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Write your **student number** in the boxes above. **Letter**

Biology

Question and Answer Book

VCE Examination – Friday 1 November 2024

- Reading time is **15 minutes**: 9.00 am to 9.15 am
- Writing time is **2 hours 30 minutes**: 9.15 am to 11.45 am

Materials supplied

- Question and Answer Book of 48 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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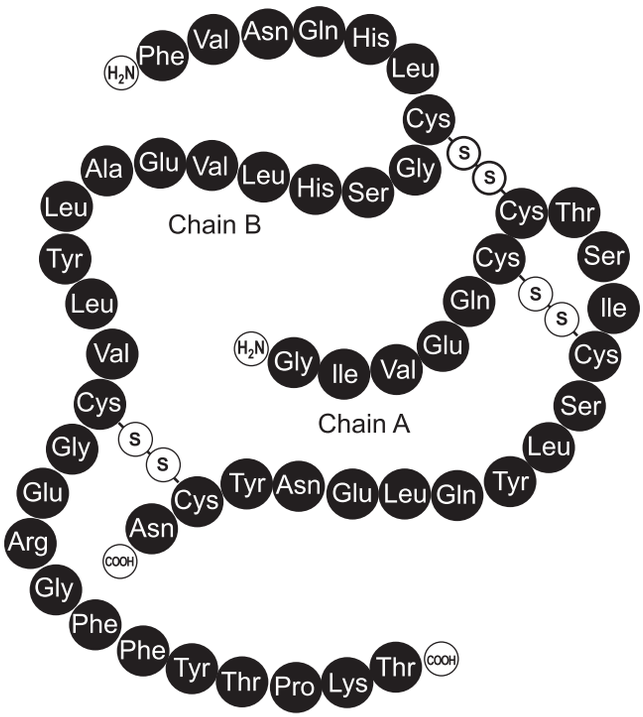
Section A – Multiple-choice questions

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.

Question 1

The molecule shown below has a quaternary structure.



Source: Adapted from spline_x/Shutterstock.com

Which of the following is correct?

A. The monomers in this molecule are amino acids.

B. The molecule does not have a primary structure.

C. Translation of the molecule occurs in the nucleus of a cell.

D. The molecule has two chains of equal length.

Question 2

Which one of the following correctly identifies both the structure and a possible role of an RNA molecule in a eukaryotic cell?

	Structure	Possible role
A.	is a double-stranded molecule	is decoded at the ribosome during translation
B.	nucleotides may have a cytosine base	stores the instructions for proteins that are synthesised in the nucleus
C.	contains an equal amount of adenine and thymine bases	makes up part of the structure of the ribosome
D.	nucleotides have a ribose sugar	carries the instructions for the synthesis of proteins to the ribosome

Question 3

Prokaryotic cells such as *Escherichia coli* use gene regulation to control the amount of tryptophan (trp) that is produced within the cell. One mechanism used by *E. coli* in gene regulation is attenuation. Attenuation prevents the

A. cell from producing trp by stopping the ribosomes from attaching to the mRNA.

B. production of enzymes involved in the production of trp by preventing the completion of transcription.

C. RNA polymerase from transcribing genes through the binding of a repressor protein to the operator region in the operon.

D. production of trp by activating the repressor protein that then detaches the ribosome from the mRNA molecule.

Question 4

Choose the diagram below that most accurately represents the structure of a eukaryotic gene.

A.

	upstream						downstream	
5′	promoter	exon	operator	intron	exon	intron	terminator	3′

B.

	upstream					downstream	
5′	operator	exon	intron	exon	intron	terminator	3′

C.

	upstream				downstream	
5′	promoter	exon	intron	exon	intron	3′

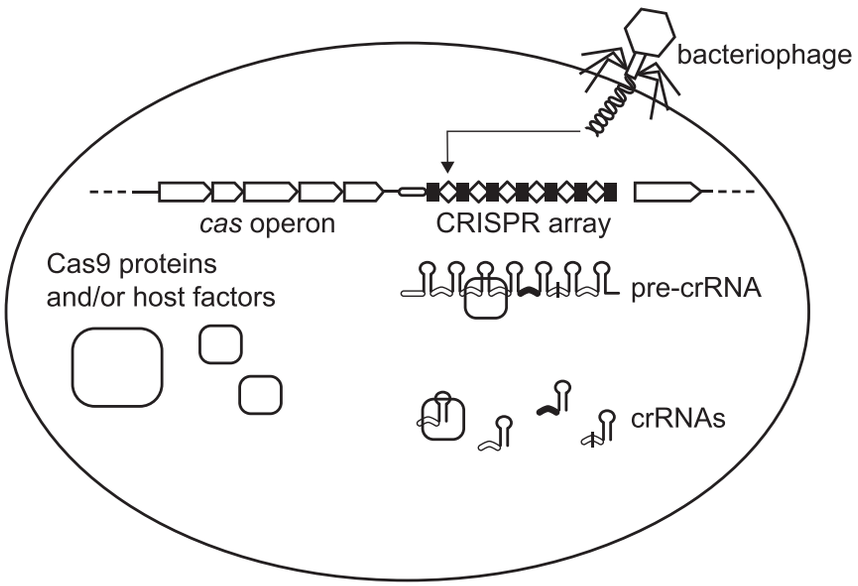
D.

	upstream					downstream	
5′	promoter	exon	intron	exon	intron	terminator	3′

Do not write in this area.

Question 5

The following diagram is a representation of the CRISPR-Cas9 system in the bacterium *Streptococcus pyogenes*. The diagram shows a bacteriophage (virus) attaching to the membrane of *S. pyogenes* and injecting its DNA into the cell.



Source: Adapted from A Le Rhun, A Escalera-Maurer, M Bratovič and E Charpentier, 'CRISPR-Cas in S*treptococcus pyogenes*', *RNA biology*, vol 16, no. 4, 2019, pp. 380–389, licensed CC-BY 4.0 <https://creativecommons.org/licenses/by/4.0/>

Based on the diagram, which one of the following statements is correct?

A. The viral DNA is included as spacers in the CRISPR array.

B. The PAM sequence is adjacent to the repeats in the CRISPR array.

C. Attachment of the bacteriophage is a signal for Cas9 proteins to be transcribed.

D. The *cas* operon is translated and processed to produce CRISPR RNAs (crRNAs).

Question 6

The function of the CRISPR-Cas9 system in the bacterium *S. pyogenes* is to

A. become a recombinant plasmid to produce human insulin.

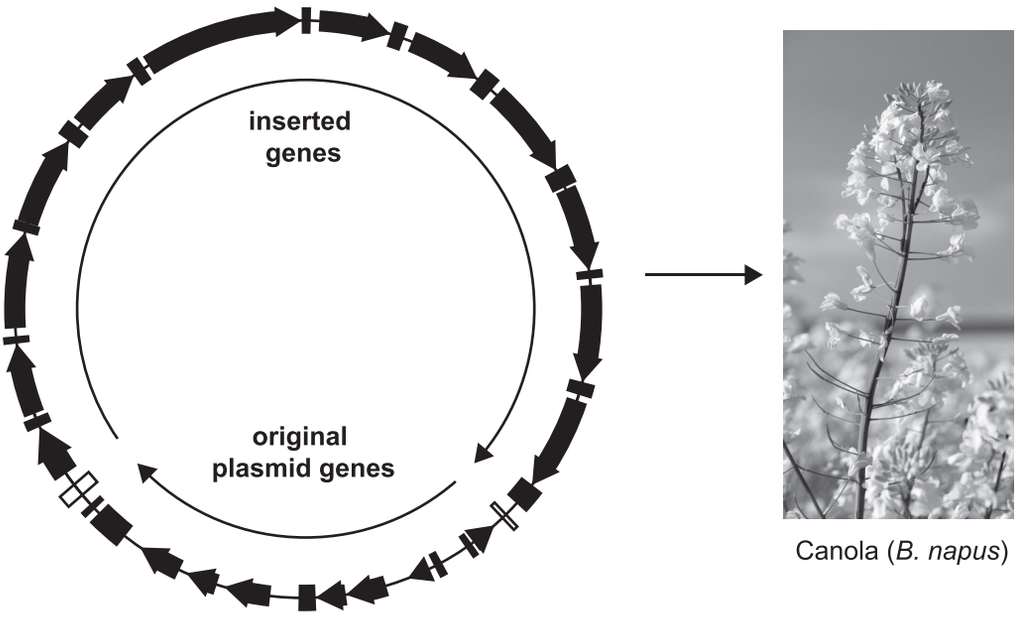
B. respond to specific viruses if they reinfect the cell.

C. act as a promoter for transcription.

D. increase antibiotic resistance.

Question 7

Canola oil is made from the seeds of the canola plant (*Brassica napus*). Genetically modified (GM) canola plants are herbicide resistant and contain modified omega-3 fatty acids. Herbicide resistance and modified omega-3 fatty acid production are catalysed by proteins from cress plants (*Arabidopsis thaliana*). The genes from the cress plants are transferred to the canola plant cells using recombinant plasmids from the bacterium *Agrobacterium*.



***Agrobacterium* recombinant plasmid with inserted genes from the cress plant**

Source: Adapted from 'Food Standards Australia New Zealand, 'Food derived from EPA and DHA producing and herbicide-tolerant canola line LBFLFK (Supporting document 1 – Safety assessment)', <www.foodstandards.gov.au>; Adapted from Daniel Prudek/Shutterstock.com, licensed CC-BY 3.0 <https://creativecommons.org/licenses/by/3.0/>

Based on the information provided, it is likely that the

A. oil produced from the canola plant could be considered genetically modified as it is synthesised using proteins from the cress plant genes.

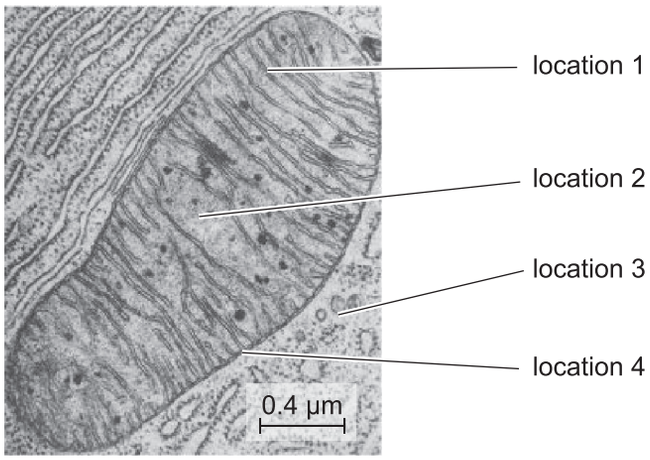
B. *Agrobacterium* recombinant plasmids would be incorporated into the cress plant genome.

C. herbicide resistance decreases crop productivity.

D. canola genome is transgenic but not genetically modified.

Use the following information to answer Questions 8–10.

The following image is an electron micrograph of a mitochondrion found in the cytosol of a bat pancreas cell.



Source: Keith Porter, in Mae-Wan Ho, 'Cancer a redox disease', <www.researchgate.net/figure/Electron-micrograph-of-a-mitochondrion-in-a-cell-of-the-bat-pancreas-by-Keith-Porter_fig1_256809470>

Question 8

In which location would you expect the Krebs cycle to occur?

A. location 1

B. location 2

C. location 3

D. location 4

Question 9

Which one of the following gives the correct relative output of ATP in aerobic respiration at the correct locations labelled above?

	Location 1	Location 2	Location 3	Location 4
A.	high	low	low	none
B.	low	high	none	low
C.	low	none	low	high
D.	high	low	high	none

Question 10

A biochemical analysis of the bat pancreas cells showed a high level of lactic acid.

Which one of the following is a valid conclusion for a high level of lactic acid in the bat pancreas cells?

	Conclusion	Reason for conclusion
A.	Levels of ADP would remain constant.	No ADP is used during anaerobic respiration.
B.	Carbon dioxide levels would increase.	An output of anaerobic respiration is carbon dioxide.
C.	There are high levels of mitochondria.	Anaerobic respiration occurs in the mitochondria.
D.	No or very low oxygen is present.	Anaerobic respiration occurs in the absence of sufficient oxygen.

Question 11

Which one of the following statements about the electron transport chain is correct?

A. The outputs of the electron transport chain are water, ATP and NADH. The role of water is to donate energy.

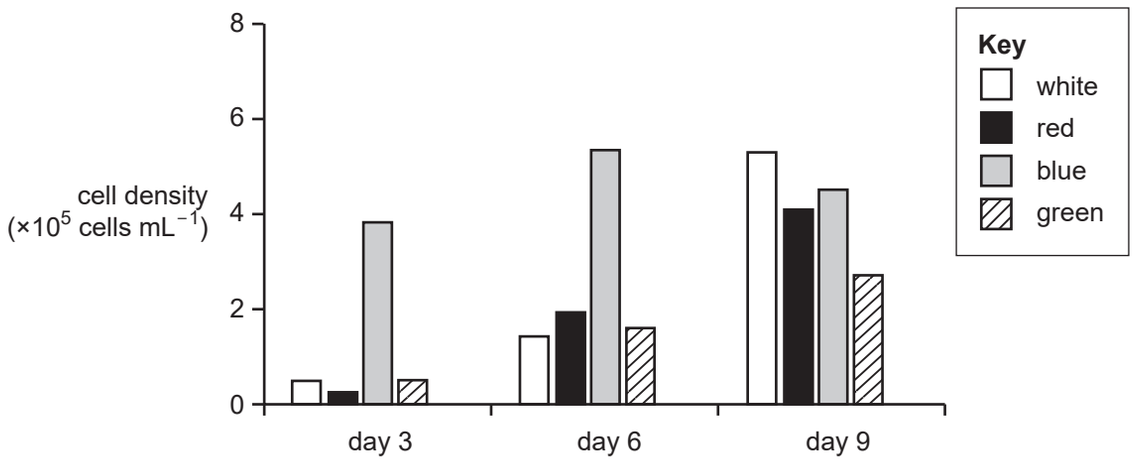
B. The outputs of the electron transport chain are oxygen, ATP and NAD^+. The role of oxygen is to accept energy from ATP molecules.

C. The outputs of the electron transport chain are water, ATP and NAD^+. The role of NADH is to donate electrons and hydrogen ions.

D. The outputs of the electron transport chain are oxygen, ATP and $NADP^+$. The role of $NADP^+$ is to accept electrons from the electron transport chain.

Use the following information to answer Questions 12–14.

The graph below shows the effect of different light conditions on the cell density of a photosynthetic microalgae, *Emiliania huxleyi*, over nine days. This controlled experiment was carried out at the optimal temperature of 22 °C. Other conditions were kept constant.



Source: Adapted from J Zhang, et al., 'Effect of Light Wavelength on Biomass, Growth, Photosynthesis and Pigment Content of *Emiliania huxleyi* (Isochrysidales, Cocco-Lithophyceae)', *Journal of Marine Science and Engineering*, vol. 11, 2023, p. 456, graph licensed CC-BY 4.0 <https://creativecommons.org/licenses/by/4.0>

Question 12

Which one of the following is a reasonable conclusion to draw from the graph?

A. For all light conditions, the cell densities continually increased over nine days.

B. Under green light conditions, the cell densities decreased from day 3 to day 9.

C. Blue light conditions resulted in the highest cell densities by day 9 compared to the other light conditions.

D. Under white light conditions, the cell densities increased on each day measurements were taken.

Question 13

A controlled variable in this experiment should be the

A. amount of glucose produced by the microalgae.

B. amount of oxygen produced by the microalgae.

C. light intensity of all the different lights.

D. molecules of chlorophyll present.

Question 14

The light energy absorbed by the microalgae cells is immediately used in a significant stage of photosynthesis to split water molecules.

In which part of the microalgae's cell would you expect this process to occur?

A. grana

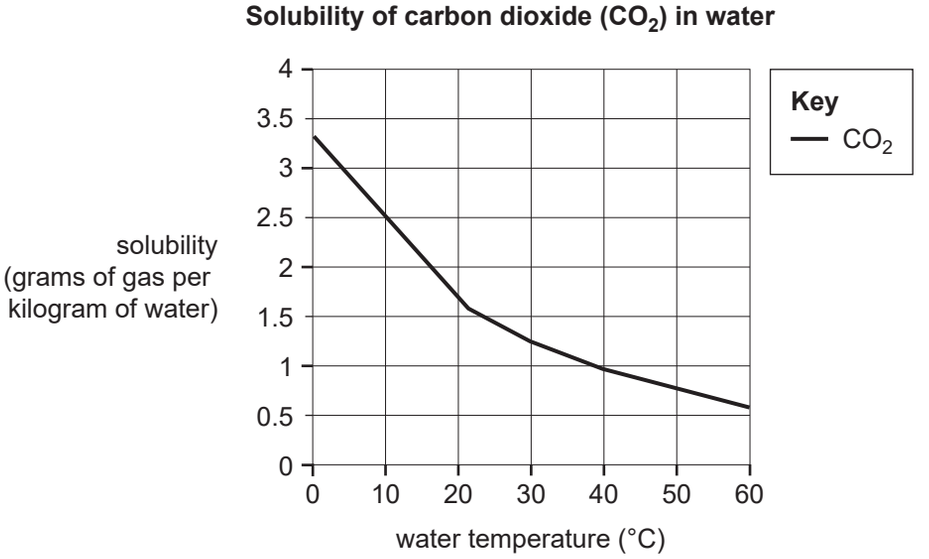
B. stroma

C. Golgi apparatus

D. plasma membrane

Question 15

During photosynthesis, carbon dioxide (CO_2) enters chloroplasts. One method CO_2 uses to enter chloroplasts is to dissolve in water. The graph below shows the solubility of CO_2 as temperature increases.



Source: The Engineering ToolBox, *Solubility of Gases in Water vs. Temperature*, <https://www.engineeringtoolbox.com/gases-solubility-water-d_1148.html>

Based on the information provided and your knowledge of photosynthesis, which one of the following statements is correct?

A. At 30 °C, photosynthesis and photorespiration will be taking place at equal rates.

B. Changes in water temperature will only affect the rate of light-independent reactions.

C. At a temperature of 40 °C, Rubisco will be fixing carbon at a slower rate than at 20 °C.

D. The number of oxygen molecules entering Rubisco's active site will decrease as temperature increases.

Question 16

Biomass can be used to produce bioethanol. The production of bioethanol is a process that has many steps.

In this process

A. bioethanol is the only product produced.

B. an environment free of microorganisms is required.

C. the same enzyme catalyses each step in the process.

D. the biomass could be plants containing high levels of cellulose.

Use the following information to answer Questions 17 and 18.

Gout is a disease that includes swelling, heat and significant pain in a joint, especially in the big toe. It is caused by a build-up of needle-shaped crystals of urate.

Question 17

The needle-shaped crystals of urate rub against the tissues lining the joint, causing irritation and some tissue damage, which triggers the inflammatory response.

During an attack of gout

A. dendritic cells in the lining of the joint produce histamines as part of an allergic reaction to crystals of urate, leading to the inflammation.

B. the inflammation is an innate immune response because crystals of urate are not present in the joints of healthy individuals.

C. the heat and swelling are caused by the effects of signalling molecules on blood vessels in the tissues of the joint**.**

D. neutrophils perform phagocytosis of crystals of urate and act as antigen-presenting cells to B lymphocytes.

Question 18

An investigation to determine if alcohol consumption contributes to the development of gout was undertaken. Non-identifying data about gender, age and ethnicity was also collected to ensure that a diverse sample of the population was considered.

Individuals diagnosed with gout by their doctor were invited to take part in the anonymous study. If they accepted, they were given a survey that included questions about the frequency of their gout attacks and their consumption of alcohol.

Which one of the following correctly describes this study?

	Type of study	Types of data used	Evidence of ethical standards being applied
A.	correlational study	primary	data recording gender, age and ethnicity was non-identifying
B.	fieldwork	secondary	individuals took part voluntarily
C.	case study	anecdotal	participants decided on the frequency rating of attacks for themselves
D.	controlled experiment	secondary	the study was anonymous

Question 19

The complement system is a group of proteins that

A. enhance the inflammatory response by attracting phagocytes to the site of infection.

B. remain activated within the circulatory system, ready to encounter foreign antigens.

C. are activated by helper T cells to create a series of events leading to cell death.

D. act as allergens, causing the release of histamine.

Question 20

Neutrophils and dendritic cells both play important roles in the immune system.

Which one of the following correctly describes the roles of these cells?

	Neutrophils only	**Both neutrophils and dendritic cells**
A.	place antigen fragments on their MHC Class II markers	secrete chemicals that can kill pathogens
B.	secrete chemicals that can kill pathogens	act as phagocytes
C.	place antigen fragments on their MHC Class II markers	act as phagocytes
D.	act as phagocytes	secrete chemicals that can kill pathogens

Question 21

Which one of the following best describes a role of the lymphatic system?

A. transports lymphocytes to sites of infection

B. synthesises interferon and transports it to specific organs and glands

C. synthesises and stores proteins for cells and tissues throughout the body

D. returns excess red blood cells from the tissues to the circulatory system

Question 22

Which one of the following correctly matches the type of immunity obtained with the strategy used to gain immunity?

	Type of immunity obtained	Strategy used to gain immunity
A.	passive	antigens are injected into a person
B.	active	antibodies are injected into a person
C.	passive	antibodies cross the placenta to a foetus
D.	active	antibiotics are given orally to a baby

Use the following information to answer Questions 23 and 24.

Dengue is a disease primarily transported by mosquitoes. A group of students wish to investigate whether mosquitoes can be effectively controlled by spraying insecticide. The students will investigate the effect of spraying five different insecticides on mosquitoes.

Question 23

Which one of the following techniques could the students use to generate quantitative primary data?

A. obtaining data from other students' investigations

B. recording the smell of the five different insecticides

C. reading newspaper articles on the effect of insecticides on mosquitoes

D. measuring the mass of dead mosquitoes after spraying each insecticide

Question 24

The students want to check the reproducibility of their results.

To do this, they should ensure that the investigation

A. uses only recently calibrated equipment.

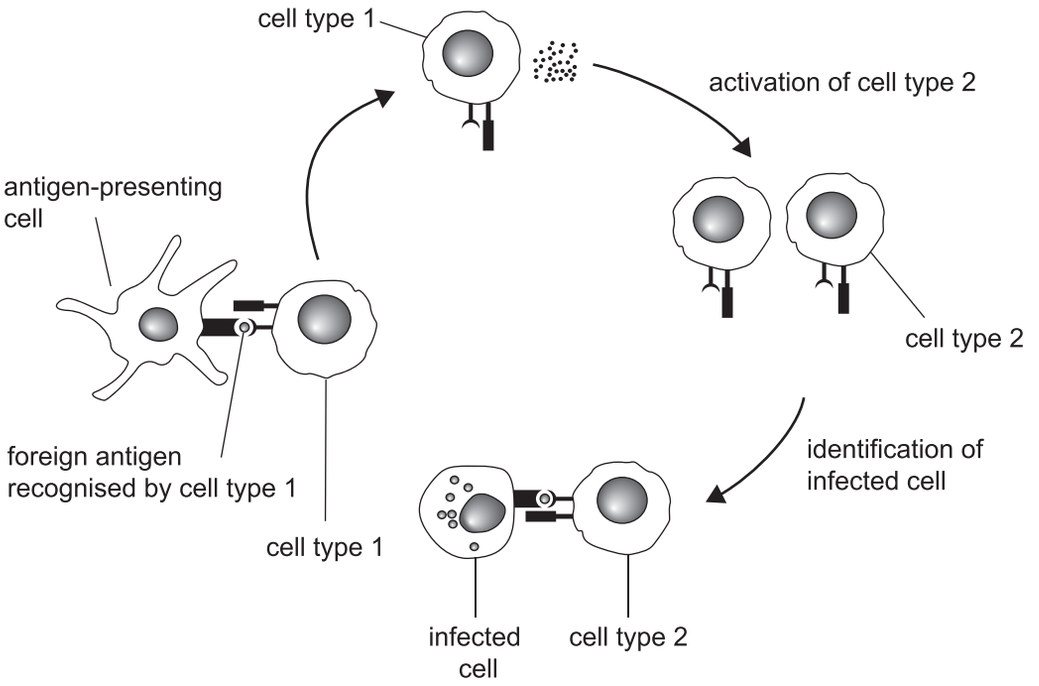
B. has both a positive and a negative control.

C. is conducted by only one student, in the same laboratory.

D. is conducted on different days by different students.

Use the following information to answer Questions 25–27.

The following diagram shows some of the steps that occur during cell-mediated immunity.



Source: Adapted from Ph-HY/Shutterstock.com

Question 25

Referring to the diagram, cell type 1 would be classified as a

A. mast cell.

B. plasma cell.

C. helper T cell.

D. cytotoxic T cell.

Question 26

Which one of the following statements is correct?

A. Cell type 1 releases antibodies to activate cell type 2.

B. The action of cell type 2 on an infected cell initiates cell death.

C. One particular cell type 2 can recognise many different antigens.

D. An infected cell displays foreign antigens on its MHC Class II markers to cell type 2.

Question 27

Where would the antigen-presenting cell, carrying a foreign antigen, most likely come into contact with cell type 1?

A. at the site where the antigen-presenting cell attaches to the foreign antigen

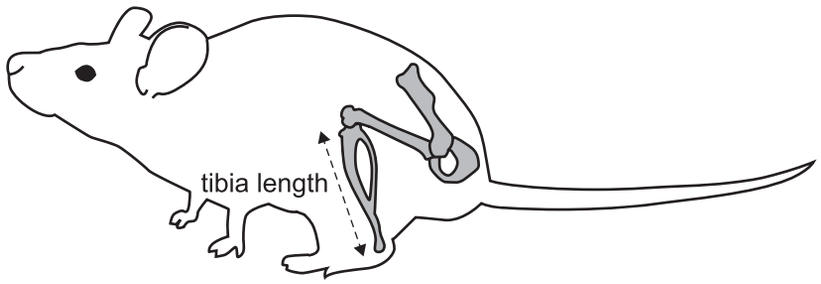
B. at the site of pathogen entry into the human body

C. within a blood vessel

D. within a lymph node

Use the following information to answer Questions 28–30.

Scientists investigated tibia size in mice from two populations of the same species over 20 generations. The diagram below shows the position of the tibia bone in the mouse.

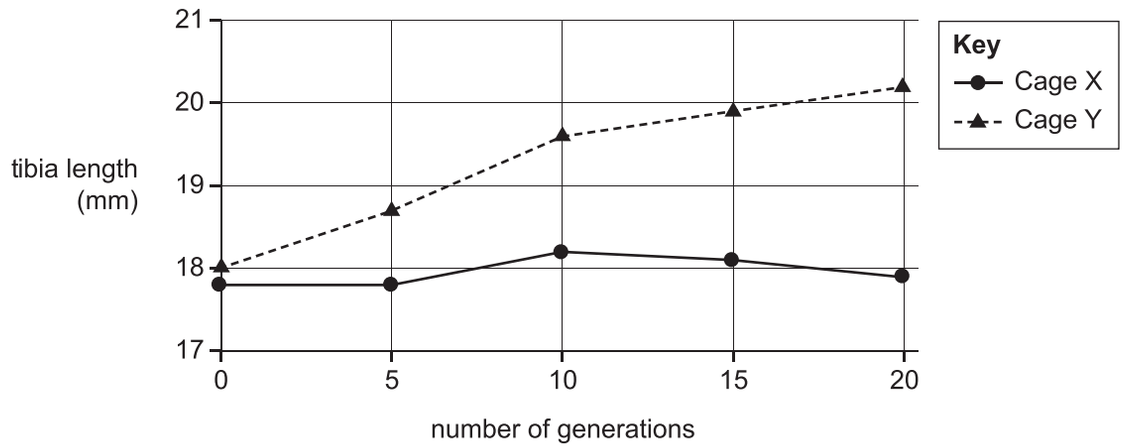


Source: João PL Castro, et al., (2019), 'An integrative genomic analysis of the Longshanks selection experiment for longer limbs in mice', eLife, 8:e42014; https://doi.org/10.7554/eLife.42014; licensed CC-BY 4.0 <https://creativecommons.org/licenses/by/4.0/>

The scientists set up cages to keep the two populations separate. Fourteen pairs of mice were allowed to breed in each population. After the first generation was produced, the tibia length of the offspring was measured. Fourteen pairs of mice were then returned to each cage to produce the next generation. They were returned in the following ways:

- Cage X: random mice were returned.
- Cage Y: mice with the longest tibias were returned.

The change in mean length of the mouse tibia over 20 generations is shown below.



Question 28

Which one of the following options correctly identifies the independent and dependent variables in this experiment?

	Independent variable	Dependent variable
A.	method of selecting mice to return to the cage	length of the tibia
B.	length of the tibia	method of selecting mice to return to the cage
C.	length of the tibia	number of generations
D.	method of selecting mice to return to the cage	number of generations

Question 29

Which option best explains why mice in Cage X may still exhibit changes in tibia length, despite random selection?

A. gene flow

B. genetic drift

C. allopatric speciation

D. environmental selection pressures

Question 30

The results from mice in Cage Y show a significant change in the tibia length over generations.
It is most reasonable to conclude that this change is due to

A. a mutation.

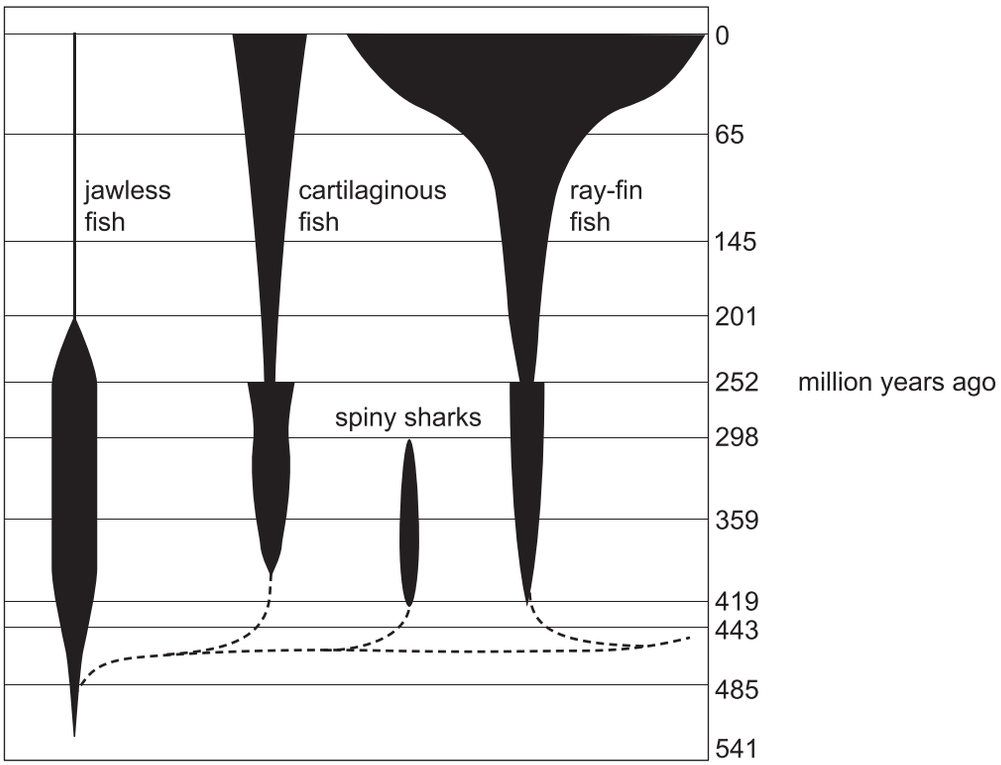
B. antigenic drift.

C. natural selection.

D. selective breeding.

Use the following information to answer Questions 31 and 32.

The diagram shows information about the evolution of fish groups through geological time. The width of each shaded area indicates the diversity of each fish group. The data is based on current species numbers and fossil evidence.



Source: Adapted from MJ Benton, *Vertebrate Palaeontology*, 3rd edition, Blackwell, 2005, p. 73

Question 31

Referring to the diagram, it is most reasonable to conclude that

A. there was a greater diversity of total fish 201 million years ago than there is today.

B. most of the fossils found are around 359 million years old.

C. the oldest fish group evolved more than 485 million years ago.

D. all groups have species that are still alive today.

Question 32

What technique is likely to have been used to date the spiny shark fossils?

A. absolute dating using the decay of carbon-14 in fossilised bones

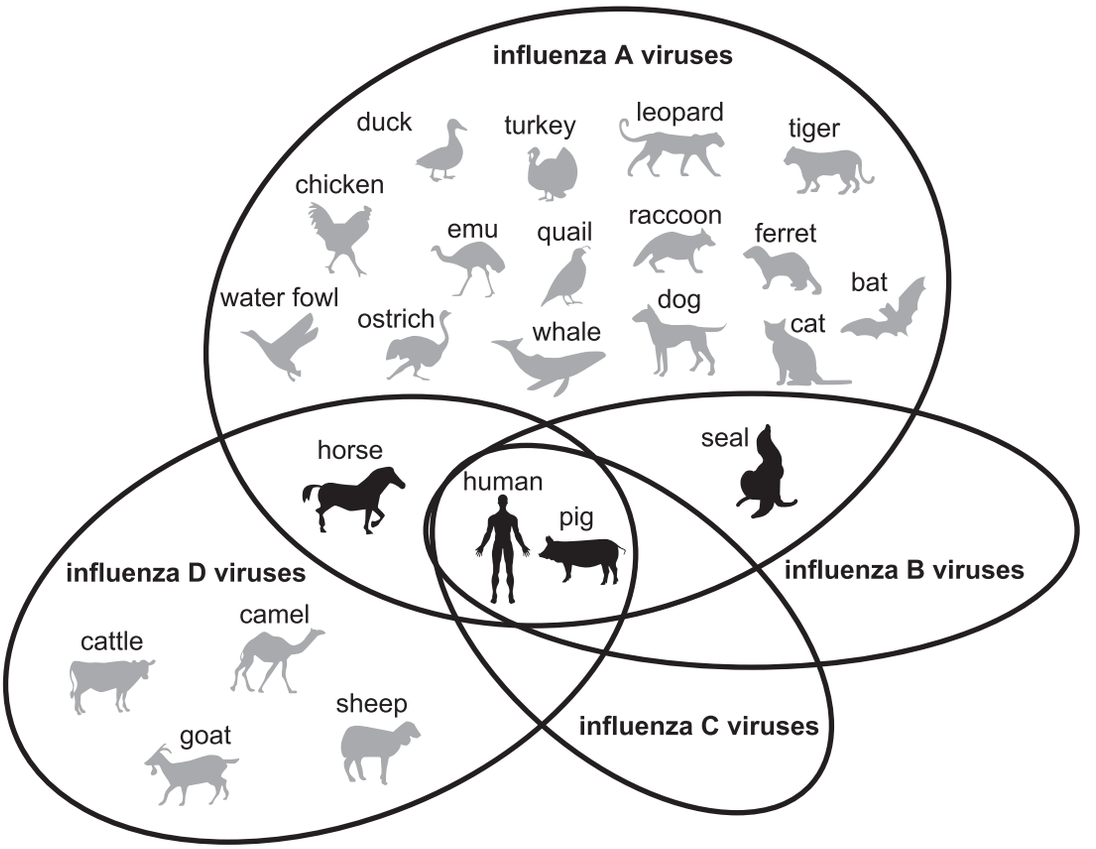
B. relative dating using transitional fossils to understand evolutionary sequences

C. relative dating using the law of superposition to determine the age of fossils based on rock layers

D. absolute dating using muscle tissue to compare the spiny shark fossils to other known fossils

Question 33

The diagram below shows a range of hosts for four different strains of influenza virus.



Source: SV Kuchipudi and RH Nissly, 'Novel Flu Viruses in Bats and Cattle: "Pushing the Envelope" of Influenza Infection', *Veterinary Sciences*, vol. 5, no. 3, 2018, p. 71, licensed CC-BY 4.0 <https://creativecommons.org/licenses/by/4.0/>

Based on this diagram, it is most likely that an antigenic drift in

A. influenza B would equally threaten both goat and chicken farming industries.

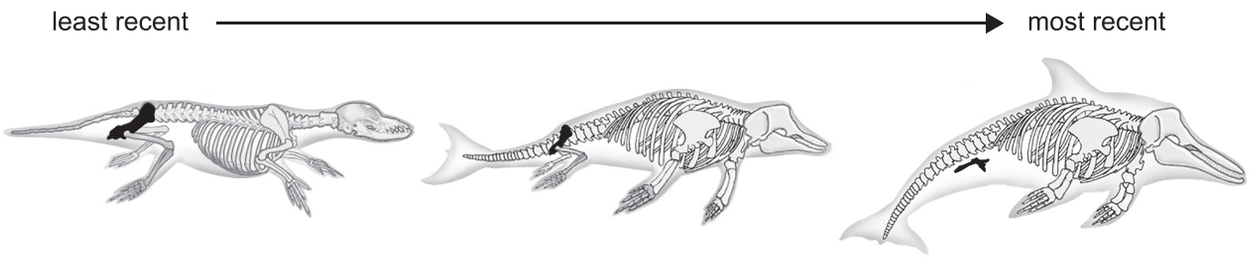
B. influenza C would prompt public health measures to protect humans who may have little to no immunity to the new variant.

C. influenza A would be less severe due to its wide host range, which provides opportunities for the genetic material to mix.

D. influenza D would result in major changes to the antigen, which would have little effect on the immunological memory present in seals, provided by previous infections.

Question 34

The following image shows the evolution of dolphins from least recent to most recent. The pelvis structure is indicated by the dark shading.



Source: Adapted from Amadeu Blasco/Shutterstock.com

The pelvis bone structure has changed over time.

In the most recent dolphin, the pelvis bones demonstrate

A. transitional fossils.

B. vestigial structures.

C. sympatric speciation.

D. homologous structures.

Question 35

Hylobates lar is found in the rainforests of South-East Asia.

It lives in trees, particularly the upper tree canopy, swinging from tree to tree by fully rotating its long arms.

Source: teekayu/Shutterstock.com

H. lar are small (around 60 cm long), have short, thick fur and no tail. They live in small family groups, where females give birth to live young after a gestation period of around seven months.

H. lar would most likely be classified as a

A. hominoid and hominin.

B. primate and hominoid.

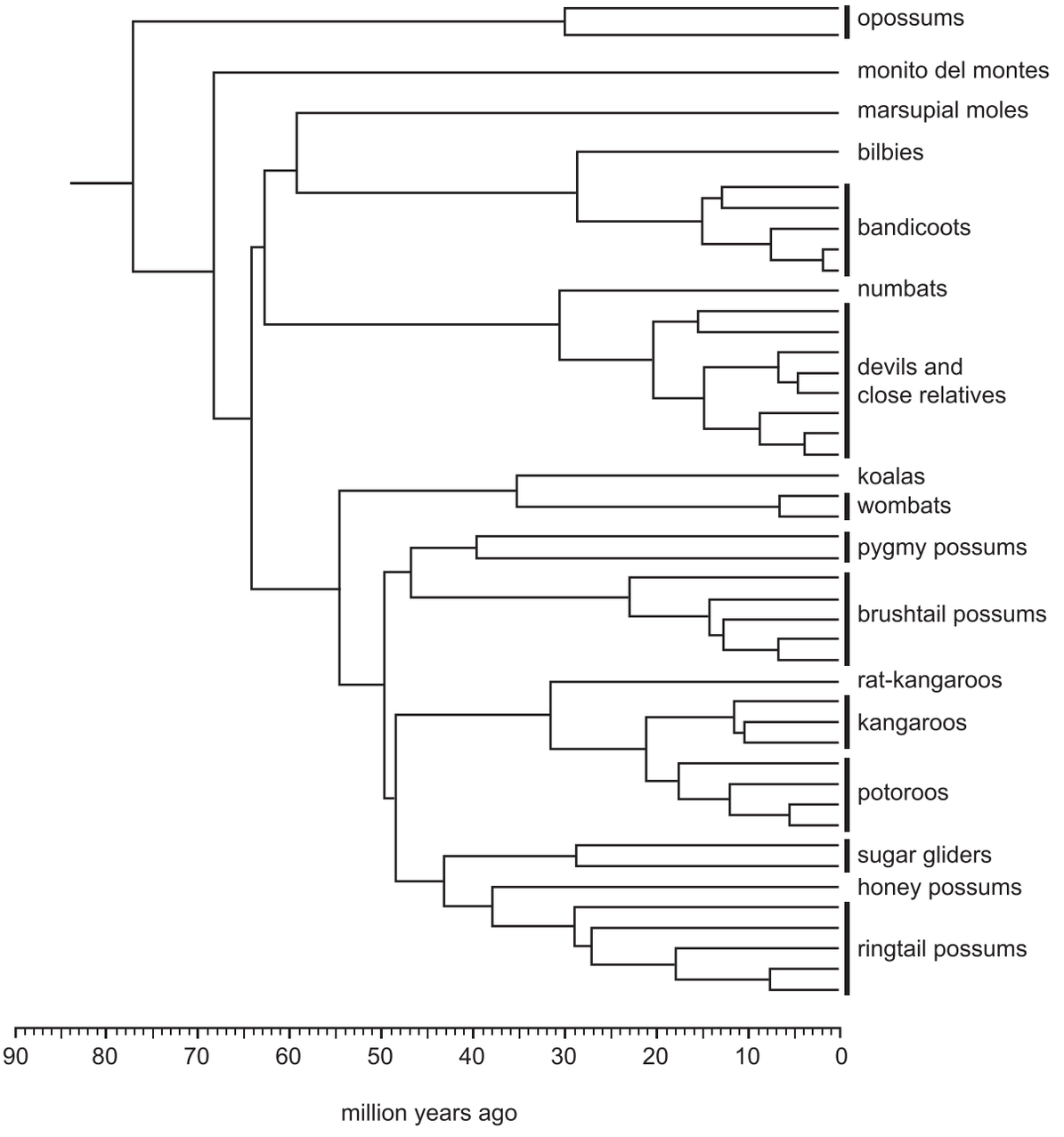
C. mammal and hominin.

D. primate and a *Homo* species.

Question 36

Most marsupials are found in Australia. Two groups of marsupials are found living outside Australia: opossums in North America and monito del montes in South America.

The phylogenetic tree below shows the evolutionary relationships between these marsupials.



Source: Adapted from DA Duchene, 'What do genomes have to say about marsupial history?', *Australasian Science*, vol. 39, no. 4, 2018, pp. 32–34

Referring to the phylogenetic tree, it is most reasonable to conclude that

A. there would be more differences in DNA sequences between opossums and bandicoots than between bilbies and numbats.

B. speciation only occurs as populations became isolated in different countries.

C. koalas and wombats diverged from their most recent common ancestor 55 million years ago.

D. sugar gliders do not have a common ancestor with rat-kangaroos.

Use the following information to answer Questions 37 and 38.

In 2015, the fossil remains of at least 15 individuals were found in caves in South Africa. The remains were classified as a new species, *Homo naledi*. *H. naledi* shares common features with *Australopithecus* and modern *Homo* species. The fossil remains date to between about 335 000 and 236 000 years ago.

Structural morphology of *H. naledi*

Image	Characteristics
	• well-developed thumb • long, curved fingers
	• wide, flat pelvis • relatively long leg length compared to arm length

Source: (Hand) LR Berger, et al., '*Homo naledi*, a new species of the genus *Homo* from the Dinaledi Chamber, South Africa', *eLife*, vol. 4; (Skeleton) DR Bolter, 'Immature remains and the first partial skeleton of a juvenile *Homo naledi*, a late Middle Pleistocene hominin from South Africa', *PLoSOne*, vol. 15, no. 4, 2020, licensed CC-BY 4.0 <https://creativecommons.org/licenses/by/4.0/>

Question 37

Referring to the table and your knowledge of human evolution, the characteristics *H. naledi* are most likely to share with modern *Homo* species are

A. well-developed thumb and relatively long leg length compared to arm length.

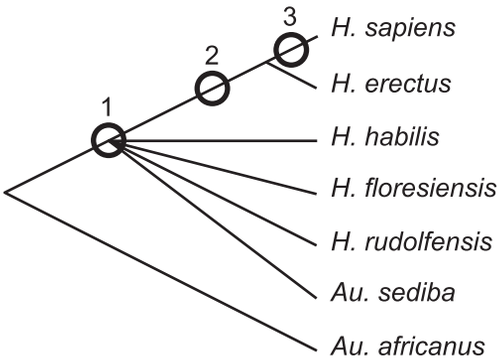
B. relatively long leg length compared to arm length and long, curved fingers.

C. wide, flat pelvis and well-developed thumb.

D. long, curved fingers and wide, flat pelvis.

Question 38

Scientists have created a simplified phylogenetic tree with three different positions (numbered 1, 2 and 3 in the diagram below) suggesting where *H. naledi* may be placed in the fossil record.



Source: LR Berger, et al., '*Homo naledi* and Pleistocene hominin evolution in subequatorial Africa', *eLife*, vol. 6, 2017, licensed CC-BY 4.0 <https://creativecommons.org/licenses/by/4.0/>

Based on the information provided, the most likely placement of *H. naledi* in the phylogenetic tree would be

A. position 1, as it has characteristics of both *Homo* and *Australopithecus* in its skeleton.

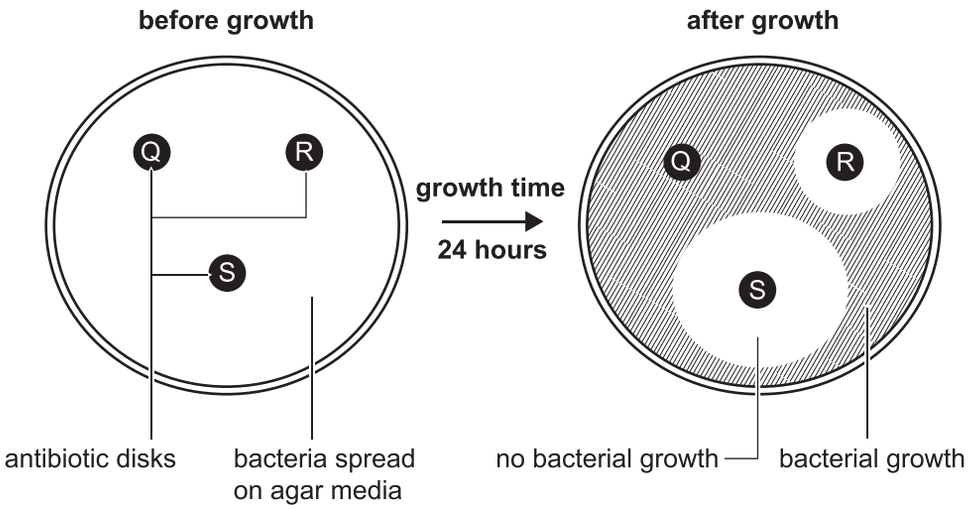
B. position 2, as its characteristics are more similar to *Homo* than to *Australopithecus*.

C. position 3, as its fossil remains are dated at 335 000–236 000 years ago.

D. none of these positions. *H.naledi* cannot be confidently placed on the phylogenetic tree without further fossil and DNA evidence.

Use the following information to answer Questions 39 and 40.

In diagnostic laboratory tests, scientists use the disk diffusion test to see how effective different antibiotics are against bacteria. An effective antibiotic stops bacterial growth, creating a clear area around the disk. If one of the disks shows no clear area, it suggests that the bacteria are resistant to the antibiotic on that disk. The diagram below shows the results of testing three antibiotics, Q, R and S, against a particular bacteria.



Question 39

A technician repeated the experiment several times and each time measured the diameter of the clear areas. They obtained very similar results each time, but these measurements significantly deviate from the standard reference true values for the antibiotics used.

This establishes that the results are

A. both precise and accurate.

B. neither accurate nor precise.

C. precise but not necessarily accurate.

D. accurate but not necessarily precise.

Question 40

From the results of this experiment, the bacteria could be resistant to which antibiotic(s)?

A. Q only

B. R only

C. S only

D. both R and S

End of Section A

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Examination continues on the next page.

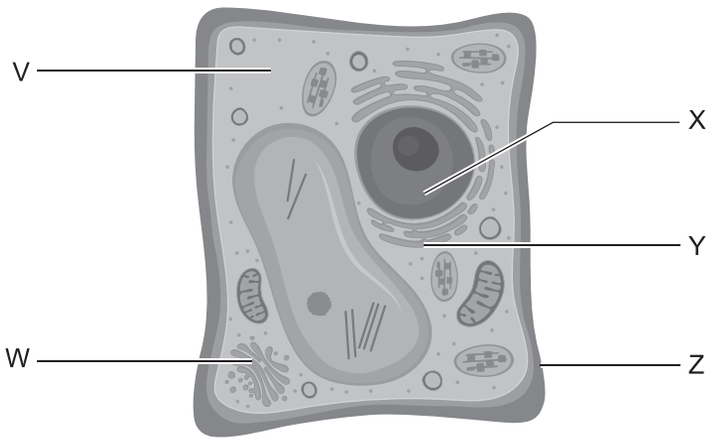
Section B

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 (11 marks)

The diagram below shows a typical plant cell. Several locations have been labelled.



Source: Adapted from LDarin/Shutterstock.com

a. **i.** With reference to the cell above, which location (V, W, X, Y or Z) shows the Golgi apparatus? 1 mark

ii. Describe the role of the Golgi apparatus in a cell. 3 marks

b. Describe the role of tRNA in the production of a protein. 2 marks

c. Explain how an enzyme catalyses the breakdown of a protein. 2 marks

d. Some proteins need to be secreted from the plant cell.

Describe the role of vesicles in the export of protein from a cell. 1 mark

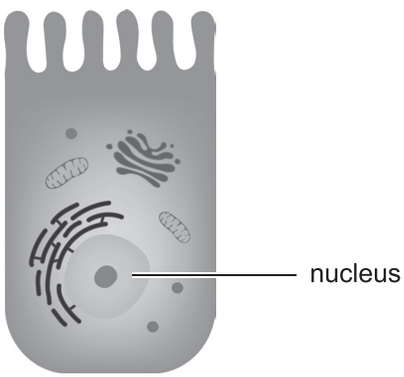
e. The process of protein synthesis can be considered a scientific model. The current knowledge of protein synthesis has been developed over many years, with contributions from different scientists. However, models have limitations.

Identify a limitation of the model of protein synthesis, and suggest a possible solution to this limitation. 2 marks

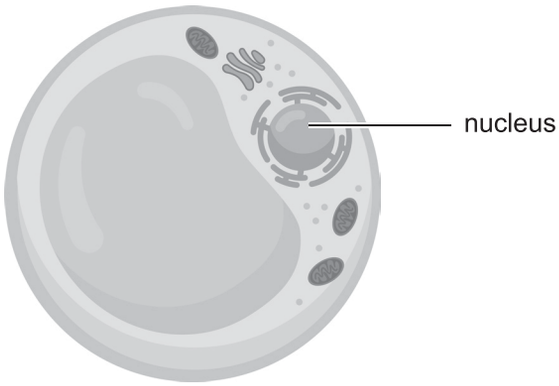
Question 2 (5 marks)

Complex multicellular organisms, such as humans, have many cell types that perform different functions. Two such cell types are shown in the diagrams below. Intestinal epithelial cells allow for the uptake of nutrients along the digestive tract. Fat cells (adipocytes) store fat. The organism's proteome plays a part in allowing for this complexity.

Intestinal epithelial cell



Fat cell



Source: (left image) Adapted from Dee-sign/Shutterstock.com; (right image) Adapted from inspiring.team/Shutterstock.com

The different cell types contain the same genes, yet they have very different structures and functions.

Describe an organism's 'proteome', and use this concept to explain how organisms achieve such diversity in cell types. Refer to the cells in the diagrams in your response.

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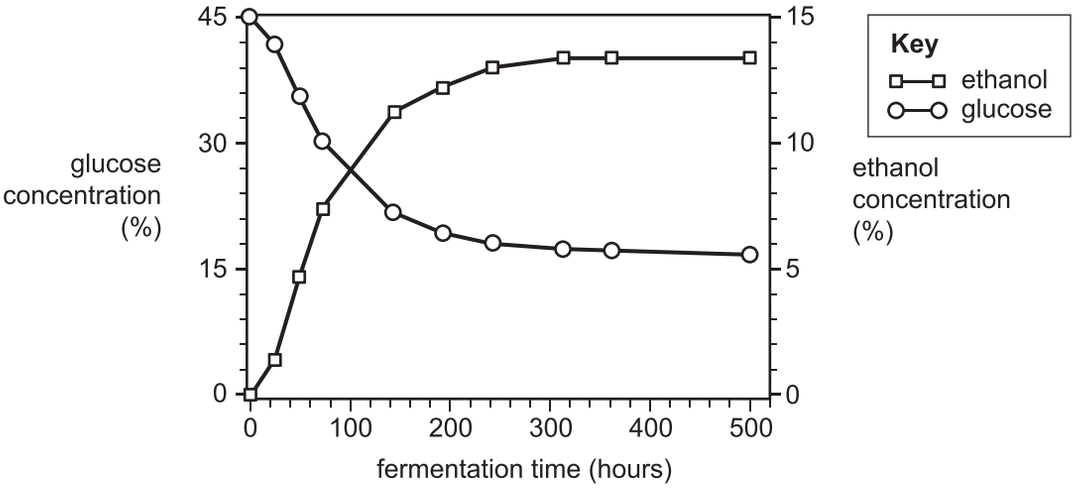
Question 3 (4 marks)

Researchers have been investigating methods for the accurate analysis of ethanol production by yeast cells. The data below represents the production of ethanol by yeast cells from a solution of 45% glucose in water, plus some trace nutrients. No oxygen was present.



Source: D Mackie, et al., 'Simple, fast and accurate methodology for quantitative analysis using Fourier transform infrared spectroscopy, with bio-hybrid fuel cell examples', *MethodsX*, vol. 3, 2016, pp. 128–138, licensed CC-BY 4.0 <https://creativecommons.org/licenses/by/4.0/>

a. State **two** reasons why the glucose concentration does not reduce to zero over the 500 hours in a solution containing yeast cells. 2 marks

b. One of the researchers suggested that adding oxygen would enable the yeast cells to produce more ethanol and consume more glucose. This would make the production of the ethanol more efficient.

Describe the effect of adding oxygen on the production of ethanol by yeast cells. Give a reason for your response. 2 marks

Do not write in this area.

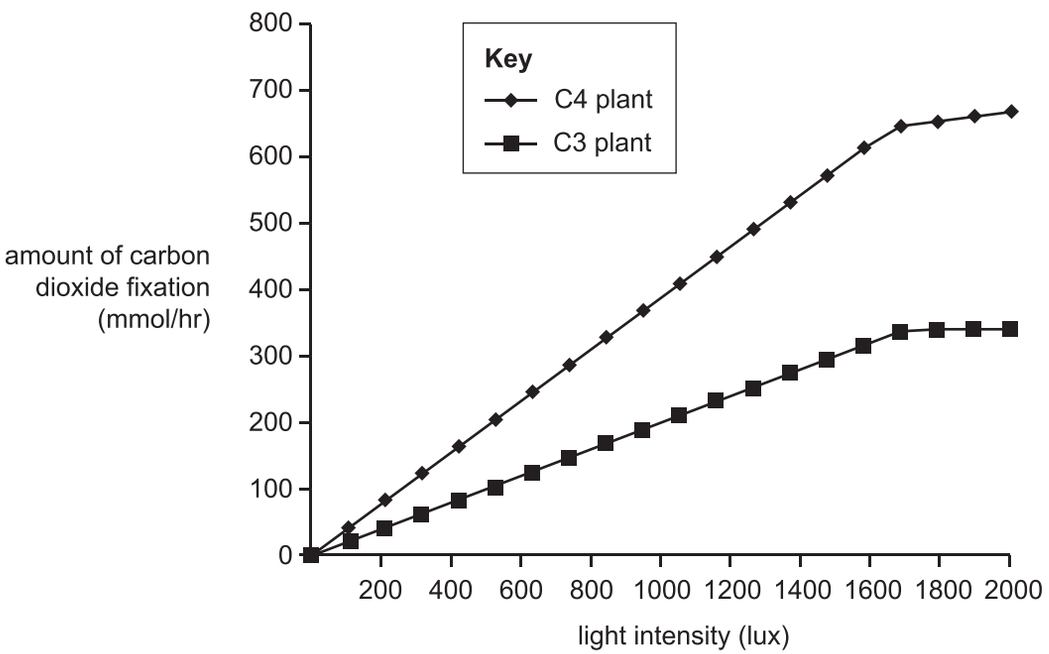
Question 4 (11 marks)

Photosynthesis is an important biochemical pathway in plants and some single-cell organisms that produce glucose as an energy source.

a. Explain why photosynthesis is considered to be a biochemical pathway. 3 marks

Use the following information to answer parts b and c.

Photosynthesis requires the fixation of carbon dioxide (CO_2). The graph below shows the fixation of carbon dioxide during the light-independent stage at different light intensities for a C3 plant and a C4 plant.



Source: Adapted from C Wang, et al., 'Systematic Comparison of C3 and C4 Plants Based on Metabolic Network Analysis', *BMC Systems Biology*, vol. 6, suppl. 2, 59, 2012, licensed CC-BY 2.0 <https://creativecommons.org/licenses/by/2.0/>

Do not write in this area.

b. A student stated that C4 plants growing next to C3 plants had an advantage.

Use the data from the graph to support this statement. Justify your response. 3 marks

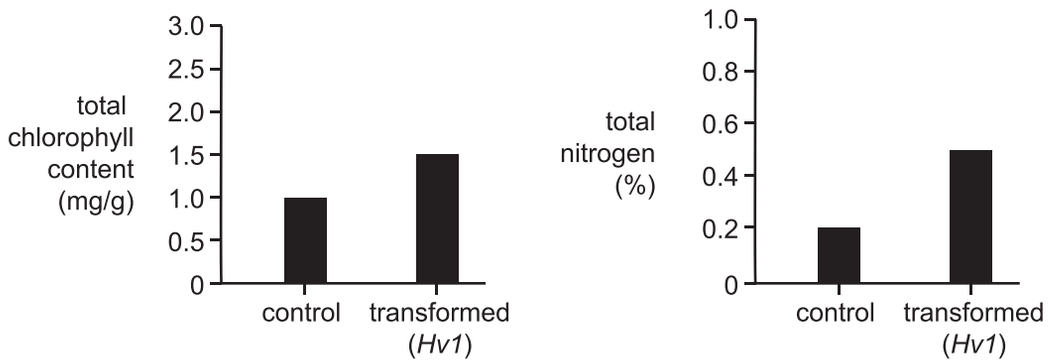
c. Referring to the graph, explain why the rate of CO_2 fixation in the C3 plants changes as light intensity changes and then plateaus (levels off) above a light intensity of 1700 lux. 2 marks

d. Explain how C4 plants are better adapted to reducing photorespiration compared to C3 plants. 3 marks

Question 5 (9 marks)

Barley (*Hordeum vulgare*) is an important cereal crop that provides food for people and animals. Scientists from Western Australia have successfully used CRISPR-Cas9 gene-editing techniques to develop barley plants with an increased ability to take up and use nitrogen. These new barley varieties will reduce the amount of nitrogen fertiliser used in crop farming. They will also reduce greenhouse gas emissions because nitrogen from fertiliser is emitted as nitrous oxide into the environment.

CRISPR-Cas9 technologies are used to edit a gene in the barley seed by causing a single nucleotide substitution. One of the edited genes is *Hv1*, which alters the amount of chlorophyll and nitrogen in the transformed barley plant, is shown in the graphs below.



Source: Adapted from SD Karunarathne, et al., 'CRISPR/Cas9 gene editing and natural variation analysis demonstrate the potential for HvARE1 in improvement of nitrogen use efficiency in barley', *Journal of Integrative Plant Biology*, vol. 64, 2022, pp. 756–770

a. **i.** Referring to the graphs, complete the table for the amounts of chlorophyll and nitrogen in the control and transformed barley plants. 1 mark

	Total chlorophyll content (mg/g)	**Total nitrogen (%)**
Control		
Transformed		

ii. Referring to **either** chlorophyll **or** nitrogen, explain how the change in the transformed barley plant could impact the plant. 2 marks

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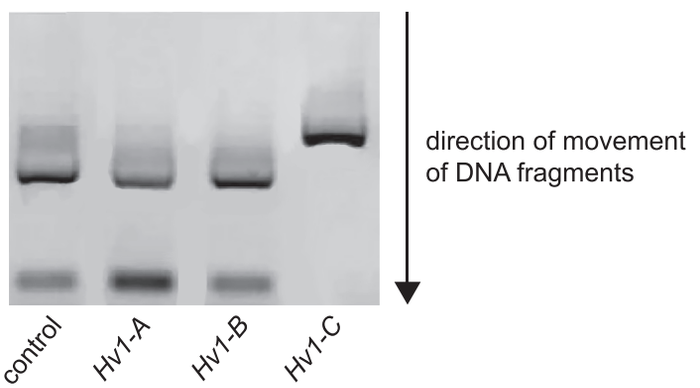
b. Scientists using CRISPR-Cas9 technologies to edit barley seeds are aware that not all barley seeds are transformed.

Explain why some barley seeds may not be transformed when using CRISPR-Cas9 technologies. 2 marks

c. To identify the transformed seeds, scientists grow three *Hv1* barley plants, *Hv1-A*, *Hv1-B* and *Hv1-C*. They also grow a control barley plant. Scientists then extract DNA from the barley plants and mix it with *Bst*N1, an endonuclease. *Bst*N1 has one recognition site for DNA from non-transformed barley plants and no recognition sites for DNA from transformed barley plants. The mixture of DNA from the barley plants and *Bst* N1 undergoes gel electrophoresis to identify the transformed barley plants. The results are shown below.



Source: Adapted from SD Karunarathne, et al., 'CRISPR/Cas9 gene editing and natural variation analysis demonstrate the potential for HvARE1 in improvement of nitrogen use efficiency in barley' *Journal of Integrative Plant Biology*, vol. 64, 2022, pp. 756–770

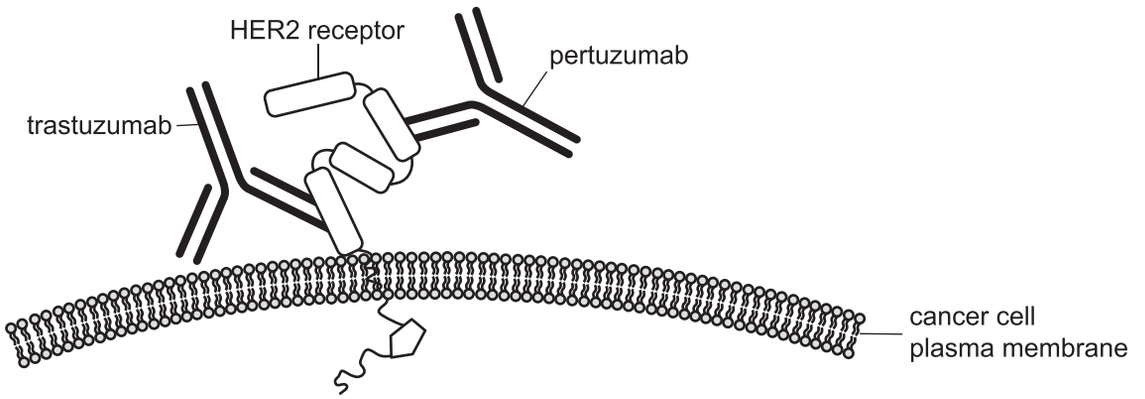
Using the gel electrophoresis results, identify the transformed barley plant. Justify your response. 2 marks

Question 5 continues on the next page.

d. Describe how DNA fragments are separated in gel electrophoresis. 2 marks

Question 6 (4 marks)

Trastuzumab and pertuzumab are monoclonal antibodies used in the treatment of human epidermal growth factor receptor 2 (HER2)-positive breast cancer. Both monoclonal antibodies attach to a cancer cell as shown in the diagram below.



Source: Adapted from J Wang and B Xu, 'Targeted therapeutic options and future perspectives for HER2-positive breast cancer', *Signal Transduction and Targeted Therapy*, vol. 4, no. 34, 2019, licensed CC-BY 4.0 <https://creativecommons.org/licenses/by/4.0/>

a. Referring to the diagram, compare the two variable regions of the monoclonal antibodies trastuzumab and pertuzumab. 2 marks

b. Identify **two** ways in which the monoclonal antibodies could function to help treat a person with HER2-positive breast cancer. 2 marks

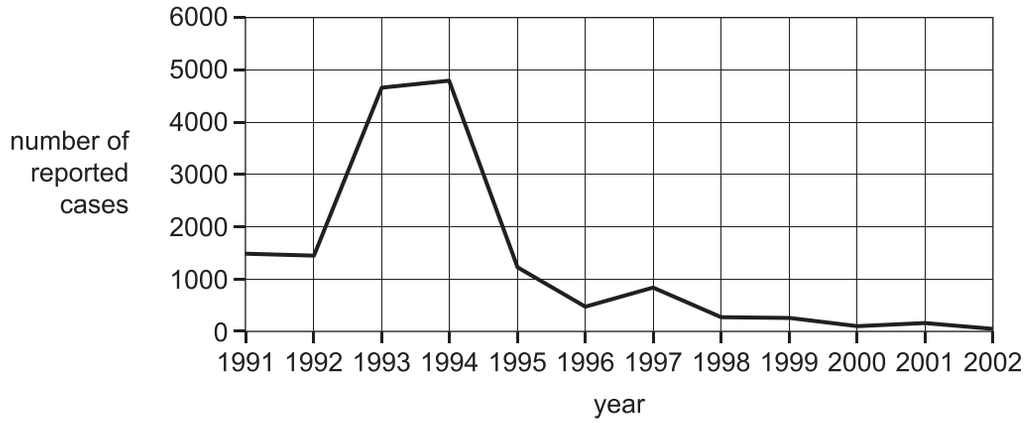
Do not write in this area.

Question 7 (10 marks)

Measles is a highly contagious viral infection. The virus is spread when a person infected with the virus coughs or sneezes.

In Australia, health authorities report cases of measles to a national body. The number of reported cases of measles from 1991 to 2002 is shown in the graph below.

Number of reported cases of measles in Australia (1991 to 2002)



Source: *National Notifiable Diseases Surveillance System,* Australian Government Department of Health and Aged Care <www.health.gov.au/our-work/nndss>

a. Identify **one** action taken within the Australian population that may have led to the change in number of cases from 1994 onwards. Explain how this action could cause this change. 3 marks

Do not write in this area.

b. Measles is no longer endemic in Australia. In January 2024, the Victorian Department of Health issued a health alert when three new measles cases were reported. The health alert listed the public locations that the infected individuals had visited.

Identify a potential source of the measles infection for the three individuals, and state **two** benefits of listing the public locations that they had visited. 3 marks

c. Measles is a known pathogen that is re-emerging around the world. New pathogens are also emerging.

Describe two factors that are contributing to the emergence of new pathogens in human populations. 4 marks

Factor	Description

Question 8 (8 marks)

Researchers studied *Eucalyptus salubris* in its natural habitat in Western Australia. *E. salubris* is an evergreen tree that reaches up to 25 metres in height. It has small, white flowers that are thought to be pollinated by insects. It also has seeds that fall directly beneath the tree canopy.

The researchers sampled 20 populations of *E. salubris*. They noted differences in the appearance of the trees and the thickness of the leaves.

The results indicated that the 20 populations could be divided into two distinct groups, represented in the images below. Image A shows an example of one group, with thicker leaves, and Image B shows an example of the other group, with thinner leaves.

The two groups live in close geographical proximity but those with thinner leaves are only found in soils with high phosphorus levels. Genetic analysis comparing the two groups showed significant differences. These findings strongly indicate that the two groups should be classified as two separate species.

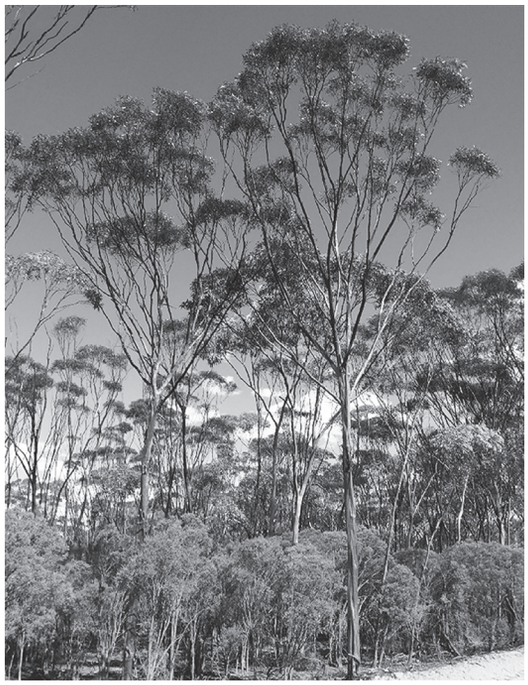


Image A

Image B

Source: RM Binks, DA Steane and M Byrne, *Ecology and Evolution*, vol. 11, 2021, pp. 5096–5110, licensed CC-BY 4.0 <https://creativecommons.org/licenses/by/4.0/>

a. State the scientific investigation methodology used to collect the samples of *E. salubris*. 1 mark

Do not write in this area.

b. Identify the evidence that suggests that the two groups should be classified as two separate species. 2 marks

c. **i.** Identify the type of speciation that may be occurring between the two distinct groups of *E. salubris.* 1 mark

ii. Explain what led to the genetic diversity between the two distinct groups of trees. 4 marks

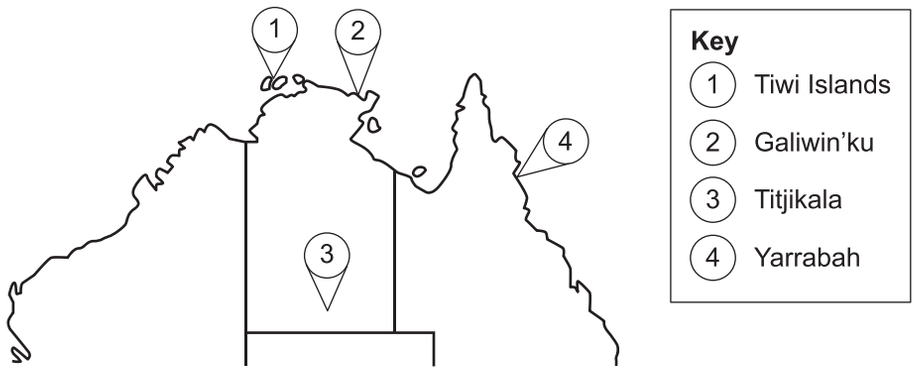
Question 9 (9 marks)

Genomic variation in Indigenous Australians

A recent study explored variation in the DNA sequences of Indigenous Australians. Genome DNA sequencing was used to increase understanding of both human genomic diversity and genetic disease.

Indigenous Australian communities were invited to take part in the genomic research. The research was conducted in accordance with required ethical guidelines to ensure that the research was beneficial to the communities and aligned with their own ways of knowing. The collection of genomic data also falls under Indigenous Australian governance and custodianship.

People from four remote Indigenous communities across northern and central Australia, as well as non-Indigenous Australians, consented to take part in the research. The four remote Indigenous communities were: Tiwi Islands, Galiwin'ku, Titjikala and Yarrabah. Their locations are shown on the partial map of Australia below.



Source: Adapted from Figure 1a in ALM Reis, et al., 'The landscape of genomic structural variation in Indigenous Australians', *Nature*, vol. 624, Dec. 2023, pp. 602–610, licensed CC-BY 4.0 <https://creativecommons.org/licenses/by/4.0/>

DNA from 121 Indigenous Australian individuals and 18 non-Indigenous Australian individuals of European ancestry was sequenced. The sequencing focused on the 0.4% of the human genome that varies among individuals. In these areas of the genome, 46% of DNA sequence variation was found within Indigenous individuals in the same community. Only 2.8% of similar DNA sequence variation was shared across all four remote Indigenous communities.

It was concluded that each community has different and highly diverse DNA sequences. Similarly, each community is highly diverse in their culture and languages. The study also found that Indigenous Australians have the highest amount of DNA sequence variation outside Africa, and are highly genetically distinct from non-Indigenous Australians.

The Tiwi Islands geographically separated from the Australian mainland around 9000 years ago. However, since at least 26,000 years ago, all communities have been genetically isolated, with little detectable migration. This is supported by Indigenous Australians' unique knowledges and connections to Country and Place.

Source: Adapted from ALM Reis, et al., 'The landscape of genomic structural variation in Indigenous Australians', *Nature*, vol. 624, Dec. 2023, pp. 602–610; M Silcocks, et al., 'Indigenous Australian genomes show deep structure and rich novel variation', *Nature*, vol. 624, Dec. 2023, pp. 593–601.

a. One of the aims of the study was to explore variation in DNA sequences of Indigenous Australians.

DNA from 18 non-Indigenous Australian individuals of European ancestry was also sequenced in the study.

Give **one** reason for this. 1 mark

b. Identify how the researchers applied the ethical principle of respect in this study. Give a reason for your response. 2 marks

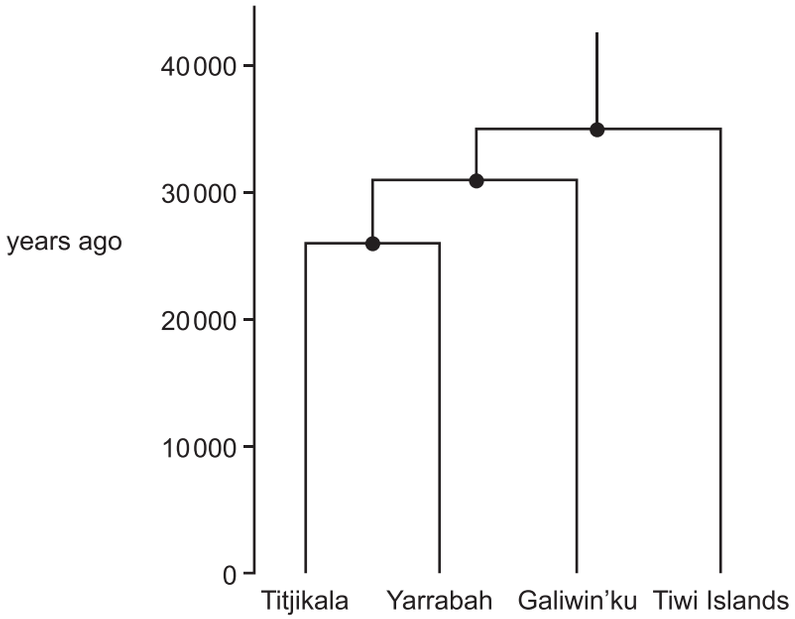
c. The study concluded that each of the four communities has highly diverse DNA sequences, and that there are different DNA sequence variations across communities.

Complete the table below using the data provided to support each conclusion. 4 marks

Conclusion	Data	Explanation
Communities have highly diverse DNA sequences.		
There are different DNA sequence variations across communities.		

Question 9 continues on the next page.

d. The genomic data was used to calculate genetic divergence times between communities. The results are outlined in the following diagram.



Source: Adapted from Figure 4 in M Silcocks, et al., 'Indigenous Australian genomes show deep structure and rich novel variation', *Nature*, vol. 624, Dec. 2023, pp. 593–601, licensed CC-BY 4.0 <https://creativecommons.org/licenses/by/4.0/>

Explain how the results of the study contribute to advancing the understanding of **either** human genomic diversity **or** the treatment of genetic disease. 2 marks

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Examination continues on the next page.

Question 10 (9 marks)

For their student-designed scientific investigation, a student wanted to investigate whether highlighting herd immunity in vaccination advertising campaigns influences an individual's vaccination decisions in Australia. They based their investigation on Scandinavian research that included three different groups: Group A, Group B and Group C.

The student recruited 121 participants via the school newsletter and social media pages. Participants were randomly placed into each group.

Individuals within each group received the following information:

'Imagine that there is a new and infectious disease in the world. The infected people have influenza symptoms, but usually recover quickly. The virus has caused a few deaths, but scientists have concerns that the virus will mutate and become more infectious. A vaccine against the virus is available, but it is not yet fully tested for side effects.'

Groups B and C received additional information as outlined in the table below.

Group	Additional information received
B	'The vaccine stimulates the body to rapidly respond to the virus, which helps to prevent illness. This is an individual benefit of vaccination.'
C	'Due to young age, allergies or poor health, a portion of the population cannot be vaccinated. To prevent illness in this group, it is important that the majority of the population get vaccinated. This highlights the benefit of herd immunity to the population.'

Source: Adapted from S Arnesen, et al., *Scandinavian Journal of Public Health*, vol. 46, no. 8, 2018

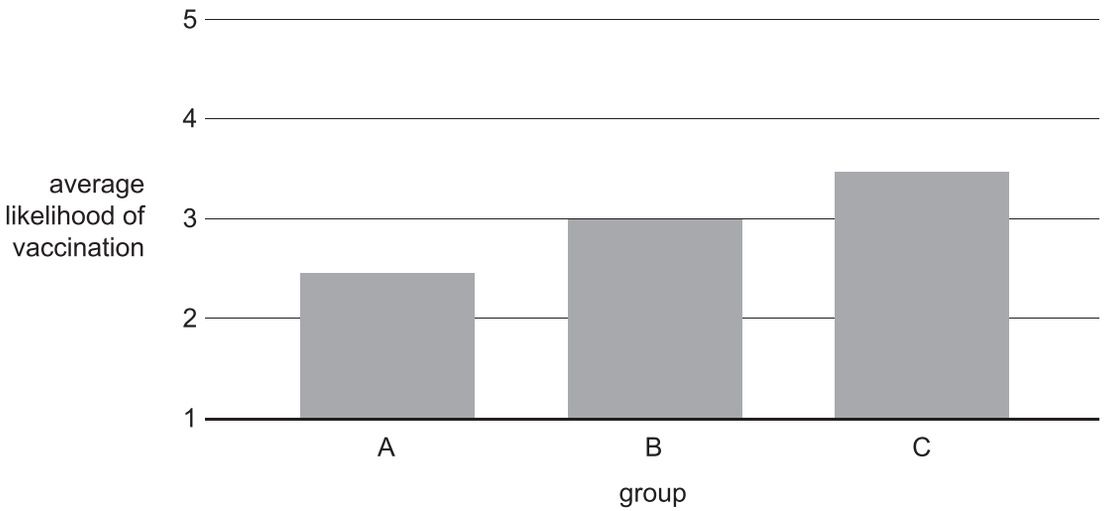
After reading the information, participants were asked to answer the question 'How likely are you to get vaccinated?'

Each participant rated the likelihood that they would get vaccinated by choosing one option from the scale below.

Not likely	Slightly likely	Somewhat likely	Likely	Very likely
1	2	3	4	5

Participants submitted their answers anonymously online.

The results of the student's investigation are summarised in the graph below.



a. Analyse the results. 3 marks

b. **i.** Based on their findings, what strategy could the student recommend to Australian health authorities to increase vaccination rates? 1 mark

ii. Propose another strategy that Australian health authorities could use to increase vaccination rates within a population. 1 mark

Question 10 continues on the next page.

c. **i.** Outline the importance of randomly placing participants into groups. 2 marks

ii. Comment on the validity of the results. Do not refer to randomly placing participants into groups in your answer. 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.