

Victorian Certificate of Education
2017

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

STUDENT NUMBER

Letter

BIOLOGY
Written examination

Friday 3 November 2017

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 39 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.

Question 1

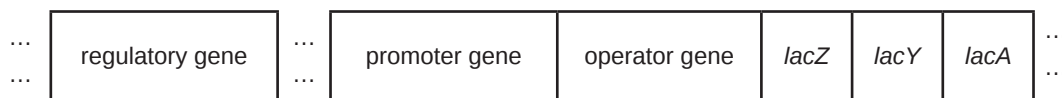
Consider the structure and functional importance of proteins.

Which one of the following statements about proteins is correct?

- A. A change in the tertiary structure of a protein may result in the protein becoming biologically inactive.
- B. Proteins with a quaternary structure will be more active than proteins without a quaternary structure.
- C. Two different proteins with the same number of amino acids will have identical functions.
- D. Denaturation will alter the primary structure of a protein.

Use the following information to answer Questions 2–4.

The *lac* operon was originally identified in *Escherichia coli*. The *lac* operon has three structural genes: *lacZ*, *lacY* and *lacA*. The *lacZ* gene codes for the production of the enzyme β -galactosidase, which catalyses the breakdown of lactose into glucose and galactose. Below is a diagram that shows the order of the genes found in the *lac* operon. The dots represent the DNA nucleotides between the genes.

**Question 2**

To begin transcription of the three structural genes, RNA polymerase needs to bind to the

- A. operator gene.
- B. promoter gene.
- C. regulatory gene.
- D. structural genes.

Question 3

A mutation in the regulatory gene of the *lac* operon may result in

- A. inhibition of the operator gene.
- B. RNA polymerase not being able to perform transcription.
- C. the *lac* operon switching on in the presence of lactose only.
- D. production of a repressor molecule that is unable to bind to the operator gene.

Question 4

When lactose is present in *E. coli*, the lactose molecules are rearranged to become allolactose molecules. Following this rearrangement, the structural genes in the *lac* operon are transcribed.

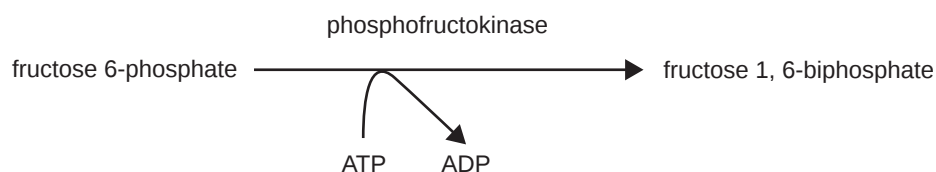
This is because

- A. the *lac* operon is switched off.
- B. allolactose binds to the promoter gene.
- C. repressor molecules bind to allolactose.
- D. the regulatory gene produces more RNA polymerase.

Question 5

The biochemical pathway of glycolysis involves nine intermediate reaction steps.

One of these steps is represented in the diagram below.



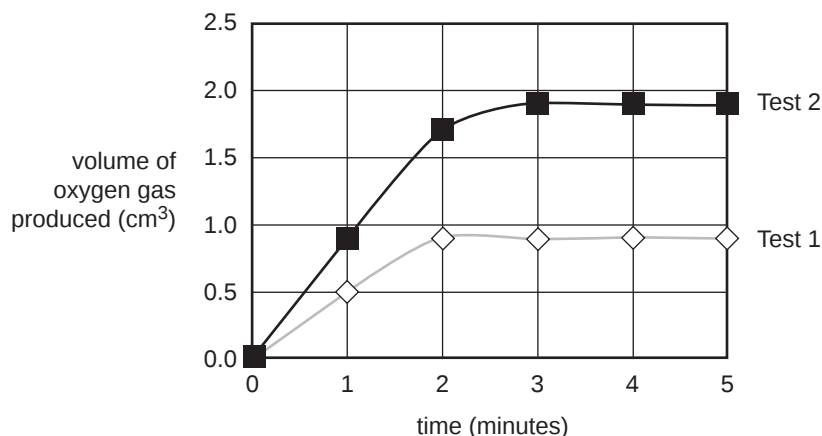
It is correct to state that, in this reaction, phosphofructokinase

- A. acts as a coenzyme.
- B. increases the rate of reaction.
- C. is the substrate for the reaction.
- D. releases energy in the form of ADP.

Use the following information to answer Questions 6–8.

Hydrogen peroxide is a toxic by-product of many biochemical reactions. Cells break down hydrogen peroxide into water and oxygen gas with the help of the intracellular enzyme catalase. The optimum pH of catalase is 7.

A Biology student measured the activity of catalase by recording the volume of oxygen gas produced from the decomposition of hydrogen peroxide when a catalase suspension was added to it. The catalase suspension was made from ground, raw potato mixed with distilled water. The student performed two tests and graphed the results.



Test 1 used 5 mL of 3% hydrogen peroxide solution and 0.5 mL of catalase suspension, and was conducted at 20 °C in a buffer solution of pH 7.

Test 2 was carried out under identical conditions to Test 1, except for one factor that the student changed.

Question 6

An explanation for the results of Test 2 would be that the student

- A. increased the concentration of catalase by adding less water to the ground potato.
- B. increased the temperature by placing the test tube in a water bath set at 30 °C.
- C. used a hydrogen peroxide solution with a higher concentration.
- D. added a catalase suspension made from a cooked potato chip.

Question 7

The student then performed more tests by varying the pH of the buffer solution.

It is expected that

- A. at pH 6 the reaction will cease.
- B. at pH 9 the reaction will be faster.
- C. at pH 2 and pH 10 very little oxygen will be produced.
- D. a greater volume of oxygen will be produced each time the pH is increased.

Question 8

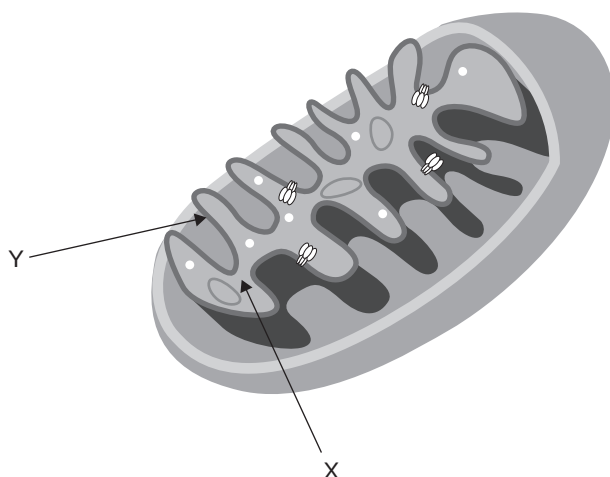
During the experiment, the student measured the varying pH levels using a digital pH meter. The student calibrated the meter using a pH 7 buffer solution.

The reason the student calibrated the pH meter was to

- A. ensure a random error would not influence the results.
- B. eliminate the effect of all uncontrolled variables.
- C. enable the use of the instrument with precision.
- D. allow the pH to be measured accurately.

Use the following information to answer Questions 9 and 10.

The following is a three-dimensional diagram of an organelle found in eukaryotic cells.



Source: Alila Medical Media/Shutterstock.com

Question 9

The region labelled X is called the

- A. matrix.
- B. crista.
- C. inner membrane.
- D. intermembrane space.

Question 10

The structure labelled Y is where

- A. glucose enters glycolysis.
- B. NAD^+ is converted into NADH.
- C. the majority of ATP is produced in the cell.
- D. pyruvate is broken down, releasing carbon dioxide.

Question 11

An animal cell culture was exposed to radioactively labelled oxygen. The cells were then monitored for three minutes. After this time, the radioactively labelled oxygen atoms would be present in which cellular chemical?

- A. adenosine triphosphate
- B. carbon dioxide
- C. glucose
- D. water

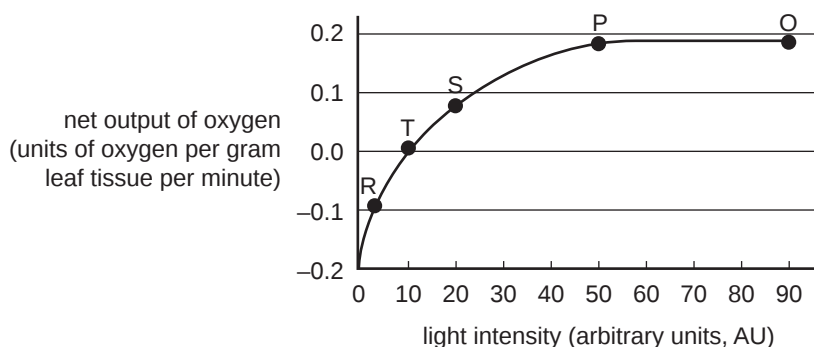
Question 12

Evidence for the bacterial origin of chloroplasts is supported by observations that both chloroplasts and bacteria

- A. do not contain ribosomes.
- B. reproduce and divide by mitosis.
- C. have a single circular chromosome.
- D. store chlorophyll in their outer membrane.

Use the following information to answer Questions 13 and 14.

The graph below shows the net output of oxygen in spinach leaves as light intensity is increased. Temperature is kept constant during the experiment.

**Question 13**

Which one of the following conclusions can be made based on the graph?

- A. At point T photosynthesis is no longer occurring.
- B. The optimal level of light intensity for photosynthesis is 40 AU.
- C. At point S the amount of oxygen output is a third of that at point P.
- D. Below 10 AU of light intensity the aerobic respiration rate is greater than the photosynthesis rate.

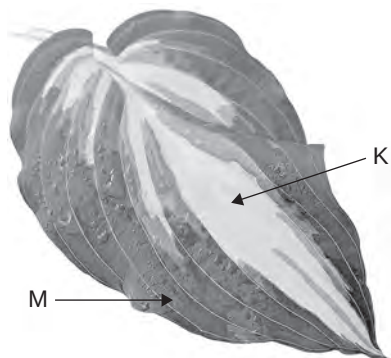
Question 14

The rate of oxygen output remains constant between points P and O because

- A. heat has denatured the enzymes involved in the photosynthesis reactions.
- B. the concentration of available carbon dioxide limits the rate of photosynthesis.
- C. the light intensity has damaged the chlorophyll molecules present in the spinach chloroplasts.
- D. high levels of oxygen produced at point P have accumulated around the spinach leaves, resulting in no more oxygen being produced.

Question 15

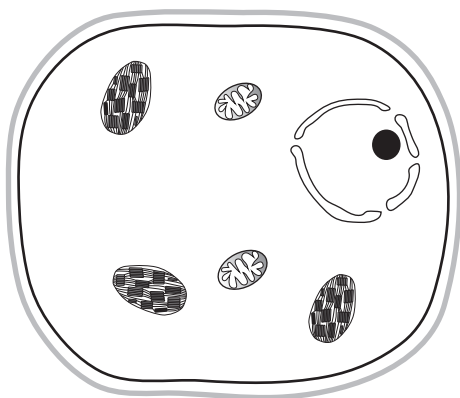
A variegated leaf from a plant is shown below.



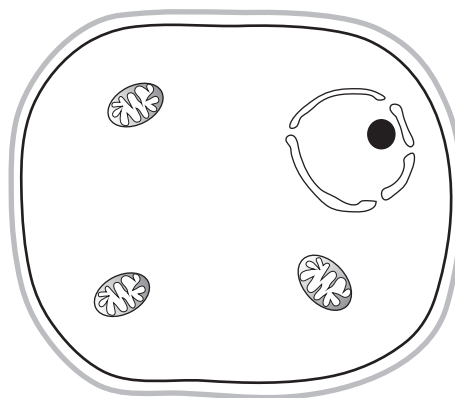
Source: Le Do/Shutterstock.com

Cells from sections M and K were examined and simple sketches were produced.

A typical cell from section M



A typical cell from section K



From this information, it can be concluded that

- A. cells in section K would be unable to carry out aerobic respiration.
- B. light-independent reactions of photosynthesis can occur in cells from section K.
- C. there is chlorophyll present in cells from section K but not in cells from section M.
- D. glucose would be manufactured from carbon dioxide and water in cells from section M but not in cells from section K.

Question 16

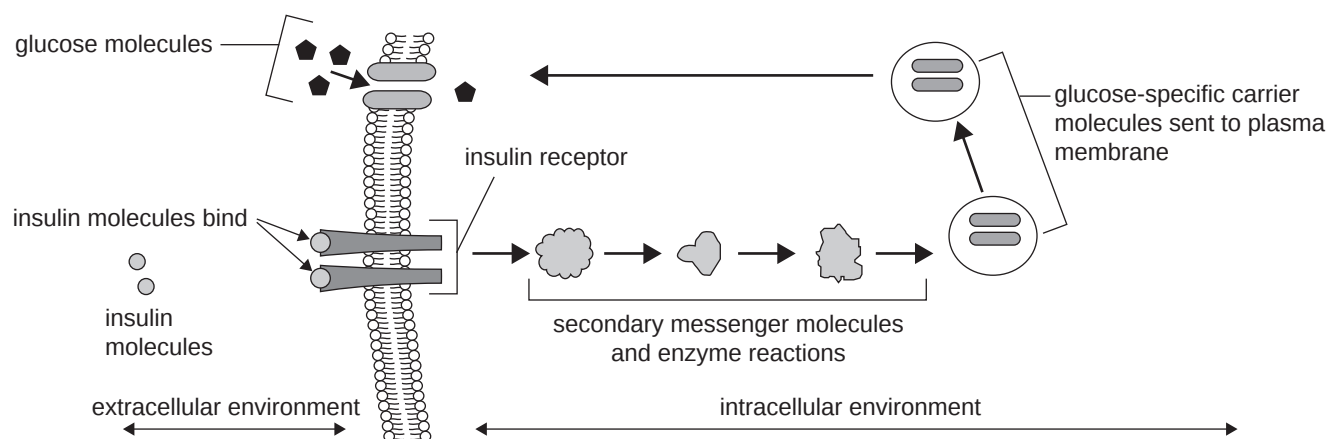
A molecule that takes part in many biochemical reactions is NADP^+ .

It is correct to state that

- A. NADP^+ becomes NADH when it is loaded.
- B. NADP^+ has a higher energy level when it is unloaded.
- C. energy is released when NADP^+ is converted to NADPH .
- D. NADP^+ carries additional energy when protons and electrons are added to it.

Use the following information to answer Questions 17 and 18.

The diagram below shows a summary of the steps in an insulin signalling pathway that results in increased glucose uptake.



A scientist studied the insulin signalling pathways of two female patients, Eleni and Shani.

Eleni's pathway is the same as that shown in the diagram above.

The scientist discovered that the gene that encodes the insulin receptor in Shani has a mutation. Insulin molecules cannot bind to Shani's insulin receptors.

Question 17

From this information, it would be correct to conclude that

- A. insulin acts as a hydrophilic signalling molecule in Eleni and Shani.
- B. there would be more glucose-specific carrier molecules in Shani's plasma membranes than in Eleni's.
- C. the binding of insulin molecules to the receptor initiates transduction and the uptake of glucose into Eleni's cells.
- D. the presence of insulin in Shani would cause an increase in the concentration of the secondary messenger molecules.

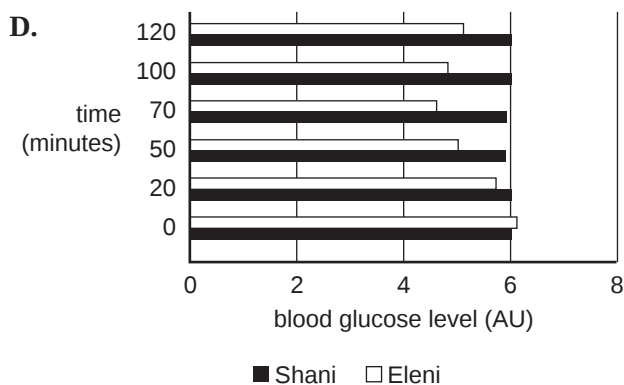
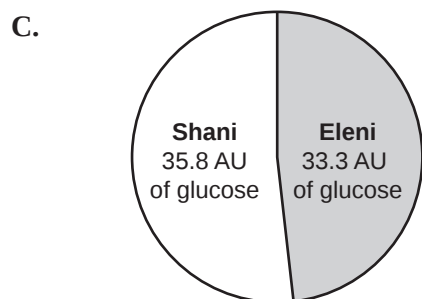
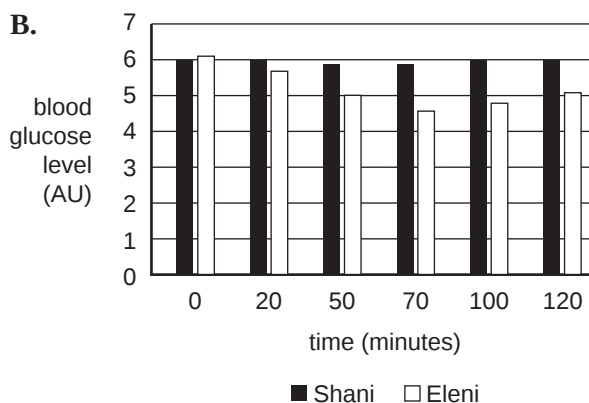
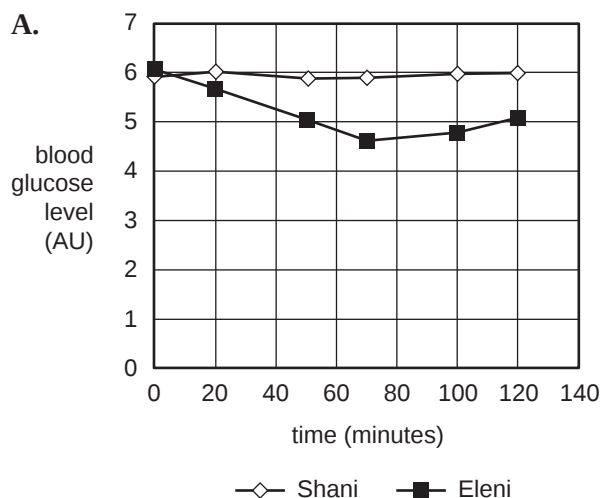
Question 18

The scientist measured the blood glucose levels of both Eleni and Shani over a 120-minute period after they were injected with the hormone insulin. The table below shows the results.

Time (minutes)	Shani's blood glucose level (arbitrary units, AU)	Eleni's blood glucose level (arbitrary units, AU)
0	6.0	6.1
20	6.0	5.7
50	5.9	5.0
70	5.9	4.6
100	6.0	4.8
120	6.0	5.1

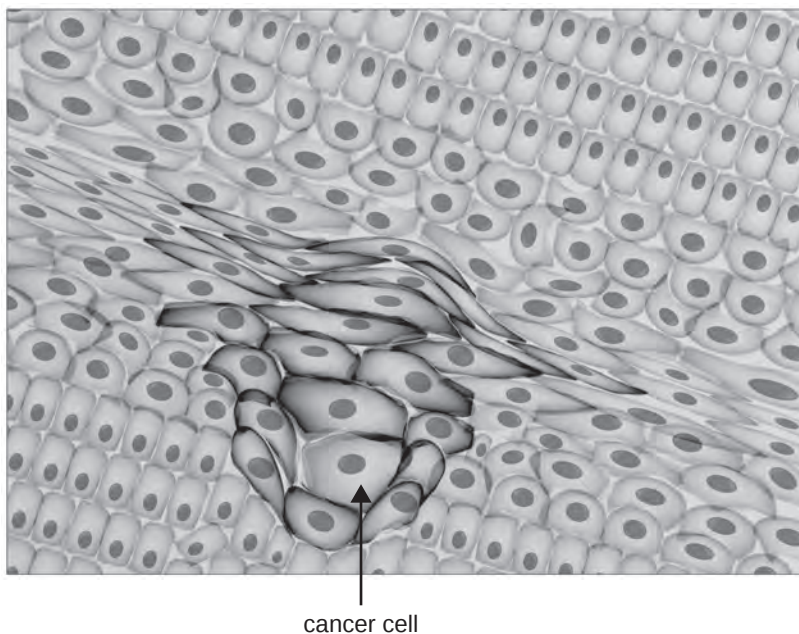
The scientist wanted to compare Eleni's and Shani's blood glucose levels at the 90-minute mark.

Which one of the following graphs would allow the scientist to predict their blood glucose levels most accurately 90 minutes after they were injected with insulin?



Question 19

The diagram below shows the location of cancer cells within a tissue.



Source: inbevel/Shutterstock.com

The number of cancer cells within the tissue is rapidly increasing.

This increase in the number of cancer cells can be explained by

- A. increased caspase function within each of the cancer cells.
- B. decreased rate of apoptosis in the surrounding normal cells.
- C. reduction in size of the nuclei of cancer cells compared to those of normal cells.
- D. impaired signalling from death receptors located on the membrane of the cancer cells.

Question 20

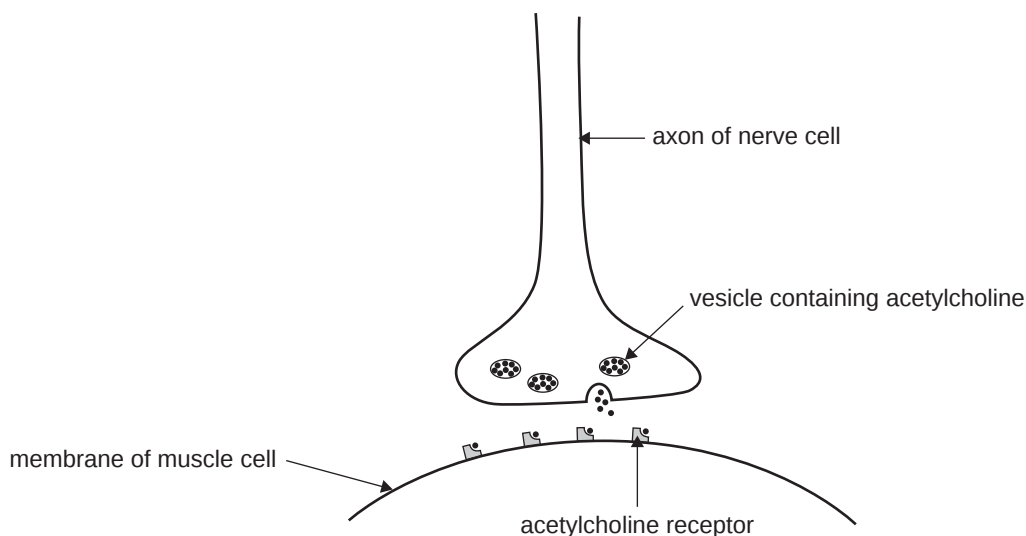
Cytokines are an example of a signalling molecule.

Cytokines

- A. are hydrophobic (lipid-based) hormones.
- B. produced by a cell can diffuse to a nearby target cell.
- C. cross a synapse by moving down a concentration gradient.
- D. are secreted by an animal, then released into the air and produce an effect in another animal.

Question 21

Myasthenia gravis is an autoimmune disease in which autoantibodies affect the transmission of a nerve impulse. In myasthenia gravis, communication between a nerve and a muscle across a neuromuscular junction is disrupted. The muscle cannot contract when this communication is disrupted. The diagram below shows a neuromuscular junction.



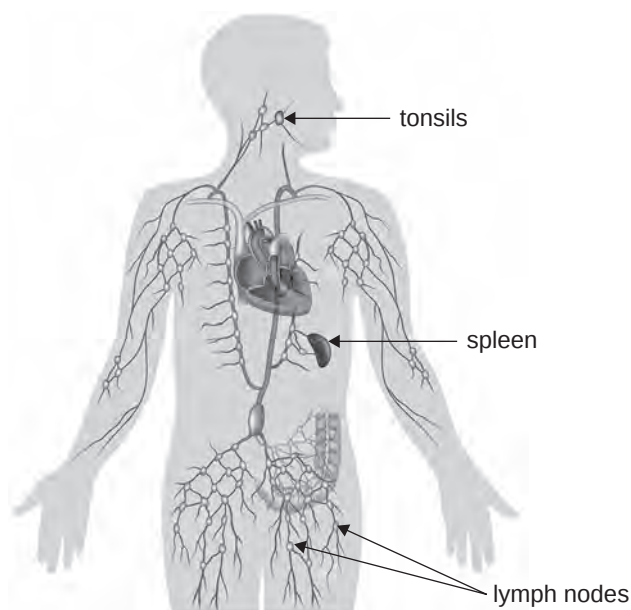
Which one of the following could explain the functional cause of myasthenia gravis?

- A. Acetylcholine is a hydrophobic molecule.
- B. Acetylcholine is released from vesicles by endocytosis.
- C. Myasthenia gravis autoantibodies attach to and block the acetylcholine receptors.
- D. Signal transduction in the muscle cell is amplified by autoantibodies produced in people with myasthenia gravis.

Question 22

Which of the following matches a cell correctly with its role in an immune response?

	Cell	Role
A.	macrophage	stimulates inflammation by secreting interferon
B.	dendritic cell	presents fragments of antigens to T helper cells
C.	mast cell	engulfs bacteria and debris
D.	neutrophil	secretes antibodies

Question 23**The human lymphatic system**

Source: Alila Medical Media/Shutterstock.com

The lymphatic system includes the lymph nodes, spleen and tonsils.

In these particular organs

- A. clotting factors are inactivated to help seal a wound.
- B. clonal selection and proliferation of B cells occurs.
- C. non-self antigens are identified by red blood cells.
- D. the initial response to an allergen is triggered.

Use the following information to answer Questions 24 and 25.

Multiple sclerosis (MS) is an autoimmune disease. In sufferers of MS, the myelin coating of nerve cell axons is damaged. This damage results in poor transmission of nerve messages between the brain, the spinal cord and the rest of the body. One aspect of MS diagnosis is imaging the brain to detect visible areas of demyelination, called plaques.

Question 24

Researchers investigating MS have analysed various tissue samples from patients.

In these samples they would expect to find

- A. an abundance of allergens in nerve cells.
- B. cancer cells in MS plaques in brain tissue.
- C. increased numbers of T helper cells in spinal fluid.
- D. an absence of T cytotoxic cells in the spinal cord and brain.

Question 25

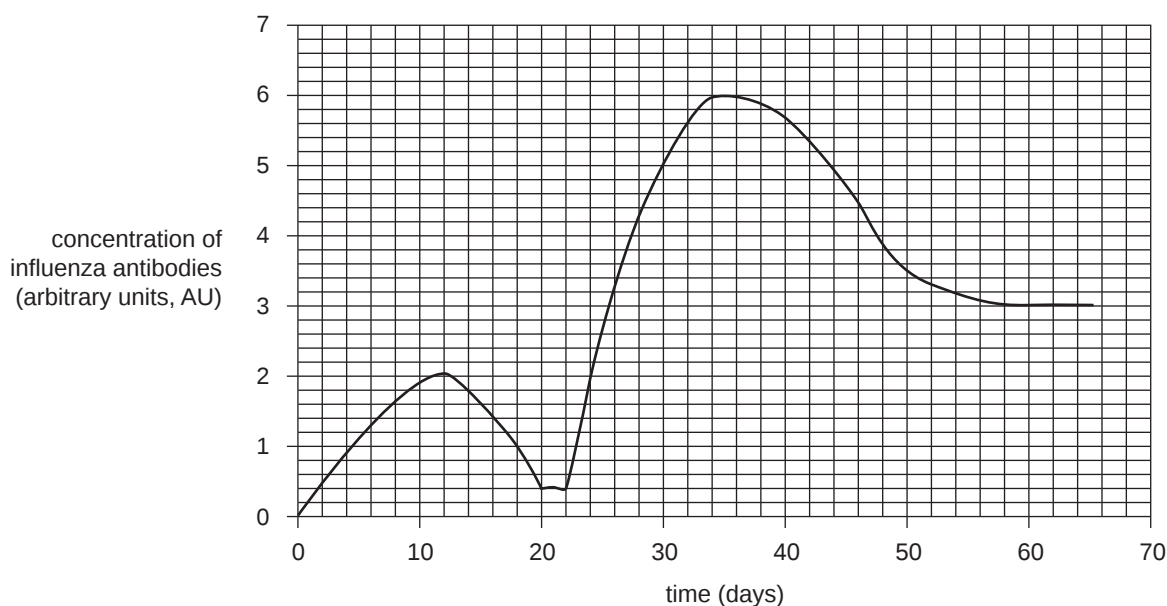
Scientists are investigating factors that increase the likelihood of developing MS. Recently, the ‘hygiene theory’ has been considered a possible factor. This theory proposes that, if a child’s environment is overly hygienic and does not allow sufficient exposure to a wide range of non-self antigens, an overactive immune system will result later in life. A recent study tested for the presence of antibodies to the bacteria that cause stomach ulcers, *Helicobacter pylori*, in the blood of 550 MS patients and 299 healthy people. Both groups of people had the same proportion of each gender and were of similar age. Exposure to *H. pylori* usually occurs by the age of two years. The results of the antibody testing showed that the rate of *H. pylori* infection was 30% lower in the women with MS than in the healthy women or healthy men.

The findings of this study are consistent with the suggestion that

- A. monoclonal antibodies could be used to treat MS.
- B. males are affected by MS 30% more often than females.
- C. suffering from a stomach ulcer is a common symptom of MS.
- D. in females childhood exposure to *H. pylori* helps to protect against MS.

Question 26

A daily blood sample was obtained from an individual who received a single vaccination against a particular strain of the influenza virus. The individual had no prior exposure to this strain of influenza. The graph below shows the concentration of antibodies present in the individual’s blood for this strain of influenza over a period of 65 days.



Which one of the following conclusions can be made using this data?

- A. Memory B cells were activated by exposure to the same strain of the influenza virus on day 22.
- B. B plasma cells specific to this strain of influenza were most numerous on day 12.
- C. Herd immunity to this particular strain of influenza was achieved by day 55.
- D. The vaccination containing weakened influenza antigens occurred on day 10.

Use the following information to answer Questions 27 and 28.

The codon table below can be used to determine the sequence of 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

The following nucleotide sequence occurs on the template strand of a DNA molecule.

AAA GCT ACC TAT CGG TTA

Question 27

In a mutation, the eighth nucleotide in this sequence was changed from C to T.

What would be the result of this mutation?

- A. The peptide chain would be shortened.
- B. The third amino acid would change from Thr to Ile.
- C. The fourth amino acid would change from Ile to Tyr.
- D. There would be no change in the amino acid sequence.

Question 28

In a different mutation, a T was inserted after the fourth nucleotide on the given template strand.

The result of this mutation would be that

- A. all amino acids in this entire sequence would change.
- B. only the first amino acid in the sequence would change.
- C. only the second amino acid in the sequence would change.
- D. all amino acids after the first in the sequence would change.

Question 29

A newborn baby was diagnosed with Patau syndrome. Her karyotype showed three copies of chromosome 13.

This is an example of

- A. frameshift mutation.
- B. block mutation.
- C. aneuploidy.
- D. polyploidy.

Question 30

In the 18th century, farmer Robert Bakewell separated large, fine-boned sheep with long, shiny wool from his native stock to interbreed for future sheep flocks.

This is an example of

- A. genetic fitness.
- B. natural selection.
- C. selective breeding.
- D. allopatric speciation.

Question 31

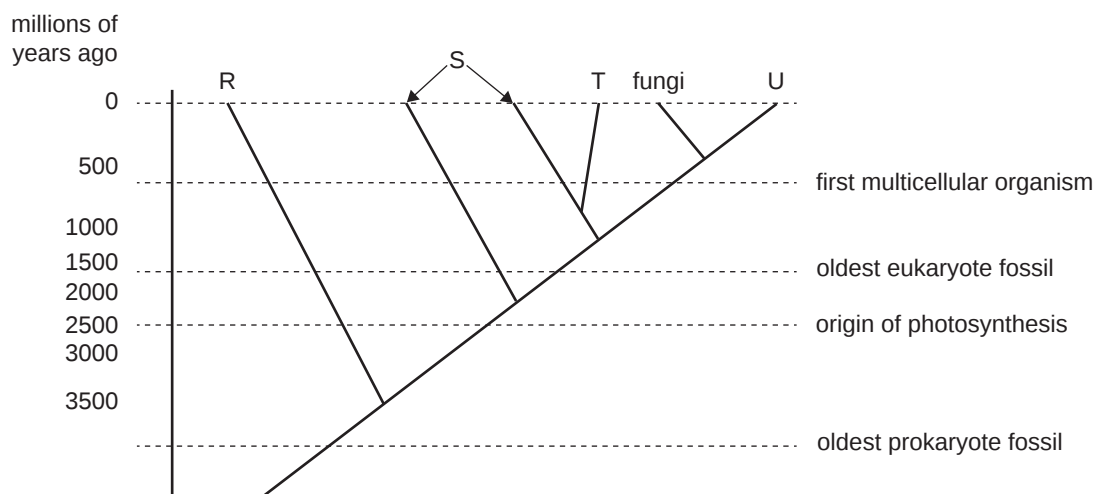
Master genes control the jaw formation of cichlid fish and the beak formation of Galápagos finches by

- A. controlling the timing of protein production at crucial stages of embryonic development.
- B. causing mutations in the structural genes for jaw and beak formation.
- C. binding with mRNA, preventing gene expression.
- D. cutting DNA sequences at specific points.

DO NOT WRITE IN THIS AREA

Question 32

The phylogenetic tree below represents one model of the order and approximate time of appearance of the major groups of living organisms, and includes four groups represented by the letters R, S, T and U.



Which of the following shows the correct placement of the organisms on the phylogenetic tree?

- A. R – animals, S – plants, T – bacteria, U – protists
- B. R – bacteria, S – protists, T – plants, U – animals
- C. R – protists, S – animals, T – bacteria, U – plants
- D. R – plants, S – animals, T – bacteria, U – protists

Question 33

Mass extinctions

- A. kill all but the most primitive species.
- B. are caused by the introduction of competing species.
- C. are followed by a period of rapid divergent evolution.
- D. have been caused by continental drift and earthquakes.

Question 34

The process known as polymerase chain reaction (PCR) involves repeated cycles made up of several steps. During PCR the

- A. first step in each cycle is to anneal primers to the DNA at a low temperature.
- B. temperature must be lowered to 37 °C before the beginning of each cycle.
- C. second step in each cycle is to heat the DNA to a high temperature.
- D. final step of each cycle involves the use of DNA polymerase.

Question 35

Modern African *Homo sapiens* do not contain Neanderthal DNA. Modern non-African *H. sapiens* contain a small percentage of Neanderthal DNA because of interbreeding between Neanderthals and *H. sapiens*. This interbreeding is thought to have occurred within the time period 65 000 to 47 000 years ago. A recent study has found *H. sapiens* DNA in the genomes of 100 000-year-old Neanderthal remains.

From this new discovery, it would be reasonable to conclude that

- A. modern Africans are the descendants of Neanderthals.
- B. there was an early migration of *H. sapiens* out of Africa before 100 000 years ago.
- C. the ancestors of modern Africans migrated from Europe to Africa between 65 000 and 47 000 years ago.
- D. approximately 100 000 years ago, Neanderthals bred with *H. sapiens* in Africa before the Neanderthals spread to the rest of the world.

Question 36

In recent years, scientists have discovered that Neanderthals took care of their elderly relatives, used burial rituals for their dead and gave symbolic meaning to natural objects. Studies have also shown that Neanderthals used complex methods to obtain sharp stone implements and produce glues to attach sharp stones to spears.

These discoveries suggest that Neanderthals

- A. had bigger brains than previously thought.
- B. had a highly developed culture.
- C. lived a solitary lifestyle.
- D. used a written language.

Question 37

Yellow fever is a viral disease that is transmitted primarily by mosquitoes.

An outbreak of yellow fever was reported to have occurred in an area of Brazil in January 2017. This outbreak was reported to be spreading to other areas within Brazil.

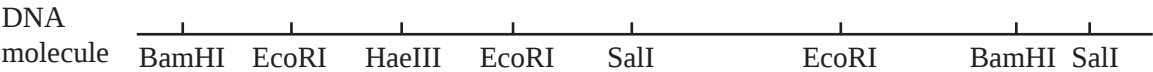
Which one of the following is a correct statement about this outbreak of yellow fever?

- A. This outbreak of yellow fever is considered to be a pandemic.
- B. Infected individuals who travel to other areas of Brazil will not increase the spread of the disease.
- C. This outbreak of yellow fever is occurring in populations with high vaccination rates for yellow fever.
- D. Elimination of mosquito breeding sites in areas with yellow fever will reduce the number of individuals affected.

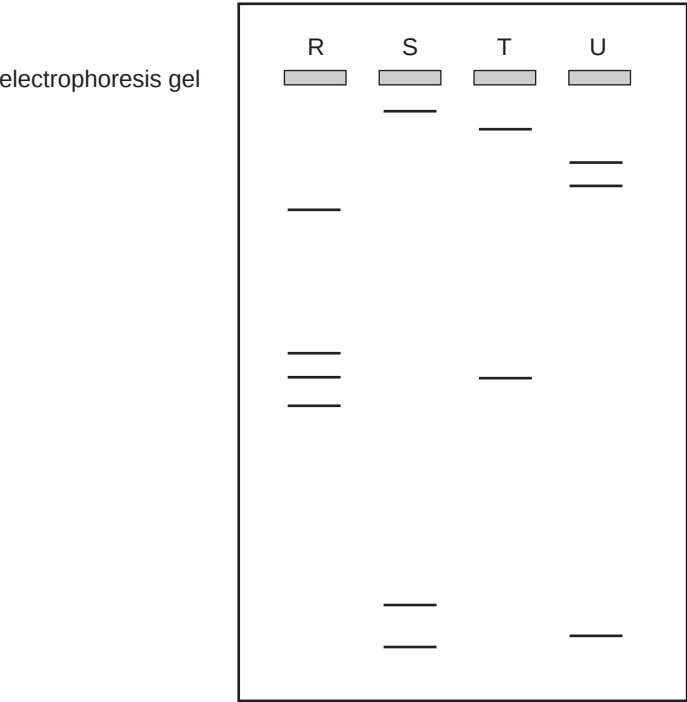
DO NOT WRITE IN THIS AREA

Question 38

The diagram below represents a DNA molecule and the position of the recognition sites for the restriction enzymes BamHI, EcoRI, HaeIII and SalI.



Also shown is a diagram of an electrophoresis gel in which the lanes R, S, T and U show the separation of DNA segments resulting from digestion of the molecule with one of the restriction enzymes.



Which of the following shows the correct match between the lane and the restriction enzyme used to digest the DNA molecule?

	R	S	T	U
A.	SalI	EcoRI	HaeIII	BamHI
B.	EcoRI	BamHI	HaeIII	SalI
C.	EcoRI	BamHI	SalI	HaeIII
D.	HaeIII	SalI	BamHI	EcoRI

DO NOT WRITE IN THIS AREA

Question 39

DNA profiling, using short tandem repeats (STR) within a person's DNA, helps to determine the genetic relationship between individuals.

DNA profiles based on four STRs for five individuals are shown below. The results of a gender identifier are also shown.

STR	Individual 1	Individual 2	Individual 3	Individual 4	Individual 5
CSF1PO	7,14	7,11	8,13	7,14	7,14
TPOX	6,10	10,12	6,9	10,12	10,10
D21S11	27,30	29,32	27,27	29,30	27,28
D8S1179	9,11	12,13	17,17	11,12	9,11

	Individual 1	Individual 2	Individual 3	Individual 4	Individual 5
Gender identifier	male	female	female	male	male

Which one of the following conclusions can be made using the information given?

- A. Individual 4 is the father of Individual 5.
- B. Individual 3 is the mother of Individual 4.
- C. Individual 5 could be the child of Individual 1 and Individual 3.
- D. The parents of Individual 4 could be Individual 1 and Individual 2.

Question 40

Plant viruses are a major problem for farmers growing crops. A particular plant virus can infect many different plant species. Scientists are trialling a spray treatment on tobacco crops. The treatment does not alter the DNA of the tobacco plants.

During this treatment, tobacco plants are sprayed with clay nanoparticles containing double-stranded RNA (dsRNA). The dsRNA released from each of the clay nanoparticles enters the plant cells. Inside each cell the dsRNA silences a gene from the virus by causing viral RNA to break down.

In this technique the

- A. dsRNA would have a nucleotide sequence complementary to a section of DNA nucleotides in the tobacco plants.
- B. dsRNA would silence a gene from the virus by initiating changes that prevent translation of the viral gene.
- C. spray treatment would be effective only on tobacco plants and not on other plant species.
- D. sprayed tobacco plants would be regarded as transgenic organisms.

**END OF SECTION A
TURN OVER**

SECTION B

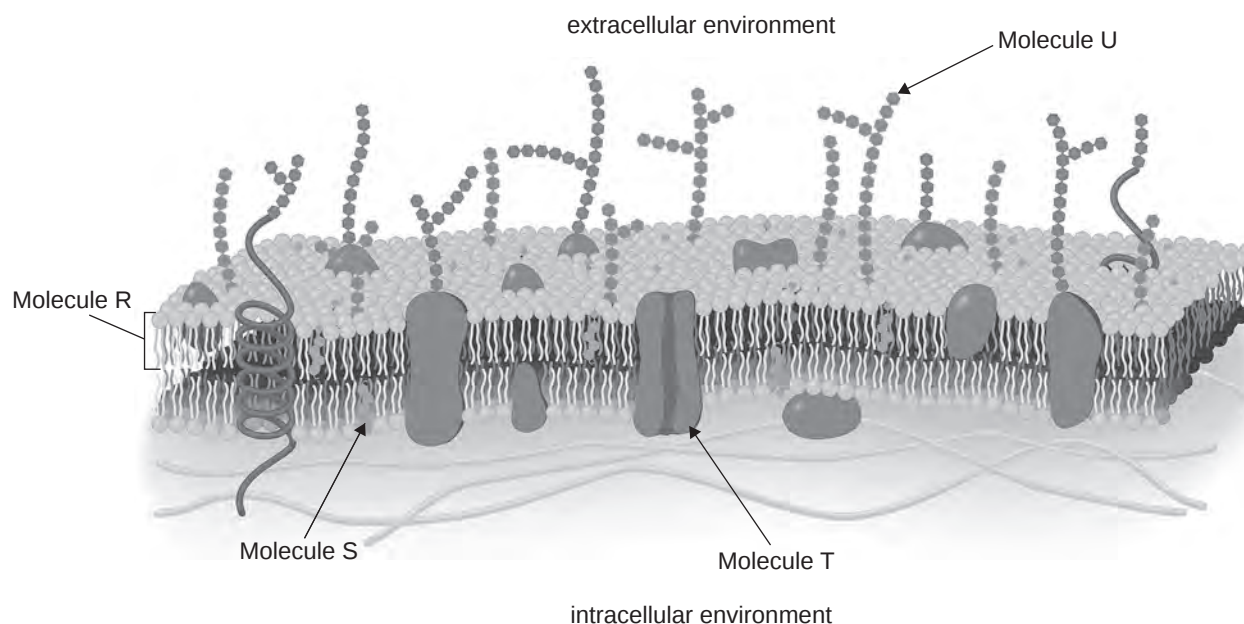
Instructions for Section B

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

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

Question 1 (11 marks)

Consider the diagram of a plasma membrane below.



Source: Jamilia Marini/Shutterstock.com

- a. i. There is a higher concentration of a small hydrophobic molecule in the extracellular environment than in the intracellular environment.

Draw **one** arrow on the diagram above to show the pathway taken by the small hydrophobic molecule across the plasma membrane.

1 mark

- ii. Justify the pathway you have drawn.

2 marks

- b. i.** One of the molecules – Molecule R, Molecule S, Molecule T or Molecule U – contains many amino acids.

Circle the molecule below that contains many amino acids.

1 mark

Molecule R

Molecule S

Molecule T

Molecule U

- ii.** Name the organelle within a cell where the molecule circled in **part b.i.** is synthesised.

1 mark

- iii.** Describe the chemical reaction that takes place to join together the amino acids of this molecule.

3 marks

- c.** Different cells within an organism have different proteins. In some cases different proteins can be coded for by the same gene.

Explain how the expression of a single gene can lead to the production of different proteins.

3 marks

DO NOT WRITE IN THIS AREA

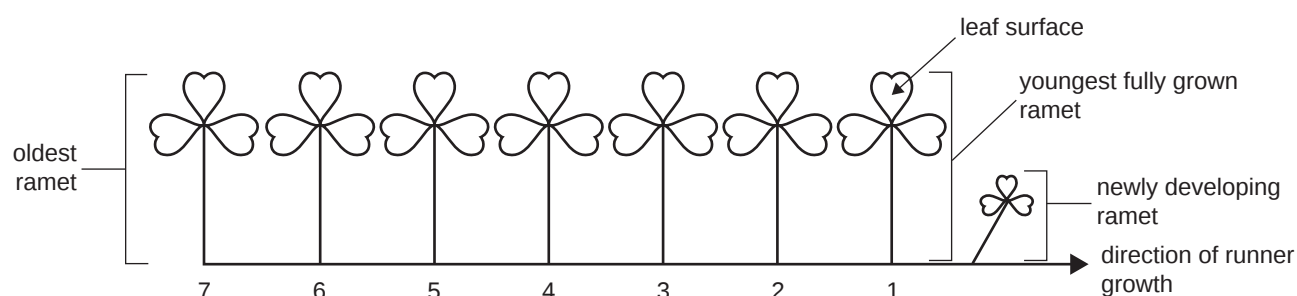
Question 2 (5 marks)

Although plants have no immune systems, they do have many chemical and physical methods of defence against pathogens and attacks by insects.

- a. Describe **one** example of a physical method of defence in a plant.

2 marks

White clover (*Trifolium repens*) reproduces asexually from a runner that grows along the soil surface. The connected new plants are called ramets. The white clover plant in the diagram below is producing ramets in the direction left to right. The fully grown ramets are numbered 1 to 7, from the youngest ramet to the oldest ramet.



Source: adapted from S Gómez, Y Onoda, V Ossipov and JF Stuefer, 'Systemic induced resistance: A risk-spreading strategy in clonal plant networks?', *The New Phytologist*, vol. 179 no. 4 (September 2008), p. 1144

Scientists hypothesised that when *T. repens* ramets are damaged by caterpillars of *Spodoptera exigua*, the damaged ramets stimulate other ramets to defend themselves against attack by the caterpillars. The scientists conducted an experiment to test their hypothesis. The experiment used two genetically identical runners, A and B. The method is outlined in the flow chart on page 23.

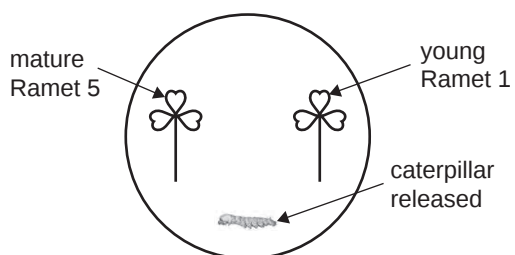
Runner A**Stage 1 – Leaf damage preparation****Runner B**

Ramets 6 and 7 were each enclosed in a separate, plastic mesh cage for four days.

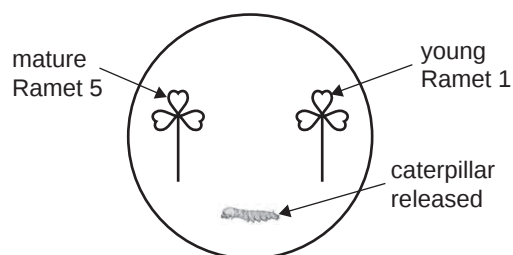
Ramets 6 and 7 were each enclosed in a separate, plastic mesh cage. Each cage contained one caterpillar. The cages were left on for four days, during which time 30% of leaf surfaces were eaten.

Stage 2 – Food choice test

Ramets 1 and 5 were cut off Runner A and placed into a Petri dish. A caterpillar was released midway between the two ramets and allowed to feed freely.



Ramets 1 and 5 were cut off Runner B and placed into a Petri dish. A caterpillar was released midway between the two ramets and allowed to feed freely.

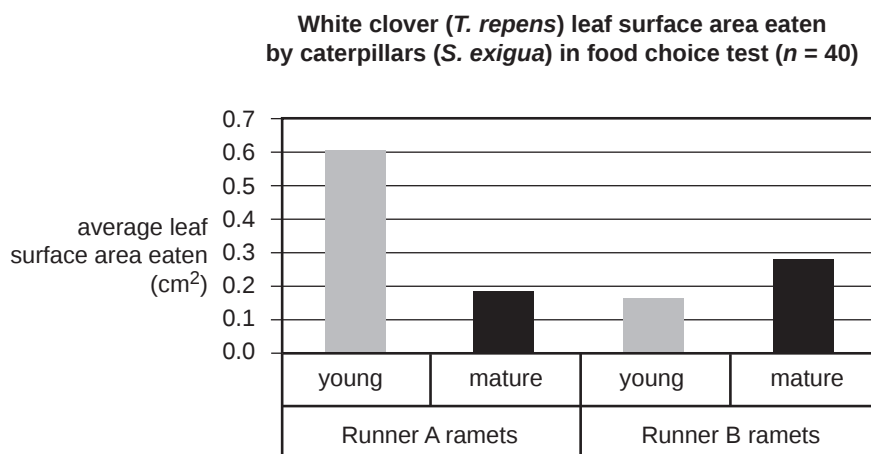


After two days, the leaf surface area eaten on each ramet was measured.

b. What was the role of the Runner A ramets?

1 mark

The experiment was repeated 40 times. The average results obtained after Stage 2 are shown in the graph below.



Data: S Gómez, Y Onoda, V Ossipov and JF Stuefer, 'Systemic induced resistance: A risk-spreading strategy in clonal plant networks?', *The New Phytologist*, vol. 179 no. 4 (September 2008)

- c. Referring to the data, compare the average leaf surface area of young ramets eaten by the caterpillars in Runner A and Runner B.

1 mark

- d. After the experiments, the contents of the leaves were analysed. Significantly higher quantities of phenolic acid were found in the young ramets from Runner B. Phenolic acid acts as a signalling molecule.

It was noticed that the caterpillars preferred to eat the mature leaves in Runner B.

Suggest an effect of the signalling molecule on the cells of the young leaves that would account for the caterpillars' preference for eating the mature leaves in Runner B.

1 mark

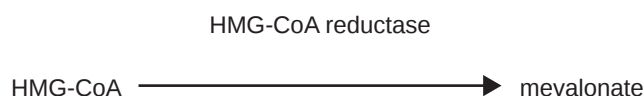
Question 3 (5 marks)

Rational drug design was used by scientists to develop the drug Relenza.

- a. What is meant by the term 'rational drug design'?

2 marks

- b. Many people in Australia have high blood cholesterol levels. High blood cholesterol levels are linked to coronary heart disease. Cholesterol is produced by a series of chemical reactions. One of the reactions in the series is shown below.



Lovastatin is used to treat high blood cholesterol. When administered, the lovastatin is converted to an active form that is a reversible competitive inhibitor of HMG-CoA reductase.

- i. What does this suggest about the structure of the active form of lovastatin?

1 mark

- ii. To successfully treat high levels of cholesterol, lovastatin must be taken every day at regular time intervals.

Considering the mode of action of lovastatin, why is it important to prevent the blood concentration of lovastatin from becoming too low?

2 marks

DO NOT WRITE IN THIS AREA

Question 4 (11 marks)

Australian marsupials, such as wallabies, kangaroos, wombats and koalas, give birth to very undeveloped young called joeys. When a joey enters the mother's pouch, it is at a stage equivalent to a seven-week-old human fetus. It spends many weeks in the pouch feeding on milk produced by mammary glands. Although the pouch provides protection from predators, it is neither sealed nor sterile.

- a. i.** What is meant by the term 'sterile' in the context given?

1 mark

- ii.** Consider a hospital environment. Give **two** examples of how sterile conditions can be achieved in a hospital.

2 marks

The joey's primary immune tissue (in the bone marrow and thymus) does not mature until 30 days after birth and its humoral immunity does not function effectively until 90 days after birth. Biologists have analysed milk samples from several marsupial species and found that they contain various antibodies. Some of the antibodies in the mother's milk remain in the joey's gut, while others cross the gut wall and enter the joey's bloodstream.

- b.** Describe at a molecular level how antibodies perform their function.

2 marks

DO NOT WRITE IN THIS AREA

- c. Name the type of immunity that the joey obtains from the antibodies in the milk and explain how this form of immunity is beneficial to the joey.

3 marks

Scientists have found that the milk of the tammar wallaby (*Macropus eugenii*) contains high levels of peptides with antibiotic properties, as well as lysozyme, complement proteins, cytokines and venom inhibitors.

- d. i. Name the part of the immune system to which these peptides and the other listed chemicals belong.

1 mark

- ii. Circle one of the chemicals below, found in tammar wallaby milk, and describe its role in protecting the joey against pathogens.

1 mark

lysozyme complement proteins cytokines venom inhibitors

Role

- e. Scientists tested the tammar wallaby milk peptides and found them to be 10 times more effective than antibiotics such as tetracycline and ampicillin, which are commonly used to fight human diseases. The scientists are keen to find a pharmaceutical company that will support further testing and development of these peptides with antibiotic properties.

Suggest what the scientists would hope to achieve as a result of further testing of these peptides with antibiotic properties.

1 mark

Question 5 (6 marks)

The rufous bristlebird (*Dasyornis broadbenti*) is a ground-dwelling songbird. The rufous bristlebird is found in gardens near thick, natural vegetation and builds nests in shrubs close to the ground. The rufous bristlebird feeds on ground-dwelling invertebrates. It is a weak flyer and is slow to go back to areas from which it has been previously eliminated. Two distinct populations of rufous bristlebird exist in Victoria. The distribution of each population is shown on the map of Victoria below. The distance between Population A and Population B is over 200 km.



Source: *Flora & Fauna Guarantee Action Statement*, 1993, no. 49;
© The State of Victoria, Department of Sustainability and Environment, 2003

- a. Define the term ‘gene flow’ and explain whether gene flow is likely to occur between these two populations.

3 marks

- b. Both of the rufous bristlebird populations in Victoria are small.

Referring to the theory of natural selection, explain why the rufous bristlebird is at risk of extinction.

3 marks

Question 6 (5 marks)

DNA hybridisation is a molecular technique used to determine the evolutionary relationships between species. DNA is extracted from each species and cut into fragments.

- a. Outline the steps involved in the DNA hybridisation technique following the extraction and cutting of DNA.

3 marks

- b. How does the technique of DNA hybridisation enable scientists to determine the evolutionary relationships between species?

2 marks

DO NOT WRITE IN THIS AREA

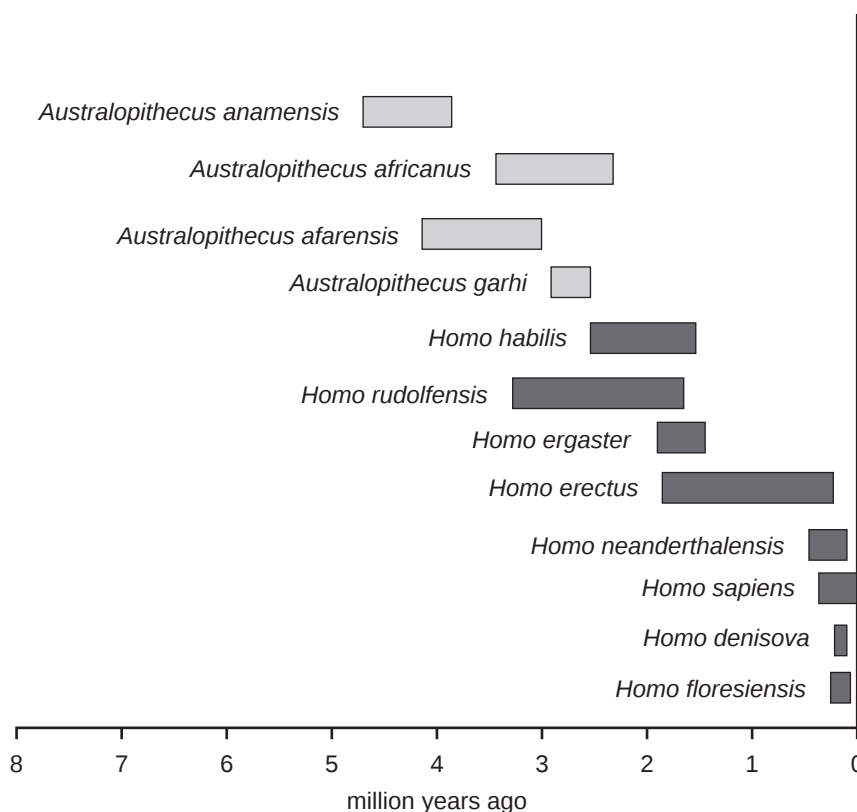
Question 7 (3 marks)

In 2013, about 1500 fossil bones of a hominin species were found in a cave in South Africa. From these bones, scientists have managed to construct an almost complete skeleton. The fossil bones have some features in common with those of the genus *Australopithecus*; however, they have enough similarities to the genus *Homo* that scientists have classified the fossil skeleton as belonging to a new species, *Homo naledi*.

- a. What are **two** features that the fossil skeleton would need to have in order to be classified in the genus *Homo* and not in the genus *Australopithecus*?

2 marks

Finding out the age of these *H. naledi* fossils has been both difficult and controversial. A group of scientists claims that the age of the fossils is more than 2 million years and suggests that *H. naledi* might be a 'link' between *Australopithecus* and *Homo*. A second group of scientists has calculated the age of the *H. naledi* fossils to be only about 900 000 years and claims that *H. naledi* cannot be the 'link' between *Australopithecus* and *Homo*. The diagram below indicates the time periods for different *Australopithecus* and *Homo* species.



- b. If the second group of scientists has correctly dated the *H. naledi* fossils, what evidence from the diagram above supports this group's claim that *H. naledi* cannot be the 'link' between *Australopithecus* and *Homo*?

1 mark

Question 8 (4 marks)

In Australia, genetic screening is carried out on newborn babies.

- a. Explain why it is important to have a genetic screening program for newborn babies. 2 marks

- b. State **two** ethical implications of the genetic screening of newborn babies. 2 marks

DO NOT WRITE IN THIS AREA

Question 9 (7 marks)

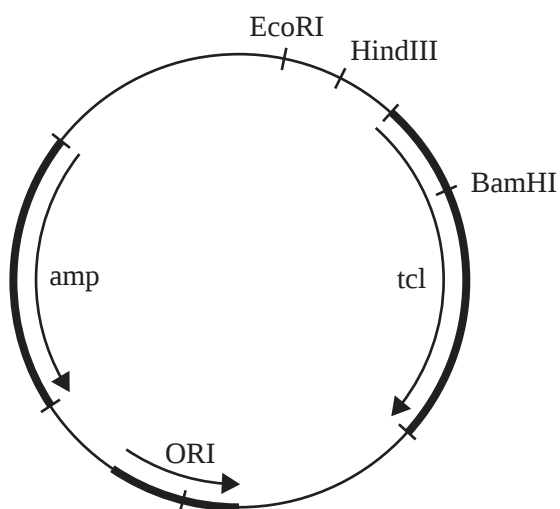
Scientists use recombinant bacterial plasmids as vectors to transform bacteria for a range of purposes in research and biotechnology.

- a. What is meant by the term 'vector' in the context given?

1 mark

A particular bacterial plasmid contains recognition sites for the restriction enzymes EcoRI, HindIII and BamHI, along with two antibiotic-resistant genes, ampicillin resistance (amp) and tetracycline resistance (tcl), and an origin of replication (ORI).

The diagram below shows the positions of these recognition sites and antibiotic-resistant genes as well as the position of the origin of replication within this plasmid.



One purpose of using recombinant bacterial plasmids is to produce bacteria capable of synthesising human protein.

DO NOT WRITE IN THIS AREA

- b. The restriction enzyme BamHI was used to help insert a gene coding for a human protein into this plasmid.

- i. Describe how restriction enzymes such as BamHI are used to help insert a gene coding for a human protein into this plasmid.

2 marks

- ii. Draw and label a diagram in the space below to show the position of the human gene in this plasmid when BamHI is used. Include the position of the recognition sites for the restriction enzymes EcoRI, HindIII and BamHI on the plasmid.

1 mark

- c. After the scientists had carried out the steps required to make plasmids with the inserted human gene, these plasmids were mixed with a culture of bacteria. This mixture was treated so that these plasmids would move into the bacterial cells. Not all bacteria took up these plasmids.

Explain how scientists use antibiotics to identify which of the bacterial cells have been successfully transformed with plasmids carrying the human gene.

3 marks

Question 10 (9 marks)**Aboriginal Australians co-existed with the megafauna for at least 17 000 years**

Australia was once home to giant reptiles, marsupials and birds known as megafauna.

Many researchers have suggested a rapid extinction model to account for the extinction of megafauna thought to have occurred soon after the arrival of the First Australians¹.

The First Australians regularly burnt the landscape to encourage new growth for food and to attract prey for hunting. Perhaps this burning dramatically altered ancient Australia's ecology. One species, the giant flightless bird *Genyornis newtoni*, was shown to have succumbed to significant habitat change and excessive hunting.

In contrast, other evidence shows no record of fire-sensitive plants going through genetic bottlenecks as a result of significant burning events. Furthermore, evidence suggests that for tens of thousands of years, Aboriginal populations were not that large. Some researchers have argued that it is possible many of the 45 or so megafauna species thought to have become extinct may have in fact become extinct tens of thousands of years before the First Australians arrived.

If it can be shown that megafauna disappeared soon after the arrival of the First Australians, then there is support for the rapid extinction model. On the other hand, proof that megafauna and people co-existed suggests that other explanations for their extinction need to be proposed.

Recent dating of a specimen of *Zygomaturus trilobus*, a large wombat-like marsupial, showed that the specimen died around 33 000 years ago. This evidence suggests that people and megafauna co-existed for at least 17 000 years.

It is now possible that the rapid extinction model needs to be abandoned and researchers need to start to untangle how climate may have played a role or how changes in Aboriginal population numbers may have impacted on the ecology of the megafauna.

Source: extract adapted from M Westaway (Griffith University), J Olley (Griffith University), R Grun (Griffith University), 'Aboriginal Australians co-existed with the megafauna for at least 17 000 years', The Conversation website, 12 January 2017, <<https://theconversation.com/au>>

¹**First Australians** – the ancestors of Aboriginal Australians

DO NOT WRITE IN THIS AREA

- a. Using the information in the text, explain how the rapid extinction model may account for the extinction of Australia's megafauna.

3 marks

- b. Complete the following table by identifying three pieces of evidence in the text that cast doubt on the rapid extinction model. Justify how each piece of evidence can be used to reject the rapid extinction model.

6 marks

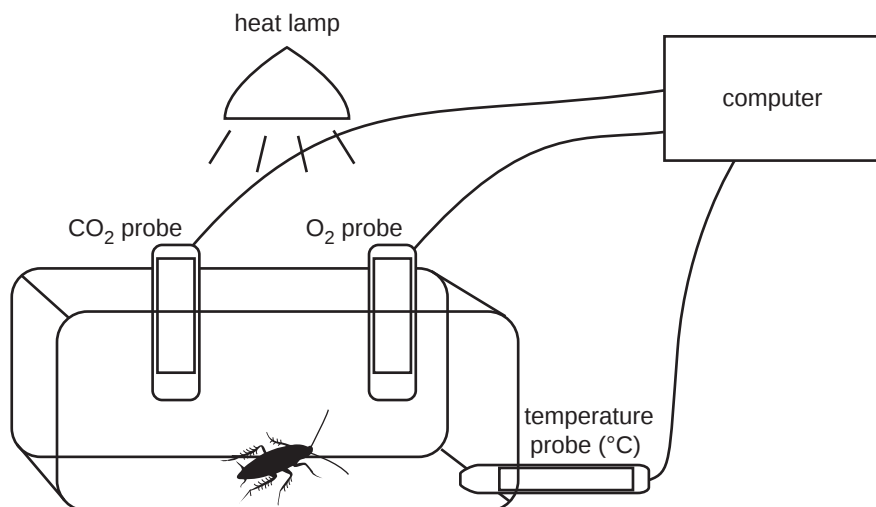
Evidence	Justification
1.	
2.	
3.	

DO NOT WRITE IN THIS AREA

SECTION B – continued
TURN OVER

Question 11 (14 marks)

Matthew investigated how changes in environmental temperature affected oxygen (O_2) and carbon dioxide (CO_2) levels in the air around a cockroach. He used three digital probes linked to a computer, a closed animal chamber and a heat lamp in the experimental set-up shown.



- a. Name the cellular process being investigated in Matthew's experiment.

1 mark

- b. Identify the
- dependent variables

2 marks

- independent variable.

Before placing the cockroach in the chamber, Matthew decided to measure the temperature, and carbon dioxide and oxygen levels for four minutes. The following results were recorded.

Time (minutes)	CO_2 (%)	O_2 (%)	Temperature ($^{\circ}C$)
0	0.04	22.3	29.5
1	0.04	22.1	29.8
2	0.04	22.0	30.0
3	0.04	22.0	30.0
4	0.04	22.0	30.0

- c. Explain why Matthew recorded the data for four minutes and not just one minute.

1 mark

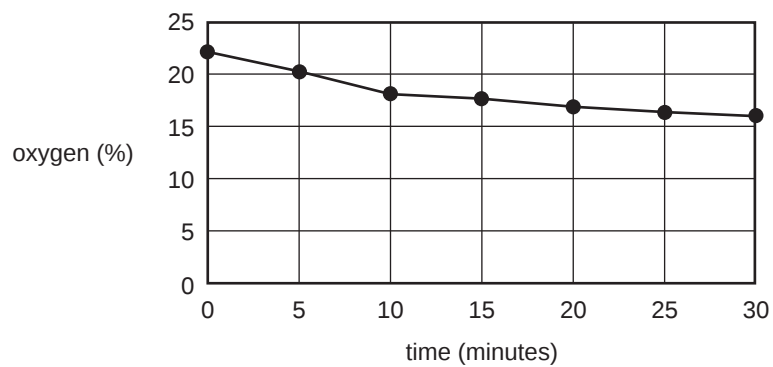
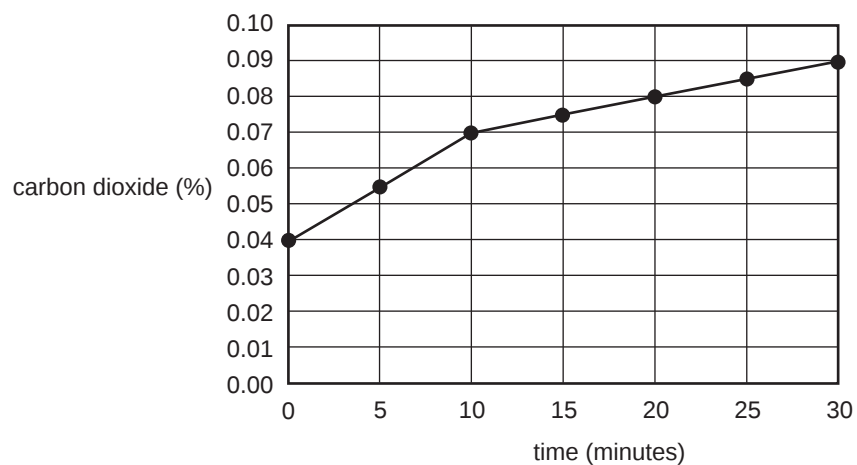
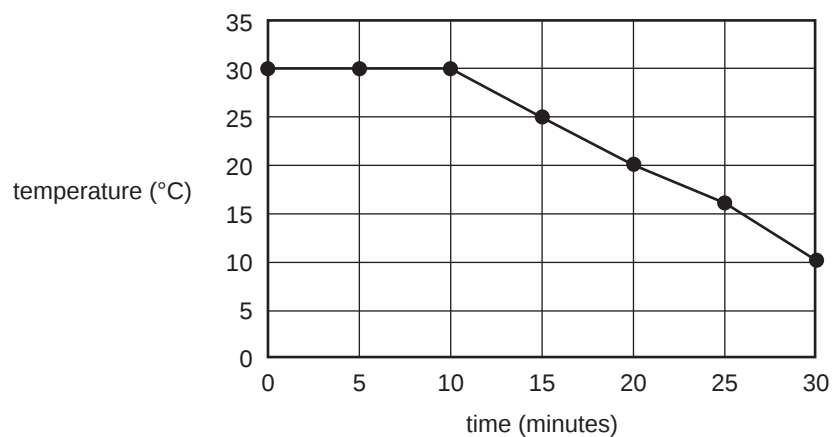
After the initial four-minute period, Matthew quickly placed the cockroach in the chamber and began recording the data from the digital probes. After 10 minutes, he placed ice packs around the sides of the animal chamber to slowly bring the temperature of the chamber down to 10 °C. He recorded the data using the digital probes for a further 20 minutes. He repeated the experiment once every day for the next six days with the same cockroach. At all times, he took care to ensure that the cockroach showed no signs of stress.

- d. Other than repeating the entire experiment, identify **two** control measures Matthew should have included in his experimental design. Explain how each of these control measures could affect the results if not kept constant.

4 marks

DO NOT WRITE IN THIS AREA

Matthew constructed the following graphs from the averaged results of the seven experiments.



DO NOT WRITE IN THIS AREA

- e. i. Using the graphical data, describe the changes in the levels of carbon dioxide and oxygen when the temperature in the chamber was kept constant compared to when the temperature was decreasing.

2 marks

- ii. What conclusion do you think Matthew can draw from his investigation? You should refer to each of the following in your response:

- the cellular process named in **part a.**
- the variables identified in **part b.**
- the evidence collected during Matthew's experiments

4 marks
