



▶ innovative ▶ engaging ▶ evolving

YEAR 12 *Trial Exam Paper*

2023

BIOLOGY

Written examination

Reading time: 15 minutes

Writing time: 2 hours 30 minutes

STUDENT NAME:

QUESTION AND ANSWER BOOK

Structure of book

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

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

Materials provided

- Question and answer book of 47 pages
- Answer sheet for multiple-choice questions

Instructions

- Write your **name** in the box provided above and on the multiple-choice answer sheet.
- 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.

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SECTION A – Multiple-choice questions**Instructions for Section A**

Answer **all** questions in pencil on the answer sheet provided for multiple-choice questions.

Choose the response that is **correct** or that **best answers** the question.

A correct answer scores 1; an incorrect answer scores 0.

Marks will **not** be deducted for incorrect answers.

No marks will be given if more than one answer is completed for any question.

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

Use the following information to answer Questions 1–3.

DNA is made up of a sequence of nucleotides joined together. Sections of DNA known as genes are information molecules that determine the sequence of amino acids in a polypeptide. Nucleic acids are polymers made up of nucleotides, which are arranged in triplets.

Question 1

The table below shows examples of triplets of bases in DNA, mRNA and tRNA and identifies the amino acid coded for.

Molecule	Information	Example
1	DNA triplet	TAC
2	mRNA triplet	AUG
3	tRNA triplet	UAC
4	amino acid	methionine

With reference to the examples above, identify the triplet sequences representing a codon and an anticodon.

	Codon	Anticodon
A.	TAC	UAG
B.	AUG	UAC
C.	UAC	TAC
D.	UAC	AUG

Question 2

Based on the information given, a structural difference between the triplets of Molecules 1 and 2 could be that

- A. Molecule 1 is longer than Molecule 2.
- B. Molecule 1 has thymine instead of adenine.
- C. Molecule 1 has the sugar deoxyribose, whereas Molecule 2 has the sugar ribose.
- D. Molecule 1 is read by RNA polymerase and Molecule 2 is read by a ribosome.

Question 3

The table below has further information about the DNA sequence of the gene, the complementary mRNA and the amino acid sequence.

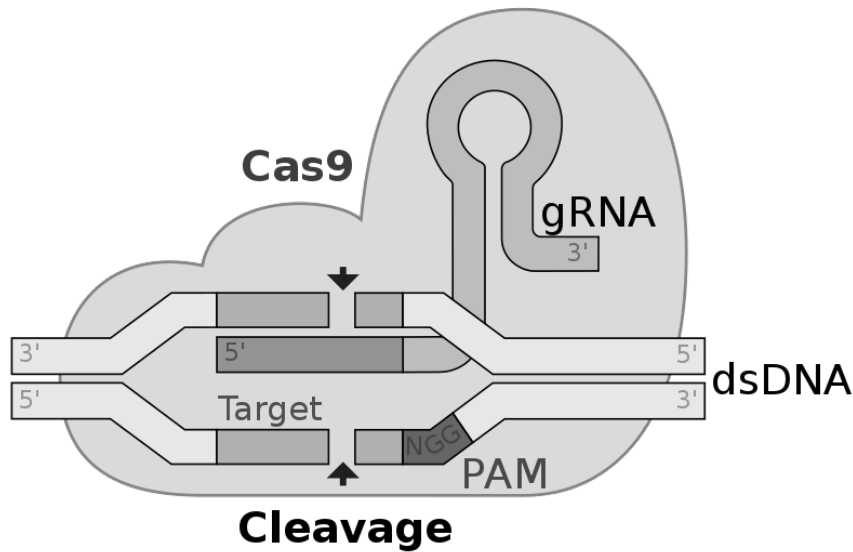
DNA sequence	TAC	TCA	AGT	CAT	CTC
mRNA sequence	AUG	AGU	UCA	GUA	GAG
Amino acid sequence	Met	Ser	Ser	Val	Glu

Which feature of the genetic code is referred to in this information?

- A. The genetic code is universal.
- B. The genetic code is degenerate.
- C. The genetic code can be duplicated.
- D. The genetic code is interchangeable.

Question 4

The diagram below shows an overview of the CRISPR-Cas9 gene editing technique.



Source: Mariuswalter/Wikimedia Commons/CC SA-BY 4.0

What is the role of gRNA in CRISPR-Cas9?

- A. It acts as a spacer containing viral DNA.
- B. It recognises damaged DNA and repairs it.
- C. It directs the Cas9 endonuclease to the target site.
- D. It recognises a specific target sequence to which it binds and then cuts.

Question 5

Mucins are a type of glycoprotein secreted by epithelial cells that line the respiratory tract. Glycosylation is a reaction in which a carbohydrate is attached to other molecules, such as proteins. In which component of the cell does glycosylation of proteins occur?

- A. nucleus
- B. cytoplasm
- C. Golgi apparatus
- D. mitochondria

Question 6

Consider the following statements regarding the role of vesicles in the transport of proteins within a cell and their subsequent export.

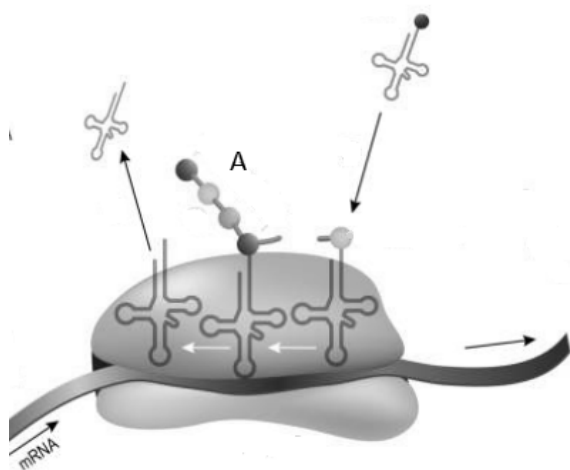
1	The Golgi apparatus packages proteins into vesicles for release by exocytosis.
2	Vesicles form a hydrophobic coating that protects proteins after they are released into the tissue fluid that surrounds the secreting cell.
3	Proteins are packaged into vesicles that pinch off from the rough endoplasmic reticulum.
4	Secretory vesicles enable proteins to be transported from the rough endoplasmic reticulum to the Golgi apparatus.

Which of the statements above are correct?

- A. 1
- B. 1, 2 and 4
- C. 1 and 3
- D. 2, 3 and 4

Question 7

This diagram shows an overview of translation.



Source: ttsz/iStockphoto.com

What level of protein structure is shown at point A?

- A. primary
- B. secondary
- C. tertiary
- D. quaternary

Use the following information to answer Questions 8 and 9.

Several research groups have so far announced ongoing research with the intention of laying the foundations for applying CRISPR technology to human embryos. One such group used non-viable embryos to attempt to correct a mutation that causes a lethal form of the genetically inherited disease β -thalassemia. The group was successful in changing some of the intended genes but found that there were also off-target effects.

Question 8

Which one of the following is a correct statement about the meaning of an off-target effect?

- A. Cleavage occurred at unintended positions.
- B. Genes, other than those intended, were inserted.
- C. Mutated genes were introduced into the target genome.
- D. The corrected genes were not inserted into sufficient cells to meet the therapeutic target.

Question 9

Bioethics is a field that involves the study of the philosophical, social and legal issues that arise in medicine and the life sciences. There are four principles that are supposed to be applied in conjunction with each other. These are defined in the table below.

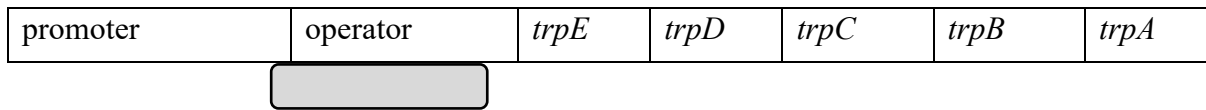
Principle	Meaning
Autonomy	People and their right to make choices about their body and health should be respected.
Beneficence	All interventions and treatments should include positive steps to help, not merely the avoidance of harm.
Non-maleficence	The obligation to not inflict harm on others. All efforts should be made to avoid or minimise harm.
Justice	Health care is to be provided in a fair and equitable manner.

Based on the information above, which of these principles were being applied?

- A. justice and beneficence
- B. autonomy and beneficence
- C. non-maleficence and justice
- D. beneficence and non-maleficence

Question 10

The *trp* operon is an example of a process in which gene expression is regulated. It is found in certain species of bacteria, and the purpose of the genes in the operon is to code for the enzymes the bacteria require to make the amino acid tryptophan. The diagram below shows an overview of the *trp* operon with a repressor protein bound to the operator region.



Based on the information provided, it would be reasonable to conclude that

- A. the rate at which tryptophan is synthesised will decrease.
- B. RNA polymerase will be unable to bind to the promoter region.
- C. the bacterium has permanently lost the ability to synthesise tryptophan.
- D. the function of the repressor protein is dependent on its ability to form a complex with mRNA.

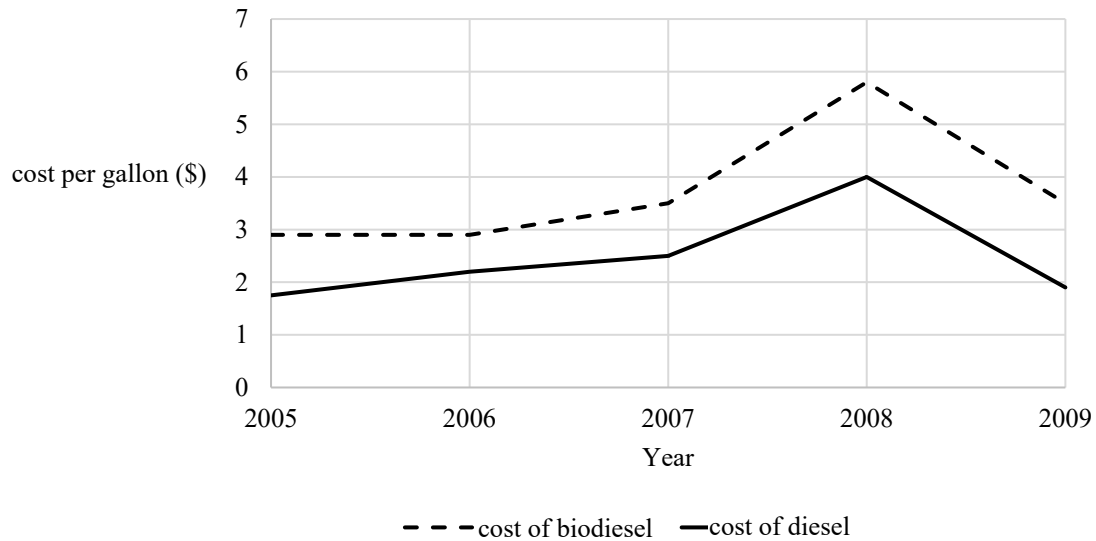
Question 11

Roundup Ready is a type of genetically modified soybean. These plants have been designed to be resistant to the herbicide glyphosphate, a chemical that kills plants because it prevents them from synthesising the amino acids phenylalanine, tyrosine and tryptophan. The purpose of producing these genetically modified soybeans is to

- A. reduce crop damage by preventing insects from eating the soybeans.
- B. increase crop yield by killing weeds but not affecting the soybeans.
- C. increase the nutritional content of the soybeans by adding extra amino acids.
- D. increase crop productivity by causing farmers to choose different types of crops.

Question 12

The graph below compares the cost of biodiesel produced from soybeans to petroleum-based diesel.

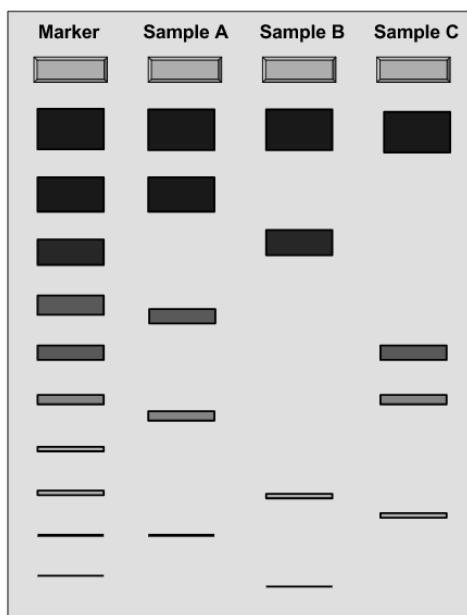


As of June 2022, global biodiesel costs remained between 70% and 130% higher than petroleum-based diesel. Based on this information, it has been concluded that biodiesel is unable to compete with petroleum-based diesel on price alone. Which of the following would be the best reason for continuing to produce biodiesel?

- A. Biodiesel has more applications than diesel.
- B. Biodiesel does not have to be purified or refined.
- C. Biodiesel is perceived as being more environmentally friendly.
- D. Biodiesel can be produced by anaerobic fermentation of biomass.

Question 13

The diagram below shows an example of an electrophoresis gel.



Source: adapted from Mckenzielower/Wikimedia Commons/CC SA-BY 4.0

Which of the following correctly identifies the purpose of the marker lane?

- A. to sort the DNA samples into different-sized fragments
- B. to prove that the process of electrophoresis has worked effectively
- C. to enable the person interpreting the gel to identify the number of fragments in each sample
- D. to enable the person interpreting the gel to estimate the size of the fragments in each sample

Question 14

The following is an example of a word equation for the process of photosynthesis.

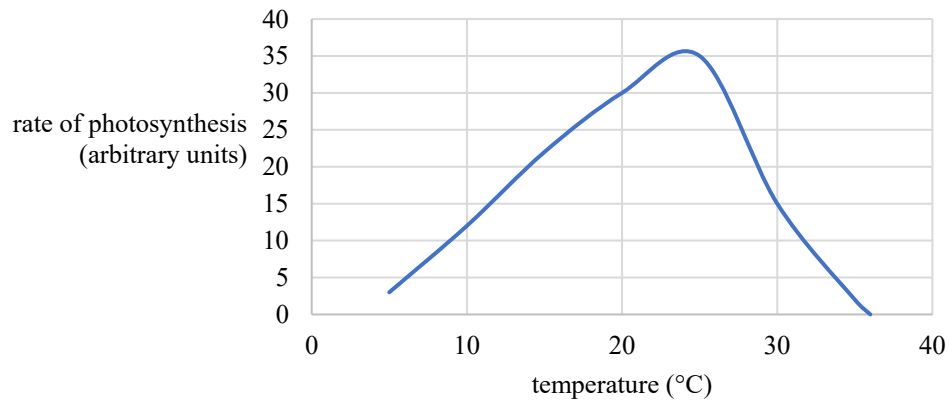


Oxygen is released as a by-product of which of the following processes that occur during photosynthesis?

- A. splitting of water molecules
- B. electron transfer in the light-dependent stage
- C. loading NADP^+ to make NADPH
- D. phosphorylating ADP to make ATP

Use the following information to answer Questions 15 and 16.

This graph shows the effect of temperature on the rate of photosynthesis in a C₃ plant when light intensity and carbon dioxide concentration were kept constant.



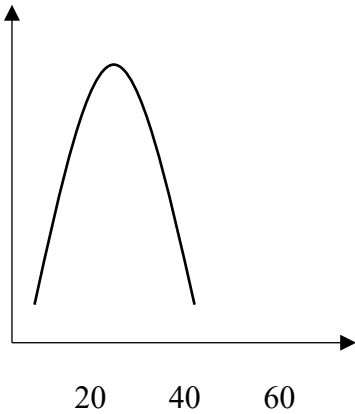
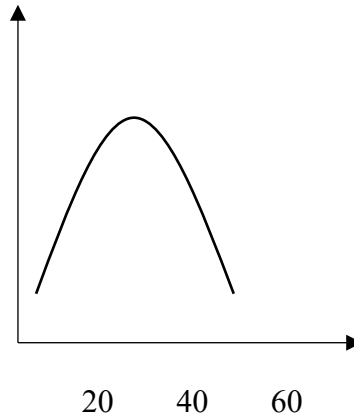
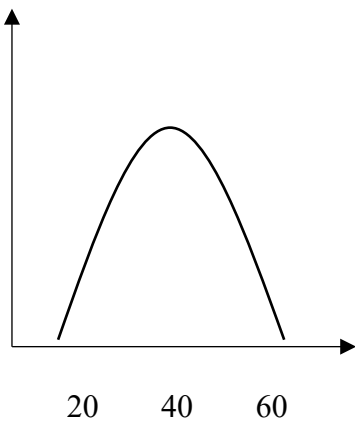
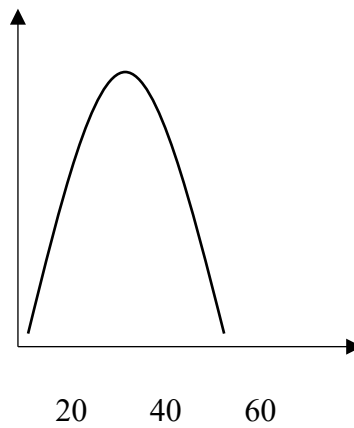
Question 15

Based on the information provided, it could be concluded that

- A.** the rate of carbon fixation increases as temperature increases.
- B.** once the temperature exceeds 25 °C, Rubisco progressively denatures.
- C.** carbon dioxide concentration becomes the limiting factor governing the rate of photosynthesis.
- D.** the rate of photosynthesis initially increases because stomata only open at low temperatures.

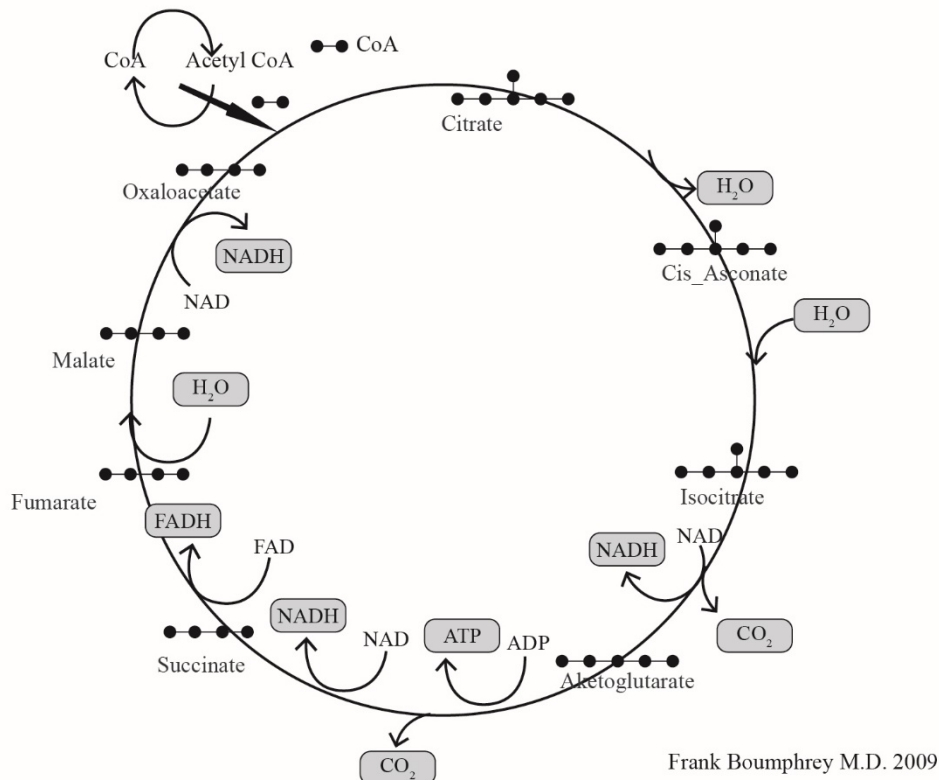
Question 16

Four students each drew a rough graph predicting the effect of changing temperature on the rate of photosynthesis of a C₄ plant. Which of the graphs produced is the most accurate?

A.**B.****C.****D.**

Use the following information to answer Questions 17 and 18.

The diagram below shows an overview of the Krebs (citric acid) cycle.



Source: adapted from Boumphreyfr/Wikimedia Commons/CC BY-SA 3.0

Question 17

As can be seen in the diagram above, oxygen is not an input into the Krebs cycle.

Why is the Krebs cycle referred to as an aerobic process?

- A. Oxygen molecules act as a cofactor.
- B. Oxygen molecules bind to NAD^+ and FAD^+ .
- C. The absence of oxygen inhibits the conversion of CoA to acetyl CoA.
- D. The electron transport chain will not function in the absence of oxygen.

Question 18

Consider the diagram provided. The hydrogen removed from isocitrate molecules is accepted by

- A. NAD^+ .
- B. water.
- C. carbon dioxide.
- D. α -ketoglutarate.

Use the following information to answer Questions 19 and 20.

Question 19

Succinate dehydrogenase (SDH) plays an important role in the Krebs cycle because it is responsible for catalysing the reaction in which succinate is converted into fumarate. Some students carried out an investigation to determine the effects of malonic acid on this stage of the cycle. The conditions of the investigation and the results generated are shown in this table.

	Tube 1	Tube 2	Tube 3	Tube 4
Water	10 mL	—	—	—
SDH	1 mL	1 mL	1 mL	1 mL
Succinate	—	10 mL	10 mL	15 mL
Malonic acid	1 mL	—	1 mL	1 mL
Concentration of fumarate product	zero	high	very low	low

Based on the information provided, it would be reasonable to conclude that

- A. malonic acid is an inhibitor of SDH.
- B. malonic acid is a coenzyme needed to activate SDH.
- C. malonic acid changes the pH, causing SDH to denature.
- D. malonic acid acts as a substrate for SDH, resulting in the production of fumarate.

Question 20

Consider the substances included in each of the tubes. It would be reasonable to assume that the purpose of including Tube 2 in the investigation was to

- A. enable the impact of malonic acid to be identified.
- B. show the impact of changing the total volume of reactants in each tube.
- C. isolate a sample that contained the only conditions that showed the effect of exposing succinate to SDH.
- D. isolate a sample that contained the only conditions proving that malonic acid has an impact on the conversion of succinate into fumarate.

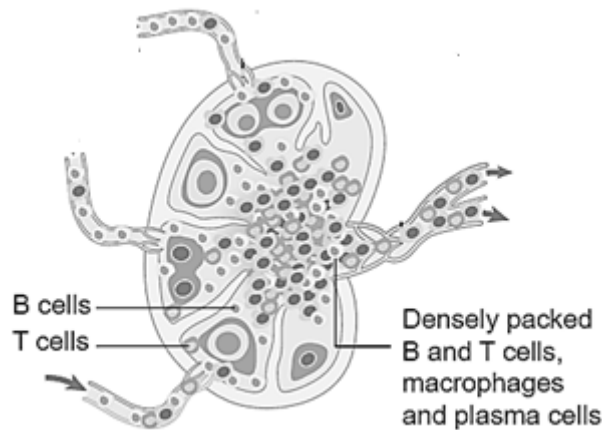
Question 21

Some species of plant, including coffee, tea and cacao plants, secrete caffeine, which is toxic to a range of fungal pathogens and fosters the growth of parasites that target the same pathogens. These defences are examples of

- A. physical and chemical barriers.
- B. physical and microbiota barriers.
- C. pathogenic and chemical barriers.
- D. chemical and microbiota barriers.

Use the following information to answer Questions 22–24.

The lymphatic system is made up of lymphatic organs, lymphoid tissues, lymph nodes and a network of lymph vessels that transport a fluid known as lymph. Lymph nodes, such as the one shown below, are small bean-shaped organs that occur throughout the human body, including the neck. They generally form where major blood vessels meet. Body cells are surrounded by tissue fluid, some of which returns to the bloodstream and some of which moves into the lymphatic vessels.



Source : adapted from Cancer Research UK/Wikimedia Commons/CC BY-SA 4.0

Question 22

What is the role of the lymph vessels in the lymphatic system?

- A. to filter the lymph fluid
- B. to activate the B and T cells
- C. to prevent pathogens from entering the bloodstream
- D. to transport lymph fluid through the lymphatic system

Question 23

A person who has laryngitis experiences a swelling of the lymph nodes in their neck. The cause of the swelling is

- A. the proliferation of B and T cells in the lymph nodes.
- B. the lymph node is blocked by an influx of pathogens.
- C. an increase in the number of pathogens in the tissue fluid.
- D. macrophages increasing in size because of engulfing pathogens.

Question 24

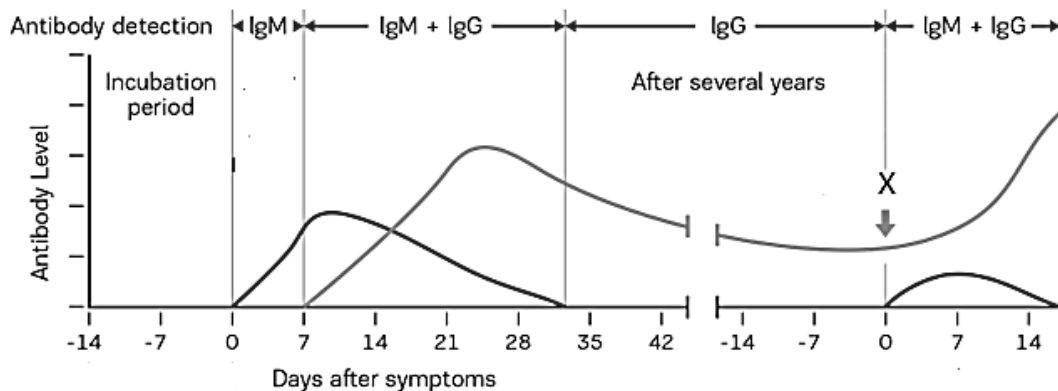
Which of the following correctly identifies the role of lymph nodes?

They are

- A. responsible for the production of antibodies.
- B. sites for antigen recognition by T and B lymphocytes.
- C. the only locations in the body where phagocytosis occurs.
- D. able to develop immunological memory to specific antigens.

Use the following information to answer Questions 25 and 26.

There are five classes of antibody. Two of these are IgM and IgA. These antibodies can be used in the detection of infections. The diagram below shows an overview of the concentration of IgM and IgG over a period of several years.



Source: modified from 'SARS-CoV-2 (Covid-19): Diagnosis by IgG/IgM Rapid Test Clinisciences'

Question 25

Consider the diagram provided. It would be reasonable to conclude that

- A. IgG is always produced before IgM.
- B. IgG and IgM cannot be produced at the same time.
- C. IgM can remain circling in the bloodstream for several years.
- D. if a test is positive for IgM and negative for IgG, there is a current infection.

Question 26

Consider the diagram provided. Which of the following best explains what happened at point X?

- A. T helper cells began secreting antibodies.
- B. The person was re-exposed to the antigen.
- C. The person must have been re-exposed to the pathogen.
- D. The decrease in IgG antibodies triggered an increase in IgM antibodies.

Question 27

A person was injected with antivenin after being bitten by a venomous snake. Which of the following statements is correct?

- A. This is an example of natural immunity because it was triggered by a natural event.
- B. This is an example of passive immunity because antivenin contains antibodies.
- C. This is an example of active immunity because the injection had to be actively carried out.
- D. This is an example of artificial immunity because the venom was acquired from an external source.

Question 28

A person got a splinter in their finger and noticed that the surrounding area of skin became red and appeared swollen. This occurred as a result of vasodilation, which is important because

- A. toxins from the splinter are contained in one area.
- B. it enables the skin surrounding the wound to remain hydrated.
- C. it increases permeability of the blood vessels around the area of the wound.
- D. it facilitates removal of white blood cells from the area surrounding the wound.

Question 29

A farmer carried out selective breeding in a flock of sheep over many generations, resulting in the production of sheep with finer wool. Based on this information it could be assumed that the

- A. increase in fineness of wool was due to the impact of genetic mutations.
- B. fineness of wool increased as a result of allowing only specific animals to breed.
- C. fineness of wool increased because this trait enhanced the ability of the sheep to survive.
- D. changes that occurred were gradual and were a result of the sheep adapting to environmental changes.

Question 30

One organism in an isolated population was born with the ability to digest a previously undigestible food source. After 10 generations, 7% of the population had developed the same trait. Based on your understanding of factors that cause genetic changes in populations over time, the initial source of the trait could have been

- A. genetic drift occurring in the population.
- B. the result of a mutation causing a new allele.
- C. the organism adapting to changes in the environment.
- D. interbreeding occurring with other organisms that also had this trait.

Use the following information to answer Questions 31 and 32.

A fossil of *Archaeopteryx lithographica* was found in a limestone deposit in Germany. It formed after an *Archaeopteryx* was buried in mud. Over millions of years, the mud hardened and turned into limestone rock, which preserved every detail of the skeleton, including feathers and wings like those of modern birds, as well as a full set of teeth, a bony tail and claws similar to those in several species of dinosaur. The fossil is considered to be about 147 million years old, which was established by dating contemporary igneous rocks.

Question 31

Based on the information provided, the *Archeopteryx* fossil is an example of

- A. an index fossil.
- B. a traditional fossil.
- C. a succession fossil.
- D. a transitional fossil.

Question 32

The age of this fossil could best be determined by

- A. radiocarbon dating.
- B. analysing rock strata.
- C. potassium to argon dating.
- D. establishing the age of similar fossils located at different sites.

Use the following information to answer Questions 33 and 34.

The University of Adelaide's Australian Centre for Ancient DNA analysed samples of mitochondrial DNA from 111 samples of Aboriginal hair obtained in the early to mid-1900s. Information obtained by analysing the mitochondrial DNA led to maps being annotated with information, such as this one.



Question 33

Consider the information provided. Which of the following statements is not accurate?

- A. Populations spread down the east and west coasts.
- B. The migration patterns shown are an example of genetic drift.
- C. All First Nations people living today are the descendants of a single founding population.
- D. The strong connection to country is due to the fact that movement of populations was minimal for approximately 50 000 years.

Question 34

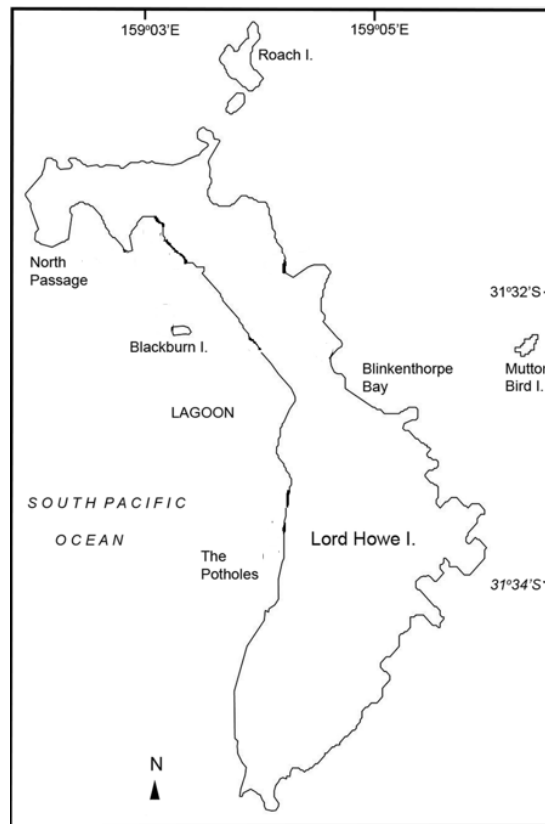
Mitochondrial DNA is used instead of nuclear DNA to establish the degree of relationship between populations because

- A. mutations do not occur in mitochondrial DNA.
- B. mitochondrial DNA does not degrade over time.
- C. mitochondrial DNA does not undergo recombination.
- D. mitochondrial DNA is more stable than nuclear DNA.

SECTION A – continued
TURN OVER

Use this information to answer Questions 35 and 36.

In July 2022, scientists from the University of Sydney found an example of a species of wood-eating cockroach on Lord Howe Island. The species had been believed to be extinct because none of them had been seen in more than 80 years.



Question 35

Similar cockroaches have also been found on Blackburn Island. The scientists compared the two populations of cockroaches by a molecular homology technique. Which of the following correctly identifies an example of this type of technique?

- A. comparing DNA sequences
- B. constructing a phylogenetic tree
- C. comparing homologous structures
- D. identifying vestigial structures in common

Question 36

Scientists have compared the Lord Howe archipelago (series of islands) to the Galapagos Islands because it is home to more than 1600 species of invertebrates, many of which are not found anywhere else in the world. Which of the following conditions favour allopatric speciation after a founding population spreads out across an island chain?

- A. Geographic isolation limits gene flow between the islands.
- B. Islands provide unique selection pressures that do not exist anywhere else.
- C. Animals adapt to island conditions more rapidly than to mainland conditions.
- D. Being surrounded by water completely prevents individuals on different islands from breeding with the parent population.

Question 37

A range of strains of influenza virus were studied. Strain A underwent small genetic changes that accumulated over time. Strains B and C infected the same host cells at the same time, which resulted in the formation of strain D. Based on the information provided, it would be reasonable to conclude that

- A. initially no one would have immunity against strain D.
- B. the changes to strain A are an example of antigenic shift.
- C. immunity to strains B and C would confer immunity to strain D.
- D. the change to strain A is seen as being more serious than that which produced strain D.

Question 38

Approximately half of all giant panda births result in twins; however, in most cases the mother rejects the weaker twin. Baby pandas are unable to move very much or see for about 2 months. They are completely dependent on their mother for everything. Which one of the following conclusions is based on the normal practice of one infant being rejected?

- A. The weaker twin always dies anyway.
- B. There is insufficient food to support two offspring at a time.
- C. Female pandas are physically unable to feed two offspring at the same time.
- D. The rejection of one twin increases the chance that the other twin will survive.

Question 39

Cancer cells produce tumour specific antigens (TSAs), which may be expressed onto the cell surface as part of the major histocompatibility complex. These antigens are unique to tumour cells. Monoclonal antibodies can be used in the treatment of some cancers because

- A. monoclonal antibodies bind to the cancer cells and cause them to clump together.
- B. monoclonal antibodies can be radioactively labelled, increasing the ability to detect cancers.
- C. monoclonal antibodies bind to nutrients, preventing the cancerous cells from obtaining them.
- D. drugs can be bound to monoclonal antibodies, which then deliver them to the targeted cancerous cells.

Question 40

Of all primates, only hominins are considered to have specific adaptations that enable bipedalism. Which of the following adaptations do humans have that contributes to bipedalism?

- A. The pelvis is shorter and wider.
- B. Each foot has a divergent big toe.
- C. The foramen magnum is further towards the back of the skull.
- D. Femurs are always completely vertical between the hips and the knees.

**END OF SECTION A
TURN OVER**

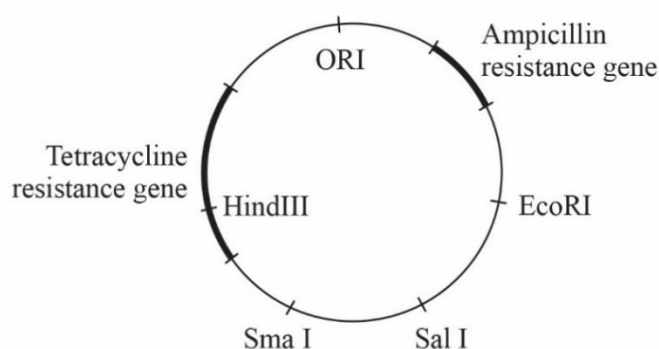
SECTION B**Instructions for Section B**

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 (9 marks)

Plasmids may be cut with endonucleases (also called restriction enzymes). Laboratory plasmids used for genetic engineering typically have recognition points for several endonucleases; in this case, these include EcoRI, SalI, SmaI and HindIII. In addition, the plasmid shown below also has an origin of replication (ORI) and genes for resistance to the antibiotics ampicillin and tetracycline.



A group of scientists used this type of plasmid to produce a strain of bacterial cells that would secrete human insulin.

Name of enzyme	Recognition and cleavage site	Type of end
EcoRI	G AATTC CTTAA G	sticky
HindIII	A AGCTT TTCGA A	sticky
BamHI	G GATCC CCTAG G	sticky
SalI	TGG CCA ACC GGT	blunt
HaeIII	GG CC CC GG	blunt
SmaI	CCC GGG GGG CCC	blunt

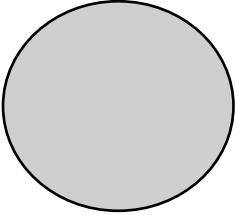
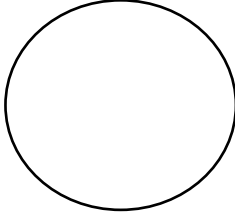
- a. The first step in the process involved cutting the plasmid with an endonuclease. Discuss the advantage of using HindIII compared to SmaI.

2 marks

- b. State the name of the enzyme used to seal the gene for human insulin production into the plasmid.

1 mark

A culture of bacteria was exposed to the modified plasmids. Heat shock of the solution was carried out to increase permeability of the bacterial cells to DNA. Samples of the bacteria were then placed onto three different agar plates, as shown below, and left for 24 hours. At the end of this time, plate 1 was completely covered in bacteria.

		
Plate 1: Nutrient agar	Plate 2: Nutrient agar with tetracycline	Plate 3: Nutrient agar with ampicillin

- c. Plate 2 was observed 24 and 48 hours after being incubated. No bacteria were observed on the plate.

Explain why this occurred.

2 marks

- d. Use the space provided in the table above to draw a diagram predicting the appearance of Plate 3 after 24 hours.

1 mark

- e. Explain why Plate 3 would appear as you predicted in **part d**.

1 mark

- f.** It was predicted that the results would have been different if the scientists had used EcoRI instead of HindIII.

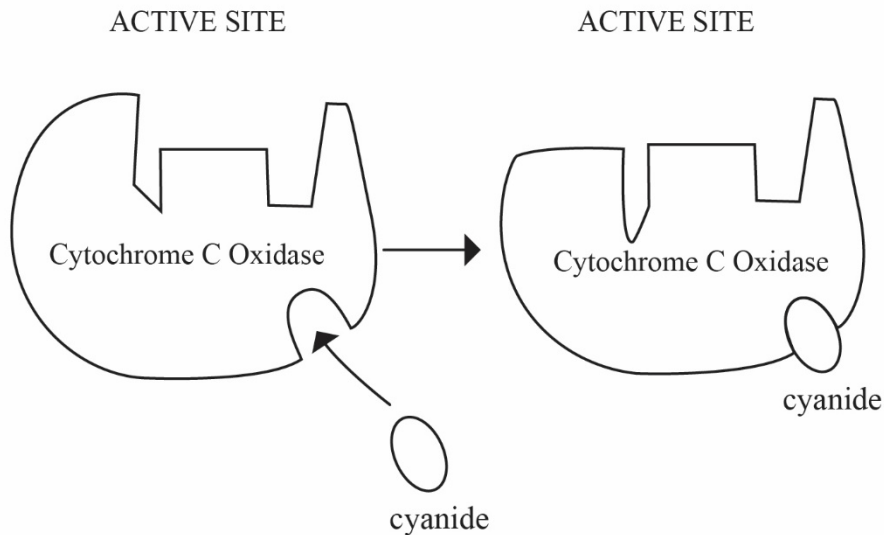
Identify how the results would have differed and state why the difference would have occurred.

2 marks

CONTINUES OVER PAGE

Question 2 (8 marks)

Cytochrome oxidase C (COX) is the terminal enzyme in the electron transport chain. It catalyses the transfer of electrons to molecular oxygen. The diagram below shows the effect of exposing COX to cyanide.



Source: adapted from hakan.demir/Shutterstock.com

- a. Based on the information provided, state whether cyanide is a competitive inhibitor or a non-competitive inhibitor. Justify your response.

2 marks

The majority of ATP molecules are formed in the mitochondria by the process of oxidative phosphorylation.

- b. Give the name of another location in the cell where ATP is formed. What is the net yield of ATP in this location?

2 marks

Mitochondria were extracted from some animal cells and incubated under several conditions. The mitochondria were suspended in a solution containing oxygen, NAD^+ and hydrogen ions.

The other conditions and results are shown in the table below.

Condition mitochondria is incubated under	Carbon dioxide produced?	Lactic acid produced?
pyruvate	yes	no
glucose	no	no

- c. Explain why carbon dioxide was produced when the mitochondria were incubated with pyruvate but not when they were incubated with glucose.

2 marks

- d. Some cells were suspended in a solution containing glucose, oxygen and cyanide. Why did the cells produce lactic acid but not any carbon dioxide?

2 marks

Question 3 (8 marks)

Soybean, a C3 plant, and sorghum, a C4 plant, are both important crop plants. Some students carried out an investigation into the responses of the plants to being kept at a low temperature for a short period of time. The plants were initially kept at 30 °C for 2 weeks before being kept at 10 °C for 4 days. The temperature was then increased to 25 °C for a week. Throughout the experiment, light intensity, day length and carbon dioxide concentration were all kept constant.

The uptake of carbon dioxide absorbed per gram of dry leaf mass was measured at the following times.

1. The last day when the plants were at 30 °C
2. During each of the 4 days when the plants were kept at 10 °C
3. During each day of the final week when the plants were kept at 25 °C

Plant	Carbon dioxide uptake (mg CO ₂ per gram)					
	Final day at 30 °C	4 days at 10 °C				Average of final week at 25 °C
		Day 1	Day 2	Day 3	Day 4	
Plant 1	10.8	13.3	14.5	15.4	16.2	12.1
Plant 2	24.1	14.2	10.8	8.2	4.5	18.6

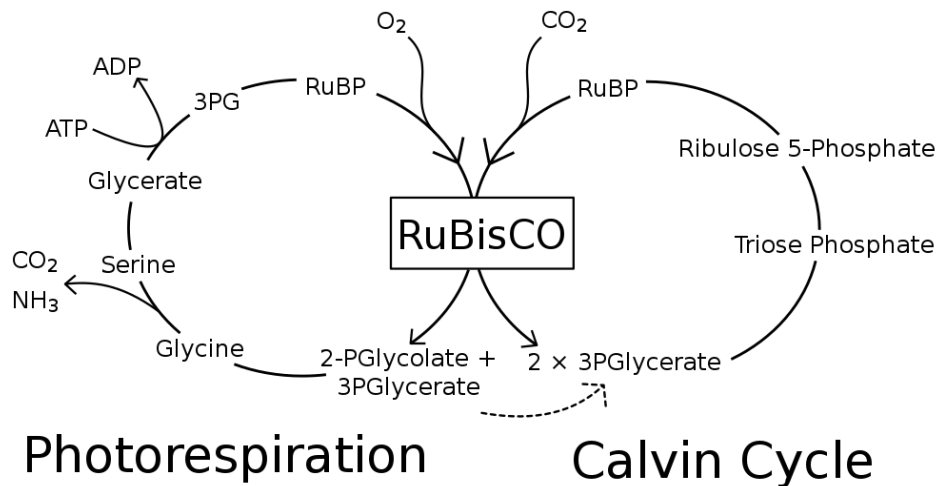
- a. The students forgot to identify which of the plants was sorghum and which was soybean.

Identify each of the plants and use the data to support your answer.

4 marks

[illegible]

As shown in this diagram, Rubisco plays an essential role in the Calvin cycle. Both oxygen and carbon dioxide can bind to the active site of Rubisco. At low temperatures, carbon dioxide is more likely than oxygen to bind to Rubisco.



- b. Discuss the impact of increasing temperature on the rate of photosynthesis in a C₃ plant. Include a reference to both processes in your answer.

2 marks

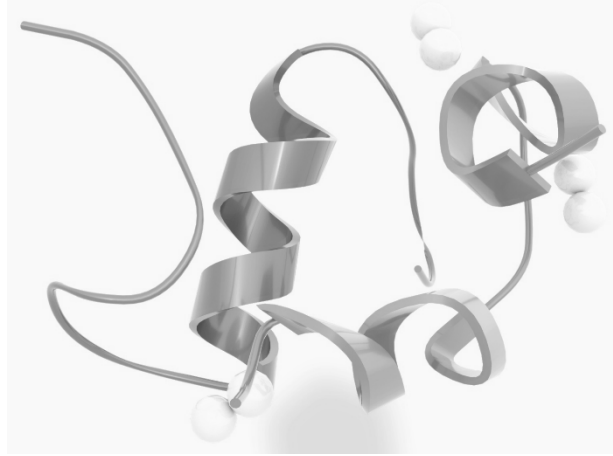
- c. During the week that the plants were kept at 10 °C, the structure of the chloroplasts in the sorghum changed. The thylakoid membranes moved closer to each other, reducing the space between them and causing the size of the grana to decrease.

Discuss two reasons to explain how these changes could cause a low rate of photosynthesis in these plants.

2 marks

Question 4 (6 marks)

The diagram below represents insulin. Insulin is a small, globular protein consisting of two chains; chain A consists of 21 amino acids and chain B consists of 30 amino acids. Both chains are alpha helices. The production of human insulin is one of the most common applications of the use of recombinant plasmids to transform bacterial cells. The process involves the insertion of two different genes into two different plasmids, each of which is exposed to different bacteria. The insulin genes are inserted next to a gene for β -galactosidase protein.



Source: AtikaAtikawa/Wikimedia Commons/CC BY-SA 4.0

- a.** Explain why the production of human insulin involves the insertion of two different genes into two different plasmids, each of which are exposed to different bacteria.

1 mark

INS is an example of a gene that codes for the production of human insulin. The gene is 1425 base pairs long and consists of three exons and two introns. The section of DNA inserted into the plasmid is much shorter than 1425 base pairs.

- b.** State a reason for the difference in size between the original gene and the insert. Justify your response.

2 marks

- c. Explain how the results of an electrophoresis gel could be used to determine the difference between an unmodified *INS* gene and a modified *INS* gene to be inserted into a plasmid.

2 marks

- d. Describe the purpose of inserting the genes for insulin production next to a gene for the production of the protein β -galactosidase.

1 mark

Question 5 (10 marks)

Australia has a national immunisation program in which a series of immunisations are given at specific times, starting from birth and going through into adulthood. Polio is one of the diseases for which vaccinations are provided at 2 months, 4 months, 6 months, 4 years and 12 to 13 years. The polio vaccine used to be given orally; however, in November 2005 it was replaced by an inactivated polio vaccine, which is given by injection.

- a.** Vaccinations are recommended in order to achieve long-term immunity.

Describe the events that occur during a primary immune response, beginning with exposure to the polio antigen and including an outline of the cells and chemicals associated with a specific immune response.

5 marks

- b.** A child is expected to have at least three booster shots for polio by the age of 4. Outline the benefit of having these booster shots. Justify your response.

2 marks

- c. Viruses, such as those that cause polio, enter and take over host cells in order to reproduce. Once viruses are inside a host cell, antibodies are ineffective against the virus, but are able to act on virally infected cells by recognising specific antigens on their surface.

Identify a type of cell that can detect and act against virally infected cells. Explain the role those cells play in carrying out an immune response.

2 marks

- d. The last directly transmitted case of polio in Australia occurred in 1972, and Australia has since been declared polio free by the Department of Health. However, a person was hospitalised in Australia with a case of polio in 2007.

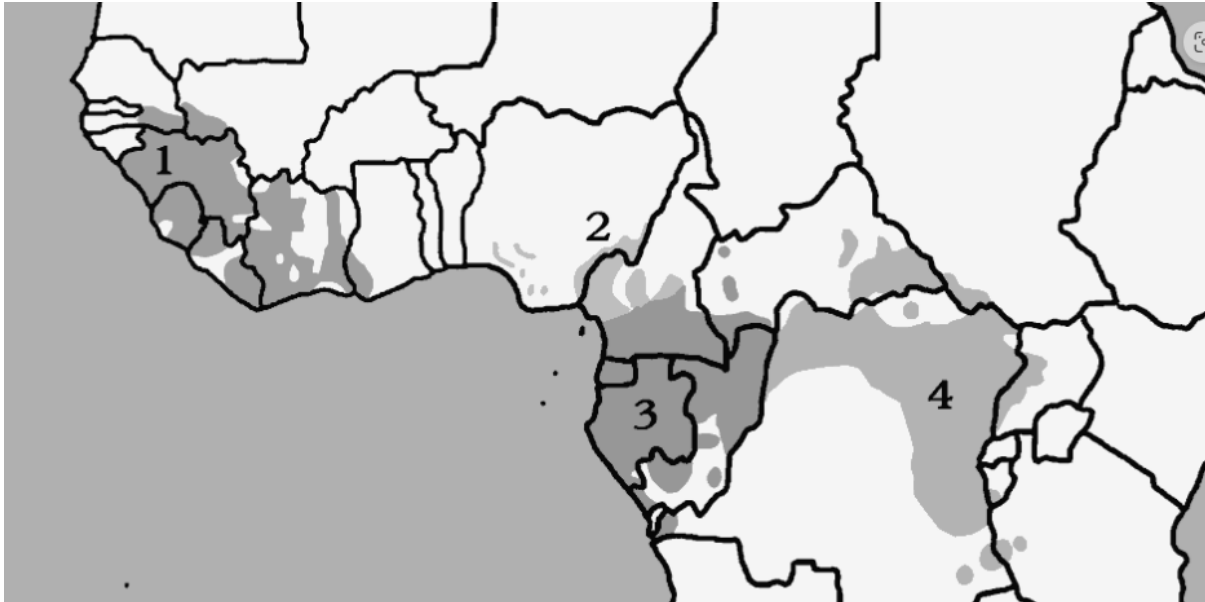
Suggest a reason that could explain why both statements are accurate.

1 mark

Question 6 (7 marks)

Currently there are four known subspecies of chimpanzees, as shown on the map.

1. *Pan troglodytes verus* (*P. t. verus*)
2. *Pan troglodytes ellioti* (*P. t. ellioti*)
3. *Pan troglodytes troglodytes* (*P. t. troglodytes*)
4. *Pan troglodytes schweinfurthii* (*P. t. schweinfurthii*)



Source: adapted from Luis Fernández García/Wikimedia Commons/CC SA-BY 3.0

Initially all chimpanzees in areas 2 and 3 were considered to be members of the *P. t. troglodytes*; however, it has now been proved that the small population in area 2 is also a subspecies called *P. t. ellioti*. DNA profiles were used to compare mitochondrial DNA obtained from the saliva of different chimpanzees.

- a. What results would you expect to observe in DNA profiles from members of the two different subspecies to support this claim?

1 mark

- b.** Areas 3 and 4 are separated by a river. Discuss how these two subspecies arose from a single ancestral population. Identify the type of speciation that is occurring and explain why these organisms are referred to as different subspecies rather than different species.

5 marks

- c.** One of the reasons for undertaking this study was to obtain the correct subspecies classification of chimpanzees in captivity.

Give one reason why a zoo may wish to know this information.

1 mark

Question 7 (7 marks)

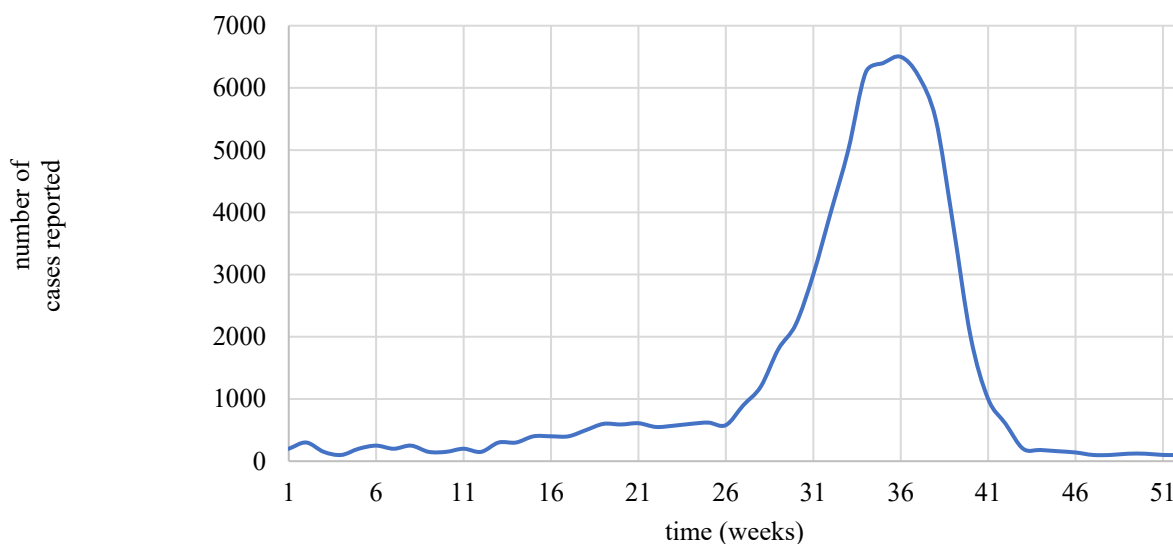
Influenza is an infection of the respiratory tract. The action of the influenza virus is facilitated by two antigenic surface proteins. Haemagglutinin (H) enables viruses to bind to and enter host cells. Neuraminidase (N) enables the host cell to produce new virions that will be released from the host cell.

- a. It has been suggested that having vaccinations acts as a selection pressure for the viruses.

Consider the information provided and state which of the genes for the two surface proteins would most likely be affected by a selection pressure. Justify your response.

2 marks

It has been estimated that up to 20% of the population is infected by an influenza virus every year, with infections tending to be seasonal. The graph below shows an overview of the reported number of cases in Victoria in 2021.



Source: based on figures from the Australian Government Department of Health

- b. Why might doctors advise that people should be vaccinated about week 21?

1 mark

In 2009, there was an outbreak of influenza called ‘swine flu’ or ‘pandemic flu’. It was caused by a new strain of the influenza virus, which was later identified as being caused by a quadruple genetic re-assortment. The virus was found to contain segments from two different swine flu strains, an avian flu strain and a human flu strain.

- c. Use your understanding of antigens and immune responses to explain why this strain of influenza virus caused a pandemic.

2 marks

- d. Identify a mode of transmission of the influenza virus. Describe a social measure that could be used to control the transmission of the virus and explain why this method should be effective.

2 marks

Question 8 (6 marks)

Beginning in the 1980s, conservation efforts focused on the maintenance of small, multiple populations of a species. For example, in Victoria, populations of the mountain pygmy possum are found in just three regions of Australia's alpine zone. Each of these regions has been isolated for more than 100 000 years, and the possums are becoming restricted to smaller and smaller habitats as a result of human pressures, climate change and the onslaught of invasive species.

- a.** Once fragmented, or reduced in size for other reasons, populations become more prone to genetic drift.

Identify how this affects the genetic diversity of the populations and explain why this occurs.

2 marks

- b.** Identify two disadvantages of the effect on genetic diversity identified in **part a**.

2 marks

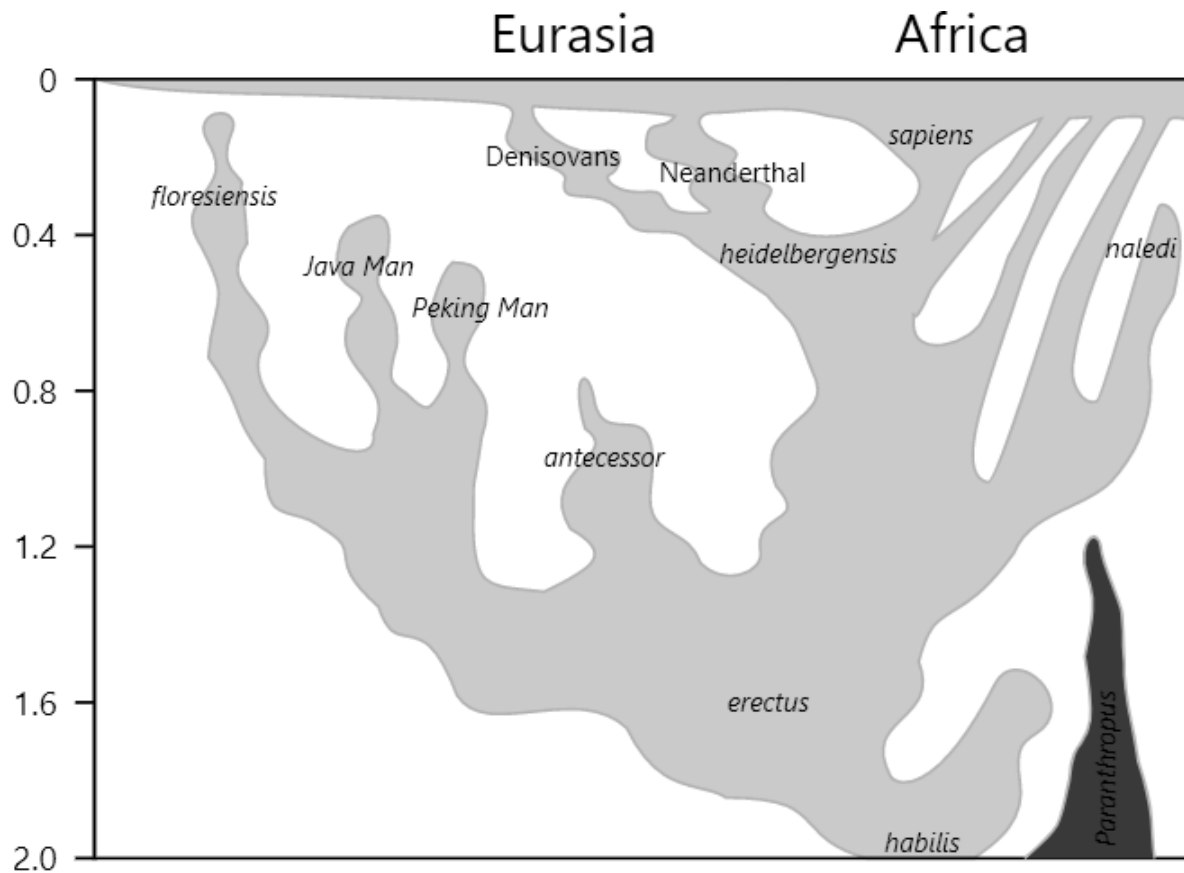
- c. Conservationists have recently implemented a process known as targeted gene flow. This is done by introducing organisms with desirable traits into a population.

Identify the impact on gene flow for the isolated population and explain how an isolated population, such as the mountain pygmy possums, could benefit from this process.

2 marks

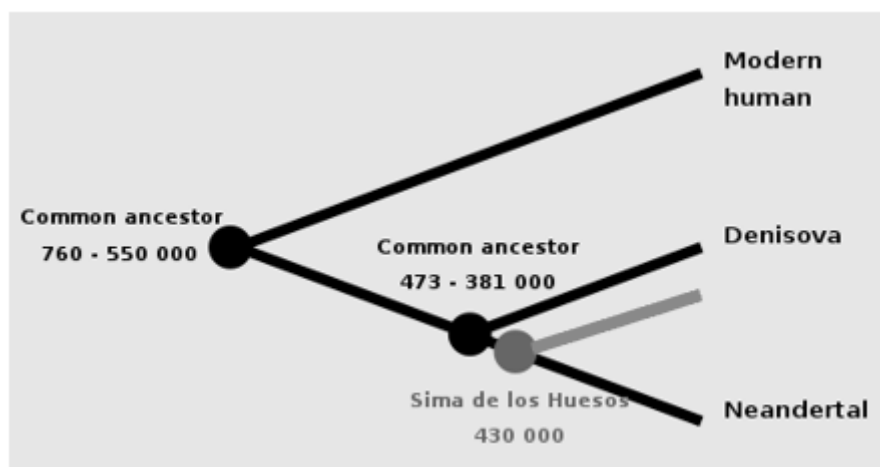
Question 9 (7 marks)

The following phylogenetic tree shows an overview of one theory relating to the evolution of the hominin genus *Homo*.



Source: Conquistador/Wikimedia Commons/CC BY-SA 4.0

Sima de los Huesos is an excavation site in Spain, from which more than 7000 hominin fossils have been recovered since 1984. These have been used to reconstruct full skeletons. Initially, these fossils were identified as being from members of *Homo heidelbergensis*; however, upon analysis, it was determined that the Sima de los Huesos group diverged from Neanderthals and Denisovans approximately 430 000 years ago. After this analysis, a segment of the phylogenetic tree was modified as shown below.



Source: UtaUtaNapishtim/Wikimedia Commons/CC BY-SA 4.0

- a.** Explain why the phylogenetic tree was modified as shown in the diagram provided.

2 marks

Initially, a mitochondrial genome retrieved from one individual from Sima de los Huesos was analysed and found to be more closely related to the mitochondrial DNA of Denisovans than to that of Neanderthals. However, the researchers carrying out the investigation stated that this provided only half of the story, so they analysed nuclear genomic sequences from two individuals, which showed those individuals were more closely related to Neanderthals.

- b.** Suggest a conclusion that could be drawn from the analysis of the mtDNA.

1 mark

- c.** Why would the researchers have stated that mtDNA tells only half of the story?

1 mark

- d.** Consider the results of both analyses. What conclusion could be drawn from both pieces of information?

1 mark

- e. Hominins have a number of traits in common, but they also have some differences. Morphologically, Sima de los Huesos hominins are most similar to Neanderthals.

Based on your knowledge of human evolution and the information provided, state two morphological differences you would expect to see if a skeleton of a Sima de los Huesos hominin were to be compared with that of a modern human.

2 marks

CONTINUES OVER PAGE

Question 10 (5 marks)**A taste for sweet – an anthropologist explains the evolutionary origins of why you’re programmed to love sugar**

Published: 6 January 2022, 7.01 am AEDT

Stephen Wooding

...

A fundamental challenge for our ancient ancestors was getting enough to eat.

The basic activities of day-to-day life, such as raising the young, finding shelter and securing enough food, all required energy in the form of calories. Individuals more proficient at garnering calories tended to be more successful at all these tasks.

...

In nature, sweetness signals the presence of sugars, an excellent source of calories. So foragers able to perceive sweetness could detect whether sugar was present in potential foods, especially plants, and how much.

...

Different subtypes of cells within taste buds are each responsive to a particular taste quality: sour, salty, savoury, bitter or sweet. The subtypes produce receptor proteins corresponding to their taste qualities, which sense the chemical makeup of foods as they pass by in the mouth.

One subtype produces bitter receptor proteins, which respond to toxic substances. Another produces savoury receptor proteins, which sense amino acids, the building blocks of proteins. Sweet-detecting cells produce a receptor protein called TAS1R2/3, which detects sugars.

...

Genes encode the instructions for how to make every protein in the body. The sugar-detecting receptor protein TAS1R2/3 is encoded by a pair of genes on chromosome 1 of the human genome, named TAS1R2 and TAS1R3.

Comparisons with other species reveal just how deeply sweet perception is embedded in human beings. The TAS1R2 and TAS1R3 genes aren’t only found in humans – most other vertebrates have them, too. They’re found in monkeys, cattle, rodents, dogs, bats, lizards, pandas, fish and myriad other animals. The two genes have been in place for hundreds of millions of years of evolution ...

Geneticists have long known that genes with important functions are kept intact by natural selection, while genes without a vital job tend to decay and sometimes disappear completely as species evolve. Scientists think about this as the use-it-or-lose-it theory of evolutionary genetics. The presence of the TAS1R1 and TAS2R2 genes across so many species testifies to the advantages sweet taste has provided for eons.

...

Source: Stephen Wooding, The Conversation, 6 January 2022, <<https://theconversation.com/a-taste-for-sweet-an-anthropologist-explains-the-evolutionary-origins-of-why-youre-programmed-to-love-sugar-173197>>

- a.** The ability to detect sweetness is believed to be the result of natural selection in humans.

Suggest a reason why this trait would be selected for.

2 marks

- b.** Discuss a reason why the ability to taste sweet things would be an advantage for ancestral humans when deciding which crops to plant.

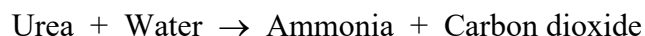
1 mark

- c.** Explain why many mammals have the *TAS1R1* and *TAS2R2* genes, but carnivores have only broken-down relics of *TAS1R2*.

2 marks

Question 11 (7 marks)

Urease is an enzyme commonly found in bacteria, fungi, algae and some species of terrestrial plants. The enzyme is responsible for catalysing the break down of urea, as shown in this word equation.



Ammonia is alkaline and increases the pH of soil or of any other medium surrounding plants that carry out this reaction.

A group of students carried out an investigation to determine whether different species of beans secrete urease. They decided to monitor the progress of the reaction by using Yamada's universal indicator, which undergoes a range of colour changes as pH changes.

The students followed these steps during their investigation.

1. Seeds of different species of bean were placed into a Petri dish lined with cotton wool.
2. All seeds were exposed to the same volume of water and left to germinate for 2 days.
3. The germinating seeds were placed into the same volume of water and ground up in a blender.
4. Each mixture was then filtered.
5. All filtrates and a volume of solution containing urea were placed into a water bath at 30 °C for 5 minutes.
6. 10 mL of filtrate 1 and of the urea solution were then mixed and replaced into the water bath.
7. This procedure was repeated with the other filtrates at 30-second intervals.
8. A sixth tube was set up containing distilled water instead of bean filtrate.
9. Every 5 minutes, a sample was taken and the pH was tested with universal indicator. The students recorded the following results.

Tube	Bean species	Test for alkaline pH at 5-minute intervals						
		0	5	10	15	20	25	30
1	broad	–	–	–	–	–	–	–
2	borlotti	–	+	+	+	+	+	+
3	green	–	–	–	–	–	–	–
4	mung	–	–	–	–	–	+	+
5	soy	–	–	–	–	+	+	+
6	distilled water	–	–	–	–	–	–	–

- a. Write an appropriate hypothesis for this investigation.

1 mark

- b.** Identify a benefit of the students using the staggered start as outlined in step 7.

1 mark

- c.** What term describes the purpose of test tube 6 in this investigation? Why was test tube 6 included in this experiment?

2 marks

- d.** Analyse the results of the experiment carried out. Use the data to explain your response.

3 marks

END OF QUESTION AND ANSWER BOOK