VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Print exam correction: Section B, Q5, flow diagram, 3rd line, right-side protein, 'Y' added before '22'

Victorian Certificate of Education 2023

STUDENT NUMBER | | | | | | | | | Letter |

BIOLOGY

Written examination

Friday 27 October 2023

Reading time: 9.00 am to 9.15 am (15 minutes)
Writing time: 9.15 am to 11.45 am (2 hours 30 minutes)

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	40	40	40
B	11	11	80
			Total 120

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or correction fluid/tape.
- No calculator is allowed in this examination.

Materials supplied
- Question and answer book of 43 pages
- Answer sheet for multiple-choice questions
- Additional space is available at the end of the book if you need extra space to complete an answer.

Instructions
- Write your **student number** in the space provided above on this page.
- Check that your **name** and **student number** as printed on your answer sheet for multiple-choice questions are correct, **and** sign your name in the space provided to verify this.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses must be in English.

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

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

SECTION A – Multiple-choice questions

Instructions for Section A

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1; an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.
Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.

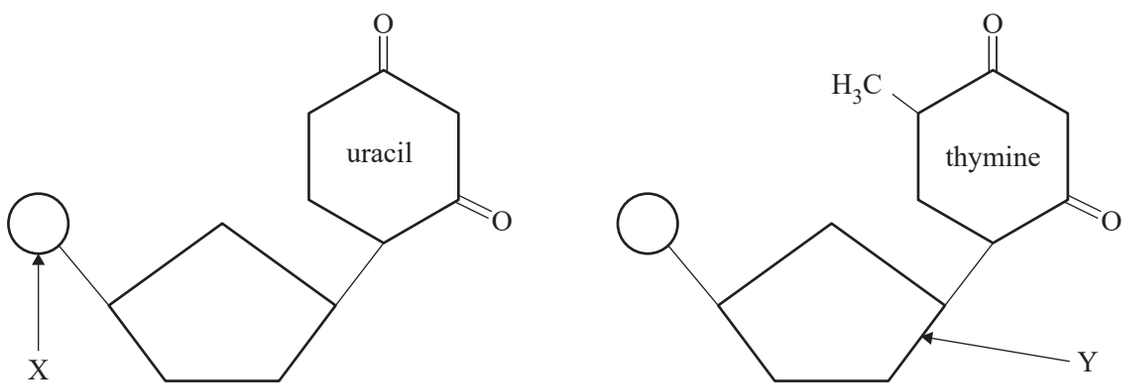
Question 1

Which one of the following correctly matches the nucleic acid molecule with its role?

	Molecule	Role
A.	DNA	carries genetic information to ribosomes
B.	tRNA	carries amino acids to ribosomes
C.	mRNA	structural component of ribosomes
D.	rRNA	contains genetic information that is transcribed

Question 2

The basic structure of two nucleotides is shown below. Each nucleotide has three subunits.



Source: A Step BioMed/Shutterstock.com

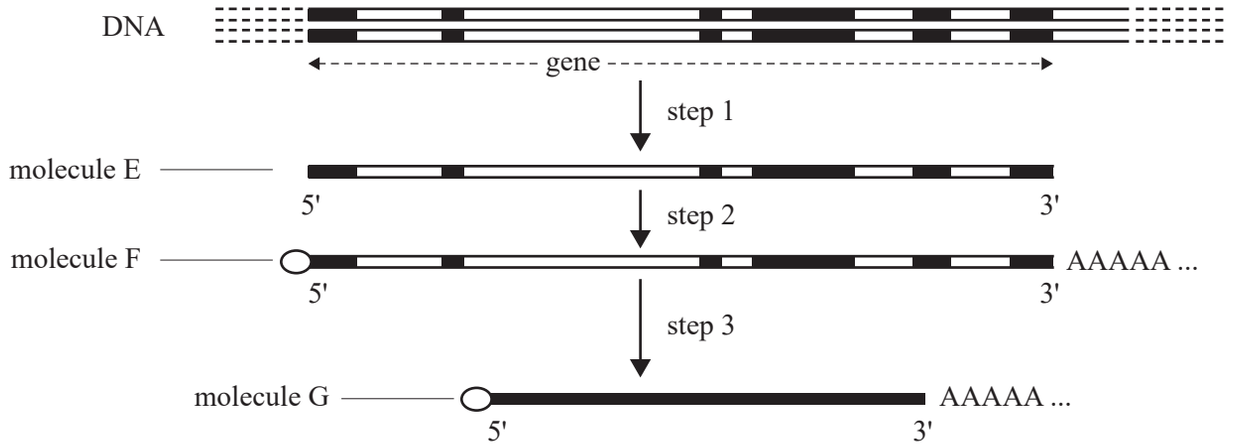
It can be concluded that the

A. subunit labelled X is a nitrogen base.
B. subunit labelled Y is a ribose sugar.
C. nucleotide with the subunit labelled uracil can be found in DNA.
D. nucleotide with the subunit labelled thymine will have a pentose sugar subunit.

DO NOT WRITE IN THIS AREA

Use the following information to answer Questions 3 and 4.

The following diagram shows some of the steps in the production of a protein within a cell.



Question 3

Which one of the following is a correct statement?

A. Step 1 represents translation.

B. There are six introns in the gene.

C. RNA polymerase is required for Step 3.

D. The circle on molecule F represents a modified guanine molecule.

Question 4

Molecule G codes for a protein containing 100 amino acids that form a single polypeptide chain.

The number of codons required to code for these 100 amino acids is

A. 33.

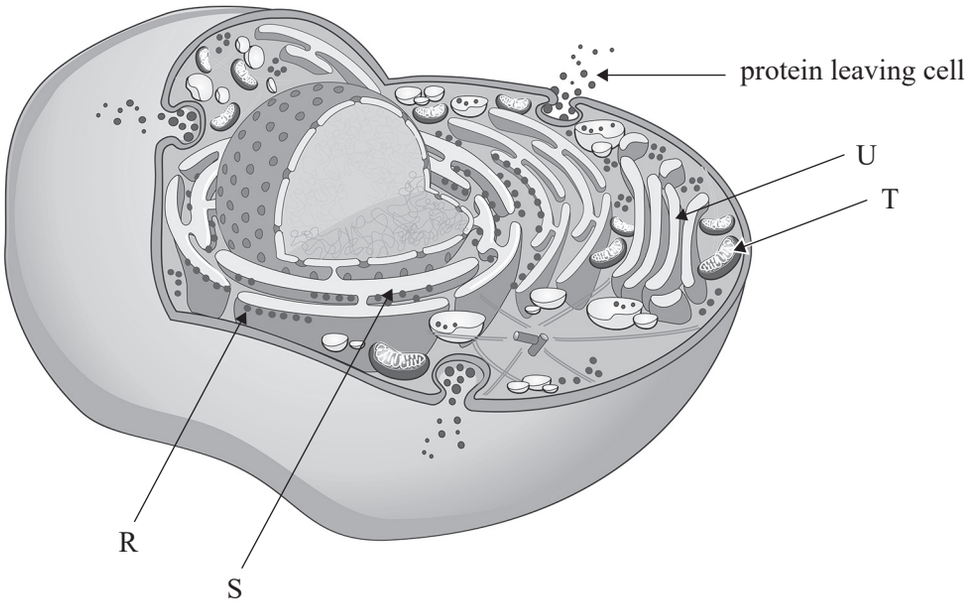
B. 66.

C. 100.

D. 300.

Question 5

The diagram below represents a mammalian cell undergoing the process of exocytosis.



Source: adapted from Soleil Nordic/Shutterstock.com

In the process of exocytosis, the role of

A. organelle R is to carry the protein to the plasma membrane.

B. organelle S is to enable folding and transport of the protein.

C. organelle T is to synthesise the protein.

D. organelle U is to produce energy for the synthesis of the protein.

Use the following information to answer Questions 6 and 7.

Students investigated the proteins found in several different types of human cells.

Question 6

In their investigation, the students would have expected

A. all proteins within each cell type to be identical.

B. that proteins within the same cell could differ in structure and function.

C. all proteins to consist of multiple polypeptide chains.

D. gene expression for each protein in each cell to be occurring continuously.

Question 7

Students completed their investigation and analysed their results. They suggested their results were affected by systematic errors.

Systematic errors

A. result in a spread of readings.

B. affect the precision of a measurement.

C. are easy to identify and eliminate.

D. cause readings to differ from the true value by a consistent amount each time.

Use the following information to answer Questions 8–10.

Wheat plants can be affected by rust disease, which is caused by a number of different fungal pathogens.

Wheat plants without rust disease **Wheat plants with rust disease**

Sources (from left): naor/Shutterstock.com; Photomusk/Shutterstock.com

Question 8

Plants have a number of barriers and mechanisms to prevent entry of pathogens.

The most likely route of entry of the fungal pathogen to the wheat plants above is via the

A. stomata.

B. waxy cuticle.

C. leaf receptors.

D. external layer of small hairs.

Question 9

Some plants, such as rye and wild grasses, have genes that code for proteins that make them resistant to rust disease. Recently, scientists have taken genes coding for resistance to rust disease and transferred them into a variety of wheat plants susceptible to rust disease.

Wheat plants with transferred genes for resistance to rust disease are known as

A. recombinant.

B. transgenic.

C. polyploid.

D. vectors.

Question 10

To determine the uptake of resistance genes by the wheat plants, scientists investigate gene fragments using electrophoresis to

A. cut the DNA.

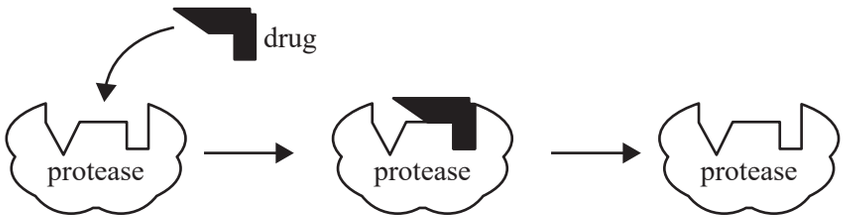
B. amplify the DNA.

C. separate the DNA.

D. denature the DNA.

Use the following information to answer Questions 11 and 12.

A new drug for the treatment of specific cancers has been developed and was assessed in clinical studies. A number of participants were recruited for the study and monitored to determine the effectiveness of the drug in the treatment of the cancer. The drug has been designed to interact with protease as shown below.



Source: hakan.demir/Shutterstock.com

Question 11

The interaction with the drug will result in the protease being

A. denatured.

B. activated.

C. catalysed.

D. inhibited.

Question 12

After the research was concluded, the results of the study, whether favourable or unfavourable, were published.

The publishing of all of the results would most closely align to the ethical concept of

A. non-maleficence.

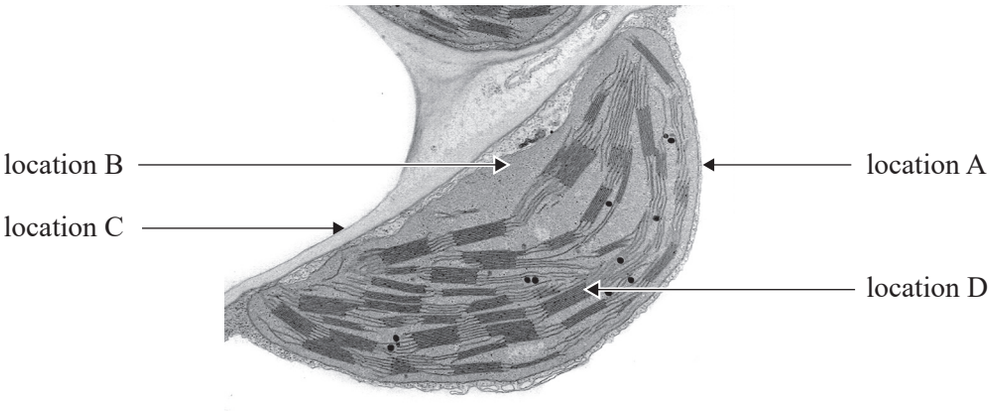
B. beneficence.

C. integrity.

D. justice.

Question 13

The following image is an electron micrograph of a chloroplast.



Source: adapted from Eldon Newcomb, University of Wisconsin
<https://search.library.wisc.edu/digital/ADJFWJEB7OGBAB85>

Where in this chloroplast would you find the Calvin cycle occurring?

A. location A
B. location B
C. location C
D. location D

Question 14

Which one of the following statements about the Calvin cycle is correct?

A. It is light-independent.
B. It requires glucose as an input.
C. It only occurs in complete darkness.
D. It only occurs when the humidity is high.

Question 15

Which molecules are involved in a light-independent reaction?

A. oxygen, ADP and NADH
B. oxygen, ADP and NADPH
C. carbon dioxide, ATP and NADH
D. carbon dioxide, ATP and NADPH

Question 16

Where in a plant leaf cell does a light-dependent reaction occur?

A. stroma
B. mitochondrion
C. thylakoid membrane
D. chloroplast inner membrane

Question 17

The enzymes involved in glucose metabolism are what type of biological molecule?

A. carbohydrates

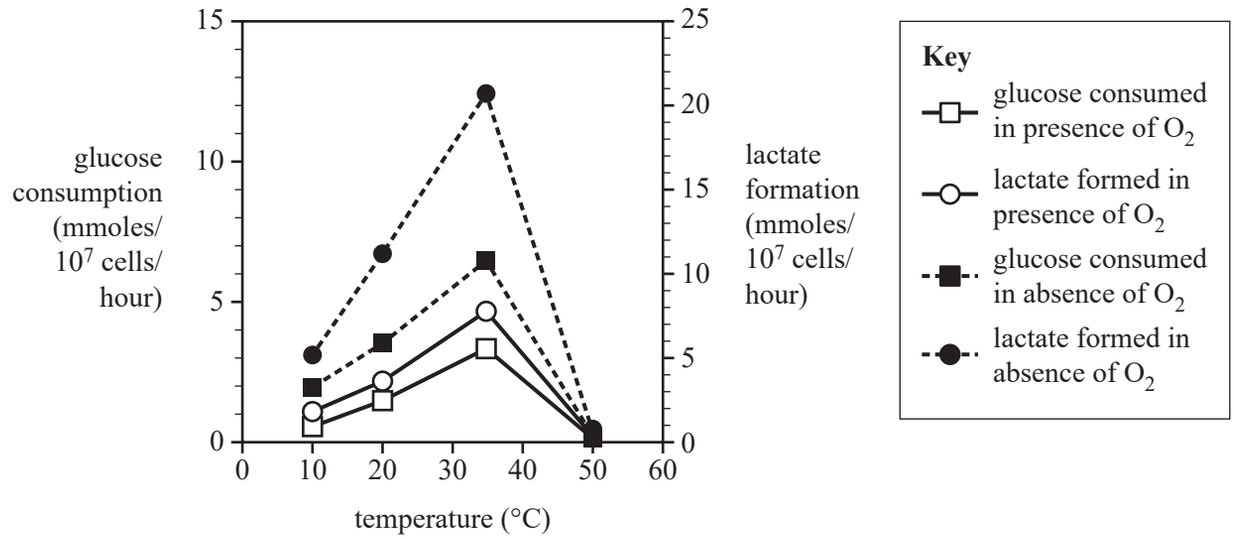
B. nucleotides

C. proteins

D. lipids

Use the following information to answer Questions 18–20.

The graph below shows the effect of temperature and oxygen on the rate of consumption of glucose and the corresponding rate of production of lactate in white blood cells at four different temperatures (10 °C, 20 °C, 35 °C and 50 °C).



Question 18

Under which of the following conditions is the rate of lactate formation highest?

A. 10 °C in the absence of oxygen

B. 20 °C in the absence of oxygen

C. 35 °C in the presence of oxygen

D. 50 °C in the presence of oxygen

Question 19

Why is the rate of consumption of glucose higher in the absence of oxygen than in its presence at 35 °C?

A. Oxygen stimulates lactate formation.

B. Oxygen inhibits the uptake of glucose by the cell.

C. Glycolysis reactions require the presence of oxygen.

D. Less ATP is formed from glucose in the absence of oxygen.

Question 20

Why are the rates of consumption of glucose and formation of lactate at 50 °C the same irrespective of oxygen levels?

A. Most of the enzymes involved in glycolysis have become denatured.

B. Glucose is converted to ATP by a single chemical reaction.

C. At 50 °C the cell uses heat as a source of energy.

D. At 50 °C metabolic pathways are very efficient.

Question 21

Hay fever (allergic rhinitis) is caused by a range of allergens, including pollen, animal fur, dust mites and moulds entering the body via the eyes, nose or mouth.

The cells that release histamine in the allergic response are

A. mast cells.

B. eosinophils.

C. macrophages.

D. natural killer cells.

Question 22

Allergens are presented by antigen-presenting cells to specific T cells using which of the following?

A. IgE antibodies

B. complement proteins

C. dendritic cell receptors

D. major histocompatibility complex proteins

Question 23

Tea-tree oil is derived from the leaves of *Melaleuca alternifolia*, which is endemic to Australia and native to Bundjalung country located in northern New South Wales.

Bundjalung people have used tea-tree oil as a traditional medicine. It is typically used as a topical medication for the treatment of skin conditions. It has anti-inflammatory properties and reduces skin inflammation caused by insect bites or hives.

It is reasonable to conclude that tea-tree oil inhibits the

A. physical barrier of the skin.

B. innate immune response.

C. proliferation of B cells.

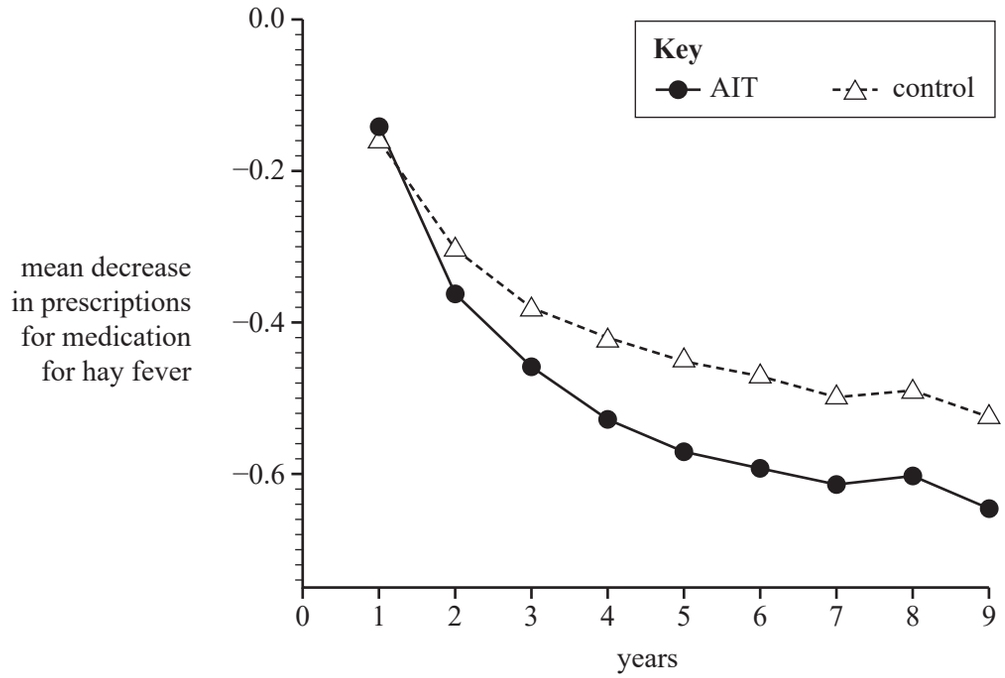
D. lymphatic system.

Use the following information to answer Questions 24 and 25.

A study was conducted over nine years to determine the effectiveness of allergen immunotherapy treatment (AIT). Participants in the study had been diagnosed with hay fever and were receiving prescriptions for medication to reduce the symptoms of hay fever. The experimental group comprised over 40 000 participants who received AIT. The control group received no AIT.

Over the course of the study, both groups were still able to take their hay fever medication to treat their symptoms as required. The following graph shows the mean change in number of prescriptions issued for hay fever medication in the experimental group and control group over the study, compared to the mean number of prescriptions at the beginning of the study.

Mean change in number of prescriptions for hay fever medication over time



Source: adapted from B Fritzsching et al, 'Results from the REACT study, a retrospective cohort study', *The Lancet,* vol 13, February 2022 , licensed CC-BY-NC-ND [http://creativecommons.org/licenses/by-nc-nd/4.0/]

Question 24

It is most reasonable to conclude that AIT

A. demonstrates long-term and sustained effects.

B. was not administered correctly in the first year.

C. is most effective between the first and second year.

D. is not effective, as both the experimental group and control group reduced the number of prescriptions required.

Question 25

It is reasonable to conclude that, compared to the experimental group, the control group

A. was randomly selected from the general population.

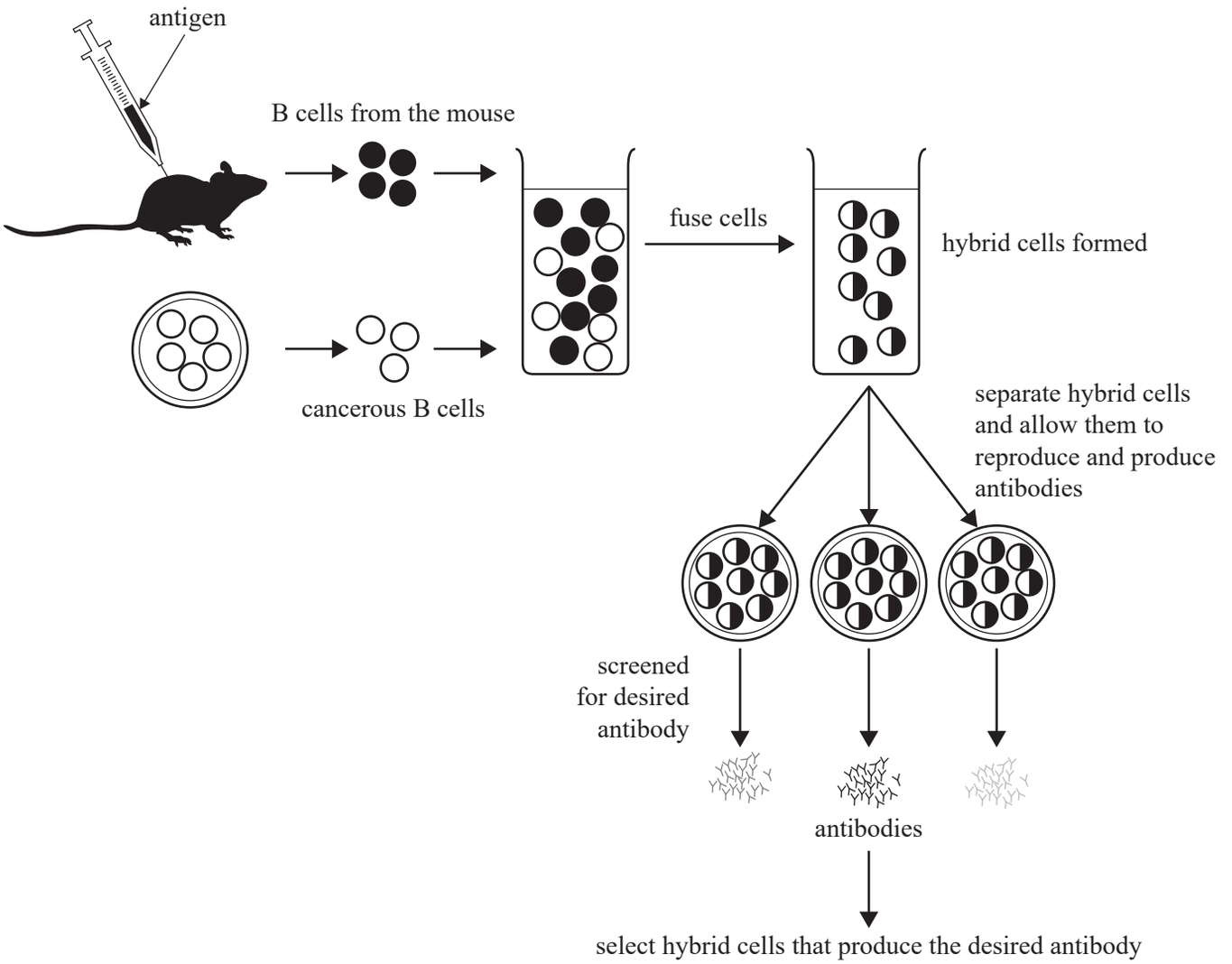
B. participants were unable to leave the study.

C. had a similar number of participants.

D. had double the number of participants.

Question 26

Monoclonal antibodies (mAbs) have been the focus of much attention in the fight against cancer. The basic process of monoclonal antibody production is summarised in the diagram below, beginning with a mouse being injected with cancer antigens.



Source: Nina Parker, Mark Schneegurt, Anh-Hue Thi Tu, Philip Lister, Brian M. Forster, Microbiology (Openstax, Nov 2016); https://openstax.org/books/microbiology/pages/1-introduction; licensed CC-BY [http://creativecommons.org/licenses/by/4.0/]

Which one of the following statements regarding the production of monoclonal antibodies is correct?

A. The monoclonal antibodies produced by one hybrid cell are identical to each other.

B. The monoclonal antibodies are specific to the antigens on mouse skin cells.

C. The cancerous B cells are extracted from the mouse.

D. The antigens are combined with cancerous B cells.

Question 27

Bevacizumab is a humanised monoclonal antibody that is used to treat several different cancers. Humanising involves removing part of the constant region of a mouse monoclonal antibody and replacing it with the constant region from a human antibody. Therefore the humanised antibody has both human-derived and mouse-derived components.

An advantage of humanising monoclonal antibodies such as bevacizumab would be to

A. decrease the binding strength between bevacizumab and the cancer cell antigens.

B. reduce the chances of an immune response against bevacizumab.

C. allow greater destruction of cancerous and non-cancerous cells.

D. deliver toxic substances less effectively to the cancer cells.

Question 28

Mosunetuzumab is a bispecific monoclonal antibody. Bispecific antibodies are designed to simultaneously bind to two different targets, such as a cancer cell antigen and a cytotoxic T cell. The T cell then destroys the cancer cell.

Mosunetuzumab's bispecificity would arise from the fact that it

A. lacks a constant region.

B. contains only heavy chains.

C. contains both a light and a heavy chain.

D. has two different-shaped variable regions.

Question 29

Which one of the following correctly describes an event that may occur in the lymphatic system?

A. antigen presentation by a dendritic cell to helper T cells

B. valves moving lymph fluid in two different directions

C. histamine triggering the release of IgE antibodies

D. phagocytosis of eosinophils

Question 30

Atlantic salmon (*Salmo salar*) are fish that are farmed in the waters of Tasmania. A selective breeding program was introduced that focused on increasing the growth of the fish, increasing the resistance of the fish to disease and maintaining the colour and oil content of the fish meat. The selective breeding program resulted in at least a 10% increase in growth of the fish in each generation. Increased resistance to disease has been noted as fewer fish in each generation have required treatment for disease.

In this selective breeding program

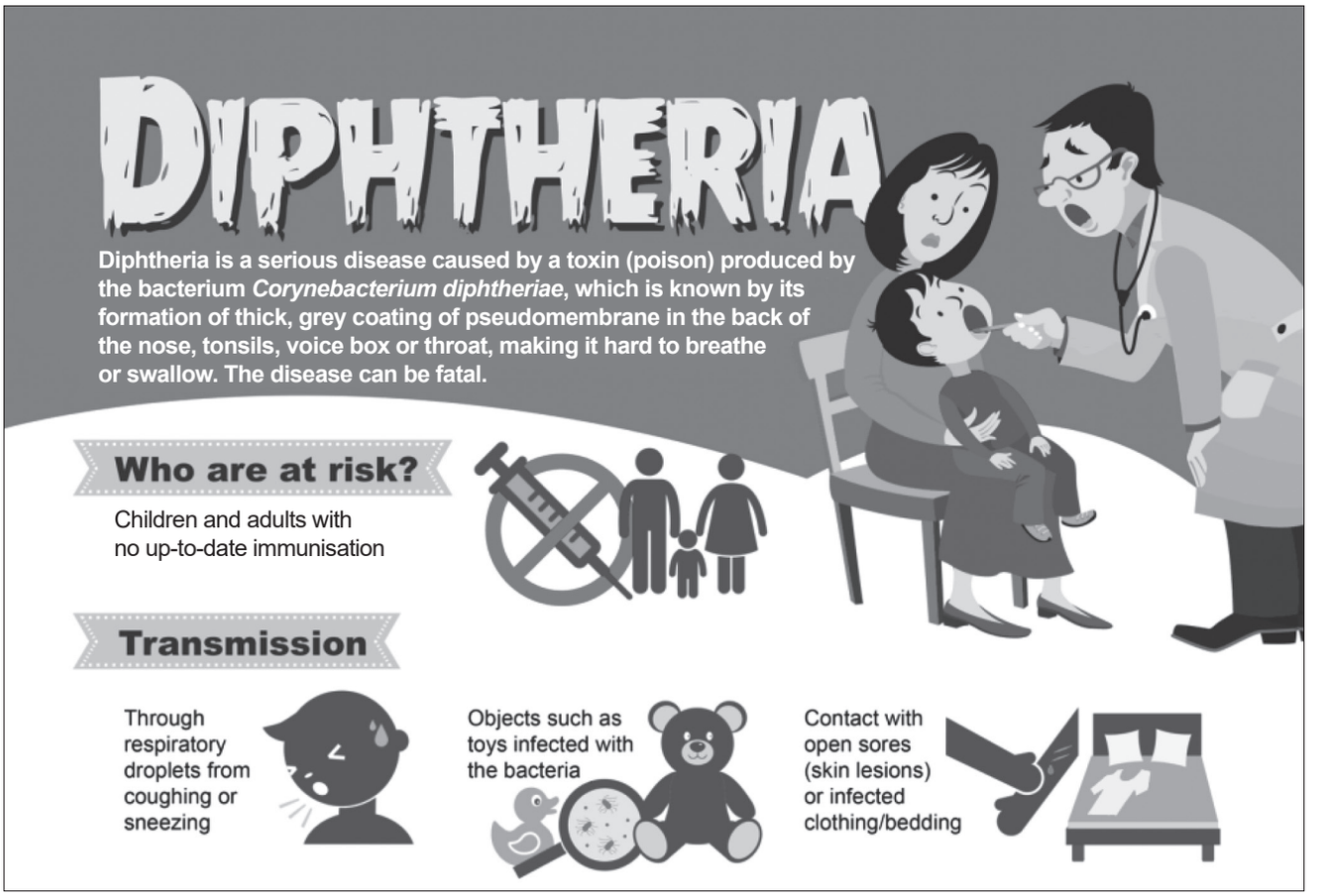
A. offspring will be produced by random mating of parents.

B. genetic variation within the fish population will increase.

C. the frequency of alleles for the desired phenotypes will increase over generations.

D. maintaining the colour and oil content of the fish meat will be advantageous for the fish.

Use the following information and your own knowledge to answer Questions 31 and 32.



Source: adapted from 'Diphtheria', *Positive Parenting,* July 28, 2016, <https://mypositiveparenting.org/2016/07/28/diphtheria>

Question 31

The diphtheria vaccine contains an inactivated form of the diphtheria toxin.

Which type of immunity will be acquired by individuals who receive this vaccine?

A. artificial active

B. natural active

C. natural passive

D. artificial passive

Question 32

Outbreaks of diphtheria occasionally occur.

Which statement is the most likely explanation for outbreaks of diphtheria?

A. Mutations produce a new strain, which means the bacteria are less able to enter cells in the nose and throat.

B. Herd immunity is lost due to parents choosing not to vaccinate their children.

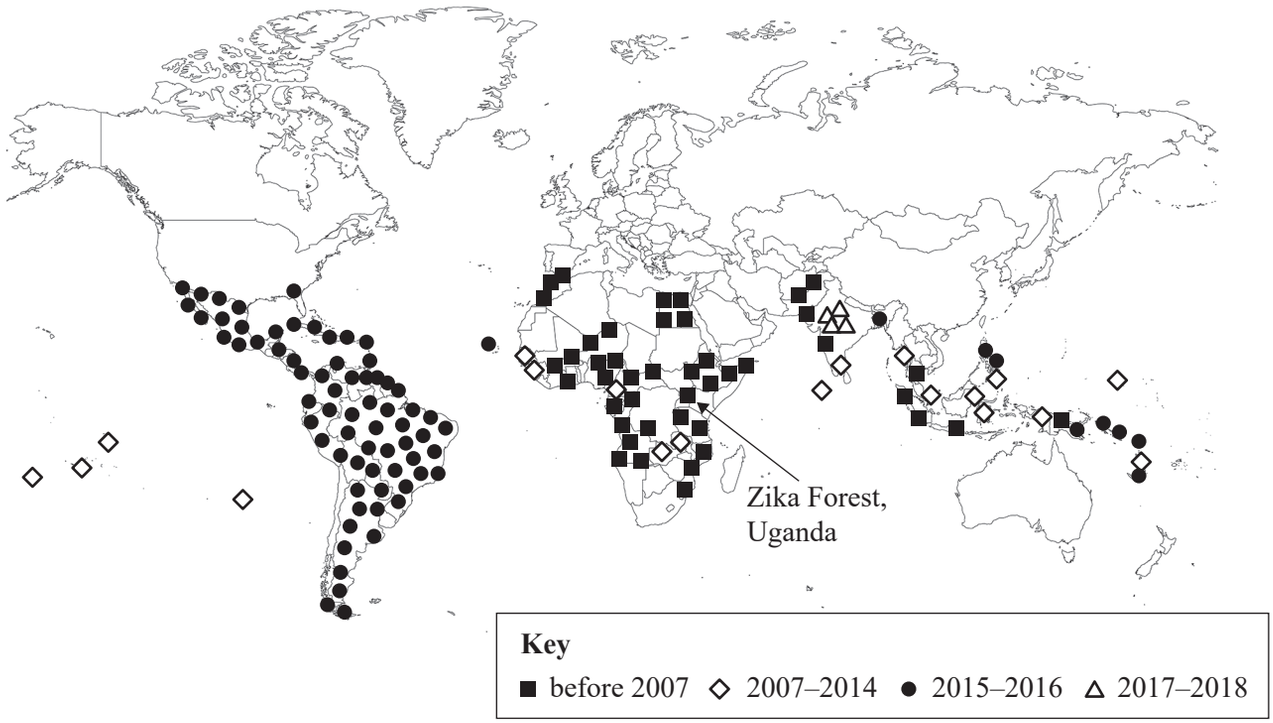
C. Free genetic testing to identify individuals who are at risk is not provided.

D. There was a failure to use antiviral medication to treat individuals quickly.

Use the following information to answer Questions 33 and 34.

Zika virus is an emerging infectious disease that was first identified in Uganda in 1947. The virus is mainly transmitted when mosquitoes bite an infected person. The mosquitoes then go on to bite other people, infecting them. Most infected people develop no symptoms. Those that do generally have mild symptoms including a rash, fever, and muscle and joint pain that usually lasts two to seven days. There is currently no treatment or vaccination available.

The map below shows the geographical distribution of Zika virus cases during various outbreaks between 1947 and 2018.



Source: V Sharma, M Sharma, D Dhull, Y Sharma, S Kaushik and S Kaushik, 'Zika virus: an emerging challenge to public health worldwide', *Canadian Journal of Microbiology*, vol 66, No 2, <https://cdnsciencepub.com/doi/10.1139/cjm-2019-0331>

Question 33

The World Health Organization declared that the outbreak of Zika virus in 2015 and 2016 was an epidemic rather than a pandemic because

A. the cases were confined to specific geographic regions.

B. no vaccination was available for the pathogen.

C. cases were confirmed in different countries.

D. people of all ages were affected.

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Question 34

Which one of the following measures would be least effective in controlling the spread of Zika virus?

A. using television and radio advertisements to educate people on how Zika virus spreads

B. providing free face masks and encouraging people to wear them in public

C. quarantining infected individuals inside their homes

D. wearing clothing that covers arms and legs

Question 35

Students designed a controlled experiment. After they had performed the experiment, another group of students gave them feedback suggesting that they should modify the experiment to improve the accuracy of their results.

A change that the first group of students could make to improve the accuracy of their results could include

A. ignoring outlying results.

B. repeating the experiment many times.

C. carefully calibrating the equipment used.

D. having many people take the measurements.

Question 36

An evolutionary biologist used several methods to construct a phylogenetic tree for a group of mammals.

Which one of these methods would have been least useful?

A. amino acid sequences

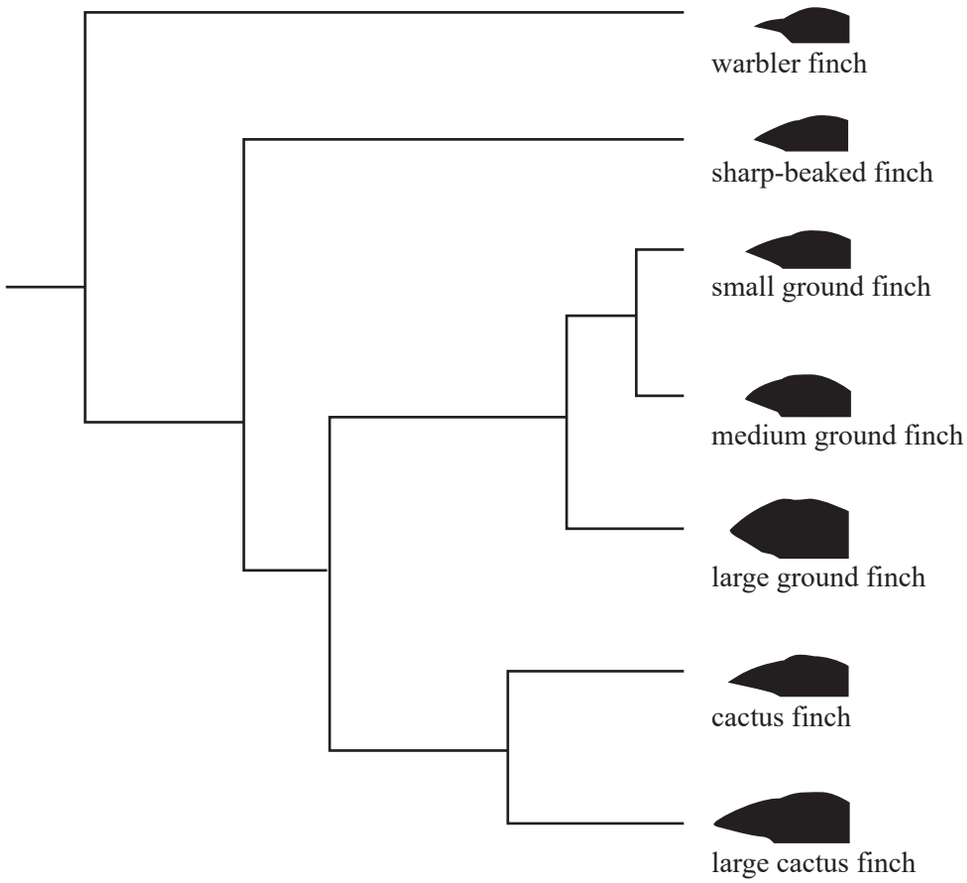
B. protein sequences

C. bone structure

D. presence of hair

Question 37

The phylogenetic tree below shows the evolutionary relationship between several species of finches.



Source: adapted from WJ Cromie, 'How Darwin's finches got their beaks', *The Harvard Gazette*, 24 July 2006, <https://news.harvard.edu/gazette/story/2006/07/how-darwins-finches-got-their-beaks>

Which pair of finches has the most recent common ancestor?

A. large cactus finch and cactus finch

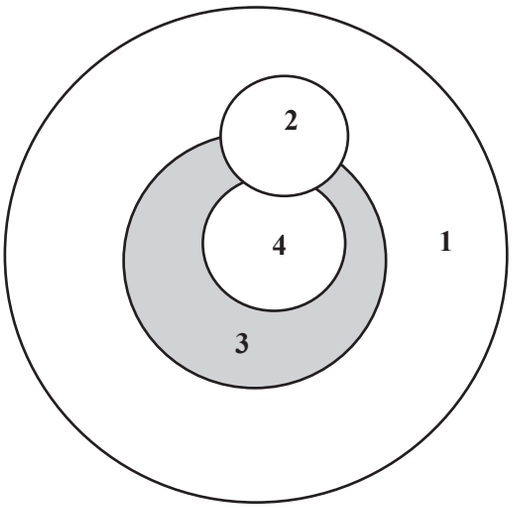
B. sharp-beaked finch and warbler finch

C. large ground finch and medium ground finch

D. small ground finch and medium ground finch

Question 38

Students constructed a diagram to illustrate the relationships between hominins and other groups. They produced the following diagram.



Which one of the following options correctly represents each group?

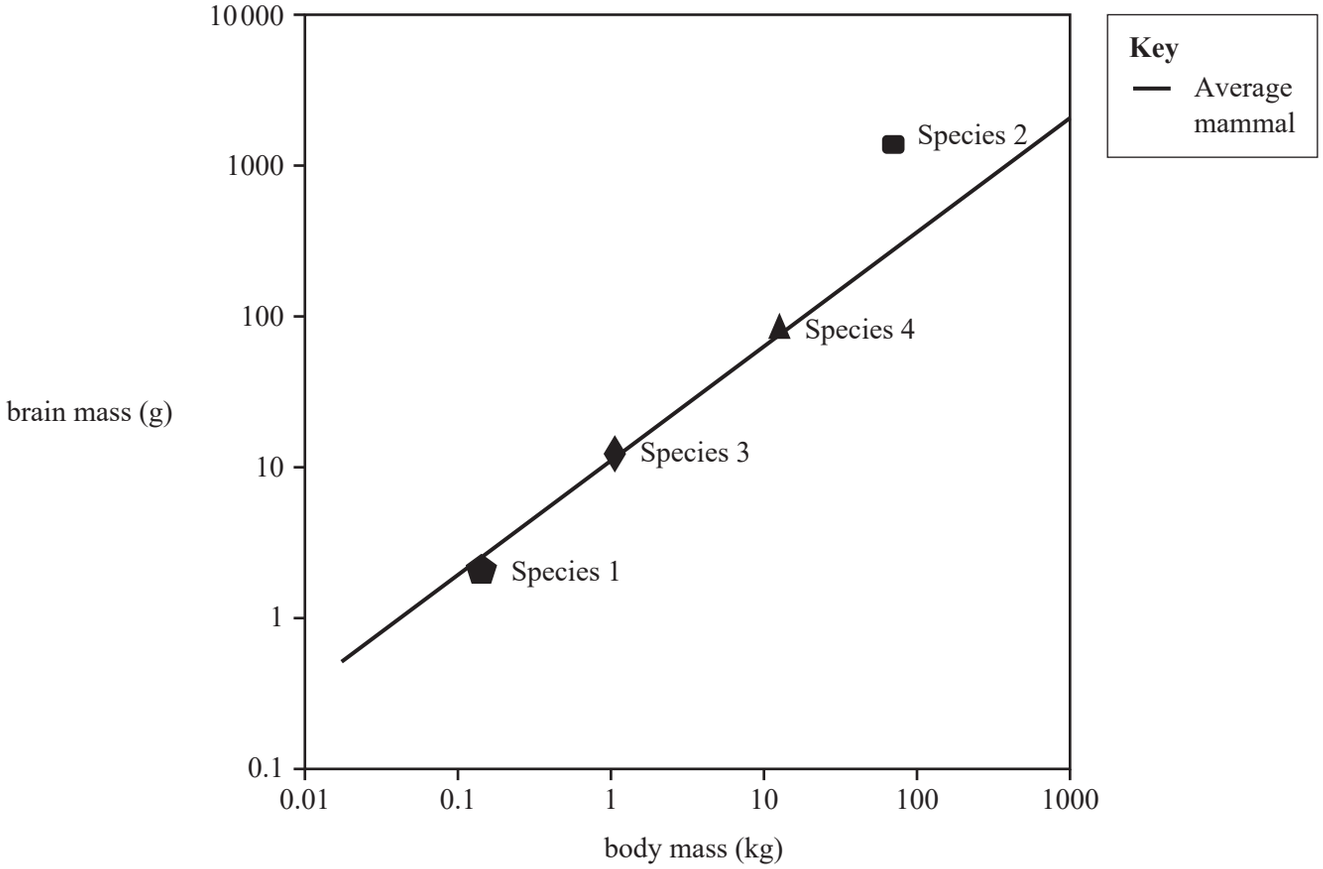
	Circle 1	Circle 2	Circle 3	Circle 4
A.	mammals	primates	hominoids	hominins
B.	mammals	primates	hominins	hominoids
C.	primates	hominins	hominoids	mammals
D.	hominins	hominoids	primates	mammals

Question 39

Scientists investigated the relationship between body mass and brain mass in primate species.

The graph below shows the data for several primate species including *Homo sapiens*.

Both the body mass (kg) and brain mass (g) of each species have been plotted using a logarithmic scale.



Source: adapted from P Schoenemann (2008), 'Evolution of the Size and Functional Areas of the Human Brain', *Annual Review of Anthropology* 35(1), <https://www.researchgate.net/publication/228173421>

Based on the information in the above graph, which species is most likely to represent *Homo sapiens*?

A. Species 1

B. Species 2

C. Species 3

D. Species 4

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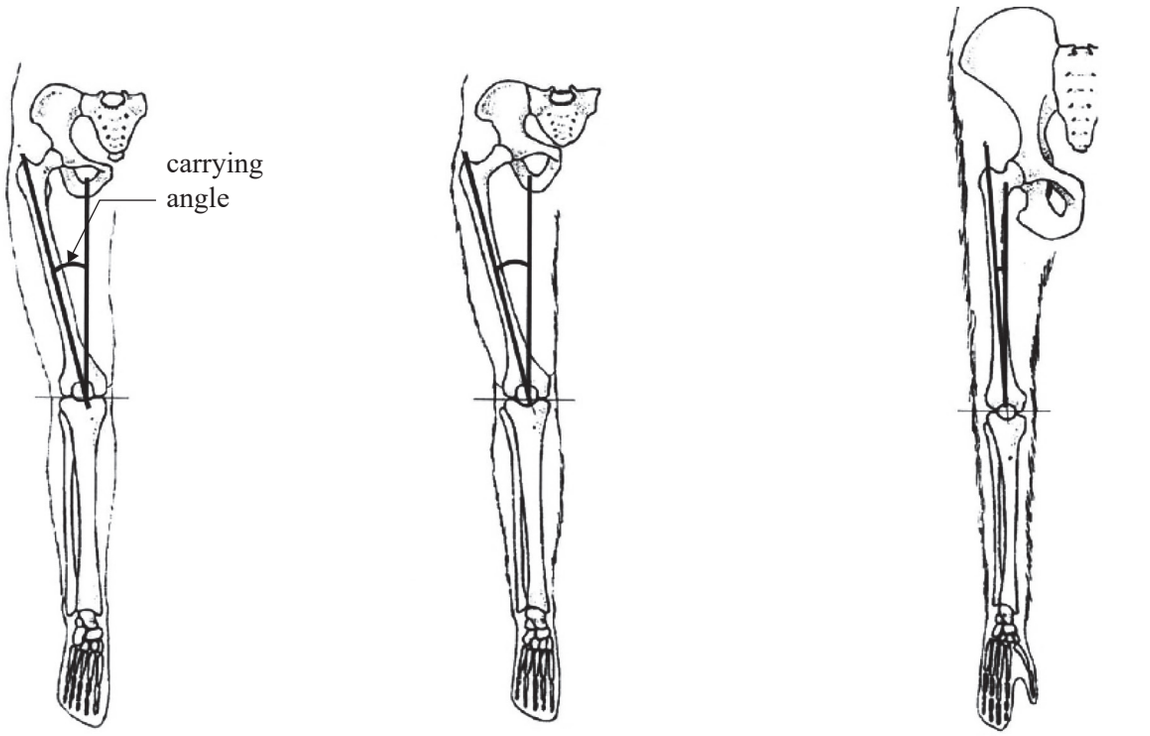
Question 40

The diagram below shows the position of the pelvis and leg bones of *Homo sapiens*, *Australopithecines* and chimpanzees (*Pan troglodytes*). The carrying angle for each is shown.



Homo sapiens *Australopithecines* *Pan troglodytes*

Source: adapted from S Shefelbine, C Tardieu and D Carter, *Bone*, 2002, vol. 30

Which one of the following statements is correct?

A. *Homo sapiens* have the smallest carrying angle of the skeletons shown.

B. The carrying angle in *Australopithecines* allows their centre of gravity to be shifted forward.

C. The carrying angle of the *Pan troglodytes* suggests that, of the three species, it is the best suited to bipedalism.

D. The large carrying angle of *Australopithecines* supports bipedalism.

END OF SECTION A
TURN OVER

SECTION B

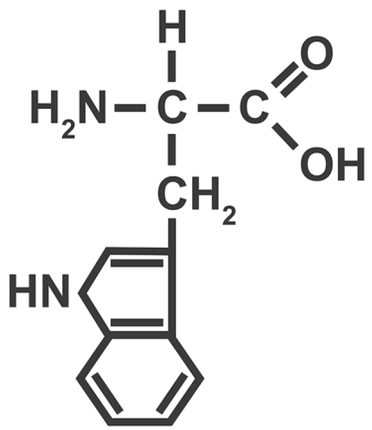
Instructions for Section B

Answer **all** questions in the spaces provided.

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

Question 1 (8 marks)

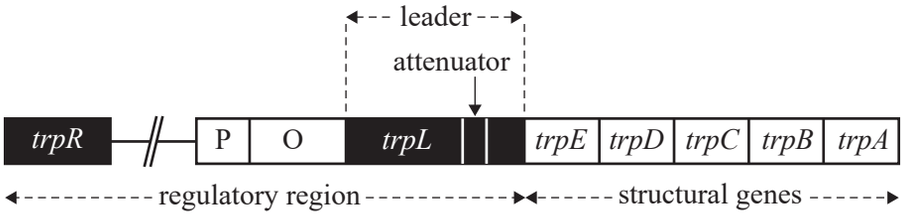
The diagram below shows the structure of tryptophan.



Source: Ali DM/Shutterstock.com

a. To what group of biological monomers does tryptophan belong? Use information in the diagram to justify your response. 2 marks

b. The synthesis of tryptophan in prokaryotic cells such as *Escherichia coli* is regulated. The positions of both the regulatory region and the structural genes are shown in the diagram below.



Source: adapted from Trpoperon, <https://en.wikipedia.org/wiki/File:Trpoperon.svg licensed CC-BY SA 3.0>, licensed CC-BY-SA 3.0 [https://creativecommons.org/licenses/by-sa/3.0/deed.en]

E. coli has two mechanisms that regulate the expression of the structural genes for the synthesis of tryptophan: repression and attenuation.

Compare the two mechanisms of regulation. Refer to the diagram in your answer. 6 marks

Question 2 (7 marks)

A student found an unusual plant species growing in the local park. Without knowing what type of plants they were, the student undertook experiments to identify the photosynthetic output of the plants as measured by the rate of starch formed per day. Plants of the same size were exposed to different environmental conditions, and the rate of starch formed per day was measured. The results are shown in the table below.

Effect of different environmental conditions on starch production per day

Temperature (°C)	Light source	Carbon dioxide (%)	Relative humidity (%)	Rate of starch formed (mg/day)
20	white	5	70	1.5
20	white	1	70	1.2
20	white	5	30	1.8
20	green	5	30	0.3
20	blue	5	30	1.4
40	white	5	70	2.8
40	white	1	70	2.4
40	white	5	30	3.0
40	green	5	30	0.4
40	blue	5	30	2.7

a. To which plant group (C3, C4 or CAM) would this unusual plant species most likely belong? Justify your answer. 3 marks

DO NOT WRITE IN THIS AREA

b. Why does exposing the plants to green or blue light as opposed to white light affect the formation of starch? Justify your answer. 4 marks

Question 3 (10 marks)

Streptococcus pyogenes is a pathogenic bacterium that can cause a range of diseases including a sore throat. People infected by *S. pyogenes* produce specific antibodies against the bacterium that normally enable them to recover after several days.

a. Describe the functions of these specific antibodies during an *S. pyogenes* infection and how this leads to recovery. 3 marks

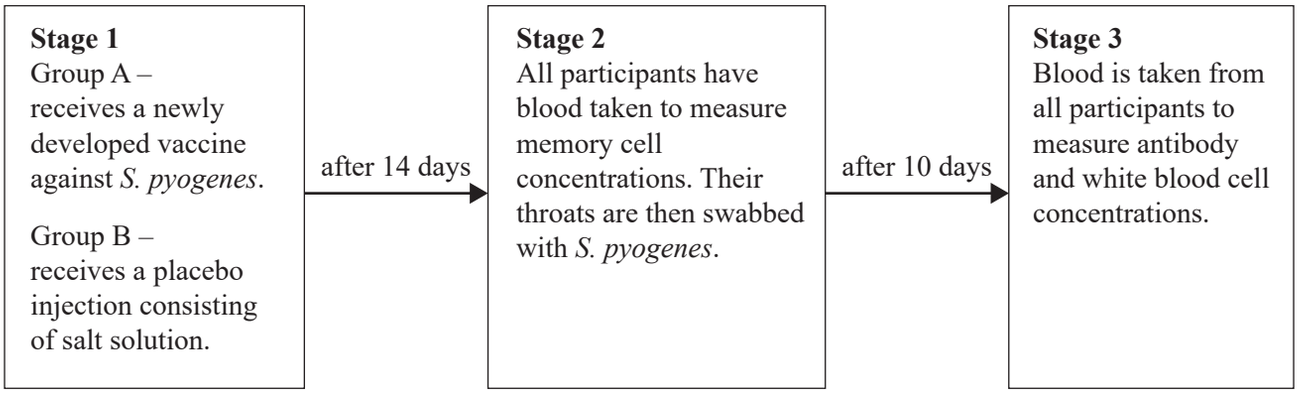
In 2021, researchers from Melbourne's Nucleus Network were involved in the early stages of developing a vaccine against *S. pyogenes.* Part of their investigation involved determining the bacterial concentration needed to cause a sore throat in at least 60% of people whose throats were deliberately infected with *S. pyogenes.*

b. Some scientists suggest that this study may have violated a principle of bioethics. Suggest which principle this may be and explain why. 2 marks

Principle violated:

Explanation:

In a follow-up study, the participants were divided into two groups (A and B) of equal size and put through a three-stage trial, as shown below.



Participants also indicated whether they suffered from a sore throat at any point during the study.
The data in the table below shows the results from four participants at the end of the study.

	Participant			
	1	**2**	**3**	**4**
Sore throat during study?	yes	no	no	yes
Blood memory cell concentration at stage 2	low	high	medium	high
Blood memory cell concentration at stage 3	medium	high	high	high
Blood antibody concentration at stage 3	medium	high	high	high
Blood cytotoxic T cell concentration at stage 3	low	low	low	high

c. Explain which participant is the most likely to have received the placebo injection. 3 marks

d. Another example of a pathogenic bacteria is *Mycobacterium tuberculosis.* This bacterium causes the disease tuberculosis (TB). Some strains of this bacterium have become resistant to many of the common drugs used in the treatment of TB.

Outline **two** ongoing challenges for treatment strategies as a result of this resistance. 2 marks

Question 4 (6 marks)

In most mammalian cells the ATP produced from the complete breakdown of glucose occurs by a series of chemical reactions. Coenzymes also play an important role in glucose metabolism.

a. Describe the roles of coenzymes in the formation of ATP. 3 marks

A student measured the effect of oxygen on the metabolism of glucose in red blood cells at 37 °C and observed the results shown in the table below.

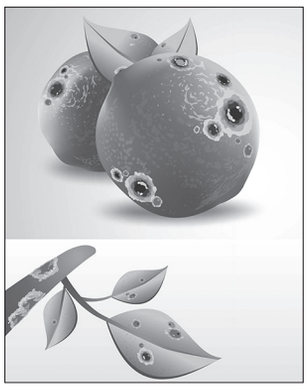
Effect of oxygen availability on the metabolism of glucose by red blood cells

Oxygen	Glucose consumed (nmoles/10^7 cells/hour)	Lactate produced (nmoles/10^7 cells/hour)
absent	1.6	3.2
present	1.6	3.2

b. Why are the results the same irrespective of the presence of oxygen? Explain your answer. 3 marks

Question 5 (6 marks)

Citrus canker is a disease that affects citrus plants such as lime and orange trees, reducing fruit yield and quality by causing the development of dark spots on the fruit and leaves. It is caused by several different bacteria species, including *Xanthomonas axonopodis.* There have been several outbreaks in Australia.



Source: adapted from kaew409/Shutterstock.com

Scientists have recently tried to use CRISPR-Cas9 technology to inactivate genes involved in the citrus canker pathway. This pathway for citrus canker disease is summarised below:

Xanthomonas axonopodis bacteria enter a citrus plant.

↓

CsWRKY22 gene in citrus plant cells is activated by the bacteria.

↓

CsWRKY22 gene is transcribed producing CsWRKY22 protein.

↓

CsWRKY22 protein then binds to *CsLOB1* gene.

↓

Transcription of *CsLOB1* gene produces proteins that result in citrus canker development.

a. Using the information in the flow chart above, explain how CRISPR-Cas9 technology could be used to produce citrus-canker-resistant plants. 4 marks

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During outbreaks of citrus canker, the infected trees and fruit are removed and burned. Recently it has been proposed that instead of being burned, the trees could be used to produce biofuel.

The first stage in the production of biofuel from infected trees could involve a technique known as **steam explosion**. This involves using very hot steam at high pressures inside a pressure chamber to break open the cells from the trees.

An investigation was conducted to determine the relationship between temperature and the percentage of cells broken open during the steam explosion technique. The results are shown below.

Temperature inside pressure chamber (°C)	Percentage of cells broken open
20	36
80	47
150	57
200	85
250	94

b. Scientists decided to use the steam explosion technique at 250 °C. The temperature was then lowered to 35 °C and yeast was added to the ruptured cell mixture.

Why did the scientists decide to do each of the following?

i. Use 250 °C 1 mark

ii. Lower to 35 °C and add yeast 1 mark

Question 6 (11 marks)

Diabetes can be an autoimmune condition where the body is activated to destroy the beta cells in the pancreas that produce insulin. Human insulin is a polypeptide hormone. Insulin consists of two polypeptide chains, chain A (21 amino acids) and chain B (30 amino acids), connected by two disulfide bridges. Human insulin can be made using recombinant plasmids.

a. Outline how human insulin is made using recombinant plasmids. 5 marks

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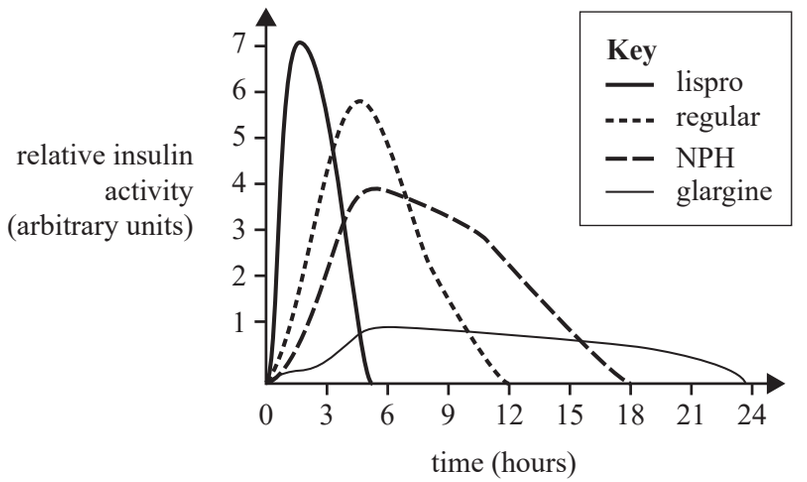
There are different types of insulin available for use. The activity profile of each of these insulins is shown in the graph below.

Activity profiles of different types of insulin



Source: adapted from 'Types of Insulin', Diabetes Education Online, <https://dtc.ucsf.edu/types-of-diabetes/type2/treatment-of-type-2-diabetes/medications-and-therapies/type-2-insulin-rx/types-of-insulin/>, Copyright © 2009 The Regents of the University of California, all rights reserved, www.deo.ucsf.edu

b. Identify which type of insulin is rapid acting compared to regular insulin. Use data from the graph to justify your response. 3 marks

Insulin contains 2 polypeptide chains.

c. **i.** What hierarchical level of organisation is insulin? 1 mark

Scientists alter the primary structure of insulin to create different types of insulin.

ii. What should scientists consider when altering the primary structure of insulin? Justify your response. 2 marks

Question 7 (8 marks)

The helmeted honeyeater (*Lichenostomus melanops cassidix*) can be found in forest to the east of Melbourne. There are only three small wild populations. The bird has been listed as critically endangered.

a. Explain how the genetic diversity of helmeted honeyeaters may change over time as a result of genetic drift. 3 marks

b. Since 1989, Zoos Victoria has run a captive-breeding program for the helmeted honeyeater. More than 250 helmeted honeyeaters have been released into the wild and the total number of birds in the wild has tripled since 1989. Each year, eggs are swapped between the wild populations and the captive-bred population.

How is genetic diversity within the wild populations being maintained? 2 marks

c. Define a consequence-based approach to bioethics and outline how this relates to the work by Zoos Victoria to prevent extinction of the helmeted honeyeater. 3 marks

Question 8 (4 marks)

Neanderthals and early *Homo sapiens* share a common ancestor that originated in Africa. By the time modern humans left Africa around 300 000 years ago, Neanderthals had been living in Europe and Asia for approximately 100 000 years.

Early genetic studies identified around 0.02% of Neanderthal DNA in genomes of modern Africans. New research has identified that those with African ancestry have closer to 0.5% Neanderthal DNA. The same study found that Neanderthal DNA contributed 1.7% to European genomes and 1.8% in Asian genomes.

a. Suggest **two** possible ways in which people with African ancestry could have some Neanderthal DNA in their genomes. 2 marks

b. Suggest why it is reasonable that modern Europeans and Asians show greater percentages of Neanderthal DNA than people who originated in Africa. 2 marks

Question 9 (5 marks)

Scientists recorded flowering information for two *Howea* palm species found on Lord Howe Island. The information recorded is presented in the following table.

Palm species	Flowering frequency each week over 13 weeks												
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
male *H. forsteriana*	0.16	0.25	0.27	0.16	0.05	0.02	0.01	0.01	0.01	0	0	0	0
female *H. forsteriana*	0.04	0.06	0.15	0.25	0.26	0.15	0.03	0	0	0	0	0	0
male *H. belmoreana*	0	0	0	0	0.03	0.04	0.05	0.17	0.25	0.17	0.14	0.1	0.02
female *H. belmoreana*	0	0	0	0	0.01	0.04	0.15	0.16	0.21	0.14	0.16	0.11	0.05

Source: adapted from V Savolainen, MC Anstett, C Lexer, I Hutton, J Clarkson, M Norup, M Powell, D Springate, N Salamin, & W Baker, *Nature*, 2006, <https://www.researchgate.net/publication/7306249>

a. Using the information in the table, identify **two** factors that may have contributed to speciation in these two palms. 2 marks

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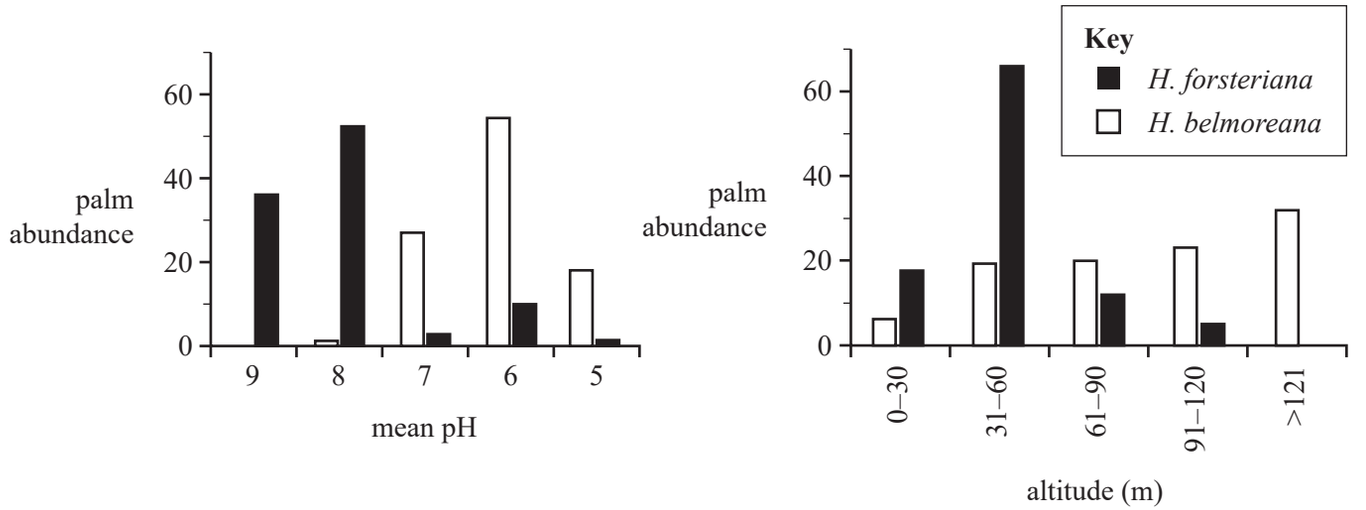
Scientists also recorded the pH of the soil in which the palm species were growing and the altitude where the plants could be found.



Source: adapted from V Savolainen, MC Anstett, C Lexer, I Hutton, J Clarkson, M Norup, M Powell, D Springate, N Salamin, & W Baker, *Nature*, 2006, <https://www.researchgate.net/publication/7306249>

b. **i.** Referring to the graphs above, complete the table below, listing the most ideal environment for *H. forsteriana* and *H. belmoreana.*

1 mark

	pH	Altitude range (m)
H. forsteriana		
H. belmoreana		

ii. Evidence suggests that a common ancestor of the two palm species colonised acidic (pH below 7) volcanic soils on the island around 6 million years ago. Much more recently (2 million to 500 000 years ago), *H. forsteriana* diverged from the common ancestor.

Explain how these differences between pH and altitude could have led to speciation. 2 marks

Question 10 (8 marks)

The platypus (*Ornithorhynchus anatinus*) is a semi-aquatic animal, historically present in rivers throughout Victoria.

Source: John Carnemolla/Shutterstock.com

Platypuses usually occur in areas that have stable banks for burrowing, invertebrates for food, and reliable water flows. The platypus is potentially vulnerable to a range of natural and human-induced threats that degrade aquatic ecosystems, including drought, predators, habitat destruction, poor water quality and altered river flows. The Victorian Government listed the platypus as vulnerable in 2021.

Source: metha1819/Shutterstock.com

An innovative detection technique using environmental DNA (eDNA) allowed scientists to develop a detailed map of platypus populations across the state. eDNA is comprised of traces of DNA that wildlife shed into their environment. Volunteers were provided with water-sampling kits and collected water samples from over 1500 selected sampling sites on Victorian rivers.

At each sampling site, six water samples were collected and tested in the laboratory using the Polymerase Chain Reaction (PCR) method. The PCR results were analysed using a platypus-specific DNA probe. At least two positive PCR results (out of six water samples) were required to classify the site as positive for the presence of platypus DNA.

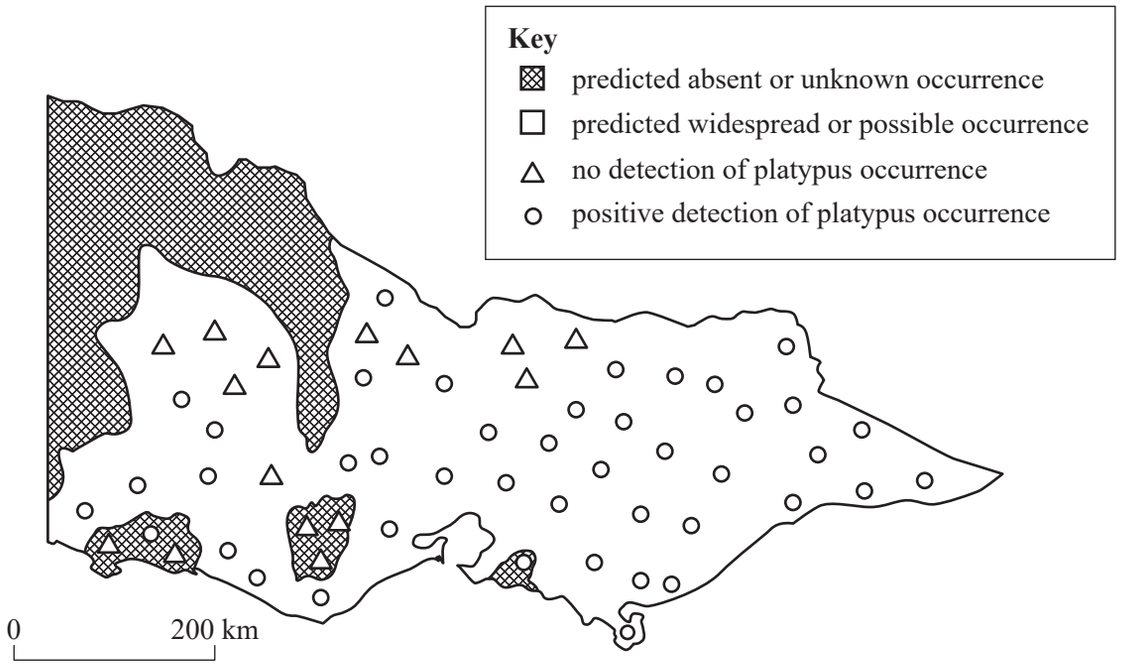
a. Give **two** examples of possible sources of eDNA from the platypus. 2 marks

b. Explain **two** factors to consider when sampling the water to reduce sources of error. 2 marks

c. State why PCR was used in the test of the water samples. 2 marks

Prior to the project, state-wide data on the occurrence of platypuses across Victorian rivers was collated. Refer to the shading on the map below for **predicted** platypus occurrences.

The project detected platypuses at 19–25% of sampled Victorian rivers. Refer to the icons on the map below for the **results** from eDNA surveys for detection of platypus occurrence at a range of sampling sites.



Source: adapted from 'eDNA tells story of platypus distribution throughout Victoria', *EnviroDNA*, <https://www.envirodna.com/news/edna-tells-story-of-platypus-distribution-throughout-victoria>

d. Referring to the map above, describe **one** difference between predicted platypus occurrence and detection of platypus occurrence from the eDNA survey results. Justify your response. 2 marks

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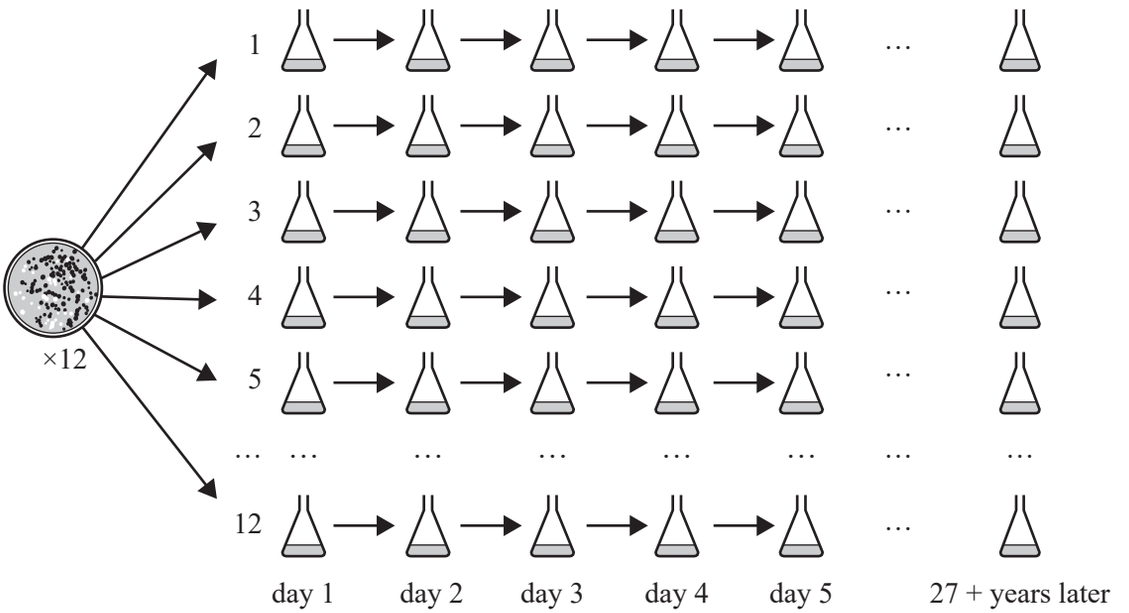
Question 11 (7 marks)

In 1988 a scientist called Richard Lenski and his group used a single ancestral genome of *Escherichia coli* to put 12 genetically identical populations in 12 identical environments. Each environment consisted of a flask filled with 10 mL of bacterial growth medium, a nutrient broth containing glucose and citrate. Citrate is a potential food source that *E. coli* cannot use.

The group was interested in observing the evolution of diversification and adaptation as they happened in the laboratory.

The method of their experiment involves a simple serial transfer protocol: As the populations grow over the course of every 24 hours, they use up the resources in their flasks, so every day a 0.1 mL sample of each population is transferred to a flask of 9.9 mL of fresh growth medium and thus allowed to keep reproducing. The method is shown in the diagram below.



Source: E Parke, 'Experiments, Simulations, and Lessons from Experimental Evolution', *Publicly Accessible Penn Dissertations*, 1114, 2015, <https://repository.upenn.edu/edissertations/1114>

The experiment had been running for 27 years at the time the results were shown. This was equivalent to 65 000 generations of bacteria. A generation is the time between when an organism is formed and when it reproduces.

a. State **two** factors that were controlled in this experiment. 2 marks

b. At about 30 000 generations, a mutation was seen that allowed the mutant bacteria to use citrate as an energy source.

What effect would you expect this mutation to have on subsequent generations of this group of bacteria and why? 2 marks

c. Assume that you are a scientist looking to further this research and you have access to the bacteria from a generation after 30 000.

Describe how you would conduct an experiment to investigate the effect of different glucose concentrations on the frequency of the mutant citrate phenotype. 3 marks

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Extra space for responses

Clearly number all responses in this space.

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