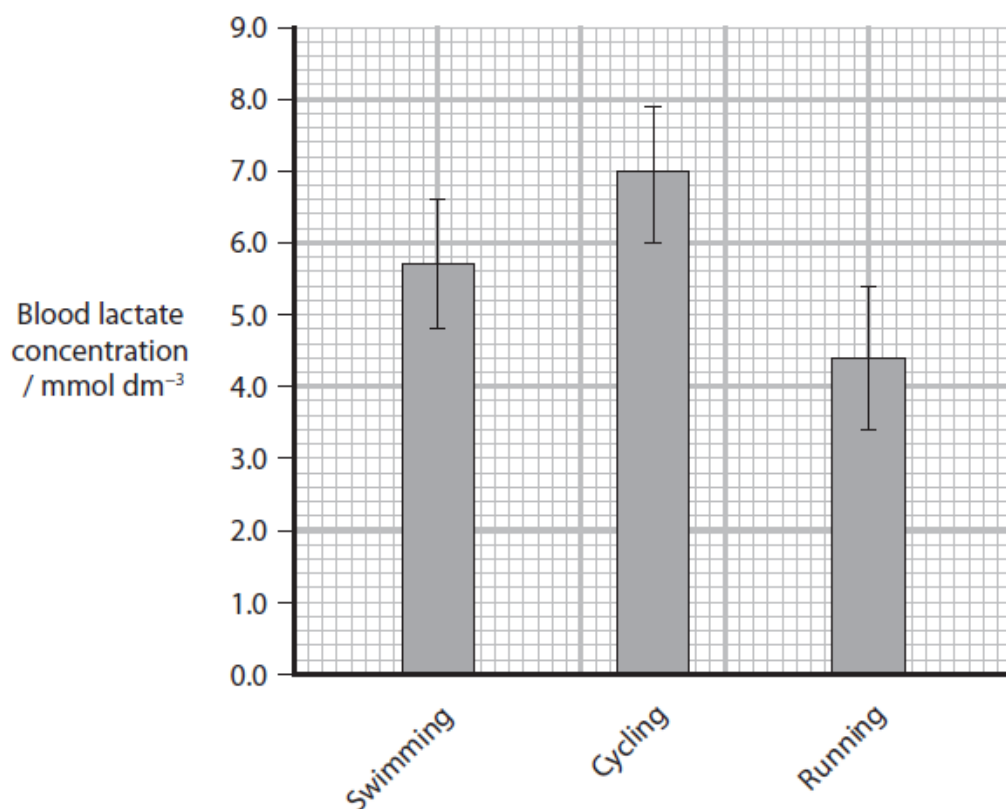
The heart rate for each athlete was measured as they completed each sport.

The mean heart rate for each sport was then calculated and is shown in the table.

Sport	Mean heart rate / bpm
Swimming	163
Cycling	165
Running	159

The blood lactate level for each athlete was also measured as they completed each sport. Means for lactate level after each sport were calculated.

The results are shown in the graph.



It was concluded that cycling was the most demanding of the three triathlon sports. This was followed by swimming and then running.

Evaluate the validity of this conclusion.

(6)

(Total for question = 8 marks)

Q6.

The structure of the cell surface membrane can be explained using the fluid mosaic model.

This model suggests that there are a variety of different proteins and glycoproteins present in a phospholipid bilayer.

* The ratio of lipid to protein in a cell surface membrane is approximately 1:1.

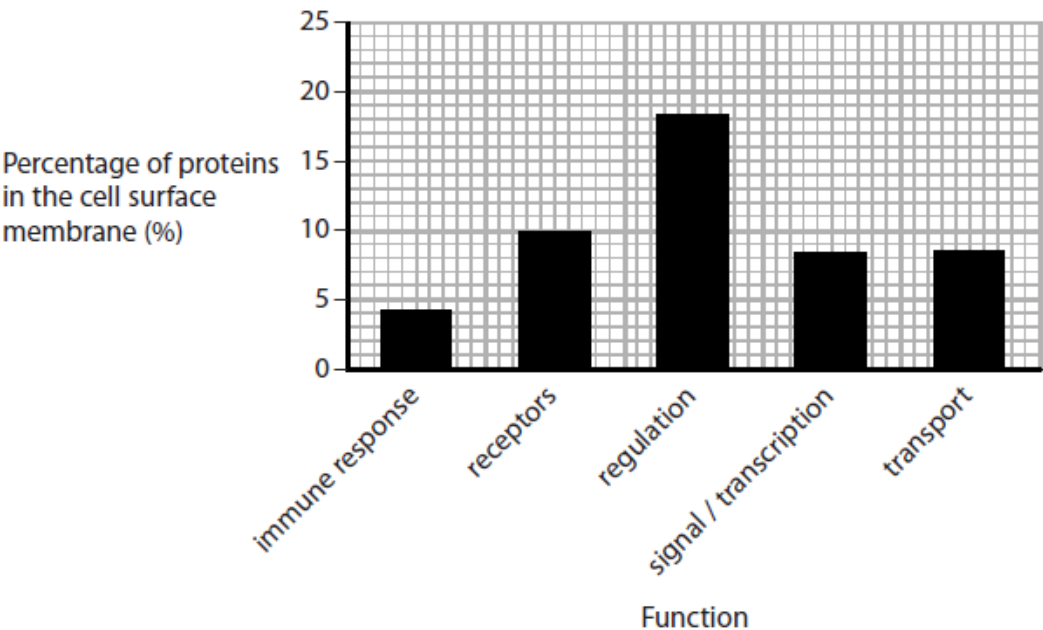
Scientists have studied the proteins present within human cells. Proteins in a cell are found in several locations.

The table shows the percentage of protein found in some locations in a cell.

Location within a cell	Percentage of total protein present (%)
cell surface membrane	68.2
cytoplasm	1.4
endoplasmic reticulum / Golgi apparatus	1.4
nucleus	14.5
other	14.5

The proteins within the cell surface membrane were further analysed for their function.

The graph shows some of the results of this analysis.



Analyse the data to evaluate the following statement.

'The variety of different proteins present in the cell surface membrane makes them more important than the phospholipid bilayer to the functioning of that cell.'

(9)

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(Total for question = 9 marks)

Q7.

Tuberculosis (TB) is an infectious disease caused by mycobacteria.

Individuals infected with M. tuberculosis can be treated with antibiotics.

Four of the antibiotics used to treat TB are shown in the table.

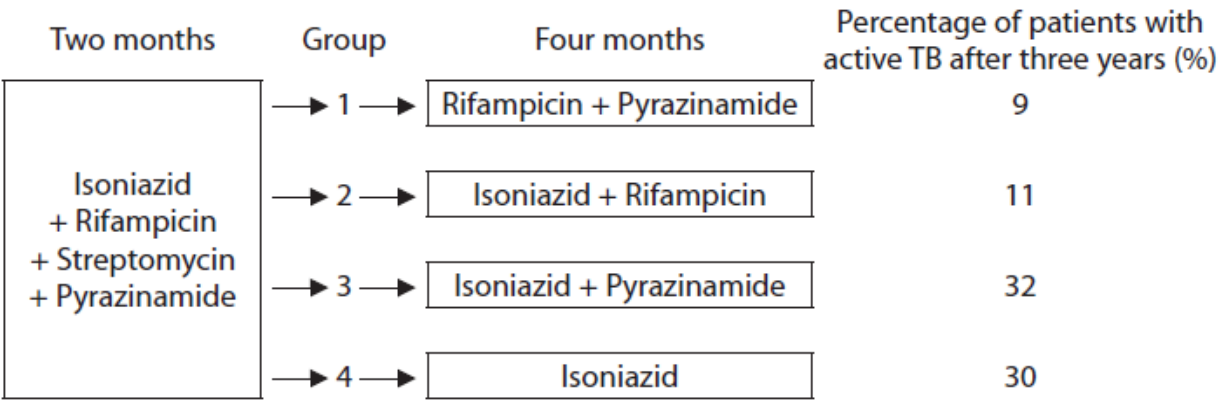
Antibiotic	Mechanism of action
Isoniazid	Inhibits the synthesis of a fatty acid needed to make bacterial cell walls
Rifampicin	Inhibits bacterial RNA polymerase
Streptomycin	Binds to bacterial ribosomes to prevent the binding of tRNA
Pyrazinamide	Not yet known, but not the same mechanisms as the other three antibiotics

In one clinical trial lasting six months, the effect of treating TB with these antibiotics was investigated.

All patients were treated with all four antibiotics for two months. Then they were treated with different pairs of antibiotics or isoniazid alone for a further four months.

All patients were free of any signs of active TB at the end of the clinical trial.

The design of the trial and the percentage of these patients with TB three years after the trial ended are shown in the diagram.



Analyse the data to comment on the effectiveness of these antibiotics for the treatment of TB.

(6)

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(Total for question = 6 marks)

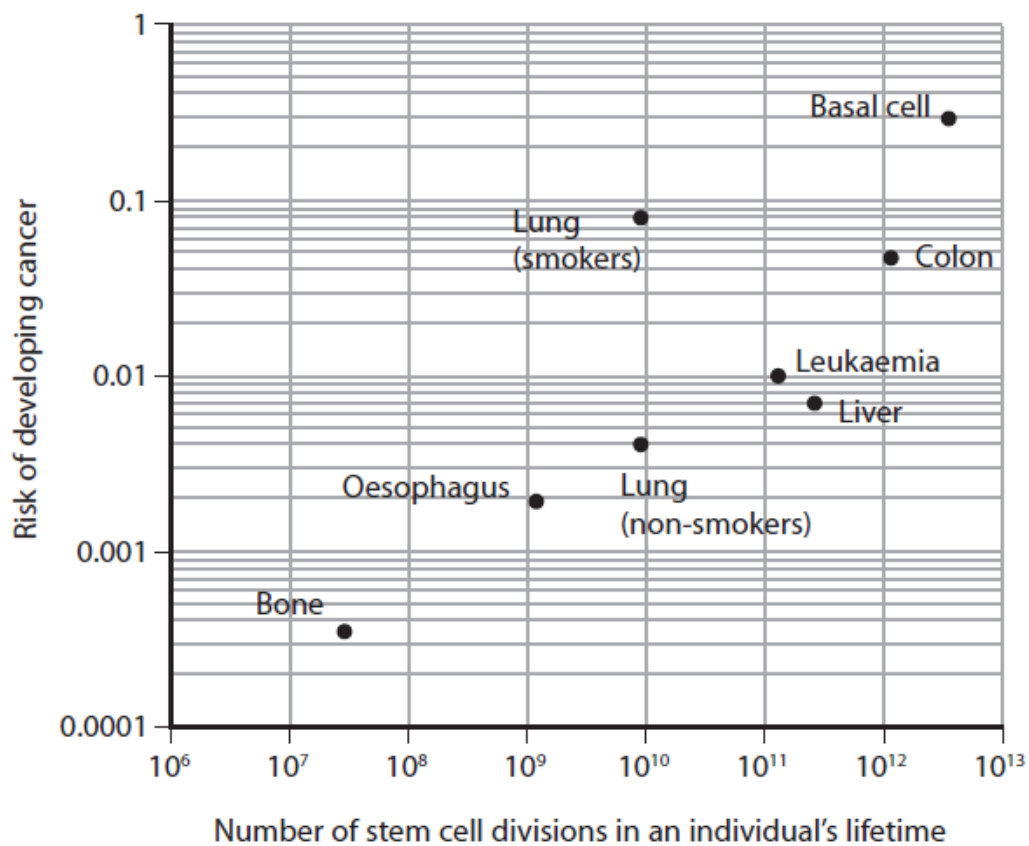
Q8.

Tissues of the human body have different stem cell populations.

These stem cells divide to replace and renew cells in these tissues.

Scientists have observed a relationship between the number of times a stem cell population divides in a tissue and the risk of developing cancer in that tissue.

This relationship is shown in the graph.



(i) The correlation coefficient for the data is 0.937.

The table shows some critical values for this correlation coefficient.

Critical values for the correlation coefficient	
n	p = 0.05
4	1.00
5	0.90
6	0.83
7	0.71
8	0.64
9	0.60
10	0.56

Which of the following correctly describes the correlation?

(1)

- ☐ **A** non-significant and positive
- ☐ **B** non-significant and negative
- ☐ **C** significant and positive

☒ **D** significant and negative

(ii) Explain the relationship between the number of stem cell divisions and the risk of developing cancer.

(2)

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(iii) The graph shows that the risk of developing lung cancer is greater in a cigarette smoker compared to a non-smoker.

Calculate how many times greater.

(2)

Answer

(iv) Explain why cigarette smokers have a higher risk of developing lung cancer than non-smokers.

(2)

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Q9.

*Genetic testing can be used to identify individuals who have genetic disorders such as Batten disease.

The table shows examples of some types of genetic screening and examples of where they may be used.

Type of screening	Method	Example
Blood test to identify risk of a disease	DNA from a blood sample is examined	Identifying presence of BRCA1 and BRCA2 mutations where there is a family history of breast cancer
Blood test to identify carriers of a genetic disease	DNA from a blood sample is examined	Establishing if a person is heterozygous for a recessive condition such as cystic fibrosis (CF)
Amniocentesis	Fetal DNA from amniotic fluid is tested	Identifying genetic disorders in the fetus
Chorionic villus sampling (CVS)	Fetal DNA from placental tissue is tested	Identifying genetic disorders in the fetus
Non-invasive prenatal diagnosis (NIPD)	Analysis of fetal DNA fragments from blood samples from the mother	Identification of chromosomal disorders and a small number of single gene disorders in the fetus
Pre-implantation genetic diagnosis (PGD)	Combined with IVF to test embryo at 8-cell stage	Ensures only embryos without a genetic disorder such as CF are implanted

Assess the advantages and disadvantages of these types of screening for genetic disorders.

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(Total for question = 6 marks)

Q10.

All known organisms can be placed into one of the three domains of life.

The table shows some information about the three different domains.

Feature	Archaea	Bacteria	Eukaryota
DNA is circular	Yes	Yes	No
DNA is single-stranded	No		No
Growth inhibited by the antibiotic streptomycin	No	Yes	No
Name of the link between fatty acids and glycerol in lipids	Ether	Ester	Ester
Presence of cell wall	Some	Yes	
Methionine required for starting protein synthesis	Yes	No	Yes
Transcription factors required for transcription	Yes	No	Yes

Complete the table to show the features in Bacteria and in Eukaryota.

(2)

(Total for question = 2 marks)

Q11.

Scientists have studied behavioural, anatomical and genetic variation in elephants.

The table shows some information about two populations of African elephants.

Population	Location	Feeding behaviour	Anatomical differences
Forest elephant	tropical forest of central and West Africa	feeds on leaves and fruits of high-growing plants such as shrubs and trees	• lower jaw longer and narrower • tusks straighter and downward facing • overall a much smaller size
Savannah elephant	African savannah	feeds on grass and leaves of low-growing shrubs	• lower jaw shorter and wider • tusks more curved and upward facing • overall a larger size

The photographs show elephants from the two populations.



Forest elephant



Savannah elephant

DNA samples were collected from these two populations of elephants.

One of the genes showing variation was the GBA gene. The table shows the frequency of the alleles of the GBA gene in the two populations.

GBA allele	Frequency of allele in the elephant population	
	Savannah elephant	Forest elephant
J	0.05	0.43
K	0.00	0.57
L	0.95	0.00

(i) State what is meant by the term **allele**.

(1)

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(ii) Use the Hardy-Weinberg equation to show that more than 50% of the forest elephant population are homozygous for the GBA gene.

(3)

Answer

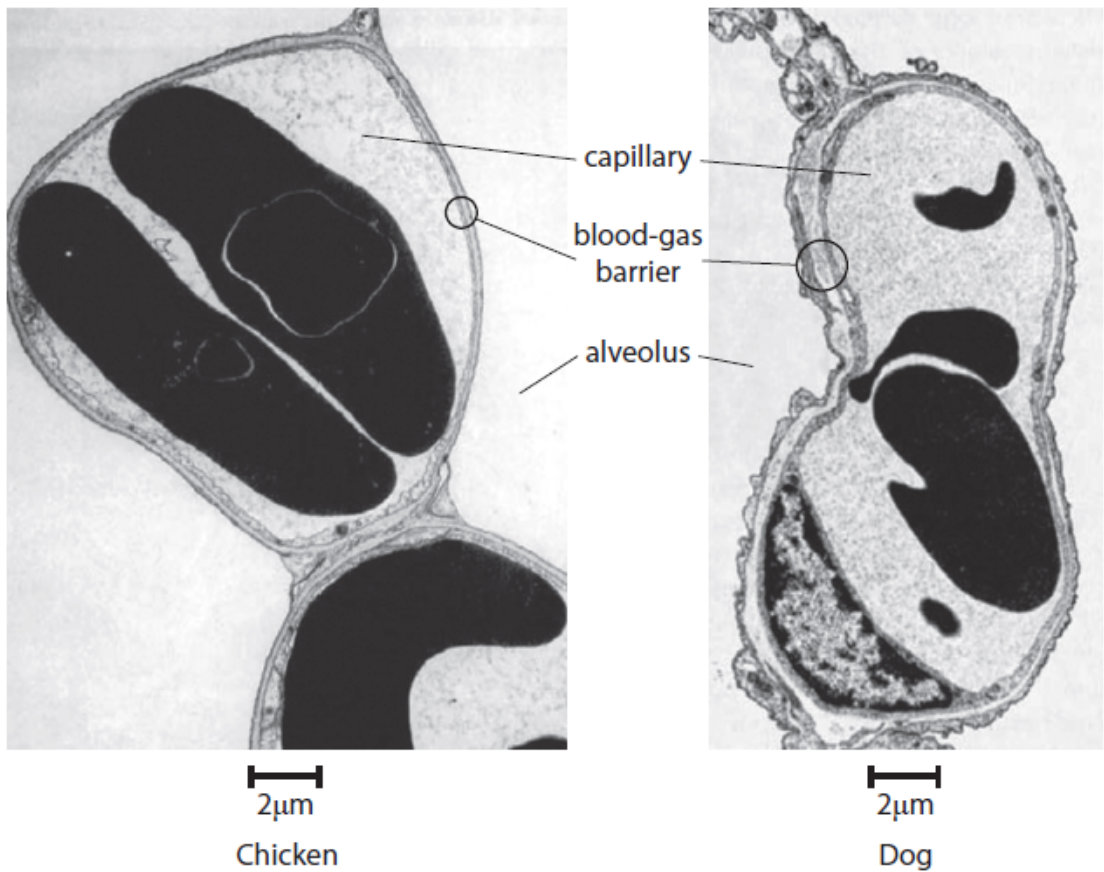
(Total for question = 4 marks)

Q12.

In birds and mammals, gas exchange takes place between the blood in the capillaries and the air in the alveoli.

There are three layers between the blood and the air in the alveoli: the capillary wall, a layer of extracellular matrix and the alveolar wall. This is called the blood-gas barrier.

The electron micrographs show the blood-gas barriers for a chicken and a dog.



Explain how the blood-gas barrier of the chicken is adapted to give more efficient gas exchange than the blood-gas barrier of the dog.

(3)

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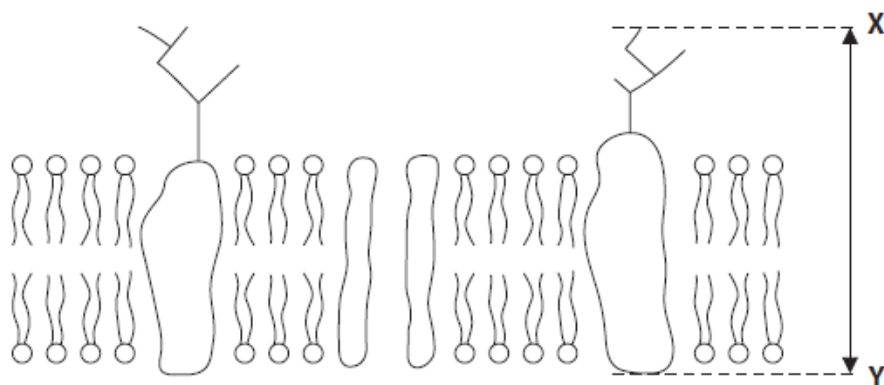
(Total for question = 3 marks)

Q13.

The structure of the cell surface membrane can be explained using the fluid mosaic model.

This model suggests that there are a variety of different proteins and glycoproteins present in a phospholipid bilayer.

The drawing shows the cell surface membrane of a liver cell. The drawing has a magnification of 5×10^6 .



Calculate the actual length of the glycoprotein between points **X** and **Y**.
Give your answer with an appropriate unit.

(2)

Answer

(Total for question = 2 marks)

Q14.

During the development of the mammalian heart, there is a hole between the left ventricle and the right ventricle.

This hole usually becomes sealed before the mammal is born. If it is not sealed, the mammal will become easily tired due to a lack of energy.

Explain why a mammal born with a hole between the two ventricles will have these symptoms.

(3)

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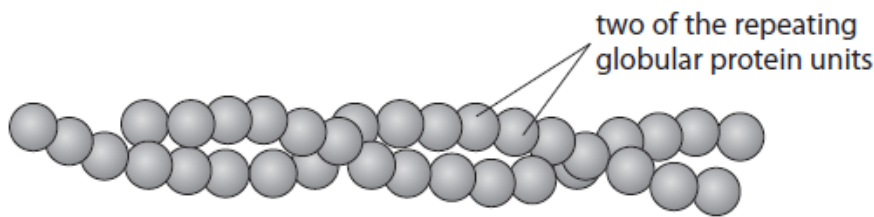
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(Total for question = 3 marks)

Q15.

Actin and collagen are both proteins.

The diagram shows two filaments of actin from a muscle fibre. Each filament is a polymer of repeating globular protein units.



Compare and contrast the structures of an actin filament and collagen.

(3)

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(Total for question = 3 marks)

Q16.

Glucosaminoglycans (GAGs) are the by-products of chemical reactions inside cells. GAGs are broken down by enzymes inside lysosomes in cells.

Mucopolysaccharidosis type I (MPS I) is a genetic condition that results in the build-up of GAGs inside cells.

MPS I affects the production of enzyme G that breaks down GAGs inside lysosomes.

Enzymes work by

(1)

- ☐ **A** increasing the activation energy of a reaction
- ☐ **B** lowering the activation energy of a reaction
- ☐ **C** providing energy to the reactants
- ☐ **D** removing energy from the products

(Total for question = 1 mark)

Q17.

Beetroot cells contain the pigment betalain.

When beetroot cells are placed in alcohol, the concentration of betalain in the cells changes.

Explain why alcohol affects the concentration of betalain in these cells.

(3)

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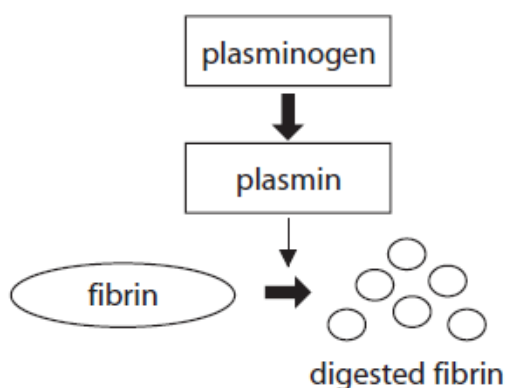
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(Total for question = 3 marks)

Q18.

Plasmin is an enzyme that digests fibrin.

Plasmin is produced, in the blood, from an inactive form of the enzyme called plasminogen.

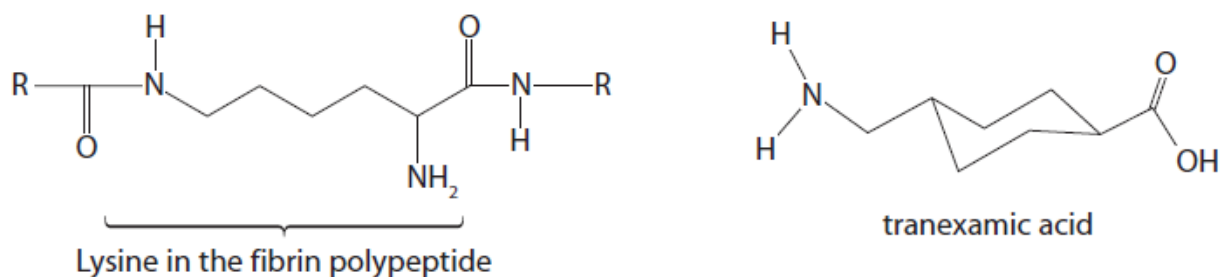


Pharmaceutical companies have developed drugs that inhibit the activity of plasmin.

One of these drugs, tranexamic acid, is used in surgery to reduce blood loss.

The active site of the plasmin enzyme binds to the amino acid lysine on the fibrin protein molecule.

Plasmin binds to part of the fibrin molecule in order to break down the fibrin. The diagrams show the structure of lysine in the fibrin polypeptide and the structure of tranexamic acid.



Deduce why tranexamic acid prevents plasmin breaking down fibrin.

(3)

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(Total for question = 3 marks)

Q19.

Leptin is a protein hormone with a role in the control of appetite in humans.

The leptin gene is located on chromosome 17.

(i) State what is meant by the term gene.

(2)

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(ii) Describe the role of tRNA in the production of leptin.

(3)

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(iii) Describe how the primary structure of leptin enables it to be soluble in water.

(3)

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(Total for question = 8 marks)

Q20.

Leptin is a protein hormone with a role in the control of appetite in humans.

Several mutations of the leptin gene have been identified. All these mutations are frameshift mutations that result in shortened primary structures.

A frameshift mutation involves the insertion or removal of one or two nucleotides from a gene.

Describe how a frameshift mutation could result in the production of leptin with a variety of shorter primary structures.

(2)

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(Total for question = 2 marks)

Q21.

Some species of bacteria have developed resistance to antibiotics.

This has led scientists to investigate many molecules for antimicrobial properties.

Peptides extracted from broad bean plants and cowpea plants have been studied.

Describe how a peptide bond is formed.

(2)

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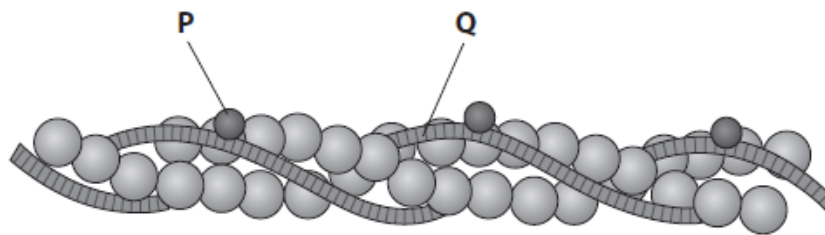
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(Total for question = 2 marks)

Q22.

The diagram shows actin and other components (P and Q) of a thin filament in a myofibril.



(i) Describe the interaction between P and Q that allows muscle contraction.

(2)

(ii) The thick filament in a myofibril contains myosin. The myosin head contains the enzyme ATPase.

Explain the importance of the primary structure for the functioning of this enzyme.

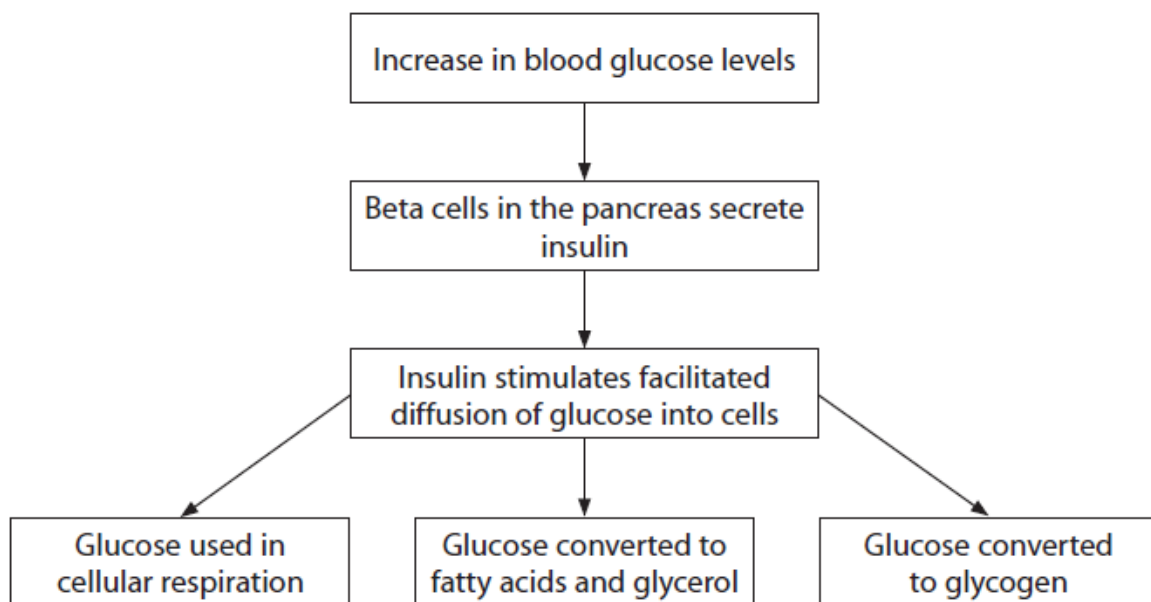
(3)

(Total for question = 5 marks)

Q23.

The internal conditions within the body are maintained by homeostatic mechanisms. The regulation of blood glucose involves homeostatic mechanisms.

The diagram shows part of the sequence of events when there is an increase in blood glucose levels.



(i) Describe how glucose moves into cells by facilitated diffusion.

(2)

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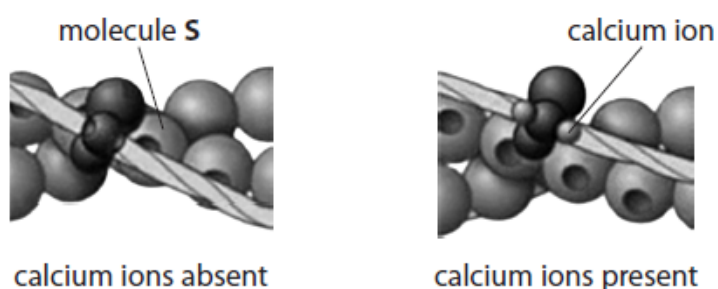
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[illegible]

(Total for question = 5 marks)

Q24.

Muscle cells contain myofibrils. The diagrams show the arrangement of some of the molecules present in a myofibril when calcium ions are absent and when they are present.



Describe how the concentration of calcium ions around the myofibrils is controlled.

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(Total for question = 3 marks)

Q25.

The scientific article you have studied is adapted from several sources.

Use the information from the scientific article and your own knowledge to answer the following questions.

'The hunger system is mediated by hormones from the gut and from fat cells' (paragraph 6).

Describe how these fat cells could release hormones.

(2)

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(Total for question = 2 marks)

Mark Scheme

Q1.

Question Number	Answer	Mark
(i)	The only correct answer is D – the sperm cell releases enzymes that digest the zona pellucida A is not correct because the enzymes are released by the sperm and digest the zona pellucida B is not correct because enzymes are released by the sperm C is not correct because the enzymes digest the zona pellucida	1

Question Number	Answer	Mark		
(ii)	The only correct answer is A – <table><tr><td>one copy of each gene</td><td>different alleles of some genes</td></tr></table> B is not correct because sperm can contain a different allele of a gene C is not correct because sperm will contain one copy of each gene D is not correct because sperm contain one copy of each gene and can have a different allele of some genes	one copy of each gene	different alleles of some genes	1
one copy of each gene	different alleles of some genes			

Q2.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to two of the following: - pyruvate (1) - oxygen (1) - reduced NAD / ADP (1)		(2)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to four of the following: - to stop H^+ diffusing out (of mitochondrion) / into cytoplasm (1) (therefore) maintaining a high concentration (of H^+) in the intermembrane space (1) - so {hydrogen ions / protons / H^+} can move down {concentration / electrochemical} gradient (1) (by) chemiosmosis (1) - to synthesise ATP (1)	ALLOW moves out for diffuses out ALLOW enabling/allowing/establishing formaintaining	(4)

Q3.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: {chemicals in smoke / carcinogens / radiation} can damage DNA (1) - by changing the {DNA base sequence / chromosome number} (1) - with age there have been a greater number of cell divisions (1) - therefore a greater chance of an error (being introduced) in the base sequence of the DNA (during replication) (1)	IGNORE they cause mutations ALLOW 'they damage DNA' ALLOW causing {epigenetic changes / methylation of DNA / acetylation of histones} ALLOW longer period of exposure (to mutagens) ALLOW (with age) there is a greater chance of change in chromosome number	Expert (3)

Q4.

Question Number	Answer	Additional Guidance	Mark
(i)	C (amino acids joined by peptide bonds)		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	A description that makes reference to - carboxyl group / COOH (1) - amine group / NH₂ (1) - R group (1)		(3)

Q5.

Question Number	Answer	Mark
(i)	The only correct answer is A - ligaments only <i>B is not correct because the tendons do not join bones to bones in the elbow joint</i> <i>C is not correct because the tendons do not join bones to bones in the elbow joint</i> <i>D is not correct because the ligaments do join bones to bones in the elbow joint</i>	(1)

Question Number	Answer	Mark
(ii)	The only correct answer is D rows 3 and 4 <i>A is not correct because the tendons showing a change is not a change in genotype</i> <i>B is not correct because the tendons also show a physiological adaptation</i> <i>C is not correct because the tendons showing a change is not a change in genotype</i>	(1)

Question Number	Answer	
* (iii)	Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is relevant. Additional content included in the response must be scientific and relevant. Indicative content Valid because: • {sufficient replicates / 12 individuals} used and a mean calculated • All same gender • Means of both heart rate and blood lactate agree with conclusion • Spread of data (standard deviation / error bars) between cycling and running does not overlap Not valid because: • Insufficient / only 12 individuals involved • Insufficient detail relating to the athletes e.g. they maybe athletes that focus on different sports/have done more than one previous triathlon / more experienced • The three disciplines are always done in the same order / different distances covered • Spread of cycling data (standard deviation / error bars) for blood lactate overlaps with swimming • As no time allowed to recover between sports, some of blood lactate shown for cycling could have been produced during swimming • Agree or not agree with conclusion	(6)

			Additional Guidance
Level 0	Marks	No awardable content	
Level 1	1-2	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Considers one area only e.g. comparing mean data or spread of data only Conclusion based on only one set of data or only one sport considered e.g. cycling is most demanding
Level 2	3-4	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Considers both a valid and an invalid aspect e.g. relevance of spread of data for lactate concentrations overlap in some cases or elements of the study Conclusion given that takes both valid and invalid aspects into account
Level 3	5-6	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	Considers both a range of valid and invalid aspects A conclusion based on a range of considered evidence

Q6.

Question Number	Answer
	Answers will be credited according to candidates' deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Comparisons between phospholipid bilayer and proteins in the cell surface membrane: - judgement about the relative importance of the phospholipid bilayer and the proteins within that bilayer Use of data: - most proteins in the cell are associated with the cell membrane - whilst quantities of phospholipid are the same the proteins have more functions Importance of proteins in the cell surface membrane: - immune response e.g. as antigens and therefore body defence, antibodies, MHC proteins - receptors e.g. receptor proteins on tip of sperm allowing acrosome reaction when encounters zona, for neurotransmitters - regulation e.g. with regards to hormones such as insulin - signal / transcription e.g. transcription factors, secondary messengers - transport e.g. active transport, as channel proteins allowing facilitated diffusion, as {voltage-gated / eq} channels for the nerve impulse / resting potential or / and role of Na⁺-K⁺ pump Importance of phospholipid bilayer in some of: - the role of fluidity and structure of cell the membrane - inhibiting polar substances moving across due to having a hydrophobic component - having both hydrophilic and hydrophobic components which leads to the separation of the aqueous contents of the cell from its aqueous external surroundings - allowing diffusion of gases directly across it - myelin sheath / nerve impulse

Level	Marks	Descriptor	Additional guidance
0		No awardable content	
1	1-3	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Discussion of one type of membrane protein linked to its role May have lots of irrelevant information
2	4-6	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of more than one piece of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Discussion of more than one membrane protein linking them to their function Also discussing the role of phospholipids
3	7-9	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of several pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Good discussion of role of proteins and phospholipids – reaching a judgement Linking role of proteins and phospholipids Number of specific examples of membrane proteins Very little if any irrelevant information

Q7.

Question Number	Indicative content
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Basic information • All the treatment combinations were effective at treating TB • All treatments had some { relapses / individuals with TB } 3 years after treatment • { Group 1 / Groups 1 and 2 / Rifampicin + Pyrazinamide / Rifampicin + Isoniazid } had the lowest number of patients with TB (3 years later) Evidence for linkages made • Percentage relapse varies depending on second part of treatment • Combinations involving Rifampicin most effective • The antibiotics tested act on different targets in bacteria • Gaps in information - not all combinations tested, other combinations might be more effective • Other time scales may have been more effective Evidence for sustained scientific reasoning • Could be other reasons for infections with TB 3 years later not due to the antibiotic treatment • No information about dormant TB (only percentage of active cases) • Bacterial RNA polymerase possibly the best target for antibiotics • Antibiotics targeting synthesis of cell wall fatty acids least effective in terms of relapses • Idea of combination of antibiotics with different mode of activity most effective

Level	Mark	Descriptor	
Level 0	Marks	No awardable content	
Level 1	1-2	An answer may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The answer will contain basic information with some attempt made to link knowledge and understanding to the given context.	Reference to effectiveness of different combinations of antibiotics.
Level 2	3-4	An answer will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The answer shows some linkages and lines of scientific reasoning with some structure.	Reasons for differences in effectiveness considered.
Level 3	5-6	An answer is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The answer shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	Information about action of antibiotics related to effectiveness. Evaluation of study design considered.

Q8.

Question Number	Answer	Additional Guidance	Mark
(i)	C (significant and positive)		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: - greater number of cell divisions means more opportunities for errors in DNA replication (1) - more mutations result in greater chance of cancer (1)		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	- correct risks identified (1) - correct calculation (1)	0.08 and 0.004 <u>Example of calculation:</u> $0.08 \div 0.004$ $= 20.0$ Allow full marks for correct answer with no working	(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iv)	An explanation that makes reference to two of the following: - cigarettes { are an environmental risk factor / contain carcinogens } (1) - that increases the number of mutations in cells (1) - resulting in uncontrolled cell division (1)	Accept description of how mutations arise	(2)

Q9.

Question Number	Answer
*	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. <u>Indicative content</u> Adult screening advantages and disadvantages - Identifies risk of developing a particular disease in the future so choices can be made e.g. extra screening for breast cancer or preventative mastectomy/screening and lifestyle changes for some types of CVD - Identification of carriers so choices can be made about family planning – both partners tested, risk can be identified and have prenatal screening - May not want to know if you have a high likelihood of developing a disease, if one person is tested it may give other family members information they would chose not to know, may potentially affect life insurance

	Prenatal screening advantages and disadvantages - Amniocentesis – prepares parents for child with disease/gives choice of abortion - Chorionic villus sampling – as amniocentesis, carried out earlier in pregnancy - Some of the conditions tested for are very unpleasant and may be life limiting - NIPD non-invasive, less traumatic procedure, no increased risk of miscarriage - PGD only implant healthy embryos, do not have to make decision about abortion - Both amniocentesis and CVS carry increased risk of miscarriage, especially CVS (although it can be carried out earlier in the pregnancy) - Can't cure the disease, only choice is to have an abortion-not acceptable to everyone - For conditions such as CF, where there is more than one possible mutation, test is only for most common mutations so there may be false negatives - NIPD currently only available for chromosome disorders such as Down's syndrome - PGD involves IVF, which can be emotionally traumatic and only has about 30% success rate - All pre-natal screening has a risk of false positives with abortion of a healthy fetus. - Procedures involving IVF can be regarded as unethical because many embryos are discarded - Invasive nature of some of the tests
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Level	Mark	Descriptor	Additional Guidance
0	Mark	No awardable content	
1	1-2	Limited scientific judgement made with a focus on one side of the argument only. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made.	Only considered one benefit or one risk without further explanation beyond a brief description. A generalised discussion without focusing on the details of specific types of screening
2	3-4	A scientific judgement is made through the application of relevant evidence to both sides of the argument. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made.	Considers at least two types of screening One advantage and one disadvantage of each type of screening discussed.
3	5-6	A scientific judgement is made, which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made.	Advantages and disadvantages of blood tests and pre-natal tests discussed fully. Discussion of blood tests to identify adults with genetic disorders. Conclusion or judgement made, e.g. identifying genetic disorders by blood tests in adults is better as the disadvantages have less impact than disadvantages of genetic testing on embryos / fetuses.

Q10.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to: - no (in row two) (1) - some (in row five) (1)		(2)

Q11.

Question Number	Answer	Additional Guidance	Mark
(i)	A answer that makes reference to the following: {alternative form / different form / version / variation} of a gene (1)	IGNORE type of gene	1

Question Number	Answer	Additional Guidance	Mark
(ii)	- correct use of Hardy-Weinberg equation (1) - correct calculation of probability of each homozygote (1) - correct answer (1)	<u>Example of calculation</u> $p^2 + 2pq + q^2 = 1$ $p^2 =$ either 0.185 or 0.325 $q^2 =$ either 0.325 or 0.185 or $2pq = 0.43 \times 0.57 \times 2 = 0.4902$ frequency = 50.98 % / 51% (which is greater than 50%) Correct answer with no working gains full marks	3

Q12.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: - thinner blood-gas barrier (1) - because of thinner { alveolar walls / capillary walls / extracellular matrix layer } (1) - therefore a reduced diffusion distance (1) - a faster rate of { diffusion / gas exchange } (1)	ALLOW greater rate	3

Q13.

Question Number	Answer	Additional Guidance	Mark
	- width of X to Y $\div$ magnification (1) - correct answer with appropriate units (1)	<u>Example of calculation</u> 50(mm) $\div$ 5 000 000 / 5(cm) $\div$ 5 000 000 10 nm / 0.01 μm	(2)

Q14.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: - less oxygen available for aerobic respiration (1) - deoxygenated blood mixes with oxygenated blood (1) - therefore reducing the concentration of oxygen in the blood circulating in the body (1) - because some deoxygenated blood {does not leave right ventricle / is transferred to the left ventricle / does not go to the lungs / goes to the respiring tissues} (1)	ALLOW lack of oxygen leads to (some) anaerobic respiration ALLOW some oxygenated blood {does not leave left ventricle / is transferred to the right ventricle / does not go to the respiring tissues / goes to the lungs}	(3)

Q15.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to three of the following: Differences: - only actin has a tertiary structure (1) - collagen has three chains whereas an actin (filament) has one chain (1) Similarities: - both are made up of (a sequence of) amino acids joined together by peptide bonds (1) - both have a secondary structure / both have { more than one polypeptide chain / a quaternary structure } (1)		(3)

Q16.

Question Number	Answer	Mark
	B - lowering the activation energy of a reaction <i>The only correct answer is B</i> <i>A is incorrect because enzymes do not increase activation energy</i> <i>C is incorrect because enzymes do not provide energy to reactants</i> <i>D is incorrect because enzymes do not remove energy from reactants</i>	(1)

Q17.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: - decreases betalain concentration (in the cells) (1) - due to betalain {diffusing out / moving down a concentration gradient} (1) (because) the alcohol increases membrane permeability (1) - membrane {lipids/ phospholipids} dissolve in alcohol (1)	IGNORE reference to cell wall	(3) Exp

Q18.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: - tranexamic acid has a (very) similar {structure / shape} to lysine - tranexamic acid { binds to the active site on plasmin / acts as a competitive inhibitor } - stopping plasmin binding to { fibrin / lysine }	ALLOW preventing plasmin and fibrin forming enzyme – substrate complex	(3)

Q19.

Question Number	Answer	Additional Guidance	Mark
(i)	An answer that makes reference to the following: - sequence of {bases / nucleotides} in DNA - that codes for the {primary structure / amino acid sequence / polypeptide}	ALLOW that codes for a protein	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	A description that makes reference to the following: - tRNA molecules {transport amino acids to the ribosome} - tRNA molecule has an anticodon that {binds to / recognises} a codon on the mRNA - each tRNA carries a particular amino acid	ALLOW the amino acid on the tRNA is determined by the anticodon	(3)

Question Number	Answer	Additional Guidance	Mark
(iii)	A description that makes reference to three of the following: {primary structure / sequence of the amino acids} determines the folding (of the polypeptide) - forming a globular structure - hydrophobic (R) groups located in the centre of the protein / hydrophilic (R) groups located on the outside of the protein - water forms hydrogen bonds with { protein / hydrophilic groups}	ALLOW position of R groups ALLOW determines tertiary structure ALLOW polar for hydrophilic / non-polar for hydrophobic ALLOW dipole-dipole / hydrophilic interactions (between water and the protein)	(3)

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to two of the following: • (adding or removing one or two nucleotides) changes the triplet code • introducing a new {start / stop} codon • coding for a shorter sequence of amino acids (1)	ALLOW different codons produced (1) ALLOW one amino acid shorter	(2)

Q21.

Question Number	Answer	Additional guidance	Mark
	A description that makes reference to the following: • (a peptide bond is formed by a) condensation reaction (1) • between the {amine group / NH₂} and the {carboxyl group / COOH} of adjacent amino acids (1)	ALLOW 'amino' for 'amine' and 'carboxylic acid' for 'carboxyl'	(2)

Q22.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to the following: • { P / troponin } changes shape (1) • causing { Q / tropomyosin } to move away from the myosin-binding sites (on actin) (1)	ALLOW P binds with calcium ions ALLOW Q is displaced away from myosin binding sites	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: (primary structure) determines interaction between {amino acids / R groups} (1) (primary structure) determines { folding / tertiary structure } (1) (therefore) affecting the shape of the active site (1) (active site is) complementary to ATP (1)	e.g. bonds formed between R groups ALLOW 3D shape ALLOW ATP fits active site	(3)

Q23.

Question Number	Answer	Additional Guidance	Mark
(i)	A description that makes reference to two of the following: - carrier protein (in cell surface membrane) (glucose moves from) high to low concentration - glucose binds to (carrier) protein / (carrier) protein changes shape to move glucose (across the membrane) (1)	IGNORE channel protein ALLOW 'down a concentration gradient'	(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: - polymer of glucose - to provide glucose for respiration {branched / contains 1,6-glycosidic bonds / has many terminal ends} for rapid hydrolysis - compact to allow large amount (of glucose / energy) to be stored in a small space / insoluble therefore no osmotic effect on cells	ALLOW polysaccharide /made of many glucose monomers DO NOT ALLOW β- glucose IGNORE 'easy to hydrolyse' ALLOW break down instead of hydrolyse	(3)

Q24.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to three of the following points: - calcium ions released from sarcoplasmic reticulum (1) - in response to { nerve impulse / action potential / depolarisation } (at neuromuscular junction) (1) - calcium channels open (to allow calcium ions to cross the membrane / enter the sarcoplasm) (1) - calcium ions taken back up into the sarcoplasmic reticulum by active transport (1)	ALLOW Ca^{2+} for calcium ions ALLOW calcium ions moving through channel protein	(3)

Q25.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to the following: - vesicles (containing hormone) (1) - fuse with the cell (surface) membrane (of fat cells) / by exocytosis (1)		(2)

Q1.

The scientific article you have studied is adapted from several sources.

Use the information from the scientific article and your own knowledge to answer the following questions.

'The hunger system is mediated by hormones from the gut and from fat cells' (paragraph 6).

Describe how these fat cells could release hormones.

(2)

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(Total for question = 2 marks)

Q2.

The movement of materials into and out of a cell needs to be controlled.

Describe what is meant by the term **fluid mosaic** with reference to cell membranes.

(2)

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Q3.

Hereditary spherocytosis is a condition that affects red blood cells.

Most cases of hereditary spherocytosis are caused by a dominant allele.

Use a genetic diagram to determine the probability of a child inheriting this condition if one parent is heterozygous and the other parent does not have the condition.

(2)

Answer

(Total for question = 2 marks)

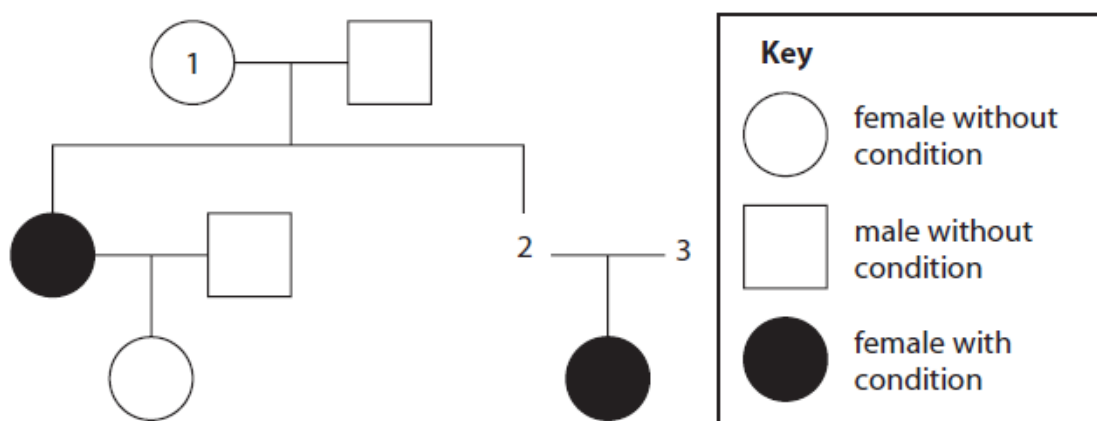
Q4.

Mucopolysaccharides are complex molecules found in the human body.

Mucopolysaccharidosis type 1 (MPS 1) is a recessive genetic condition.

People with MPS 1 cannot break down mucopolysaccharides.

The pedigree diagram shows the inheritance of MPS 1 in a family.



Determine the probability that person 2 has the same sex and MPS 1 phenotype as person 1.

(4)

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(Total for question = 4 marks)

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(Total for question = 6 marks)

Q6.

An experiment was carried out to determine the effect of temperature on the activity of the enzyme catalase in yeast cells.

The substrate was hydrogen peroxide. A suspension of yeast cells was added to hydrogen peroxide.

The volume of oxygen produced during the initial two minutes was recorded. This was repeated at a range of temperatures.

The results are shown in the table.

Temperature / °C	Mean volume of oxygen / mm ³
20	80
30	240
40	540
50	320
60	120

(i) Calculate the temperature coefficient (Q_{10}) for this reaction between 20 °C and 30 °C.

(1)

Answer

(ii) Explain the effects of a temperature increase from 20 °C to 30 °C on the initial rate of activity of catalase in the yeast cells.

(3)

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(iii) Explain what happens to the Q_{10} value between 40 °C and 50 °C.

(2)

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(Total for question = 6 marks)

Q7.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Batten disease is a rare, inherited disorder of the nervous system. It usually begins in childhood. It is a recessive disorder.

(i) Parents without Batten disease have a child with Batten disease.

Which of the following describes the genotype of the parents?

(1)

☐ **A** bb and Bb

☐ **B** Bb and Bb

☐ **C** BB and BB

☐ **D** BB and bb

(ii) Draw a genetic diagram to show the probability of their future children developing Batten disease.

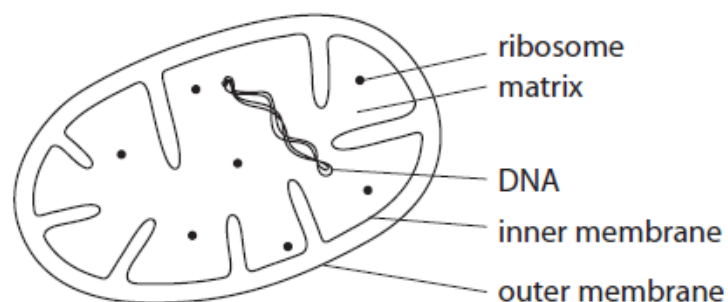
(2)

(Total for question = 3 marks)

Q8.

Mitochondria are organelles found in eukaryotic cells.

The diagram shows a mitochondrion.



Mitochondrial diseases are caused by mutations in the DNA of the mitochondria.

One type of mitochondrial disease is caused by the production of defective ATP synthase.

(i) Explain how a mutation in the mitochondrial DNA could result in defective ATP synthase being produced.

(3)

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(ii) Mitochondrial myopathy is a mitochondrial disease. The symptoms of this disease vary in severity.

The table shows the relationship between the percentage of mitochondria with mutated DNA in parents and the severity of the symptoms in their child.

Percentage of mitochondria with mutated DNA in the mother (%)	Percentage of mitochondria with mutated DNA in the father (%)			
	0	20	50	80
0	No symptoms	No symptoms	No symptoms	No symptoms
20	No symptoms	No symptoms	No symptoms	No symptoms
50	Mild symptoms	Mild symptoms	Mild symptoms	Mild symptoms
80	Severe symptoms	Severe symptoms	Severe symptoms	Severe symptoms

Explain the effects that the percentage of mitochondria with mutated DNA in the parents has on the severity of symptoms in their child.

(3)

Q9.

The Atlantic tomcod is a fish found in the rivers of North America.

The photograph below shows an Atlantic tomcod.



Magnification $\times 1$

Atlantic tomcod in the Hudson River are able to survive high levels of polychlorinated biphenyls (PCBs). PCBs enter the water from industrial processes.

One group of scientists identified a mutation in the DNA of these fish. They found that the AHR2 gene had six bases missing. This mutation was rarely found in Atlantic tomcod in the unpolluted St. Lawrence River.

(a) Suggest how scientists in other countries learnt of these findings.

(2)

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*(b) (i) Describe how the DNA and protein of Atlantic tomcod from the Hudson River could be compared with the DNA and protein of Atlantic tomcod from the St. Lawrence River.

(6)

This image shows a full page of white paper with horizontal ruling lines. The lines are evenly spaced and extend across the width of the page, typical of notebook or legal stationery. There are no margins, text, or other markings present.

(ii) Suggest **one** similarity in the DNA of the Atlantic tomcod from these two rivers.

Give an explanation for your answer.

(2)

[illegible]

(iii) Suggest **one** difference in the protein of the Atlantic tomcod from these two rivers.

Give an explanation for your answer.

(2)

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(Total for question = 12 marks)

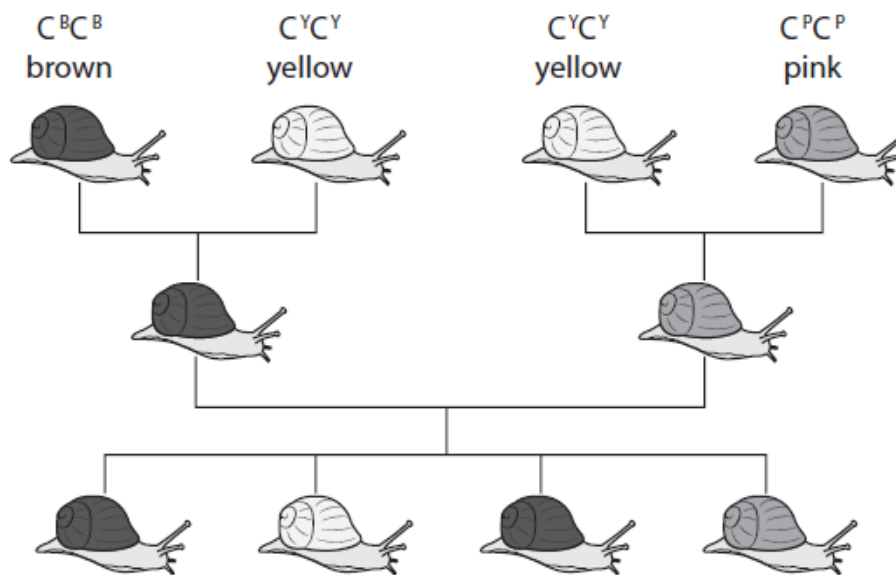
Q10.

The shell colour of the banded snail can be yellow, pink or brown.

A single gene controls shell colour in the banded snail.

There are three alleles for this gene, C^Y , C^P , and C^B .

The effects of these alleles on shell colour is shown in the genetic pedigree diagram.



Deduce the dominance of the alleles for shell colour.

(2)

(Total for question = 2 marks)

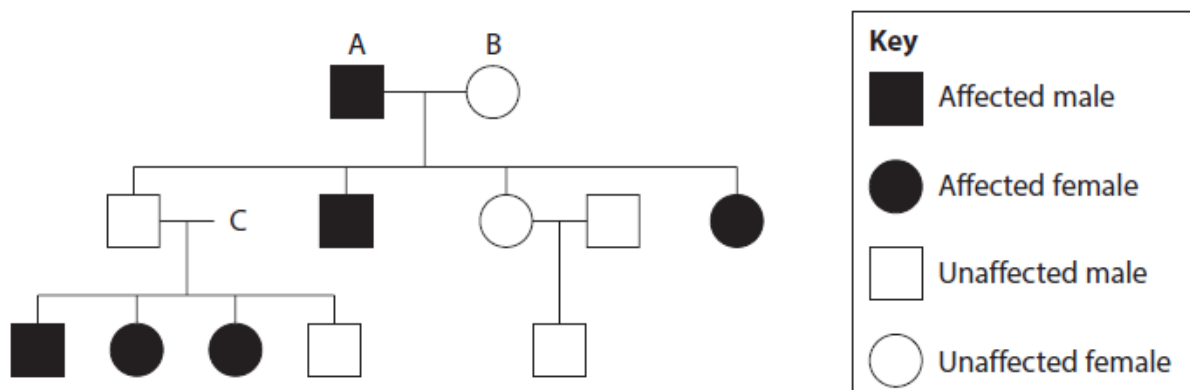
Q11.

Porphyria is a life-threatening genetic disease. It is caused by a mutation in the gene coding for an enzyme involved in the production of haem.

In people with porphyria, haem cannot be produced.

Porphyria is caused by a dominant allele and may not develop until later in life.

The pedigree diagram shows a family in which some individuals have porphyria.



(i) State the genotype and phenotype of person C.

(1)

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(ii) Person A and Person B have one son with porphyria. What was the probability of them having a child that was male and had porphyria?

(1)

- ☐ **A** 0.00
- ☐ **B** 0.25
- ☐ **C** 0.50
- ☐ **D** 1.00

(Total for question = 2 marks)

Q12.

The phenotype of an organism can be influenced by a variety of factors.

Phenotypic plasticity is the mechanism that many organisms use to phenotypically alter due to a change in environmental conditions.

An investigation to study phenotypic plasticity was carried out using a species of freshwater snail.

Newly hatched freshwater snails were used. These snails were divided into three groups and each group was placed in a tank with a different set of conditions.

Three different conditions were used. One was a control and the other two are described in the table.

Condition	Description
A	In water taken from a tank containing predator fish that had eaten some of the snails
B	In water in a tank exposed to ultraviolet light (UV)

(a) Describe a suitable control to be used with the third group of snails.

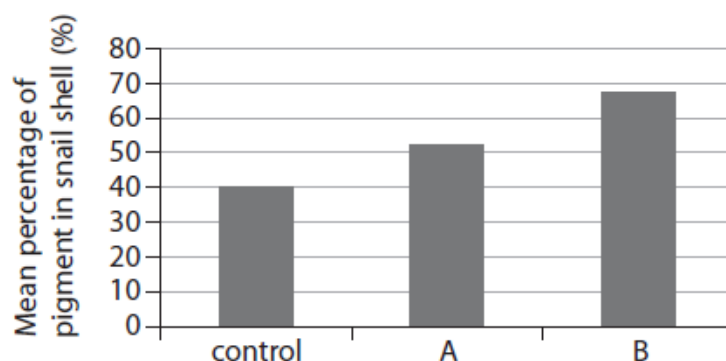
(2)

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(b) The snails were allowed to grow for eight weeks and then the mean percentage of pigment in the snail shells was assessed for each group. The results are shown in the graph.



(i) Scientists predicted that the snails exposed to both UV light and water from a tank of predator fish would have 80% shell pigmentation.

Explain how this prediction was made.

(2)

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(ii) It is thought that an increase in shell pigmentation levels provides protection against UV light. UV is a form of radiation that can damage DNA.

Explain how the DNA of the snail could be damaged.

(2)

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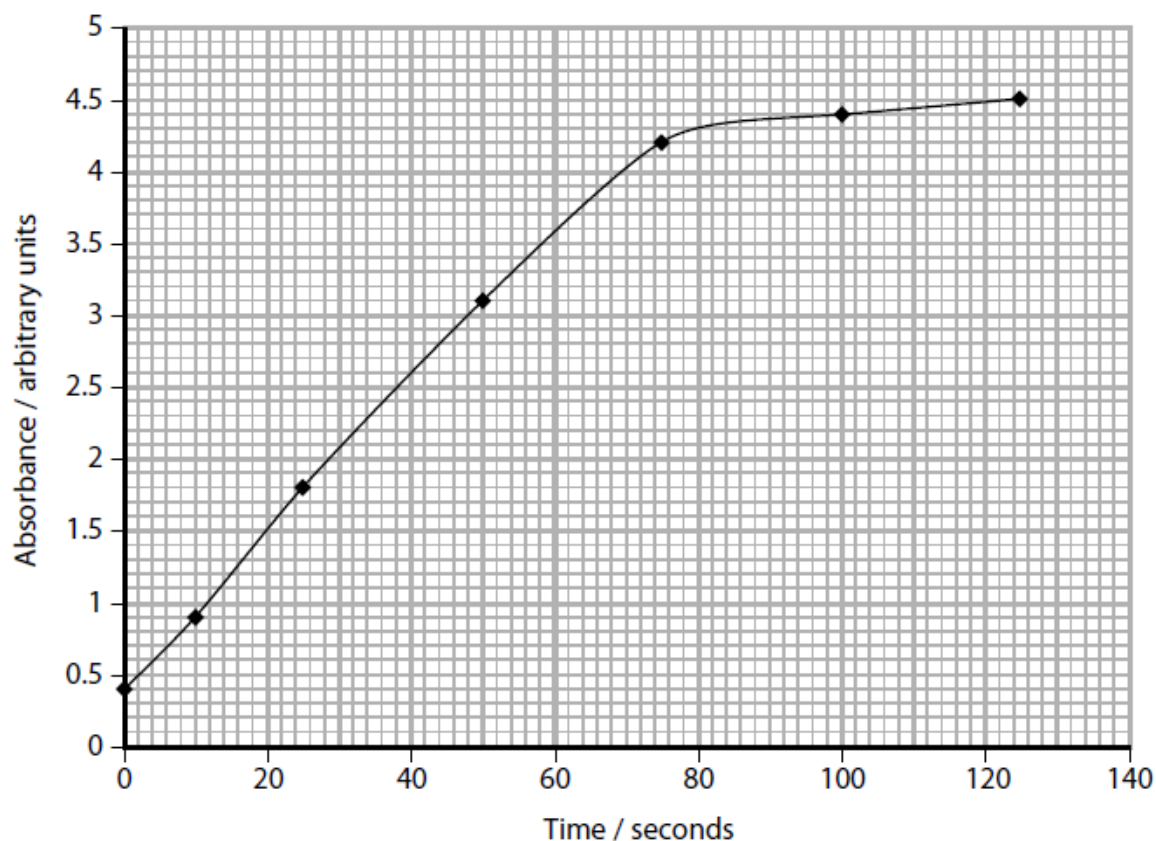
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Q13.

L-dopa forms a colourless solution in water. Dopa oxidase is an enzyme that converts L-dopa into dopachrome, which is red.

A colorimeter can be used to study this reaction. As the red colour appears, the amount of light absorbed by the solution increases.

(a) The graph shows the course of a reaction in which there was an enzyme concentration of 20 (arbitrary units) of reaction mixture.



Calculate the initial rate of reaction for this concentration of enzyme.

(3)

Answer

(b) In another study, a student used this procedure with a range of enzyme concentrations. The results are shown in the table below.

Enzyme concentration / arbitrary units	Initial rate of reaction / absorbance s ⁻¹
0	0.0
10	2.5
30	6.1
50	9.0
70	11.0
90	11.0

Explain the effect of enzyme concentration on the initial rate of this reaction.

(3)

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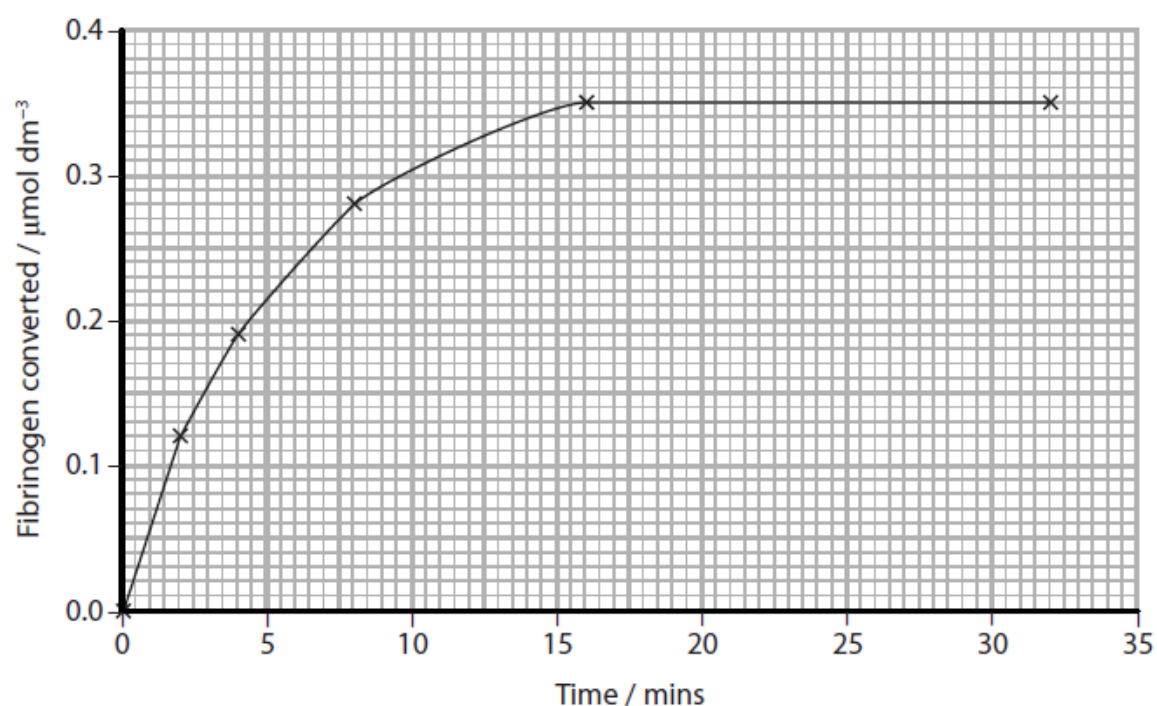
(Total for question = 6 marks)

Q14.

Fibrin is involved in the formation of blood clots.

Thrombin is an enzyme that converts fibrinogen to fibrin.

The graph shows the effect of one concentration of thrombin on the conversion of fibrinogen to fibrin.



(i) Calculate the initial rate of reaction.

(2)

Answer

(ii) On the graph, draw a line to show the effect of halving the concentration of thrombin.

(1)

(iii) Explain the effect of changes in the initial rate of reaction on the time taken for a blood clot to form.

(2)

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(Total for question = 5 marks)

Q15.

Emphysema is a condition that causes changes to the tissues in the lungs.

In an investigation, the surface area for gas exchange and the volume of the lungs of three groups of individuals were determined. The results are shown in the table.

Measurement	Individuals without emphysema	Individuals with mild emphysema	Individuals with severe emphysema
Mean surface area for gas exchange / m ²	118 ± 11	97 ± 8	30 ± 5
Mean total lung volume / cm ³	4772 ± 223	6232 ± 410	6725 ± 384
Mean surface area for gas exchange : volume ratio	247.3 : 1		44.6 : 1

(i) Calculate the mean surface area for gas exchange : volume ratio for individuals with mild emphysema.

(2)

Answer

(ii) There appears to be a difference in the lung volume of individuals with mild emphysema and those with severe emphysema.

Which of the following would be a relevant statistical test to determine whether this difference is significant?

(1)

- ☐ **A** chi-squared
- ☐ **B** correlation coefficient

☐ C standard deviation

☐ D Student's t-test

(iii) Give reasons for the variation in the lung volumes of healthy individuals.

(2)

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(iv) Give a reason for calculating the surface area for gas exchange to volume ratio in this investigation.

(1)

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(Total for question = 6 marks)

Q16.

The scientific article you have studied is adapted from an article from '*The Scientist*'.

Use the information from the scientific article and your own knowledge to answer the following questions.

Explain how cyanobacteria evolved to 'handle high temperatures' (paragraphs 14 and 15).

(5)

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[illegible]

(Total for question = 5 marks)

Q17.

The scientific article you have studied is adapted from *The Biologist*.

Use the information from the scientific article and your own knowledge to answer the following question.

Mice used in research have a number of limitations (paragraph 6). Mice that are homozygous for a recessive trait are rare in the population, but can be produced in genetic crosses.

Explain how genetic crosses could be used to generate a mouse line expressing a recessive trait.

(3)

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(Total for question = 3 marks)

Q18.

Goblet cells lining the bronchi produce mucus. This mucus is released by exocytosis.

Explain how goblet cells release mucus by exocytosis.

(2)

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Q19.

All cells have a cell surface membrane.

Explain how phospholipids form a cell surface membrane.

(3)

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(Total for question = 3 marks)

Q20.

Glucosaminoglycans (GAGs) are the by-products of chemical reactions inside cells. GAGs are broken down by enzymes inside lysosomes in cells.

Mucopolysaccharidosis type I (MPS I) is a genetic condition that results in the build-up of GAGs inside cells.

MPS I affects the production of enzyme G that breaks down GAGs inside lysosomes.

More than 50 different mutations in the gene for enzyme G have been found to result in MPS I. Most of these mutations involve changing a single base in the gene.

(i) Explain how a single base mutation can lead to an altered primary structure of enzyme G.

(3)

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(ii) Explain how human genome sequencing can be used to identify the mutations associated with MPS I.

(3)

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(Total for question = 6 marks)

Q21.

Batten disease is a rare, inherited disorder of the nervous system. It usually begins in childhood. It is a recessive disorder.

Explain what is meant by an inherited recessive disorder.

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(Total for question = 2 marks)

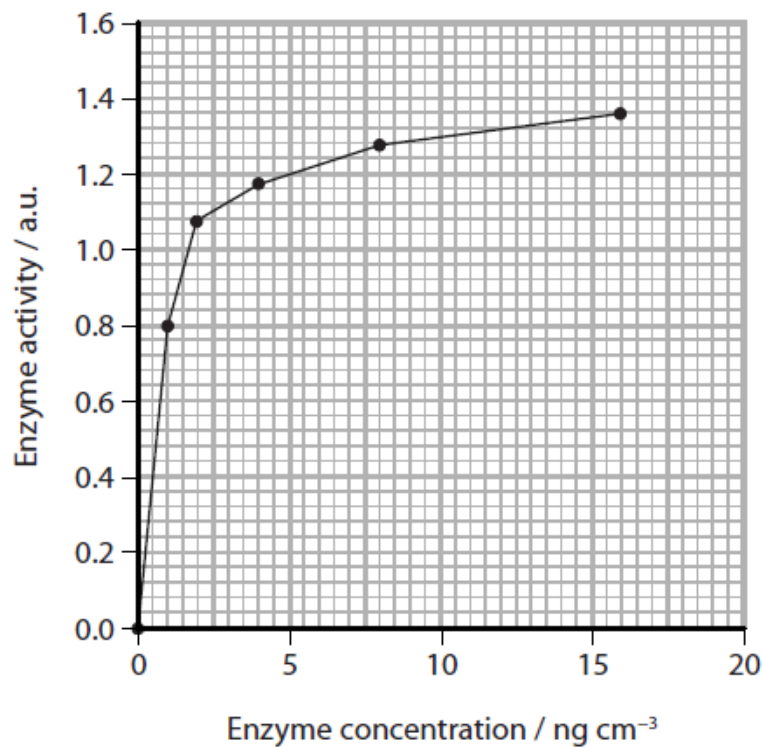
Q22.

Trypsin is an enzyme found in many groups of living organisms.

Trypsin specifically acts on a polypeptide to form amino acids.

In an experiment, the effect of enzyme concentration on the activity of human trypsin was measured.

The results are shown in the graph.



Explain which range of enzyme concentrations should be used to compare the activity of trypsin from different species.

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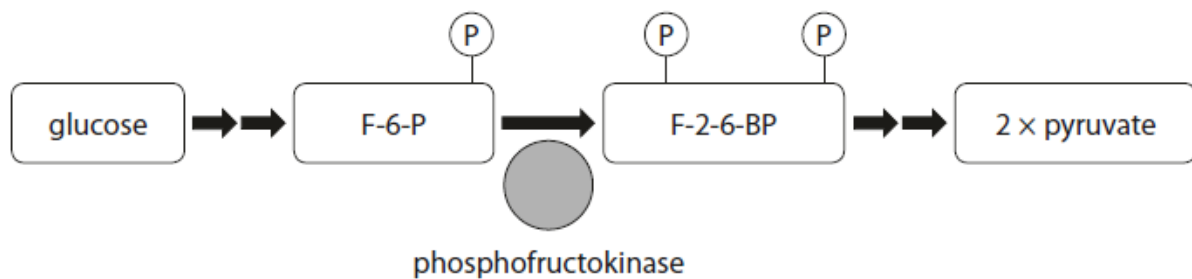
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(Total for question = 2 marks)

Q23.

Phosphofructokinase is an enzyme that uses ATP to convert fructose-6-phosphate (F-6-P) into fructose-2,6-bisphosphate (F-2,6-BP).

The conversion of F-6-P by this enzyme is a rate-determining step in glycolysis. This is shown in the diagram.



(i) Explain why ATP is required for this reaction.

(3)

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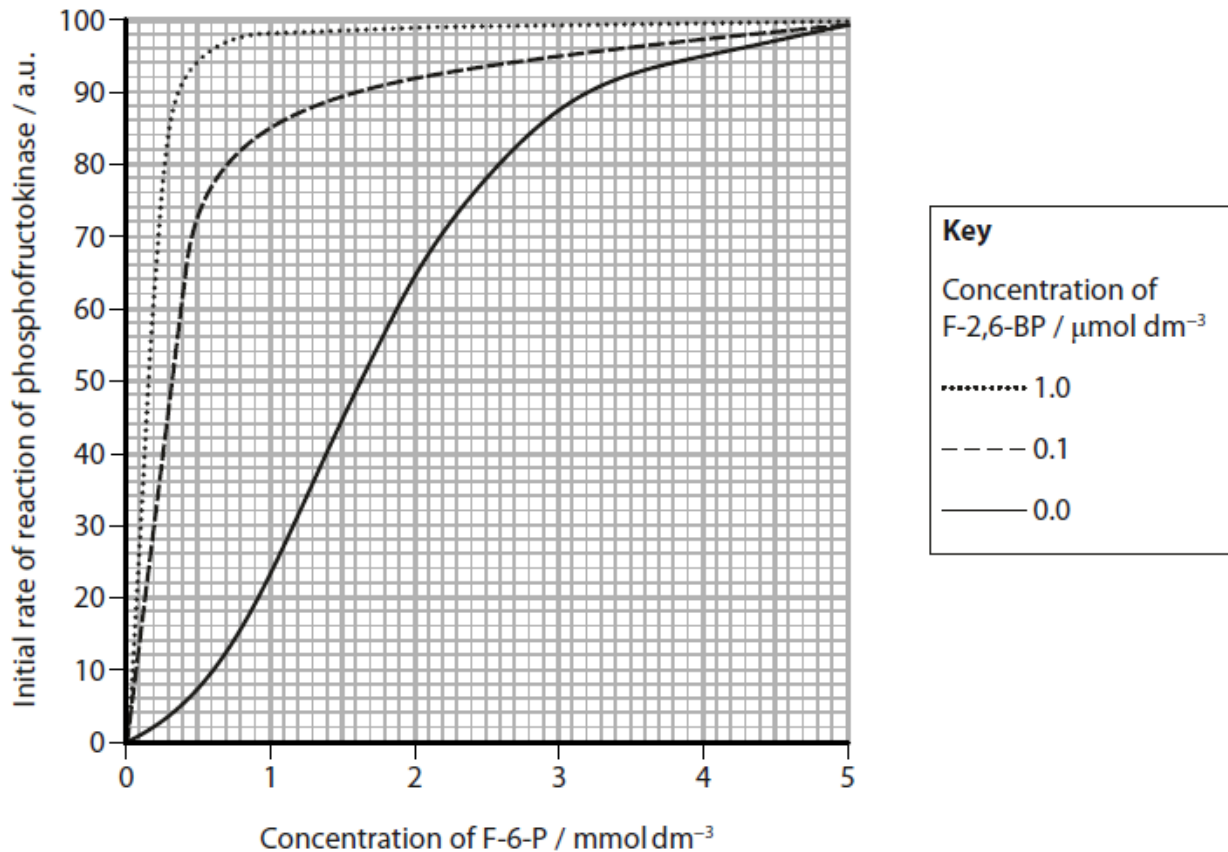
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The effect of substrate concentration on the initial rate of reaction of phosphofructokinase was investigated.

This investigation was repeated with the addition of two concentrations of F-2,6-BP.

The graph shows the results of this investigation.



Comment on the effects of F-6-P and F-2,6-BP concentrations on the rate of glycolysis.

(3)

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(Total for question = 6 marks)

Q24.

Cystic fibrosis is a condition that affects breathing.

Explain why cystic fibrosis affects the rate of oxygen uptake in the lungs.

(3)

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(Total for question = 3 marks)

Q25.

Emphysema is a condition that causes changes to the tissues in the lungs.

In an investigation, the surface area for gas exchange and the volume of the lungs of three groups of individuals were determined. The results are shown in the table.

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Mean surface area for gas exchange : volume ratio	247.3 : 1		44.6 : 1

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to the following: • vesicles (containing hormone) (1) • fuse with the cell (surface) membrane (of fat cells) / by exocytosis (1)		(2)

Q2.

Question Number	Acceptable Answer	Additional Guidance	Mark
	A description that makes reference to the following: • fluid refers to the movement of the phospholipids in the plane of the membrane (1) • mosaic refers to the random association of proteins (of different shapes and sizes) within the membrane (1)		(2)

Q3.

Question Number	Answer	Additional guidance	Mark									
	An answer that makes reference to the following • correct genetic diagram used to determine genotypes of offspring (1) • correct probability 0.5 linked to correct genotypes of offspring (1)	e.g. <table><tr><td></td><td>S</td><td>s</td></tr><tr><td>s</td><td>Ss</td><td>ss</td></tr><tr><td>s</td><td>Ss</td><td>ss</td></tr></table> Ss and ss ALLOW 50% / ½ / 1 in 2		S	s	s	Ss	ss	s	Ss	ss	(2)
	S	s										
s	Ss	ss										
s	Ss	ss										

Q4.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: 0.5 probability for being { same sex / female } (1) - person 1 is heterozygous for MPS 1 (1) (therefore) person 2 has a 0.75 probability of having same phenotype as person 1 for MPS 1 (1) - therefore probability of being female and not having MPS 1 will be 0.375 (1)	ALLOW 50% for 0.5 ALLOW detail of proof of phenotype of person 1 e.g. does not show condition therefore has to have one dominant allele but (at least) one daughter has condition so received a recessive allele from person 1 ALLOW carrier for heterozygous ALLOW 75% for 0.75 ALLOW $\frac{3}{8}$ or 37.5% for 0.375	(4)

Q5.

Question Number	Answer	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content For DNA • Double stranded so more stable • Allows for a template strand • Larger as includes promotor / site for transcription factors to bind For mRNA • Ribose rather than deoxyribose <u>and</u> uracil rather than thymine • Smaller as not bound to other genes / fewer bases (minimum of 396) • So can {exit the nucleus / move through the nuclear pore} • Single-stranded • So {bases / codon} exposed to (tRNA's with) complementary anticodons / bases can bind • Amino acids {brought/joined} in the correct sequence • Removal of introns / post-transcriptional modification	(6) Exp

Level 0	Marks	No awardable content	Additional guidance
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.	Basic description of differences between DNA and mRNA
Level 2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.	Reasons provided for differences in structure of DNA and mRNA.
Level 3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information.	Explanation for differences in the gene described and the mRNA – greater number of bases in DNA than in the mRNA.
		The explanation shows a well-developed and sustained line of	

		scientific reasoning which is clear and logically structured.	Reference to removal of introns and post transcriptional changes to RNA before it is translated.
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Q6.

Question Number	Answer	Additional guidance	Mark
(i)	correct calculation of Q_{10} value	<u>Example of calculation</u> $(240 \div 80 =) 3$	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to three of the following: (between 20 °C and 30 °C) there is more kinetic energy available (1) - therefore there will be more frequent collisions (between enzyme and substrate) (1) - more enzyme-substrate complexes formed (1) (the Q_{10} value indicates) the activity triples with the 10 °C temperature rise (1)	ALLOW more frequent collisions between catalase and hydrogen peroxide	(3)

Question Number	Answer	Additional guidance	Mark
(iii)	An explanation that makes reference to two of the following: Q_{10} value is less than 1.0 (1) - because the enzyme is denatured (1) - therefore no increase in formation of enzyme-substrate complexes / substrate no longer fits active site (1)	ALLOW Q_{10} value of 0.59 ALLOW fewer enzyme-substrate complexes formed	(2)

Q7.

Question Number	Answer	Mark
(i)	The only correct answer is B Bb and Bb A is not correct because the parent who is bb would have Batten disease C is not correct because neither parent has the b allele D is not correct because the parent who is bb would have Batten disease and the parent who is BB would not have the b allele	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to the following: - correct genetic diagram with reference to offspring genotypes (1) - correct probability of inheriting Batten disease (1)	e.g. BB, Bb, Bb and bb 1 in 4 / 25% / 0.25 IGNORE ratios	(2)

Q8.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following: • a (random) change in the sequence of bases in the DNA (1) • involving { deletion / substitution / addition } of a base (1) • this affects the triplet code / changes sequence of amino acids in the enzyme molecule (1) • change in shape of active site (1)		(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • the severity of symptoms is related to the proportion of mitochondria with damaged DNA in the mother only (1) • because (the child's mitochondria) are derived from the { oocyte / egg cell } (1) • mitochondria in sperm do not enter the egg on fertilisation (1)		(3)

Q9.

Question Number	Answer		Mark
(a)	1. {scientific / peer reviewed} {papers / journals / magazines / article} ; 2. (scientific) {conferences / lecture / forums} ; 3. media reports ;	3. e.g. TV, radio. newspaper ' internet	(2)

Question Number	Answer	Additional Guidance	Mark
* (b)(i)	(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence)	QWC focussing on spelling	
	1. idea of using <i>proteomics</i> (to study protein); Any 5 from : 2. idea of using DNA {<i>profiling / fingerprinting</i>} (to study DNA) ; 3. idea of obtaining {<i>tissue / cell</i>} sample from tomcod ; 4. multiple copies of DNA made / eq ; 5. using {PCR / <i>polymerase chain reaction</i>} ; 6. ref to <i>restriction</i> {<i>enzymes / endonucleases</i>} to produce DNA {<i>fragments / eq</i>} ; 7. reference to (<i>gel</i>) <i>electrophoresis</i> ; 8. idea of {loading / eq} the DNA onto the {<i>gel / named gel</i>} ; 9. idea that an {<i>electric current / charge</i>} is applied ; 10. reference to use of {<i>dye / fluorescent staining / UV light / Southern blotting / gene probes / radioactive labelling / eq</i>} ;	4. IGNORE refs to amplification, large amounts 8. e.g. <i>agarose, agar</i> 9. ACCEPT apply <i>potential difference</i>	(6)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	1. same number of chromosomes ; 2. idea that the mutation affected the sequence of DNA ; OR 3. idea that (all / most of) the {bands / eq} are the same (size / position / width) ; 4. idea that only {a small region of DNA / the AHR2 gene} is affected ;	1. ACCEPT both contain AHR2 gene	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	1. a protein with a different {structure / amino acids / function} / eq ; 2. idea that the mutation will affect the DNA ;	1. ACCEPT two AAs missing 2. e.g. two codons missing	(2)

Q10.

Question number	Answer	Additional guidance	Mark
	An answer that makes reference to the following: {C^B / C^P} is dominant and C^Y is recessive - the order of dominance is C^B over C^P over C^Y	ALLOW C ^B is dominant over C ^P / C ^P is dominant over C ^Y / C ^B is dominant over C ^Y ALLOW brown is dominant to yellow and pink / pink is dominant to yellow ALLOW both marks if correct order of dominance stated	(2)

Q11.

Question Number	Answer	Additional guidance	Mark
(i)	• (the genotype is) heterozygous and (the phenotype is) affected with the disease (1)	ALLOW any upper case and lower case letter to show heterozygous e.g. Pp IGNORE male/female	Graduate (1)

Question Number	Answer	Additional guidance	Mark
(ii)	The only correct answer is B 0.25 A, C and D are not correct.		Computer (1)

Q12.

Question Number	Acceptable Answer	Additional Guidance	Mark
(a)	A description that makes reference to the following: • no UV (1) • water added but not from tank with fish in it that have eaten snails (1)		(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	An explanation that makes reference to the following: • calculating increase above control for 'fish' and for 'UV' (1) • adding effects of 'fish' and 'UV' (1)	fish exposure effect is 12% (above control) and (UV is) 28%	(2)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(ii)	An explanation that makes reference to the following: • interferes with DNA replication (1) • (potentially) leading to mutations (1)		(2)

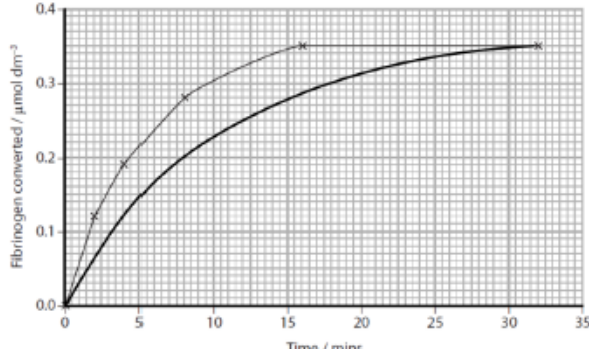
Q13.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	- suitable time interval chosen (in range 0 to 70 s, must be on straight line portion) (1) - absorbance change calculated (1) - ans. 0.053 au s^{-1} (or as appropriate for part of graph chosen) (1)	Example: at 0 s abs = 0.4, at 60 s abs = 3.6 (1) so change is $3.6 - 0.4 = 3.2$ (1) over 60 s, make rate $3.2 \div 60 = 0.053 \text{ au s}^{-1}$ (1)	(3)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	An explanation that makes reference to three of the following: - as enzyme concentration increases the rate of reaction increases and levels off (1) - because number of active sites of the enzyme molecules is increasing (1) - because enzyme concentration is the limiting factor (1) - it levels off because the substrate concentration is limiting (1)		(3)

Q14.

Question Number	Answer	Additional Guidance	Mark
(i)	- correct values taken from the graph (1) - correct answer with correct units (1)	<u>Example of calculation</u> $0.12 \div 2 =$ $= 0.06 \text{ } \mu\text{mol dm}^{-3} \text{ min}^{-1}$ $= 0.06 \text{ } \mu\text{mol per dm}^3 \text{ per minute}$ or $= 0.001 \text{ } \mu\text{mol dm}^{-3} \text{ s}^{-1}$ $= 0.001 \text{ } \mu\text{mol per dm}^3 \text{ per second}$ Correct answer with no units gains one mark Correct answer with correct units but no working gains full marks	2

Question Number	Answer	Additional Guidance	Mark
(ii)	curve that is less steep but reaches the same plateau (1)	e.g. 	1

Question Number	Answer	Additional Guidance	Mark
(iii)	An explanation that makes reference to the following: - the slower the initial rate of reaction the longer it will take for a clot to form (1) - because fibrin will be produced more slowly (1)	Allow converse arguments	2

Q15.

Question number	Answer	Additional guidance	Mark
(i)	- conversion of surface area from m^2 to cm^2 (1) - correctly dividing surface area by volume to determine ratio (1)	<u>Example of Calculation:</u> $97 \times 10000 = 970\,000$ divided by lung volume of 6232 Correct ratio of 155.6 : 1 (ALLOW 155.65 :1) ALLOW one mark only for 0.0155 : 1 / 0.156 : 1 / 155.6 Correct answer with no working gains full marks	(2)

Question number	Answer	Mark
(ii)	The only correct answer is D – Student's t-test <i>A is not correct because chi-squared does not test difference between means</i> <i>B is not correct because there is no correlation to test</i> <i>C is not correct because SD does not compare means</i>	(1)

Question number	Answer	Additional guidance	Mark
(iii)	An answer that makes reference to two of the following points: - different { height / weight / mass } (1) - different { gender / sex } (1) - different age (1)	IGNORE 'size' ALLOW 'men have larger lungs than women'	(2)

Question number	Answer	Additional guidance	Mark
(iv)	to allow (valid) comparison / show differences (1)		(1)

Q16.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to five of the following: • as a result of a mutation (1) • (cyanobacteria) produce proteins containing the amino acid cysteine (1) • (cysteine rich proteins) produce {heat stable enzymes / proteins resistant to unfolding} (1) • other adaptations such as {enzymes with large hydrophobic cores / simpler protein folds / amino acids that do not bond to metal ions } (1) • high temperatures act as a selection pressure (1) • allowing them to {survive / replicate} and pass advantageous allele to next generation (1)	ALLOW 'pass alleles for heat tolerance to next generation'	(5)

Q17.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: • {screen / produce} a (large) population of mice (1) • cross (two) heterozygous mice (1) • select the homozygous recessive mice (1) • and breed from these for subsequent generations (1)	ALLOW labelled genetic diagrams ALLOW carriers for heterozygous ALLOW breed for select ALLOW select mice expressing the recessive trait	(3)

Q18.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • mucus contained in membrane bound vesicles inside the cell (1) • (these vesicles) fuse with the cell membrane releasing the mucus (1)		(2)

Q19.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: • hydrophilic parts associate with water (1) • hydrophobic parts {associate with each other / repel water }(1) • a bilayer forms with hydrophobic parts pointing { in towards the centre of the bilayer / towards each other } (1)	ALLOW converse ALLOW phosphate groups associate with water ALLOW fatty acids face away from water ALLOW annotated diagram to show arrangement of phospholipids	3

Q20.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following: - changing a base results in a change in the triplet code - this changes the codon(s) in the mRNA - resulting in a different { amino acid / amino acid sequence } (in the primary structure)	ALLOW deletion / substitution / insertion / frameshift. ALLOW illustration of change in triplet code e.g. ATT to ATG ALLOW introducing a stop codon / terminating translation	(3)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: - sequence the genome of people with MPS1 - sequence the genome of a number of people without the condition - compare the base sequences to identify mutations found only in individuals with the condition	ALLOW comparison of base sequences of people with MPS1 and people without MPS1	(3)

Q21.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following: (a recessive disorder is one) caused by a faulty allele (1) - that is only expressed in the { homozygous condition / absence of a normal allele } (1)	ALLOW faulty gene ALLOW only expressed if genotype is { homozygous recessive / bb } or if two recessive alleles are inherited	(2)

Q22.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to two of the following: • use a range of concentrations between 0 and 2.0 (ng cm^{-3}) • so that enzyme concentration is the only limiting factor • because the initial rates of reaction have to be compared		(2)

Q23.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference the following: • hydrolysis of ATP (1) • provides energy for the reaction (1) • provides phosphate group for phosphorylation of F-6-P (1)	ALLOW as the reaction requires energy ALLOW provides {phosphate / Pi} that is added to F-6-P	(3)

Question Number	Answer	Additional guidance	Mark
(ii)	An answer that makes reference to three of the following: - as concentration of { F-6-P / F-2,6-BP } increases so does the (initial) rate of reaction of the phosphofructokinase (1) - an increasing in the concentration of { F-6-P / F-2,6BP } will increase the rate of glycolysis (1) - up to a maximum (rate) (1) - increasing the concentration of F-2,6-BP reduces the concentration of F-6-P required to achieve the maximum rate of glycolysis (1)	ALLOW 'enzyme' for 'phosphofructokinase' ALLOW F-2,6-BP provides positive feedback to the enzyme activity	(3)

Q24.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following: { thick / sticky / viscous } mucus (1) (accumulation of mucus) which cannot be moved by cilia (1) - restricting air flow through { bronchioles / bronchi } (1) {increases diffusion distance / reduces surface area for gas exchange } in the alveoli (1)	IGNORE 'airways' ALLOW narrowing of bronchioles	(3)

Q25.

Question number	Answer	Additional guidance	Mark
	An explanation that makes reference to three of the following points: • { smaller surface area / increased diffusion distance } for gas exchange (1) • therefore reduction in oxygen uptake (1) • therefore less oxygen for aerobic respiration (1) • leading to more anaerobic respiration (causing fatigue) (1)	ALLOW smaller SA:vol	(3)

Q1.

Explain why the phospholipids are arranged in two layers in a cell surface membrane.

(3)

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(Total for question = 3 marks)

Q2.

Describe how thicker mucus would affect gas exchange across the walls of the alveoli.

(2)

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Q3.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ~~☒~~ and then mark your new answer with a cross ☒.

Farmers use fertilisers to increase the growth of crops such as wheat.

(i) Fertilisers contain phosphate ion compounds.

Plants need phosphate in order to synthesise

(1)

- ☐ **A** both cellulose and phospholipids
- ☐ **B** both phospholipids and polysaccharides
- ☐ **C** both polynucleotides and phospholipids
- ☐ **D** both polynucleotides and polysaccharides

(ii) After the grain is harvested, farmers plough the stems (straw) from wheat plants into the soil.

This improves the quality of the soil. These stems contain polysaccharides.

Explain how microorganisms in the soil break down the stems.

(3)

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(Total for question = 4 marks)

Q4.

Emphysema is a condition that causes changes to the tissues in the lungs.

In an investigation, the surface area for gas exchange and the volume of the lungs of three groups of individuals were determined. The results are shown in the table.

Measurement	Individuals without emphysema	Individuals with mild emphysema	Individuals with severe emphysema
Mean surface area for gas exchange / m ²	118 ± 11	97 ± 8	30 ± 5
Mean total lung volume / cm ³	4772 ± 223	6232 ± 410	6725 ± 384
Mean surface area for gas exchange : volume ratio	247.3 : 1		44.6 : 1

Fick's law of diffusion can be used to calculate a value for the effectiveness of the uptake of oxygen by the lungs.

This value can be calculated using the equation

$$\text{value} = \frac{\text{surface area} \times \text{concentration difference}}{\text{diffusion distance}}$$

The diffusion distance in alveoli is 0.5 µm.

The mean oxygen concentration in alveoli is 14 kPa and in the capillaries is 5 kPa.

The calculated value for healthy individuals is 2124.

(i) Calculate the value for individuals with severe emphysema.

(2)

Answer

(ii) Calculate the percentage difference between the value for individuals with severe emphysema and the value for individuals without emphysema.

(2)

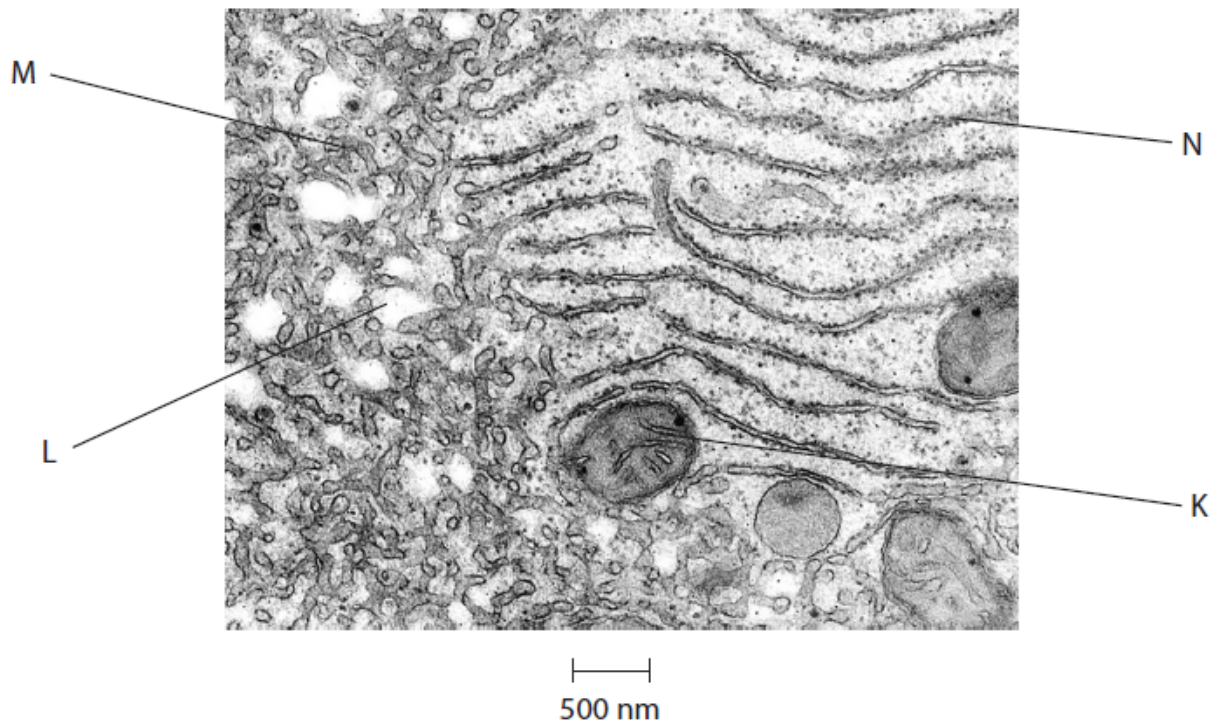
Answer

(Total for question = 4 marks)

Q5.

Liver cells synthesise and export a variety of proteins.

The image is a transmission electron micrograph of part of a liver cell.



(i) Which of the following structures is involved in respiration?

(1)

☐ **A** K

☐ **B** L

☐ **C** M

☐ **D** N

(ii) Which of the following structures is involved in synthesising lipids?

(1)

☐ **A** K

☐ **B** L

☐ **C** M

☐ **D** N

(iii) The site of synthesis of proteins to be released by exocytosis is

(1)

☐ **A** K

☐ **B** L

☐ **C** M

☐ **D** N

(iv) Calculate the maximum width of the structure labelled **K**.

(2)

Maximum length nm

Q6.

Hereditary spherocytosis is a condition that affects red blood cells.

The red blood cells of individuals with spherocytosis are spherical instead of having a biconcave disc shape.

Explain the effect of spherocytosis on the uptake of oxygen by red blood cells.

(3)

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(Total for question = 3 marks)

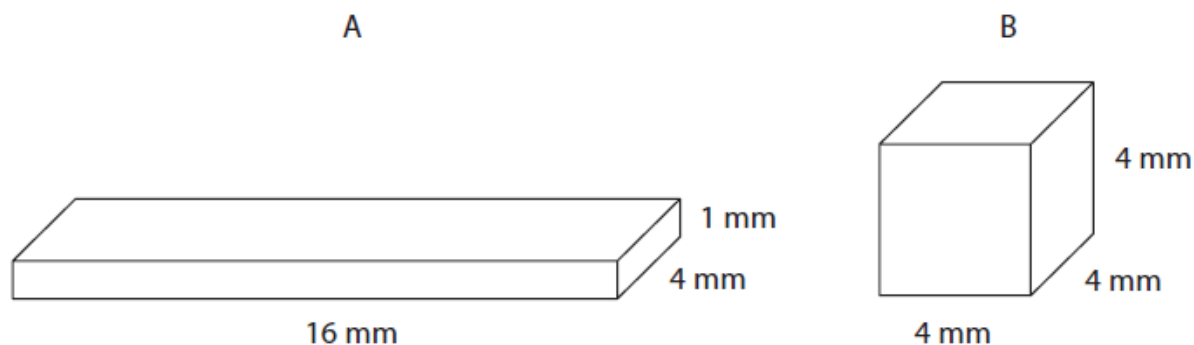
Q7.

Scientists can use models to explain the need for a circulation system in animals.

The shapes in the diagram represent two different animals that live in water.
The figures represent the height, width and breadth of the animals.

Determine why animal A does not need a circulation system but animal B does.

(4)



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(Total for question = 4 marks)

Q8.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

Thalassaemia is a recessive genetic disorder that affects the production of haemoglobin. It is caused by a gene mutation.

Scientists are developing methods to repair gene mutations such as the one that causes thalassaemia.

A gene mutation can be a change in a single base in the

(1)

- ☐ **A** DNA that codes for a different amino acid
- ☐ **B** DNA that codes for a different monosaccharide
- ☐ **C** RNA that codes for a different amino acid
- ☐ **D** RNA that codes for a different monosaccharide

(Total for question = 1 mark)

Q9.

Porphyria is a life-threatening genetic disease. It is caused by a mutation in the gene coding for an enzyme involved in the production of haem.

In people with porphyria, haem cannot be produced.

A new technique known as gene silencing has been developed to treat this disease.

Molecules known as small interfering RNA (siRNA) combine with mRNA to prevent translation.

Deduce how siRNA may be used to prevent the development of porphyria.

(4)

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(Total for question = 4 marks)

Q10. The sequence of bases in DNA determines the sequence of amino acids in a polypeptide.

The table below shows the genetic code for each amino acid.

TTT	Phe	TCT		TAT	Tyr	TGT	Cys
TTC		TCC	Ser	TAC		TGC	
TTA	Leu	TCA		TAA	Stop	TGA	Stop
TTG		TCG		TAG		TGG	Trp
CTT		CCT		CAT	His	CGT	
CTC	leu	CCC	Pro	CAC		CGC	Arg
CTA		CCA		CAA	Gln	CGA	
CTG		CCG		CAG		CGG	
ATT		ACT		AAT	Asn	AGT	Ser
ATC	Ile	ACC	Thr	AAC		AGC	
ATA		ACA		AAA	Lys	AGA	Arg
ATG	Met	ACG		AAG		AGG	
GTT		GCT		GAT	Asp	GGT	
GTC	Val	GCC	Ala	GAC		GGC	Gly
GTA		GCA		GAA	Glu	GGA	
GTG		GCG		GAG		GGG	

(a) The diagram below shows the DNA base sequence coding for part of a polypeptide.

A	T	G	G	G	C	A	T	T
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(i) Using the information in the table, state the order of amino acids for this part of the polypeptide.

(1)

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(ii) Explain what is meant by the term **non-overlapping genetic code**.

(1)

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(b) (i) Explain why there are **three** bases in each of the codes shown in the table.

(2)

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(ii) Suggest an advantage for most amino acids having more than one code. Give an explanation for your answer.

(2)

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(c) Explain the role of the base sequences TAA, TAG and TGA.

(4)

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(d) Explain how the amino acids are joined together in a polypeptide.

(3)

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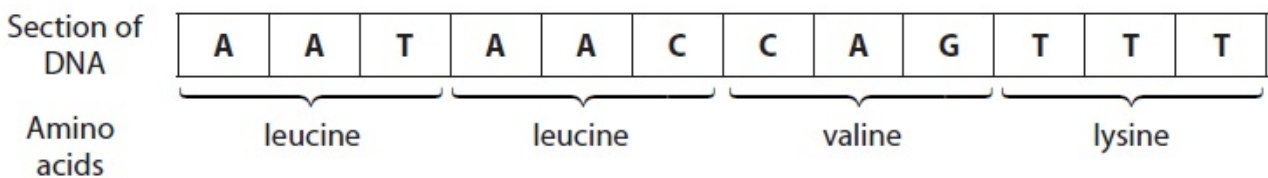
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(Total for Question = 13 marks)

Q11. The diagram below shows the base sequence on a short section of DNA consisting of 12 mononucleotides. This base sequence contains the genetic code for a short section in the primary structure of a polypeptide.



(a) Name each of the bases represented by the letters, **A**, **C**, **G** and **T** in the diagram.

(1)

A.....

C.....

G.....

T.....

(b) Using the sequence shown in the diagram, explain the meaning of each of the following terms.

(i) Triplet code

(2)

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(ii) Non-overlapping

(2)

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(iii) Degenerate

(2)

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(c) Place a cross ☒ in the box next to the names of the two components, other than the bases, that form part of each mononucleotide in this sequence.

(1)

- ☐ **A** deoxyribose and nitrate
- ☐ **B** deoxyribose and phosphate
- ☐ **C** ribose and nitrate
- ☐ **D** ribose and phosphate

*(d) Transcription of this section of DNA forms a complementary strand of mRNA.
Describe how translation of this mRNA synthesises part of a polypeptide molecule.

(5)

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(Total for Question = 13 marks)

Q12.

Some people have a disorder that reduces their ability to produce an enzyme required to break down glycogen. This enzyme is glycogen phosphorylase.

The symptoms of this disorder include muscle weakness and lack of stamina when exercising.

(i) Explain why a low concentration of this enzyme would cause the symptoms described.

(3)

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(ii) Devise an experiment to investigate the effect of glycogen phosphorylase concentration on the breakdown of glycogen.

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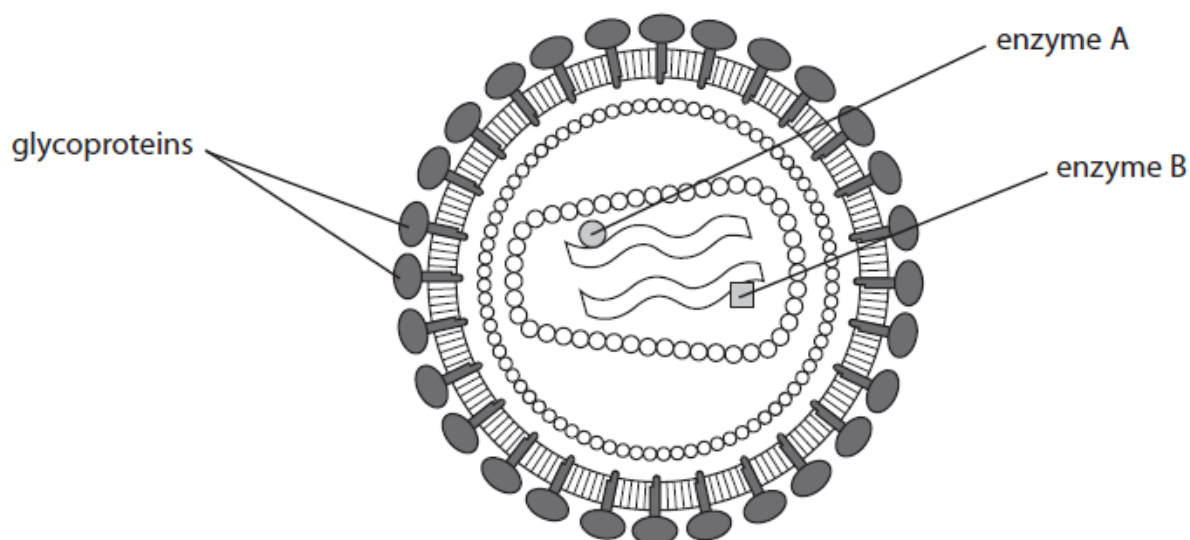
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Q13.

Anti-viral drugs have been developed to treat patients infected with Human Immunodeficiency Virus (HIV).

The diagram below shows the structure of HIV.



(a) A glycoprotein has a carbohydrate attached to a protein molecule.
Describe the three-dimensional structure of a glycoprotein.

(3)

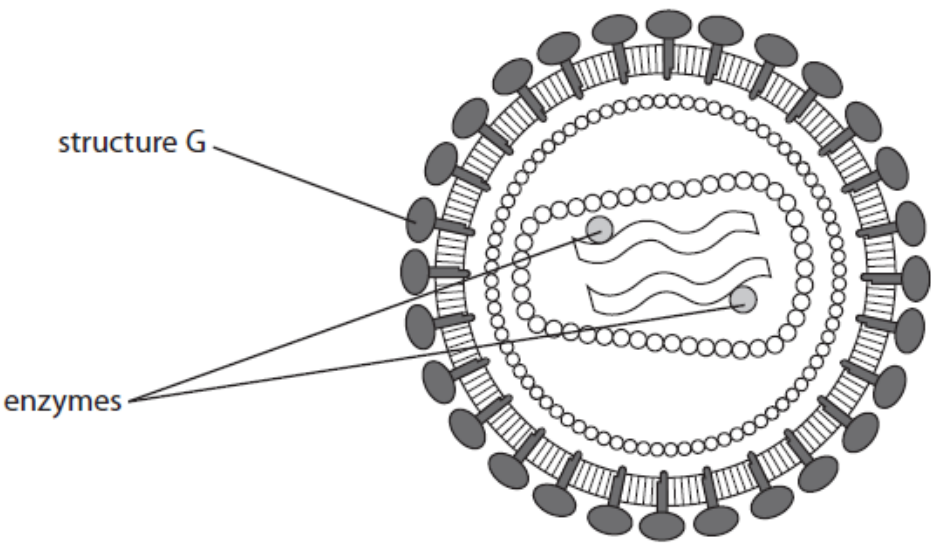
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This image shows a full page of white paper with horizontal dashed lines, typical of primary school writing paper. The lines are evenly spaced and run across the entire width of the page. There are no margins, text, or other markings present.

Q14.

Anti-viral drugs have been developed to treat patients infected with Human Immunodeficiency Virus (HIV).

The diagram below shows the structure of HIV.



(a) Explain how **structure G** enables HIV to infect human cells.

(3)

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(b) Some anti-viral drugs used to treat patients infected with HIV are inhibitors of enzymes found within HIV.

(i) Describe the structure of an enzyme.

(3)

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*(ii) Suggest how these anti-viral drugs would work in the treatment of patients infected with HIV.

(5)

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(Total for question = 11 marks)

Q15.

Wasps are insects that live in groups.

One species of wasp (*Vespula germanica*) has been shown to knock its body repeatedly against a hard surface. This signals the presence and quality of food to other wasps.

When threatened by another animal, it may use its stinger to inject a venom to protect itself.



bugguide.net

The stinger injects a venom that contains the enzyme phospholipase. This enzyme hydrolyses phospholipids, releasing fatty acids.

Describe how the structure of phospholipase allows it to hydrolyse phospholipids.

(4)

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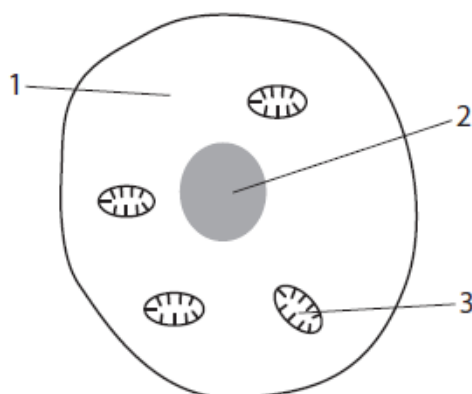
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(Total for question = 4 marks)

Q16.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The diagram shows some of the features of a human liver cell.



(i) Which of the labelled features in the liver cell contain RNA?

(1)

- ☒ **A** 1 only
- ☐ **B** 1 and 3 only
- ☐ **C** 2 and 3 only
- ☐ **D** 1, 2 and 3

(ii) Cells produce lactate during anaerobic respiration. Lactate travels in the blood to the liver.
Liver cells can absorb lactate from the blood.

Deduce what happens to the lactate in these cells.

(2)

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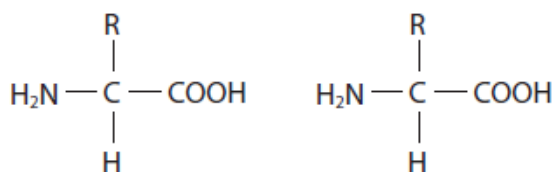
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(iii) During protein synthesis, two amino acids are joined together to form a dipeptide.

The diagram shows two identical amino acids.

Complete the diagram to show how the dipeptide is formed from these two amino acids.

(2)



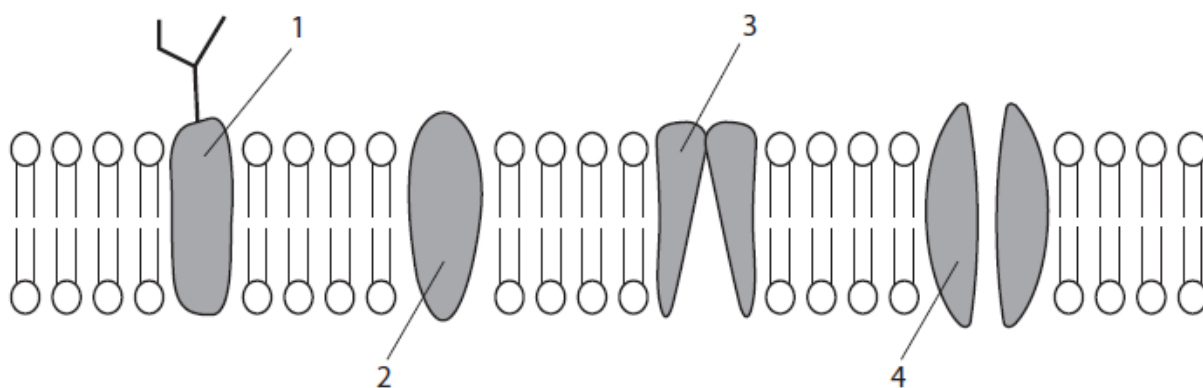
(Total for question = 5 marks)

Q17.

Answer the questions with a cross in the boxes you think are correct ☐. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☐.

The structure of the cell surface membrane can be described by the fluid mosaic model.

The diagram shows the fluid mosaic model of the cell surface membrane.



(i) Which of the shaded structures transport charged molecules or ions across the membrane?

(1)

- ☐ **A** 1 and 2 only
- ☐ **B** 3 and 4 only
- ☐ **C** 1, 2 and 3 only

☐ **D** 1, 2, 3 and 4

(ii) Which of the shaded structures contain both hydrophilic regions and hydrophobic regions?

(1)

☐ **A** 1 and 2 only

☐ **B** 3 and 4 only

☐ **C** 1, 2 and 3 only

☐ **D** 1, 2, 3 and 4

(iii) A student measured the width of the phospholipid bilayer shown on the diagram as 2.5 cm. The actual size of this bilayer is 5 nm.

What is the approximate magnification of the diagram?

(1)

☐ **A** × 5000

☐ **B** × 50 000

☐ **C** × 500 000

☐ **D** × 5 000 000

(Total for question = 3 marks)

Q18.

Answer the question with a cross in the box you think is correct ☐. If you change your mind about an answer, put a line through the box ☐ and then mark your new answer with a cross ☐.

Cystic fibrosis can be caused by a number of different mutations in the CFTR gene.

(i) A gene contains a number of base pairs. Of the base pairs in this gene, 50% are adenine and thymine.

Q = the number of base pairs in this gene.

Which of the following shows the total number of hydrogen bonds (H bonds) present in this gene?

(1)

☐ **A** $2.0 \times Q$

☐ **B** $2.5 \times Q$

☐ **C** $4.0 \times Q$

☐ **D** $5.0 \times Q$

(ii) Explain why different mutations in the CFTR gene can lead to differences in the severity of the symptoms of cystic fibrosis.

(2)

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(Total for question = 3 marks)

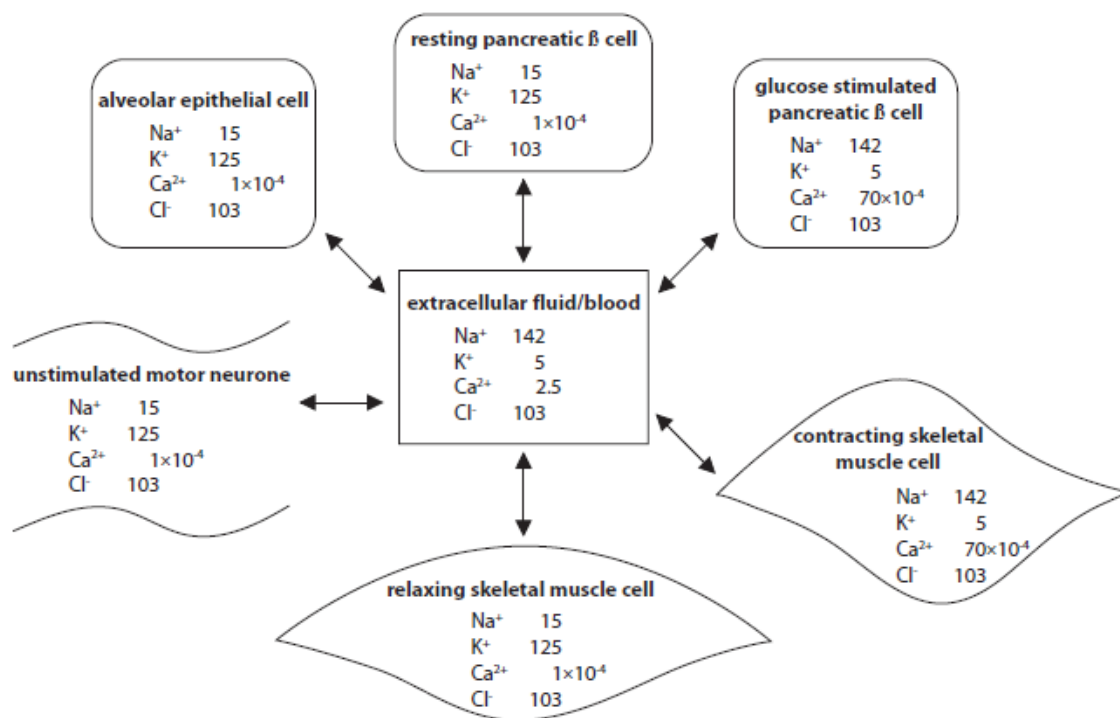
Q19.

*Cells use ions in many different processes.

Ion transport across cell membranes is a fundamental property of all living cells.

The diagram shows some typical ion concentrations in healthy human cells and in the extracellular fluid.

All values are in mmol dm^{-3} .



The tables show information about the human genome and types of transport channel in humans.

Some information about the human genome	
Number of genes in the human genome	approximately 20 000
Number of genes coding for membrane proteins	approximately 5 400
Number of genes coding for proteins involved in the transport of ions across cell membranes	more than 350
Number of diseases associated with mutations in genes involved in the transport of ions across cell membranes	more than 28
Organs and systems in which ion channel mutations cause disease	central nervous system, heart, lungs, pancreas and skeletal muscle

Type of transport channel	Number of each type of transport channel
Voltage gated ion channels	147
Chloride channels	17
Active transport	81

Discuss the importance of ion transport across membranes in human health and disease.

(Total for question = 9 marks)

Q20.

Glycolysis is inhibited by acidic conditions.

Devise an investigation to determine the effect of acidic conditions on the initial rate of reaction of phosphofructokinase.

(4)

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(Total for question = 4 marks)

Q21.

Lettuce plants usually grow upright. This is the 'upright' phenotype.

In one variety of lettuce the stem of the lettuce grows along the ground. This is the 'weary' phenotype.

These two phenotypes are shown in the diagram.



Upright



Weary

Inheritance of the weary phenotype has been investigated.

Scientists crossed weary lettuce plants with upright lettuce plants.
The F_1 generation produced from this cross were all upright.

In the second cross, two of the F_1 lettuce plants were crossed with each other to produce the F_2 generation.

The phenotypes of the F_2 generation and the results of a statistical test are shown in the table.

Number of offspring with weary phenotype	Number of offspring with upright phenotype	Chi-squared (χ^2)
159	414	2.31

Degrees of freedom	Probability		
	0.01	0.05	0.1
1	2.71	3.84	6.64
2	4.61	5.99	9.21
3	6.25	7.82	11.35
4	7.78	9.49	13.28

Justify the conclusion that the weary phenotype was inherited as a recessive trait.

(3)

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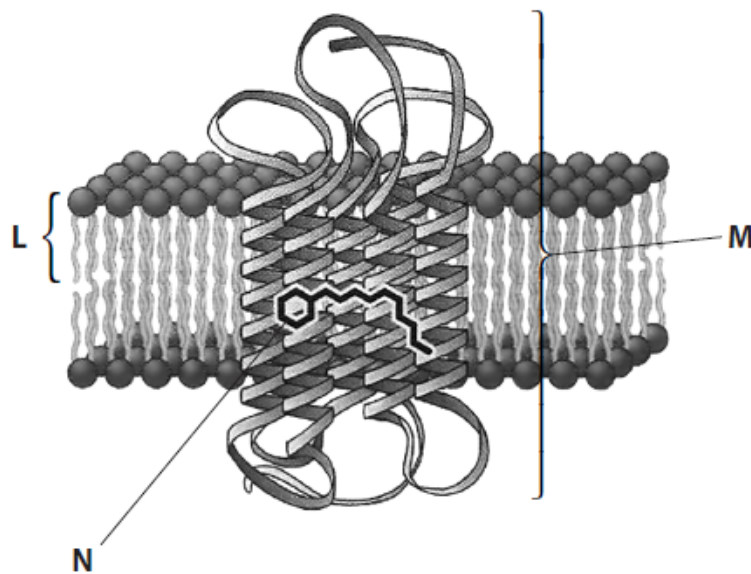
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(Total for question = 3 marks)

Q22.

The diagram shows part of the membrane of the outer segment of a rod cell.



(a) Which of the following is the part labelled **L**?

(1)

- ☐ **A** fatty acid tail
- ☐ **B** phosphate head
- ☐ **C** phospholipid
- ☐ **D** phospholipid bilayer

(b) (i) Give the name of the visual pigment labelled **M**.

(1)

(ii) Give the name of the light-absorbing part of the visual pigment labelled **N**.

(1)

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(c) Describe how the absorption of light by the part labelled **N** results in an action potential in the optic nerve.

(3)

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(Total for question = 6 marks)

Q23.

Malaria is a disease that kills more than 400 000 people every year.

It is caused by *Plasmodium*, a single-celled organism that lives in the blood.

Plasmodium is transmitted by mosquitoes.

Malaria can be controlled by killing the mosquitoes that transmit the disease.

Scientists are genetically modifying *Metarhizium pingshaense*, a fungus that infects mosquitoes.

The genetically modified (GM) fungus contains a gene from a species of spider. This gene codes for a protein that kills mosquitoes.

(i) The GM fungus transcribes and translates the gene for this protein.

Describe the primary structure of a protein.

(2)

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(ii) The primary structure of this protein is then converted into a tertiary structure and modified by organelles in the cell.

Describe the role of the organelles involved in these processes.

(5)

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(Total for question = 7 marks)

Mineral ions are required for plant growth.

Mineral ions enter the plant through the roots.

Mineral ions in the soil are in lower concentrations than in the vacuoles of root hair cells.

Describe how mineral ions are taken up by root hair cells.

(3)

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(Total for question = 3 marks)

Q25.

Mineral ions are required for plant growth.

(i) Nitrate ions are required for the synthesis of

(1)

- ☐ **A** amino acids
- ☐ **B** cellulose
- ☐ **C** starch
- ☐ **D** sucrose

(ii) Phosphate ions are required for the synthesis of

(1)

- ☐ **A** cellulose
- ☐ **B** chlorophyll
- ☐ **C** nucleic acids
- ☐ **D** sucrose

(iii) Magnesium ions are present in the structure of

(1)

- ☐ **A** amino acids
- ☐ **B** cellulose
- ☐ **C** chlorophyll
- ☐ **D** starch

(Total for question = 3 marks)

Mark Scheme

Q1.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following: - hydrophilic region (of phospholipid) orientated towards water (1) (and) hydrophobic regions away from the water (1) (but need the two layers as) { water-based / aqueous } solution either side of the cell membrane (1)	ALLOW phosphate head / polar region ALLOW hydrocarbon chain / fatty acid tails e.g. separating tissue fluid from cytoplasm	(3)

Q2.

Question Number	Acceptable Answer	Additional Guidance	Mark
	A description that makes reference to the following: - increased diffusion distance / decreased surface area (1) - reduced (rate of) gas exchange (1)		(2)

Q3.

Question Number	Answer	Mark
(i)	The only correct answer is C – polynucleotides and phospholipids <i>A is incorrect because phosphate is not in cellulose</i> <i>B is incorrect because polysaccharides do not contain phosphate</i> <i>D is incorrect because phosphate is not in polysaccharides</i>	(1)

Question Number	Answer	Additional guidance	Mark
(ii)	An explanation that makes reference to three of the following - the stems contain starch or cellulose(1) - enzymes are { secreted / released } by the microorganisms (1) - which break down the glycosidic bonds(1) - which releases glucose that is used by the microorganisms in respiration (1)	ALLOW lignin ALLOW enzymes from microorganisms digest(starch/ cellulose)	(3)

Q4.

Question number	Answer	Additional guidance	Mark
(i)	- values substituted into the equation (1) - correct answer (1)	<u>Example of calculation:</u> $(30 \times 9) \div 0.5$ $= 540$ Correct answer with no working gains full marks	(2)
(ii)	- calculation of the difference using the value from (i) (1) - correct answer (1)	<u>Example of calculation:</u> $2124 - 540 (= 1584)$ $1584 / 2124 \times 100 = 74.6\% \text{ or } 75\%$ ECF full marks if calculated correctly for value other than 540 Correct answer with no working gains full marks	(2)

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	A (K)		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	C (M)		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iii)	D (N)		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(iv)	- measures width on diagram (1) - correct answer (1)	<u>Example of calculation</u> $(500 \times \text{width of K}) \div \text{length of bar}$ $= 940 \text{ nm}$ Allow full marks for correct answer with no working	(2)

Q6.

Question Number	Answer	Additional guidance	Mark
	An explanation that makes reference to the following - oxygen enters the cells by diffusion (1) - change in shape {reduces surface area to volume ratio /increases diffusion distance} (1) - therefore gas exchange decreases / less oxygen enters the cells (1)		(3)

Q7.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to four of the following: - both have same volume (1) - animal A has a larger surface area (1) - animal A has a larger surface area to volume ratio (1) - so sufficient (surface area in animal A) for diffusion (1) - distance to cells in centre of A is shorter than for B allowing {quicker/sufficient} diffusion / shorter diffusion distance (in A) (1)	ALLOW both have a volume of 64 mm³ ALLOW converse ALLOW figures given (e.g. 168 mm² v 96mm²) or difference given as 72 mm² ALLOW {168:64 / 2.6:1} compared to {96:64 / 1.5:1} ALLOW converse ALLOW converse	(4)

Q8.

Question Number	Answer	Mark
	The only correct answer is A - DNA which codes for a different amino acid <i>B is incorrect because DNA does not code for monosaccharides</i> <i>C is incorrect because the change is not in RNA</i> <i>D is incorrect because the change is not in RNA and it does not code for monosaccharides</i>	(1)

Q9.

Question Number	Answer	Additional guidance	Mark
	An answer that makes reference to the following • siRNA binds to the mRNA (from the mutated allele) (1) • mRNA cannot bind to ribosome (1) • tRNA is prevented from binding with mRNA(1) • {polypeptide / protein} not synthesised (1) • (no development of porphyria) as the faulty enzyme is not produced (1)	ALLOW amino acids not brought to mRNA ALLOW functioning gene transcribed instead	Expert (4)

Q10.

Question Number	Answer	Additional Guidance	Mark
(a)(i)	{Met Gly Ile} / {methionine glycine isoleucine} ;	Not other abbreviations	(1)

Question Number	Answer	Additional Guidance	Mark
(a)(ii)	idea that each {triplet is discrete / base is only used once in a triplet / eq} ;	Accept a description of how the code could be read if overlapping	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	1. idea that each amino acid needs a code ; 2. idea that {using three bases give enough codes / using less bases does not give enough codes} ; 3. idea of three bases means there can be 64 {triplets / codes / combinations / eq} ;	Accept codons	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	1. idea that {effects of mutations are reduced / the amino acid may not be altered} ; 2. reference to the third base (being the one that can be changed with no effect) ; 3. no effect on (resulting) {polypeptide / protein} / eq ;	1. Accept description of effect Accept from a description of a specific example Accept always results in same amino acid Not similar amino acid 2 NB If mp 2 is awarded it will usually incorporate mp 1 as well = 2 marks	(2)

Question Number	Answer	Additional Guidance	Mark
(c)	1. reference to (TAA, TAG and TGA as) stop codons ; 2. occur at the end of the gene (on the DNA) / eq ; 3. reference to transcribed as mRNA / eq ;	1. Not codes, triplets	

	4. as AUU, AUC and ACU ; 5. idea that they are recognised by ribosome ; 6. idea that they signal the end of the polypeptide (chain) ; 7. reference to (during) translation ;	6. Accept stops the synthesis of the polypeptide / the polypeptide is finished	(4)
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Question Number	Answer	Additional Guidance	Mark
(d)	1. ref to peptide {bond / link} ; 2. between (amino group / NH_3 / NH_4^+) and {carboxyl group / COOH / COO^- } ; 3. ref to condensation (reaction) ; 4. idea of role of {tRNA / ribosome / enzymes / correctly named enzyme} in joining amino acids together ;	Accept mp 1 and 2 from correctly drawn and labelled diagram 2. NB formulae must be correct if only these are given 4. Accept e.g. hold the amino acids next to each other, ribosome contains enzyme	(3)

Q11.

Question Number	Answer	Additional Guidance	Mark
(a)	A = adenine C = cytosine G = guanine T = thymine ;	Accept reasonable phonetic spellings Not: adenosine cysteine glycine thiamine, thyosine, tyrosine	(1)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	1. idea that each amino acid is coded for by three {nucleotides / bases} ; 2. credit quoted example / idea that 12 {nucleotides / bases} code for 4 amino acids ;	Accept in context of RNA AAT / AAC = leucine, CAG = valine, TTT = lysine	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(ii)	- idea that each {triplet is discrete / each base is only used once in a triplet / eq } ; - idea that AAT + AAC + CAG + TTT gives 4 (distinct) {triplets / codes} ;	Accept a specific example eg the first T can only be used in code for first leucine Accept a description of how the code could be read if overlapping	(2)

Question Number	Answer	Additional Guidance	Mark
(b)(iii)	- idea that more than one code can be used for a {particular amino acid/ stop code} ; - AAT and AAC code for leucine ;	Accept more codes than are needed to code for all the amino acids (and stop code)	(2)

Question Number	Answer	Additional Guidance	Mark
(c)	B ;		(1)

Question Number	Answer	Additional Guidance	Mark
*(d)	QWC – Spelling of technical terms must be correct and the answer must be organised in a logical sequence - reference to mRNA with sequence UUA UUG GUC AAA ; - idea that ribosome is involved ; - idea that each tRNA molecules is attached to one (specific) amino acid ; - credit example of tRNA anticodon with specific amino acid - reference to anticodons on tRNA {bind / link to / line up against / eq} codons on mRNA ; - credit a specific example (from this DNA) ; - idea of hydrogen bonds between bases (of tRNA and mRNA) ; - reference to formation of peptide {bonds / links} between (adjacent) amino acids ;	QWC emphasis is logical sequence NB The mps do not have to be given in this order necessarily Not tRNA carries amino acids AAU /AAC = leucine, CAG = valine, UUU = lysine Ignore complementary eg UUA codon and AAU anticodon Accept between codon and anticodon	(5)

Q12.

Question Number	Acceptable Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following: - low blood glucose levels (1) - less glucose for respiration (1) - less { energy / ATP } in muscle tissue (1)		(3)

Question Number	Acceptable Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to the following: - range of enzyme concentration (1) - control of other named variables (1) - measurement of rate of glucose production (1)	e.g. temperature, pH, concentration of substrate	(3)

Q13.

Question Number	Answer	Additional Guidance	Mark
(a)	1. proteins consist of amino acids joined together by peptide bonds; 2. credit reference to named bonds (between R groups) involved in holding {3D structure / eq} ; 3. carbohydrates consist of {monosaccharides / glucose / eq} ; 4. reference to glycosidic {bonds / eq} between (adjacent) {glucose / eq} molecules ;		(3)

Question Number	Answer	Additional Guidance	Mark
(b)	1. idea that the drugs could {bind to / alter shape of} {glycoproteins / gp120} ; 2. idea that drugs bind to {receptors / antigens} on membrane / eq ; 3. called CD4 (antigen / molecules) ; 4. preventing virus attaching to T (helper / CD4⁺) cells / eq ;		(3)

Question Number	Answer	Additional Guidance	Mark
*(c)	(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence) 1. reference to reverse transcriptase ; 2. idea of formation of (viral) DNA ; 3. from (viral) RNA ; 4. reference to integrase ; 5. idea of integration of (viral) DNA into (host) DNA ; 6. idea that {T helper cells / eq} would be {destroyed / killed / burst / eq} (by virus particles leaving cell) ; 7. idea that more T (helper) cells would become infected ;	QWC focussing on clarity of expression 2. reject idea that RNA is {turned into / converted into} DNA 5. ACCEPT idea of {latency / formation of provirus / eq}	(5)

Q14.

Question Number	Answer	Additional Guidance	Mark
(a)	1. (structure G is {glycoprotein / gp120} ; 2. used for {attachment / eq} to CD4 (molecules / receptors /antigens) ; 3. on T helper {cells / lymphocytes} ;	1. IGNORE gp 41 and gp 160 and other wrong numbers 3. ACCEPT macrophages / dendritic cells / CD4 cells	(3)

Question Number	Answer	Additional Guidance	Mark
(b)(i)	1. they are globular proteins ; 2. it has an active site ; 3. idea of {charged R groups on outside of molecules / composed of many small R groups} ;	2. idea of active site R groups enable binding of substrate 3. idea of hydrophilic on the outside	(3)

Question Number	Answer	Additional Guidance	Mark
*(b)(ii)	(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence) 1. idea that drugs would prevent viral replication ; 2. idea that T (helper) {cells / lymphocytes} will not be { killed / burst / destroyed}(by virus particles leaving cell) ; 3. idea of {inhibition / eq} of reverse transcriptase ; 4. idea that (viral) DNA could not be made; 5. from the (viral) RNA ; 6. idea of {inhibition / eq} of integrase ; 7. idea that (viral) DNA cannot integrate into (host) {DNA / genome} / eq ;	QWC emphasis on clarity of expression 1. ACCEPT description of virus formation 3. ACCEPT drugs prevent action of reverse transcriptase 4. reject idea that RNA is {turned into / converted into} DNA 6. ACCEPT drugs prevent action of integrase 7. ACCEPT idea that drugs would prevent {latency / formation of provirus / eq} ;	(5)

Q15.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to four of the following: - the structure of the enzyme is determined by the sequence of amino acids (1) { tertiary structure / globular shape } provides an active site (1) - active site complementary to { (part of) phospholipid / ester bond } (1) - to break { ester bonds / bonds between glycerol and fatty acids } (1) - relevant detail concerning bonding { within the enzyme molecule / between enzyme and substrate } (1)	ALLOW primary structure for sequence of amino acids e.g. hydrophilic R groups / hydrophobic R groups	(4)

Q16.

Question Number	Answer	Mark
(i)	<i>The only correct answer is D because there is RNA in the cytoplasm, nucleus and mitochondria 1, 2 and 3</i> <i>A is incorrect because there is also RNA in the nucleus and mitochondria</i> <i>B is incorrect because there is also RNA in the nucleus</i> <i>C is incorrect because there is also RNA in the cytoplasm (as tRNA, mRNA or in ribosomes)</i>	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An answer that makes reference to two of the following: (lactate is) { oxidized to form / converted to } pyruvate (1) (pyruvate is) converted to { glucose / glycogen } (1) (pyruvate / glucose) used in respiration (1)	ALLOW glucose produced from the lactate ALLOW correct named stage e.g. glycolysis for glucose or link reaction for pyruvate	(2)

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following: - dipeptide correctly drawn with peptide bond (1) - water molecule released (1)		(2)

Q17.

Question Number	Answer	Mark
(i)	<i>The only correct answer is B 3 and 4 only</i> <i>A is incorrect because 1 and 2 do not transport charged molecules or ions across membranes</i> <i>C is incorrect because 1 and 2 do not transport charged molecules or ions across membranes and 4 does transport</i> <i>D is incorrect because 1 and 2 do not transport charged molecules or ions across membranes</i>	(1)

Question Number	Answer	Mark
(ii)	<i>The only correct answer is D 1, 2, 3 and 4</i> <i>A is incorrect because 3 and 4 also have both these regions</i> <i>B is incorrect because 1 and 2 also have both these regions</i> <i>C is incorrect because 4 also has both these regions</i>	(1)

Question Number	Answer	Mark
(iii)	D - $\times 5\,000\,000$ <i>The only correct answer is D – $(2.5 \div 5) \times 10^7$</i> <i>A is incorrect</i> <i>B is incorrect</i> <i>C is incorrect</i>	(1)

Q18.

Question Number	Answer	Mark
(i)	The only correct answer is B - $2.5 \times Q$ <i>The only correct answer is B because 50% of the base pairs are A-T with 2 hydrogen bonds and 50% C-G with 3 hydrogen bonds making a mean of $2.5 \times Q$</i> <i>A is incorrect because $2.0 \times Q$ is only correct if all base pairs were A-T</i> <i>C is incorrect because it assumes that each base in a pair has 4 hydrogen bonds and all the base pairs are A-T</i> <i>D is incorrect because it assumes that each base in the A-T base pair has 4 hydrogen bonds and each base in the G-C has 6 hydrogen bonds</i>	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to two of the following: • (different mutations) will have different effects on the protein produced (1) • chloride ion transport affected by the extent of changes to the (CFTR) protein (1) • varying the { stickiness / thickness } of the mucus (1)	ALLOW absence of protein / different { folding / tertiary structure / shape } of the protein ALLOW faulty CFTR protein has less impact on chloride ion transport than a missing CFTR protein	(2)

Q19.

Question number	Answer	Mark
	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive, and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Reference to role of ions in • nerve conduction • release of neurotransmitters • muscle contraction Mention of • passive diffusion through ion channels • active transport against concentration gradients Examples of ion transport • active transport – sodium potassium pump • hydrogen ions in chemiosmosis • calcium channels in pre-synaptic knob • sodium and potassium channels in neurones Idea that ions moving down a concentration gradient can do work • ATP synthase in chemiosmosis • cotransporters Ion channels in disease • chloride channels in cystic fibrosis • credit any other sensible suggestions • Ideas around control • lots of different genes/proteins involved in transporting ions across membranes • specificity of channels for particular ions • control of opening and closing of different channels	(9)

Level	Marks		Additional Guidance
0	0	No awardable content	
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.	simple description of data provided or discussion of one aspect from specification e.g. role of ions in action potentials / muscle contraction / mucus production
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.	Level 1 criteria plus discussion of another aspects from specification including consideration in {disease / ill-health} in at least one
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.	Level 2 criteria plus appropriate use of data from tables linked to health or disease or

		The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.	attempt at higher level reasoning e.g explaining role of {ion gradients / active transport of ions} expanding on role of mutations in disease beyond cystic fibrosis / discussion of channel specificity or evolution of variety of channels with many functions
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Q20.

Question Number	Answer	Additional guidance	Mark
	An answer the makes reference to four of the following: • use pH buffers at a range of pH values below 7 (1) • provide an excess of ATP (1) • (use) F-6-P at an appropriate concentration (1) • suitable variable controlled (1) • measure quantity of F-2,6-BP produced per unit time (1)	e.g. 2 mmol dm⁻³ (values between 1 and 2.5 mmol dm⁻³) e.g. {enzyme / phosphofructokinase } concentration / temperature ALLOW measure change in concentration of F-2,6-BP / phosphate incorporated	(4)

Q21.

Question Number	Answer	Additional guidance	Mark
	An answer the makes reference to three of the following: • no offspring from the cross between weary and upright lettuce had the weary phenotype (1) • the ratio of weary to upright lettuce in the F₂ generation was 1: 3 (1) • the chi-squared test value was below the critical value (1) • result not statistically different from expected result (1)	ALLOW none of the F₁ generation had the weary phenotype / all the F₁ generation were upright ALLOW {25% / ¼ / 27.7%} of the F₂ generation were weary lettuce ALLOW less than a critical value of 3.84 IGNORE degrees of freedom or incorrect cv ALLOW the null hypothesis can be accepted	(3)

Q22.

Question Number	Answer	Additional Guidance	Mark
(a)	C (phospholipid)		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(i)	rhodopsin		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(b)(ii)	(cis) retinal		(1)

Question Number	Acceptable Answer	Additional Guidance	Mark
(c)	A description that makes reference to the following: - opsin released causing sodium ion channels to be blocked (1) - which causes hyperpolarisation in the rod cell (1) - causing action potential in bipolar cell (results in action potential in the optic nerve) (1)		(3)

Q23.

Question Number	Answer	Additional guidance	Mark
(i)	A description that makes reference to the following - sequence of amino acids (1) - joined together by peptide bonds (1)		graduate (2)

Question Number	Answer	Additional guidance	Mark
(ii)	A description that makes reference to five of the following - folding of protein inside the {rough endoplasmic reticulum / rER } (1) - bonds formed between R groups (1) - rER {forms / packages proteins in} vesicles (1) - vesicles transport the protein to the Golgi apparatus (1) - protein modified in Golgi apparatus (1) - detail of modification (1)	ALLOW formation of named bonds ALLOW processed e.g. carbohydrates/sugar molecules added / prosthetic group	Expert (5)

Q24.

Question number	Answer	Additional guidance	Mark
	A description that makes reference to the following • (mineral ions) are taken up by active transport (1) • through carrier proteins (1) • this requires {energy / ATP} (1)	IGNORE channel ALLOW protein pumps	Expert (3)

Q25.

Question Number	Answer	Mark
(i)	The only correct answer is –A <i>amino acids</i> B is incorrect because nitrates are not found in cellulose C is incorrect because nitrates are not found in starch D is incorrect because nitrates are not found in sucrose	Computer (1)

Question Number	Answer	Mark
(ii)	The only correct answer is –C <i>nucleic acids</i> A is incorrect because phosphate is not found in cellulose B is incorrect because phosphate is not found in chlorophyll D is incorrect because phosphate is not found in sucrose	Computer (1)

Question Number	Answer	Mark
(iii)	The only correct answer is – C <i>chlorophyll</i> A is incorrect because magnesium is not found in amino acids B is incorrect because magnesium is not found in cellulose D is incorrect because magnesium is not found in starch	Computer (1)