VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

Victorian Certificate of Education 2017

SUPERVISOR TO ATTACH PROCESSING LABEL HERE

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

BIOLOGY
Written examination

Friday 2 June 2017

Reading time: 10.00 am to 10.15 am (15 minutes)
Writing time: 10.15 am to 12.45 pm (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	70
			Total 110

- 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 36 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.
- 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** for 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.

Question 1

Cellulose belongs to the group of biomacromolecules called

A. triglycerides.

B. polypeptides.

C. nucleic acids.

D. polysaccharides.

Question 2

Which one of the following statements about cellulose is true?

A. It is composed of the same monomer as proteins.

B. It does not provide stability to the plant cell.

C. It is synthesised via condensation reactions.

D. It has exactly the same structure as starch.

Question 3

Both plant and animal cells have plasma membranes. Consider the structure of the plasma membranes of plant cells.

The plasma membranes of plant cells

A. have identical proteins to the plasma membranes of animal cells.

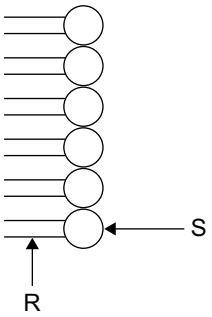
B. have a phospholipid bilayer structure similar to animal cells.

C. are made up mainly of fats and starch.

D. contain mainly cellulose.

Question 4

Six molecules that form part of the plasma membrane of an animal cell are shown below.



Which one of the following statements is true?

A. The R portions of the molecules are on the outer surface of the cell.

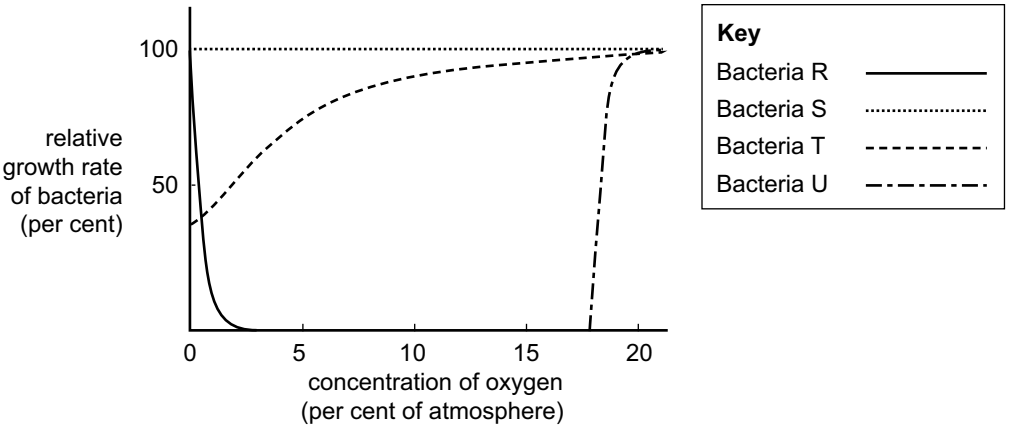
B. The S portions of the molecules represent the hydrophilic phosphate heads.

C. Both the S and R portions of the molecules remain fixed in position within the membrane.

D. The S and R portions of the molecules together allow for the easy transport of glucose.

Question 5

The graph below shows the growth rate of different types of bacteria when the bacteria are exposed to varying concentrations of atmospheric oxygen.



Based on your knowledge and the information in the graph, which one of the following statements is true?

A. Bacteria R are unable to carry out anaerobic respiration.

B. Bacteria U are poisoned by a high concentration of oxygen.

C. Bacteria S are able to carry out both aerobic and anaerobic respiration.

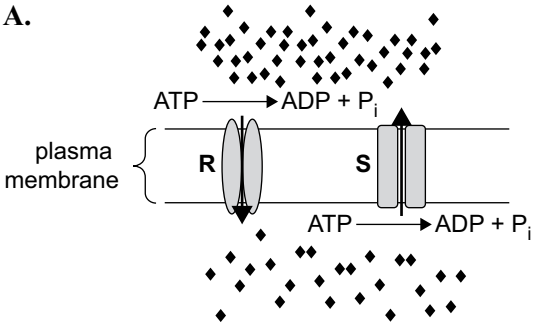
D. Bacteria T are unable to carry out both aerobic and anaerobic respiration.

Question 6

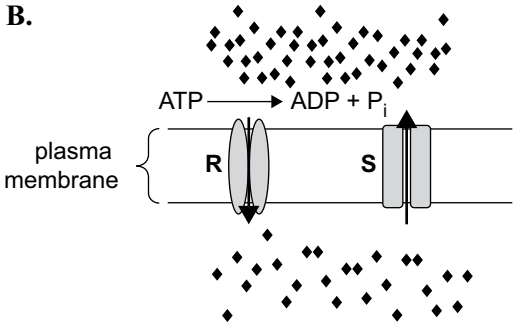
Which one of the following diagrams is a correct representation of the way the ions move across a plasma membrane?

Key
- ♦ ions on either side of plasma membrane
- **R** ion pump
- **S** ion channel

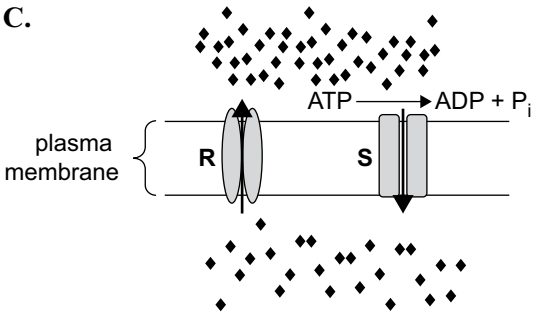
A.



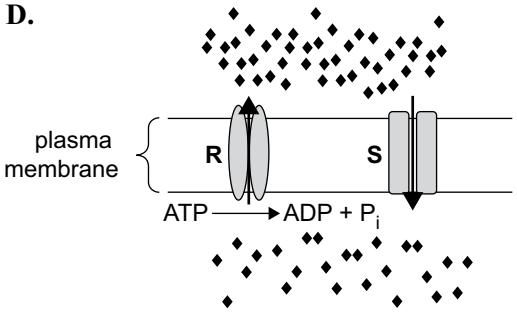
B.



C.



D.



Question 7

When a hydrophilic signalling molecule reaches a target cell, which sequence of steps occurs?

A. binding to glycolipid on cell surface, transduction, response

B. binding to protein receptor on cell surface, transduction, response

C. binding to cytoplasmic receptor molecule, transduction, response

D. binding to endoplasmic reticulum receptor molecule, stimulation of gene regulator, transduction, response

Question 8

When rats are stressed, they release a chemical that appears to cause other rats nearby to become anxious. This chemical is a

A. neurotransmitter.

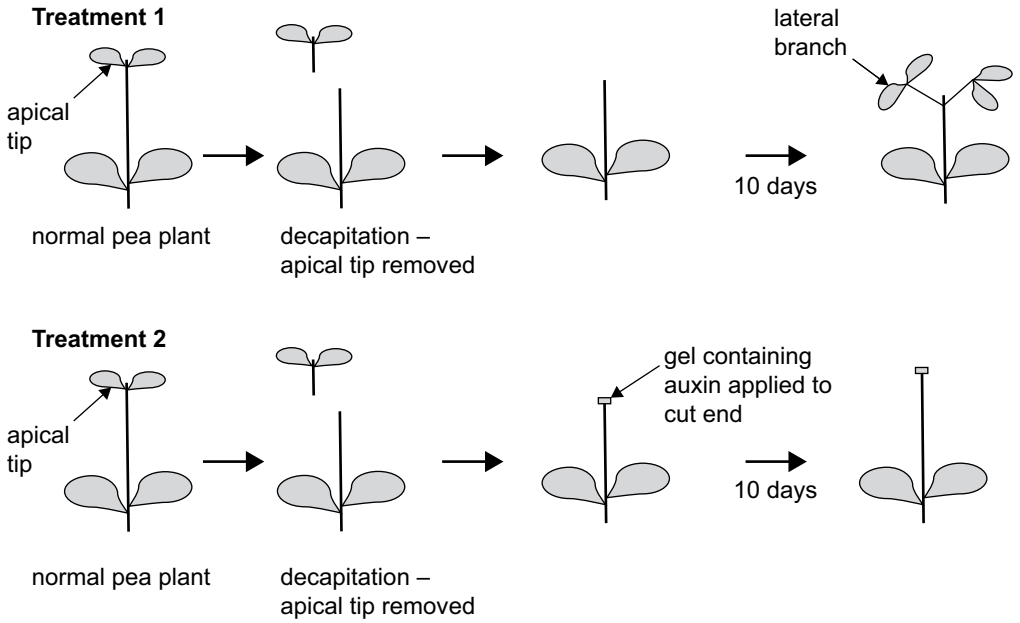
B. pheromone.

C. pathogen.

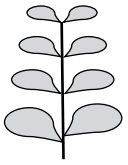
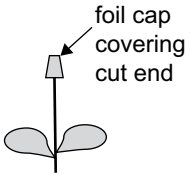
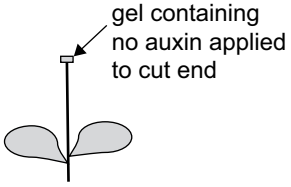
D. enzyme.

Question 9

To test the hypothesis that auxin produced in the apical tip inhibits the lateral growth of branches in peas, a student set up an experiment as shown in the diagram below.



Which one of the following is a control for Treatment 2?

A.	a pea plant with the bottom leaves removed	
B.	an intact pea plant with many leaves	
C.	a decapitated pea plant with a foil cap placed on the cut end	
D.	a decapitated pea plant to which a gel containing no auxin is applied to the cut end	

Question 10

Which one of the following statements about the transmission of a nerve signal is true?

A. A nerve impulse is facilitated by Na^+/K^+ pumps on the membrane of the neuron.

B. Calcium ions are involved in the transmission of the impulse along the neuron.

C. The greater the stimulus, the greater the size of the nerve impulse.

D. Neurotransmitters are actively transported across the synapse.

Question 11

When apoptosis is initiated by DNA damage in a cell

A. the plasma membrane ruptures, releasing the cell contents.

B. a cascade of reactions occurs in the cytoplasm.

C. all enzyme activity within the cell is inhibited.

D. uncontrolled replication of the cell occurs.

Question 12

The lymphatic system plays an important role in defending the human body against disease.

Which one of the following is true of the lymphatic system?

A. Lymph nodes provide a natural barrier against the entry of pathogens into the internal environment.

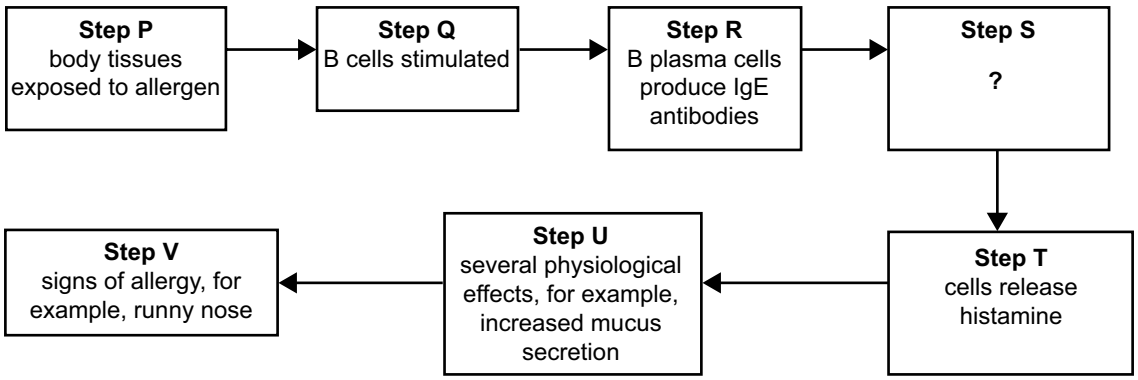
B. Lymph contains hydrochloric acid, which kills many bacteria.

C. Cells within the lymph nodes detect antigens.

D. Lymph contains mucus to trap bacteria.

Use the following information to answer Questions 13 and 14.

In extremely rare cases, injection of an influenza vaccine may cause an allergic reaction, which usually occurs within a few hours of the vaccine being administered. The flow chart below outlines the key stages in an allergic response.



Question 13

Which one of the following statements best summarises Step S?

A. Cytotoxic T cells are activated.

B. Secreted IgE antibodies bind to mast cells.

C. Complement proteins stimulate T-helper cells.

D. Secreted IgE antibodies attach to macrophages.

Question 14

Another example of a physiological effect at Step U and a resulting sign of allergy at Step V could be

A. capillaries becoming permeable and leaky, causing swelling.

B. increasing numbers of phagocytes, leading to redness of the skin.

C. vasodilation of the skin blood vessels, leading to paleness of the skin.

D. relaxation of the smooth muscles in lung tubules, causing breathing difficulties.

Question 15

Guillain-Barré syndrome is a human autoimmune disease that affects the nervous system. There is no cure for Guillain-Barré syndrome, but researchers have developed a treatment that can reduce the symptoms of Guillain-Barré syndrome in patients.

Which one of the following could be a useful treatment for Guillain-Barré syndrome?

A. vaccination with an attenuated form of the Guillain-Barré pathogen in order to develop B memory cells

B. injection of phagocytic cells that have been developed to recognise and destroy the Guillain-Barré pathogen

C. repeated removal of the patient's blood and filtering of antibodies before returning the blood to the patient's body

D. administration of higher-than-normal doses of the antibiotic penicillin within the first 48 hours of symptoms of Guillain-Barré syndrome being noticed

Question 16

Canola is an economically important crop plant in Australia. Pathogens that reduce canola production are a concern to growers. One significant disease is blackleg, caused by the fungus *Leptosphaeria maculans.* A detailed examination of infected canola stems has shown the presence of the fungus.

The structure of the *L. maculans* pathogen consists of

A. a single protein molecule.

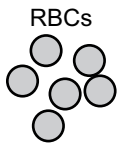
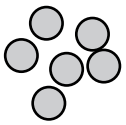
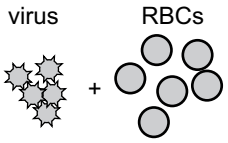
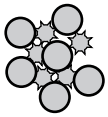
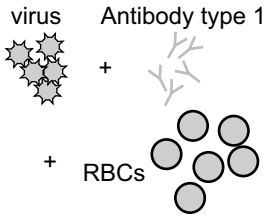
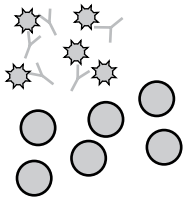
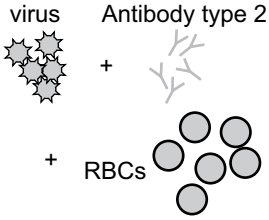
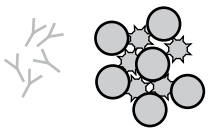
B. cells without DNA molecules.

C. a protein coat enclosing RNA molecules.

D. cells with a cell wall and a nuclear membrane.

Question 17

Scientists performed an experiment in which they observed the interaction of red blood cells (RBCs), antibodies and the influenza virus. Different combinations of these were mixed together in small containers called wells. Two different antibodies were tested. The results are shown below.

	Components added to the well	**Interaction**	**Observation**
Well A			no clumping of red blood cells
Well B			clumping of red blood cells
Well C			no clumping of red blood cells
Well D			clumping of red blood cells

Source: adapted from Centers for Disease Control and Prevention (www.cdc.gov/)

Which one of the following would be a reasonable conclusion to draw?

A. Antibody type 1 is not specific to the surface proteins of the virus.

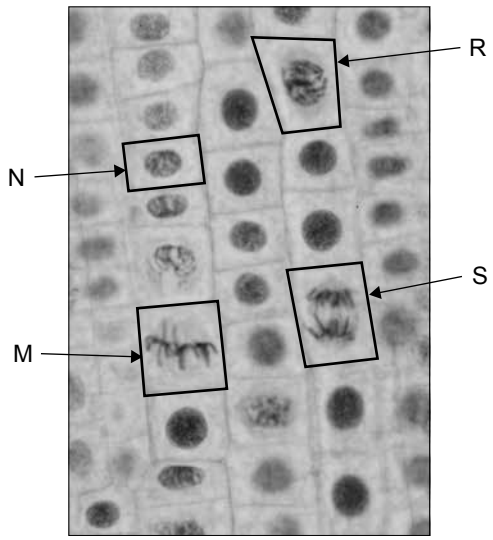
B. Antibody type 2 prevents interaction between the RBCs and the virus.

C. In Well B, the RBCs and the surface proteins of the virus do not interact with each other.

D. In Well C, the antigen–antibody interaction interferes with the RBCs binding to the virus.

Use the following information to answer Questions 18 and 19.

Consider the following photograph of onion cells undergoing cell division. These cells were found in a growing root tip.



Source: PIYAPONG THONGDUMHYU/ Shutterstock.com

Question 18

Which one of the following is a correct statement?

A. Homologous chromosomes are paired in the cell labelled R.

B. Each chromosome in the cell labelled M will contain one molecule of DNA.

C. Separated sister chromatids are moving to opposite poles of the cell labelled S.

D. The nucleus of the cell labelled N has half the number of chromosomes compared to its parent nucleus.

Question 19

The stage of cell division at which the nuclear envelope arises from fragments of the parent nuclear envelope, and the nucleoli reappear, is shown by the cell labelled

A. M.

B. N.

C. R.

D. S.

Question 20

Consider cells dividing by meiosis.

The cells produced

A. are the result of one nuclear division and two divisions of the cytoplasm.

B. have the same number of chromosomes as the parent cell.

C. are genetically identical to each other.

D. are haploid.

Question 21

During meiosis, the process of crossing over

A. involves the exchange of genetic material between non-sister chromatids of homologous chromosomes.

B. occurs between sections of non-homologous chromosomes.

C. results in less genetic variation in the gametes.

D. occurs during the second meiotic division.

Question 22

Synthesis of DNA molecules is required in the production of new cells.

Which one of the following is a correct statement about the synthesis of DNA molecules?

A. DNA primers act as a starting point for the synthesis of new DNA molecules.

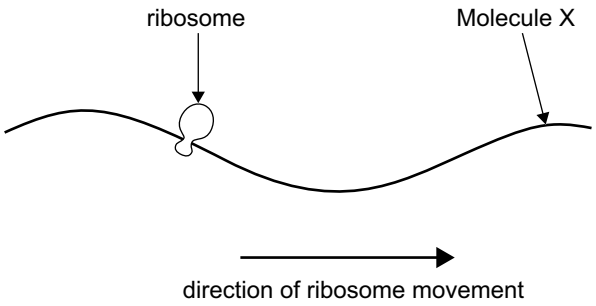
B. The synthesis of DNA molecules occurs in the G_2 stage of the cell cycle.

C. Only one strand of the original DNA molecule acts as a template.

D. DNA polymerase joins nucleotides to a growing strand of DNA.

Use the following information to answer Questions 23 and 24.

Ricin is a naturally occurring, powerful poison that affects eukaryotic organisms. Large mammals that ingest small amounts of ricin can die within three to five days. Studies have concluded that ricin stops the movement of a ribosome along a specific molecule. This specific molecule has been labelled Molecule X in the diagram below.



Question 23

What is the name of Molecule X?

A. rRNA

B. tRNA

C. mRNA

D. pre-mRNA

Question 24

Eukaryotic organisms die from ricin poisoning because the ricin immediately causes

A. nerve damage to motor neurons.

B. the process of mitosis in the cells to stop.

C. irreversible damage to DNA in the nuclei of cells.

D. the process of protein synthesis in the cells to stop.

Question 25

A section of a DNA strand has the base sequence AGCGCATAGCAA.

During DNA replication to form the complementary DNA strand, a mutation involving a single base substitution occurred in the last triplet of this section.

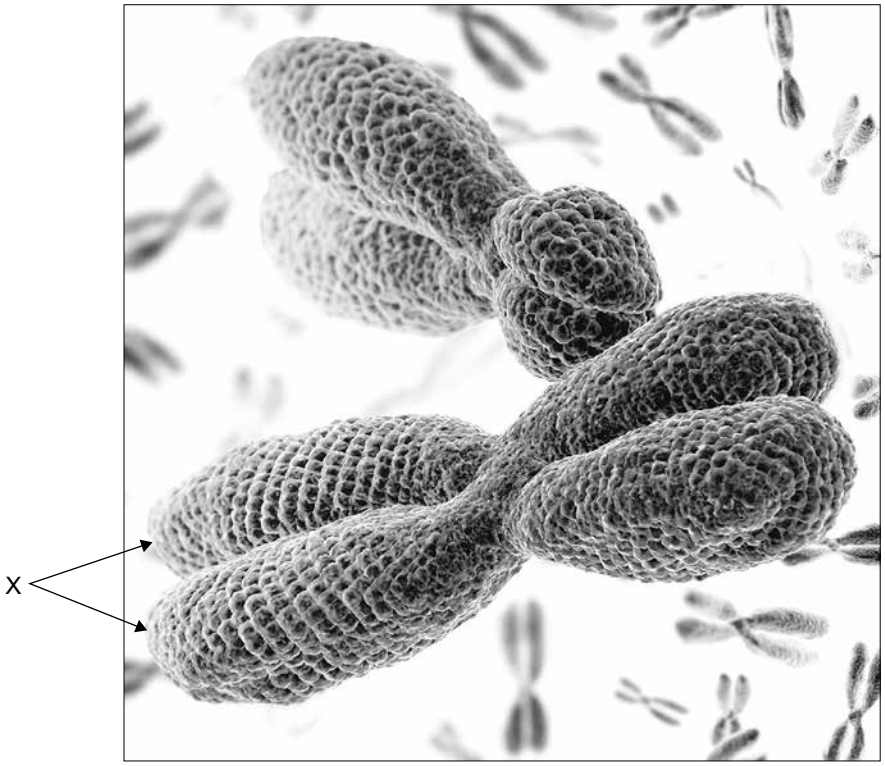
This mutation was then passed on to the mRNA when transcription of the complementary strand occurred.

The base sequence of the mRNA containing the mutation could be

A. AGCGCAUAGCAA
B. AGCGCAUAGUAA
C. UCGCGUAUCGUU
D. UCGCGUAUCAUU

Question 26

Consider the diagram of the chromosomes below.



Source: Iaremenko Sergii/Shutterstock.com

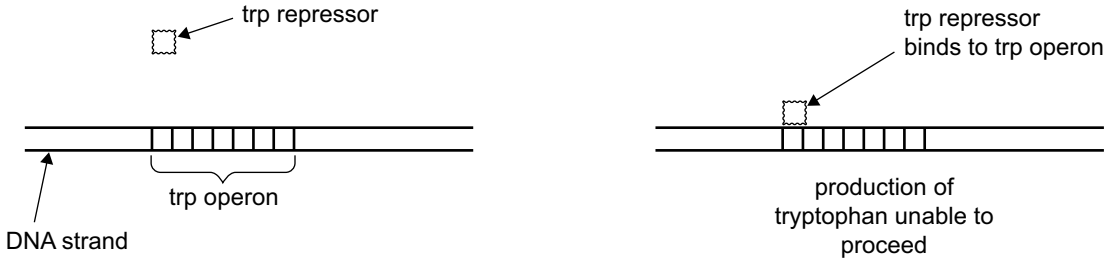
The structures labelled X are

A. centromeres.
B. spindle fibres.
C. sister chromatids.
D. homologous chromosomes.

Use the following information to answer Questions 27 and 28.

Tryptophan is an amino acid that is produced by many bacteria. Genes that code for the production of tryptophan are found on bacterial DNA and together are called the trp operon.

In the process of gene regulation, a repressor protein (trp repressor) binds to the trp operon. When such binding occurs, the process of tryptophan production stops. This is illustrated in the diagram below.



Question 27

When the trp repressor binds to the trp operon, which one of the following enzymes would be blocked from functioning normally?

A. RNA polymerase

B. DNA polymerase

C. endonuclease

D. DNA ligase

Question 28

Which one of the following factors would increase the concentration of the trp repressor in bacterial cells?

A. low concentration of tryptophan

B. high concentration of tryptophan

C. high concentration of DNA ligase

D. low concentration of DNA polymerase

Use the following information to answer Questions 29 and 30.

Haemophilia A is a recessive genetic disorder. Humans with this disorder tend to bleed more than normal because one of the proteins needed in blood clotting is missing. The gene controlling the production of this protein is found on the X chromosome. This gene has two alleles.

Question 29

A female carrier of haemophilia A

A. will be homozygous with respect to this gene.

B. has one copy of each of the alleles of this gene.

C. will have the same genotype as a female with haemophilia A.

D. passes the allele for haemophilia A to all of her daughters.

Question 30

Consider the children of a father whose blood clots normally and a mother who is a carrier of haemophilia A.

Which one of the following is a correct statement about the children of these parents?

A. Each child will have an equal chance of inheriting haemophilia A.

B. Daughters will have a 50% chance of inheriting haemophilia A.

C. All daughters will be homozygous with respect to this gene.

D. Sons will have a 50% chance of inheriting haemophilia A.

Question 31

In a population, a trait will be more likely to show continuous variation if

A. the trait is influenced by many genes.

B. genes controlling the trait are closely linked.

C. there is a low mutation rate in the gene controlling the trait.

D. the environment has little effect on the expression of the trait.

Use the following information to answer Questions 32 and 33.

The presence of horns and the colour of hair in goats (*Capra hircus*) are genetically inherited. In a particular breed of goats, hair colour may be brown or white. These goats may have horns or horns may be absent.

Question 32

Crosses between individual goats were performed and the phenotypes of the offspring were recorded. The results of the crosses are shown in the table below.

Cross	Phenotypes of parents	Phenotype(s) of offspring
1	brown × white	brown
2	brown × brown	some brown and some white
3	white × white	white
4	horns × no horns	no horns
5	horns × horns	horns
6	no horns × no horns	some with horns and some with no horns

Based on the information provided, which one of the following conclusions can be made?

A. All goats with brown hair have the same genotype with respect to hair colour.

B. The brown-haired parent in cross 1 is heterozygous with respect to hair colour.

C. All goats with horns have the same genotype with respect to the presence or absence of horns.

D. The two parents without horns in cross 6 have different genotypes with respect to the presence or absence of horns.

Question 33

To determine if the gene for hair colour and the gene for the presence or absence of horns are linked, the following crosses were carried out.

Cross	Phenotypes of parents	Phenotypes of offspring and ratio
1	brown hair, no horns × white hair, horns	all have brown hair, no horns
2	brown hair, no horns × brown hair, no horns	9 brown hair, no horns : 3 brown hair, horns : 3 white hair, no horns : 1 white hair, horns
3	brown hair, no horns × white hair, horns	1 brown hair, no horns : 1 brown hair, horns : 1 white hair, no horns : 1 white hair, horns
4	brown hair, no horns × white hair, horns	4 brown hair, no horns : 1 brown hair, horns : 1 white hair, no horns : 4 white hair, horns

Evidence that the genes are linked would be provided by

A. cross 1.

B. cross 2.

C. cross 3.

D. cross 4.

Question 34

Radio-isotopic dating (radiometric dating) is used to determine the age of fossils and their surrounding rocks.

Which statement about radio-isotopic dating is true?

A. Radio-isotopic dating techniques are only reliable when dating fossils that were formed less than 20 million years ago.

B. Radio-isotopic dating calculations assume that the breakdown of a radioactive isotope occurs at a constant rate.

C. Carbon is the best element to provide useful radio-isotopic dating evidence for calculating the age of all fossils.

D. Radio-isotopic dating techniques cannot provide an estimate of how many years ago a fossil was formed; they are only useful to compare if one fossil is older than another.

Question 35

Researchers studied the phylogenetic relationship between two amphibian species, Species G and Species H.

Based on molecular homology, which one of the following would be useful evidence to help determine the relationship between the two species?

A. The rate of a particular metabolic reaction, catalysed by the same enzyme, is considerably faster in Species G than in Species H.

B. The structure of the eye muscles is significantly different between the two species.

C. The amino acid sequence of a particular protein is the same in both species.

D. The molecule tRNA is present in both species.

Question 36

Comparative genomics

A. is a tool used by scientists to study evolutionary change.

B. compares the biogeographical distribution of present-day species.

C. is the study of the homologous and analogous structures of different species.

D. relies on the ability of scientists to separate different carbohydrates from the cells of different species.

Question 37

Several species of flightless birds can be found on different landmasses of the world. Examples include the African ostrich, the Australian emu and the New Zealand kiwi.

Recent studies have made scientists rethink the evolutionary relationship between flightless birds.

Scientists now hypothesise that these flightless birds have evolved by convergent evolution.

This suggests that

A. the loss of the ability to fly developed independently in each of the three bird species.

B. each of the three bird species occupies very different ecological niches.

C. the ostrich, the emu and the kiwi share a recent common ancestor.

D. the rate of mutation in each of the three bird species is high.

Question 38

Which of the following characteristics are shared by both hominoids and hominins?

A. colour vision, omnivorous, nails, opposable thumbs, simple tool use, living in groups

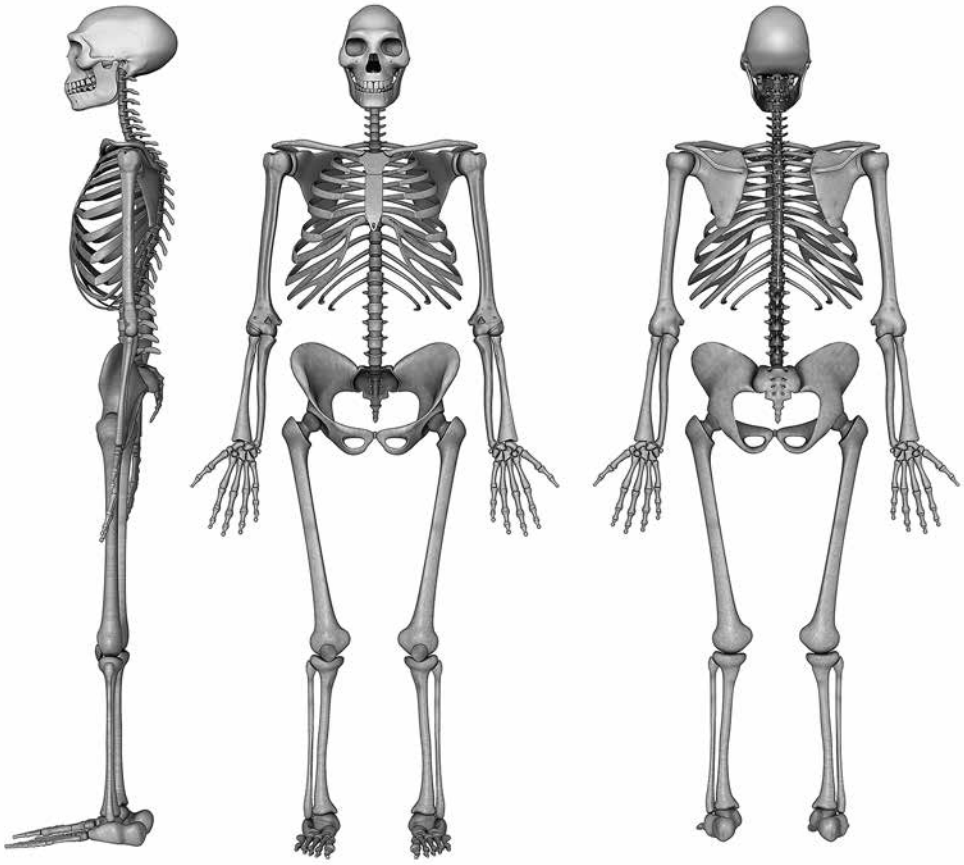
B. colour vision, carnivorous, highly developed sense of smell, forward-facing eyes, solitary living

C. poor vision, eats only fruit, poor sense of smell, claws, highly developed hearing, living in groups

D. well-developed peripheral vision, herbivorous, poor sense of smell, forward-facing eyes, well-developed hearing, living in groups

Question 39

The diagram below shows three views of the skeleton of a hominin species.



Source: 3drenderings/Shutterstock.com

Based on your knowledge and the information provided in the diagram, which one of the following is a correct statement?

A. The species shown in the diagram is older than *Australopithecus afarensis*.

B. The species shown in the diagram has a pelvic structure allowing bipedal locomotion.

C. The species shown in the diagram has a sloping forehead similar to modern-day humans.

D. The species shown in the diagram has prominent brow ridges similar to those seen in all hominin species.

Question 40

Fossil bones of the hominin species *Homo floresiensis* were discovered in a cave on the Indonesian island of Flores. The fossil bones have been dated from about 100 000 to 60 000 years ago.

This suggests that this species lived at the same time as members of our own species, *Homo sapiens*. Scientists looked for evidence of cultural evolution in the cave where the fossil remains of *H. floresiensis* were found.

Evidence of cultural evolution could include

A. footprints indicating that *H. floresiensis* was bipedal.

B. hand bones that indicate that *H. floresiensis* had an opposable thumb.

C. an average body size in *H. floresiensis* that is smaller than that of *H. sapiens*.

D. *H. floresiensis* being found with various fossilised burnt animal bones with cut marks on them.

END OF SECTION A
TURN OVER

SECTION B – Short-answer questions

Instructions for Section B

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

Question 1 (6 marks)

Haemoglobin is the molecule in red blood cells that delivers oxygen to cells throughout the body. In adults, haemoglobin normally consists of four sub-units: two sub-units of beta-globin and two sub-units of alpha-globin. Each sub-unit is bound to an iron-containing molecule called haem. The haem molecule binds to oxygen.

a. Name the group of biomacromolecules that haemoglobin belongs to. 1 mark

b. Sickle-cell disease (SCD) is a group of blood disorders. People with SCD may have just a single nucleotide change in the HBB gene – the segment of DNA that codes for the beta-globin of the haemoglobin. This results in an altered haemoglobin molecule.

Explain how a single nucleotide change in the HBB gene can alter the structure of the haemoglobin molecule in people with SCD. 2 marks

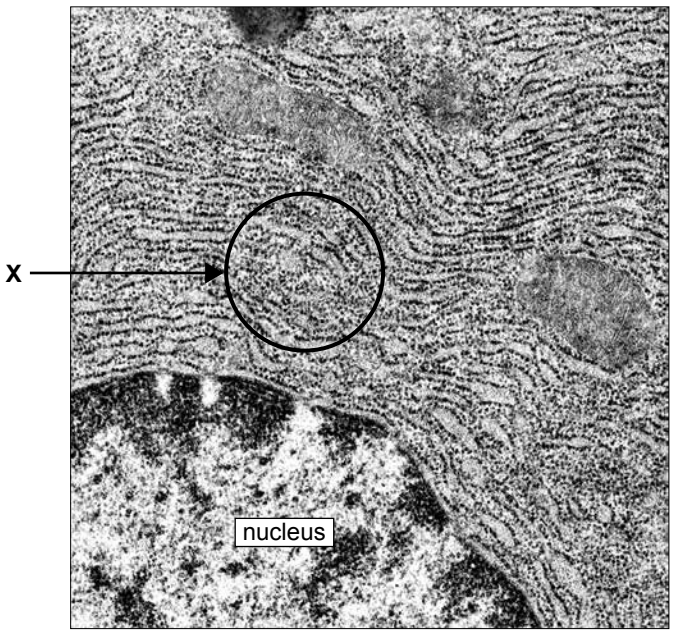
c. Recent advances in DNA-editing techniques have great potential to cure conditions such as SCD. One such technique involves the use of RNA. RNA is a molecule closely related to DNA.

Complete the table below to provide a comparison between DNA and RNA. 3 marks

	DNA	**RNA**
Names of nucleotide bases present		
Function 1		
Function 2		

Question 2 (4 marks)

A transmission electron micrograph of part of a cell is shown below. The nucleus of the cell has been labelled.



Source: Jose Luis Calvo/Shutterstock.com

The cell shown above is a secretory cell. The secretory product of the cell is synthesised by an organelle, part of which is enclosed by the circle labelled X.

a. Name this organelle. 1 mark

_____

b. Describe the transportation pathway taken by the secretory product from the organelle named in **part a.** until it leaves the cell. 3 marks

_____

_____

_____

_____

_____

_____

Question 3 (5 marks)

a. **i.** Give an example of a catabolic reaction that occurs in a cell. 1 mark

ii. Justify why this reaction is classified as a catabolic reaction. 1 mark

b. A protein called AMP-activated protein kinase (AMPK) has been shown to control metabolic reactions in cells. AMPK regulates the level of ATP in the cell, controlling the rate of both anabolic and catabolic reactions so that the level of ATP remains optimal for cellular activities.

i. Complete the following table using the words 'increases' or 'decreases' to indicate how the rate of cellular reactions is controlled by AMPK when the level of ATP within the cell falls. 1 mark

	Type of cellular reaction	
	Catabolic	**Anabolic**
Rate of cellular reaction		

ii. Give a reason for each of your answers to **part b.i.** 2 marks

Question 4 (7 marks)

The smoke produced during a fire is usually more dangerous than the heat. Two of the many toxic chemicals in the smoke of a fire are carbon monoxide and hydrogen cyanide.

Carbon monoxide molecules bind to haemoglobin molecules in the blood, reducing the blood's capacity to transport oxygen. This causes a significant reduction in oxygen supply to the cells of the body.

a. Oxygen is required for the process of cellular respiration. The three stages of this process are listed in the table below.

Complete the table by naming the missing inputs and outputs of each stage of cellular respiration when normal oxygen levels are available. 3 marks

Stage	Inputs	Outputs
glycolysis	_____ $ADP + P_i$ $NAD^+ + H^+$	_____ ATP NADH
Krebs cycle	_____ $ADP + P_i$ $NAD^+ + H^+$ $FAD + 2H^+$	_____ ATP NADH $FADH_2$
electron transport chain	_____ $ADP + P_i$ NADH $FADH_2$	_____ ATP $NAD^+ + H^+$ $FAD + 2H^+$

b. Suggest why blood lactate (lactic acid) levels might be used to diagnose carbon monoxide poisoning. 1 mark

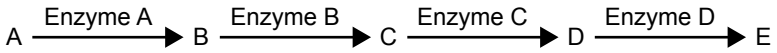
_____

_____

c. Hydrogen cyanide is an inhibitor of the enzyme cytochrome c oxidase, an important enzyme in the electron transport chain.

Explain how a molecule such as hydrogen cyanide may act as an inhibitor of the enzyme cytochrome c oxidase. 2 marks

d. Refer to the general biochemical pathway shown below.



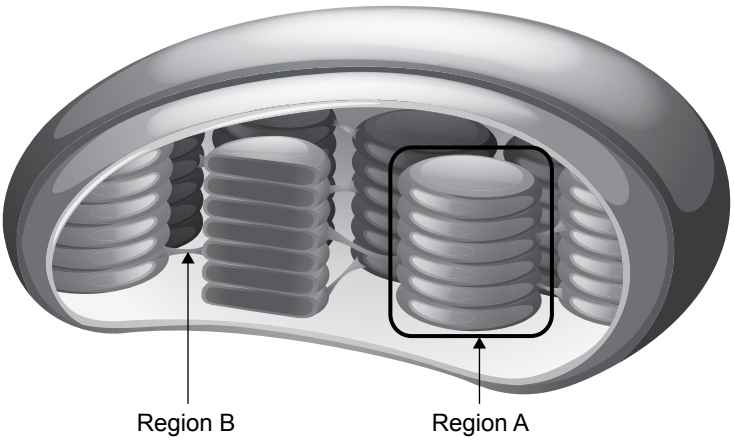
Describe what happens when any one of the enzymes A, B, C or D in the pathway is inhibited. 1 mark

Question 5 (7 marks)

a. On the diagram of the chloroplast below, use labelled arrows to indicate the positions of the following structures:

- grana
- stroma

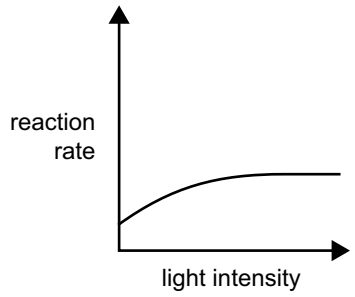
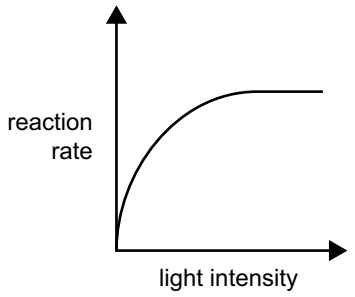
2 marks



Source: BlueRingMedia/Shutterstock.com

b. Two students set up an experiment to measure the reaction rate of the light-dependent stage of photosynthesis. Thylakoid membranes were removed from chloroplasts and suspended in solution. The membranes were then exposed to differing light intensities and the rate of the reaction was measured. Student A was given thylakoid membranes from Region A and Student B was given thylakoid membranes from Region B. Both followed the same method.

The results obtained by both students are shown below.

Student A	**Student B**
	

i. What could the students have measured in their experiment to indicate the reaction rate? 1 mark

_____

ii. State **two** factors that each student must control when setting up their experiment so that they can compare their results and know that their results are valid. 2 marks

_____

_____

iii. Each student set up their experiment in an identical manner.

Explain the differences observed in their results. 2 marks

_____

_____

Question 6 (8 marks)

a. Innate immunity helps protect humans from invading pathogens.

How does the skin help protect humans from invading pathogens? 1 mark

Research suggests that the microorganisms that normally live on the skin have a very complex and beneficial relationship with their hosts. *Staphylococcus epidermidis* is one of the most common species of bacteria on human skin. To investigate the possible beneficial role of this bacterium, scientists designed an experiment as follows.

Two groups of mice were used. The mice in Group 1 had *S. epidermidis* applied to their skin. The mice in both Group 1 and Group 2 were infected with a pathogenic fungus. The mice were left for several days, and then scientists measured the levels of antigen-presenting cells (APCs) and cytotoxic T cells (T_c cells) in the skin of the mice from both groups.

b. Describe the role of APCs in an immune response. 2 marks

c. In which type of immune response would the T_c cells and APCs play a part? 1 mark

d. In addition to the levels of APCs and T_c cells, the growth of the pathogenic fungus was also measured in all of the mice. The results of this experiment are summarised in the table below.

Mice	Level of APCs	Level of T_c cells	Growth of the pathogenic fungus
Group 1	high	high	no growth on skin
Group 2	low	low	fungus covering a large area of skin

i. State a hypothesis that this experiment is testing. 1 mark

ii. Explain which group of mice served as a control in this experiment. 1 mark

iii. Explain the difference in growth of the pathogenic fungus in the two groups of mice. 2 marks

Question 7 (8 marks)

Researchers studying the process of flowering in a plant hypothesised that the onset of flowering is controlled by the regulation of a specific gene.

The researchers decided to sequence the gene.

a. What information is obtained from gene sequencing? 1 mark

A portion of the DNA of the plant was amplified. The DNA amplification mixture was made up of the specific gene segment, a supply of four nucleotide bases, Taq polymerase and DNA primers.

The temperature of the mixture was changed as follows.

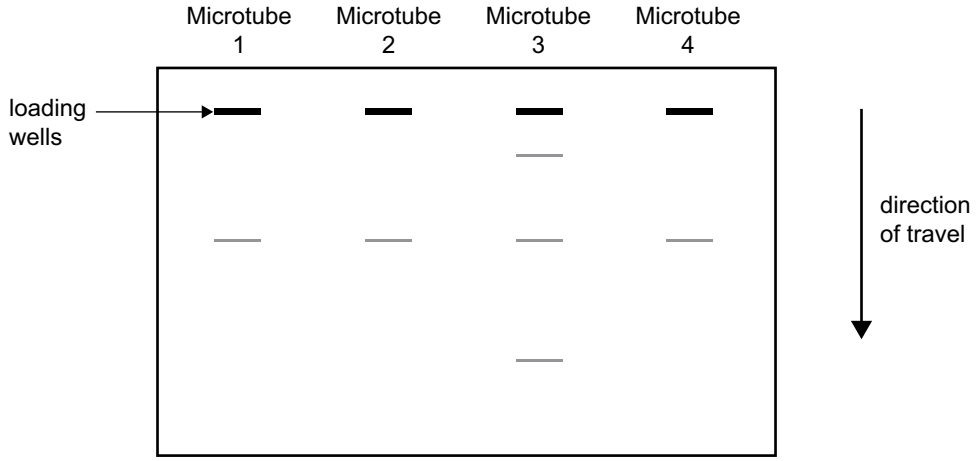
Step	Temperature
1	94 °C
2	55 °C
3	72 °C

b. Describe what happens to the DNA when the mixture is heated during Step 1. Name the end product of this stage. 2 marks

c. What is the function of the DNA primers in the mixture? 1 mark

d. Explain why the temperature was reduced to 55 °C in Step 2 and then increased to 72 °C in Step 3. 3 marks

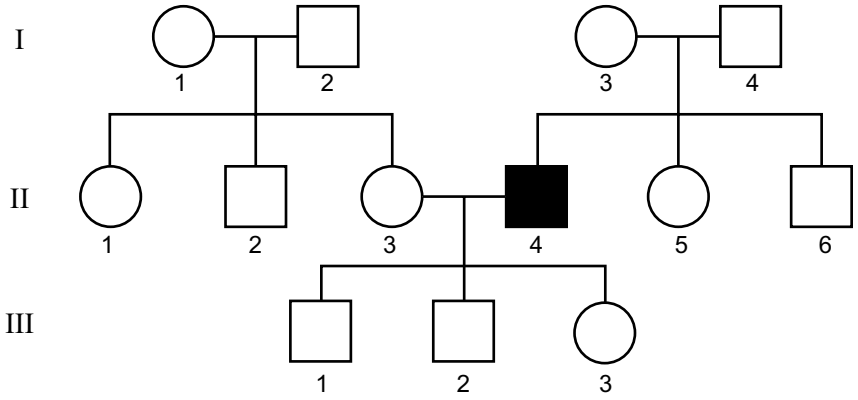
e. The researchers repeated this amplification process three more times in separate microtubes. They then carried out gel electrophoresis on samples from each of the four microtubes. Their results are shown below.



Suggest a possible reason why the results for Microtube 3 are different from the results for the other three microtubes. 1 mark

Question 8 (7 marks)

Consider the following pedigree.

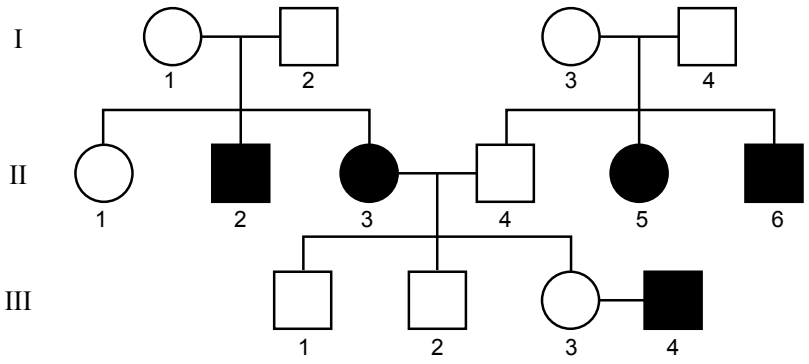


Individual II-4 displays a trait that is inherited. The inheritance of this trait is X-linked dominant. It is known that this trait is also found in individuals within this family in generations I and III.

a. **i.** In the pedigree above, shade in all individuals who must also display the same trait as individual II-4. 1 mark

ii. Give a reason for shading in those individuals. 1 mark

b. A **different** inherited trait was investigated in a family. Individuals displaying this trait have been shaded in the pedigree below.



i. Determine the mode of inheritance of this trait. 1 mark

ii. Give **two** pieces of evidence to support your answer to **part b.i.** 2 marks

iii. If individuals III-3 and III-4 have a child, what is the probability that this child will have the trait? Show your working. 2 marks

Question 9 (5 marks)

In Africa, the malaria-carrying mosquito *Anopheles gambiae* has been the focus of a mosquito-eradication campaign using the insecticide pyrethroid. Researchers found that allele 1 of gene L1014 produces resistance to pyrethroid in these mosquitoes; however, allele 2 does not produce resistance to pyrethroid. Researchers studied the frequency of both of these alleles over a period of time. In the particular population of mosquitoes where this study was carried out, an intense program of pyrethroid spraying was begun in 2008 and was maintained until 2011.

The results of the allele frequency studies are presented in the table below.

Allele frequencies for gene L1014 in *A. gambiae*

Allele type	Frequency in 2007	Frequency in 2011
1	36.4%	77.7%
2	63.6%	22.3%

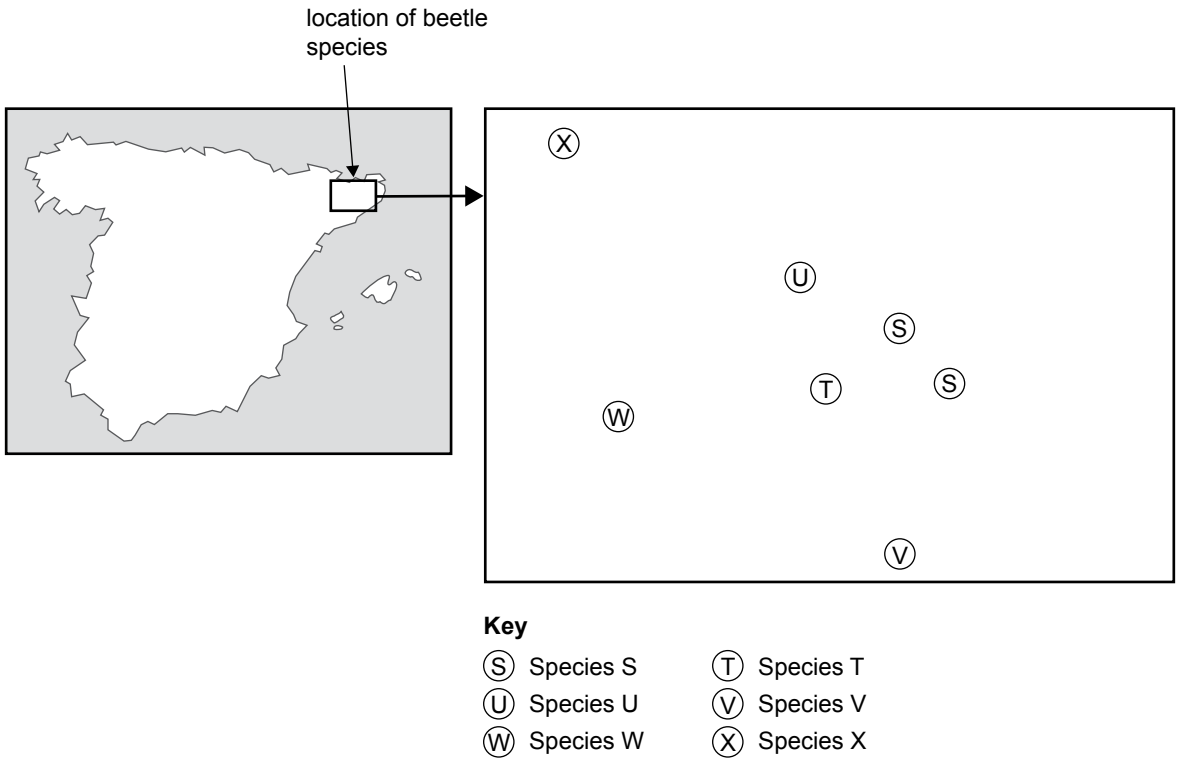
It is considered that this data provides evidence that the process of natural selection has occurred in the *A. gambiae* species.

a. Using the information above, explain how natural selection has operated in this population of the *A. gambiae* mosquito. 3 marks

b. Based on the information above, has the gene pool of this population of the *A. gambiae* mosquito been altered by the spraying of this insecticide? Explain your answer. 2 marks

Question 10 (9 marks)

Six different beetle species have been studied by scientists. The six species are found within caves in the northern part of Spain (see map). All six species belong to the genus *Geotrechus*. The relative positions of the six species within the region are shown in the diagram below.



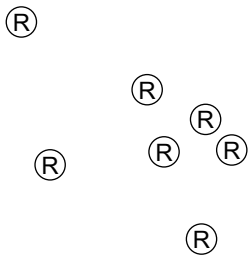
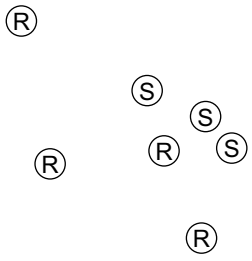
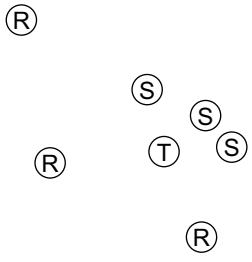
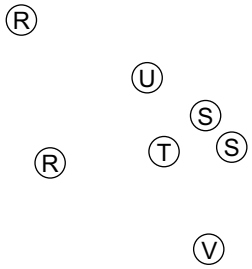
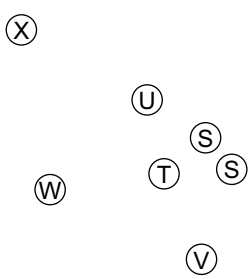
a. Scientists used DNA sequences and protein structures to help classify the six beetle species.

Describe other evidence the scientists could use to help classify the beetles into different species. 2 marks

b. The scientists gathered information to construct a phylogenetic tree for the six beetle species.

What information is displayed in a phylogenetic tree? 1 mark

By examining fossil evidence in the area, the timing of the appearance of each of the species has been determined. This is shown in the table below.

Location of beetle species	Species present	Time period in which species were found (millions of years ago)
	Ⓡ Species R	24
	Ⓡ Species R Ⓢ Species S	16
	Ⓡ Species R Ⓢ Species S Ⓣ Species T	8
	Ⓡ Species R Ⓢ Species S Ⓣ Species T Ⓤ Species U Ⓥ Species V	6
	Ⓢ Species S Ⓣ Species T Ⓤ Species U Ⓥ Species V Ⓦ Species W Ⓧ Species X	2

Source: adapted from A Faille, C Bourdeau, X Belles and J Fresneda, 'Allopatric speciation illustrated: The hypogean genus *Geotrechus* Jeannel, 1919 (Coleoptera: Carabidae: Trechini), with description of four new species from the Eastern Pyrenees (Spain)', in *Arthropod Systematics & Phylogeny*, 73(3) 2015, p. 453

c. Scientists compared DNA sequences in four mitochondrial genes and two chromosomal genes found in the nucleus of the beetles.

Identify the **two** beetle species that would have the least number of differences in their DNA sequences. Explain your answer. 3 marks

d. Scientists explained the appearance of the six beetle species by suggesting that, over time, allopatric speciation had occurred.

Describe the process of allopatric speciation. 3 marks

Question 11 (4 marks)

Coral reefs are found in oceans around the world. Corals are animals that build up calcium carbonate skeletons. Single-celled algae live within the coral tissues. Queensland scientists have reported that many of the corals in a region of the Great Barrier Reef have recently become bleached. Bleaching occurs when the single-celled algae leave the coral tissues due to environmental changes. Corals turn white without the algae and may die. This bleaching has been attributed to an increase in water temperature and acidity.

Two approaches have been proposed to help reverse the bleaching occurring in the coral reefs.

Approach 1

Scientists selectively breed corals containing single-celled algae within a laboratory setting. Particular corals with algae are then reintroduced into the coral reef.

a. Explain how selective breeding may help reverse the bleaching of the coral. 2 marks

_____

_____

_____

_____

Approach 2

Single-celled algae from the coral reef are exposed to mutagens within a laboratory setting. Some of these algae are reintroduced back into the coral reefs.

b. **i.** What would be the purpose of exposing the single-celled algae to mutagens? 1 mark

_____

_____

ii. What is a disadvantage of this approach? 1 mark

_____

_____

END OF QUESTION AND ANSWER BOOK