

Units 3&4 Biology Practice Exam 2023 – Assessment Guide

Section A

VCAA Key Knowledge

Question

Answer Guide

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

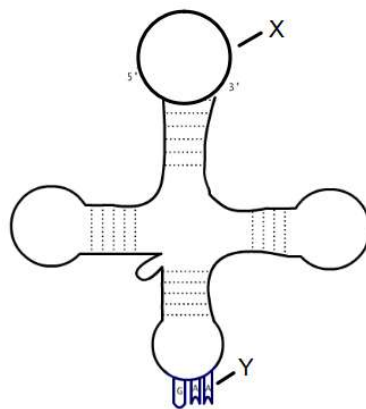
Question 1

There are 20 amino acids that are used to make proteins. Which part of the structure varies between each of these amino acids?

- A. the amino group
- B. the carboxyl group
- C. the R group
- D. hydrogen

C The R group is the only variable region in an amino acid. The amine group, the carboxyl group and hydrogen atoms are the same in each amino acid.

Use the following diagram to answer Questions 2 and 3.



Adapted From: <https://commons.wikimedia.org/wiki/File:.png>

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 2

The molecule shown in the diagram above does not contain which of the following nitrogenous bases?

- A. uracil
- B. thymine
- C. cytosine
- D. adenine

B The diagram shows tRNA which does not contain thymine as it is only found in DNA.

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 3

What do the structures labelled X and Y represent respectively?

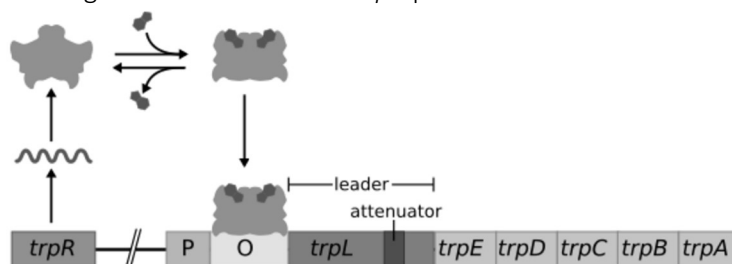
- A. amino acid and anti-codon
- B. anti-codon and amino acid
- C. codon and anti-codon
- D. amino acid and codon

A Transfer RNA has an amino acid and anti-codon attached to it. Y represents an anti-codon as it is composed of three RNA bases; so, X must be an amino acid.

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

Question 4

The diagram below shows the *trp* operon.



Adapted from: https://en.wikipedia.org/wiki/Trp_operon#/media/File:Trpoperon.svg

Which statement below is correct when describing what is occurring in the diagram?

- A. an inactive repressor is unable to bind to the operator
- B. RNA polymerase is binding to the promoter to begin transcription
- C. the repressor undergoes a conformational change to become active
- D. tryptophan is unable to bind to the repressor

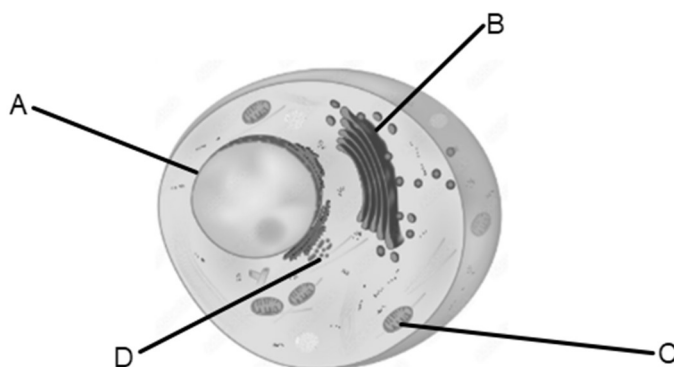
C A is incorrect as a repressor is shown to be attached to the operator region.

B is incorrect as RNA polymerase is being blocked from beginning transcription.

C is correct as binding to tryptophan has caused a change in the repressor shape.

D is incorrect as tryptophan is shown to be attached to the repressor.

Use the following information to answer Questions 5 and 6.
Consider the diagram of the eukaryotic cell shown below.



Adapted From: <https://stock.adobe.com/images/components-of-a-typical-animal-cell-unlabeled/168443766>

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 5

The correct sequence of organelles that are involved in the protein secretory pathway is

- A. vesicle, Golgi body, endoplasmic reticulum and structure A.
- B. structure C, ribosome, vesicle and structure B.
- C. rough endoplasmic reticulum, vesicle, structure B and vesicle.
- D. nucleus, structure D, vesicle and cell membrane.

C The rough endoplasmic reticulum transports proteins via vesicles to the Golgi body (structure B), which then packages proteins into vesicles for export. The nucleus (structure A) and ribosomes (structure D) are not involved in secretion. C shows the correct sequence of organelles that are involved in secretion.

the general role of enzymes and coenzymes in facilitating steps in photosynthesis and cellular respiration the general structure of the biochemical pathways in photosynthesis and cellular respiration from initial reactant to final product

Question 6

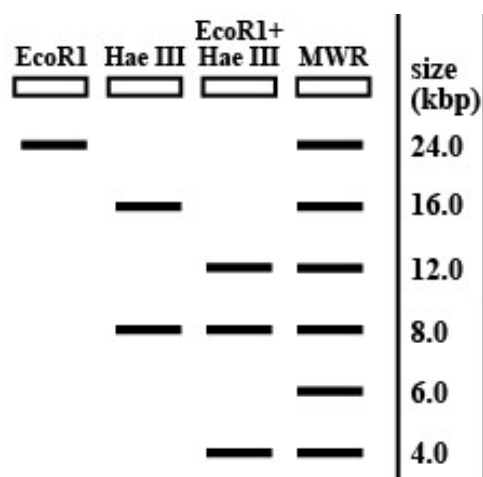
Which statement below best describes the role of structure C?

- A. site of photosynthesis
- B. site of aerobic respiration
- C. site of anaerobic respiration
- D. the only site where ATP is produced in a cell

B Structure C is the mitochondria and is the site of aerobic cellular respiration. Anaerobic respiration occurs in the cytosol and ATP can also be produced in the cytosol via glycolysis.

the use of enzymes to manipulate DNA, including polymerase to synthesise DNA, ligase to join DNA and endonucleases to cut DNA

Question 7



Source: <https://www.toppr.com/ask/question/a-gel-electrophoresis-was-run-to-show-the-fragments-produced-by-restriction-digests-with-different/>

When a bacterial plasmid is cut by both EcoRI and Hae III enzymes, how many restriction sites are needed to produce the fragments that are shown in the above gel electrophoresis?

- A. one
- B. two
- C. three
- D. four

C Plasmids are circular; hence, the number of restriction sites is the same as the number of fragments that are produced.

In the lane where the plasmid is cut with both EcoRI and Hae III, there are three fragments and, so, there must be three restriction sites.

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 8

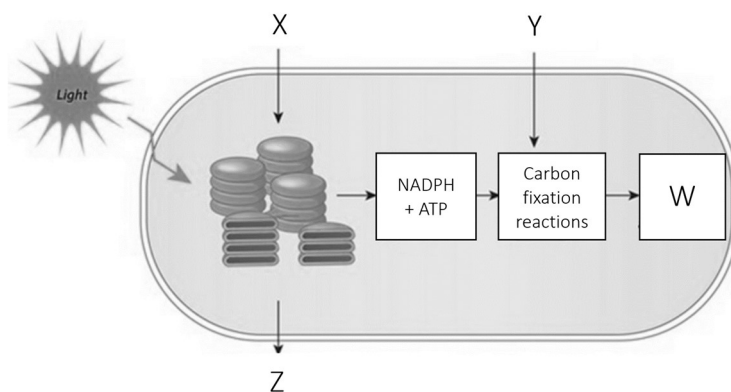
Which of the following is the best explanation for why two genetically different primers are used during PCR?

- A. because DNA is an anti-parallel double-stranded molecule
- B. because two new copies of DNA will be produced per single strand
- C. so that Taq polymerase can anneal to the primers
- D. so that genetically varied DNA copies can be made

A DNA is double-stranded and anti-parallel, which means that two genetically different primers are needed to anneal to the two 3' ends of the two strands.

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)

Question 9



Source: <https://www.nature.com/scitable/topicpage/photosynthetic-cells-14025371/>

Refer to the diagram to identify the molecule/s that are the outputs of light independent reactions of photosynthesis.

- A. X and Y
- B. W and Z
- C. Z only
- D. W and NADP

D Glucose is an output of the light-independent stage and is depicted by 'W.' NADP is also an output as it is a recyclable molecule that loses its H during the light-independent stage to become unloaded.

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

Question 10

Which of the following is NOT a strategy that is used by CAM plants to avoid photorespiration?

- A. closing stomata during the day
- B. absorbing CO₂ at night
- C. completing most of the Calvin cycle in bundle sheath cells
- D. starting the Calvin cycle in mesophyll cells

C CAM plants close their stomata during the day and open them at night to absorb CO₂.

CAM plants carry out the Calvin cycle in the mesophyll cells; C4 plants use bundle sheath cells to complete the Calvin cycle.

the factors that affect the rate of cellular respiration: temperature, glucose availability and oxygen concentration

Question 11

When the amount of glucose increases in a yeast cell, it would be expected that the amount of CO₂ that is produced

- A. decreases.
- B. increases.
- C. stays the same.
- D. decreases first then rapidly increases.

B Glucose is an input of cellular respiration, whereas CO₂ is an output; therefore, as more glucose becomes available, more CO₂ will be produced.

potential uses and applications of CRISPR-Cas9 technologies to improve photosynthetic efficiencies and crop yields

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

Question 12

CRISPR-Cas9 can be applied to change gene expression in the thylakoid membranes of chloroplasts. What is the benefit of using CRISPR-Cas9 to edit the genes of photosynthesising plant cells?

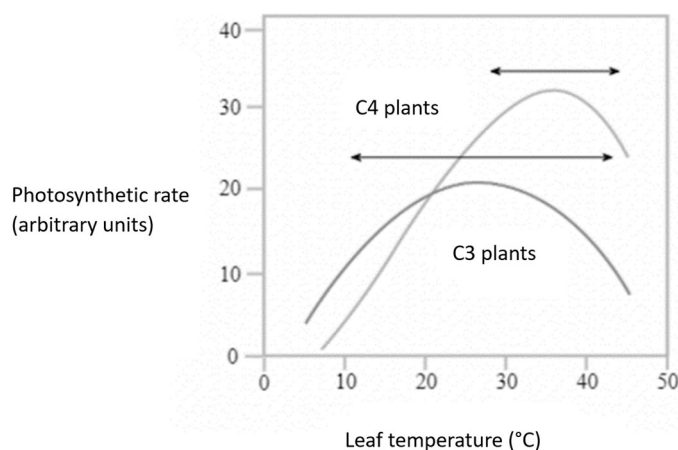
- A. it is easy and cost-effective
- B. it edits Rubisco to have an affinity to bind with O₂
- C. it increases the photorespiration rate
- D. all of the above

A CRISPR-Cas9 is a cost-effective and easy process for gene editing.

CRISPR-Cas9 is used to increase the rate of photosynthesis to increase crop yield; this would require Rubisco to bind with CO₂ rather than O₂.

Use the following information to answer Questions 13 – 15.

The graph below shows the results of an experiment that investigated the relationship between temperature and the photosynthetic rate of C3 and C4 plants.



Source: <https://www.aakash.ac.in/important-concepts/biology/photosynthesis>

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 13

Which of the following statements is true regarding the graph above?

- A. the enzymes in C3 and C4 plants denature at 10°C
- B. at 20°C, the photosynthetic rate for C3 plants is lower than C4 plants
- C. at 40°C, the photosynthetic rate for C3 plants is 25 arbitrary units
- D. C4 plants have a higher optimal temperature than C3 plants

D The graph shows that C4 plants have a higher optimal temperature than C3 plants.

At 20°C, the activity for both plants is the same. At 10°C, the activity is slower, but the enzymes have not denatured. At 40°C, the activity of C4 plants is approximately 25 arbitrary units, not C3 plants.

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 14

Which of the following explains the results that were obtained at 10°C for both plants?

- A. the enzyme activity was reduced due to the action of competitive inhibitors
- B. the low pH had begun to denature the enzymes
- C. the kinetic energy is reduced compared to other temperatures
- D. the activation energy is too low

C Increased heat increases kinetic energy, which accelerates reactions. The temperature does not affect the activation energy nor inhibition.

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 15

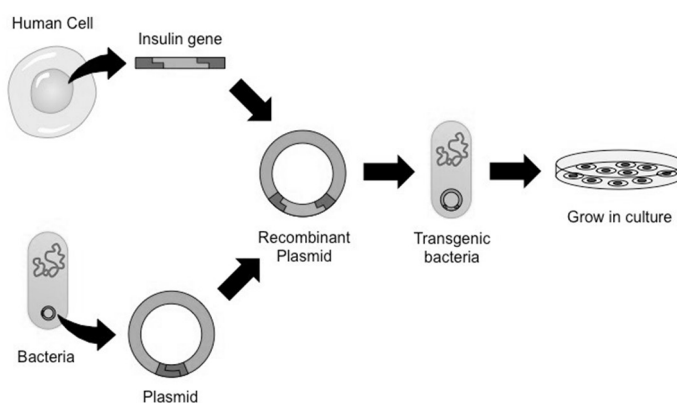
A controlled variable that would be included when collecting the data for this experiment would be

- A. leaf temperature.
- B. the photosynthetic rate.
- C. repeating the experiment in the absence of light.
- D. the CO₂ concentration.

D The temperature is the IV and, so, changes. The photosynthetic rate is the DV. Repeating the experiment is to increase the reliability of results.

The concentration of CO₂ could impact the photosynthetic rate and, therefore, would need to be controlled.

Use the following information to answer Questions 16 and 17.
The following diagram shows how recombinant technology is used to produce human insulin.



Source: <https://ib.bioninja.com.au/standard-level/topic-3-genetics/35-genetic-modification-and/gene-transfer.html>

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

Question 16

Which of the following is the vector in the process that is depicted in the image?

- A. insulin gene
- B. bacteria
- C. recombinant plasmid
- D. human cell

C In this process, the vector carries the DNA from one cell to another; in this case, it is the recombinant plasmid.

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

Question 17

Why are the bacteria referred to as 'transgenic' after the insertion of the recombinant plasmid?

- A. it has non-bacterial DNA
- B. it is antibiotic resistant
- C. it is a GMO
- D. the genes have been silenced

A The term 'transgenic' describes the addition of DNA from a foreign species.

the accuracy, precision, reproducibility, repeatability and validity of measurements

Question 18

A Year 12 biology class carried out an experiment testing the effect of glucose concentration on the rate of ethanol production by yeast cells. They ensured that all variables besides glucose concentration were controlled. This was done to ensure that the results were more

- A. precise.
- B. reproducible.
- C. valid.
- D. repeatable.

C As the glucose concentration is the IV, keeping all other variables consistent contributes to validity.

uses and applications of anaerobic fermentation of biomass for biofuel production

Question 19

Pyruvate is used by yeast cells to make ethanol, which is then converted to biofuel. The process in yeast cells that produces ethanol

- A. is aerobic fermentation.
- B. is carried out in mitochondria.
- C. requires more energy than it releases.
- D. is carried out in the absence of oxygen.

D Ethanol is an output of the anaerobic fermentation process in yeast cells; this occurs in the absence of oxygen.

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

Question 20

A chemical barrier of plants against pathogens is/are

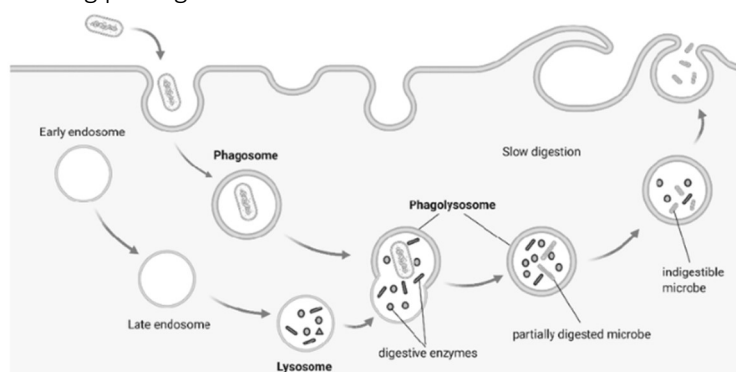
- A. thick waxy cuticles.
- B. oxalic acid.
- C. the formation of galls.
- D. interferon.

B Thick waxy cuticles and the formation of galls are physical barriers whilst interferon is found in animals, not in plants.

Oxalic acid is a chemical barrier.

Use the following information to answer Questions 21 and 22.

This diagram shows the action of macrophages in response to invading pathogenic bacteria.



Source: https://www.researchgate.net/figure/Schema-of-phagocytosis-performed-by-macrophages-Macrophages-are-professional-phagocytes_fig1_360073222

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 21

The action of macrophages as shown in the diagram is an example of a

- A. first-line of defence and specific immunity.
- B. second-line of defence and adaptive immunity.
- C. first-line of defence and passive immunity.
- D. second-line of defence and innate immunity.

D Macrophages are involved in phagocytosis and this is an example of the second line of defence and innate immunity.

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 22

Once macrophages digest the pathogenic bacteria, they travel to the lymph nodes. Which is the most correct description of what occurs here?

- A. macrophages display antigens on their MHC II markers
- B. macrophages attract Tc cells
- C. macrophages secrete antibodies
- D. macrophages respond to cytokines, causing apoptosis of the affected cells

A Macrophages are antigen-presenting cells and display antigens on MHC II markers. They do not attract Tc cells in lymph nodes, while plasma B cells secrete antibodies. Macrophages are not involved in the apoptosis of infected cells.

the difference between natural and artificial immunity and active and passive strategies for acquiring immunity

Question 23

A child was bitten by a venomous snake; she was taken to the hospital immediately, where anti-venom was administered. The type of immunity that is provided by the anti-venom is

- A. artificial and active.
- B. natural and active.
- C. artificial and passive.
- D. natural and passive.

C Anti-venom is the passive administration of antibodies; it is artificial as it is a result of medical intervention.

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 24

Which of the following statements is an accurate description of something that may occur during the humoral response?

- A. cytotoxic T cells release perforin
- B. NK cells destroy infected cells
- C. antibodies bind to pathogens and activate complement proteins
- D. mast cells release histamine

C *The humoral response does not include cytotoxic T cells, NK cells or mast cells; humoral immunity involves antibodies.*

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

Question 25

Adalimumab is a monoclonal antibody that is used in the treatment of rheumatoid arthritis, which is an autoimmune disease.

Source: <https://arthritisaustralia.com.au/medication-search/adalimumab/>

Adalimumab is likely to be an effective treatment for an autoimmune disease because

- A. of its ability to block the release of cytokines.
- B. it activates the immune system.
- C. it triggers apoptosis.
- D. it allows NK cells to kill infected cells.

A *Since adalimumab is involved in the treatment of an autoimmune disease, it would need to suppress the action of the immune system. Blocking cytokines is a form of immune repression.*

Use the following information to answer Questions 26 and 27.

Ross River virus is spread by infected mosquitoes when they bite through the skin. People are at increased risk of infection if they spend a lot of time near bodies of water, such as wetlands or rivers. It is not spread from person to person and a vaccine is not currently available in Australia.

Source: <https://www.health.nsw.gov.au/Infectious/factsheets/Pages/ross-river-fever.aspx>

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

Question 26

Ross River virus

- A. is spread through physical contact.
- B. can be prevented with the use of hand sanitizer.
- C. can only be controlled by killing mosquitoes.
- D. involves vectors.

D *Mosquitoes act as vectors of the virus by carrying the virus from one host to another.*

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

Question 27

Australia does not have herd immunity to the Ross River virus because

- A. you cannot have vaccines for viruses.
- B. there is no available vaccine.
- C. a majority of the population has already been infected.
- D. it is spread by mosquitoes.

B In Australia, Ross River is not a widely encountered disease and we do not have a vaccine available.

You can have vaccines for viruses. To achieve herd immunity, a large number of the population needs to have either been infected previously with the Ross River virus or have been immunised. Additionally, viral spread by mosquito vectors does not preclude a population from developing herd immunity.

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

Question 28

Refer to the following codon table to answer the question.

		Second Base				
		U	C	A	G	
First Base	U	UUU } Phe UUC } UUA } Leu UUG }	UCU } Ser UCC } UCA } UCG }	UAU } Tyr UAC } UAA } STOP UAG }	UGU } Cys UGC } UGA } STOP UGG } Trp	U C A G
	C	CUU } CUC } Leu CUA } CUG }	CCU } CCC } Pro CCA } CCG }	CAU } His CAC } CAA } Gln CAG }	CGU } CGC } Arg CGA } CGG }	U C A G
	A	AUU } AUC } Ile AUA } AUG } Met or Start	ACU } ACC } Thr ACA } ACG }	AAU } Asn AAC } AAA } Lys AAG }	AGU } Ser AGC } AGA } Arg AGG }	U C A G
	G	GUU } GUC } Val GUA } GUG }	GCU } GCC } Ala GCA } GCG }	GAU } Asp GAC } GAA } Glu GAG }	GGU } GGC } Gly GGA } GGG }	U C A G

Source: https://commons.wikimedia.org/wiki/File:Genetic_Code.png

A ACT results in a nonsense mutation because it codes for a STOP codon.

Which of the following sequences would result in a nonsense mutation?

- A. ACT
- B. UAA
- C. UAG
- D. ACU

biological consequences of changing allele frequencies in terms of increased and decreased genetic diversity

Question 29

A population will likely have low genetic diversity if

- A. random mating occurs.
- B. there is gene flow.
- C. there are high levels of inbreeding.
- D. there is a very high mutation rate.

C Random mating, gene flow and a high mutation rate would all increase genetic diversity, whereas inbreeding involves the passing down of the same alleles, decreasing genetic diversity.

manipulation of gene pools through selective breeding programs

Question 30

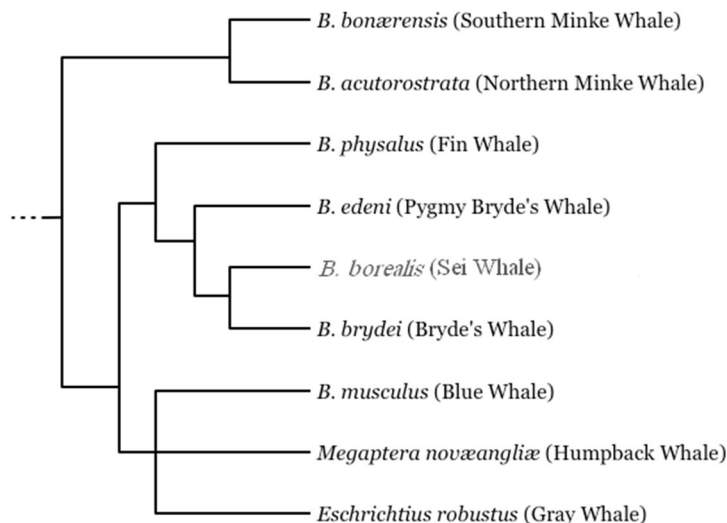
Which of the following is the most likely reason for selectively breeding sheep in Australia?

- A. to increase genetic diversity
- B. to increase wool quality
- C. to allow for more gene flow
- D. to allow natural selection to occur

B Selective breeding involves people choosing desired traits to be passed on to future generations; increased wool quality could be such a trait.

Use the following information to answer Questions 31 – 33.

The diagram below shows the evolutionary relationship between different species of whale.



Source: https://upload.wikimedia.org/wikipedia/commons/a/a1/Sei_Whale_Cladogram.PNG

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

Question 31

Which of the following statements is correct?

- A. the blue whale is more closely related to the sei whale than the Bryde's whale
- B. the southern minke whale and the northern minke whale would have more DNA in common with each other than with the other whales
- C. the pygmy Bryde's Whale shares a more recent common ancestor with the fin whale than the sei whale
- D. the humpback whale is the least closely related to the fin whale

B The southern minke whale and the northern minke whale share the most recent common ancestor with each other and, so, would be expected to have more DNA in common with each other than when compared with other whale species.

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

Question 32

The diagram above is referred to as a

- A. pedigree.
- B. evolutionary time scale.
- C. family tree.
- D. phylogenetic tree.

D The diagram shows a phylogenetic tree as it shows the evolutionary relationships between different species.

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

Question 33

Which statement is correct about the structural characteristics of the whales?

- A. the pelvic bone in whales is likely to be an example of a vestigial organ that demonstrates the ancestors of whales walked on land
- B. whales do not share any homologous structures
- C. structures that increase the chance of survival would be selected against
- D. structures that allow swimming are not inherited

A The pelvic bone is a likely a vestigial organ as whales no longer have a use for this bone; it shows, however, that their ancestors walked on land.

Since the whales share a recent common ancestor, they would have homologous structures in common. Structures that increase the chance of their survival would be selected for, not against, and structures that allow swimming are inherited adaptations.

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 34

Which of the following is not necessary for fossilisation to occur?

- A. a low oxygen environment
- B. low pressure
- C. a lack of decomposers
- D. protection from scavengers

B High pressure, rather than low pressure, is a condition of fossilisation.

Low oxygen, a lack of decomposers and protection from scavengers are all conditions of fossilisation.

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

Question 35

Which of the following gives the most accurate information when analysing the relatedness between species?

- A. comparative anatomy
- B. vestigial structures
- C. amino acids sequencing
- D. DNA sequencing

D DNA sequencing is more accurate than amino acid sequencing as the DNA code can be used to deduce the amino acid sequence but not vice versa. Structural homology is less accurate as it includes analogous structures which are not evidence of evolutionary relatedness.

the shared characteristics that define mammals, primates, hominoids and hominins

Question 36

Primates

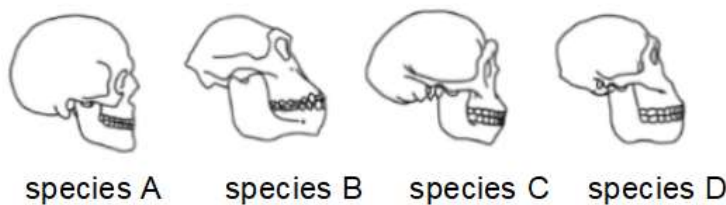
- A. have a small cranium-to-body ratio.
- B. have sensitive touch receptors in their fingers.
- C. carry out bi-pedal locomotion.
- D. lack a tail.

B Primates have sensitive touch receptors in their fingers and toes.

Conversely, primates: have a large cranium-to-body ratio when compared with other mammals; do not universally perform bi-pedal locomotion; and can have a tail.

Use the following information to answer Questions 37 and 38.

The diagram below shows a selection of skulls of various extinct and living human species.



Source: https://commons.wikimedia.org/wiki/File:Skull_evolution.png#/media/File:Skull_evolution.png

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

Question 37

Which of the skulls above has the most central foramen magnum?

- A. species A
- B. species B
- C. species C
- D. species D

A Species A is the *Homo sapiens* skull so it would have the most central foramen magnum.

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

Question 38

From oldest to most recent, which is the correct order of the four species that are shown in the diagram?

- A. B, D, C, A
- B. A, B, C, D
- C. B, D, A, C
- D. A, C, D, B

A A feature, such as the size of the cranium, could be used to determine the oldest to most recent species. Species A is *Homo sapiens*; species B is *Australopithecus africanus* (3.3 – 2 million years old); species C is *Homo erectus* (2 million – 100,000 years old) and species D is *Homo habilis* (2.4 – 1.5 million years old).

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

Please note: the following question refers to research collecting the DNA of Indigenous Australians who have died.

Question 39

Studies of Indigenous Australian mtDNA have found a high amount of genetic diversity and estimate the age of the genetic haplogroups, a combination of alleles that are closely linked and that tend to be inherited together, to be over 40,000 years old.

Source: <https://www.latrobe.edu.au/news/articles/2017/release/dna-study-of-indigenous-australians>

This supports the suggestion that

- A. Indigenous Australians migrated to Australia from Sahul.
- B. Indigenous Australians interbred with Denisovans in Asia.
- C. there was a low mutation rate in the DNA of Indigenous Australians.
- D. Indigenous Australians have one of the oldest continuous cultures in the world.

D Genetic haplogroups over the age of 40,000 years old and high rates of genetic diversity suggest that more mutations would accumulate over a longer period of time.

A long period of time alone does not give evidence of interbreeding or migration patterns. A low mutation rate would not lead to high genetic diversity.

the health, safety and ethical guidelines relevant to the selected scientific investigation

Question 40

When conducting a scientific experiment that involves human test subjects, scientists are required to

- 1) honestly report findings;
- 2) receive consent from the participants; and
- 3) reduce the possibility of any harm to the participants.

Match the requirement with the correct ethical concept.

	Requirement 1	Requirement 2	Requirement 3
A.	integrity	respect	non-maleficence
B.	beneficence	respect	non-maleficence
C.	justice	justice	beneficence
D.	integrity	justice	beneficence

A Integrity involves being trustworthy and honestly reporting findings. Receiving consent from participants is respecting the wishes of individuals, which is part of respect. Non-maleficence involves reducing harm.

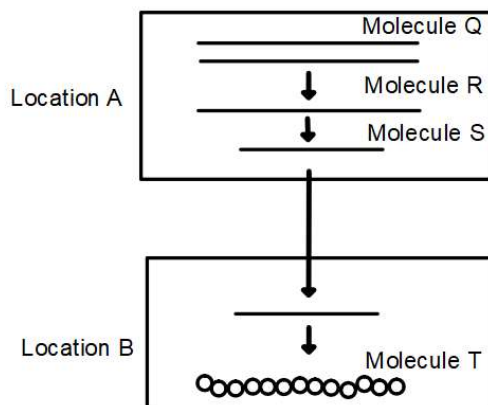
Section B

VCAA Key Knowledge

Question

Answer Guide

The following diagram shows the steps involved in the processes of gene expression.



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 1a (3 marks)

Identify Molecule Q and Molecule S. State two differences between these two molecules.

Answer:

- *Molecule Q is DNA and Molecule S is RNA/mRNA.*

Differences between DNA and RNA include:

- *DNA is double-stranded whereas RNA is single-stranded.*
- *DNA contains the sugar deoxyribose, whereas RNA contains the sugar ribose.*
- *DNA contains the base thymine, whereas RNA contains the base uracil.*

Marking Protocol:

One mark for the first point.

One mark for any difference, to a maximum of two. Any other correct differences between DNA and RNA should be awarded a mark.

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 1b (1 mark)

Justify why the length of Molecule S is shorter than that of Molecule R.

Answer:

- *Introns are cut out of pre-mRNA/molecule R, and therefore only exons are included in the final mRNA sequence/molecule S, leading to this molecule being shorter.*

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 1c (4 marks)

Outline the steps of the process that occurs in Location B that leads to the formation of Molecule T.

In your answer, identify the organelle that Location B represents and state the biological molecule that Molecule T represents.

Answer:

- *Location B is the ribosome and Molecule T is a protein/polypeptide.*
- *The mRNA is read by the ribosome, three nucleotides/one codon at a time, and tRNA molecules bring specific amino acids to the ribosome.*
- *When the anti-codon of a tRNA molecule is complementary to the codon on the mRNA and they combine, the amino acid that is carried on that specific tRNA is released.*
- *The amino acid joins to the growing polypeptide chain (linked by peptide bonds) until a STOP codon is reached by the ribosome.*

Marking Protocol:

One mark for each of the above points.

CRISPR-Cas9 is a gene-editing technique that can be used to alter the genome of plants to improve crops for human benefit. The CRISPR-Cas9 system is one way of editing a plant's genome to increase the rates of photosynthesis.

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

Question 2a (2 marks)

What type of enzyme is Cas9 and what is the role of Cas9 in the CRISPR-Cas9 complex?

Answer:

- *Cas9 is an endonuclease/restriction enzyme.*
- *Its role is to cut a specific section of double-stranded DNA.*

Marking Protocol:

One mark for each of the above points.

potential uses and applications of CRISPR-Cas9 technologies to improve photosynthetic efficiencies and crop yields

Question 2b (2 marks)

Explain how CRISPR-Cas9 technology could edit genes to change the rate of photosynthesis in plants.

Answer:

- *CRISPR-Cas9 can be used to edit the gene that codes for the enzyme Rubisco.*
- *The Rubisco protein can be edited to bind more to CO₂ (or less to O₂), which could increase the rate of photosynthesis.*

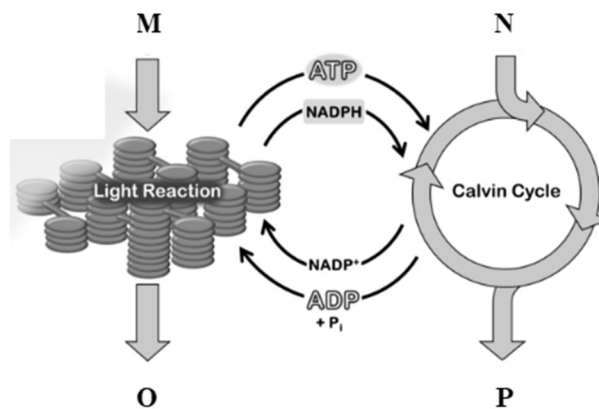
OR

- *Genes could be edited to increase the amount of chlorophyll.*
- *More chlorophyll would increase the amount of sunlight captured and hence more water split to provide more H for glucose production.*

Marking Protocol:

One mark for any of the above points, to a maximum of two.

The diagram below represents the process of photosynthesis.



Source: https://commons.wikimedia.org/wiki/File:Photosynthesis_overview.png

inputs, outputs and locations of the light dependent and light independent stages of photosynthesis in C3 plants

Question 3a (3 marks)

Name the input molecules M and N and describe how they react to produce the output molecules O and P.

Answer:

- Molecule M is water and molecule N is carbon dioxide.
- Water (M) is split by sunlight energy to produce molecule O (oxygen).
- Carbon dioxide (N) reacts with hydrogen to produce molecule P (glucose) or carbon dioxide (N) is fixed into molecule P (glucose).

Marking Protocol:

One mark for each of the above points.

inputs, outputs and locations of the light dependent and light independent stages of photosynthesis in C3 plants

Question 3b (1 mark)

Identify the structure where the light-dependent reaction of photosynthesis occurs.

Answer:

- The thylakoid membranes/grana.

Marking Protocol:

One mark for the above point.

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

Question 3c (3 marks)

Sugarcane plants are adapted to hot, sunny conditions and are an example of C4 plants. These adaptations change how the Calvin cycle of photosynthesis is carried out. Most plants are examples of C3 plants and carry out the Calvin cycle differently to C4 plants.

Explain the differences in the adaptations that affect the process of photosynthesis between sugarcane plants and C3 plants.

Answer:

- Sugarcane plants split the location of the Calvin cycle into two locations, whereas, in C3 plants, there is no separation.
- In sugarcane, the Calvin cycle begins in mesophyll cells and then finishes in bundle sheath cells, whereas, in C3 plants, the Calvin cycle only occurs in the mesophyll cells.
- Sugarcane plants have this adaptation to reduce the amount of photorespiration and to increase the amount of photosynthesis that occurs, which is not a concern for C3 plants.

Marking Protocol:

One mark for each of the above points. Any correct alternative differences between sugarcane and C3 plants should also be awarded marks.

Duckweed is a fast-growing aquatic plant that is being studied as an option to use in the production of biodiesel; currently, soybeans are the most commonly used plant to produce biodiesel.

In a new study in the *Plant Biotechnology Journal*, researchers found that genetically modifying duckweed plants could lead to the production of seven times more oil when compared with using soybeans. CRISPR-Cas9 technology was one of the techniques that was used to edit the duckweed genome. Bacterial transformation was also utilised to insert foreign genes into the duckweed plant genome to test its potential for biofuel production.

Source: <https://onlinelibrary.wiley.com/doi/full/10.1111/pbi.13943>

uses and applications of anaerobic fermentation of biomass for biofuel production

Question 4a (1 mark)
Identify the input molecule that produces bioethanol.

Answer:
• *Plant sugars.*

Marking Protocol:
One mark for the above point.

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

Question 4b (2 marks)
Would genetically modified duckweed plants be considered transgenic? Justify your response.

Answer:
• *The genetically modified duckweed plants would be considered transgenic...*
• *...because they have genes from another species inserted into their genome using bacterial transformation.*

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

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

Question 4c (2 marks)
Agrobacterium bacterial cells were used in the bacterial transformation process.

State the structure in the agrobacterial cells that allows it to be used in the bacterial transformation process and describe its role.

Answer:
• *Plasmids allow for agrobacterial cells to be used in transformation.*
• *They act as a vector to transfer DNA/genes from outside the duckweed cells into the duckweed cells.*

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

the use of enzymes to manipulate DNA, including polymerase to synthesise DNA, ligase to join DNA and endonucleases to cut DNA

Question 4d (3 marks)

Enzymes play an important role in the bacterial transformation process.

In the table, identify two enzymes that are involved in bacterial transformation and state their respective roles.

Enzyme	Role
1.	
2.	

Answer:

Enzyme	Role
1. Restriction Enzyme/Endonuclease	The role of the restriction enzyme is to cut the double-stranded DNA of the target gene and/or plasmid at a specific site.
2. DNA Ligase	The role of DNA ligase is to create phosphodiester bonds and join together the target gene and plasmid fragments of DNA.

Marking Protocol:

One mark for correctly identifying both of the names of the two enzymes.

One mark each for the correct roles of each enzyme.

potential uses and applications of CRISPR-Cas9 technologies to improve photosynthetic efficiencies and crop yields

Question 4e (1 mark)

Using CRISPR-Cas9 technology to edit the duckweed plant genome to produce large amounts of biodiesel was a breakthrough in plant biology research.

List another possible application of CRISPR-Cas9 technology on plants.

Answer:

- To increase crop yield.
- To increase the nutritional value of crops.
- To improve the appearance of fruit or vegetables to appeal to consumers.
- To change the ripening period.
- To increase the shelf life of fruit or vegetables.
- To improve drought or pest resistance.

Marking Protocol:

One mark for any one of the above points or any other reasonable answer.

Measles is a highly contagious viral disease that is spread primarily through coughing and sneezing. It can also be passed on by touching contaminated surfaces.

Source: <https://www.abc.net.au/news/health/2019-04-10/measles-spikes-prompts-immunisation-warning-are-you-at-risk/10986172>

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 5a (2 marks)

Identify whether measles is caused by a cellular or non-cellular pathogen, and provide one piece of information to support your answer.

Answer:

- Measles is a viral disease and is, therefore, non-cellular.

AND any one of:

- Viruses need a host to reproduce.
- Viruses cannot reproduce independently.
- Viruses do not have cellular components/organelles.
- Viruses do not have ribosomes, a cell membrane or a cytosol.

Marking Protocol:

One mark for the correct identification and a second mark for a correct supporting piece of information.

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

Question 5b (2 marks)

Referring to the modes of transmission of measles, describe one physical and one chemical first line of defence.

Answer:

Physical barriers

- *An intact skin barrier; to prevent the entry of pathogens after contact with a contaminated surface.*
- *Mucus; to trap any virus that enters through respiratory droplets.*
- *Cilia; to sweep the virus away from the airways (to the digestive tract).*

Chemical barriers

- *Acidic sweat; to destroy the virus on the skin.*
- *Stomach acid; to destroy the ingested/swallowed virus.*
- *Lysosomal enzymes in the saliva; to break down the virus (if it entered through the mouth).*

Marking Protocol:

One mark for any one of the points for physical defence and one mark for any one of the points for chemical defence, to a maximum of two.

Note: There must be a description and not simply an identification of a defence mechanism to warrant a mark (e.g. 'intact skin' alone would receive no marks).

MMR (measles-mumps-rubella) is the vaccine that is available to protect people from measles. In Australia, children receive two doses of the MMR vaccine – the first when they are 12 months old and the second when they are 18 months old. 90% of those who are not immunised against measles catch the disease after an exposure event.

Source: <https://www.abc.net.au/news/health/2019-04-10/measles-spikes-prompts-immunisation-warning-are-you-at-risk/10986172>

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

Question 5c (4 marks)

Outline how the MMR vaccine works to provide protection against measles.

Answer:

- *The MMR vaccine contains measles antigens/proteins that induce an immune response.*
- *B plasma cells produce measles-specific antibodies.*
- *B memory cells specific to measles are produced.*

AND either:

- *This provides protection/immunity as, upon subsequent exposure, the immune response is faster and greater than if no vaccination had occurred.*

OR

- *This leads to an immediate immune response if exposed to the virus after vaccination, providing protection against measles.*

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 5d (2 marks)

Justify whether MMR vaccination is an example of active or passive immunity.

Answer:

- *Vaccination is an example of active immunity.*

AND any one of:

- *A vaccinated individual makes their own antibodies.*
- *A vaccinated individual makes their own memory cells.*

Marking Protocol:

One mark for each of the above points.

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

Question 5e (3 marks)

The MMR vaccine is important for two reasons. It allows individuals immunised to both protect themselves and the wider population by enabling herd immunity to be achieved.

Explain the importance of herd immunity for containing an outbreak of a contagious disease such as measles, and protecting the community.

Answer:

- *Herd immunity is when an overwhelming/significant majority of a population is vaccinated, which leads to...*
- *...reduced spread of measles, as there are fewer hosts carrying the virus.*
- *It also contributes to the protection of those that cannot be vaccinated, such as babies, the elderly or the immunocompromised.*

Marking Protocol:

One mark for each of the above points.

Galápagos Island Tortoises on the slopes of the Alcedo volcano, referred to as the Alcedo Volcano Tortoise population, have comparatively lower genetic diversity than compared with other Galápagos Island tortoise populations. Evidence of volcanic eruptions burying areas of the Alcedo Volcano Tortoise population habitat in pumice and ash have been found.

Source: https://en.wikipedia.org/wiki/Population_bottleneck

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

Question 6a (1 mark)

Identify the process that most likely resulted in a reduced population size of the Alcedo Volcano Tortoise population, following the volcanic eruptions.

Answer:

- *The bottleneck effect.*

Marking Protocol:

One mark for the above point.

Biological consequences of changing allele frequencies in terms of increased and decreased genetic diversity

Question 6b (2 marks)

Provide two reasons why the process that was identified in Question 6a could contribute to the lower genetic diversity in the Alcedo Volcano Tortoise population.

Answer:

- *The Alcedo volcano tortoise population has a reduced gene pool due to its smaller population size.*
- *Certain alleles may have been lost from the population when tortoises died.*
- *Some alleles may be represented at a greater percentage than others as, due to chance, as they were possessed by tortoises that survived.*
- *Smaller populations are more vulnerable to genetic drift.*
- *Inbreeding in the population can occur leading to the same alleles being passed on to the next generation repeatedly.*

Marking Protocol:

One mark for any of the above points, to a maximum of two.

manipulation of gene pools through selective breeding programs

Question 6c (2 marks)

A different population of Galápagos Island Tortoises, the Giant Tortoise species, have seen a reduction in their population numbers over time in the Galápagos Islands.

Scientists have observed, that in the first five years in the wild, Giant Tortoise mortality rates are at their highest due to a lack of food and water, as well as the predation of hatchlings.

Today, there are conservation programs to revive Giant Tortoise populations.

Adapted From:
<https://www.galapagos.org/conservation/giant-tortoise-restoration/>

Suggest one action that conservationists can take to protect Giant Tortoise species and outline how this may increase population size.

Answer:

- *Captive breeding in the first five years.*
- *This ensures that tortoises have adequate access to food and water as well as protection from predators.*

OR

- *The removal of predators by culling or trapping.*
- *This reduces the number of hatchlings that are eaten so that more can survive to a mature age.*

Marking Protocol:

One mark for each of the above points.

Note: Please accept any other reasonable suggestion with an adequate explanation.

Lord Howe Island, found 600km from Australia's mainland, is a very small, isolated subtropical island that was formed from volcanic remains. It is shown in reference to Australia's east coast on the map below, in the centre of the triangle.



There are two *Howea* palm plant species on Lord Howe Island and they survive in close proximity to one another; these palms do not rely on insects for pollination but on wind dispersal of pollen instead.

Adapted From: https://www.mq.edu.au/__data/assets/pdf_file/0007/1217293/Plant-of-the-week-Lord-Howe-Island-Palms-Howea-spp.pdf

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

Question 7a (2 marks)

State the type of speciation of which *Howea* palms are an example. Justify your answer.

Answer:

- *Sympatric speciation.*
- *This is because there is no geographical isolation between the two species.*

Marking protocol:

One mark for each of the above points.

The two *Howea* palm species are called 'Belmore palms' and 'Kentia palms.'

Belmore palms grow on volcanic soils, whereas Kentia palms grow on calcareous soil, which is composed mostly of calcium carbonate. The soil type also seems to affect the flowering times of the two different plants. Calcareous soils, where Kentia palms successfully grow, are low in nutrients, causing flower production to occur six weeks before the Belmore palms, which grow on nutrient-rich volcanic soils.

Given that both species are wind-pollinated, biologists believe that there is enough evidence that speciation has occurred.

Adapted From: https://www.mq.edu.au/__data/assets/pdf_file/0007/1217293/Plant-of-the-week-Lord-Howe-Island-Palms-Howea-spp.pdf

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

Question 7b (2 marks)

Describe the term selection pressure. Using the provided information about the two *Howea* palm species, identify the selection pressure that was involved in this example.

Answer:

- *Selection pressure is an environmental factor that affects the survival of a species.*
- *The selection pressure in the *Howea* palm example is different soil types.*

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 and gene flow; and mutations as the source of new alleles

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

Question 7c (2 marks)

Biologists have sequenced the DNA of various Kentia palms and Belmore palms. They found that there were a small number of genetic differences between different palms of the same species; they also found that there was a significant amount of shared DNA between the two different species of palms.

Explain the biological reasons for both of these findings.

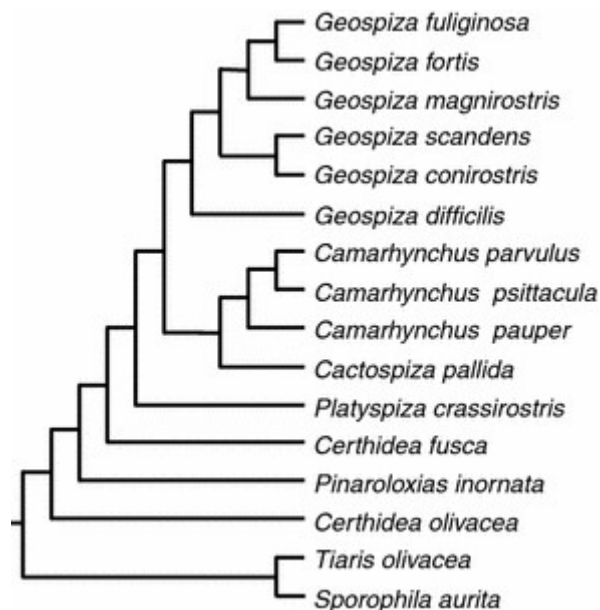
Answer:

- Genetic variation between members of the same species is due to random mutations.
- Shared DNA between members of different species is due to sharing a recent common ancestor.

Marking Protocol:

One mark for each of the above points.

The diagram below shows the evolutionary relationship between different finches in the Galapagos Islands.



Source: <https://link.springer.com/article/10.1007/s10682-008-9257-1/figures/1>

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

Question 8a (1 mark)

Identify a molecule other than DNA that can be used to construct a diagram such as the one above.

Answer:

- RNA/amino acids/protein.

Marking Protocol:

One mark for the above point.

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 8b (3 marks)

Explain which species you would expect *Geospiza scandens* to share the most DNA in common with.

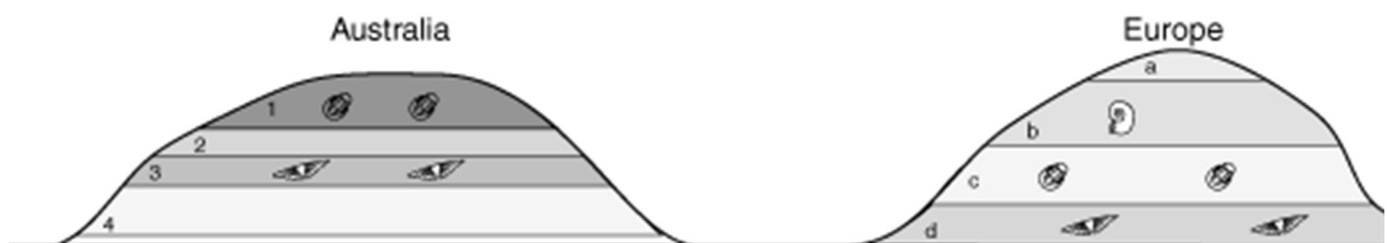
Answer:

- *Geospiza scandens* would share the most DNA with *Geospiza conirostris*, as they share the most recent common ancestor.
- Since they diverged most recently from a common ancestor compared with other species, there will have been less time since the divergence...
- ...hence, a lower number of mutations will have accumulated, resulting in the species having more DNA in common.

Marking Protocol:

One mark for each of the above points.

Study the following diagram comparing fossils that are found in Australia and Europe.



Source: <https://www.geol.umd.edu/~jmerck/geol342/lectures/18.html>

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 9a (2 marks)

Identify the oldest fossil layers for both Australia and Europe.

Answer:

- The oldest fossil layer in Australia is '3.'
- The oldest fossil layer in Europe is 'd.'

Marking Protocol:

One mark for each of the above points.

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 9b (2 marks)

Name the dating technique that is depicted in the diagrams. Identify one limitation of this technique.

Answer:

- Stratigraphy/relative dating.

AND one of:

- This technique only gives the age of a fossil relative to another fossil; it does not give the actual age of a fossil.
- Sometimes, rock strata shift positions, which makes it difficult to date the age of fossils accurately.

Marking Protocol:

One mark for each of the above points.

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 9c (3 marks)

The fossils in the top layer of the Australian rock strata are found in the second-last layer (c) in the European example.

Identify this type of fossil and how it is useful in this example of relative dating between areas in Australia and Europe.

Answer:

- *This is an index fossil.*
- *It is useful in dating geological periods.*
- *In this example, it is useful to show that Australian strata '1' is the same/similar age as European strata 'c.'*

Marking Protocol:

One mark for each of the above points.

How do you make a universal flu vaccine? A microbiologist explains the challenges, and how mRNA could offer a promising solution.

Published in The Conversation: February 8, 2023

The recent success of mRNA vaccines for COVID-19 shows promise for their use in achieving the vision of an effective universal influenza vaccine.

There are 20 known subtypes of influenza. Prior to the development of mRNA vaccines, it wasn't feasible to make a single flu vaccine against all 20 subtypes due to the complexities and costs in manufacturing. Unlike traditional vaccines, constructing and producing mRNA vaccines is rapid and simple because manufacturers don't have to produce and purify the protein directly. Instead, mRNA vaccines provide the genetic sequence of the protein and then use the body's own cells to generate that protein in its natural structure. This makes it relatively easy to incorporate any antigen or many antigens.

Recently, a team of researchers designed a mosaic mRNA vaccine with sequences from multiple versions of the haemagglutinin protein, each representing one of the 20 influenza subtypes. This vaccine induced broad immunity against each variant in mice and ferrets.

There are still several challenges before a universal influenza mRNA vaccine can be made available.

For one, it is not clear which conserved antigens provide the broadest protection and some don't naturally induce strong immune responses; so, mRNA vaccines may need improvements, like additional components that help activate immune cells. One such addition could include using mRNA to express nanoparticles that stimulate stronger immune responses against the conserved antigens that are presented by the vaccine.

The mosaic approach is also limited by the maximum dose possible for mRNA vaccines because higher doses could cause increased adverse reactions to the vaccine. When that dose gets divided into 20 or more antigens, the dose of one or more of those antigens may drop below the threshold that is needed for protection.

Scientists are working on these challenges, including by developing new mRNA technologies that work with a much lower dose. If mRNA vaccines work for universal protection from influenza, the same strategies could also apply to other frequently mutating viruses, such as the virus that causes COVID-19 and maybe even HIV.

Adapted From: <https://theconversation.com/how-do-you-make-a-universal-flu-vaccine-a-microbiologist-explains-the-challenges-and-how-mrna-could-offer-a-promising-solution-195807>

consequences of bacterial resistance and viral antigenic drift and shift in terms of ongoing challenges for treatment strategies and vaccination against pathogens

Question 10a (2 marks)

The article states that there are 20 influenza subtypes.

Identify and describe the biological process that causes this to occur.

Answer:

- *Antigenic shift.*
- *This involves small, gradual changes (mutations) in the genes that code for viral antigens.*

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 10b (2 marks)

Referring to the information in the article, discuss one social and one biological implication of designing mosaic mRNA vaccines.

Answer:

Social

- *It is easier to provide protection for the community/herd immunity with one vaccine that covers all influenza subtypes.*
- *Producing mosaic mRNA vaccine is a rapid and simple procedure that allows quicker access to vaccines for the community.*
- *If mRNA vaccines are effective with influenza, the technology could be applied to other rapidly mutating viruses, such as HIV, protecting community members from these conditions.*

Biological

- *mRNA vaccines include genetic sequences that the body then uses to produce the protein antigens, making it easier to include new mutated antigens.*
- *These vaccines provide broad immunity.*
- *A biological limitation of mosaic vaccines is that it is not clear which conserved antigens provide the broadest protection and some do not naturally induce strong immune responses.*
- *mRNA vaccines are limited in that there is a maximum dose that is possible, which may prevent the vaccine from adequately covering all influenza subtypes.*

Marking Protocol:

One mark for any of the above points, to a maximum of two.

Note: The response must include one social aspect and one biological aspect to obtain full marks.

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 10c (1 mark)

Human clinical trials, where vaccines are tested on people to see if they are safe and effective, must be carried out before a vaccine is made available to the broader population.

Outline one ethical consideration scientists conducting the trials would need to address.

Answer:

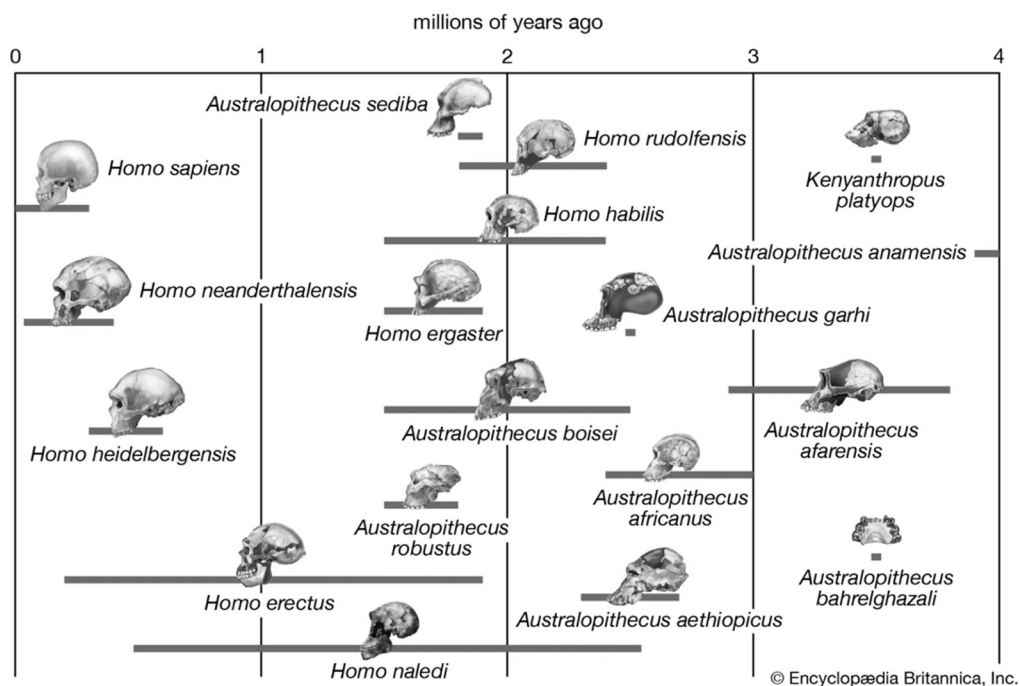
- The participants need to give informed consent, this relates to the concept of respect.
- The safety of the participants needs to be maintained (e.g. with fast access to medical professionals in case of unexpected side effects), this relates to the concept of non-maleficence.
- Scientists need to commit to having integrity while conducting the trial and reporting findings honestly whether favourable or not.
- The participants' health information must be kept private, this relates to the concept of respect.

Marking Protocol:

One mark for any one of the above points.

Note: Any other reasonable response should be awarded a mark.

The diagram below provides simple estimated time ranges for different hominin species.



Source: <https://www.britannica.com/topic/Homo-sapiens>

analyse and interpret qualitative and quantitative data to provide evidence, recognising patterns, relationships and limitations of data

Question 11a (1 mark)

Which species is the oldest species that is depicted on the diagram?

Answer:

- *Australopithecus anamensis*.

Marking Protocol:

One mark for the above point.

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

Question 11b (2 marks)

List two structural trends in the evolution of hominins from the *Australopithecus* genus to the *Homo* genus.

Answer:

- *An increased cranial capacity/brain size.*
- *A reduced arm-to-leg ratio.*
- *A more-central foramen magnum.*
- *Shorter and less-curved fingers and toes.*
- *A less prominent brow ridge/flatter face.*
- *A more-parabolic/less-rectangular jaw.*

Marking Protocol:

One mark for any of the above points, to a maximum of two.

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 11c (2 marks)

The diagram shows that *Homo sapiens* and *Homo neanderthalensis* have overlapping times of existence. Modern humans who live outside of Africa have been shown to have 1 – 4% Neanderthal DNA in their genome. This has led to a debate in the scientific community about whether to classify *Homo sapiens* and *Homo neanderthalensis* as separate species or as sub-species.

Adapted From:
<https://humanorigins.si.edu/evidence/genetics/ancient-dna-and-neanderthals>

Provide two reasons which explain how there can be disagreement between scientists when classifying different human species using the same fossil record.

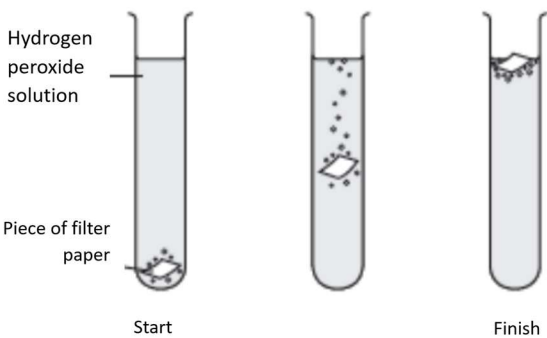
Answer:

- *There are many gaps in the fossil record.*
- *As new discoveries of fossils are made, this can alter previous views or ideas that were held by scientists.*
- *Some fossils are incomplete or only very small fragments are found.*
- *There can be different interpretations of the limited evidence collected so far in the fossil record.*

Marking Protocol:

One mark for any of the above points, to a maximum of two.

Students were testing the effect of temperature on the ability of catalase enzyme to break down hydrogen peroxide into oxygen gas. Each group of students completed three trials per temperature and measured the time that it took for paper soaked in catalase to rise when placed in a hydrogen peroxide solution.



Source: <https://qrpastpapers.com/exam/1184>

Table 1: Student Group 1 Results

Temperature (°C)	Trial 1	Trial 2	Trial 3
5	70 seconds	77 seconds	100 seconds
25	55 seconds	60 seconds	52 seconds
40	30 seconds	33 seconds	30 seconds
60	300 seconds	280 seconds	302 seconds

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 12a (1 mark)
Identify two controlled variables that could be introduced to this experiment.

Answer:

- The concentration of catalase.
- The concentration of hydrogen peroxide.
- The size of the paper disc.
- The volume of hydrogen peroxide solution.

Marking Protocol:
One mark for any two of the above points.

ways of organising, analysing and evaluating primary data to identify patterns and relationships including sources of error and uncertainty

Question 12b (2 marks)
Identify the optimal temperature for catalase. Justify your answer by referring to the data that was collected by Student Group 1.

Answer:

- The paper disc floated up most quickly when the temperature was 40°C.
- It took 30 to 33 seconds for the paper to float up, which is the fastest time when compared with the other temperatures.

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

Below are the results for another group of students.

Table 2: Student Group 2 Results

Temperature (°C)	Trial 1	Trial 2	Trial 3
5	72 seconds	75 seconds	71 seconds
25	55 seconds	56 seconds	51 seconds
40	40 seconds	35 seconds	41 seconds
60	150 seconds	155 seconds	146 seconds

*accuracy,
precision,
reproducibility,
repeatability and
validity of
measurements in
relation to the
investigation*

Question 12c (2 marks)

Analyse the results in Table 2 and justify which of the temperature measurements are the least precise.

Answer:

- *The measurements for 60°C are the least precise.*
- *These measurements have the largest range/biggest difference (of nine seconds) when compared with the other temperatures.*

Marking Protocol:

One mark for each of the above points.

*the quality of
evidence,
including validity
and authority of
data and sources
of possible errors
or bias*

Question 12d (2 marks)

Compare the results from Table 1 and Table 2 and identify which results could have resulted from a possible systematic error. Suggest a cause of that error.

Answer:

- *Either 60° in Table 1 or 60° in Table 2 could be due to a systematic error as the results for each trial in Table 1 are almost double that of the results in Table 2 (or Table 2's results are almost half of the results in Table 1).*
- *This could be due to having double the amount of enzyme being added in Group 2 or half the amount of enzyme being added in Group 1.*

Marking Protocol:

One mark for each of the above points.

**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	<input type="checkbox"/> A	<input type="checkbox"/> B	<input checked="" type="checkbox"/> C	<input type="checkbox"/> D
2	<input type="checkbox"/> A	<input checked="" type="checkbox"/> B	<input type="checkbox"/> C	<input type="checkbox"/> D
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