

YEAR 12 *Trial Exam Paper*

2019

BIOLOGY
Written examination

Reading time: 15 minutes
Writing time: 2 hours 30 minutes

STUDENT NAME:

QUESTION AND ANSWER BOOK

Structure of book

<i>Section</i>	<i>Number of questions</i>	<i>Number of questions to be answered</i>	<i>Number of marks</i>
A	40	40	40
B	11	11	80
			Total 120

- Students are permitted to bring pens, pencils, highlighters, erasers, sharpeners and rulers into the examination.
- Students are NOT permitted to bring blank sheets of paper and/or correction fluid/tape into the examination.
- Calculators are NOT allowed in this examination.

Materials provided

- Question and answer book of 51 pages
- Answer sheet for multiple-choice questions

Instructions

- Write your **name** in the box provided above and on the multiple-choice answer sheet.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses must be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

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SECTION A – Multiple-choice questions**Instructions for Section A**

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1; an incorrect answer scores 0.

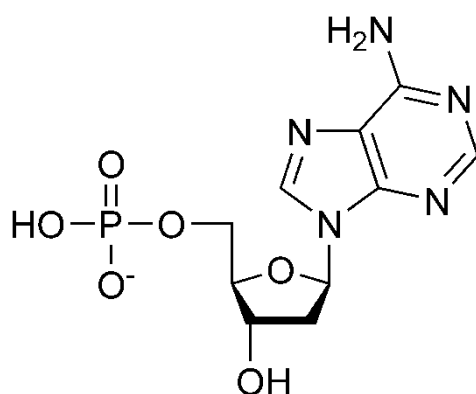
Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1

The diagram below shows the structure of a nucleotide, which is the sub-unit of a nucleic acid.



Which one of the following statements is correct?

- A. All nucleotides are chemically identical.
- B. This nucleotide could contain the amino acid thymine.
- C. The nucleotide shown in the diagram can only be found in DNA.
- D. Adjacent nucleotides are joined together as a result of a condensation reaction.

Question 2

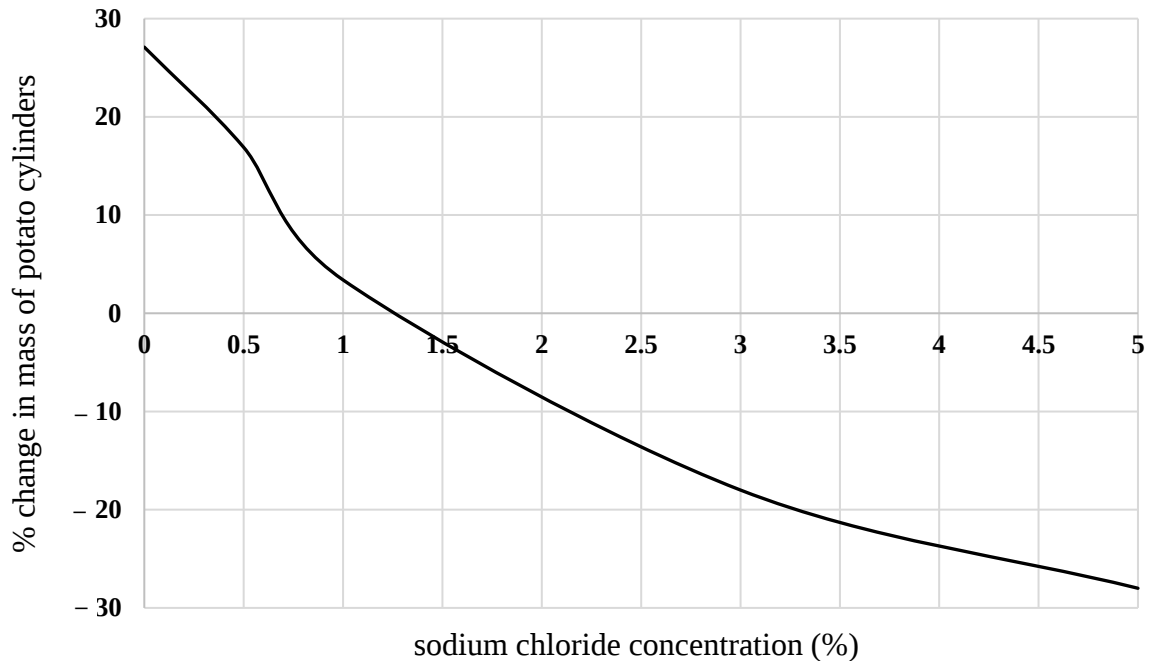
Which one of the following best describes the quaternary structure of a protein?

- A. the sequence of amino acids in the protein
- B. the bonding between amino acids that make up the protein
- C. the bonding between two polypeptides to make a single functional unit
- D. the folding that occurs within the protein causing it to assume a three-dimensional shape

Question 3

A group of students conducted an experiment to determine the solute concentration of cytosol inside potato cells. They accomplished this by placing cylinders of potato into solutions with differing concentrations of sodium chloride.

Their results are shown in the graph below.



Based on the information in the graph, which one of the following is an appropriate explanation for these results?

- A. Cytosol in potatoes must contain 1.25% sodium chloride.
- B. Active transport occurs when the concentration of sodium chloride is above 1.25%.
- C. The potato cylinders change in mass as a result of the net movement of water molecules.
- D. The loss of mass from potato cells is caused by the movement of sodium chloride from the potato cells into the surrounding solution.

Question 4

Proteins are exported from cells by the process of exocytosis, which is a sequential process. Several of the stages that occur during the export of proteins are listed below.

- I The secretory vesicle moves through the cytosol towards the plasma membrane.
- II The Golgi apparatus produces a secretory vesicle containing the protein.
- III The secretory vesicle fuses with the plasma membrane.
- IV The contents of the vesicle are released into the extracellular fluid.

Which one of the following is the correct sequence of events?

- A. I, II, III, IV
- B. II, I, III, IV
- C. III, IV, II, I
- D. I, III, II, IV

Question 5

A researcher is investigating the effect that the size and polarity of substances has on their ability to diffuse across a plasma membrane. The researcher prepares several solutions containing water and a radioactively labelled solute. Information about each of the solutes is shown below.

Solution	Description
1	The solute is small and polar.
2	The solute is large and polar
3	The solute is small and non-polar.
4	The solute is large and non-polar.

The researcher then exposes separate samples of cells to each of the solutions. At the end of the experiment, each cellular sample is tested to determine its level of radioactivity.

Which of the cell samples would be expected to exhibit radioactivity?

- A. the cells in solutions 1 and 3 only
- B. the cells in solutions 3 and 4 only
- C. the cells in solutions 1, 2, 3 and 4
- D. the cells in solutions 1, 3 and 4 only

Question 6

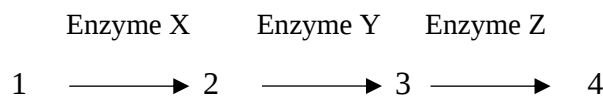
The CTBP1 gene codes for the CTBP1 protein, which acts as a transcriptional repressor and plays a role in cellular proliferation during foetal development.

Which one of the following attributes would the CTB1 protein be expected to have?

- A. It can change shape, enabling it to act as a repressor.
- B. It plays a structural role by contributing to cellular proliferation.
- C. It contains a regulatory region that enables it to bind to developing cells.
- D. It plays a regulatory role by determining the number of foetal cells that need to be produced.

Question 7

The diagram below shows an example of a metabolic pathway in which substance 1 is the initial substrate and substance 4 is the final product.



Two experiments were carried out using this pathway, and in both cases the same high concentration of substance 1 was used.

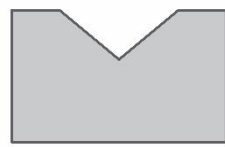
- In experiment 1, the concentrations of enzymes X, Y and Z were identical.
- In experiment 2, the concentration of enzyme X was double that of enzymes Y and Z.

How would the rate of the production of substance 4 be affected in experiment 2 compared with experiment 1?

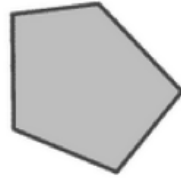
- A. In experiment 2, the reaction would cease to occur.
- B. The same amount of product 4 would be produced in both experiments.
- C. The amount of product 4 would be higher in experiment 2 than in experiment 1.
- D. The amount of product 4 would be higher in experiment 1 than in experiment 2.

Question 8

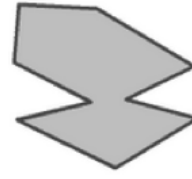
The structure of two substances is shown in the diagram below. Substance A is the substrate in an enzyme-catalysed reaction. A student noticed that the rate of the reaction decreased when substance B was placed into the same test tube as substance A.



Enzyme



Substance A



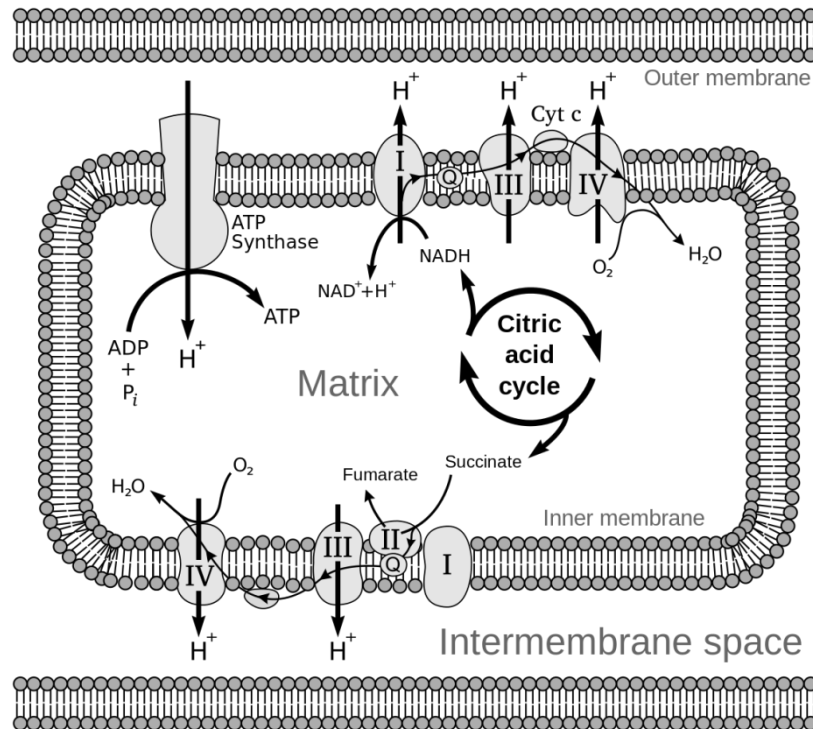
Substance B

Considering this information, the most likely reason for the decrease in the reaction rate is that substance B

- A. formed a complex with the enzyme, causing the enzyme to change shape.
- B. changed the pH of the environment causing the enzyme to denature.
- C. is a repressor that has bound to the regulatory region of the enzyme.
- D. is a competitive inhibitor and has bound to the active site of the enzyme.

Question 9

For the electron transport chain to occur, it is necessary for the enzyme cytochrome c oxidase to transport electrons to oxygen, the terminal acceptor, as shown in the following diagram.



Cyanide is a toxin that prevents this process from occurring.

What is the maximum amount of ATP that can be produced aerobically if an individual has been poisoned with cyanide?

- A. 0 ATP
- B. 4 ATP
- C. net 2 ATP
- D. 32–34 ATP

Question 10

A student is studying the mode of cellular transport of a specific chemical. They observe that the rate at which this substance is transported decreases when the cells are exposed to a substance that inhibits energy production.

This means that the substance is most likely to be entering the cell by the process of

- A. osmosis.
- B. active transport.
- C. simple diffusion.
- D. facilitated diffusion.

Question 11

Consider the processes of cellular respiration and photosynthesis.

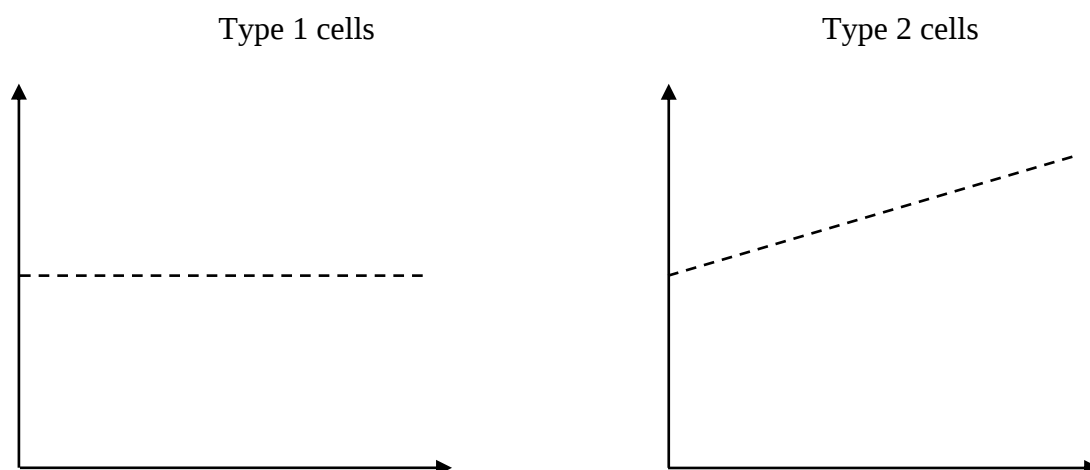
Which one of the following statements applies to both processes?

- A. Both occur in all plant cells.
- B. Both use an electron transport chain to produce ATP
- C. Both processes are endergonic, requiring an input of energy.
- D. Both processes involve the use of the carrier molecule NADH.

Question 12

Two types of cells were each placed into a solution inside a sealed flask. All of the oxygen was removed from the flasks. Both samples of cells were supplied with all required nutrients, including glucose. A data logger inside each of the sealed flasks was used to monitor the concentration of carbon dioxide.

The graphs below show the change in the concentration of carbon dioxide in each of the solutions over the same period of time.

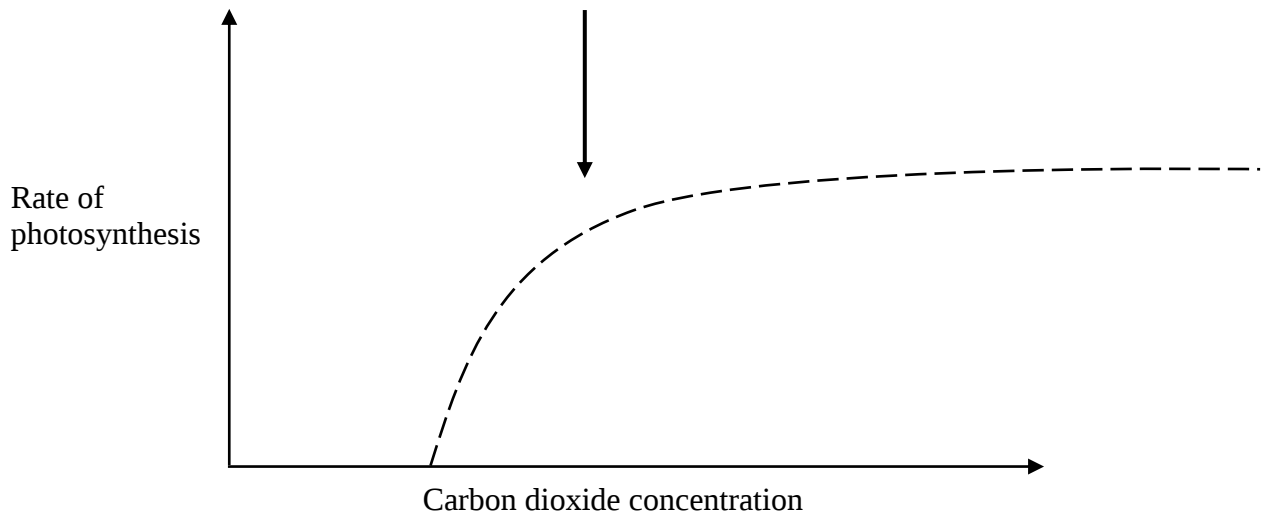


Based on the information supplied, which one of the following conclusions is the most accurate?

- A. The cells came from different organs in the same organism.
- B. Both types of cell are carrying out aerobic cellular respiration.
- C. The type 1 cells are from an animal and the type 2 cells are from a plant.
- D. Both types of cell continue to produce carbon dioxide after being placed into the solution.

Question 13

A student completed an experiment to determine the effect that changing carbon dioxide concentration would have on the rate of photosynthesis. They used their results to produce the following graph.



The rate of photosynthesis becomes constant after the point indicated by the arrow because

- A. the plant is unable to produce oxygen.
- B. oxygen concentration has become a limiting factor.
- C. carbon dioxide concentration has become a limiting factor.
- D. carbon dioxide concentration has ceased to be a limiting factor.

Question 14

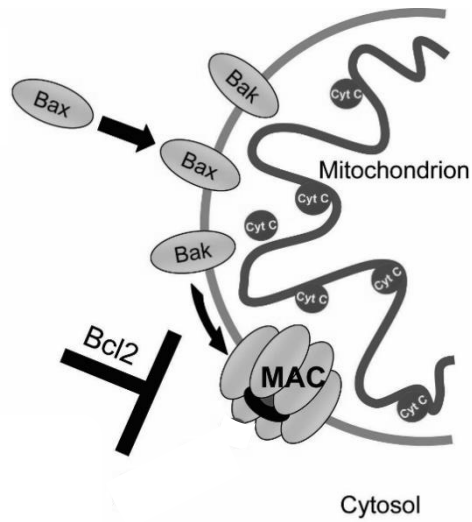
Human growth hormone (HGH) is an example of a hydrophilic signalling molecule.

Which one of the following statements is correct?

- A. Cells that receive HGH will respond by increasing in size.
- B. The receptor for HGH is located in the cytosol of all target cells.
- C. Reception of HGH will activate a second messenger inside the target cell.
- D. HGH will form a complex with the receptor, which will migrate to the nucleus and bind to a specific region of DNA.

Question 15

Bax and Bak are proteins that respond to cellular stress by changing their shape and forming pores that pierce the outer membrane of mitochondria, as shown in the diagram below.

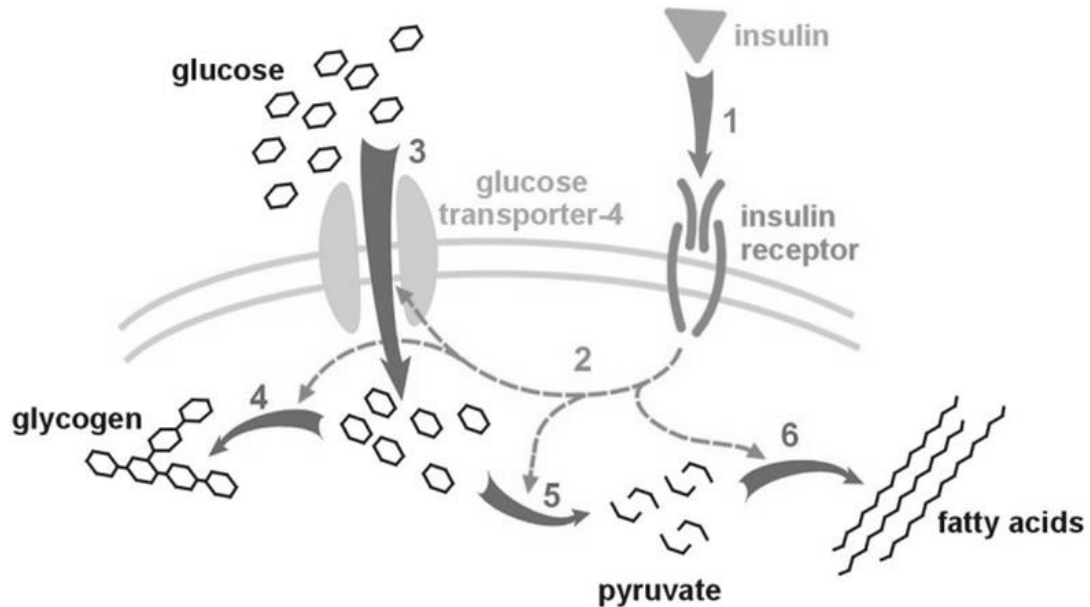


Which cellular process would be initiated by the action of these proteins?

- A. apoptosis
- B. active transport
- C. signal transduction
- D. cellular respiration

Question 16

Liver cells play a vital role in blood glucose regulation. As shown in the diagram below, these cells are able to take up glucose from the bloodstream, convert it to glycogen and then store it. Liver cells are also able to convert glycogen back into glucose and then release it into the bloodstream.



Source: 'Effect of insulin on glucose uptake and metabolism' by User Meiquer available at https://commons.wikimedia.org/wiki/File:Insulin_glucose_metabolism.jpg under a Creative Commons Attribution-Share Alike 3.0 license. Full terms at <https://creativecommons.org/licenses/by-sa/3.0/deed.en>.

The ability of liver cells to carry out both processes means that

- A. a single signalling molecule has bound to two different receptors.
- B. a single signalling molecule triggered different second messengers, inducing the different cellular responses.
- C. the signal to take up glucose came from the external environment and the signal to release glucose originated inside the liver cells.
- D. liver cells have several receptors that enable them to receive and respond to different signalling molecules.

Question 17

‘Complement’ is the term applied to a set of over 30 different proteins that play a role in the immune system.

Which one of the following identifies a role played by complement proteins?

- A. They trigger clonal expansion.
- B. They facilitate the production of antibodies.
- C. They facilitate and enhance the process of phagocytosis.
- D. They act as a barrier, preventing pathogens from entering cells.

Question 18

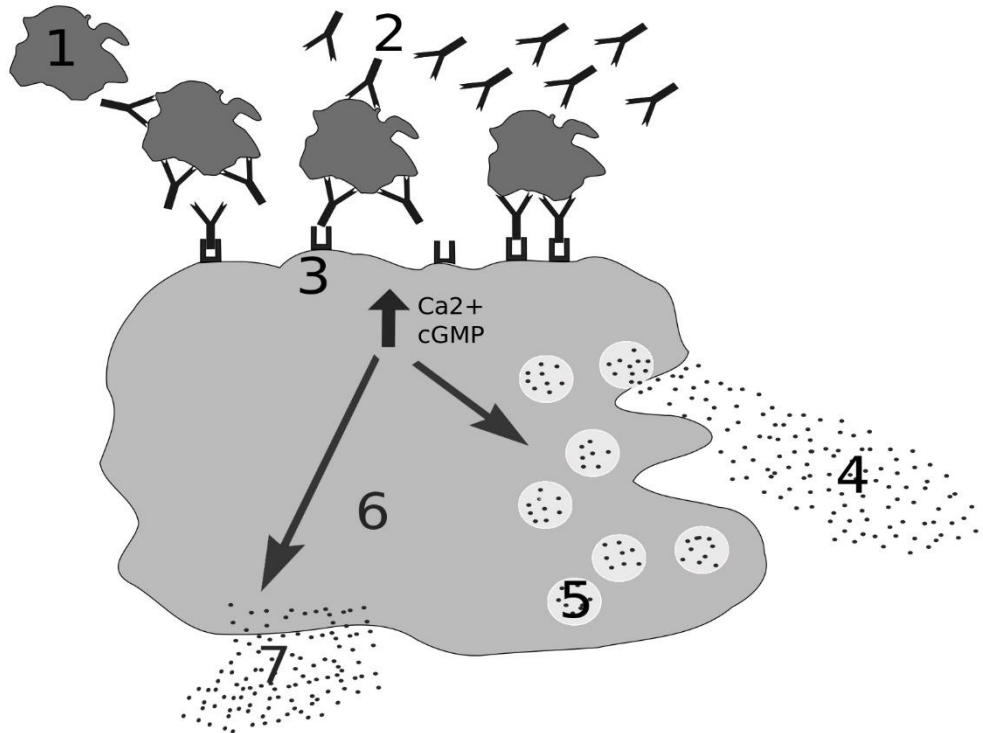
A student is confused regarding the difference between cytotoxic T cells and natural killer cells. The student asks several people for assistance and is provided with a range of answers.

Which one of the following answers is correct?

- A. Cytotoxic T cells carry out specific responses; natural killer cells carry out non-specific responses.
- B. Cytotoxic T cells and natural killer cells play similar roles; they both produce antibodies that act against viruses.
- C. There is no difference between cytotoxic T cells and natural killer cells; both terms apply to the same type of cell.
- D. Cytotoxic T cells produce toxins that act against pathogens; natural killer cells kill pathogens by engulfing them.

Question 19

After a previously sensitised person is exposed to pollen, mast cells degranulate, as shown in the image below. Histamine is released and binds to histamine receptors, causing cellular responses that result in the person experiencing symptoms such as inflammation, production of tears and a runny nose.



Source: 'The degranulation process in a Mast cell' by Paweł Kuźniar available at https://en.wikipedia.org/wiki/Degranulation#/media/File:Allergy_degranulation_processes_01.svg under a Creative Commons Attribution-Share Alike 3.0 license. Full terms at <https://creativecommons.org/licenses/by-sa/3.0/deed.en>.

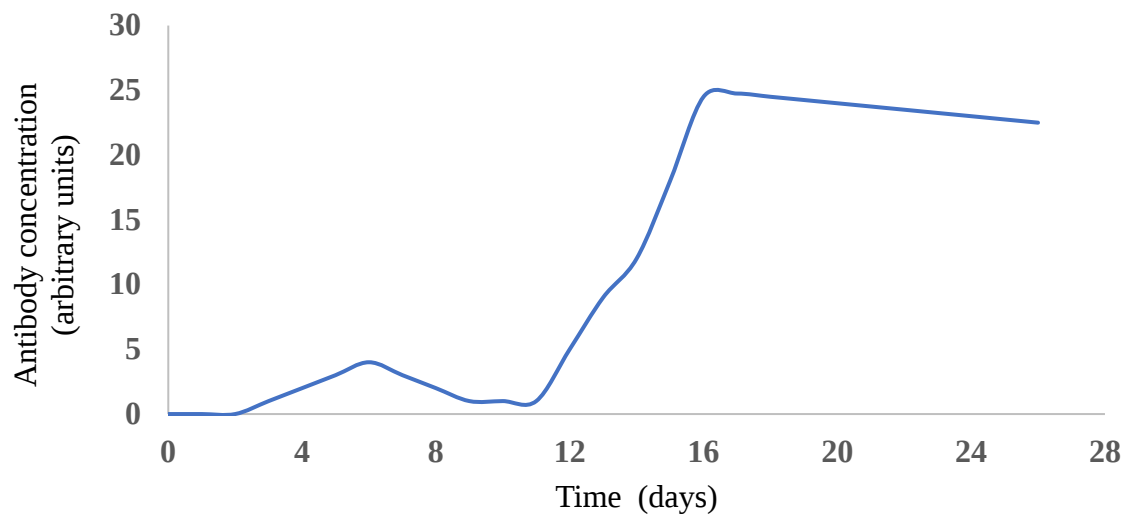
An experimental drug was created to stop the symptoms.

Which one of the following attributes should this drug have to prevent the exposed person from developing symptoms?

- A. It should prevent pollen antibodies from binding to mast cells.
- B. It should bind to mast cells, preventing them from releasing histamine.
- C. It should bind to histamine receptors, blocking the binding of histamine.
- D. It should bind to IgE antibodies, preventing them from binding to mast cells.

Question 20

Blood samples were taken from a person over a 26-day period to determine their antibody concentration. The results were used to create the following graph.



Which one of the following conclusions could be drawn from this graph?

- A. The response after day 11 could have been due to a booster shot.
- B. The person must have been exposed to the same pathogen twice.
- C. The person must have experienced the worst symptoms on day 16.
- D. This graph shows an example of artificially acquired passive immunity.

Question 21

The fossil of an ammonite, such as the one in the image below, was determined to be approximately 200 million years old.



Source: 'Dactylioceras commune fossil ammonite (Whitby Formation, Lower Jurassic; Yorkshire coast, England)' by James St. John available at <https://www.flickr.com/photos/47445767@N05/15053793770> under a Creative Commons Attribution 2.0 Generic license. Full terms at <https://creativecommons.org/licenses/by/2.0/deed.en>.

Which one of the following methods could have been used to determine the absolute age of the fossil?

- A. analysing the fossil using radiocarbon dating
- B. analysing the fossil using potassium-to-argon dating
- C. determining the structural similarity of the ammonite to other fossils
- D. comparing the position of the ammonite to that of other fossils found in other rock strata

Question 22

Which one of the following is an indication that a mass extinction occurred?

- A. A rock stratum contains charcoal, indicating that a fire occurred.
- B. Rock layers dated as being 3.5 billion years old do not contain any fossils.
- C. A rock stratum that originated in a prehistoric lake contains fossils of few species.
- D. A rock stratum containing few fossils is located between two strata that contain many fossils.

Question 23

Which one of the following statements correctly represents evolution?

- A. Changes in allele frequencies occurred over many generations.
- B. Modern organisms are more complex than their prehistoric counterparts.
- C. New species have developed as biologically fit individuals survive and reproduce.
- D. Individual members of a population develop new adaptations as a result of responding to environmental changes.

Question 24

Claytonia virginica is an herbaceous plant that produces flowers that vary in colour between white and bright pink. It was determined that the hue of the flowers affected their reproductive success, with bees preferring to pollinate the plants that produced pink flowers.

Ten generations of plants were produced. During this time, bees were removed and pollination was carried out by organisms that had no colour preference.

Which one of the following would be most likely to occur?

- A. The incidence of pink flowering plants would increase.
- B. The incidence of white flowering plants would increase.
- C. There would be no change in the incidence of pink and white flowering plants.
- D. Equal numbers of white flowering and pink flowering plants would be produced.

Question 25

The following information shows the sequence of an allele in an individual with a genetic condition compared to an individual who does not have the condition.

Affected individual:	ATGCAGGTCAACGAG
Unaffected individual:	ATGCACGGTCAACGAG

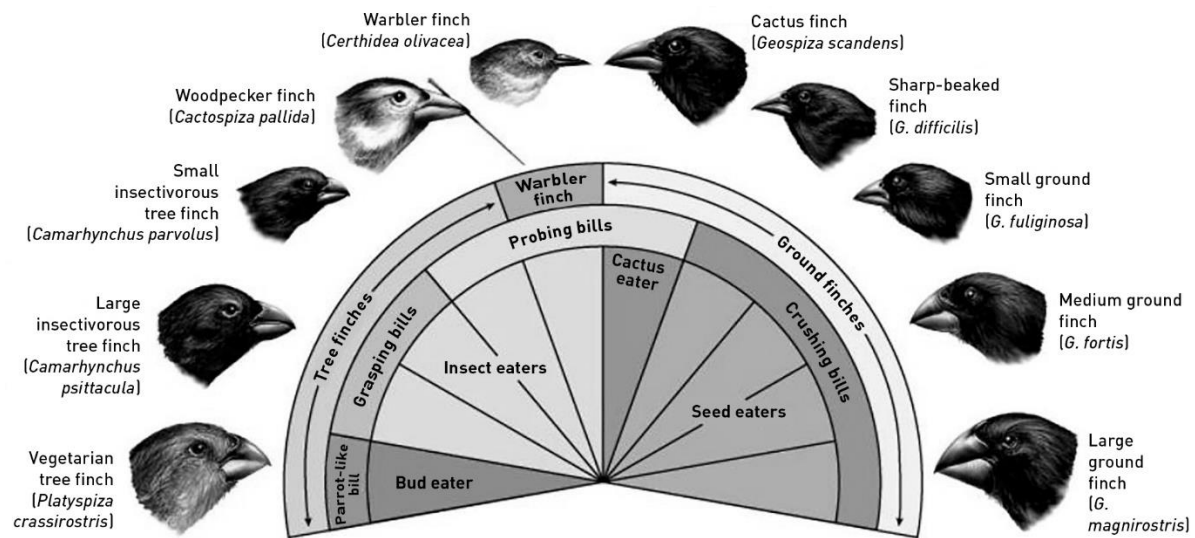
The genetic condition occurs because

- A. the mutation caused the production of a new allele.
- B. the genetic mutation caused the protein to denature.
- C. the condition was caused by an addition mutation.
- D. the mutation prevented the affected individual from expressing the gene.

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Question 26

The diagram below shows the range of different species of finches that Charles Darwin observed on the Galapagos Islands. These finches are all genetically different and have become specialised to consume different food sources.



Which one of the following is the first stage that would have resulted in the evolution of the range of different finch species?

- Genetic equilibrium was achieved.
- Geographic isolation was achieved on different islands.
- Competition occurred between the different species of finch.
- A founding population reached one island from the mainland.

Question 27

Beak size and shape in Darwin's finches is heavily influenced by the degree of expression of two genes: CaM and BMP4.

Low BMP4 expression leads to the formation of a narrow beak.
High BMP4 expression leads to the formation of a beak with a high depth.
Low CaM expression leads to the formation of a short beak.
High CaM expression leads to the formation of an elongated beak.

The warbler finch shown in the image below is characterised as having a short, narrow beak.



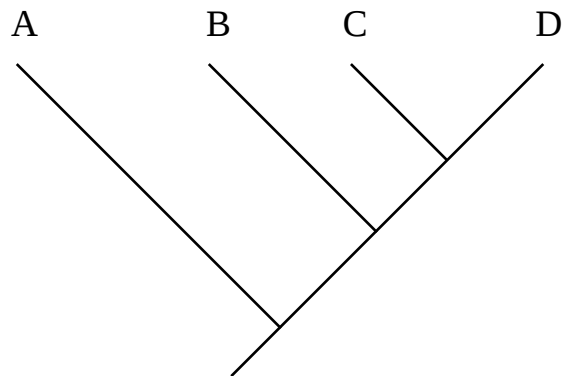
Source: 'Wood Warbler (*Phylloscopus sibilatrix*)' by Steve Garvie available at <https://www.flickr.com/photos/rainbirder/4649168731/> under a Creative Commons Attribution-Share Alike 2.0 Generic license. Full terms at <https://creativecommons.org/licenses/by-sa/2.0/deed.en>.

Which one of the following would be expected to cause this?

- A. high CaM, low BMP4
- B. low CaM, high BMP4
- C. low CaM, low BMP4
- D. high CaM, high BMP4

Question 28

The following diagram is an example of a phylogenetic tree.



If DNA hybridisation were carried out using DNA from these species, which one of the following DNA hybrids would have the lowest melting temperature?

- A. the hybrid containing DNA from species B and D
- B. the hybrid containing DNA from species B and C
- C. the hybrid containing DNA from species C and D
- D. the hybrid containing DNA from species A and D

Question 29

The image below shows the fossilised tooth of an extinct megalodon shark compared with two teeth from a modern great white shark. Like all modern sharks, the megalodon was an example of cartilaginous fish, which have skeletons that consist of cartilage and connective tissue. It is not known exactly what this shark looked like because teeth are the only remains that have been found.



‘Megalodon tooth with great white sharks teeth’ by Brocken Inaglory available at https://commons.wikimedia.org/wiki/File:Megalodon_tooth_with_great_white_shark_s_teeth.jpg. Ruler added by Parzi, https://en.wikipedia.org/wiki/File:Megalodon_tooth_with_great_white_sharks_teeth-3-2.jpg. Used under a Creative Commons Attribution-Share Alike 3.0 Unported license. Full terms at <https://creativecommons.org/licenses/by-sa/3.0/deed.en>.

Which one of the following is the correct reason that fossils of other megalodon body parts have not been found?

- A. Cartilage is a soft tissue and does not tend to fossilise.
- B. All megalodons died in conditions that did not promote fossilisation.
- C. Fossils of the bodies of megalodons have all been broken down due to their extreme age.
- D. Megalodon sharks lived in deep water and we have not been able to retrieve any fossils from these depths.

Question 30

As new information becomes available, ideas relating to modern humans (*Homo sapiens*) and Neanderthals (*Homo neanderthalensis*) have also changed.

Which one of the following statements is **not** currently supported by research?

- A. *Homo sapiens* and *Homo neanderthalensis* were contemporaries.
- B. *Homo sapiens* are direct descendants of *Homo neanderthalensis*.
- C. *Homo sapiens* and *Homo neanderthalensis* both derived from a common ancestor.
- D. The majority of *Homo sapiens* currently alive have some genes derived from *Homo neanderthalensis*.

SECTION A – continued
TURN OVER

Question 31

Mitochondrial DNA (mtDNA) was extracted from 151 mummies to determine familial relationships.

Identifying an unknown male would be best accomplished by comparing his mtDNA from an individual believed to be

- A. his father.
- B. his daughter.
- C. his sister's daughter.
- D. his maternal grandfather.

Question 32

Histone residues from four different species were compared with those taken from a human. The amino acid sequences are shown below.

Human	K	K	A	S	K	P	K	K	A	A	S	K	A	P	T	V
Species 1	K	R	A	S	K	P	K	K	A	A	S	K	A	P	V	K
Species 2	K	K	A	S	L	P	K	K	A	A	S	K	A	P	T	V
Species 3	K	K	S	S	P	P	K	K	A	I	S	K	A	N	T	V
Species 4	K	K	A	S	K	F	K	K	A	R	S	K	L	P	T	V

The organism that is most likely to be a chimpanzee is

- A. species 1.
- B. species 2.
- C. species 3.
- D. species 4.

Question 33

Significant changes in life forms have occurred during the earth's geological history. It was necessary for some events to occur before others.

Which one of the following shows the correct chronology?

- A. Flowering plants appeared before vascular plants.
- B. Photosynthetic bacteria were the first organisms to appear.
- C. Eukaryotic organisms appeared before prokaryotic organisms.
- D. Nucleated cells appeared before endosymbiosis is thought to have occurred.

Question 34

Scott Kelly is a retired American astronaut who spent 340 consecutive days in space. Prior to his trip he was the same height as his identical twin brother, Mark. However, on his return he was found to have increased in height by 5 cm, an effect that was only temporary.

Based on this information it could be concluded that

- A. Scott's children will be taller than Mark's.
- B. this is an example of acclimatisation to a different environment.
- C. Scott's increase in height was due to being exposed to a selection pressure.
- D. the increase in height was caused by a mutation induced by exposure to radiation.

Question 35

Modern humans are believed to be the sole remaining hominin species; however, we share a range of characteristics with hominoids and primates.

Which one of the following traits are unique to modern humans?

- A. The presence of a definite chin.
- B. The presence of a foramen magnum in the base of the skull.
- C. Thigh bones extend at a 90° angle between the hips and the knees.
- D. Modern humans are pentadactyl, having five digits on their hands and feet.

Question 36

Many of the cultural activities carried out by modern humans and our ancestors required the ability of speech. Evidence indicates that members of the *Homo genus* were the first hominins to develop this ability.

Which of the following evidence supports this theory?

- A. Hominins lived in social groups.
- B. Tools were developed for specific tasks.
- C. Burial rites and ceremonies were carried out.
- D. Hunting and gathering were carried out by groups.

Question 37

Recombinant DNA is produced by

- A. combining DNA with a protein.
- B. combining DNA from two different sources.
- C. extracting DNA from a cell and inserting it into another cell.
- D. using reverse transcriptase to produce DNA from an mRNA template.

Question 38

When carrying out DNA manipulation, a vector is used to

- A. provide a binding site for primers.
- B. cut a piece of DNA into fragments.
- C. anneal fragments of DNA together.
- D. transport recombinant DNA into a target cell.

Question 39

The table below shows the recognition sequences of four restriction enzymes.

Enzyme	Recognition sequence	Cut site
EcoRI	5' GAATTA 3' CTTAAG	5' G AATTC 3' 3' CTTAA G 5'
BamHI	5' GGATCC 3' CCTAGG	5' G GATCC 3' 3' CCTAG G 5'
HindIII	5' AAGCTT 3' TTCGAA	5' A AGCTT 3' 3' TTCGA A 5'
Sau3A	5' GATC 3' CTAG	5' GA TC 3' 3' CT AG 5'

EcoRI is used to cut around a gene of interest for insertion into a plasmid.

Which one of the following correctly identifies the enzyme or enzymes that should be used to cut the plasmid open?

- A. Only EcoRI should be used to cut the plasmid open.
- B. Only Sau3A should be used to cut the plasmid open.
- C. Any of the enzymes could be used to cut the plasmid open.
- D. Only EcoRI, BamHI or Hind III should be used to cut the plasmid open.

Question 40

Which one of the following must apply to all drugs produced using rational drug design?

- A. The drug must bind to the active site of an enzyme.
- B. Use of the drugs must provide a therapeutic benefit.
- C. The drugs must be able to be used to combat bacterial and viral infections.
- D. The drug must be chemically identical to the pathogen it was constructed to act against.

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SECTION B**Instructions for Section B**

Answer **all** questions in the spaces provided. Write using a blue or black pen.

Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1 (7 marks)

The COL1A1 gene provides instructions for synthesising collagen proteins, such as the one shown below. Collagens are a family of proteins that strengthen and support many tissues in the body, including cartilage, bone and skin. The COL1A1 gene is 18 kb (18 000 base pairs) in length and codes for the production of a protein that is made up of 1464 amino acids. The image below shows an example of the structure of collagen.



‘Structure of the COL9A1 protein’ by Emw available at https://commons.wikimedia.org/wiki/File:Protein_COL9A1_PDB_2uur.png under a Creative Commons Attribution-Share Alike 3.0 Unported license. Full terms at <https://creativecommons.org/licenses/by-sa/3.0/deed.en>.

- a. Identify the sub-units that make up type I collagen and explain how these sub-units are linked together to form type I collagen.

2 marks

- b.** Based on the information provided, calculate the length of the mRNA that was translated to produce the type I collagen. Explain how this answer was determined.

2 marks

Two students are discussing the information provided and they conclude that the mRNA is much shorter than expected compared with the DNA.

- c.** Use the information provided to explain how they reached this conclusion.

1 mark

- d.** Produce an annotated diagram to describe how and why the difference between the length of the DNA and the mRNA occurred. Refer to appropriate cellular processes in your answer.

2 marks

Question 2 (7 marks)

Magnesium deficiency has been identified as an issue of concern in crop plants. This occurs when plants do not obtain sufficient magnesium ions (Mg^{2+}) from the soil. The physiological responses to magnesium deficiency include the accumulation of sugars and starches in the leaves, a reduction in the size of the roots, a decline in the rate of photosynthesis, an increase in the ageing rate of leaves, and the development of yellow patches on the leaves.

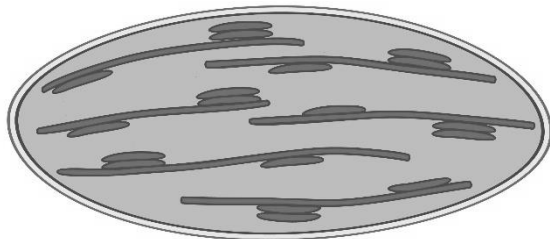


Diagram of a chloroplast from a magnesium-deficient plant.

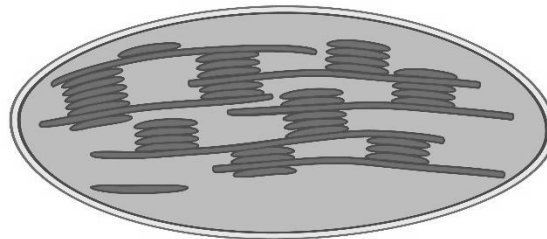


Diagram of a chloroplast from a plant with sufficient magnesium.

- a. The images above show diagrams of chloroplasts from plants provided with different amounts of magnesium.

Use this information to explain why magnesium-deficient plants experience a decline in the rate of photosynthesis compared with plants provided with sufficient magnesium.

2 marks

- b. The yellowing of the leaves of the magnesium-deficient plant indicates that these plants are less able to produce chlorophyll than plants with sufficient magnesium. Studies have found that magnesium ions are required for chlorophyll to function effectively.

State whether magnesium ions are an example of a coenzyme or a cofactor. Provide a justification for your answer.

2 marks

Glucose is actively transported by the process of translocation. This occurs through phloem vessels from the leaves to the rest of the plant. It has been found that phloem vessels contain structures that enable them to take up magnesium ions. This process is essential for translocation to occur.

- c. Explain how magnesium deficiency contributes to the accumulation of sugars in the leaves of affected plants.

1 mark

- d. Consider the cellular processes that occur within cells.

Use this information to explain why the roots in affected plants are much smaller than those of plants that have sufficient magnesium.

2 marks

Question 3 (7 marks)

Yaks, such as shown in the image below, are bovines similar in size to domesticated cattle. Yaks tend to live in high altitudes where it is cold, and there is low food availability and a reduced oxygen concentration in the air. Yaks from these areas have red blood cells that are much smaller than those of any other bovines, but they have approximately five times the number of red blood cells as any other bovine.



- a. Consider the environment in which yaks live and the role played by red blood cells.

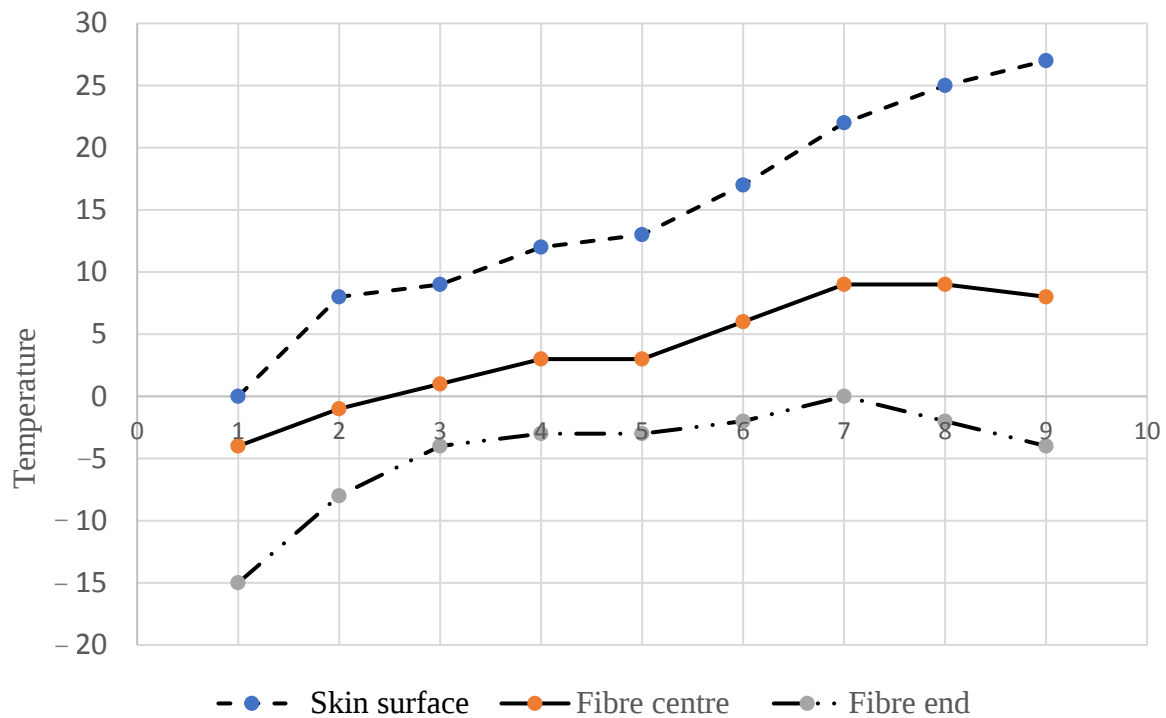
The small size of the red blood cells increases their surface area to volume ratio, thereby enabling more oxygen to bind to the haemoglobin in the red blood cells.

Explain the significance of the size of the blood cells with regard to the cellular processes required to sustain life.

1 mark

A researcher hypothesised that the yak's thick coat provided insulation and enabled the yak to survive in cold temperatures. They took a range of temperatures from the surface of the Yak's skin, halfway through the fibre and at the end of the fibre.

The results are shown in the following graph.



- b. Identify **one** error in this graph and explain how this error could affect a reader's understanding of the information provided.

2 marks

- c. Identify a valid conclusion that could be based on this data.

1 mark

- d.** Yaks living at higher altitudes have more red blood cells than yaks of the same species living at lower altitudes.

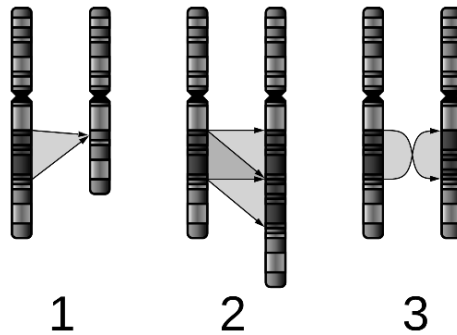
Identify the process responsible for this difference and explain how this process caused this difference.

3 marks

Question 4 (8 marks)

Di George syndrome (DGS) is an autoimmune condition caused by a mutation that occurs in chromosome 22 of humans. This condition is also called 22q11.2 deletion syndrome because over 90% of affected individuals have a deletion of approximately 3 million base pairs from chromosome 22, leading to the loss of approximately 40 genes.

An example of a deletion mutation is shown in the diagram below.



Source: 'Single Chromosome Mutations' by Richard Wheeler (vector version by NikNaks) available at https://en.wikipedia.org/wiki/File:Single_Chromosome_Mutations.svg under a Creative Commons Attribution-Share Alike 3.0 Unported license. Full terms at <https://creativecommons.org/licenses/by-sa/3.0/deed.en>.

The mutation is random and occurs spontaneously in the sperm or ova of the parents of an affected individual.

Most affected individuals have the same genetic defect, but the presentation of the condition varies. All affected individuals have thymus gland abnormalities, with most having a reduced or missing thymus gland.

There is also a wide range of other abnormalities that affected individuals may or may not develop, such as severe cardiac abnormalities

Diagnosis of DGS is frequently accomplished using the fluorescence in situ hybridisation (FISH) test. Although FISH is considered to be the gold standard test, it is not 100% accurate and is expensive to carry out.

- a.** A health professional stated that DGS is commonly underdiagnosed or misdiagnosed. Use a piece of evidence from the information provided to support this statement. Justify how this information is used to support the statement above.

2 marks

- b.** Explain why people with DGS develop T-lymphocyte deficiency.

1 mark

- c.** Explain why people with DGS are more susceptible to viral infections than unaffected individuals.

2 marks

- d.** The probes used in the FISH test are produced using a DNA amplification technique. Name this technique.

1 mark

- e.** Genetic screening may be carried out in utero for some conditions, but this is not possible for DGS. Instead, genetic testing is carried out on individuals who are deemed as being at high risk.

Discuss one reason for performing genetic testing as soon as possible after an individual is born.

1 mark

- f.** Identify an ethical issue associated with the genetic screening of babies.

1 mark

Question 5 (11 marks)

Cavendish bananas have been exposed to a human-made genetic bottleneck. There is a concern that bananas may be wiped out by existing or emerging pathogens. This has become a problem in Uganda, where bananas are a staple crop.

Extensive crops were affected by banana bacterial wilt (BBW), which is caused by a bacterial pathogen, *Xanthomonas campestris* pv. *musacearum*. There is no effective chemical control for this pathogen and no species of banana has immunity against this pathogen. BBW was first reported in Uganda in 2001 and it spread from one district to 32 districts in four years, during which time the crop yield decreased by one third. Currently, the spread of BBW is controlled by destroying affected plants.

A genetically modified strain of bananas has been produced in Queensland, where it was tested for several years, before undergoing further open field testing in Uganda.

Two genes were introduced into the genetically modified (GM) Cavendish bananas: a BBW resistance gene from green peppers and a pro-vitamin A gene obtained from a species of inedible bananas that grow in South-East Asia. The pro-vitamin A gene was introduced to increase the ability of bananas to produce vitamin A.

This is an example of a genetic (population) bottleneck.

- a.** What impact does a genetic bottleneck have on the genetic diversity of a species?

1 mark

- b.** A scientist expressed concern that an emerging pathogen could eliminate Cavendish bananas.

Discuss why this could occur.

1 mark

- c.** Identify a way in which humans could cause a genetic bottleneck.

1 mark

- d.** Considering the information provided, is BBW an epidemic or a pandemic? Provide a reason to support your answer.

1 mark

- e.** Should these bananas be referred to as being genetically modified only, or should they be referred to as genetically modified and transgenic?

Explain the difference between these terms and use the data to provide a reason to support your answer.

3 marks

- f.** Identify and discuss a benefit of using GM bananas.

2 marks

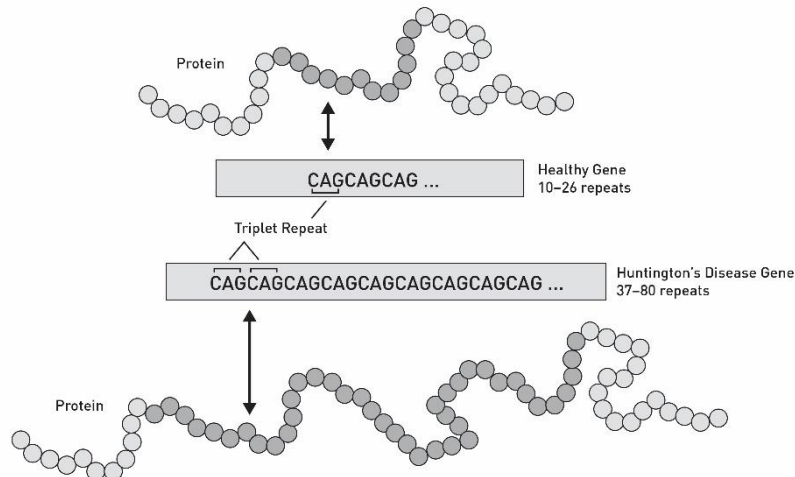
In 2017, the Ugandan parliament passed the National Biosafety Act, which approved the large-scale field testing and commercial use of GM crops. Some have expressed the idea that the passing of this bill is alarming because it opens the population up to unexamined risks.

- g.** Identify a social or biological issue raised by the use of the GM bananas and explain why this issue could create a problem.

2 marks

Question 6 (8 marks)

In humans, Huntington's disease is caused by a mutation to the Huntington's gene. This gene contains multiple repeats of the CAG sequence. Normally, the CAG sequence is repeated 10 to 35 times within the gene. In people with Huntington's disease, the CAG sequence is repeated 36 to more than 120 times.



The alleles that cause the disease are dominant, with the offspring of an affected individual having a 50% chance of inheriting the condition. Huntington's disease is a serious condition, eventually leading to death approximately 15 years after the onset of symptoms. However, symptoms generally do not commence until adulthood.

- a. Explain why there are multiple alleles of the Huntington's gene.

1 mark

- b. Define the term 'gene pool' and explain why the alleles that cause Huntington's disease have not been eliminated from the human gene pool.

2 marks

- c. Individuals can be tested for the presence of an allele that causes Huntington's disease by analysing DNA samples using electrophoresis.

Explain why electrophoresis is an appropriate technique to produce data that can be used to diagnose Huntington's disease.

1 mark

- d. Describe how a gel run of an individual with Huntington's would appear different from that of an unaffected individual. Why would this difference occur?

2 marks

The prevalence of Huntington's disease is approximately 1 per 10 000 people in the Americas, Europe and Australasia. However, the prevalence of Huntington's disease in the region surrounding Lake Maraciabo in Venezuela is unusually high, about 1 in 5, with the prevalence as high as 50 per cent in some villages. This has been traced to one woman who arrived in the area about 200 years ago. This woman was a member of a small population and had ten offspring.

- e. Identify the terminology used to describe this phenomenon and explain how it causes an unexpectedly high prevalence of the disease in this area.

2 marks

Question 7 (5 marks)

Humans have a complex immune system in which several levels of defence are used to either prevent infection or act against pathogens inside the body.

- a.** Identify **two** types of non-specific defence that act on pathogens after they have entered the body.

1 mark

- b.** Like humans, plants also have physical and chemical barriers to limit or stop the invasion of pathogens.

Identify an example of a physical or chemical barrier in plants and provide a specific explanation as to how this barrier either prevents pathogens from invading a plant or limits the spread of the pathogen.

1 mark

- c.** The third level of defence is referred to as being acquired and specific.

Complete the table below by naming three different cells or chemicals that play a role in the third level of defence. Then state the role played by each cell or chemical.

3 marks

Cell or chemical	Role

Question 8 (5 marks)

The lac operon is a method of gene regulation in some species of bacteria. It contains a series of three genes that code for the production of enzymes that facilitate the ability of the bacteria to metabolise lactose. These genes are switched on or off depending on whether lactose is present or absent.

- a.** Draw a labelled diagram to illustrate how the lac operon regulates the expression of the structural genes in the presence and absence of lactose.

2 marks

- b.** The lac operon is an example of gene regulation.

Explain how the bacterium benefits by being able to regulate the expression of the three genes that code for the production of the enzymes that facilitate the metabolism of lactose.

1 mark

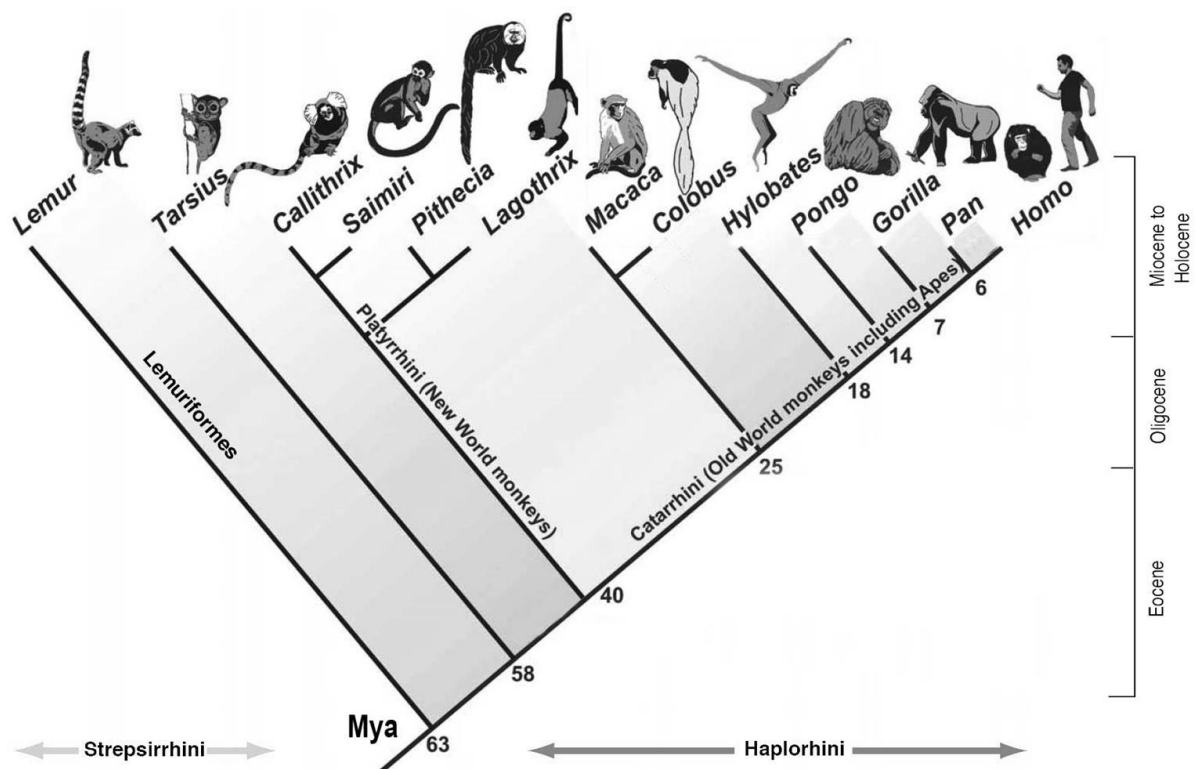
- c.** Outline the role played by structural and regulatory genes in the lac operon system.

Include a reference to the functional distinction between structural and regulatory genes in your answer.

2 marks

Question 9 (5 marks)

The phylogenetic tree below summarises the evolutionary relationships between modern species of primates.



- a. Use the information in the phylogenetic tree to provide an example of divergent evolution. Justify your answer.

1 mark

In January 2018, a report was released that related to the identification and naming of a previously unknown species of lemur, the Groves dwarf lemur (*Cheirogaleus grovesi*). The Omaha zoo had several of these lemurs and proposed that they were a new species. When this type of event occurs, the potential new species is labelled as a species nova until sufficient evidence can be presented to support their contention.

- b.** It took approximately one year for sufficient evidence to be gathered and presented before it was agreed that these lemurs were a new species.

Identify and discuss one piece of evidence that scientists would have used to prove that the Groves dwarf lemur was a different species.

2 marks

- c.** Most of the world's 113 species of lemur are found in Madagascar. The Groves dwarf lemur occupies a highly specific niche in two national parks in Madagascar.

Suggest a possible outcome for this species. Provide a reason to support your answer.

2 marks

Question 10 (7 marks)**Cheddar Man: Mesolithic Britain's blue-eyed boy**

by Kerry Lotzof

Cheddar Man was a Mesolithic hunter-gatherer (fully modern human) with dark skin and blue eyes. He was about 166 centimetres tall and died in his twenties.

His skeleton was uncovered in 1903 during improvements to drainage for Gough's Cave, a popular tourist attraction.

When Cheddar Man was first found, there were claims that he was the long-sought earliest Englishman, with an exaggerated age of 40,000–80,000 years. But subsequent radiocarbon dating from the 1970s onwards suggests he lived around 10,000 years ago.

His skeleton shows a narrow pelvis shape. It's uncertain whether a hole in his forehead was from an infection or from damage at the time of excavation.

Like all humans across Europe at the time, Cheddar Man was lactose intolerant and was unable to digest milk as an adult.

At the time Cheddar Man was alive, Britain was attached to continental Europe and the landscape was becoming densely forested.

Cheddar Man belonged to a group of people who were mainly hunter-gatherers.

In addition to seeds and nuts, his diet would have consisted of red deer, aurochs (large wild cattle) and freshwater fish.

While Cheddar Man was not found with any recorded animal or cultural remains, other Mesolithic sites offer clues about his diet and the kind of cultural life he may have been part of.

Star Carr was a Mesolithic settlement in North Yorkshire that predates Cheddar Man by around 1,000 years.

There, archaeologists uncovered red deer skull-caps (which may have been worn as headdresses); semiprecious stones including amber, hematite and pyrite; and an engraved shale pendant known as the oldest Mesolithic art in Britain.

Modern-day British people share approximately 10% of their genetic ancestry with the European population to which Cheddar Man belonged, but they aren't direct descendants.

Current thinking is that the Mesolithic population that Cheddar Man belonged to was mostly replaced by farmers who migrated into Britain later.

Source: 'Cheddar Man: Mesolithic Britain's blue-eyed boy', Natural History Museum UK website, 7 February 2018, < <http://www.nhm.ac.uk/discover/cheddar-man-mesolithic-britain-blue-eyed-boy.html> >

- a.** According to the article, modern-day British people share approximately 10% of their genetic ancestry with the European population to which Cheddar Man belonged.

Identify a piece of evidence that could be used to support this claim.

1 mark

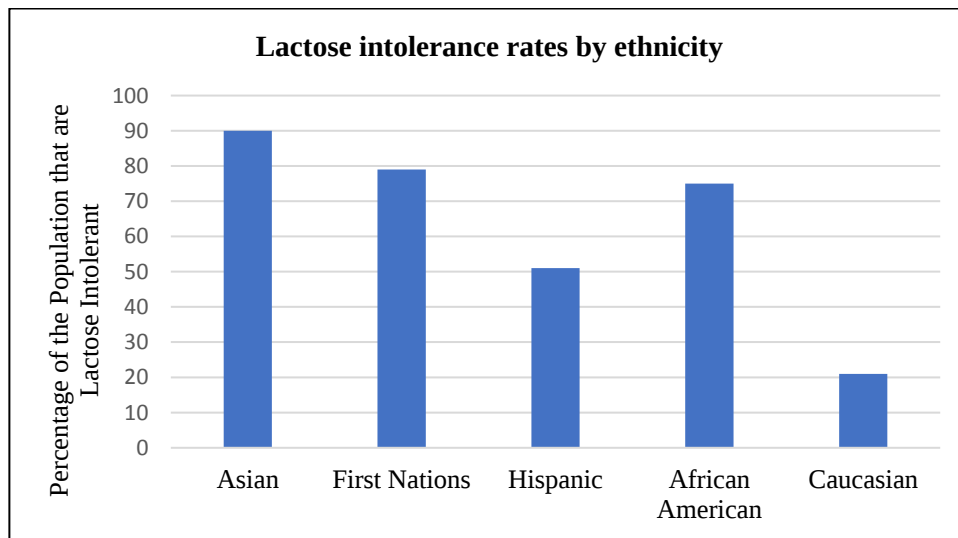
- b.** A range of structural changes have occurred during the evolution of hominins.

What information is conveyed relating to the pelvis of Cheddar Man? Is this shape expected in the pelvis of a member of the *Homo sapiens* species? Refer to information regarding the trends in hominin evolution in your answer.

2 marks

Genetic information indicates that Cheddar Man and his contemporaries could not digest milk as an adult.

The graph below contains information relating to the prevalence of lactose intolerance in the modern population.



Data: Scrimshaw NS and Murray ED, 'The acceptability of milk and milk products in populations with high prevalence of lactose intolerance', *American Journal of Clinical Nutrition*, Vol. 48, Suppl. 4, 1988, pp. 1079-1159.

- c. How does the prevalence of lactose intolerance differ in the modern Caucasian population compared with that of Cheddar Man? Discuss a valid reason to explain why the difference occurred.

2 marks

- d. Identify an example of cultural evolution referred to in the article.
What does this information indicate about the cognitive ability of the people who existed at this time?

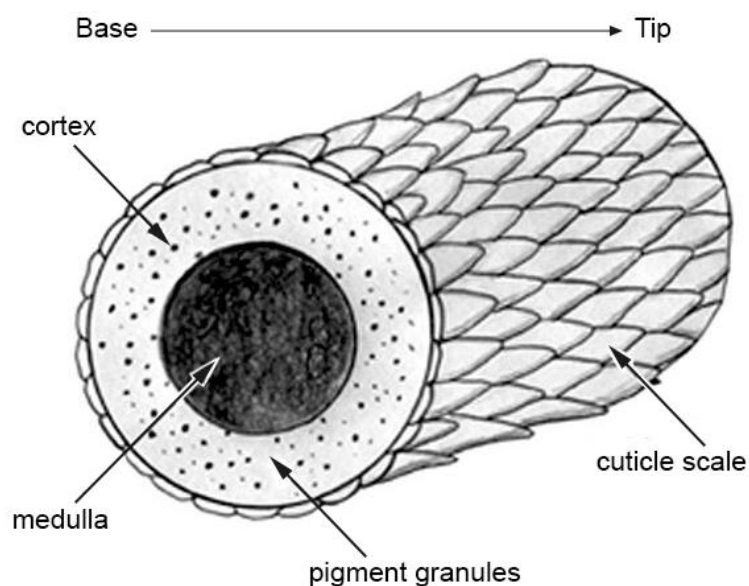
2 marks

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Question 11 (10 marks)

In 2011, a research group conducted a study to determine whether it is better to blow-dry your hair or whether it should be allowed to dry naturally.

The image below shows a cross-section of a human hair.



Source: Krome International. Reproduced with permission.

The cuticle scales are made up of hardened keratin. The cell membrane complex (CMC) is made up of lipids and polysaccharides. It acts like a glue and holds the cuticle scales together. The cortex and medulla are made up of softer keratin. The base of the hair is attached to the skull by a follicle.

The research group identified that the main types of damage are damage to the cuticles, which causes roughness and split ends, or damage to the CMC, which may cause loss of hair.

Samples of hair were divided into five groups as follows.

Group	Treatment
1	No treatment
2	Drying without using a hair dryer (room temperature, 20°C)
3	Drying with a hair dryer for 60 seconds at a distance of 15 cm (47°C)
4	Drying with a hair dryer for 30 seconds at a distance of 10 cm (61°C)
5	Drying with a hair dryer for 15 seconds at a distance of 5 cm (95°C)

After treatment, all samples were left in the same environment for 24 hours before being examined using a scanning electron microscope.

- a.** Group 1 is the control group.

Explain the purpose of using a control group.

1 mark

- b.** Each of the groups was exposed to the treatment 30 times.

Explain the purpose of carrying out the treatment multiple times.

1 mark

- c.** Consider the types of variables used in a fair test experiment.

Identify **one** way in which this experiment differs from a standard fair test. Use examples to support your answer.

2 marks

The results of the experiments are shown in the table below. Three possible areas of damage were examined.

Group	Description of hair surface	Effect on CMC	Effect on cortex
1	No cracks	No signs of damage	No signs of damage
2	No cracks	Extensive bulging	No signs of damage
3	Multiple cracks	No signs of damage	No signs of damage
4	Multiple cracks and some lifting of the cuticle scales	No signs of damage	No signs of damage
5	Multiple cracks and extensive lifting of the cuticle scales	No signs of damage	No signs of damage

- d.** A student reviewed the article that was written based on these results and stated that the results of the experiment were not valid due to the methods used.

Is this statement accurate? Provide a reason to support your answer.

2 marks

- e.** The extensive bulging of the CMC occurred due to prolonged exposure to water. Identify the process that caused the bulging to occur and explain why it occurred.

2 marks

- f.** With reference to the purpose of this experiment and the data obtained, identify **two** conclusions that this group could have made.

2 marks

END OF QUESTION AND ANSWER BOOK