Units 3&4 Biology Trial Exam 2024 – Assessment Guide

Section A

VCAA Key Knowledge	Question	Answer Guide
nucleic acids as information molecules that encode instructions for the synthesis of proteins: the structure of DNA, the three main forms of RNA (mRNA, rRNA and tRNA) and a comparison of their respective nucleotides	**Question 1** Protein synthesis can be separated into two main processes: transcription and translation. During translation, **A.** mRNA molecules bring amino acids to the ribosomes. **B.** RNA polymerase forms a complementary mRNA molecule to the template strand of the gene. **C.** codons and anticodons match up at the ribosomes. **D.** amino acids join in a hydrolysis reaction to form a peptide chain.	***C*** *Codons on an mRNA molecule match up with their corresponding anticodons, which are attached to tRNA molecules, during translation. A is incorrect as tRNA, not mRNA, carries amino acids to the ribosomes. B is incorrect as it occurs during transcription, not translation. D is incorrect as the reaction is a condensation polymerisation reaction, not a hydrolysis reaction.*
the use of enzymes to manipulate DNA, including polymerase to synthesise DNA, ligase to join DNA and endonucleases to cut DNA	**Question 2** Biologists make use of several enzymes in the manipulation of DNA. Which option correctly matches the enzyme to its function? **A.** DNA polymerase — synthesises mRNA **B.** DNA ligase — joins strands of DNA **C.** RNA polymerase — synthesises a complementary strand of DNA **D.** endonucleases — initiates the synthesis of DNA	***B*** *A is incorrect as it is RNA polymerase that synthesises mRNA. C is incorrect because it is DNA polymerase that synthesises DNA. D is incorrect as endonucleases (restriction enzymes) cut DNA. DNA ligase joins strands of DNA together.*

Use the following information to answer Questions 3 - 5.

Some biology students wish to test the effect of temperature on rates of photosynthesis in a particular C3 plant. The rate of oxygen production is used to measure rates of photosynthesis. The following graph of results is produced.

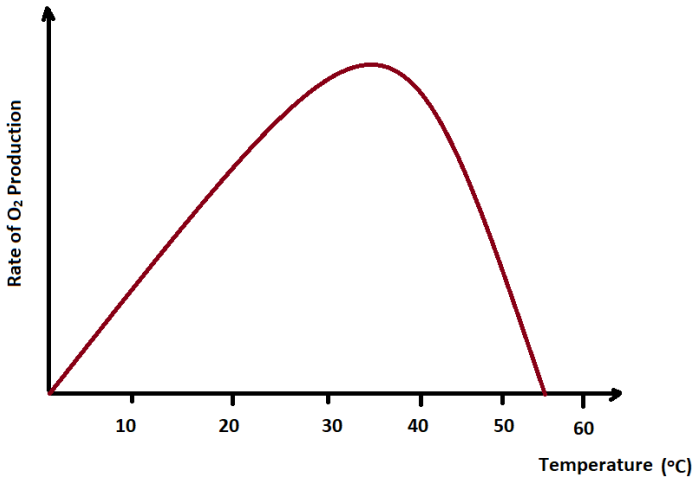

Figure 1

the general factors that impact on enzyme function in relation to photosynthesis and cellular respiration: changes in temperature, pH, concentration, competitive and non-competitive enzyme inhibitors

the factors that affect the rate of photosynthesis: light availability, water availability, temperature and carbon dioxide concentration

amino acids as the monomers of a polypeptide chain and the resultant hierarchical levels of structure that give rise to a functional protein

Question 3

What can be concluded from the information in the graph in Figure 1?

A. At temperatures higher than 45°C, the active sites of enzymes involved in photosynthesis are altered.

B. The optimum temperature for photosynthesis for this plant is 55°C.

C. At temperatures beyond 45°C, the primary structure of enzymes involved in photosynthesis begins to break down.

D. No photosynthesis will occur at temperatures below 20°C.

A

At temperatures beyond 45°C, the rate of oxygen production reduces rapidly. This is due to the denaturation of enzymes due to high temperatures. Denaturation affects the tertiary structure of an enzyme, but the primary structure remains intact.

the role of Rubisco in photosynthesis, including adaptations of C3, C4 and CAM plants to maximise the efficiency of photosynthesis

Question 4

If the students tested a C4 plant, rather than a C3 plant, how would the graph in Figure 1 be likely to differ?

A. The optimum temperature for photosynthesis would be much lower due to an increase in photorespiration.
B. Rates of photosynthesis would be higher at high temperatures due to an increase in photorespiration.
C. Rates of photosynthesis would be higher at some temperatures due to the separation of carbon fixation and the rest of the Calvin Cycle.
D. Photosynthesis would occur at higher temperatures because the stomata would only open at night.

C *In C4 plants, carbon fixation is separated from the rest of the Calvin cycle by location. This limits photorespiration, increasing rates of photosynthesis. Option D describes an adaptation of CAM plants, not C4 plants.*

identify and analyse experimental data qualitatively, handing where appropriate concepts of: accuracy, precision, repeatability, reproducibility and validity of measurements; errors (random and systematic); and certainty in data, including effects of sample size in obtaining reliable data

Question 5

Which of the following measures would increase the validity of the students' experiment?

A. increasing the number of samples tested
B. using a range of different types of plants
C. keeping the pH conditions of the samples the same
D. using a different thermometer for each sample

C *For an experiment to be valid, the only variable influencing the dependent variable (rate of photosynthesis) should be the independent variable (temperature). This can be achieved by ensuring that all other variables are controlled.*

the main inputs, outputs and locations of glycolysis, Krebs Cycle and electron transport chain including ATP yield (details of biochemical pathway mechanisms are not required)

Question 6

In aerobic cellular respiration, which process(es) do **not** require the mitochondria?

A. the Krebs Cycle only
B. the Krebs Cycle and glycolysis
C. the electron transport chain
D. glycolysis only

D *Glycolysis occurs in the cytoplasm, while the Krebs cycle and the electron transport chain occur in the mitochondria.*

the function of CRISPR-Cas9 in bacteria and the application of this function in editing an organism's genome

Question 7

CRISPR technologies offer many more opportunities for genetic engineering. A CRISPR array occurs naturally in

A. viruses, as a means to invade cells.
B. bacteria, as a defence mechanism against bacteriophages.
C. eukaryotes, as a defence against viruses.
D. most living cells, as a defence against bacteria.

B *A CRISPR array occurs naturally in bacteria as a defence against bacteriophages (viruses that infect bacteria).*

Use the following information to answer Questions 8 - 10.

An open wound, if left untreated, can lead to a potentially serious skin infection called cellulitis. This can occur through an infection by the extracellular bacterium *streptococcus*, which enters through a break in the skin.

physical, chemical and microbiota barriers as preventative mechanisms of pathogenic infection in animals and plants

Question 8

The human immune system includes physical, chemical and microbiota barriers to the entry of pathogens. Which option below correctly identifies the type of barrier provided by intact skin and identifies another example of this type of barrier?

A. physical; mucus membranes in airways
B. physical; lysozymes in tears
C. chemical; mucus membranes in airways
D. chemical; lysozymes in tears

A *Intact skin is a physical barrier against pathogens, and the mucus membranes lining the airways are another example. Lysozymes in tears are a chemical barrier.*

the innate immune response including the steps in an inflammatory response and the characteristics and roles of macrophages, neutrophils, dendritic cells, eosinophils, natural killer cells, mast cells, complement proteins and interferons

Question 9

Upon infection and detection by the body of *streptococcus*, which of the following would occur first?

A. Neutrophils would be recruited to the area of infection.
B. Infected cells would release interferons.
C. Natural killer cells would destroy the bacterial cells.
D. Mast cells would release histamine.

D *Mast cells, located near surfaces and other likely entry points for pathogens, release histamine when a pathogen is detected. This initiates the inflammatory response, which includes the recruitment of other immune cells like neutrophils to the area. Natural killer cells target infected cells rather than extracellular bacteria, and interferons are released by body cells infected with a virus.*

uses and applications of anaerobic fermentation of biomass for biofuel production

Question 10

The production of biofuels such as ethanol requires several steps.

In no particular order, some of these steps include:
W: Fermentation of biomass.
X: Blending of natural oils with fossil fuels to create commercial biofuel.
Y: Harvesting of crops for biomass.
Z: Photosynthesis to produce glucose from carbon dioxide.

The correct order of the four steps listed is

A. Z, X, Y, W.
B. Y, W, X, Z.
C. Z, Y, W, X.
D. Y, W, Z, X.

C *Photosynthesis in crops converts carbon dioxide into glucose. These crops are harvested for biomass. The biomass is fermented to produce natural oils, which are blended with fossil fuels to produce commercial biofuel.*

causes of changing allele frequencies in a population's gene pool, including environmental selection pressures, genetic drift, gene flow and mutations as the source of new alleles	**Question 11** Several factors contribute to the allele frequencies within a population. Gene flow is best defined as the **A.** transfer of genetic material between populations. **B.** changes in allele frequencies as a response to selection pressures. **C.** reduction in genetic diversity after a natural disaster and subsequent population reduction. **D.** loss of alleles from a population due to chance events.	*A*	*Gene flow refers to the transfer of alleles between populations. Option B describes natural selection, option C describes a bottleneck, and option D describes genetic drift.*

Use the following information to answer Questions 12 and 13.

Figure 2 shows an artist's impression of the extinct species *Pakicetus. Pakicetus* was a species of amphibious whale that lived around 50 million years ago. Fossils of this species are notable as they show the pathway of evolution of land mammals to sea mammals.

Figure 2

Source: https://www.forbes.com/sites/shaenamontanari/2015/11/17/four-famous-transitional-fossils-that-support-evolution

changes in species over geological time as evidenced from the fossil record: faunal (fossil) succession, index and transitional fossils, relative and absolute dating of fossils	**Question 12** Fossils such as those of *Pakicetus*, that show the evolution between major taxonomic groups, are described as **A.** index fossils. **B.** transitional fossils. **C.** reference fossils. **D.** absolute fossils.	*B*	*Transitional fossils show the evolution between major taxonomic groups, such as from dinosaurs to birds or fish to amphibians.*

evidence of relatedness between species: structural morphology – homologous and vestigial structures; and molecular homology – DNA and amino acid sequences	**Question 13** The evolutionary link between today's whales and species such as *Pakicetus* is supported by the fact that whale skeletons contain small hind limbs and a pelvis, despite whales lacking hind legs. This is an example of a **A.** homologous structure. **B.** vestigial structure. **C.** remnant structure. **D.** phylogenetic structure.	*B*	*A vestigial structure is one that a species inherited from an ancestor but no longer fulfils any function to the species. Other examples include the tailbone of humans and the eyes of blind cavefish.*

the genetic code as a universal triplet code that is degenerate and the steps in gene expression, including transcription, RNA processing in eukaryotic cells and translation by ribosomes

Question 14

A particular gene consists of 600 base pairs. The gene is transcribed and translated to form a polypeptide chain which will consist of

A. more than 200 amino acids.
B. fewer than 200 amino acids.
C. exactly 200 amino acids.
D. exactly 300 amino acids.

B *Three base pairs code for one amino acid. Due to the STOP codons, and splicing out of introns during post-transcription modification, the final mRNA molecule will contain fewer than 600 base pairs. Therefore, the polypeptide chain will have fewer than 200 amino acids.*

the innate immune response including the steps in an inflammatory response and the characteristics and roles of macrophages, neutrophils, dendritic cells, eosinophils, natural killer cells, mast cells, complement proteins and interferons

Question 15

The human immune system consists of both immune cells and complement proteins. One method by which the complement system may attack external pathogens is by causing them to lyse. This occurs through which of the following?

A. the formation of a membrane attack complex
B. the release of interferons
C. apoptosis of the invading pathogen
D. the release of histamine

A *In a membrane attack complex, complementary proteins punch a hole in the extracellular pathogen, which allows fluid to enter, causing it to lyse (burst).*

the basic elements of gene regulation: prokaryotic trp operon as a simplified example of a regulatory process

Question 16

Figure 3 shows a simplified diagram of the *trp* operon, which is found in eukaryotes such as *E. coli.*

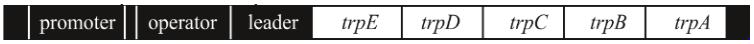

Figure 3

If levels of free tryptophan were high in the cell, which of the following would occur?

A. Tryptophan would bind directly to the operator region.
B. RNA polymerase would transcribe the *trp* genes.
C. A repressor molecule would bind to the promotor region.
D. Tryptophan would bind to a repressor molecule.

D *When levels of free tryptophan are high, tryptophan binds to a repressor molecule. This changes the shape of the repressor molecule, allowing it to bind to the operator, and preventing RNA polymerase from transcribing the trp genes.*

initiation of an immune response, including antigen presentation, the distinction between self-antigens and non-self antigens, cellular and non-cellular pathogens and allergens

Question 17

What is the general cause of most autoimmune diseases?

A. Histamine is released from mast cells to cause an inflammatory response.
B. T helper cells are absent.
C. Certain self-tissues are misidentified as “non-self” by the immune system.
D. IgE antibodies attach to mast cells.

C *In autoimmune diseases, the immune system attacks self-tissue.*

Use the following information to answer Questions 18 and 19.

Figure 4 shows a bacterial plasmid. This plasmid contains recognition sites for the restriction enzymes EcoRI, HindIII and BamHI. These plasmids are mixed with the BamHI restriction enzyme and a particular gene of interest that is to be used to transform certain bacteria. These bacteria do not naturally have resistance to either ampicillin or tetracycline.

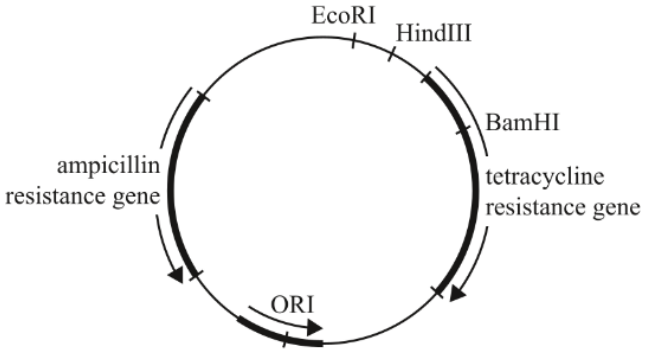

Figure 4

the use of recombinant plasmids as vectors to transform bacterial cells as demonstrated by the production of human insulin

Question 18

What is the significance of the ampicillin resistance gene in the chosen plasmid?

A. Only bacteria that have incorporated the plasmids will be resistant to ampicillin.
B. Only bacteria that have incorporated the recombinant plasmids will be resistant to ampicillin.
C. Only bacteria that have not incorporated any plasmids will be resistant to ampicillin.
D. The ampicillin resistance gene does not affect the bacteria.

A

Only bacteria that have incorporated the plasmids will be resistant to ampicillin. However, this will be true regardless of whether the plasmids are recombinant or not, as the ampicillin resistant gene is located outside of the restriction site of BamHI.

the use of recombinant plasmids as vectors to transform bacterial cells as demonstrated by the production of human insulin

Question 19

When the plasmids are mixed with bacteria, which bacteria would be transgenic organisms?

A. the bacteria that have not incorporated any plasmids
B. the bacteria that have incorporated the recombinant plasmids
C. the bacteria that have incorporated the non-recombinant plasmids
D. both B and C

D

Regardless of whether the plasmids have incorporated the foreign gene or not, since the bacteria do not naturally contain antibiotic-resistant genes, any bacteria that have incorporated plasmids will contain DNA not normally found in their genome, so can be described as transgenic organisms.

the use of genetically modified and transgenic organisms in agriculture to increase crop productivity and to provide resistance to disease

demonstrate ethical conduct when undertaking and reporting investigations

Question 20

Using CRISPR to produce genetically modified organisms (GMOs) such as crops requires consideration of several ethical concerns. Which of the following addresses the concept of non-maleficence?

A. Fair consideration should be given to the customs and beliefs of those receiving GMO crops.
B. The use of GMOs should not result in any undue harm to individuals.
C. Farmers who choose not to use GMO crops should be financially compensated.
D. Food production companies should be transparent about their use of GMO crops.

B *The principle of non-maleficence is the obligation to cause no harm.*

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the structure of genes: exons, introns and promoter and operator regions

Question 21

When a gene is transcribed, the molecule of pre-mRNA produced undergoes a series of alterations before exiting the nucleus. Which of these do *not* occur as part of RNA processing?

A. exons are spliced out
B. an adenine tail is added
C. a guanine cap is added
D. introns are removed

A *Introns are spliced out (removed) during RNA processing, so the final mRNA molecule only contains exons.*

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manipulation of gene pools through selective breeding programs

Question 22

Selective breeding programs, such as selecting crop varieties for the most desirable crop, alter the allele frequencies of a population. What is a common consequence of selective breeding?

A. increased genetic diversity
B. reduced population size
C. a reduction in genetic diversity
D. a bottleneck

C *Selective breeding programs generally reduce genetic diversity.*

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evidence of speciation as a consequence of isolation and genetic divergence, including Galapagos finches as an example of allopatric speciation and Howe palms on Lord Howe Island as an example of sympatric speciation

Question 23

The Galapagos finches provide an example of rapid evolution through the isolation of populations. This is called

A. convergent evolution.
B. allopatric speciation.
C. sympatric speciation.
D. genetic drift.

B *The evolution and speciation of the Galapagos finches is an example of allopatric speciation.*

Use the following information to answer Questions 24 and 25.

Radiocarbon dating is one technique used to measure the date of fossils. In radiocarbon dating, the ratio of carbon-14 to nitrogen-14 in the fossil is measured. Carbon-14 has a half-life of approximately 5,730 years. A particular fossil is found to have a carbon-14 to nitrogen-14 ratio of 1:3.

changes in species over geological time as evidenced from the fossil record: faunal (fossil) succession, index and transitional fossils, relative and absolute dating of fossils

Question 24

What is the approximate age of the fossil?

A. 5,730 years
B. 11,460 years
C. 17,190 years
D. 22,920 years

B *A ratio of 1:3 means that two half-lives have passed (25% C-14: 75% N-14). This is equal to 11,460 years (students should be able to estimate this without a calculator based on the options given).*

changes in species over geological time as evidenced from the fossil record: faunal (fossil) succession, index and transitional fossils, relative and absolute dating of fossils

Question 25

This fossil is used to infer the age of some other fossils found in the same layer of sediment. What type of dating is this, and what is the fossil used to date the other fossils referred to as?

A. absolute dating; transitional fossil
B. absolute dating; index fossil
C. relative dating; transitional fossil
D. relative dating; index fossil

D *This is relative dating, and the fossil is an index fossil, as it is used as a reference point for inferring the age of nearby fossils.*

the use and interpretation of phylogenetic trees as evidence for the relatedness between species

Question 26

Figure 5 shows the evolutionary relationships between a selection of species.

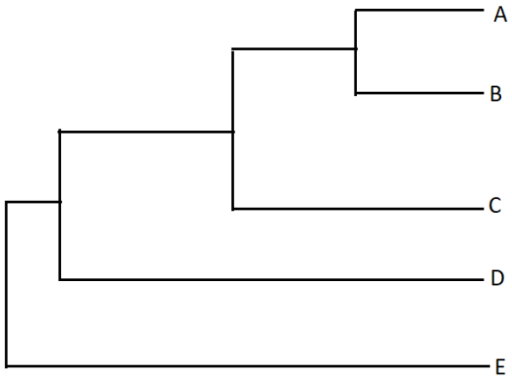

Figure 5

What can be concluded from Figure 5?

A. Species B has existed for longer than species C.
B. Species C is more closely related to species A than species D.
C. Species E has undergone the most evolutionary change.
D. Species B is more closely related to species C than species A.

B *Species C and D diverge earlier than species C and A. Therefore, species C and A are more closely related.*

the development of immunotherapy strategies, including the use of monoclonal antibodies for the treatment of autoimmune diseases and cancer

Question 27

Monoclonal antibodies are artificial proteins that are designed to target and treat specific diseases. Which of the following is **not** a process involved in the production of monoclonal antibodies?

A. An antibody that is present on the desired target cell is identified and isolated.

B. Mice or another laboratory species are used to produce B lymphocytes.

C. Extracted B lymphocytes are fused with human myeloma cells.

D. Hybridomas are formed, screened and selected.

A *An antigen, not an antibody, on the target cell is identified and isolated.*

evidence for major trends in hominin evolution from the genus Australopithecus to the genus Homo: changes in brain size and limb structure

Question 28

Homo habilis was a species of hominin, and an ancestor of *Homo sapiens,* that lived around 2 million years ago. A more recent ancestor of *Homo sapiens* is *Homo neanderthalensis.* Compared to *Homo habilis, Homo neanderthalensis* would have

A. a shorter stature.

B. flatter feet.

C. a more centrally positioned foramen magnum.

D. a smaller cranium.

C *As hominins evolved, there was a trend towards the foramen magnum being positioned closer to the centre of the skull, as an adaptation for bipedalism.*

ways of using fossil and DNA evidence (mtDNA and whole genomes) to explain the migration of modern human populations around the world, including the migration of Aboriginal and Torres Strait Islander populations and their connection to Country and Place

Question 29

Much of our knowledge about hominin evolution and interactions between *Homo sapiens* and other hominin species comes from analysis of mitochondrial DNA (mtDNA). Which option below correctly compares mtDNA to nuclear DNA?

A. mtDNA is influenced by recombination whereas nuclear DNA is not.

B. Nuclear DNA has a higher mutation rate than mtDNA.

C. mtDNA can replicate independently of the cell as a whole.

D. mtDNA contains more genes than nuclear DNA.

C *Since there are several mitochondria per cell, mtDNA can replicate independently of the cell, unlike nuclear DNA. mtDNA has a higher mutation rate and is not affected by recombination and fertilisation, making it useful for studying evolutionary relationships.*

proteins as a diverse group of molecules that collectively make an organism's proteome, including enzymes as catalysts in biochemical pathways

Question 30

The breakdown of starch into glucose is catalysed by *amylase*. In this reaction,

A. amylase is the enzyme and glucose is the substrate.

B. amylase is the enzyme and starch is the substrate.

C. starch is the enzyme and glucose is the product.

D. amylase is the substrate and glucose is the product.

B *In this reaction, starch is the substrate that binds to the active site of the enzyme amylase, and glucose is the product.*

the role of rough endoplasmic reticulum, Golgi apparatus and associated vesicles in the export of proteins from a cell via the protein secretory pathway

Question 31

Protein synthesis in eukaryotic cells contains many steps and involves several organelles. Which option correctly orders the organelles involved in protein synthesis?

A. nucleus, Golgi apparatus, ribosomes
B. ribosomes, nucleus, vesicle
C. Golgi apparatus, rough ER, vesicle
D. nucleus, rough ER, Golgi apparatus

D *The gene to make a protein is transcribed in the nucleus. The mRNA molecule then travels to the ribosomes, attached to the rough ER, where the protein is translated. The protein is then folded into its 3D structure at the Golgi apparatus and packaged into a vesicle for export from the cell.*

Use the following information to answer Questions 32 and 33.

An experiment is set up to test the effects of light intensity on rates of photosynthesis in algal balls. The vials are placed at various distances from a lamp and algal balls and pH indicators are added to each vial. The final pH of each solution after 45 minutes is recorded and the change in pH is calculated. pH is used to infer relative rates of photosynthesis and respiration, with photosynthesis producing a more alkaline solution and respiration producing a more acidic solution. Four vials are tested for each distance. The following results are produced:

Distance of Vial from lamp (cm)	Test 1		Test 2		Test 3		Test 4		Average Change in pH
	Starting pH	pH after 45min	Starting pH	pH after 45min	Starting pH	pH after 45min	Starting pH	pH after 45min	
10	7.8	8.0	7.8	8.2	7.8	8.2	7.8	8.4	+0.40
20	7.8	9.2	7.8	8.9	7.8	9.2	7.8	9.3	+1.30
30	7.8	8.8	7.8	8.6	7.8	8.6	7.8	8.6	+0.85
40	7.8	8.4	7.8	7.8	7.8	8.2	7.8	8.0	+0.30

characteristics of the selected scientific methodology and method, and appropriateness of the use of independent, dependent and controlled variables in the selected scientific investigation

Question 32

What is the independent variable in this experiment?

A. the number of vials
B. the distance of the vials from the lamp
C. final pH of the solutions
D. average change in pH of each solution

B *The distance of the vials from the lamp (and the resultant differences in light intensity) is the variable being deliberately changed. Therefore, this is the independent variable.*

inputs, outputs and locations of the light dependent and light independent stages of photosynthesis in C3 plants (details of biochemical pathway mechanisms are not required)

the general structure of the biochemical pathways in photosynthesis and cellular respiration from initial reactant to final product

Question 33

The process of photosynthesis that occurs in the algal balls contains several steps. Which of these occurs first?

A. Oxygen is released from the algal balls.
B. Carbon dioxide is fixed by enzymes.
C. Glucose is produced in the thylakoid membranes.
D. Oxygen is used in the electron transport chain.

A

The splitting of water molecules in the light-dependent reactions at the thylakoid membranes releases oxygen gas, which exits the algal balls. Carbon dioxide is fixed in the light-independent reactions, where glucose is synthesized in the stroma. The electron transport chain refers to cellular respiration, not photosynthesis.

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the general role of enzymes and coenzymes in facilitating steps in photosynthesis and cellular respiration

Question 34

A molecule that carries energy from one stage to another in photosynthesis is

A. NADH.
B. NAD^+.
C. NADPH.
D. $NADP^+$.

C

NADPH carries energy between stages in photosynthesis. NADH transfers energy in cellular respiration. $NADP^+$ is the unloaded version of NADPH.

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the role of the lymphatic system in the immune response as a transport network and the role of lymph nodes as sites for antigen recognition by T and B lymphocytes

Question 35

The lymphatic system consists of organs and networks that form the immune system. Which of the following would occur at the lymph nodes, and which part of the immune response does this form a part of?

A. Antigens are recognised by B and T lymphocytes as part of the innate immune response.
B. Antigens are recognised by B and T lymphocytes as part of the adaptive immune response.
C. Pathogens are engulfed by macrophages as part of the innate immune response.
D. Pathogens are engulfed by macrophages as part of the adaptive immune response.

B

After engulfing and displaying the antigens of a pathogen on its surface, antigen-presenting cells travel to the lymph nodes, where their antigens are matched with T cell receptors and B cell antibodies.

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the characteristics and roles of the components of the adaptive immune response against both extracellular and intracellular threats, including the actions of B lymphocytes and their antibodies, helper T and cytotoxic T cells

Question 36

T cells and B cells play important roles in the immune response. T cells and B cells differ in that

A. only T cells produce antibodies.
B. B cells target intracellular pathogens whereas T cells target extracellular pathogens.
C. only B cells have the capacity to differentiate into memory cells.
D. T cells initiate apoptosis of infected cells whereas B cells do not.

D

B cells produce antibodies, not T cells. T cells target intracellular pathogens by causing infected cells to undergo apoptosis. Both B and T cells have the capacity to differentiate into memory cells.

the human fossil record as an example of a classification scheme that is open to differing interpretations that are contested, refined or replaced when challenged by new evidence, including evidence for interbreeding between Homo sapiens and Homo neanderthalensis and evidence of new putative Homo species

Question 37

Our understanding of human ancestry is constantly being updated as new evidence becomes available. Which option below most accurately describes our current understanding of the human evolutionary path?

A. Most of the genetic diversity in today's humans can be traced to a small group of early *Homo sapiens* who spread out of Africa 55,000 – 200,000 years ago.
B. Humans are more likely to have interbred with *Homo erectus* than *Homo neanderthalensis.*
C. The human fossil record cannot provide any reliable information on our evolutionary history.
D. Early *Homo sapiens* had much higher genetic diversity as a species compared to modern-day humans.

A *According to most of the evidence provided by fossils and DNA evidence, today's humans can trace most of their ancestry back to a group of Homo sapiens that spread out of Africa.*

the location, inputs and the difference in outputs of anaerobic fermentation in animals and yeasts

Question 38

During periods of intense activity, human muscle cells may switch to anaerobic respiration. This form of respiration

A. occurs in the mitochondria.
B. requires the input of carbon dioxide.
C. produces fewer net molecules of ATP.
D. does not affect the pH of cells.

C *Anaerobic respiration produces fewer net molecules of ATP compared to aerobic respiration. It occurs in the cytoplasm, produces carbon dioxide and lowers the pH of cells through the production of lactic acid.*

amplification of DNA using polymerase chain reaction and the use of gel electrophoresis in sorting DNA fragments, including the interpretation of gel runs for DNA profiling

Question 39

Gel electrophoresis is a technique used to separate fragments of DNA. Which of the following is correct for gel electrophoresis?

A. DNA fragments move towards the negative terminal of the electrophoresis tank.
B. Larger fragments of DNA move faster through the gel.
C. The smaller fragments of DNA will be located closer to the positive terminal of the electrophoresis tank.
D. DNA moves through the electrophoresis gel because DNA is positively charged.

C *DNA is negatively charged, so when a current is applied to the electrophoresis tank, DNA will move towards the positive terminal. Smaller fragments of DNA move faster, so at the end of the run will be located closer to the positive terminal.*

scientific and social strategies employed to identify and control the spread of pathogens, including identification of the pathogen and host, modes of transmission and measures to control transmission

vaccination programs and their role in maintaining herd immunity for a specific disease in a human population

Question 40

A small community is suffering from the spread of a disease caused by a form of bacteria. The disease is spread largely through ingestion of contaminated water. Which measure would be most effective at reducing the number of cases?

A. Providing antiviral treatments to the community.
B. Wearing facemasks.
C. Quarantining visitors to the community in case they bring the disease.
D. A vaccination program against the disease.

D *Antivirals are ineffective against bacteria. Since the bacteria spread through ingestion, facemasks are unlikely to reduce the spread of disease. A vaccination program would be most effective.*

Section B

Figure 6 depicts a process that occurs in most eukaryotic cells.

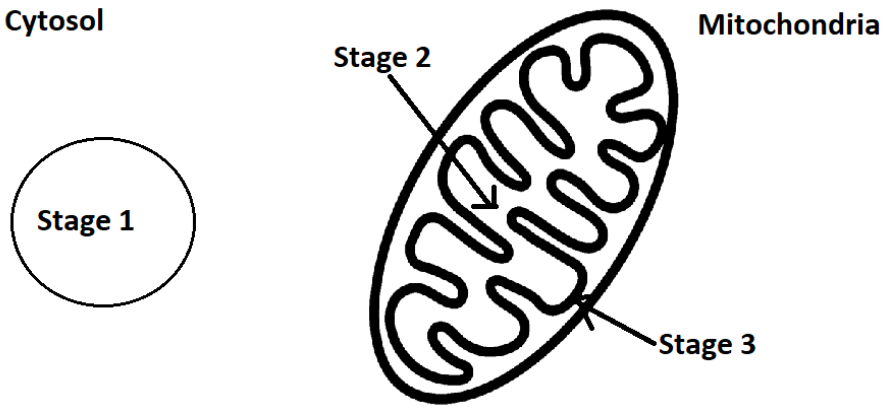


Figure 6

the main inputs, outputs and locations of glycolysis, Krebs Cycle and electron transport chain including ATP yield (details of biochemical pathway mechanisms are not required)	**Question 1a** (1 mark) Name the process depicted in Figure 6.	**Answer:** • *Aerobic cellular respiration.* **Marking Protocol:** One mark for the above point (which must state that it is *aerobic* cellular respiration).

the factors that affect the rate of cellular respiration: temperature, glucose availability and oxygen concentration *the general factors that impact on enzyme function in relation to photosynthesis and cellular respiration: changes in temperature, pH, concentration, competitive and non-competitive enzyme inhibitors*	**Question 1b** (4 marks) Several environmental factors can influence the rate at which the process in Figure 6 occurs. Describe how, and why, the rate of this reaction in mammalian cells would change as the temperature increases from 10°C to beyond 70°C.	**Answer:** • *Initially, as the temperature increases from 10°C, the rate of reaction would gradually increase.* • *This is because the reactants/substrates and the enzymes that catalyse this reaction would be moving around more and thus there would be more collisions occurring between substrates and enzyme active sites.* • *At high temperatures, beyond the optimum temperatures of the enzymes involved, the rate of reaction would rapidly decrease.* • *This is because beyond 70°C, the enzymes that catalyse the reaction become denatured, which alters the shape of their active sites so they can no longer bind with their substrates.* **Marking Protocol:** One mark for each of the above points.

the general factors that impact on enzyme function in relation to photosynthesis and cellular respiration: changes in temperature, pH, concentration, competitive and non-competitive enzyme inhibitors	**Question 1c** (2 marks) Consider your answer to Question 1b. What would the effect on the rate of reaction be if the temperature were then to be reduced to 25°C following the increase beyond 70°C? Explain your answer.	**Answer:** • *There would be no change in the rate of reaction – it would remain low or non-existent.* • *This is because the denaturation of enzymes is an irreversible process/permanent.* **Marking Protocol:** One mark for each of the above points.

the factors that affect the rate of cellular respiration: temperature, glucose availability and oxygen concentration	**Question 1d** (1 mark) Identify a factor, other than temperature, that would *increase* the rate of the reaction referred to in Figure 6.	**Answer:** • *Increased glucose availability.* • *Increased oxygen concentration.* • *Increased enzyme concentration.* **Marking Protocol:** One mark for any of the above points.

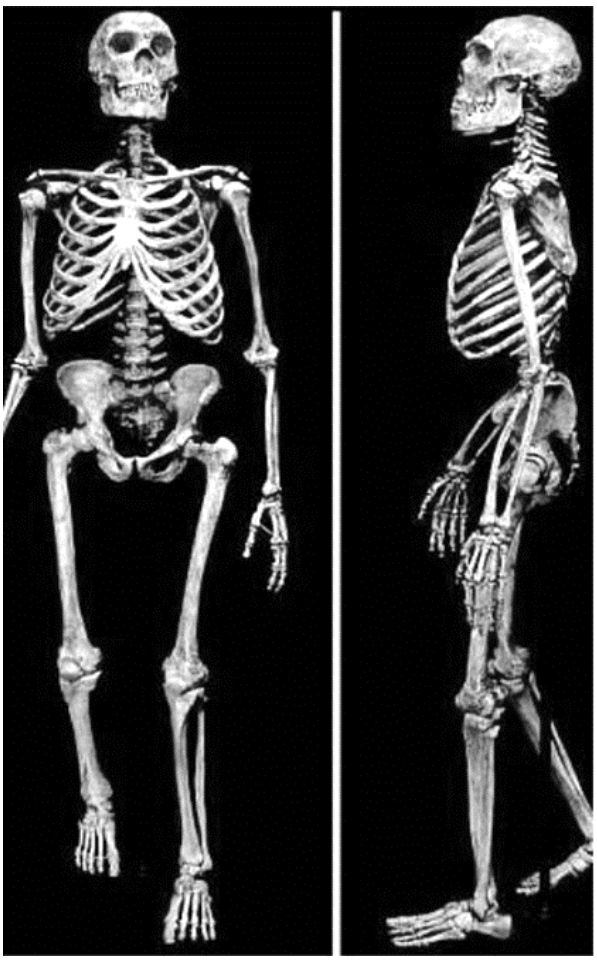
CRISPR-Cas9 can be utilised as a genome editing tool.

the function of CRISPR-Cas9 in bacteria and the application of this function in editing an organism's genome	**Question 2a** (3 marks) What type of organisms is CRISPR-Cas9 sourced from? Briefly describe the role it plays in this organism.	**Answer:** • *CRISPR-Cas9 is sourced from bacteria.* • *In bacteria it acts as a defence mechanism against bacteriophages (viruses that invade bacteria).* • *It does this by storing a copy of some of the bacteriophages/viral DNA, which it will then recognise and destroy if the cell is infected again in the future.* **Marking Protocol:** One mark for each of the above points.

the function of CRISPR-Cas9 in bacteria and the application of this function in editing an organism's genome	**Question 2b** (4 marks) Describe the steps involved in using CRISPR-Cas9 for gene editing.	**Answer:** • *Synthetic guide RNA is created that has a complementary spacer to the target DNA that is to be cut.* • *The guide RNA is mixed with a Cas-9 enzyme and a suitable complementary PAM sequence to create a CRISPR-Cas9 complex. This is injected into a cell.* • *The Cas9 finds the target PAM sequence and cuts the selected sequence of DNA with a blunt cut.* • *While the cell attempts to repair the cut DNA, selected nucleotides that scientists wish to introduce to the cell can be introduced.* **Marking Protocol:** One mark for each of the above points.

analyse and evaluate bioethical issues using relevant approaches to bioethics and ethical concepts, including the influence of social, economic, legal and political factors relevant to the selected issue	**Question 2c** (3 marks) Outline the consequences-based approach to bioethics and describe how it might be used to argue in favour of researching CRISPR-Cas9 utilising mice rather than humans.	**Answer:** ● *The consequences-based approach aims to maximise positive outcomes while minimising negative outcomes.* ● *Editing the genome of mice in experimental studies rather than humans means that any unexpected negative outcomes of such experiments are limited to animal subjects, rather than humans, which could be argued is aiming to minimise negative outcomes for humans.* ● *It could also be argued that the benefit that might be obtained from this research in terms of its applications to humans in areas such as disease and health, maximises positive outcomes.* **Marking Protocol:** One mark for each of the above points. Note: Any other correct examples of how CRISPR-Cas9 could maximise positive outcomes and minimise negative outcomes in relation to the use of mice rather than humans should be awarded marks.

Figure 8 compares the skeletons of two extinct hominin species.



Species 1

Species 2

Figure 8

Source: Adapted from www.timesofisrael.com

evidence for major trends in hominin evolution from the genus Australopithecus to the genus Homo: changes in brain size and limb structure

the human fossil record as an example of a classification scheme that is open to differing interpretations that are contested, refined or replaced when challenged by new evidence, including evidence for interbreeding between Homo sapiens and Homo neanderthalensis and evidence of new putative Homo species

Question 3a (4 marks)
Which species (1 or 2) would you consider to be the more recent ancestor of *Homo sapiens*? Give reasons for your answer, referring to three different features and how they relate to the trends in hominin evolution.

Answer:

- *Species 1 is a more recent common ancestor.*
- *Species 1 has a larger cranial capacity, inferring a larger brain size. As hominins evolved over time, there was a trend towards a larger-sized brain.*
- *Species 1 has a less robust jaw than species 2. As hominins evolved, there was a trend towards smaller jaw and teeth to coincide with an omnivorous diet.*
- *The arms of species 2 are longer in comparison to the rest of the body than species 1. This suggests that species 1 was more exclusively bipedal.*

Marking Protocol:

One mark for each of the above points. Note: other suitable features may be described, provided they are shown in the images.

evidence for major trends in hominin evolution from the genus Australopithecus to the genus Homo: changes in brain size and limb structure	**Question 3b** (2 marks) As hominins evolved, there was a trend towards a diet that included meat, rather than exclusively plants. Explain how this transition would have contributed to their evolutionary success.	**Answer:** • *Meat is much more nutrient-dense than plant matter, particularly as a source of protein.* • *Therefore, a diet that included meat would have provided energy to fuel a larger brain, which in turn would likely increase in the cognitive capacity/functioning of hominins.* **Marking Protocol:** One mark for each of the above points.

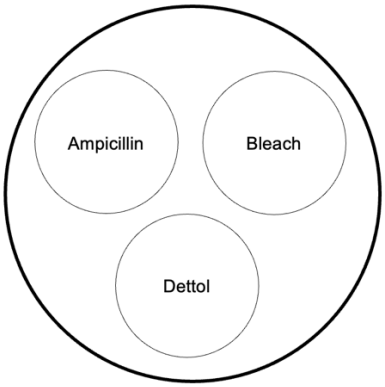
causes of changing allele frequencies in a population's gene pool, including environmental selection pressures, genetic drift, gene flow and mutations as the source of new alleles *biological consequences of changing allele frequencies in terms of increased and decreased genetic diversity*	**Question 3c** (2 marks) According to genetic analysis, significant gene flow occurred between hominin populations. Describe gene flow and explain how it can increase a population's genetic diversity.	**Answer:** • *Gene flow is the transfer of genetic material between populations, through immigration and emigration.* • *Gene flow can increase the genetic diversity of a population because immigration introduces new alleles into the population's gene pool.* **Marking Protocol:** One mark for each of the above points.

A group of biology students are interested in comparing the effectiveness of various antibacterial agents on their capacity to prevent the growth of *E. coli.* Certain strains of *E. coli* can cause gastrointestinal problems and tend to spread through contaminated food.

The students select three different antibacterial agents: ampicillin, bleach and Dettol. They set up the experiment according to the following method:

Method

1. Collect four nutrient agar plates. Label one plate as a control.
2. On the remaining three plates, draw three circles and label them with the three antibacterial agents (refer to the figure below).
3. Swab the control plate with *E. coli* broth.
4. Repeat for the remaining three plates.
5. Soak three filter paper discs in each of the three antibacterial agents.
6. In three of the plates, place one filter paper disc from each antibacterial agent in the corresponding circle. The control plate is left blank.
7. Incubate the plates at 37°C for 24 hours.
8. Remove from the incubator and measure the zone of inhibition (ZOI) around each disc (the radius of the circle in which there is no growth).



The following results were recorded:

Antibacterial Agent	Average ZOI (mm)
Ampicillin	11
Bleach	7
Dettol	6

characteristics of the selected scientific methodology and method, and appropriateness of the use of independent, dependent and controlled variables in the selected scientific investigation

Question 4a (2 marks)
Identify the independent and dependent variables in this experiment.

Answer:

- *The independent variable is the antibacterial agent used.*
- *The dependent variable is the zone of inhibition (the area around which there is no bacterial growth).*

Marking Protocol:

One mark for each of the above points.

characteristics of the selected scientific methodology and method, and appropriateness of the use of independent, dependent and controlled variables in the selected scientific investigation	**Question 4b** (1 mark) What was the purpose of the control plate in this experiment?	**Answer:** • *To act as a comparison to ensure that there were no other bacteria contaminating the agar plates, so that any bacterial growth could be attributed to E. coli growth / to determine the effect of changing the antibacterial agents by acting as a baseline.* **Marking Protocol:** One mark for the above point.

the nature of evidence that supports or refutes a hypothesis, model or theory *use reasoning to construct scientific arguments, and to draw and justify conclusions consistent with the evidence and relevant to the question under investigation*	**Question 4c** (1 mark) What can be concluded from the students' results?	**Answer:** • *According to the results, ampicillin was the most effective of the three antibacterial agents at inhibiting the growth of E. coli.* **Marking Protocol:** One mark for the above point.

the innate immune response including the steps in an inflammatory response and the characteristics and roles of macrophages, neutrophils, dendritic cells, eosinophils, natural killer cells, mast cells, complement proteins and interferons	**Question 4d** (3 marks) When a person suffers an infection of pathogenic bacteria, the immune system responds. The initial response is typically the inflammatory response. Outline the process of the inflammatory response.	**Answer:** • *Mast cells detect the entry of a pathogen and release histamine.* • *Histamine acts to recruit other immune cells to the site of infection and to make blood vessels more permeable, often causing redness and swelling.* • *The invading pathogen is then destroyed through the actions of immune cells and complement proteins.* **Marking Protocol:** One mark for each of the above points.

identify and analyse experimental data qualitatively, handing where appropriate concepts of: accuracy, precision, repeatability, reproducibility and validity of measurements; errors (random and systematic); and certainty in data, including effects of sample size in obtaining reliable data *identify outliers, and contradictory or provisional data*	**Question 4e** (2 marks) When recording the ZOI of ampicillin, the experimenters decided to omit one result as an outlier. Describe what an outlier is and what a potential cause of the outlier may be in this experiment.	**Answer:** • *An outlier is a data point that does not follow the general trend of the results, such as being much higher or much lower in numerical value (typically due to either an error in measurement or the influence of an extraneous variable).* • *The potential cause of the outlier could have been a measurement or recording error when the ampicillin ZOI was measured.* **Marking Protocol:** One mark for each of the above points.

the role of the lymphatic system in the immune response as a transport network and the role of lymph nodes as sites for antigen recognition by T and B lymphocytes *the characteristics and roles of the components of the adaptive immune response against both extracellular and intracellular threats, including the actions of B lymphocytes and their antibodies, helper T and cytotoxic T cells*	**Question 4f** (5 marks) After infection by an extracellular pathogen like bacteria, the adaptive immune response is triggered. This allows the person to acquire long-term immunity to the pathogen. Describe this process, including the relevant cells and lymphoid organs.	**Answer:** • *A macrophage or dendritic cell engulfs the extracellular pathogen or its remains and displays its antigens on its surface, thus becoming an antigen-presenting cell (APC).* • *The APC travels to the lymph nodes where it displays these antigens to naïve B cells and T helper cells until it encounters a B cell with complementary antibodies and a T helper cell with complementary receptors.* • *The T helper cell signals to the naïve B cell to multiply, and it multiplies and differentiates into B plasma cells and B memory cells.* • *The B plasma cells circulate the body, releasing antibodies that target the antigens of the pathogen, helping to immobilise or remove the pathogen.* • *The B memory cells remain in the body, and upon any future encounter with the same antigens, rapidly multiply and differentiate into B plasma cells.* **Marking Protocol:** One mark for each of the above points.

the difference between natural and artificial immunity and active and passive strategies for acquiring immunity	**Question 4g** (3 marks) Explain why the form of immunity described in Question 4f is referred to as active immunity. Distinguish this from passive immunity and explain why passive immunity is less effective in the long term.	**Answer:** ● *This is active immunity, as the body is exposed to antigens and is required to make its own antibodies and memory cells.* ● *Passive immunity occurs when the body receives a direct supply of antibodies from another source (such as from another organism).* ● *Passive immunity is less effective in the long term because memory cells are not created as part of this process (whereas they are in active immunity). Therefore, once the antibodies are out of the person's system, they no longer have immunity against any future infection.* **Marking Protocol:** One mark for each of the above points.

consequences of bacterial resistance and viral antigenic drift and shift in terms of ongoing challenges for treatment strategies and vaccination against pathogens *causes of changing allele frequencies in a population's gene pool, including environmental selection pressures, genetic drift, gene flow and mutations as the source of new alleles*	**Question 4h** (3 marks) Scientists recommend against the unnecessary or excessive use of antibiotics, as this can increase bacterial resistance. Describe the process by which a population of bacteria may become resistant to a certain antibiotic, referring to the principles of natural selection.	**Answer:** ● *Due to genetic variation within the population, there are some bacterial cells that are, due to their genotype, resistant to antibiotics.* ● *These individuals have a selective advantage over others, as they can survive and reproduce in the presence of a specific antibiotic.* ● *When the resistant bacteria reproduce, they pass on their antibiotic-resistant genes to the next generation, which can lead to a population of resistant bacteria.* **Marking Protocol:** One mark for each of the above points.

Haemoglobin is a protein found in animals and consists of four globular protein sub-units. The amino acid sequences of the protein sub-units mostly form alpha helices. In the body, haemoglobin plays an important role in transporting oxygen around the body for cellular respiration.

Because haemoglobin is found in such a wide variety of organisms, it is useful for comparing relatedness between species. The differences in amino acid sequences of the protein between different organisms can be used to infer evolutionary relationships.

The amino acid sequence of a highly conserved region of the haemoglobin protein was compared for three hypothetical species. The table below shows the sequence comparison for 20 amino acids.

Species A	phe val phe ser arg thr gly val asp cys pro arg thr trp gly ser thr val gly phe
Species B	phe thr phe ser arg thr gly phe asp cys pro arg thr trp gly ser thr val ser phe
Species C	phe val ala ser arg thr ser val gly cys pro ser thr trp gly ser thr val gly pro

amino acids as the monomers of a polypeptide chain and the resultant hierarchical levels of structure that give rise to a functional protein

Question 5a (4 marks)
Using the information provided, describe the structure of haemoglobin in reference to the four hierarchical levels of protein structure.

Answer:

- *The primary structure is the sequences of amino acids that form the polypeptide sub-units of the protein.*
- *The secondary structure is the initial/regular coiling of the polypeptide chains into alpha helices.*
- *The tertiary structure is the 3D shape that the polypeptide chains are folded into, held in place by various chemical bonds between the amino acid R side chains/groups.*
- *The quaternary structure is the four sub-units that together form the haemoglobin protein.*

Marking Protocol:
One mark for each of the above points.

nucleic acids as information molecules that encode instructions for the synthesis of proteins: the structure of DNA, the three main forms of RNA (mRNA, rRNA and tRNA) and a comparison of their respective nucleotides

the genetic code as a universal triplet code that is degenerate and the steps in gene expression, including transcription, RNA processing in eukaryotic cells and translation by ribosomes

Question 5b (3 marks)
Like all proteins, the instructions for the synthesis of haemoglobin are encoded in the organism's DNA. Describe the process in which a copy of the relevant gene is taken to the ribosomes.

Answer:

- *RNA polymerase binds to the promoter region of the gene and moves along the template strand, building a complementary pre-mRNA molecule.*
- *RNA processing occurs, in which the introns are spliced out, a guanine cap is added, and a poly-A tail is added to the pre-mRNA molecule.*
- *The molecule of mRNA exits the nucleus and attaches to a ribosome.*

Marking Protocol:
One mark for each of the above points.

nucleic acids as information molecules that encode instructions for the synthesis of proteins: the structure of DNA, the three main forms of RNA (mRNA, rRNA and tRNA) and a comparison of their respective nucleotides

Question 5c (2 marks)
Describe the role of transfer RNA (tRNA) in the synthesis of haemoglobin.

Answer:

- *Molecules of tRNA are attached to amino acids in the cytoplasm.*
- *During translation at the ribosomes, the anticodons on tRNA align with the codons of the mRNA molecule, whereby tRNA brings the specific amino acids together in the correct order to form a polypeptide chain.*

Marking Protocol:
One mark for each of the above points.

the genetic code as a universal triplet code that is degenerate and the steps in gene expression, including transcription, RNA processing in eukaryotic cells and translation by ribosomes

Question 5d (1 mark)
Name the reaction that occurs to join the amino acids of the haemoglobin proteins together.

Answer:

- *This is a condensation polymerisation reaction.*

Marking Protocol:
One mark for the above point.

the genetic code as a universal triplet code that is degenerate and the steps in gene expression, including transcription, RNA processing in eukaryotic cells and translation by ribosomes

Question 5e (2 marks)
The DNA code can be described as both universal and degenerate. How do these terms apply to the synthesis of haemoglobin?

Answer:

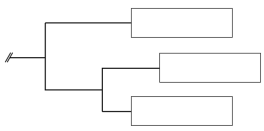
- *The universal aspect of the DNA code means that the gene that encodes the haemoglobin protein will always encode the same protein, regardless of the organism.*
- *The degenerate nature of the DNA code refers to the fact that for most amino acids, multiple codons code for the same amino acid. This means that if there is a mutation during the transcription of the haemoglobin gene, it may not affect the final amino acid sequence.*

Marking Protocol:
One mark for each of the above points.

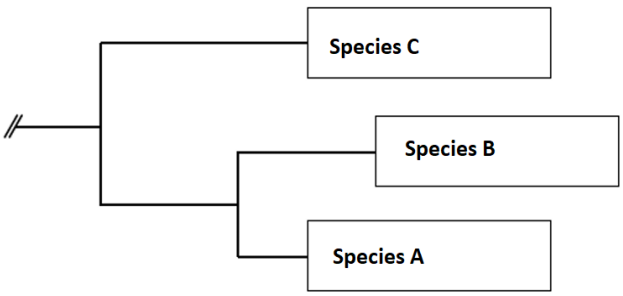
evidence of relatedness between species: structural morphology – homologous and vestigial structures; and molecular homology – DNA and amino acid sequences

the use and interpretation of phylogenetic trees as evidence for the relatedness between species

Question 5f (1 mark)
Use the information in the amino acid sequence comparison table above to place the three species on a phylogenetic tree.



Answer:



Marking Protocol:
One mark for correctly placed species.

evidence of relatedness between species: structural morphology – homologous and vestigial structures; and molecular homology – DNA and amino acid sequences	**Question 5g** (1 mark) DNA sequencing of genes can also be used to create phylogenetic trees. These are usually "highly conserved" genes. Outline what a highly conserved gene is.	**Answer:** • *Highly conserved genes are genes that are common across many different organisms.* **Marking Protocol:** One mark for the above point.

amplification of DNA using polymerase chain reaction and the use of gel electrophoresis in sorting DNA fragments, including the interpretation of gel runs for DNA profiling	**Question 5h** (4 marks) Before a gene is sequenced for comparison, it is usually necessary to "amplify" the gene by making several copies of it. Name and describe the process used to achieve this.	**Answer:** • *The process is polymerase chain reaction (PCR).* • *The DNA strand to be copied is heated to 95^{o}C to separate the two strands, then cooled to 55^{o}C to allow the primers to anneal.* • *The mixture is heated to 72^{o}C and DNA polymerase/taq polymerase builds a complementary copy of each strand of DNA.* • *The process is repeated many times to produce the desired amount of DNA.* **Marking Protocol:** One mark for each of the above points.

The Galapagos finches, which evolved on the Galapagos Islands after the migration of a single species to the islands, provide an excellent case study for speciation. Figure 8 illustrates some of the species that now exist on these islands, along with descriptions of their beaks and diets.

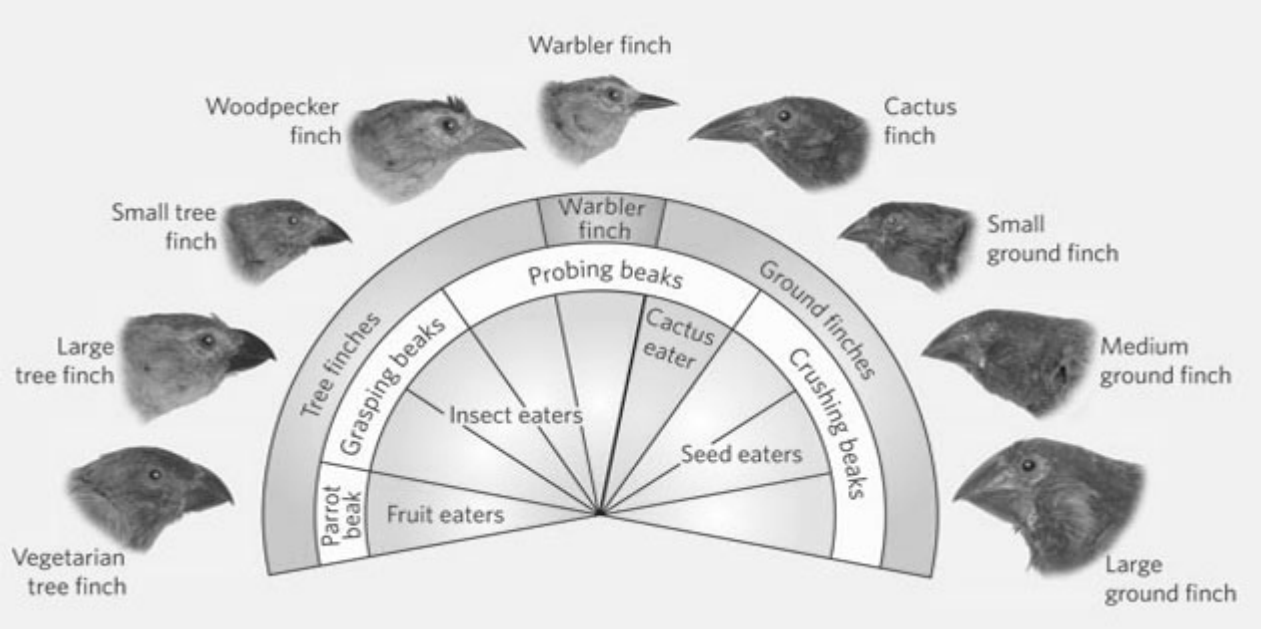


Figure 8

Source: https://cruise-tour.com/finches-galapagos/

evidence of speciation as a consequence of isolation and genetic divergence, including Galapagos finches as an example of allopatric speciation and Howe palms on Lord Howe Island as an example of sympatric speciation

causes of changing allele frequencies in a population's gene pool, including environmental selection pressures, genetic drift, gene flow and mutations as the source of new alleles

Question 6a (4 marks)
Consider the evolution of the Woodpecker finch and the Medium ground finch from a common ancestor. Describe the process that would have led to the evolution of two separate species from this common ancestor.

Answer:

- *Two populations of the ancestral species became separated by a geographical barrier so that no gene flow occurs between them.*
- *Each of the populations were exposed to different selection pressures. In this case, the selection pressure was largely due to its food source, with one species having access to foods that required crushing, and the other to foods that required probing.*
- *Over time, the beaks of the two species evolved to give them the greatest advantage in terms of food source.*
- *The two species became genetically different enough that if the two populations were brought together, they could no longer interbreed.*

Marking Protocol:
One mark for each of the above points.

causes of changing allele frequencies in a population's gene pool, including environmental selection pressures, genetic drift, gene flow and mutations as the source of new alleles	**Question 6b** (2 marks) Explain the significance of genetic mutations to the evolution of the Galapagos finches.	**Answer:** • *Genetic mutations are the source of new alleles in a population that is isolated (no immigration or emigration).* • *For the evolution of the finch species to occur, there needed to be variation in the alleles that control beak shape and size.* **Marking Protocol:** One mark for each of the above points.

evidence of speciation as a consequence of isolation and genetic divergence, including Galapagos finches as an example of allopatric speciation and Howe palms on Lord Howe Island as an example of sympatric speciation	**Question 6c** (2 marks) Distinguish between the type of speciation displayed by the Galapagos finches and the type of speciation displayed by the Howe palms on Lord Howe Island.	**Answer:** • *The speciation shown by the Galapagos finches is allopatric speciation. This occurs when a species separates into separate populations that are isolated from one another, and the evolution of new species occurs as a result.* • *The speciation shown by the Howe palms is sympatric speciation. This occurs when a single species separates into more than one new species while inhabiting the same geographic region.* **Marking Protocol:** One mark for each of the above points.

Seedlings of three different plant species were exposed to three different environments to compare their growth in each environment. One of the three plant species was classified as a C3 plant, another as a C4 plant and the third as a CAM plant. The three environmental conditions were as follows:

Environment 1: 22°C with daily watering, exposed to natural light conditions.
Environment 2: 30°C with minimal water, exposed to natural light conditions.
Environment 3: 30°C with minimal water, exposed to 24-hour light.

The following results were observed after two weeks under these conditions.

Environment	Observations after two weeks		
	Plant A	Plant B	Plant C
1	Plant has grown and appears to be healthy	Plant has grown and appears to be healthy	Plant has grown and appears to be healthy
2	Plant has grown and appears to be healthy	Plant has only grown a little and appears wilted and unhealthy	Plant has grown and appears to be healthy
3	Plant has only grown a little	Plant has only grown a little and appears wilted and unhealthy	Plant has grown and appears to be healthy

the role of Rubisco in photosynthesis, including adaptations of C3, C4 and CAM plants to maximise the efficiency of photosynthesis

Question 7a (4 marks)
From the table of observations, identify each of the plants A, B and C as either the C3 plant, C4 plant or CAM plant. Give reasons for your answers, referring to their adaptations to different environments.

Answer:

- *Plant A is the CAM plant, plant B is the C3 plant and plant C is the C4 plant.*
- *Plant A is observed to grow well under hot dry conditions, but less so when exposed to 24-hour light. CAM plants separate carbon fixation from the rest of the Calvin cycle over time, by closing their stomata during the day to limit water loss and opening them at night to let carbon dioxide in. 24-hour light exposure may mean that plant A is not triggered to open its stomata, reducing photosynthesis and therefore growth under 24-hour light.*
- *Plant B is observed to have struggled to grow under hot, dry conditions. C3 plants do not have the adaptations of C4 and CAM plants to maximise photosynthesis and limit water loss under these environmental conditions.*
- *Plant C is observed to grow well under hot, dry conditions with both natural light conditions and 24-hour light conditions. C4 plants limit photorespiration by separating carbon fixation from the rest of the Calvin cycle over space, unlike C3 plants in which all the reactions occur in the stroma.*

Marking Protocol:
One mark for each of the above points.

the role of Rubisco in photosynthesis, including adaptations of C3, C4 and CAM plants to maximise the efficiency of photosynthesis *the factors that affect the rate of photosynthesis: light availability, water availability, temperature and carbon dioxide concentration*	**Question 7b** (2 marks) Describe the role of Rubisco in photosynthesis and describe the effects of high temperatures on this process.	**Answer:** • *The role of Rubisco is to fix carbon in the light-independent stage of photosynthesis.* • *At high temperatures, Rubisco binds to O_2 more readily than it binds to CO_2, resulting in photorespiration.* **Marking Protocol:** One mark for each of the above points.

evaluate investigation methods and possible sources of personal errors/mistakes or bias, and suggest improvements to increase accuracy and precision, and to reduce the likelihood of errors *evaluate data to determine the degree to which the evidence supports the aim of the investigation, and make recommendations, as appropriate, for modifying or extending the investigation*	**Question 7c** (2 marks) Describe a limitation of the type of data collected in this experiment and suggest a modification of the investigation that may address this.	**Answer:** • *The data is qualitative, so it is not easily statistically analysed / more subjective or may be prone to researcher bias.* • *This could be addressed by measuring rates of photosynthesis quantitatively.* **Marking Protocol:** One mark for each of the above points.

VCE UNITS 3&4 BIOLOGY

Written Examination

ANSWER SHEET – 2024

Student name:	

Use a PENCIL for ALL entries. For each question, shade the box which indicates your answer.

Marks will NOT be deducted for incorrect answers.

NO MARK will be given if more than ONE answer is completed for any question.

If you make a mistake, ERASE the incorrect answer – DO NOT cross it out.

1	A	B	**C**	D
2	A	**B**	C	D
3	**A**	B	C	D
4	A	B	**C**	D
5	A	B	**C**	D
6	A	B	C	**D**
7	A	**B**	C	D
8	**A**	B	C	D
9	A	B	C	**D**
10	A	B	**C**	D
11	**A**	B	C	D
12	A	**B**	C	D
13	A	**B**	C	D
14	A	**B**	C	D

15	**A**	B	C	D
16	A	B	C	**D**
17	A	B	**C**	D
18	**A**	B	C	D
19	A	B	C	**D**
20	A	**B**	C	D
21	**A**	B	C	D
22	A	B	**C**	D
23	A	**B**	C	D
24	A	**B**	C	D
25	A	B	C	**D**
26	A	**B**	C	D
27	**A**	B	C	D
28	A	B	**C**	D

29	A	B	**C**	D
30	A	**B**	C	D
31	A	B	C	**D**
32	A	**B**	C	D
33	**A**	B	C	D
34	A	B	**C**	D
35	A	**B**	C	D
36	A	B	C	**D**
37	**A**	B	C	D
38	A	B	**C**	D
39	A	B	**C**	D
40	A	B	C	**D**