2025
NHT

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Biology

Question and Answer Book

VCE (NHT) Examination – Tuesday 20 May 2025

- Reading time is **15 minutes**: 10.30 am to 10.45 am
- Writing time is **2 hours 30 minutes**: 10.45 am to 1.15 pm

Materials supplied

- Question and Answer Book of 44 pages
- Multiple-Choice Answer Sheet

Instructions

- Follow the instructions on your Multiple-Choice Answer Sheet.
- At the end of the examination, place your Multiple-Choice Answer Sheet inside the front cover of this book.

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

Contents

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

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Section A – Multiple-choice questions

Instructions

- Answer **all** questions in pencil on your Multiple-Choice Answer Sheet.
- 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.

Use the following information to answer Questions 1 and 2.

Yeast is used to help make bread. When yeast cells respire anaerobically, they produce a gas that helps make bread rise. Tha Dah Say and Amal wanted to test how the different amounts of yeast used in dough impact the height of a loaf of bread. Each carried out their own experiment. They each used the same bread maker to bake loaves of bread with varying amounts of yeast. They then measured the height of each loaf of bread. All other variables were kept the same. All the baking was completed over the course of one day.

The following table shows the height of each loaf of bread.

	Amount of yeast (teaspoon)	Bread height (cm)	
		Tha Dah Say	Amal
Trial 1	0.5	13.8	4.2
	1.0	15.9	7.5
Trial 2	0.5	13.6	3.9
	1.0	15.7	7.4
Trial 3	0.5	13.7	4.1
	1.0	16.1	7.4

Question 1

Which one of the following statements is correct?

A. The amount of yeast is the dependent variable as it is a form of quantitative data.

B. The height of the bread is the independent variable as Tha Dah Say and Amal chose to measure it in centimetres.

C. The amount of yeast is the controlled variable as Tha Dah Say and Amal accurately measured the amount used.

D. The height of the bread is the dependent variable because it changes due to the different amounts of yeast present.

Question 2

When 0.5 teaspoon of yeast was used, the bread height was consistently lower than when 1.0 teaspoon of yeast was used.

This shows that

A. the data is quantitative, as a smaller amount of yeast would use a smaller amount of oxygen.

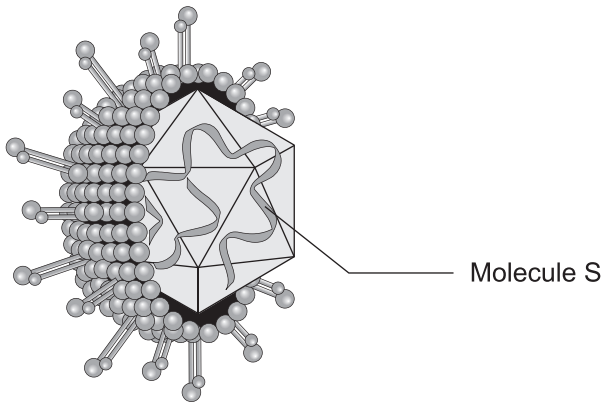
B. the trend is reproducible, as Tha Dah Say and Amal's data both showed this correlation.

C. the data is qualitative, as each trial indicates that a smaller amount of yeast would produce a smaller amount of gas.

D. the data is not repeatable, as Amal's data shows a lower bread height in all data sets.

Question 3

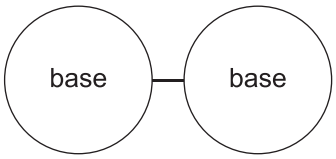
The diagram below shows the structure of a Hepatitis C virus. The virus is a single-stranded RNA virus.



Source: Adapted from <https://www.hegasy.de/>

Which one of the following diagrams could represent a repeated structure within Molecule S?

A.



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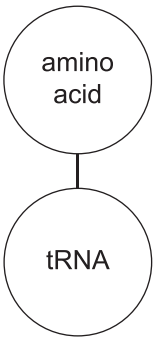

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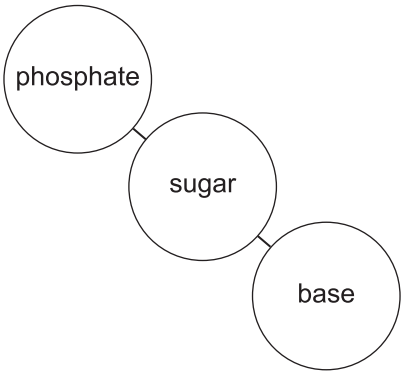

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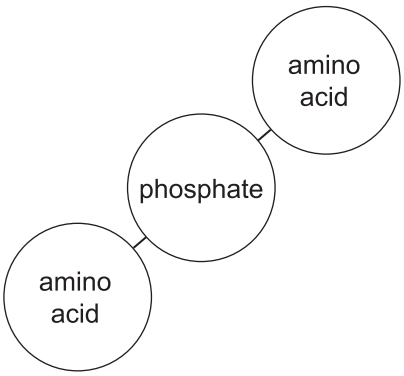


Question 4

Pre-mRNA molecules contain exons and introns.

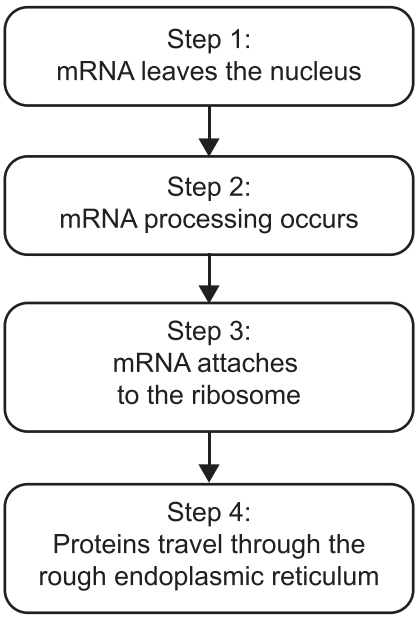
Which of the following correctly summarises the similarities and differences between exons and introns?

	Exons only	Both introns and exons	Introns only
A.	are translated	contain nucleotides	do not leave the nucleus
B.	contain nucleotides	are translated	do not leave the nucleus
C.	do not leave the nucleus	contain nucleotides	are translated
D.	are translated	do not leave the nucleus	contain nucleotides

Question 5

Which flowchart correctly orders some of the steps in a protein synthesis and secretory pathway?

A.



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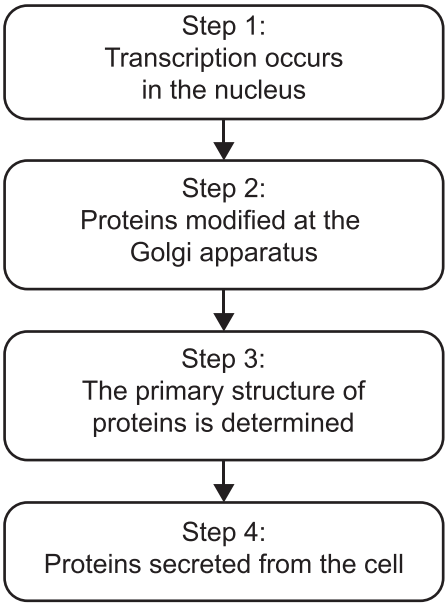

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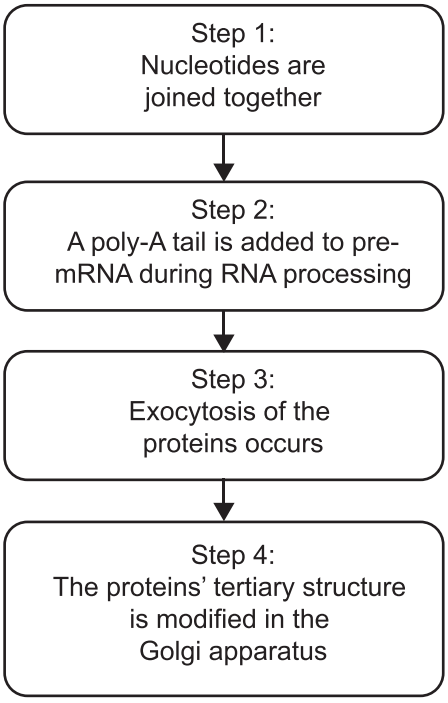

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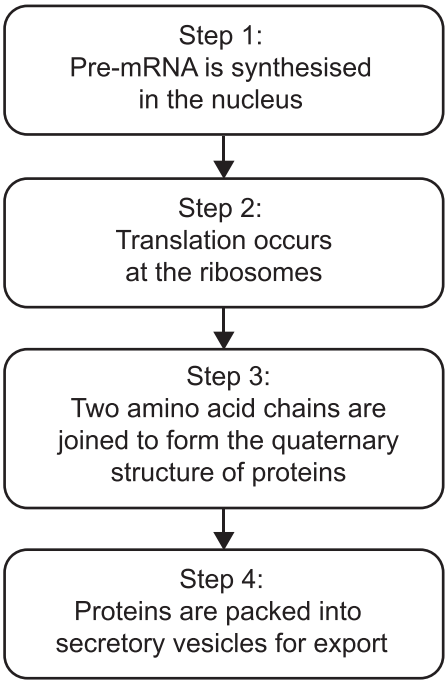
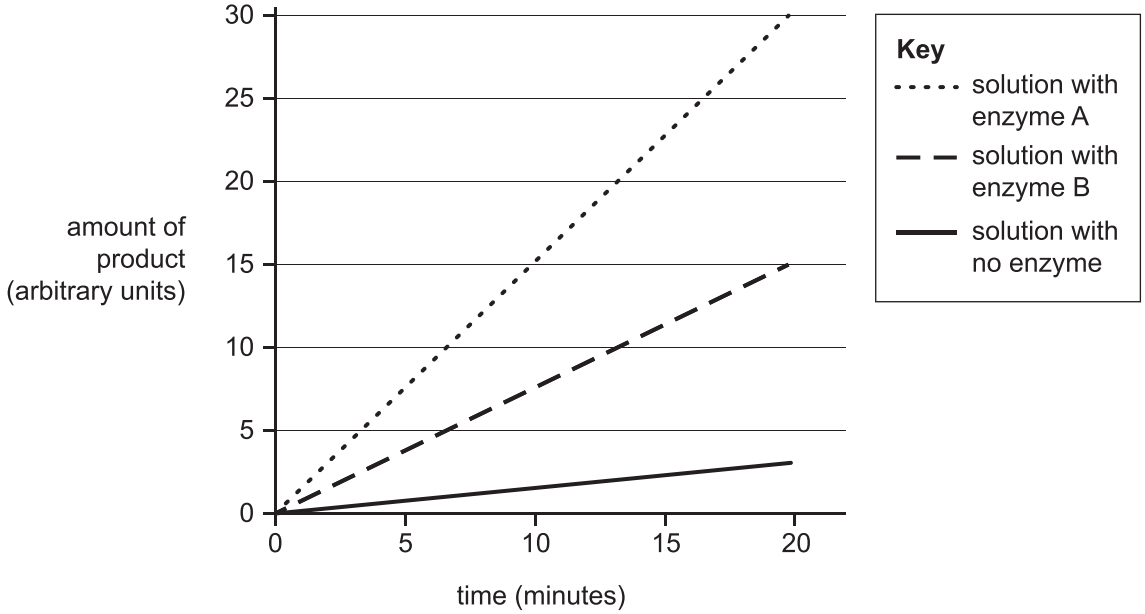


Question 6

Three separate solutions contained the same substrate and either enzyme A, enzyme B or no enzyme. All other variables were controlled. The graph below shows the amount of product produced in each solution over a 20-minute period.



Which conclusion can be drawn from this data?

A. Enzymes A and B act as catalysts in this reaction.

B. Enzyme B is denatured between 15 to 20 minutes.

C. The reaction only occurs in the presence of an enzyme.

D. The active site of enzyme A is less complementary to the substrate than that of enzyme B.

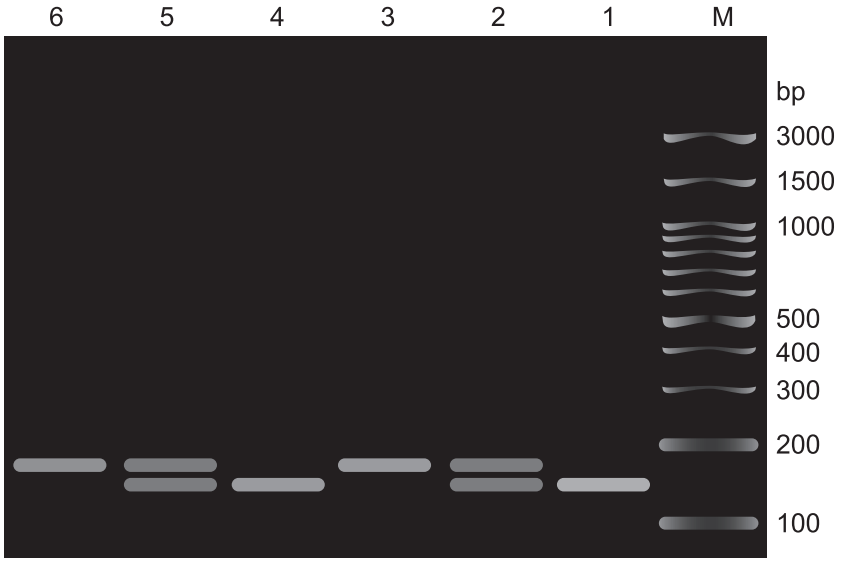
Use the following information to answer Questions 7 and 8.

Type 1 diabetes mellitus (T1DM) can be caused by genetic mutations.

DNA profiling was carried out, using gel electrophoresis, to identify if children carry the specific genetic mutation for T1DM.

Children without T1DM have fragments all of the same length that run furthest from the well. Any other combinations of fragments result in children being diagnosed with T1DM.

Each of lanes 1 to 6 represents a different child tested for the genetic mutation. Lane M is the DNA base pair (bp) ladder. The results are shown below.



Source: O Makhzoom, Y Kabalan and F Al-Quobaili, 'Association of KCNJ11 rs5219 gene polymorphism with type 2 diabetes mellitus in a population of Syria: a case-control study', *BMC Medical Genetics*, 20, 2019.

Question 7

Referring to the gel run, all the children carrying the specific genetic mutation for T1DM are shown in lanes

A. 1 and 4.

B. 2 and 5.

C. 1, 2, 4 and 5.

D. 2, 3, 5 and 6.

Question 8

To prepare the DNA for profiling T1DM using gel electrophoresis, it is most likely that the scientist would have used both

A. polymerase chain reaction and ligase.

B. CRISPR-Cas9 and plasmids.

C. endonuclease and polymerase chain reaction.

D. insulin and DNA polymerase.

Question 9

Acetyl-CoA binds with the enzyme citrate synthase in the Krebs cycle.

A competitive enzyme inhibitor that has the same shape as acetyl-CoA will

A. increase the rate of the Krebs cycle by binding to the active site of acetyl-CoA.

B. decrease the rate of the Krebs cycle by reducing the number of times acetyl-CoA binds to the active site of citrate synthase in a given time.

C. have no effect on the rate of the Krebs cycle because it binds to a site other than the active site of citrate synthase.

D. bind to an allosteric site on citrate synthase, decreasing the rate of the Krebs cycle to zero.

Question 10

In cellular respiration, the net ATP yield from a single glucose molecule is affected by various factors.

Which one of the following factors **immediately** influences the yield of ATP molecules produced during the electron transport chain?

A. the availability of glucose in the cristae

B. the number of oxygen molecules available in the mitochondria

C. the concentration of pyruvate in the mitochondrial matrix

D. the rate of glycolysis in the cytosol

Question 11

What could explain the differences in the ATP yield between aerobic and anaerobic respiration in a human cell?

A. The electron transport chain is not used in anaerobic respiration, leading to lower ATP production.

B. Anaerobic respiration produces more NADH compared to aerobic respiration, which decreases ATP yield.

C. The Krebs cycle is more efficient in anaerobic respiration, resulting in higher ATP yield.

D. Aerobic respiration produces fewer ATP molecules due to the incomplete breakdown of glucose.

Question 12

A decrease in the rate of glycolysis within a healthy muscle cell is most likely caused by an increase in the

A. concentration of glucose.

B. number of NAD^+ molecules.

C. concentration of oxygen.

D. number of ATP molecules.

Use the following information to answer Questions 13 and 14.

The two reactions shown below are both part of a biochemical pathway occurring in the same stage of photosynthesis in a plant cell.

	Inputs	Outputs
Reaction 1	water	hydrogen ions and oxygen gas
Reaction 2	hydrogen ions	NADPH

Question 13

Where in the cell would the two reactions shown be occurring?

A. inner mitochondrial membrane

B. grana

C. cytosol

D. stroma

Question 14

A limiting factor for this stage of photosynthesis could be

A. light intensity.

B. glucose concentration.

C. carbon dioxide concentration.

D. the amount of ATP molecules.

Question 15

One of the roles of water in photosynthesis is to

A. act as a catalyst in the light-independent reactions.

B. provide electrons for reactions.

C. convert directly into glucose.

D. act as a carbon source.

Question 16

In photosynthesis, which one of the following correctly describes the relationship between the light-dependent and the light-independent reactions?

A. The light-dependent reactions produce ATP, which is used in the light-independent reactions to help fix carbon into organic molecules.

B. The light-independent reactions produce ATP from carbon dioxide and water, which is used in the light-dependent reactions.

C. The light-dependent reactions use ATP to produce glucose, while the light-independent reactions produce ATP from glucose.

D. The light-independent reactions convert ATP into carbon dioxide and water, which are then used in the light-dependent reactions to form glucose.

Question 17

Immunoglobulin E (IgE) antibodies are involved in allergic responses.

Before an allergic response occurs

A. the histamines found in peanuts and dust bind to the active site of IgE antibodies.

B. IgE antibodies pass through a physical barrier to bind to mast cells at the variable region.

C. plasma B cells produce IgE antibodies, which then bind to receptors on the plasma membrane of mast cells.

D. histamines form a chemical barrier when they bind to IgE antibodies, helping to prevent entry of allergens.

Question 18

Hay fever is a common allergic response that can occur when people breathe in pollen from grasses and other plants. The symptoms may include sore eyes and a runny nose.

Considering hay fever only, which of the following correctly identifies immune responses in hay fever?

	Blood vessels dilate in response to histamine	Complement proteins directly kill pathogens	Macrophages phagocytise the pollen
A.	true	true	false
B.	true	false	true
C.	false	true	false
D.	false	false	true

Question 19

Lymph nodes are important organs of the lymphatic system.

During an immune response, the lymph nodes

A. produce plasma cells that release antigens.

B. attract bacteria that are engulfed by antibodies.

C. are the site of clonal selection and expansion of B cells.

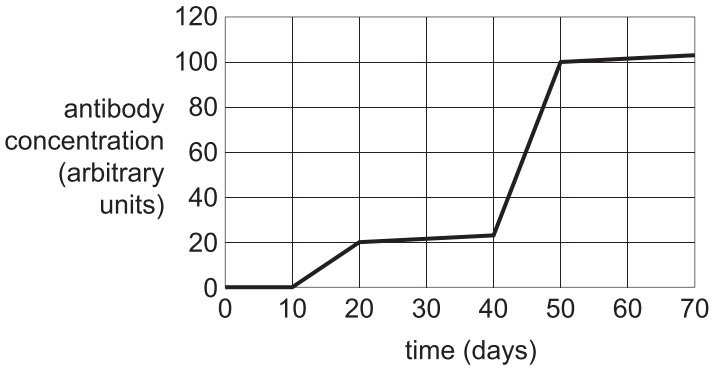
D. release allergens to cause localised swelling in the lymph node.

Question 20

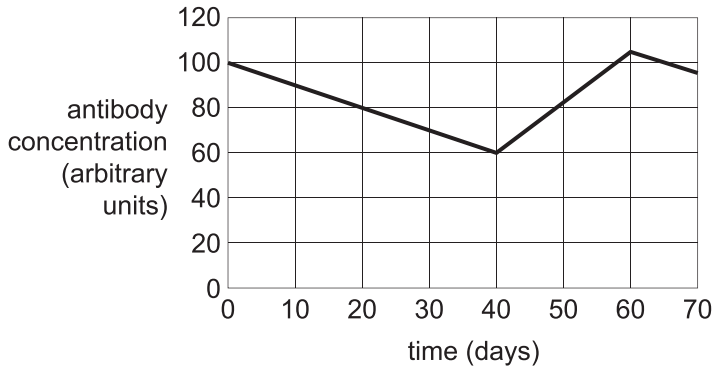
The concentration of antibodies for a particular antigen in a person can be measured.

Which of the following graphs would be consistent with the antibody concentration in a person who is developing active immunity to the same antigen they are first exposed to on day 0 and then again on day 40?

A.



B.



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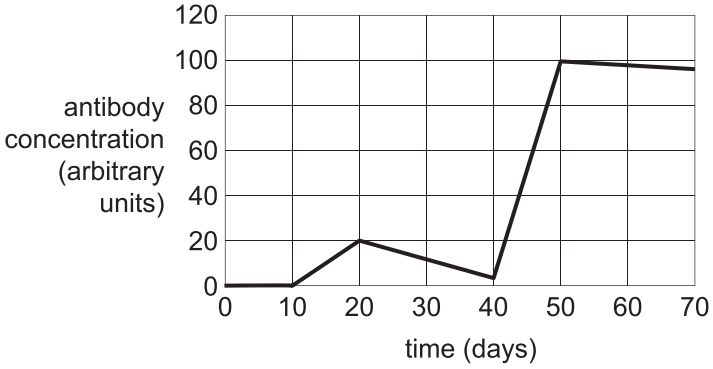
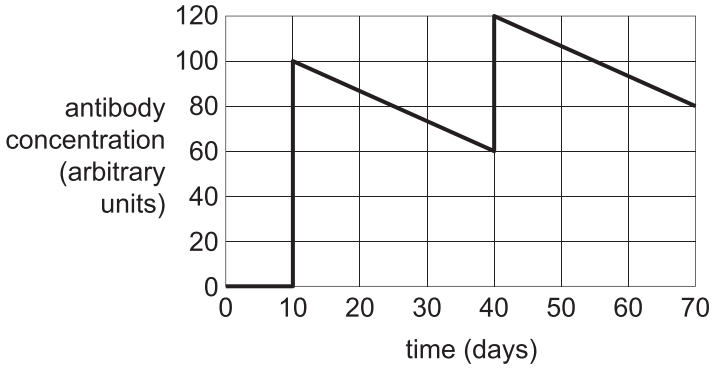


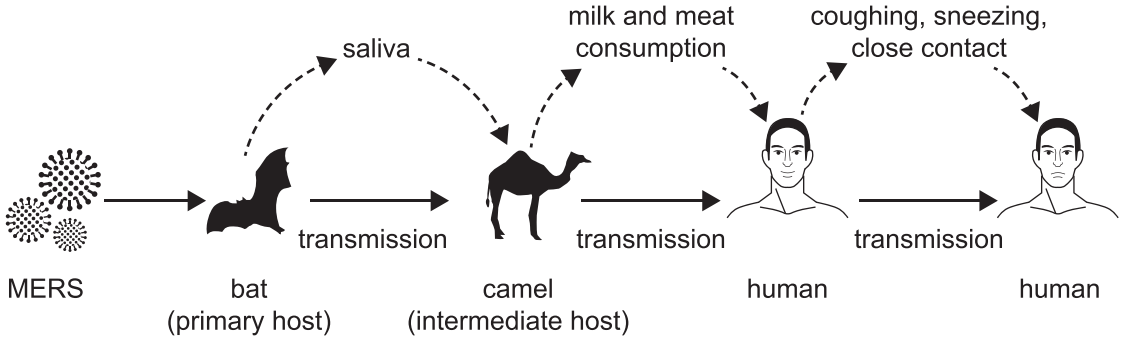
D.



Do not write in this area.

Question 21

The disease Middle East Respiratory Syndrome (MERS) is caused by a viral pathogen. It is thought that bats were the initial hosts and that the disease spread to camels and then to people. Person-to-person transmission can occur. The steps in transmission are shown below.



Adapted from: D Chandran, S Chakraborty, D Chandran et al., 'Middle East Respiratory Syndrome Coronavirus Could be a Priority Pathogen to Cause Public Health Emergency: Noticeable Features and Counteractive Measures', *Environmental Health Insights*, 18, 2024 <doi:10.1177/11786302241271545>

No specific antiviral medicines exist for the pathogen and currently there is no vaccine.

The most effective strategy to prevent the transmission of the disease from non-human to human populations would be

A. the development of specific antiviral medications for MERS.

B. allowing people to visit zoos that kept both bats and camels.

C. the removal of bats from the forests adjacent to human populations.

D. heat-treating milk and fully cooking camel meat before human consumption.

Question 22

There has been a recent resurgence of measles cases in Europe. Measles is a highly infectious virus transmitted via respiratory droplets and close contact. An effective vaccine has been available since 1963, and until the 1990s scientists thought that the disease could be eliminated. The reasons given were that previous infection or vaccination can produce lifelong immunity, and there is no animal carrier of the human measles virus.

The recent outbreaks of measles could be attributed to

A. reduced measles vaccine uptake during and after the COVID-19 pandemic.

B. increased mask wearing and use of disinfectant when in hospital settings.

C. improved immunisation programs in countries with high cases of measles.

D. increased human contact with animals known to carry the measles virus.

Use the following information to answer Questions 23 and 24.

Monoclonal antibodies can be used in the treatment of both autoimmune diseases and cancer.

Question 23

A monoclonal antibody

A. has a tertiary structure as its highest hierarchical level.

B. has codons each containing three nucleotides.

C. would contain amino acid monomers.

D. has one polypeptide chain.

Question 24

When used in the treatment of an autoimmune disease, monoclonal antibodies will

A. attach to viral-infected cells.

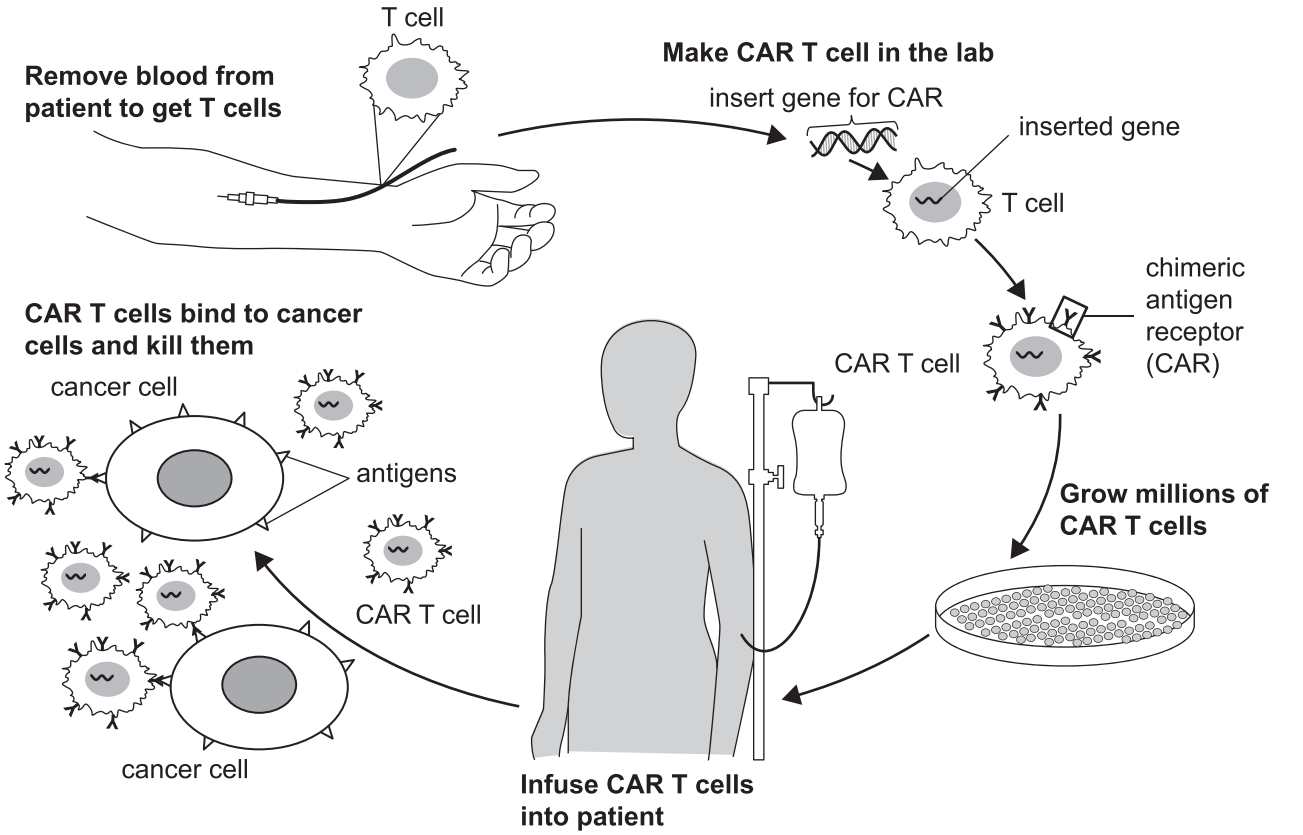
B. suppress an immune response.

C. signal cytotoxic T cells to attack self-cells.

D. increase the activity of antigen-presenting B cells.

Question 25

A new immunotherapy strategy for the treatment of some cancers uses chimeric antigen receptor (CAR) T cells. These cells are produced using the method shown below.



Source: Adapted from <https://www.cancer.gov/about-cancer/treatment/types/immunotherapy/t-cell-transfer-therapy>

For the successful treatment of a cancer, the

A. gene inserted into CAR T cells must code for the production of antibodies that act against cancer cells.

B. CAR T cells replace all other T cells within the body of the person with cancer.

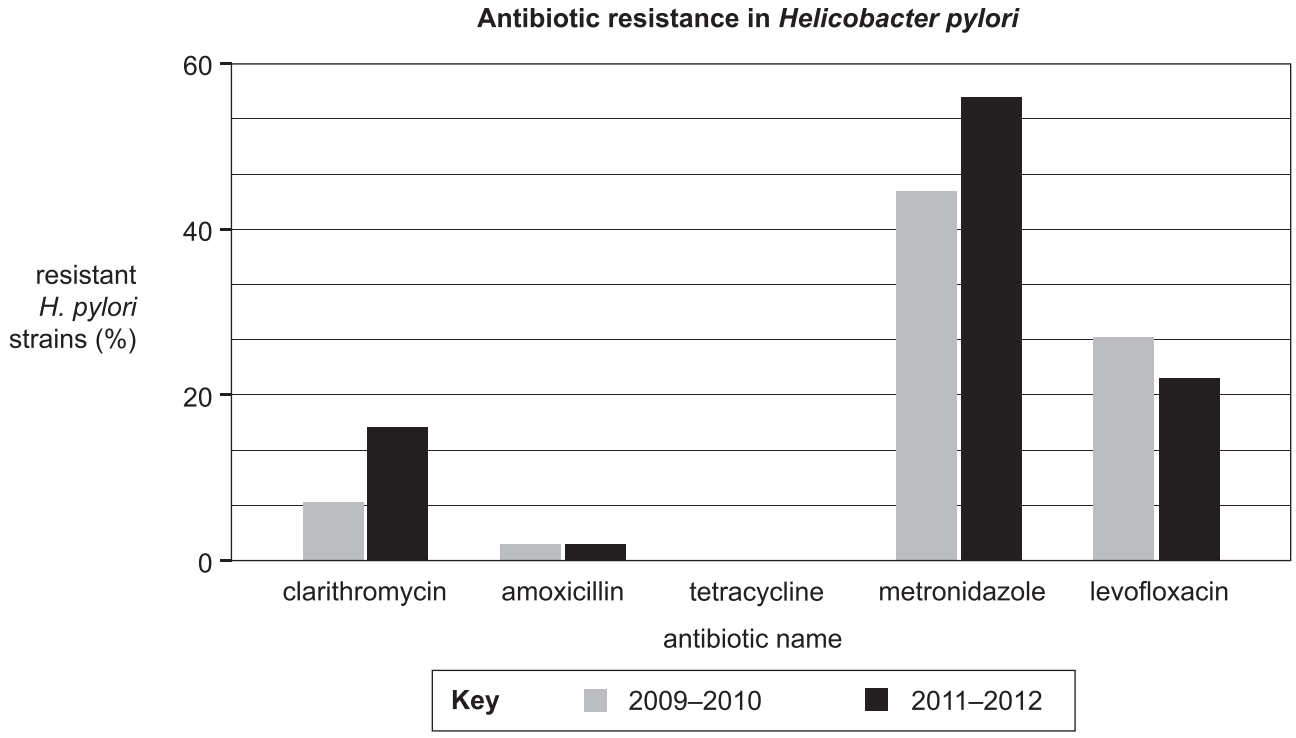
C. receptors on the CAR T cells must bind to a specific antigen on the cancer cells.

D. CAR T cells act as phagocytes and engulf the cancer cells.

Use the following information to answer Questions 26 and 27.

Helicobacter pylori are bacteria that infect the stomach lining. *H. pylori* are commonly treated with antibiotics. Some *H. pylori* are resistant to these antibiotics. A combination of antibiotics is often recommended. Without proper treatment, *H. pylori* infections can continue and lead to stomach ulcers and stomach cancer.

The graph shows how *H. pylori* responded to five different antibiotics over two time periods in patients who were infected.



Source: An, Byoungrak, Moon, Byung, Kim et al., 'Antibiotic Resistance in *Helicobacter pylori* Strains and its Effect on *H. pylori* Eradication Rates in a Single Center in Korea', *Annals of Laboratory Medicine*. 33, 2013, pp.415–9. <doi:10.3343/alm.2013.33.6.415>

Question 26

According to the graph, which two antibiotics show no change in percentage of resistant bacteria for the two time periods?

A. amoxicillin and tetracycline

B. amoxicillin and levofloxacin

C. metronidazole and levofloxacin

D. clarithromycin and metronidazole

Question 27

Based on the information provided, which of the following is most likely a consequence of antibiotic resistance after continued antibiotic treatment?

A. Use of only tetracycline will reduce the duration of *H. pylori* infections.

B. Use of only levofloxacin and clarithromycin will reduce bacterial resistance, keeping these antibiotics effective.

C. Use of only metronidazole and clarithromycin may increase the occurrence of ulcers and stomach cancers in the human population.

D. Use of only metronidazole and amoxicillin will not change the likelihood of patients developing ulcers and stomach cancers in the population.

Use the following information to answer Questions 28 and 29.

Ocean temperatures are rising, threatening coral reefs like the Great Barrier Reef. A selective breeding program is being trialled to develop heat-tolerant corals for reef recovery.

The program involves:

- identifying heat-tolerant parent corals
- collecting spawn (eggs and sperm) from parent corals
- mixing parent coral spawn, fertilisation occurring producing some heat-tolerant offspring
- exposing coral offspring to high temperatures in the lab and eliminating those that are not heat-tolerant
- testing survivors in the ocean to determine their suitability for reef recovery.

Question 28

If this program successfully aids reef recovery, the long-term effect on the coral gene pool will be

A. increased genetic diversity due to the inclusion of a wider range of parent corals.

B. unchanged, with a focus on maintaining existing genetic variation.

C. increased genetic diversity, as many coral traits are being affected.

D. increased occurrence of alleles that provide heat tolerance.

Question 29

It is important to test the coral offspring under ocean conditions in order to

A. accelerate the adaptation of corals to warmer ocean temperatures.

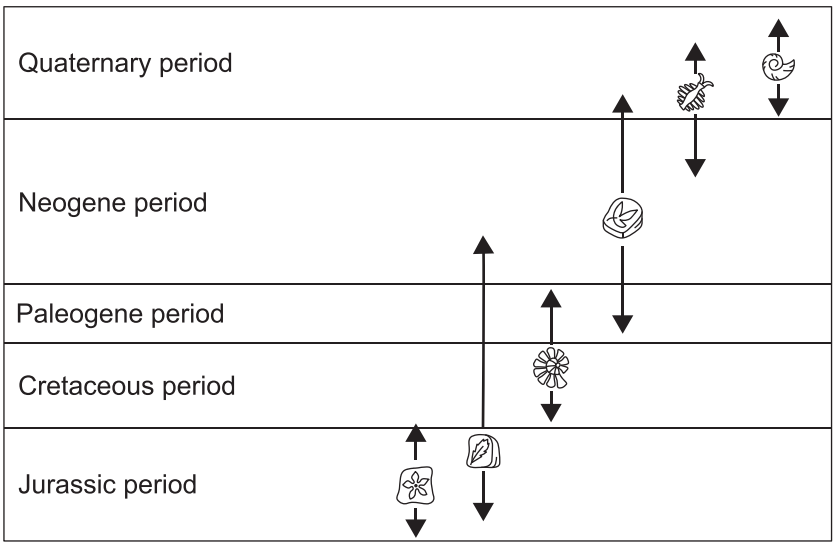
B. ensure that offspring can survive natural environmental conditions.

C. determine whether laboratory testing can be replaced by ocean testing.

D. optimise breeding methods by identifying heat-sensitive coral strains early in the process.

Use the following information to answer Questions 30 and 31.

The diagram below depicts a geological cross-section of sedimentary rock layers in which groups of fossils have been discovered.



Question 30

Consider fossils found in the Jurassic period. Absolute dating has been used to date these fossils.

Absolute dating relies on the

A. law of superposition.

B. presence of an index fossil.

C. decay of radioactive elements.

D. presence of more than one type of fossil.

Question 31

A palaeontologist uncovered four fossils within the same layer.

The specific period in which fossil S existed is unknown. By analysing the time periods indicated by the arrows in the diagram and comparing the relative positions of the fossils found alongside it, the period fossil S existed can be inferred.

In which period did fossil S exist?

A. Quaternary

B. Neogene

C. Paleogene

D. Cretaceous

Use the following information to answer Questions 32 and 33.

Birds rely heavily on songs for communication, especially in mate selection. Indigobirds usually lay their eggs in the nests of firefinch birds. A study of indigobirds' offspring showed that they learn the mating song of the firefinch species. The scientists also noticed the following.

- As adults, male indigobirds mimic the firefinch mating song.
- Adult indigobird females only select males that sing the same mating song they were raised with.
- Indigobirds rarely lay their eggs in the nest of a species other than the firefinch.

Question 32

If some female indigobirds lay their eggs in the nest of a different bird species, the consequences could be that over time it is likely that offspring will

A. fail to learn any song and will likely not reproduce, preventing sympatric speciation.

B. learn that new species' song, leading to reproductive isolation and sympatric speciation.

C. learn that new species' song and only mate with firefinch birds, leading to allopatric speciation.

D. only learn the indigobird song and only mate with indigobirds, isolating them, leading to allopatric speciation.

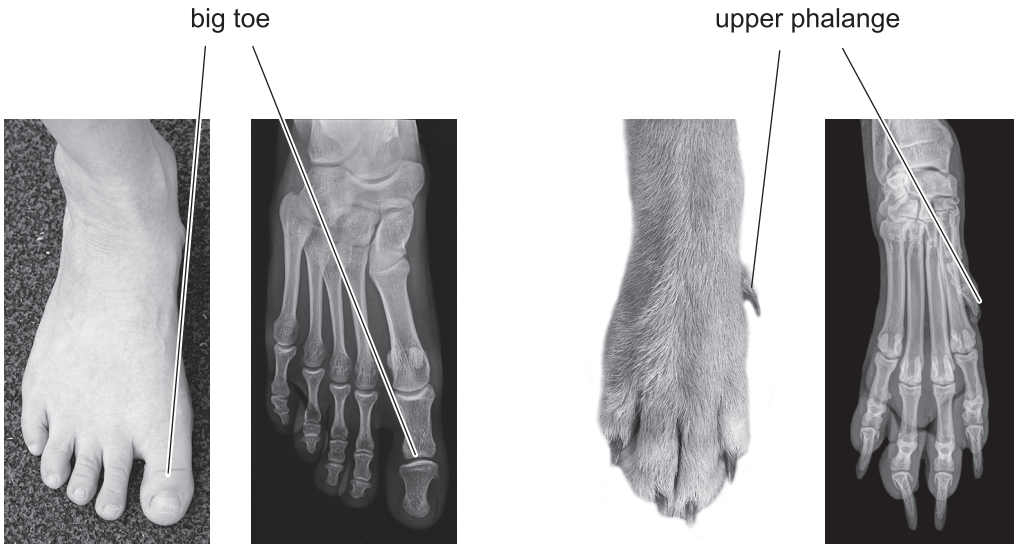
Question 33

Which of the following correctly shows the methodology used and appropriate data collected in the study of indigobirds?

	Methodology	Data collected
A.	case study	blood sampling for hormone level analysis
B.	fieldwork	observing behaviour and recording of bird songs
C.	controlled experiment	monitoring of reproductive success by counting the number of eggs in a nest
D.	correlation study	DNA sequencing to find genetic similarities between hosts and indigobirds

Question 34

Foot bones in the toes are called phalanges. In the images below, the phalanges of a human and a dog are compared.



Sources (left to right): zinchenki/Shutterstock.com; kravka/Shutterstock.com; boommaval/Shutterstock.com; Henk Vrieselaar/Shutterstock.com

The upper phalange of the dog corresponds to the big toe in humans. The upper phalanges in dogs may be considered an example of

A. selective breeding for homologous structures.

B. molecular homology and vestigial structures.

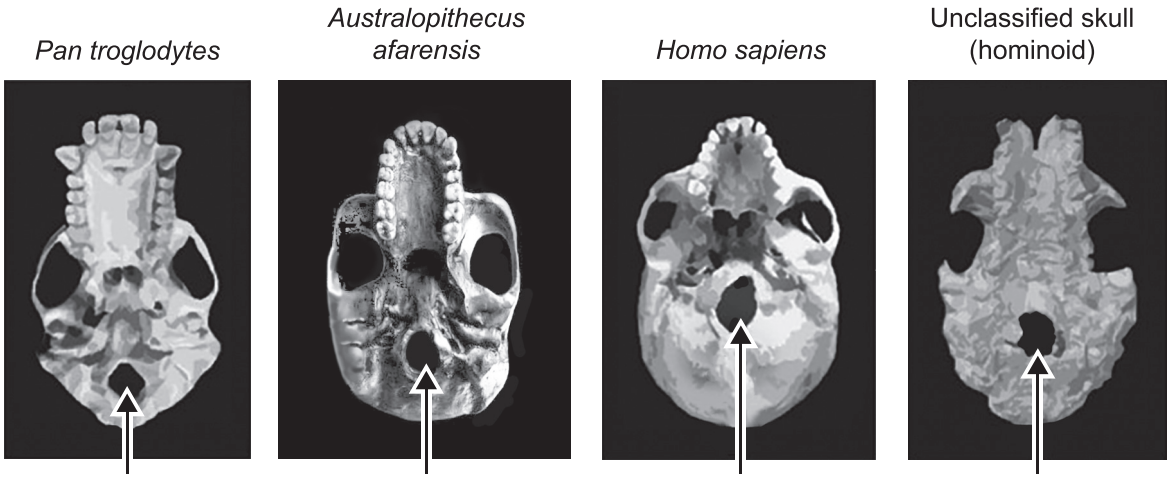
C. homologous and vestigial structures.

D. structural and molecular homology.

Question 35

The chimpanzee–human divergence date is estimated at between 8 and 5 million years ago. An unclassified hominoid skull was discovered in Africa, dated at 7.2 to 6.8 million years old.

The images show the underside of the skulls of a chimpanzee (*Pan troglodytes*), *Australopithecus afarensis* (dated at 3.7 to 3 million years old), modern human (*Homo sapiens*), and the unclassified skull (hominoid). The arrows point to the foramen magnum on each skull.



Sources: https://www.nature.com/scitable/knowledge/library/

Image of *A. afarensis*: https://www.dlt.ncssm.edu/tiger/360views/Hominid_Skull-A_afarensis-composite_800x600/bottom.htm

Referring to the unclassified skull of the hominoid, it is reasonable to conclude that the hominoid is most likely

A. not bipedal as the skull is dated at 7.2 to 6.8 million years old.

B. bipedal as the foramen magnum is positioned towards the front of the skull, more similar to that of the *H. sapiens* skull than the *P. troglodytes* skull.

C. not bipedal as the position of the foramen magnum does not align with that of either the *H. sapiens* skull or *A. afarensis* skull.

D. bipedal as the foramen magnum is positioned towards the back of the skull, more similar to that of the skulls of *P. troglodytes* and *A. afarensis* than the *H. sapiens* skull.

Use the following information to answer Questions 36 and 37.

Scientists found fossilised teeth and a fossilised humerus (upper arm) bone in Indonesia. The fossilised remains belong to an unknown hominin species (Species X). The fossils were dated at around 700 000 years old.

To determine the evolutionary relationship between Species X and other hominin species the teeth and humerus were compared to those of three other species, *Homo erectus*, *Homo floresiensis* and *Homo sapiens*. All species lived in Indonesia.

The results are shown in the table below.

		Species X	
	Age (years old)	**Teeth**	**Humerus**
H. erectus	900 000	similar	different
H. floresiensis	60 000	different	similar
H. sapiens	55 000	different	different

Question 36

Referring to the information, it is reasonable to conclude that

A. Species X may have evolved from *H. erectus*.

B. Species X could be a putative species of *H. erectus* and *H. floresiensis* as they share similarities of both species.

C. *H. floresiensis* or Species X should be classified as the same species as they both lived in Indonesia.

D. *H. sapiens* and Species X are most closely related as the fossils were found recently.

Question 37

The fossils were dated at around 700 000 years old.

The technique used to confirm this age of the fossils would be

A. measuring the decay of carbon-14 isotopes in the humerus bone.

B. DNA sequencing of the humerus bone.

C. comparing previously discovered *H. floresiensis* fossils, such as teeth, as relative dating.

D. dating of the rocks where the fossil was located.

Question 38

The EPDR1 gene found on chromosome 7 helps control the contraction of muscle in the hand of humans. This gene has many alleles. Some of the alleles have a Neanderthal origin.

A *Homo neanderthalensis* fossil was located in Europe and dated to around 120 000 years ago. The scientist discovered that the genome had an identical EPDR1 allele to that found in some individuals currently living in Europe.

The findings indicate that

A. *H. neanderthalensis* and *H. sapiens* are different species, therefore it is likely this EPDR1 allele would have an identical DNA sequence.

B. the presence of this EPDR1 allele in today's human population is evidence for *H. neanderthalensis* interbreeding with *H. sapiens*.

C. this EPDR1 allele is more likely to have arisen due to a mutation in *H. sapiens*.

D. *H. neanderthalensis* evolved in Europe before moving to Africa, as evidenced by the presence of this EPDR1 allele.

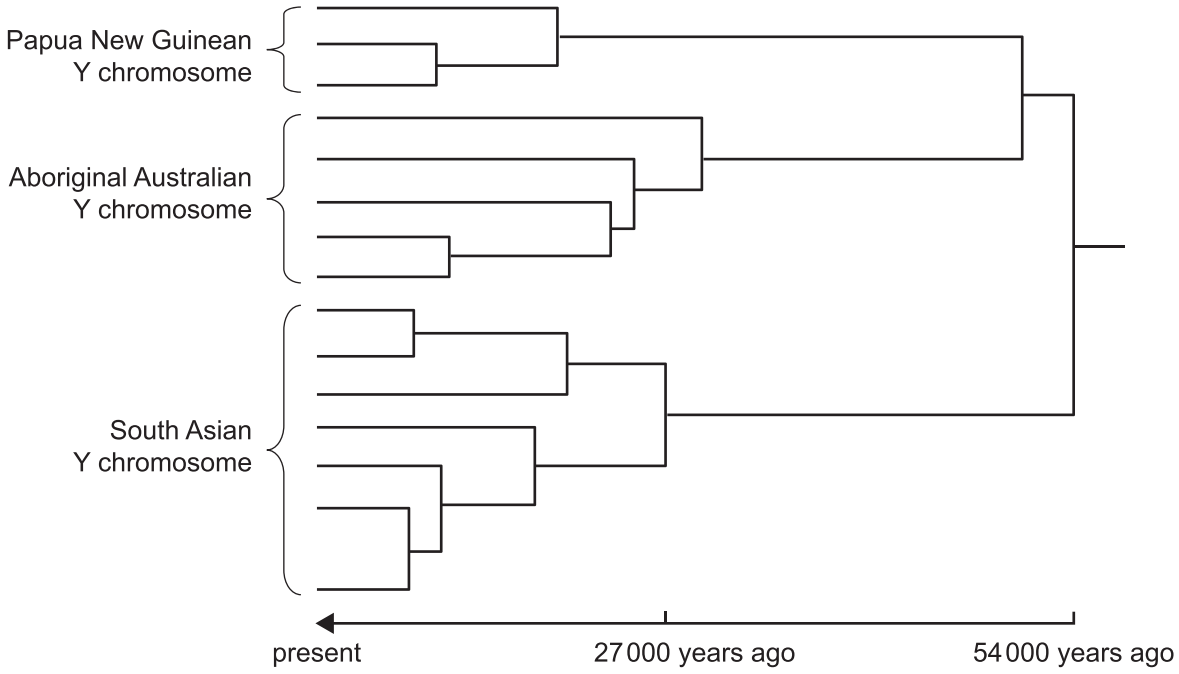
Use the following information to answer Questions 39 and 40.

DNA sequencing of the human Y chromosome in individuals can provide evidence for the migration of human populations around the world.

In 2002, scientists recorded the numbers of short tandem repeats (STRs) on a section of the Y chromosome from individuals in South Asia and Aboriginal Australians. The scientists found similar STR variation between the groups, with divergence from a recent common ancestor dated at around 5000 years ago.

In 2016, a repeat study was undertaken using improved DNA sequencing techniques and extended to include Papua New Guineans. Scientists constructed a phylogenetic tree from the results of the 2016 study.

Human Y chromosome phylogeny



Source: Adapted from A Bergström, N Nagle, Y Chen et al., 'Deep roots for Aboriginal Australian Y chromosomes', *Current Biology*, 26 (6), 2016, pp 809–813.

Question 39

The results from the 2016 study most likely indicate that

A. Aboriginal Australians are more closely related to South Asians than Papuan New Guineans as they have a similar number of divergences.

B. Aboriginal Australians are more genetically diverse compared to South Asians as they diverged around 50 000 years ago.

C. South Asians had increased divergence around 27 000 years ago and a new species of *Homo sapiens* may have evolved.

D. Aboriginal Australians diverged from South Asians around 54 000 years ago with no recent common ancestor with South Asians at 5000 years ago.

Question 40

When comparing the two studies, it is reasonable to conclude that

A. the 2002 and 2016 studies are not precise as different scientists carried out the DNA sequencing.

B. the results of the 2002 study and 2016 study are invalid as the 2002 study recorded the number of STRs and the 2016 study constructed a phylogenetic tree.

C. in the 2016 study the data is more accurate than the 2002 study as improved DNA sequencing techniques were used.

D. the results of the 2016 study do not represent the true value of the number of STRs as the true value was already determined in the 2002 study.

End of Section A

Section B

Instructions

- Answer **all** questions in the spaces provided.
- Write your responses in English.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

Question 1 (7 marks)

Tryptophan (*trp*), an amino acid, is an important part of cellular functions.

Escherichia coli is a prokaryote naturally found within the human digestive system. The environment of *E. coli* partly depends on the food intake of its human host. When there are sufficient levels of *trp* in the environment, *E. coli* can absorb it from the surroundings. When there are insufficient *trp* levels, *E. coli* can produce their own. This production is regulated by an operon.

a. Depending on the food a person eats, *E. coli* can be exposed to high levels of *trp* on one day and low levels of *trp* on another day.

Discuss the activity of the repressor protein for the *trp* operon in *E. coli* when they are in an environment with high levels of *trp* and low levels of *trp*. 4 marks

b. Both humans and *E. coli* use mRNA and *trp* in biochemical pathways to produce proteins.

Describe the function of both mRNA and *trp* in the production of proteins. 3 marks

Question 2 (5 marks)

Both human and yeast cells use glucose as an energy source but variations in biochemical pathways produce different products.

One variation in a biochemical pathway that occurs in human cells is shown below.

a. Compare the biochemical pathway shown above to fermentation in yeast cells. 2 marks

b. Coenzymes are used in fermentation.

Describe the general role of coenzymes in biochemical pathways. 3 marks

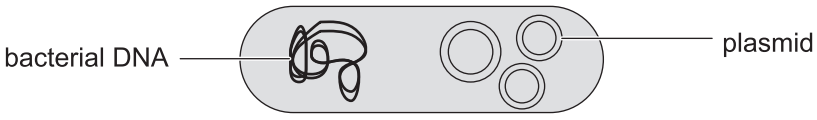
Question 3 (8 marks)

Cavendish bananas make up around 97% of bananas grown in Australia. The plants can be affected by a disease, tropical race 4 (TR4), which causes the plant to wilt and die. The disease is caused by a fungus that remains in the soil for years and cannot be detected. The disease first appeared in 2015 in Northern Queensland and is now found on nine farms. The fungus is easily transmitted and there is no treatment for this disease.

Source: 7Seven/Shutterstock.com

Australian scientists have found a wild variety of banana plant that is resistant to TR4 disease due to the RGA2 gene. Cavendish banana plants also have the RGA2 gene, but it is not functional. Both the wild variety and Cavendish banana plants are different subspecies of *Musa acuminata*.

To transform the Cavendish bananas, plasmids from bacteria were used. An image of plasmids within a bacterium is shown below.



Source: Bany's beautiful art/Shutterstock.com

The functional RGA2 gene from the wild variety of banana was isolated and then incorporated into a bacterial plasmid.

a. Outline how an isolated functional RGA2 gene may be incorporated into a bacterial plasmid. 3 marks

b. The functional RGA2 genes were transferred into the genomes of Cavendish banana cells using the plasmid. These banana cells then grew into Cavendish banana plants resistant to TR4 disease. The TR4-resistant Cavendish bananas are approved for food production in Australia. The bananas are considered safe and nutritious to eat. However, there are no immediate plans to grow the TR4-resistant Cavendish bananas on a large scale or sell them to consumers.

i. Justify whether the TR4-resistant Cavendish banana plants are transgenic or genetically modified. 2 marks

ii. Infer **three** reasons why there are no plans for Australian farmers to grow TR4-resistant Cavendish bananas on a large scale or to sell them to consumers. 3 marks

Question 4 (8 marks)

Swine flu is a respiratory disease caused by a type A influenza virus that mostly infects pigs and on rare occasions humans. The World Health Organization (WHO) is monitoring both animal and human cases of swine flu around the world. In 2023 there were several reported human cases of swine flu. These cases have not spread easily from person to person.

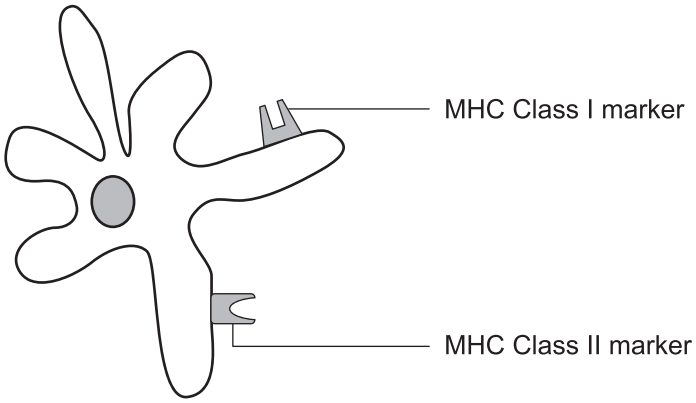
a. The WHO is conducting an ongoing case study related to swine flu.

Explain why a case study is an appropriate methodology for the WHO investigation. 2 marks

b. Swine flu causes an acute respiratory tract infection. The virus infects epithelial cells along the airways and in the lungs. All nucleated body cells, including epithelial cells, have MHC Class I markers on their surface.

Describe the function of the MHC Class I marker on an epithelial cell that is infected with the swine flu virus. 2 marks

c. Dendritic cells play important roles in the initiation of the immune response in many animal species, including humans and pigs. Dendritic cells have both MHC Class I and MHC Class II markers, as shown in the diagram below.



Dendritic cells can be split into types based on their structure and function. The table below shows relative amounts of MHC Class II markers and interferon produced by two different dendritic cell types.

	MHC Class II markers	**Interferon**
Dendritic cell A	high	low
Dendritic cell B	low	high

Consider the information from the table above.

Describe the different roles played by Dendritic cell A and Dendritic cell B in an immune response. 4 marks

Dendritic cell A _____

_____

_____

Dendritic cell B _____

_____

_____

Question 5 (10 marks)

Coxiella burnetiid, a species of bacteria, can produce a disease called Q fever in humans. Humans can be infected when coming in contact with animals carrying *C. burnetiid*. Animals that carry the bacteria include cattle, sheep and goats. Person-to-person spread of the pathogen is unlikely.

Symptoms of the disease develop two to three weeks after exposure to the bacteria. To determine if a person has the disease, a sample of blood is taken and tested for the presence of either antibodies against Q fever or the presence of *C. burnetiid* DNA.

a. Outline the roles played by helper T cells in the adaptive immune response in a person with Q fever. 3 marks

b. The detection of the bacterial DNA in a patient's blood can involve the use of polymerase chain reaction (PCR).

Explain how PCR is used to help identify the presence of the pathogen causing Q fever. 2 marks

c. Current studies in Australia suggest that only 10% of Q fever cases are identified.

State **one** reason why 90% of Q fever cases are not being identified. 1 mark

d. Other than the development of a vaccine, state **one** strategy that could be implemented by the Australian Government to control the spread of Q fever. 1 mark

e. People in Victoria can access the National Immunisation Program (NIP), which provides a series of free vaccinations. However, immunisation against Q fever is not funded under the NIP.

Using the information provided, infer why the NIP does not provide free vaccination against Q fever but does have free vaccinations for many infectious diseases. 3 marks

Question 6 (13 marks)

St Kilda is a remote island off the coast of Scotland, as shown in Figure 1. The island had a small, isolated human population originally from nearby Scottish islands. Harsh environmental conditions and a seasonal reliance on seabirds for food resulted in nutritional deficiencies. Minimal contact with the mainland and few visitors often led to food shortages. In 1940, the government relocated the population to Scottish towns on the mainland.

In contrast, Lord Howe Island is a remote island off the coast of Australia. Its location is shown in Figure 2. The island was settled by people from diverse regions such as England, South Africa, Portugal and the Pacific. The island's favourable conditions led to tourism from the 1900s and allowed for the growth of many different crops, which helped support the increasing human population.

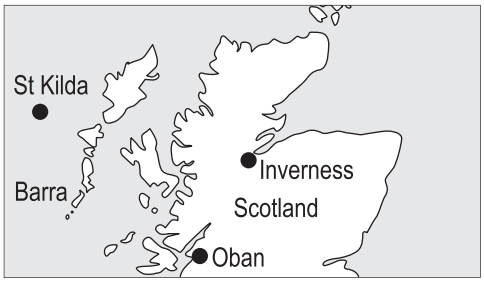


Figure 1

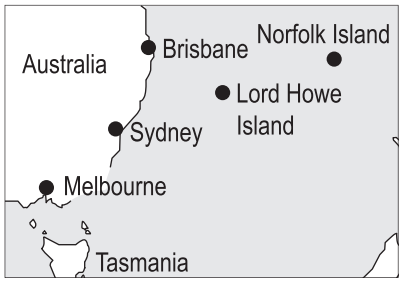
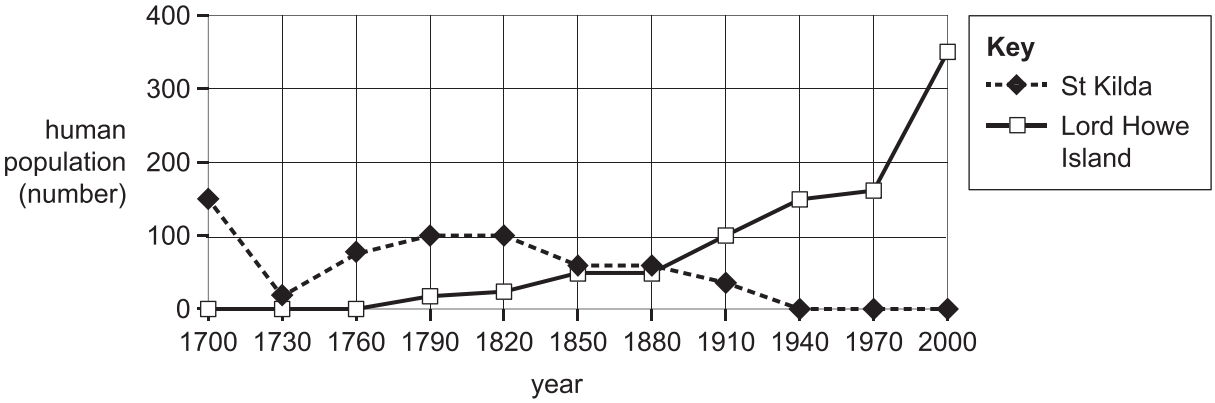


Figure 2

Human population over time



Source: P Stride, 'Survival of the fittest: a comparison of medicine and health on Lord Howe Island and St Kilda', Journal Royal College Physicians Edinburgh, 40, 2010 <doi:10.4997/JRCPE.2010.410>

a. Complete the table below with your prediction of the change in the genetic diversity in each population for the time period between 1790 and 1940. Justify your response. 4 marks

Population	Prediction (increase, decrease, stay the same)	Justification
St Kilda		
Lord Howe Island		

Do not write in this area.

b. In late 1726, a resident of St Kilda made the three-day voyage to the Scottish mainland. During his time there, he contracted smallpox and died. The deceased man's clothing and personal items were returned to his family on St Kilda. Within 10 to 14 days of their return, a smallpox outbreak occurred.

Account for the cause of the outbreak and explain its impact on St Kilda's human population. 3 marks

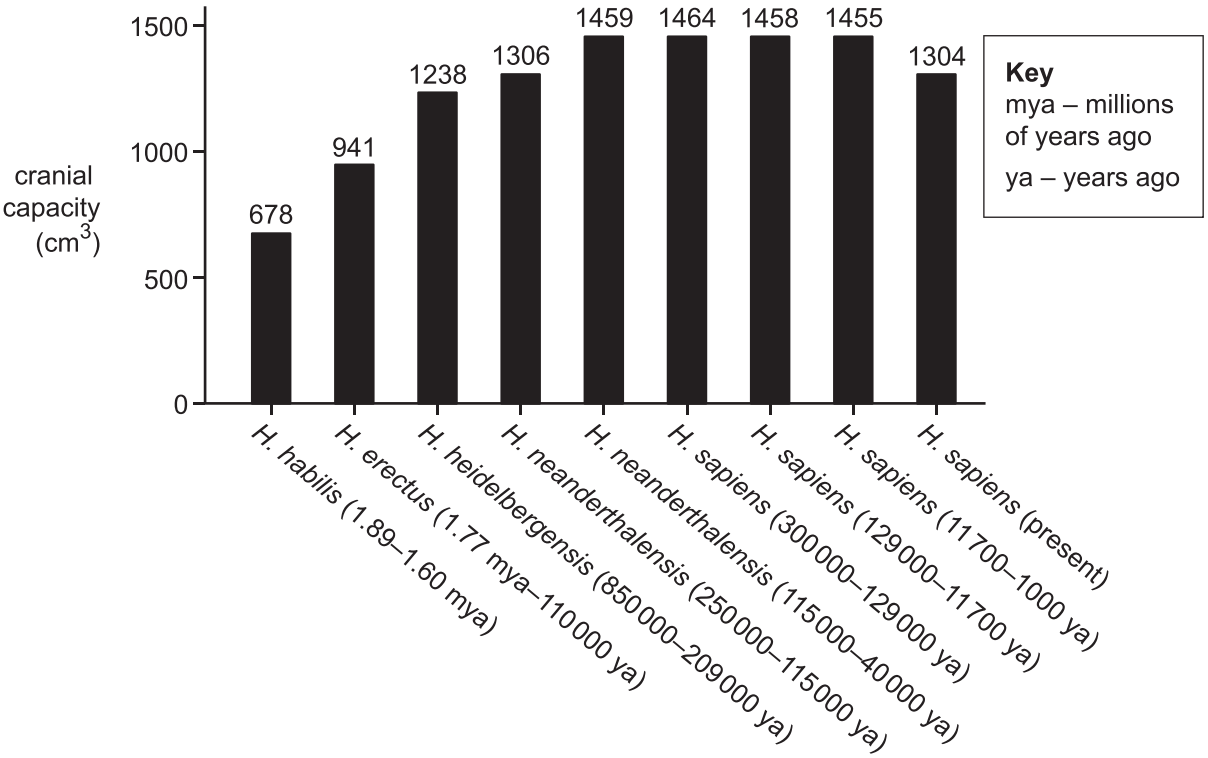
c. Referring to a bioethical concept, explain why the decision to relocate the human population from St Kilda in 1940 could be seen as ethically justified. 3 marks

d. Explain how an antigenic shift in a virus on Lord Howe Island could pose a current public health threat. 3 marks

Question 7 (8 marks)

A recent study summarised the trend in brain size for *Homo* species over time. Data was obtained from 19 different studies over 90 years. The results are presented below with brain size measured as cranial capacity (cm^3).

Cranial capacity of five *Homo* species



Source: J DeSilva, L Fannin et al., *Frontiers in Ecology and Evolution*, 11, 2023, 1191274.

a. **i.** Describe the trend of hominin brain size, from *Homo habilis* to *Homo sapiens* (300 000–129 000 years ago), with reference to data from the graph. 2 marks

ii. Discuss **one** advantage of the change in hominin brain size, over time, from *Homo habilis* to *Homo sapiens* (300 000–129 000 years ago). 2 marks

Do not write in this area.

b. The scientists completing the study concluded that the results for *Homo sapiens* (300 000 to present) challenge current understandings of trends in hominin evolution.

Justify this conclusion using data from the graph. 2 marks

c. At the end of the study, scientists suggested extending the investigation.

Recommend an extension to the investigation to improve the study. 2 marks

Question 8 (11 marks)

The World Vegetable Centre (WorldVeg) collects, conserves and identifies important traits in vegetable plants. With this information, scientists are leading an initiative to increase both crop diversity and crop yield in Africa.

The scientists involved in WorldVeg investigated many different vegetable crops. They employed advanced technology using an automated laser scanner. This scanner moves over fields of vegetable crops to capture 3D models of the plants under various conditions, allowing for the simultaneous assessment of multiple plant traits. The device scans plants three times a day, collecting as much data as 400 fieldworkers would collect in a 24-hour period.

The scanner can emit different wavelengths and intensities of light. The wavelengths reflected by the plants are one way in which data is obtained for analysis.

The scanning technology enables the monitoring of many plants and helps identify those with desirable traits for vegetable crops. Plants can be exposed to different conditions such as flooding or heat stress, and the scanner can assess individual plants' responses in real time. Plants responding well to the changed conditions can be identified, leading to the development of improved vegetable crops that are either heat- or flood-tolerant.

Heat tolerance in a plant is a characteristic that results from a combination of traits. Scientists need to study many traits simultaneously to identify those traits that make a plant heat tolerant. Using the scanner, scientists evaluate 75 different traits, including plant height, biomass and leaf characteristics, throughout the plant's life cycle to select heat-tolerant varieties. Without the scanner, scientists would have to rely on only a few traits for selection and may miss important plant features.

Once plants with desirable traits are identified, the plants are grown, and seeds are collected. In Africa the collected seeds are being distributed to African farmers. The farmers are encouraged to grow the seeds and produce crops with a higher yield.

Source: Adapted from N Parletta, 'Everything starts with the seed', *Cosmos Magazine*, *82*, March, 2024, 46–55.

a. Explain what useful information the scientists can determine about the plants of vegetable crops by measuring the reflected light wavelengths. 2 marks

b. State **two** pieces of data other than reflected wavelength that scientists collected about the plants to help determine their suitability for vegetable crops. 2 marks

Do not write in this area.

c. Referring to the information provided, outline **two** advantages of using this scanner over data collection by fieldworkers. 2 marks

d. In this study different crop species have been identified with adaptations that enable them to survive in hot, arid environments. Some of these adaptations are found in the photosynthetic pathways used by the plants.

Compare the photosynthetic pathways found in C3 and CAM plants. Explain how the adaptations in CAM plants enable them to survive in hot, arid environments. 5 marks

Question 9 (10 marks)

For one of their VCE Biology practical activities, a group of students investigated the relationship between biomass and stored carbon in different tree species. The biomass of a tree is a key indicator of how much carbon in the form of carbon dioxide (CO_2) a tree has captured from the atmosphere.

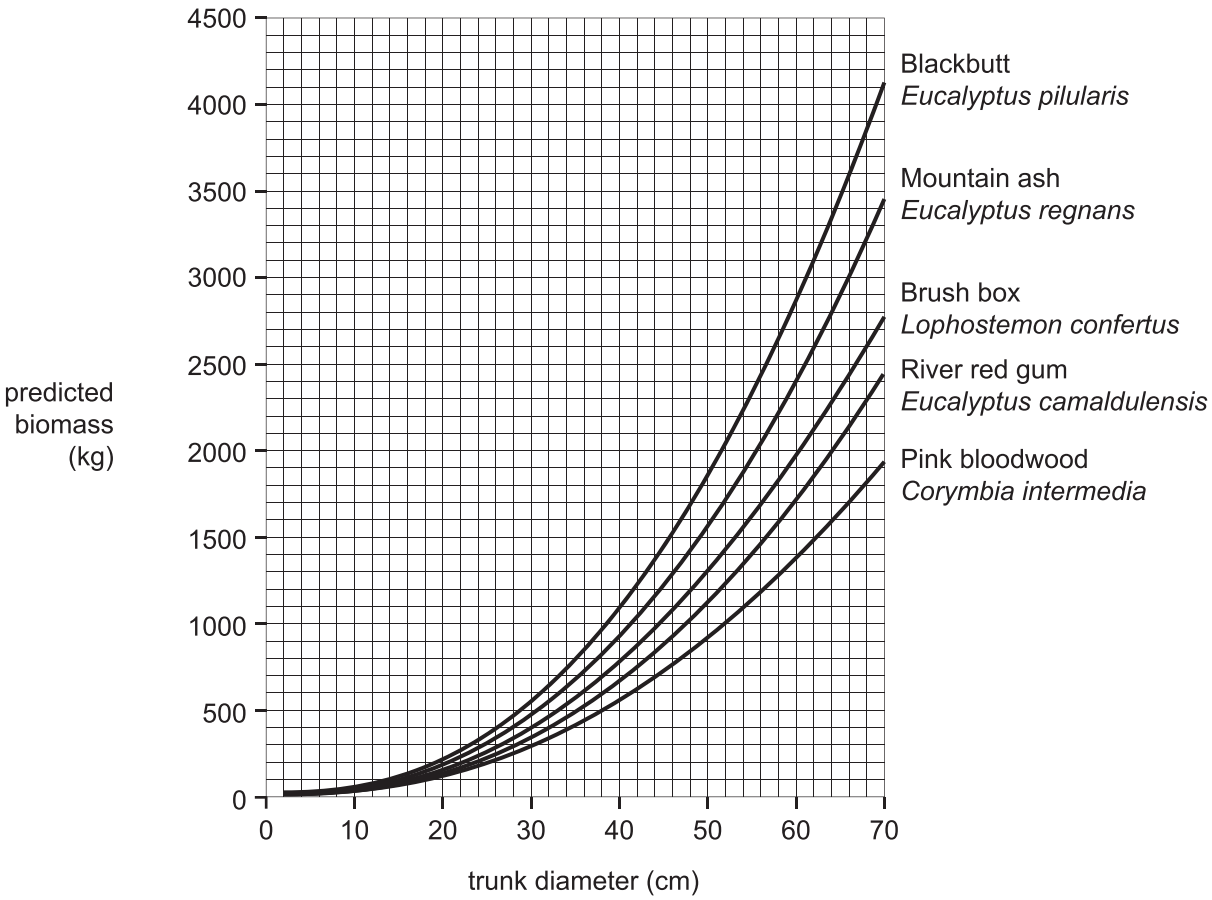
To estimate how much CO_2 a tree has captured, the students conducted fieldwork to measure the biomass of different trees. The students used a measuring tape to record the tree trunk's circumference, which they then used to calculate the diameter of each tree.

The students' method is outlined below.

Method:

1. Identify the tree species.
2. Measure the circumference (cm) of the trunk at a height of 1.4 metres.
3. Calculate the diameter of the trunk in cm.
4. Refer to the provided graph to estimate the tree's biomass (kg) based on the calculated diameter (cm).

The students were able to estimate the biomass of each tree using established relationships between the trunk diameter (cm) and predicted biomass (kg) shown in the graph below.



Source: Adapted from <https://climate.earthathome.org/photosynthesis-calculating-biomass-and-carbon-storage-in-trees/#instructions-materials>

a. Justify which tree species would be the most effective at capturing CO_2 from the atmosphere and storing it as carbon (biomass). 4 marks

b. Describe **two** limitations of the method used by the students. 2 marks

c. State **two** safety precautions and/or ethical guidelines that should be followed by the students during the investigation while in the field. 2 marks

d. As the students were writing up their practical report, they began exploring real-world applications of their findings. The students completed a literature review. They discovered that scientists were investigating new technologies, such as CRISPR-Cas9, that could be used to improve the efficiency of photosynthesis in plants.

Propose how CRISPR-Cas9 technology could improve the efficiency of photosynthesis. 2 marks

End of examination questions

Extra space for responses

Clearly **number** all responses in this space.

If you use any additional Question and Answer Books to complete your responses, write your **student number** on the front cover. At the end of the examination, place the additional Question and Answer Books inside the front cover of the first Question and Answer Book.