

Victorian Certificate of Education
2020

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Letter

BIOLOGY
Written examination

Friday 13 November 2020

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**

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

- Students are permitted to bring 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 38 pages
- Answer sheet for multiple-choice questions

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.

Use the following information to answer Questions 1–3.

The following diagrams (1, 2, 3 and 4) illustrate different ways that substances move into or out of a cell. W, X, Y and Z represent structures in the plasma membrane. The concentration of a substance is shown by the number of particles inside and outside the cell. An arrow shows the direction of movement of the substance. The properties of each substance are listed in the table below.

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this material is not supplied.

Source: adapted from LA Urry et al., *Campbell Biology*, 11th edition, Pearson Australia, Melbourne, 2018, p. 140

Symbol for substance	◆	•	△
Properties of each substance	hydrophilic	hydrophobic	hydrophilic
	small	small	large
	non-polar	non-polar	polar
	charged	uncharged	uncharged

Question 1

Structure W represents a

- A. phospholipid bilayer.
- B. channel protein.
- C. carrier protein.
- D. glycoprotein.

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Question 2

It is reasonable to state that

- A. diagram 1 could represent carbon dioxide exiting a leaf cell during photosynthesis.
- B. diagram 2 could show facilitated diffusion of urea out of an active muscle cell.
- C. diagram 3 could represent pumping potassium ions into a cell.
- D. diagram 4 could represent oxygen diffusing into a blood cell.

Question 3

Consider the fluid mosaic model of the plasma membrane.

It is correct to state that

- A. structure W changes shape to actively transport substances.
- B. multiples of structure X move during endocytosis.
- C. structure Y transports lipid-based hormones.
- D. structure Z is the most abundant membrane molecule.

Question 4

A group of Biology students set up an experiment with three test tubes. Each test tube contained the same enzyme and was kept under the same experimental conditions. All concentrations and volumes of substrate and enzyme placed in the test tubes were kept the same. The following diagram shows the initial contents of each test tube and the final contents of test tubes 1 and 2.

Initial contents of each test tube					Final contents of each test tube			
Test tube 1		+	Substrate A	→		+	product	
	enzyme				enzyme			
Test tube 2		+	Substrate B	→		+	Substrate B	
	enzyme				enzyme			
Test tube 3		+	Substrate A + Substrate B	→	?			
	enzyme							

Source: adapted from Chemistry LibreTexts,
<<https://chem.libretexts.org>>

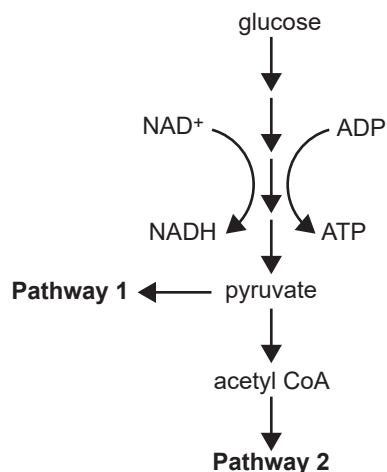
An enzyme-substrate complex was formed in each of the three test tubes.

When compared to the final contents of Test tube 1, the concentration of product contained in the final contents of Test tube 3 will

- A. be the same because both Substrate A and Substrate B are able to bind to the enzyme at the same time.
- B. increase because Substrate A is a substrate that can bind to the enzyme's active site.
- C. decrease due to competitive reversible inhibition by Substrate B.
- D. be zero due to the presence of an irreversible inhibitor.

Use the following information to answer Questions 5 and 6.

Shown below is a simplified diagram summarising a series of biochemical processes in a plant cell.



Source: adapted from MG Stovell et al., 'Assessing metabolism and injury in acute human traumatic brain injury with magnetic resonance spectroscopy: Current and future applications', *Frontiers in Neurology*, 12 September 2017, <<https://doi.org/10.3389/fneur.2017.00426>>

Question 5

Which one of the following is a correct statement?

- A. Pathway 2 releases oxygen as a by-product.
- B. Pathway 1 requires carbon dioxide as an input.
- C. ATP is produced in Pathway 1 and is used by the cell as an energy source.
- D. NADH created in Pathway 2 carries electrons into the electron transport chain.

Question 6

The final products of Pathway 1 are produced in the

- A. cristae.
- B. cytosol.
- C. mitochondrial matrix.
- D. chloroplast membranes.

Question 7

The codon table below can be used to determine amino acids coded for by a nucleotide sequence.

1st position (5' end) ↓	2nd position				3rd position (3' end) ↓
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

It is correct to state that

- A. identical amino acid sequences are found in all organisms.
- B. the genetic code is degenerate with respect to Met.
- C. the codon GGU adds Trp to a polypeptide chain.
- D. the DNA template sequence GAA codes for Leu.

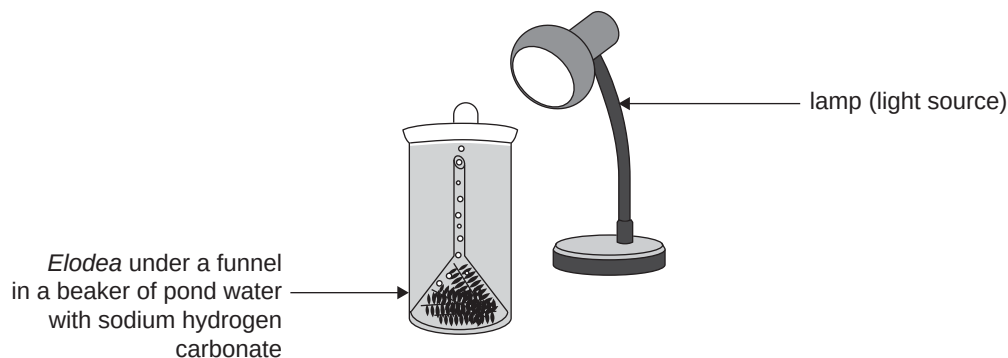
Question 8

The primary structure of a protein is important because it

- A. is the active, functional form of the protein.
- B. has a very specific three-dimensional shape.
- C. influences the way that the polypeptide folds.
- D. directly controls the way proteins are transported into a cell.

Use the following information to answer Questions 9–11.

The apparatus shown below was set up in a Biology laboratory.



Sodium hydrogen carbonate (a source of carbon dioxide) was added to pond water in a beaker. A piece of an aquatic plant called *Elodea* was added and placed under a funnel in the beaker. A lamp was placed 5 cm away from the beaker and switched on. The number of bubbles produced by the *Elodea* was recorded for one minute. The experiment was repeated with the lamp placed 10 cm, 15 cm, 20 cm and 25 cm away from the beaker. The entire experiment was repeated three times and an average result at each distance was calculated.

Question 9

The dependent variable in this experiment is the

- A. amount of sodium hydrogen carbonate added to the beaker.
- B. number of bubbles produced in one minute.
- C. time taken to count the bubbles produced.
- D. distance of the lamp from the beaker.

Question 10

The bubbles produced in this experiment are likely to contain

- A. oxygen.
- B. glucose.
- C. water vapour.
- D. carbon dioxide.

Question 11

Repeating the experiment three times and finding an average result at each distance increases the

- A. reliability of the data.
- B. accuracy of the data.
- C. precision of the data.
- D. validity of the data.

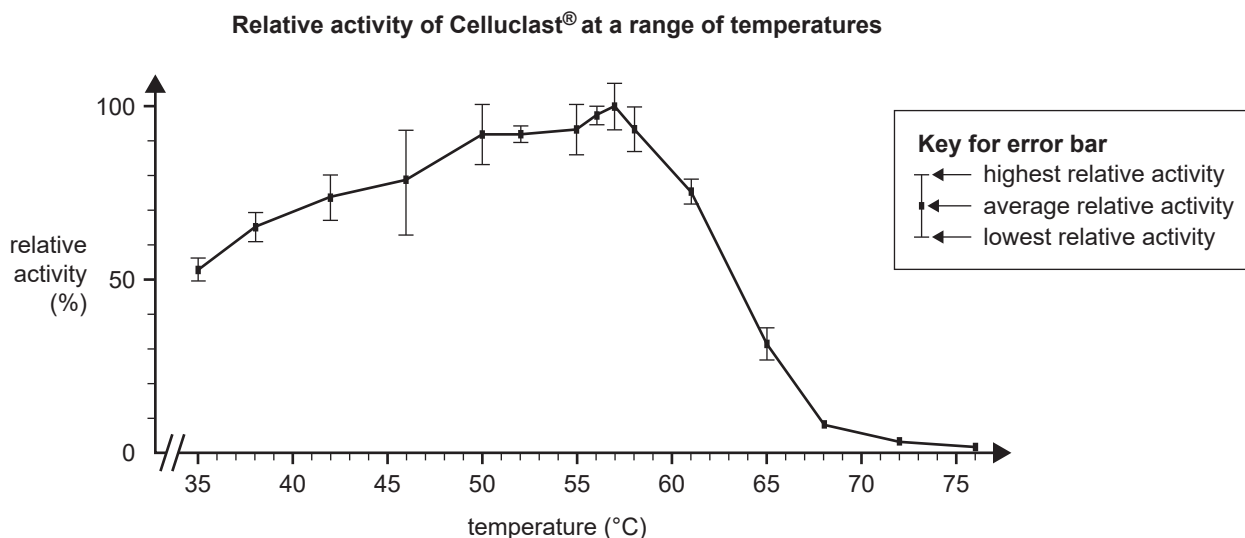
Question 12

During photosynthesis

- A. ATP and NADH created in the light-independent stage are transported to the chloroplasts' thylakoid membranes.
- B. ADP and NADH are used in the electron transport chain after being created in the light-dependent stage.
- C. ATP and NADPH are created in the grana of the chloroplasts and are used in the light-independent stage.
- D. ADP and NADPH are created during the Krebs cycle and carried to the stroma of the chloroplasts.

Use the following information to answer Questions 13 and 14.

Celluclast[®] is an enzyme. The activity of Celluclast[®] at a range of temperatures and at a pH of 5 was measured. The experiment was repeated five times. The relative activity (%) of Celluclast[®] was calculated and plotted on a graph, as shown below. The range of the calculated measurements at each temperature is shown as an error bar on the graph.



Source: J Herlet et al., 'A new method to evaluate temperature vs pH activity profiles for biotechnological relevant enzymes', *Biotechnology for Biofuels*, 10, 234 (2017), <<https://doi.org/10.1186/s13068-017-0923-9>>

Question 13

It is reasonable to conclude that

- A. Celluclast[®] is inactive at 61 °C.
- B. Celluclast[®] is denatured at 35 °C.
- C. the optimum pH for Celluclast[®] is pH 5.
- D. the optimum temperature for Celluclast[®] is around 57 °C.

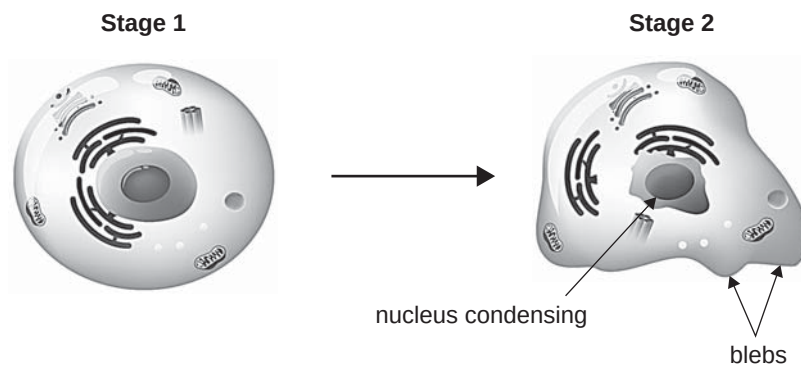
Question 14

The error bars on the graph indicate that the measurements taken at

- A. 38 °C were more valid than at 35 °C.
- B. 52 °C were more precise than at 46 °C.
- C. 46 °C were more accurate than at 55 °C.
- D. 58 °C had more random errors than at 42 °C.

Use the following information to answer Questions 15–17.

The diagram below illustrates two of the early stages of apoptosis in a human cell.



Source: Designua/Shutterstock.com

Question 15

The human cell will begin apoptosis when

- A. a toxin is released from the cell.
- B. an increase in the number of cells is required.
- C. the cell has been irreversibly damaged by very low temperatures.
- D. a signalling molecule attaches to a death receptor on the plasma membrane of the cell.

Question 16

Consider the change in appearance of the human cell that occurs from Stage 1 to Stage 2.

The change in appearance can be explained by

- A. inflammation in the area surrounding the cell.
- B. increased activity of caspases within the cell.
- C. the release of histamine from nearby mast cells.
- D. decreased activity of DNA polymerase within the nucleus.

Question 17

After the condensation of the nucleus and the production of many blebs, the human cell will

- A. swell and burst open, and its contents will be released into the surrounding environment.
- B. produce apoptotic bodies that are engulfed by phagocytes.
- C. become larger and be absorbed by adjacent cells.
- D. be completely broken down by lysosomes.

Question 18

Some human cells produce proteins called cytokines.

A major function of cytokines is

- A. signalling immune cells in inflammatory responses.
- B. stimulating B cells to directly attack virally infected cells.
- C. diffusing across a synaptic gap to stimulate the adjacent cell.
- D. communicating very rapidly with a cell that is distant from the cytokine-producing cell.

Question 19

The role of T helper cells is to

- A. destroy cells that are infected with bacteria.
- B. control the adaptive immune response.
- C. generate antibodies.
- D. engulf parasites.

Question 20

Which one of the following describes a feature common to both T cells and B cells?

- A. having immunological memory
- B. rapidly responding to pathogens on first exposure
- C. providing a physical barrier to the entry of pathogens
- D. being able to attach to both microorganisms and viruses

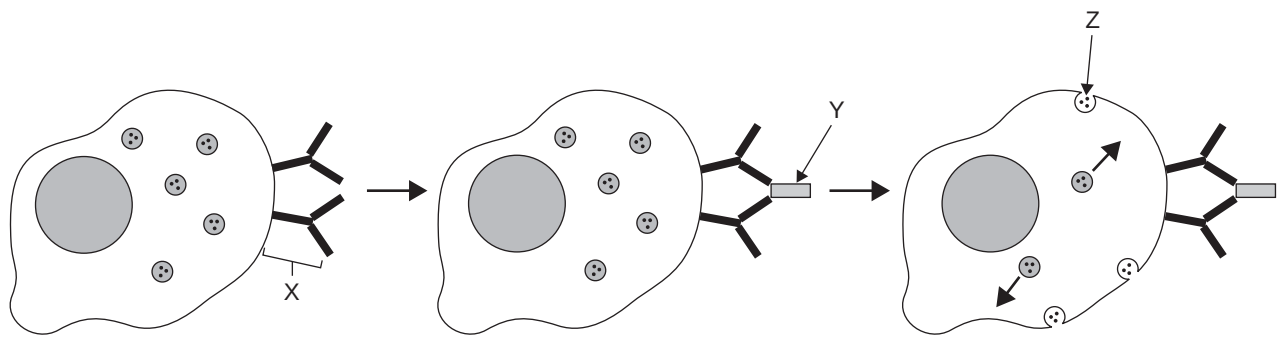
Question 21

The property of the immune system that enables it to fight infections and destroy cancer cells is the

- A. ability to kill all invading organisms.
- B. ability to adapt to donor tissue, facilitating transplants.
- C. ability to distinguish self from non-self biological molecules.
- D. generation of complement proteins and other chemical barriers.

Use the following information to answer Questions 22–24.

The diagram below shows an immune cell responding to a substance. This process occurs during certain types of allergic reactions.



Question 22

Which type of immune cell is featured in the diagram above?

- A. mast cell
- B. neutrophil
- C. macrophage
- D. dendritic cell

Question 23

What do the structures X and Y in the diagram above represent?

	X	Y
A.	antibody	allergen
B.	receptor	antibody
C.	glycolipid	G protein
D.	antigen	allergen

Question 24

In the degranulation process shown in the diagram above, an intracellular substance (Z) leaves the cell. Which intracellular substance is released?

- A. caspase
- B. histamine
- C. pheromone
- D. neurotransmitter

Question 25

DOCK8 syndrome is a disorder in which both B cells and T cells are defective. Patients with DOCK8 syndrome face a range of health issues, including repeated bacterial and viral infections, as well as an increased risk of cancer.

DOCK8 syndrome could be classified as

- A. acquired immunity.
- B. an allergic reaction.
- C. an autoimmune disease.
- D. an immune deficiency disease.

Question 26

The *lac* operon in prokaryotes illustrates the switching off and on of genes.

The operator within the *lac* operon

- A. is a regulatory gene.
- B. attaches RNA polymerase.
- C. codes for the production of an enzyme.
- D. is the binding site for the repressor protein.

Question 27

Tasmanian devils (*Sarcophilus harrisii*) were originally broadly distributed across Australia. When sea levels rose 12 000 years ago, an island, now referred to as Tasmania, was formed. The small number of Tasmanian devils on Tasmania was cut off from the Australian mainland populations. The population in Tasmania showed less genetic variation than the mainland populations. Mainland populations became extinct approximately 3000 years ago.

Over the last 20 years, the total Tasmanian devil population on Tasmania has halved. Many of the deaths have been the result of Tasmanian devil facial tumour disease (DFTD). Scientists have taken some Tasmanian devils that do not have DFTD to mainland Australia to set up a conservation program. The scientists have shown that greater genetic diversity among offspring in this program is observed when the Tasmanian devils are kept in isolated male–female pairs rather than in larger groups.

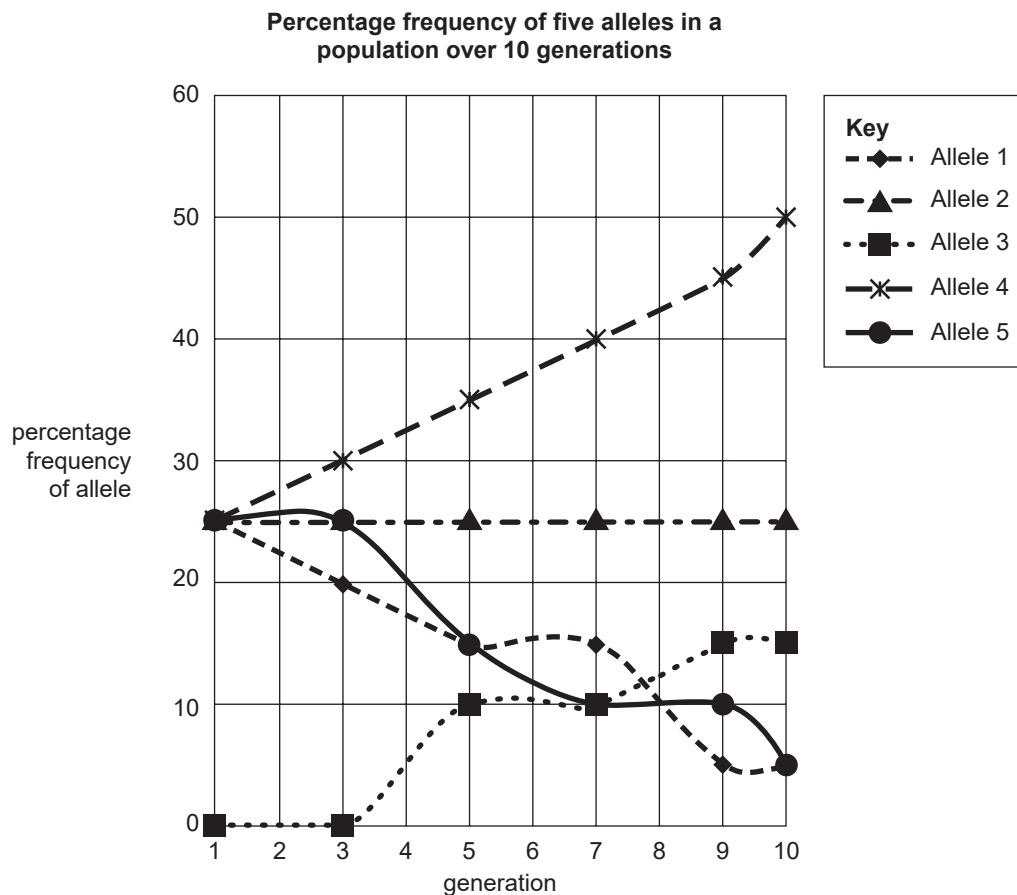
The conservation program for Tasmanian devils is an example of

- A. a population bottleneck.
- B. allopatric speciation.
- C. selective breeding.
- D. natural selection.

Question 28

The graph below shows the frequency of five alleles in a population over 10 generations.

The change in allele frequency is represented as a percentage of the frequency of the five alleles.



Based on the information in the graph, which one of the following is most likely?

- A. The founder effect can explain the change in allele frequency in the first three generations.
- B. Genetic diversity within the population remains unchanged over the 10 generations.
- C. The appearance of Allele 3 after Generation 3 may be explained by gene flow.
- D. A bottleneck event occurred between Generation 7 and Generation 9.

Question 29

A small sample of DNA was obtained from a fossil. Polymerase chain reaction (PCR) was used to amplify the amount of DNA obtained from the sample.

Which one of the following is a correct statement regarding the PCR process?

- A. DNA polymerase catalyses the pairing of primers with complementary nucleotides.
- B. RNA polymerase catalyses the additions of nucleotides to a DNA strand.
- C. Annealing and extension of the DNA occur at different temperatures.
- D. The number of copies of the DNA is quadrupled in each cycle.

Use the following information to answer Questions 30 and 31.

A bacterial plasmid was modified by inserting a gene for an enzyme that provides resistance to the antibiotic ampicillin. A nutrient solution containing cells of the bacterium *Escherichia coli* was obtained. *E. coli* is naturally sensitive to the antibiotic ampicillin. The solution was divided into two equal volumes. The bacteria in one half of the solution were left untreated. Plasmids were added to the other half of the solution and the bacteria were treated to increase their chance of taking up the plasmids.

The next day, the bacterial cells were spread on agar plates as follows:

- Plate 1 – Untreated bacterial cells on nutrient agar
- Plate 2 – Untreated bacterial cells on nutrient agar with ampicillin
- Plate 3 – Treated bacterial cells on nutrient agar with ampicillin
- Plate 4 – Treated bacterial cells on nutrient agar

The plates were incubated overnight.

Question 30

In order to collect only bacterial cells that had taken up the plasmid successfully, a sample should be taken from

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

Question 31

The process in which the bacterial cell takes up the plasmid is called

- A. translation.
- B. transcription.
- C. translocation.
- D. transformation.

Question 32

Target DNA is to be inserted into a plasmid.

For a recombinant plasmid to be produced

- A. the plasmid sections and the target DNA must have blunt ends.
- B. the target DNA must come from the same species as the bacteria.
- C. the plasmid and the target DNA must be cut by a polymerase.
- D. DNA ligase is used to rejoin the sugar-phosphate sections of the plasmid and the target DNA.

Question 33

A student completed an experiment to investigate how light is reflected from different leaves. The results were recorded qualitatively.

Which one of the following could be a correct statement about the qualitative data obtained by the student?

- A. An average result for the data could be obtained.
- B. The same number would be recorded for each result.
- C. The data was obtained by measuring the wavelength of light.
- D. The data could be the names of the different colours of the reflected light.

Question 34

Bovine spongiform encephalopathy (BSE) is a prion disease of cattle. It is sometimes called mad cow disease. It is caused by feeding cattle food that contains prions from other infected animals. The time between infection and symptoms appearing can be up to five years. There are concerns that variant Creutzfeldt-Jakob disease (vCJD) in humans could be caused by eating infected cattle meat.

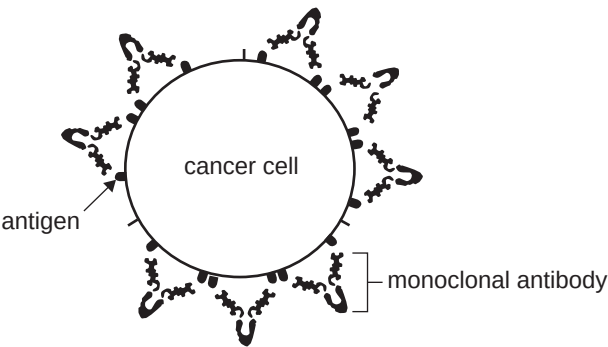
Yellow fever is a viral disease that affects humans. The yellow fever virus can cause symptoms three to six days after infection. The virus is carried by a mosquito vector.

Which combination of approaches would be most effective at controlling the risk of outbreaks of both vCJD and yellow fever?

	vCJD	Yellow fever
A.	Prevent all cattle that show symptoms of mad cow disease from reproducing.	Remove breeding grounds for mosquitoes.
B.	Test all cattle for the presence of the prions.	Ensure that all healthcare professionals wear gloves when working with infected patients.
C.	Destroy all cattle that have been fed infected food containing the prions.	Ensure that people take measures to reduce their chances of being bitten by mosquitoes.
D.	Stop selling cattle meat.	Instruct people who are infected with yellow fever to wear masks in public places.

Question 35

Monoclonal antibodies attaching to antigens on a cancer cell are shown in the diagram below.



Source: adapted from N Halim, ‘Monoclonal antibodies: A 25-year roller coaster ride’, *The Scientist*, 20 February 2000, <www.the-scientist.com>

Monoclonal antibodies

- A. are used to suppress B cells acting on cancer cells.
- B. make it easier for cells of the immune system to detect cancer cells.
- C. can bind to dendritic cells to stimulate them to destroy cancer cells.
- D. can attach to many structurally different proteins found on the surface of cancer cells.

Use the following information to answer Questions 36 and 37.

Rice (*Oryza sativa*) is a staple food for billions of people worldwide, particularly in Asia. Although rice supplies energy, it is low in micronutrients, such as iron and zinc. Australian scientists created a strain of biofortified rice that has been trialled in the Philippines and has been recently introduced to Bangladesh. The table below compares the iron and zinc content of normal white rice to that of biofortified rice in parts per million (ppm).

	Iron (ppm)	Zinc (ppm)
Normal white rice	2–5	16
Biofortified rice	15	46

The biofortified rice was created when two particular genes were inserted into normal rice. The biofortified rice plants responded as if they were iron deficient by permanently ‘switching on’ another gene to take up iron and zinc from the soil. Details of the two inserted genes are given in the table below.

Inserted gene	Protein function	Source of gene
rice nicotianamine synthase (OsNAS2)	assists iron uptake by roots of rice plants	rice plants
soybean ferritin (Sfer-H1)	binds and stores large amounts of iron	soybean plants

Question 36

It is most likely that the main aim of this research and technology is to

- A. use knowledge from the research to develop treatments for human disease.
- B. enhance the flavour of rice to encourage greater rice consumption.
- C. increase the yield of rice crops to provide more food supplies.
- D. improve the nutrition of malnourished people.

Question 37

Which one of the following is the best description for this strain of biofortified rice?

- A. genetically screened
- B. genetically modified and transgenic
- C. genetically transformed by gene silencing
- D. genetically engineered by adding iron and zinc

Use the following information to answer Questions 38 and 39.

Claims have been made about the wound-healing benefits of honey made from the flowers of New Zealand's manuka tree. Scientists investigated the effects of manuka honey on *Staphylococcus aureus*, a bacterium that infects wounds. Cultures of dividing *S. aureus* cells were grown under one of the following three conditions: manuka honey was added or jelly bush honey was added or no honey was added. After some time, estimates of cell numbers were made and proteins in the cells were analysed. The most significant findings of the investigation are summarised in the two tables below.

	Condition applied to <i>S. aureus</i> cells		
	4% manuka honey	4% jelly bush honey	0% honey
<i>S. aureus</i> average time to double cell number	78 min	38 min	33 min

Name of protein	Function of protein	Change in quantity of protein expressed in <i>S. aureus</i> cells compared to 'no honey added' group	
		4% manuka honey	4% jelly bush honey
dihydrolipoamide dehydrogenase (DLD)	involved in glycolysis	decreased to 7% of the original	no change
elongation factor protein (EF-Tu)	involved in protein translation	decreased to 33% of the original	no change
stress-related cold shock protein (CspC)	helps <i>S. aureus</i> adapt to new conditions	increased to 300% of the original	no change

Question 38

It can be concluded from the results of this investigation that manuka honey

- A. promotes the expression of elongation factor protein (EF-Tu).
- B. reduces the ability of *S. aureus* to adapt to changing conditions.
- C. is more effective than jelly bush honey at limiting the growth of *S. aureus*.
- D. heals wounds faster than jelly bush honey and much faster than when no honey is added.

Question 39

The purpose of the jelly bush honey treatment of *S. aureus* in this investigation was to

- A. provide a honey control for the experiment.
- B. develop resistance to manuka honey in *S. aureus*.
- C. test the effect of changing the dependent variable.
- D. allow natural selection in *S. aureus* cultures by changing the environment.

Question 40

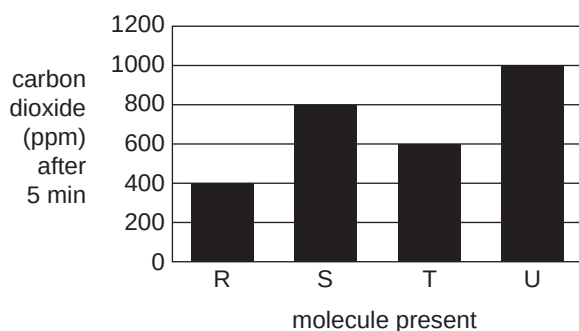
A student investigated the effect of the presence of four different molecules, R, S, T and U, on the rate of cellular respiration in human liver cells. The production of carbon dioxide by the cells was recorded over a five-minute interval. The final concentration of carbon dioxide was recorded. The data collected is shown below.

Molecule present	Concentration of carbon dioxide (ppm) after five minutes
R	400
S	800
T	600
U	1000

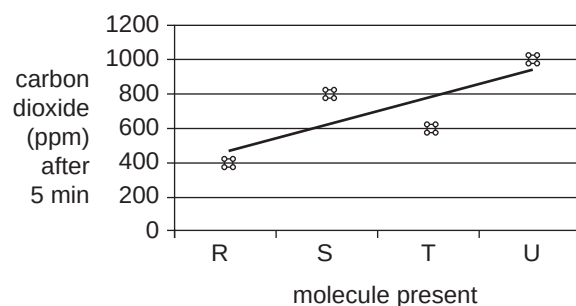
The student presented the results as a graph.

Which one of the following graphs is the best representation of the results?

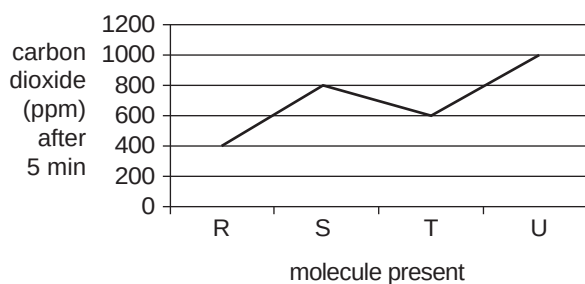
A. Effect of four different molecules on rate of cellular respiration in human liver cells



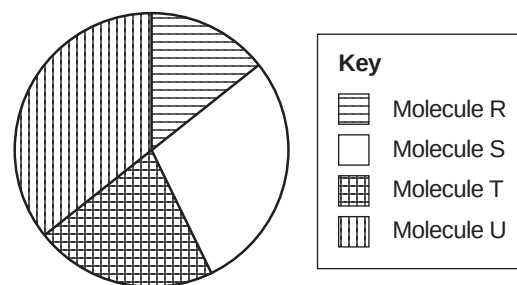
B. Effect of four different molecules on rate of cellular respiration in human liver cells



C. Effect of four different molecules on rate of cellular respiration in human liver cells



D. Effect of four different molecules on rate of cellular respiration in human liver cells



SECTION B**Instructions for Section B**

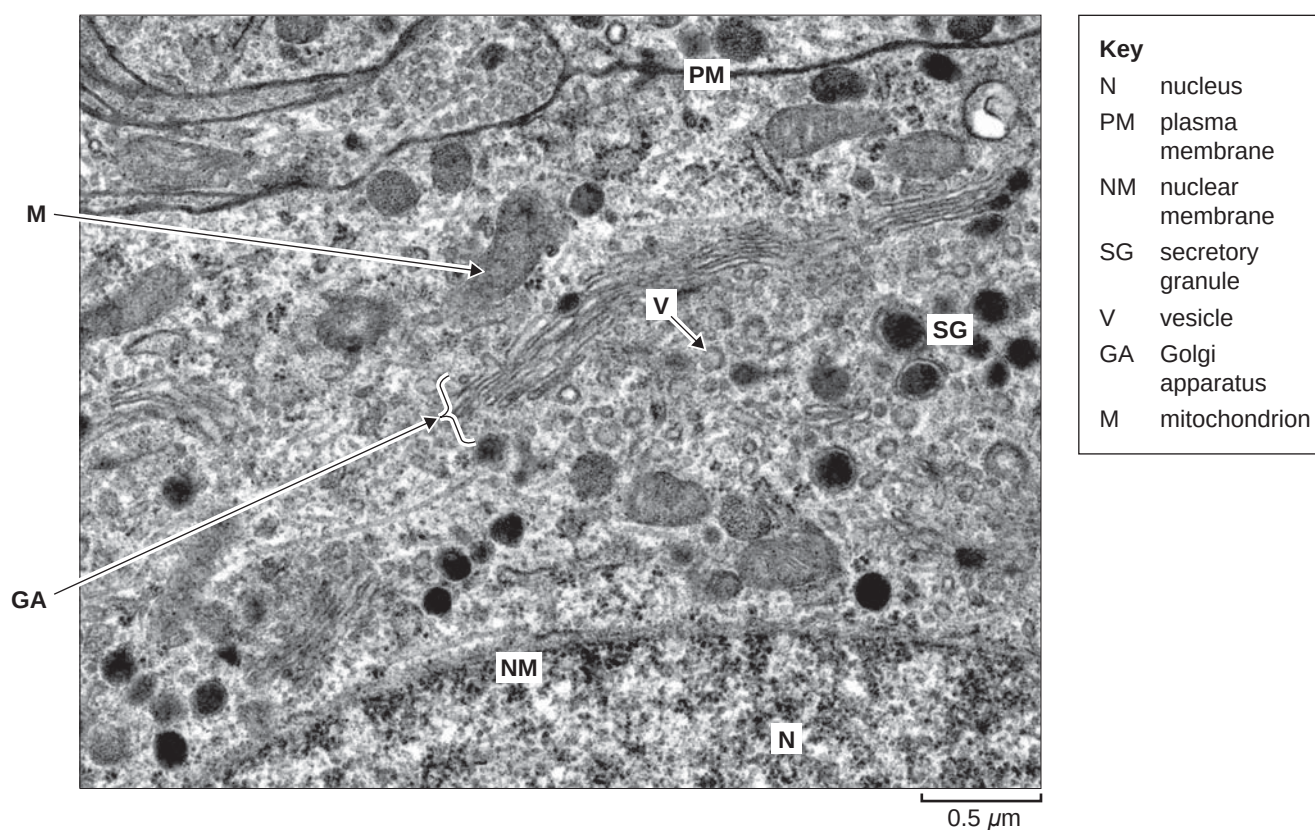
Answer **all** questions in the spaces provided.

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

Question 1 (5 marks)

Adrenaline is an amino-acid-based hormone. The image below shows a cell section of an adrenaline-secreting cell examined under a transmission electron microscope.

A secretory granule is a large vesicle formed when several smaller vesicles fuse. Each secretory granule contains a large amount of adrenaline, which is stored until the cell receives a signal to release it.



Source: Jose Luis Calvo/Shutterstock.com

- a. There are many organelles of the types labelled GA and M visible in the cell section on page 18.

Complete the table below by stating the specific function of each organelle with the following labels in the adrenaline-secreting cell.

2 marks

Label	Specific function in the adrenaline-secreting cell
GA	
M	

- b. i. Name the process by which adrenaline is secreted from the cell.

1 mark

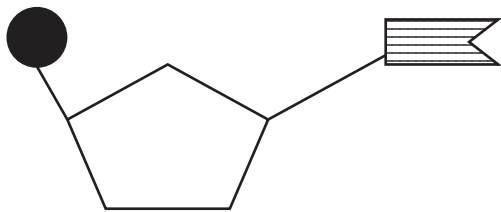
- ii. Describe this process with reference to the roles of relevant organelles labelled in the cell section on page 18.

2 marks

Question 2 (7 marks)

RNA molecules consist of long strands of joined nucleotides. Each nucleotide consists of three sub-units.

- a. Label the three sub-units on the diagram of the RNA nucleotide below.1 mark



- b. Complete the table below by describing the role in a cell of the two types of RNA listed.2 marks

Type of RNA	Role in a cell
tRNA	
mRNA	

- c. Outline **two** events that occur during RNA processing and the importance of each event in gene expression.

4 marks

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SECTION B – continued
TURN OVER

Question 3 (6 marks)

Greenhouses have been used to generate higher crop yields than open-field agriculture. To encourage plant growth in greenhouses, the conditions required for photosynthesis are controlled. Commercial greenhouses, like the ones shown below, often use a lot of energy for heating, ventilation, lighting and water.



Source: SUPEE PURATO/Shutterstock.com

- a. Consider the reactions of photosynthesis. Why would it be important to maintain the temperature within narrow limits in a commercial greenhouse? Justify your answer.

2 marks

- b. Scientists are developing a new material to cover greenhouses, which can split incoming light and convert the rays from green wavelengths into red wavelengths.

Explain how this new material increases crop yields.

2 marks

- c. In plants and algae, photosynthesis is carried out in chloroplasts. It is thought that chloroplasts originated from bacteria.

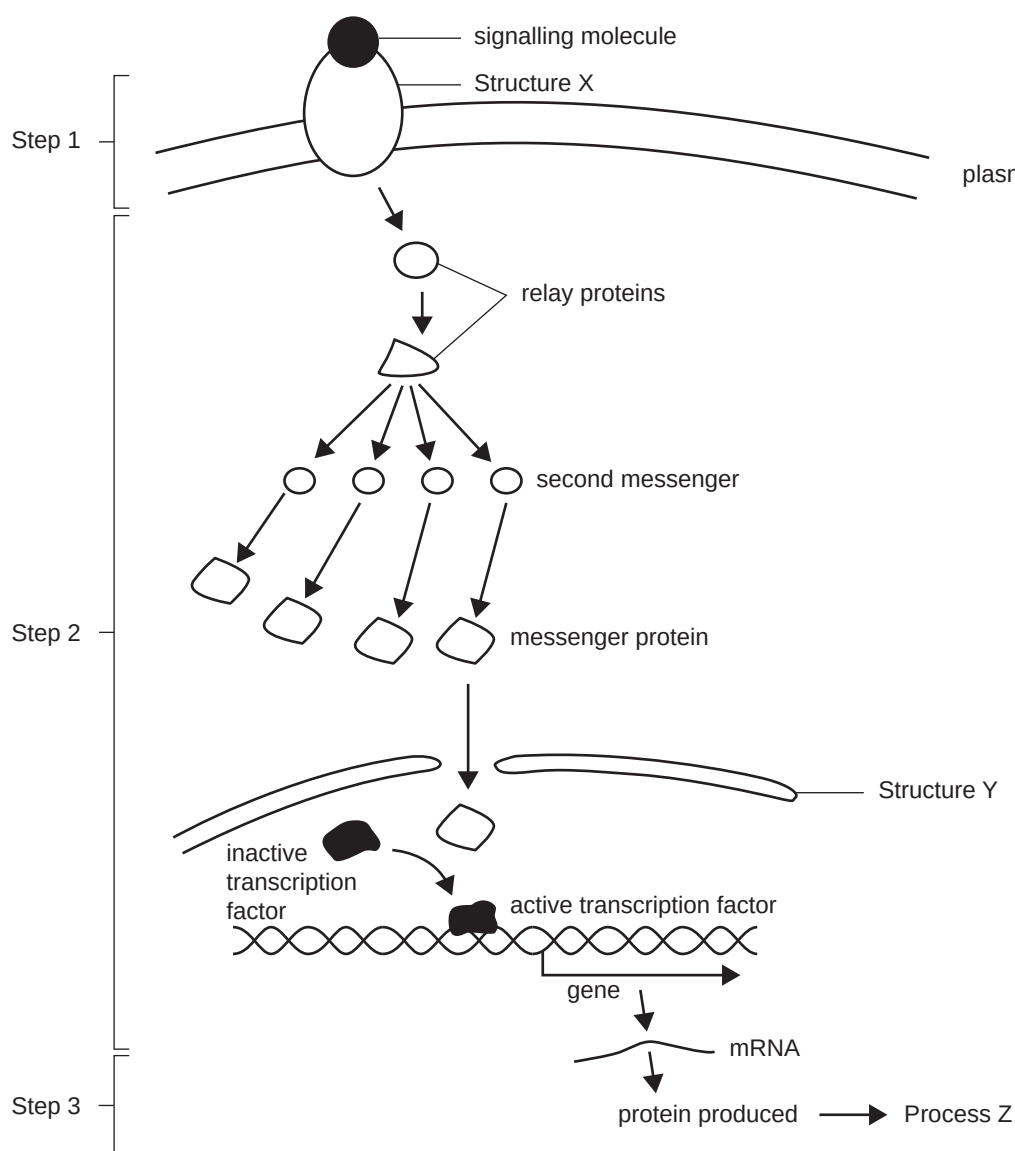
Describe **two** features of chloroplasts that support the theory that chloroplasts originated from bacteria. 2 marks

DO NOT WRITE IN THIS AREA

SECTION B – continued
TURN OVER

Question 4 (8 marks)

The diagram below is a simplified example of a signal transduction pathway. Three steps in the pathway are labelled.



a. There are three labels in the diagram that have not been named.

i. Name each of the following structures.

2 marks

Structure X _____

Structure Y _____

ii. Identify an example of Process Z.

1 mark

- b. Complete the table below by naming each step shown in the pathway on page 24 and describing the events occurring within each step.

3 marks

Step number	Step name	Description of events occurring within this step
1		
2		
3		

- c. Explain whether the pathway shown on page 24 is initiated at Step 1 by a hydrophobic molecule or by a hydrophilic molecule.

2 marks

Question 5 (7 marks)

- a.** The human immune system uses several different types of cells to eliminate virally infected cells.

Name **one** of these cells and outline how it eliminates virally infected cells.

2 marks

- b. i.** State the role played by the lymphatic system in an immune response.

1 mark

- ii.** Describe the sequence of events that occurs in the secondary lymphoid tissue that results in the production of antibodies.

4 marks

Question 6 (4 marks)

Gene cloning has allowed the pharmaceutical industry to manufacture large quantities of proteins at a low cost. These proteins are produced by bacteria and are used to treat certain health conditions.

In the past, before the development of DNA technology, proteins for treating certain health conditions could be obtained only from animals, such as cattle and pigs, or from human corpses.

- a. State **two** advantages of using gene cloning to manufacture pharmaceutical proteins rather than sourcing the proteins from animals or human corpses.

2 marks

- b. Outline **one** ethical issue associated with the use of gene cloning in the manufacture of a pharmaceutical product.

2 marks

DO NOT WRITE IN THIS AREA

Question 7 (8 marks)

Only 35% of the world's adult human population can digest lactose, which is found in milk. These people continue to produce the enzyme lactase throughout their lives. Most people who can digest lactose have European ancestry. There is evidence that people kept animals for milk in Europe 10 500 years ago.

About 7500 years ago in central Europe, a gene mutation occurred in the lactase gene, where cytosine was replaced by thymine. The allele produced by this mutation allows individuals to produce lactase and to digest lactose throughout their lives.

Researchers have estimated that populations in Europe with this mutation produced more offspring than populations who did not have this mutation.

- a.** Name the type of mutation that occurred 7500 years ago in central Europe.

1 mark

- b. i.** The increase in frequency of the allele for lactase persistence happened relatively quickly in some populations.

Explain why the frequency of this allele increased relatively quickly.

3 marks

- ii.** In some present-day populations there are no individuals with the mutation.

Give **two** reasons for the absence of the mutation in these populations.

2 marks

- c. Cows are the main source of milk in Europe. Modern dairy cow breeds can produce 25 L of milk each day – much more than their wild ancestors.

Describe how an increase in production of cow's milk could be achieved by farmers over many generations of cows.

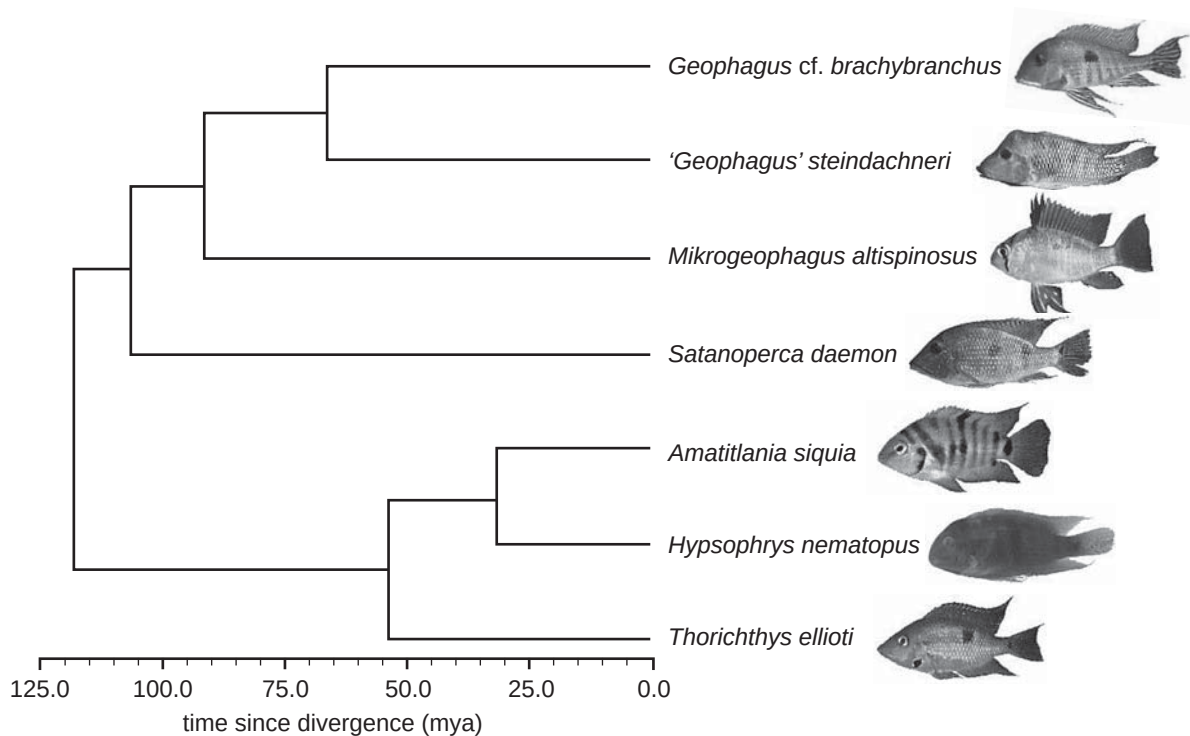
2 marks

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SECTION B – continued
TURN OVER

Question 8 (7 marks)

The phylogenetic tree below shows the evolutionary relationship between seven species of cichlid fish.



Source: H López-Fernández et al.,
 'Morphology and efficiency of a specialized foraging behavior, sediment sifting,
 in neotropical cichlid fishes', *PLoS ONE*, 9(3): e89832,
 6 March 2014, <<https://doi.org/10.1371/journal.pone.0089832>>

- a. Molecular homology can be used to construct a phylogenetic tree.

Based on the information above, state which **two** species of cichlid fish would be expected to have the most similar amino acid sequences in their proteins. Justify your answer.

3 marks

- b.** Fossils of species of fish are more likely to be found than fossils of land-dwelling animals.

Explain why this is the case with reference to **two** conditions required for the fossilisation of an organism.

2 marks

- c.** A group of scientists stated that a particular fossilised fish was 5000 years old.

Outline a dating technique that could have been used by the scientists to determine the age of the fossil. 2 marks

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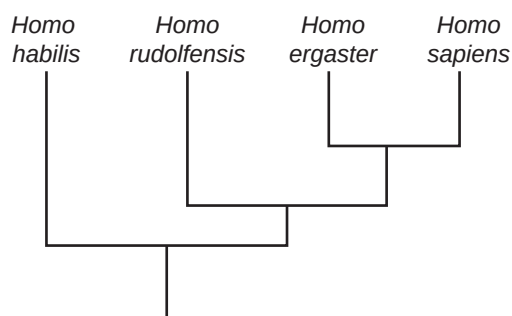
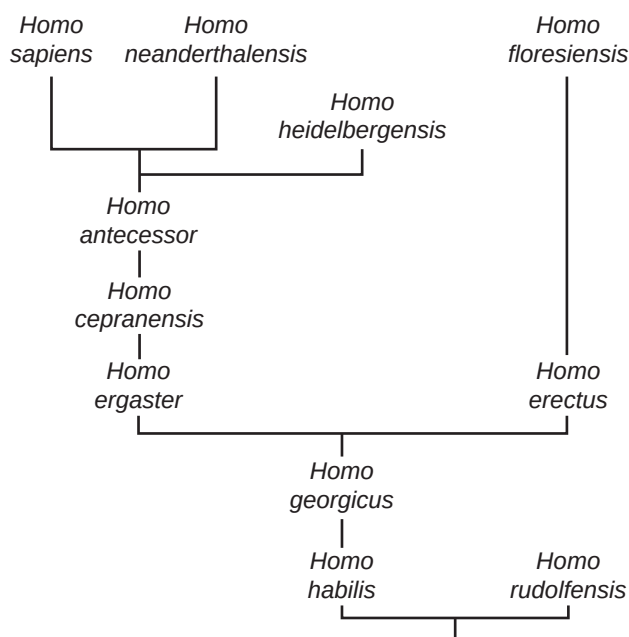
Question 9 (7 marks)

In 1931 a team of Dutch archaeologists unearthed 12 skulls and two leg bones at a site in Ngandong, Indonesia.

- a. Describe **two** key structural features of these fossils that would suggest that the skulls were from *Homo erectus* rather than from *Homo sapiens*.

2 marks

Figure 1 and Figure 2 below show *Homo* evolutionary trees that were created in 1997 and 2013 respectively.

1997 *Homo* evolutionary tree**Figure 1****2013 *Homo* evolutionary tree****Figure 2**

Sources (from left): adapted from DS Strait, FE Grine and MA Moniz, 'A reappraisal of early hominid phylogeny', *Journal of Human Evolution*, volume 32, issue 1, January 1997, pp. 17–82; C Schultz, '*Homo Sapiens*' family tree may be less complicated than we thought', *Smithsonian Magazine*, 18 October 2013, <www.smithsonianmag.com>

- b. State **one** difference between Figure 1 and Figure 2 with respect to the evolutionary relationships between *Homo ergaster* and *Homo sapiens*.

1 mark

Homo denisovans is one species that is missing from both evolutionary trees shown on page 32.

- c. Draw a branch on Figure 2, the 2013 *Homo* evolutionary tree, that represents where you think *Homo denisovans* should be placed. Justify why you have put the branch in that position.

2 marks

- d. Scientists do not always agree on the position of each *Homo* species on evolutionary trees.

Explain why this is the case.

2 marks

DO NOT WRITE IN THIS AREA

Question 10 (10 marks)**Measles in Samoa**

Measles is one of the most contagious viruses affecting humans. Measles spreads when an infected person coughs or sneezes and the virus is breathed in by another person, or by direct contact with bodily fluids. In a susceptible population – people who have neither been vaccinated nor had measles previously – one person with measles could infect 12 to 18 other people.

The Pacific island nation of Samoa had a significant measles outbreak in 2019. This started when a person who had measles arrived in Samoa by plane in August 2019. In the following months over 5000 measles cases were recorded and more than 70 people died.

A measles outbreak was declared by the Samoan Government in October 2019. On 15 November the Samoan Government declared a 30-day state of emergency as the number of measles cases continued to rise and more people died. Ninety per cent of the deaths were among children less than five years old. More than one in five Samoan babies aged six to 11 months contracted measles during this outbreak and more than one in 150 babies in this age group died. Fewer deaths occurred in babies who were less than six months old.

Prior to the measles outbreak in Samoa, the vaccination rate for measles for five-year-old children in the country had fallen to 31% in 2018. One of the responses of the government to the outbreak was a mandatory vaccination program for all people. By early December 2019 over 90% of the population had been vaccinated.

In Australia a measles-containing vaccine (MMR vaccine) is recommended for children aged 12 months of age or older. A single dose of the measles vaccine provides protection for between 95% and 98% of recipients, while two doses protects 99% of vaccinated people. In 2018 in Australia, 95% of five-year-old Australian children were fully vaccinated.

Reference: K Gibney, 'Measles in Samoa: How a small island nation found itself in the grips of an outbreak disaster', The Conversation, 12 December 2019, <<https://theconversation.com/au>>

- a.** Is the measles outbreak discussed in the article above best described as an epidemic or a pandemic? Give your reasoning.

2 marks

- b.** Consider the Samoan children who were less than five years old during the measles outbreak. Of this group, what age were the children who were least likely to die from measles? Explain why children of this age would be less likely to die.

2 marks

People who are vaccinated are unlikely to be affected by the measles virus.

- c. i. What is the percentage difference between vaccinated five-year-old children in Samoa and Australia in 2018? 1 mark

- ii. The MMR vaccine contains antigens for measles, mumps and rubella.

What form of immunity is given when a person is vaccinated with the MMR vaccine? 1 mark

- iii. Some children, for example those undergoing chemotherapy, cannot be vaccinated.

Explain how high vaccination rates can also protect unvaccinated individuals. 2 marks

- d. Describe **two** strategies, other than vaccination, that could reduce the transmission of measles. 2 marks

DO NOT WRITE IN THIS AREA

Question 11 (11 marks)

A student wanted to investigate the effect of two different endonucleases (restriction enzymes) on a linear DNA fragment.

The student used three tubes containing a buffered solution of linear DNA fragments, each fragment being 9500 base pairs in length.

Two different endonucleases were available: BamHI and HindIII.

The student followed the steps below.

Step 1 – 2 μL of BamHI was added to the sample in Tube 1.

Step 2 – 2 μL of HindIII was added to the sample in Tube 2.

Step 3 – 2 μL of HindIII and 2 μL of BamHI were added to the sample in Tube 3.

Step 4 – All three tubes were incubated for one hour at a constant temperature of 37 °C.

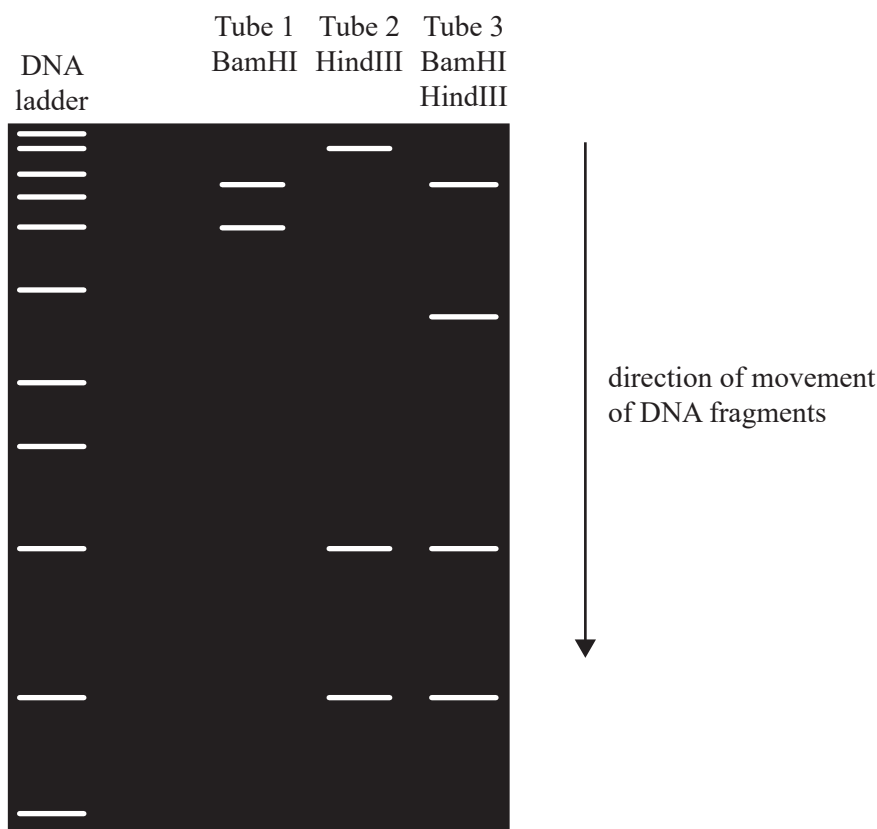
Step 5 – A 1% agarose gel was placed into an electrophoresis chamber and the gel was covered with buffer solution.

Step 6 – 40 μL of a DNA ladder with fragments of known sizes was added to the first well of the 1% agarose gel.
The known sizes of the fragments were 10 000 bp, 8000 bp, 6000 bp, 5000 bp, 4000 bp, 3000 bp, 2000 bp, 1500 bp, 1000 bp, 500 bp and 250 bp.

Step 7 – 40 μL of the contents of each of the tubes was loaded into three separate wells of the 1% agarose gel.

Step 8 – An electric current of 100 V was run through the gel for 45 minutes.

After 45 minutes the student obtained the results shown below.

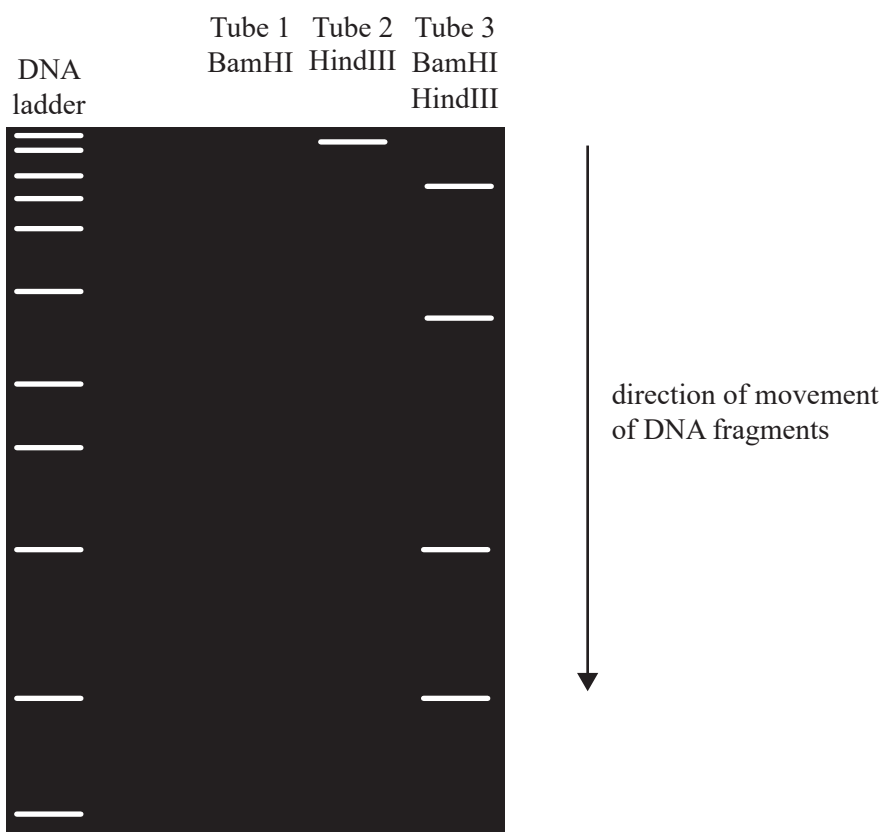


Source: results based on 1 kb DNA ladder from TEquipment, <www.tequipment.net>

- a. Analyse the results of the experiment performed by the student.

5 marks

The student repeated the experiment the next day and obtained the following results.



- b. Identify **one** difference between the new results and the previous results, and suggest a possible reason for this difference.

2 marks

- c. State **two** factors that will have an impact on the rate of movement of the DNA fragments through the agarose gel.

2 marks

- d. Outline **two** safety guidelines that should have been followed by the student.

2 marks
