

Cambridge Checkpoints VCE 2024

Biology Units 3&4

Authors:

Harry Leather
Jan Leather

Introduction

In 2024, the external assessment component for Biology Units 3 & 4 will be a single, two-and-a-half-hour end-of-year examination that will contribute 50 per cent to the study score. This book contains relevant questions useful for revising for this examination. The questions are grouped into chapters that reflect the course as described in the accredited 2022–2026 Study Design.

Each chapter consists of four sections. The first section is a list of keywords. You should be familiar with all these words, be able to define them, and be able to use them in context.

The second section consists of review questions. These look at major concepts that you should understand. Their aim is to develop your knowledge base in Biology. The review questions in this edition have been rewritten with the new Study Design in mind. Some refer to Units 1 & 2 content that is required in order to understand Units 3 & 4 concepts.

The final two sections contain the most important questions – that is, multiple-choice and short-answer questions from past June and November VCAA examination papers. The question number, year, and marks allotted are shown next to each of these questions.

For several years, Biology has had a single end-of-year examination that covers the entire year's content. The new Study Design is more specific. There is less emphasis on genetic crosses, and homeostasis. The study of biomacromolecules is mainly concerned with proteins and nucleic acids. There is greater emphasis on experimental design, gene expression and regulation, and human impact on biological processes. Coordination and regulation are considered mainly at the cellular level. Signalling molecules are confined to those involved in defence against disease. As many of the questions in this book are from past VCAA papers, some parts of questions may no longer be relevant. If you are unsure of a question's relevance, check with your teacher.

Chapter 7 contains the entire examination paper based on questions asked in the 2023 VCAA paper. We would suggest that during each semester you use the questions, that have been separated into topics, to reinforce concepts as you study them. Towards the end of the year, answer the entire paper in two-and-a-half hours plus a 15-minute reading time. This will enable you to practise working to the time limit imposed in the final examination. The examination does more than just examine knowledge. It aims to test your ability to analyse a new situation and apply the concepts you have learned. This is something students initially find difficult. The good news is that with practice you will begin to tackle the questions with more confidence.

We would suggest that during each semester you use the questions, that have been separated into topics, to reinforce concepts as you study them. Towards the end of the year, answer the entire paper in two-and-a-half hours plus a 15-minute reading time. This will enable you to practise working to the time limit imposed in the final examination. The examination does more than just examine knowledge. It aims to test your ability to analyse a new situation and apply the concepts you have learned. This is something students initially find difficult. The good news is that with practice you will begin to tackle the questions with more confidence.

About the authors

Harry Leather has taught Science and Biology for over 25 years, during which time he has also been involved in curriculum development and external examination marking.

Jan Leather has taught Senior Biology for over 25 years. She has also been an external examination marker and has been heavily involved in curriculum development.

Contents

- **Chapter 1 Course overview and study hints**
- **Chapter 2 What is the role of nucleic acids and proteins in maintaining life?**
- **Chapter 3 How are biochemical pathways regulated?**
- **Chapter 4 How do organisms respond to pathogens?**
- **Chapter 5 How are species related over time?**
- **Chapter 7 VCE Examination Paper Units 3 & 4 2023**
- **Solutions**

Chapter 1 Course overview and study hints

The accredited 2022–2026 Study Design has Units 3 & 4 organised into four Areas of Study.

Unit 3: How do cells maintain life?

This unit is divided into two areas of study: ‘What is the role of nucleic acids and proteins in maintaining life’ and ‘How are biochemical pathways regulated?’

In the first Area of Study, relationships between nucleic acids and proteins as key molecules are explored. Structure and function of nucleic acids as information molecules are analysed long with gene structure and expression in prokaryotic and eukaryotic cells. Also examined are proteins as diverse group of functional molecules. DNA manipulation and application of biotechnologies is considered.

In the second Area of Study, exploration of the structure, regulation and rate of biochemical pathways with reference to photosynthesis and cellular respiration are considered. How biotechnologies related to biochemical pathways can be applied to improving agricultural practices is also considered.

Any ethical issues that arise from the applications of any biotechnologies need to be examined while studying Unit 3.

1. Key knowledge for ‘What is the role of nucleic acids and proteins in maintaining life?’

Students need to explore the expression of the information encoded in a DNA sequence to form a protein and outline the nature of the genetic code and the proteome. Knowledge is applied to the structure and the function of the DNA molecule to examine how molecular tools and techniques can be used to manipulate the molecule for a particular purpose. Comparisons of gene technologies are used to address human and agricultural issues, while considering the ethical implications of their use.

- **The relationship between nucleic acids and proteins**
 - 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
- the structure of genes: exons, introns and promoter and operator regions
- the basic elements of gene regulation: prokaryotic trp operon as a simplified example of a regulatory process
- amino acids as the monomers of a polypeptide chain and the resultant hierarchical levels of structure that give rise to a functional protein
- proteins as a diverse group of molecules that collectively make an organism's proteome, including enzymes as catalysts in biochemical pathways
- the role of rough endoplasmic reticulum, Golgi apparatus and associated vesicles in the export of proteins from a cell via the protein secretory pathway.
- **DNA manipulation techniques and applications**
 - the use of enzymes to manipulate DNA, including polymerase to synthesise DNA, ligase to join DNA and endonucleases to cut DNA
 - the function of CRISPR-Cas9 in bacteria and the application of this function in editing an organism's genome
 - 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
 - the use of recombinant plasmids as vectors to transform bacterial cells as demonstrated by the production of human insulin
 - the use of genetically modified and transgenic organisms in agriculture to increase crop productivity and to provide resistance to disease.

2. Key knowledge for ‘How are biochemical pathways regulated?’

Students are to focus on the structure and regulation of biochemical pathways. They need to examine how biochemical pathways, specifically photosynthesis and cellular respiration involve many steps that are controlled by enzymes and coenzymes. Factors that affect the rate of cellular reactions are investigated and students need to explore applications that focus on the regulation of biochemical pathways. Key knowledge is described below.

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

- the general role of enzymes and coenzymes in facilitating steps in photosynthesis and cellular respiration
- 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.
- **Photosynthesis as an example of biochemical pathways**
 - 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 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.
- **Cellular respiration as an example of biochemical pathways**
 - 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)
 - the location, inputs and the difference in outputs of anaerobic fermentation in animals and yeasts
 - the factors that affect the rate of cellular respiration: temperature, glucose availability and oxygen concentration.
- **Biotechnological applications of biochemical pathways**
 - potential uses and applications of CRISPR-Cas9 technologies to improve photosynthetic efficiencies and crop yields
 - uses and applications of anaerobic fermentation of biomass for biofuel production.

Unit 4: How does life change and respond to challenges over time?

This unit is divided into two areas of study: ‘How do organisms respond to pathogens?’ and ‘How are species related over time?’.

The first Area of Study looks at how continual changes and challenges have an impact on life on Earth through time and currently. The human immune system and interactions between its components to provide immunity to a range of different pathogens needs to be understood. Consideration of how the application of biological knowledge can be used to respond to challenges and bioethical issues related to disease is covered.

In the second Area of Study students look at evolutionary biology and the evidence that has accumulated over time to support evolutionary theory. The impact of various environmental changes on a population's gene

pool and the consequent changes in allele frequency are examined. The various evidence for evolutionary change and the relatedness of species is examined. Such evidence comes from palaeontology, structural morphology, molecular homology and comparative genomics. The evidence from the fossil record is examined, recognising that it is incomplete and different interpretations are possible and are challenged by new evidence.

1. Key knowledge for ‘How do organisms respond to pathogens?’

In this Area of Study, students focus on the immune response of organisms to specific pathogens. Students examine unique molecules called antigens and how they illicit an immune response, the nature of immunity and the role of vaccinations in providing immunity. They explain how technological advances assist in managing immune system disorders and how immunotherapies can be applied to the treatment of other diseases.

Students consider that in a globally connected world there are biological challenges that can be mediated by identification of pathogens, the prevention of spread and the development of treatments for diseases.

- **Responding to antigens**

- physical, chemical and microbiota barriers as preventative mechanisms of pathogenic infection in animals and plants
- 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
- initiation of an immune response, including antigen presentation, the distinction between self-antigens and non-self antigens, cellular and non-cellular pathogens and allergens.

- **Acquiring 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
- 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
- the difference between natural and artificial immunity and active and passive strategies for acquiring immunity.

- **Disease challenges and strategies**

- the emergence of new pathogens and re-emergence of known pathogens in a globally connected world, including the impact of European arrival on Aboriginal and Torres Strait Islander peoples

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

2. Key knowledge for ‘How are species related over time?’

In this Area of Study, students focus on changes to genetic material over time and the evidence for biological evolution. They consider how the field of evolutionary biology is based upon the accumulation of evidence over time and develop an understanding of how interpretations of evidence can change in the light of new evidence as a result of technological advances, particularly in molecular biology. Students consider the biological consequences of changes in allele frequencies and how isolation and divergence are required elements for speciation. They consider the evidence for determining the relatedness between species and examine the evidence for major trends in hominin evolution, including the migration of modern human populations around the world.

• Genetic changes in a population over time

- 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
- biological consequences of changing allele frequencies in terms of increased and decreased genetic diversity
- manipulation of gene pools through selective breeding programs
- consequences of bacterial resistance and viral antigenic drift and shift in terms of ongoing challenges for treatment strategies and vaccination against pathogens.

• Changes in species over time

- 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
- 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.

• Determining the relatedness of species

- 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.

- **Human change over time**

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

End-of-year examination

The end-of-year examination is a two-and-a-half-hour paper with an additional 15 minutes reading time. The paper is divided into two sections. The first section consists of 40 multiple-choice questions, each worth 1 mark. The second section consists of short-answer questions and is worth 70 marks. All questions are compulsory. The examination assesses a student's ability to:

- recall facts, definitions and examples
- explain biological concepts, principles and processes
- apply understanding of concepts and processes to unfamiliar situations
- analyse the relationship of data to concepts and principles
- analyse and evaluate experimental procedures
- solve problems or make predictions or judgements based on the synthesis of several ideas.

What you can do

- Become familiar with the course outline early in the semester to develop the big picture of the whole course.
- Keep up to date with work requirements and any other tasks your teacher sets.
- Review topics regularly.
- When revising, practise questions relevant to a topic, and write notes concentrating on your areas of weakness. No matter how bad your notes, they are the best set of notes for you to develop an increased understanding of a study.
- Use acronyms, diagrams and mnemonics to aid memory. (For example: to remember Adenine bonds to Thymine and Cytosine to Guanine – use **All Tigers Can Growl**.)
- Ensure that you stay informed about local and global issues in Biology.
- Sort problems out as they arise by talking to your teacher or brainstorming with your peers.
- Apportion your study effort equally across all your subjects. Within a study you should spend your study time in proportion to the marks allotted. For example, spend more time on ‘genetics’ compared with ‘natural selection’ or ‘evidence for evolution’.
- Don't memorise things you don't understand.
- Aim to keep fit and sleep well. A brain well supplied with oxygen works better than one lacking an efficient oxygen supply!

Hints for answering the examination in November

- Highlight the key words in the articles and questions as you answer them – but don't mark the paper during reading time!
- State the obvious. Do what the question asks. When asked a question, answer yes, no, agree, or disagree, then support your answer.
- Keep your answers short and simple. Point form is often enough.
- Do not use biological terms that you do not understand. You will probably not use them in the correct context. Most ideas can be explained using simple, commonly used words.
- Use pen, not pencil, for Section B. Ageing markers have difficulty reading pencil answers late at night! Your examination will be scanned and are marked online. Pencil does not scan as well as pen for written answers.
- Use a ruler to read graphs accurately. Do not just guess! Near enough may not be good enough!
- Make sure your writing can be read. Scrawling does not hide the fact that you cannot spell or are not

sure of the answer.

- Do not spend too long on a question. If you are stuck on a question, move to another question, and return to the 'sticking point' later if you have time.
- Stay relaxed and calm. If you are finding a question difficult, chances are your fellow students will also find the question difficult. A well-reasoned answer will be rewarded.
- Good luck and don't give up!

Chapter 2 What is the role of nucleic acids and proteins in maintaining life?

Question 1/ 73

Key science skills

What is meant by 'independent' and 'dependent' variables?

Question 2/ 73

Compare categorical and numerical variables by completing the following table.

Variable	Categorical		Numerical	
qualitative/quantitative				
description/number				
graphed by				
types	Nominal	Ordinal	Discrete	Continuous
example				

Question 3/ 73

The table below summarises the 'If-then-when' hypothesis construction process.

If	Relationship phrase	Then	Trend indicator	When	Trend indicator
(the DV)	(to the IV)		(effect on the DV)		(action by the IV)
...depends			...show an		...increased/decreased
on...					...
...results			increase/decrease		
from...			...		...greater/lesser...
...is affected			...to be greater		...larger/smaller...
by...			than/less than...		
...is directly			...be		
related to...			larger/smaller...		

Use the table to write a hypothesis for the research question 'Do bananas ripen faster in the dark?'.

Question 4/ 73

Why is it important to have a control group in an experiment?

Question 5/ 73

What is the difference between the control group and controlled variables?

Question 6/ 73

Is experimental accuracy the same as experimental precision?

Question 7/ 73

How can experimental precision be improved?

Question 8/ 73

Why is a large number of individuals usually included in a treatment group?

Question 9/ 73

When are experimental results considered to be valid and reliable?

Question 10/ 73

Complete the following comparison of systemic and random errors.

Errors

	Systematic	Random

Sources		

Affect		

Improved by repeating		

Question 11/ 73

State two ethical principles that must be considered when using live organisms.

Question 12/ 73

Nucleic acids

What is the basic building block of DNA?

Question 13/ 73

Draw and label a DNA nucleotide.

Question 14/ 73

Which two components of a DNA nucleotide are constant?

Question 15/ 73

The third component's chemical makeup can vary. Name the four variations.

Question 16/ 73

What are complementary base pairs?

Question 17/ 73

What type of chemical bond holds the base pairs together?

Question 18/ 73

How are the above bonds broken?

Question 19/ 73

How do RNA and DNA differ?

Question 20/ 73

In simple terms, explain how DNA codes for proteins.

Question 21/ 73

Describe the relationship between DNA, genes and chromosomes.

Question 22/ 73

What are triplets, codons and anticodons?

Question 23/ 73

In terms of nucleotides and triplets, what is a gene?

Question 24/ 73

What information is encoded by a gene?

Question 25/ 73

Approximately how many genes does a human have in a cell?

Question 26/ 73

Introns and exons are parts of eukaryotic gene sequences. Which parts seem to have the more important function?

Question 27/ 73

How many different codons are possible in the genetic code?

Question 28/ 73

Are all codons needed? How many amino acids are there?

Question 29/ 73

Do all codons code for amino acids?

Question 30/ 73

Describe the production of a finished piece of mRNA in eukaryotes. Include the role of enzymes.

Question 31/ 73

List the major steps in protein synthesis.

Question 32/ 73

Gene structure and regulation

Name two types of functions of genes. Explain whether all genes are responsible for the production of a protein.

Question 33/ 73

Complete the following summary of the structure of a eukaryotic gene.

	Name	Function
a	Promoter	
b	Start triplet	
c	Coding region	
d	Stop triplet	

Question 34/ 73

How do eukaryotic and prokaryotic genes differ?

Question 35/ 73

Explain how the trp operon switches genes on and off in prokaryotes.

Question 36/ 73

How are transcriptional factors made and what is their role?

Question 37/ 73

Nucleic acids and proteins

What are the three parts of an amino acid and which part determines the type and its properties?

Question 38/ 73

Explain in terms of protein structure what is meant by primary, secondary, tertiary and quaternary structure.

Question 39/ 73

What type of reaction links amino acids together?

Question 40/ 73

How is denaturing caused and what types of bonds are broken?

Question 41/ 73

Complete the following table.

Types of proteins

	Fibrous	Globular

Example		

Role		

Solubility		

Structure		

Question 42/ 73

With respect to nucleic acids and proteins, complete the following table.

	monomer	polymer

nucleic acid		

protein		

Question 43/ 73

DNA manipulation techniques and applications

Where is DNA found in prokaryotic and eukaryotic cells?

Question 44/ 73

How do eukaryotic and prokaryotic genes differ?

Question 45/ 73

Complete the following table to summarise how eukaryotic and prokaryotic chromosomes differ.

Chromosome	
Prokaryote	Eukaryote
shape	
presence of histone	
number per cell	
location in the cell	

Question 46/ 73

The genetic code is universal. What does this mean and why is this important in genetic engineering?

Question 47/ 73

Complete the following table.

Enzyme	Function
Endonuclease	
DNA ligase	
Polymerase	
DNA polymerase	
RNA polymerase	

Question 48/ 73

What are endonucleases (restriction enzymes) and how are they used?

Question 49/ 73

Endonucleases were originally isolated from bacteria. What is their role in bacteria and how is this reflected in the name of the endonuclease?

Question 50/ 73

What is the function of CRISPR-Cas9 in bacteria?

Question 51/ 73

Complete the following table.

CRISPR-Cas9 compound	Function
RNA Guide	
Cas9 endonuclease	

Question 52/ 73

What are the **potential** applications of CRISPR-Cas9 technology?

Question 53/ 73

Explain the steps in the polymerase chain reaction (PCR) and give examples of its use.

Question 54/ 73

Give two reasons for performing gel electrophoresis on DNA.

Question 55/ 73

Use three words to summarise the steps in each PCR cycle.

Question 56/ 73

Why is Taq polymerase, the restriction enzyme, often used in PCR?

Question 57/ 73

Complete the following table summarising the use of gel electrophoresis in the separation of DNA of unknown lengths.

Component	Function
Agarose gel	
Electric field	
Line of wells	
Dye in the samples	
Buffer	
Ethidium bromide	
Standard	

Question 58/ 73

What two features of DNA allow it to be sorted using gel electrophoresis?

Question 59/ 73

What are short tandem repeats (STRs)?

Question 60/ 73

Using a flow chart, summarise the main steps in DNA profiling.

Question 61/ 73

Why are up to 10 different STR sites commonly used in DNA profiling?

Question 62/ 73

Complete the following table summarising the differences between plasmids and prokaryotic chromosomes.

	Plasmid	Prokaryotic chromosome
Size		
Shape		
Number per cell		
Replication		
Number of gene loci		
Can be transformed (transferred to another bacterial cell)		

Question 63/ 73

What is a recombinant plasmid?

Question 64/ 73

What role do recombinant plasmids play in DNA manipulation?

Question 65/ 73

Outline the steps in producing human insulin using bacteria.

Question 66/ 73

What is a common technique used to determine which bacterial cells have been transformed?

Question 67/ 73

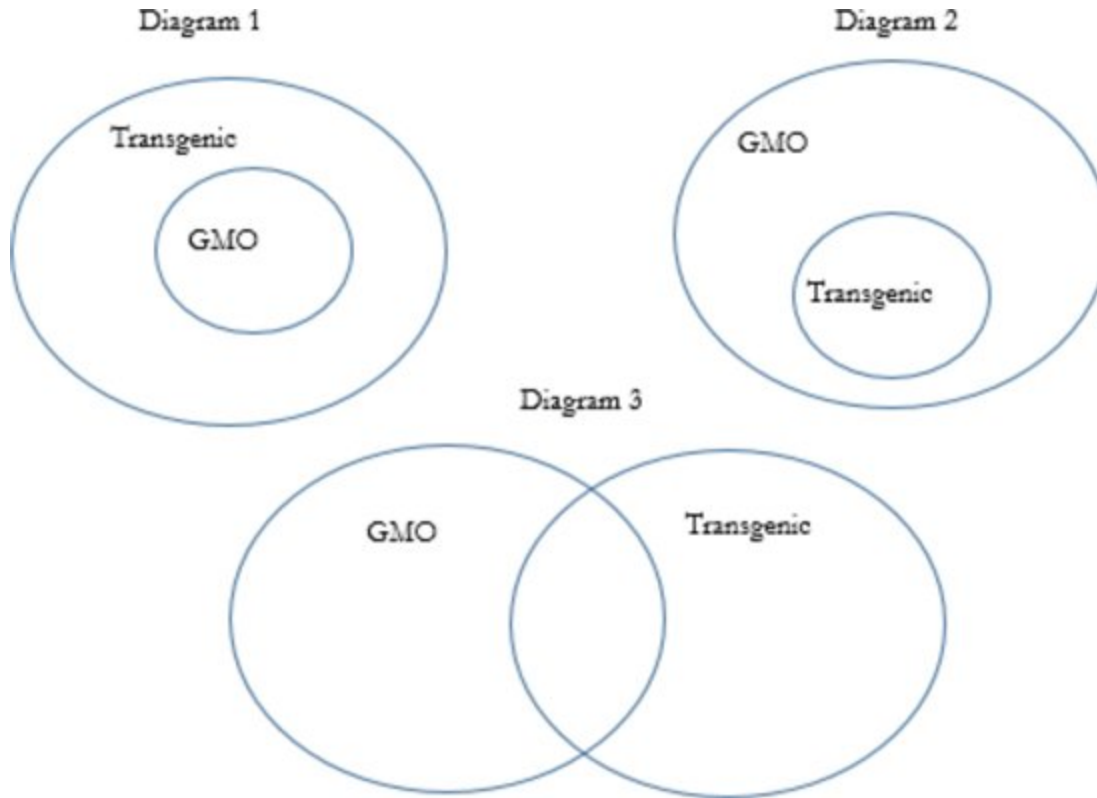
Give advantages and disadvantages of using recombinant DNA technology by completing this table.

Advantages

Disadvantages

Question 68/ 73

Which of the diagrams below best shows the relationship between genetically modified organisms (GMOs) and transgenic organisms? Explain your choice.



Question 69/ 73

What is the difference between transformation and transfection?

Question 70/ 73

List the ways foreign DNA can be inserted into a cell.

Question 71/ 73

Explain how the Ti plasmid is used to transfer genes into plants.

Question 72/ 73

Complete the following table.

Use of GMO	Example	Advantage
To provide resistance to insect predation		
To provide resistance to disease		

Question 73/ 73

Complete the following table by stating three reasons why we should use GMOs and three reasons why we shouldn't.

For	Against

Use the following information to answer Questions 1–3.

A scientist identified a single-stranded molecule with the structure shown below.

exon	intron	exon	intron	exon	intron
50 bases	150 bases	70 bases	80 bases	120 bases	40 bases

[VCAA 2022 SA Q2]

It would be reasonable for the scientist to conclude that this molecule is

A mature mRNA.

B pre-mRNA.

C copy DNA.

D DNA.

Question 2/ 136

[VCAA 2022 SA Q3]

In which part of a cell would this molecule be found?

A nucleus.

B ribosome.

C Golgi apparatus.

D endoplasmic reticulum.

Question 3/ 136

[VCAA 2022 SA Q4]

The scientist would expect the length of the molecule that is translated into a protein to be

A 240 bases.

B 270 bases.

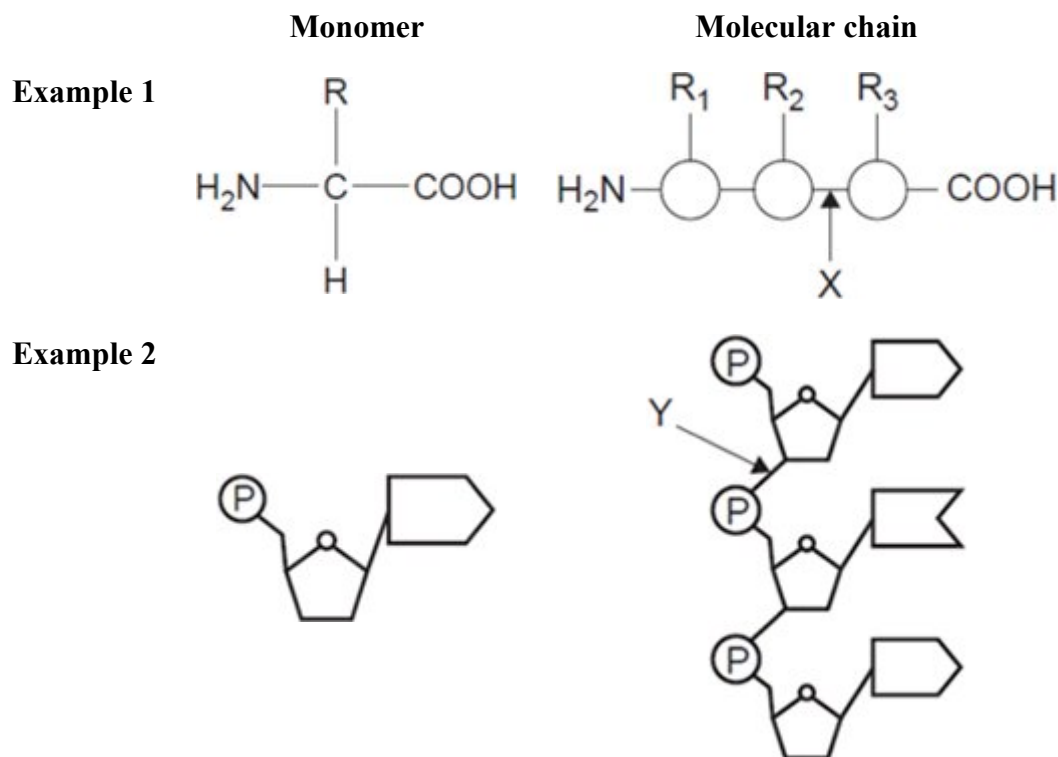
C 480 bases.

D 510 bases.

Question 4/ 136

[VCAA 2021 SA Q1]

Cells synthesise different molecular chains using distinct monomers, as shown in the two examples below.



The formation of chemical bonds X and Y

A requires a water molecule as a reactant.

B involves condensation polymerisation.

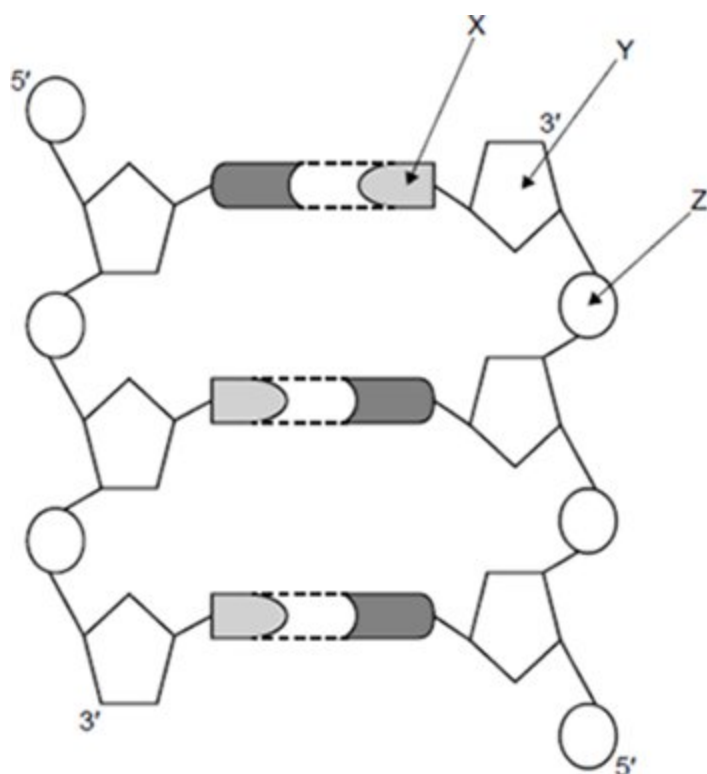
C releases energy for use in the cell.

D occurs in the Calvin cycle.

Question 5/ 136

Use the following information to answer Questions 6 and 7.

The diagram below represents part of a DNA molecule.



Question 6/ 136

[VCAA 2015 SA Q3]

A single DNA nucleotide is shown by sub-unit(s)

A X alone.

B X and Y together.

C Y and Z together.

D X, Y and Z together.

Question 7/ 136

[VCAA 2015 SA Q4]

A feature of DNA that can be seen in the diagram above is

A the anti-parallel arrangement of the two strands of nucleotides.

B the process of semi-conservative replication.

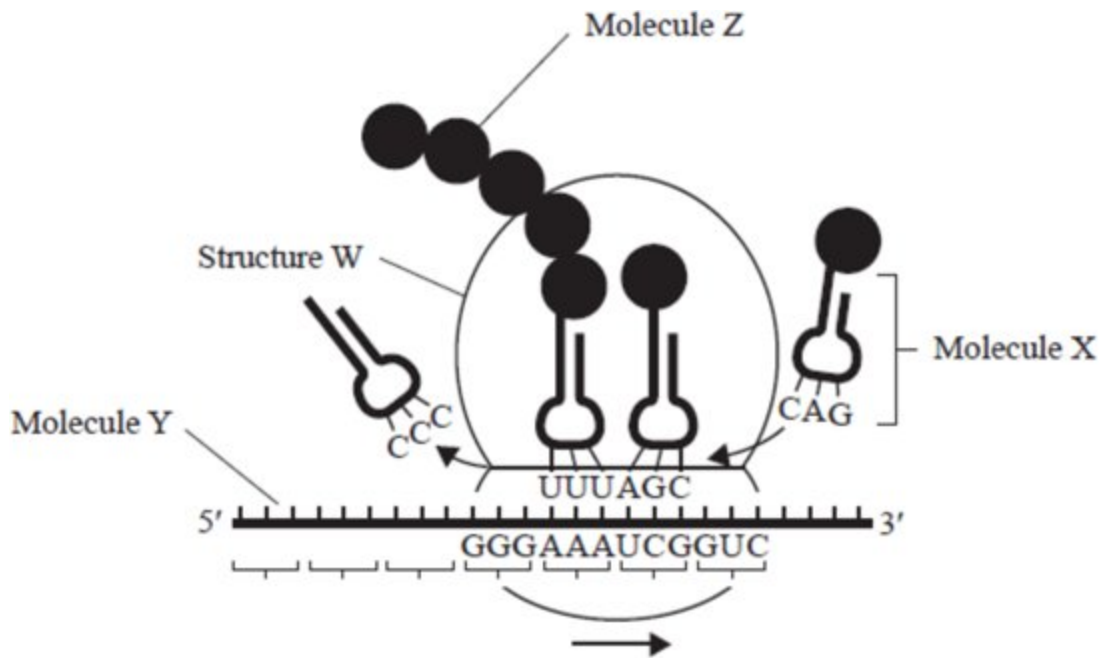
C its ribose sugar–phosphate backbone.

D its double-helix structure.

Question 8/ 136

[VCAA 2022 SA Q5]

Consider the diagram shown on the next page, with molecules X, Y and Z, and Structure W labelled. All arrows depict the movement of molecules or structures.



Source: adapted from H Lodish, A Berk, P Matsudaira et al.,
Molecular Cell Biology, 5th edition, WH Freeman and Company, New York, 2003, p. 119

Which one of the following is a correct statement about the diagram?

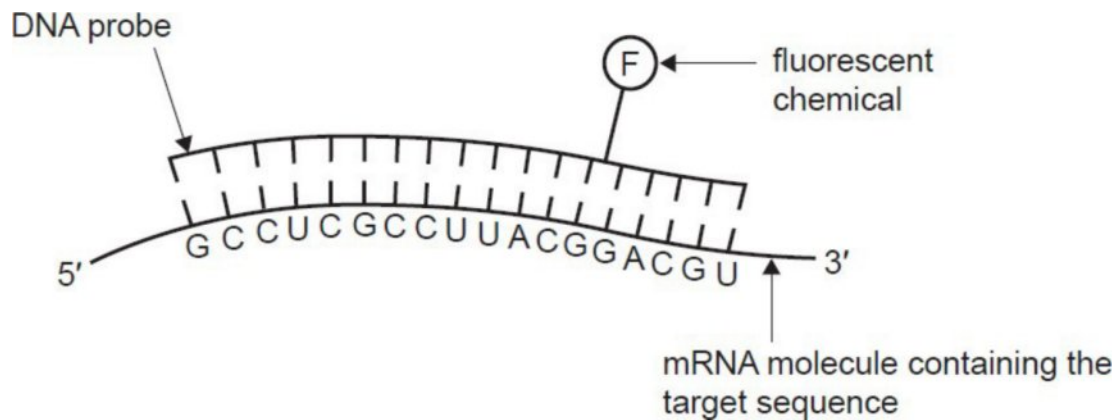
- A Structure W is a copy of template DNA found in the nucleus.
- B Molecule X carries an amino acid that will be added to the growing polypeptide.
- C Molecule Y is being read in the 3' to 5' direction.
- D Molecule Z contains a codon.

Question 9/ 136

Use the following information to answer Questions 10–12.

One method that is used to identify and measure quantities of mRNA molecules is called fluorescence in situ hybridisation (FISH).

The fluorescent chemical is attached to the DNA probe. When the DNA probe binds to the target mRNA sequence, as shown in the diagram below, the fluorescent chemical allows the mRNA molecule to be visualised.



Source: adapted from LVJC Mannack, S Eising and A Rentmeister, 'Current techniques for visualizing RNA in cells', F1000 Research, 5:F1000 Faculty Rev-775, 28 April 2016, <https://doi.org/10.12688/f1000research.8151.1>

Question 10/ 136

[VCAA 2021 SA Q2]

To make the mRNA molecule containing the target sequence, a cell must

- A synthesise DNA polymerase.
 - B attach a poly-A tail to the 3' end of the gene.
 - C create a nucleotide chain with a ribose–phosphate backbone.
 - D have a ready supply of the N-containing bases adenine, thymine, guanine, and cytosine.
-

Question 11/ 136

[VCAA 2021 SA Q3]

The mRNA molecule identified by FISH is used by the cell to produce a new type of molecule.

Which one of the following statements correctly describes one aspect of the production of this new molecule?

- A The rRNA and its associated proteins create a binding site for the mRNA.

- B The tRNA delivers and attaches a nucleotide to the new growing molecule.
- C The mRNA anticodons are complementarily matched with the tRNA codons.
- D The mRNA attaches to the smaller sub-unit of the ribosome to initiate transcription.
-

Question 12/ 136

[VCAA 2021 SA Q4]

Using the information provided in the diagram in question 9 and your own knowledge of genetic coding, which of the following (in the table that follows) is correct? Assume that there are no STOP codons in the target mRNA sequence.

	Probe sequence	Number of amino acids coded by the mRNA target sequence
A	3' GCAGGCAUUCCGAUCCGA 5'	5
B	3' CGGAGCGGAATGCCTGCA 5'	5
C	3' CGGAGCGGAAUGCCUGCA 5'	6
D	3' CGGAGCGGAATGCCTGCA 5'	6

Question 13/ 136

[VCAA 2018 SA Q4]

The genetic code is described as a degenerate code. This means that

- A in almost all organisms the same DNA triplet is translated to the same amino acid.
- B some amino acids may be encoded by more than one codon.
- C a single nucleotide cannot be part of two adjacent codons.
- D three codons are needed to specify one amino acid.

Question 14/ 136

Use the following information to answer Questions 15 and 16.

Question 15/ 136

[VCAA 2020 SA Q7]

The codon table that follows can be used to determine amino acids coded for by a nucleotide sequence.

1st position (5' end) ↓	2nd position				3rd position (3' end) ↓
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

It is correct to state that

A identical amino acid sequences are found in all organisms.

B the genetic code is degenerate with respect to Met.

C the codon GGU adds Trp to a polypeptide chain.

D the DNA template sequence GAA codes for Leu.

Question 16/ 136

[VCAA 2015 SA Q23]

The following is a sequence of amino acids located within a polypeptide:

Asn – Gly – Pro – Arg – Ser –

Using the table on the previous page, the DNA template sequence that could code for this amino acid sequence is

A TTG / CCC / GGT / GCT / TCG

B TTG / GTT / GGT / GCT / TCG

C TTG / CCC / GGT / GCT / TCT

D UUG / CCC / GGU / CGU / UGC

Question 17/ 136

[VCAA 2014 SA Q5]

The part of a molecule referred to as an anticodon can be found in

A DNA.

B transfer RNA.

C ribosomal RNA.

D messenger RNA.

Question 18/ 136

[VCAA 2011 E2 SA Q24]

The first step of gene expression is

- A translation of DNA.
 - B transcription of DNA.
 - C modification of RNA.
 - D packaging of proteins.
-

Question 19/ 136

[VCAA 2011 E1 SA Q44]

A molecule of transfer RNA could include the nucleotide sequence

- A CTCGAUTAC
 - B GGCUUUAAA
 - C CCUUTUGAG
 - D AAAATACCG
-

Question 20/ 136

[Adapted VCAA 2020 SA Q26]

The trp operon in prokaryotes illustrates the switching off and on of genes. The operator within the trp operon

- A is a regulatory gene.
- B attaches RNA polymerase.

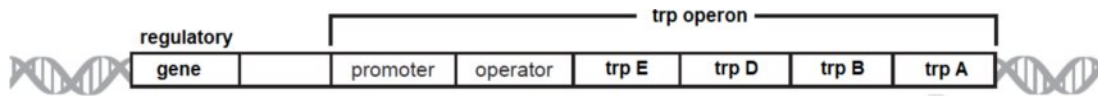
C codes for the production of an enzyme.

D is the binding site for the repressor protein and tryptophan.

Question 21/ 136

Use the following information to answer Questions 22 and 23.

Structural genes can be switched off and turned on by transcriptional factors expressed by regulatory genes. In prokaryotes, a group of genes associated with the breakdown of tryptophan is grouped together in a single operon called the trp operon. The diagram below shows the position of the genes on the prokaryotic chromosome.



Question 22/ 136

[Adapted VCAA 2019 SA Q3]

Transcription of the structural genes within the trp operon will occur when

A a repressor molecule is attached to the operator.

B RNA polymerase is attached to the promoter.

C tryptophan is in high concentration in the prokaryotic cell.

D transcription of the regulatory gene is optimal.

Question 23/ 136

[Adapted VCAA 2019 SA Q4]

Transcription of the structural genes within the trp operon results in the production of molecules of

A a transcription factor.

B a repressor protein.

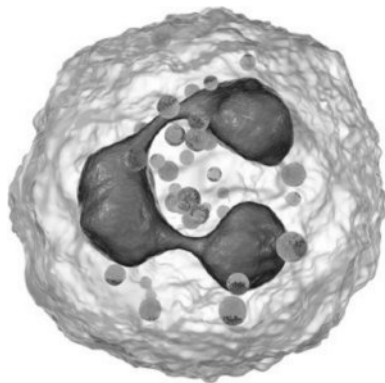
C tryptophan.

D mRNA

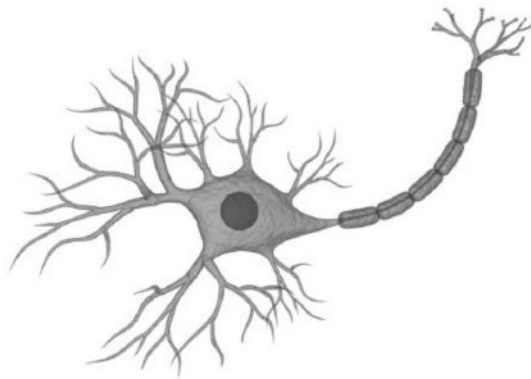
Question 24/ 136

[VCAA 2019 SA Q11]

Two different cells taken from the same human were viewed using a microscope. The diagrams below show the structure of the two cells, not drawn to the same scale.



a neutrophil



a neuron

Which one of the following is a correct conclusion to reach when comparing the two cells?

A At any given time, the genes expressed in each cell may be different.

B All proteins in each cell will have similar tertiary structures.

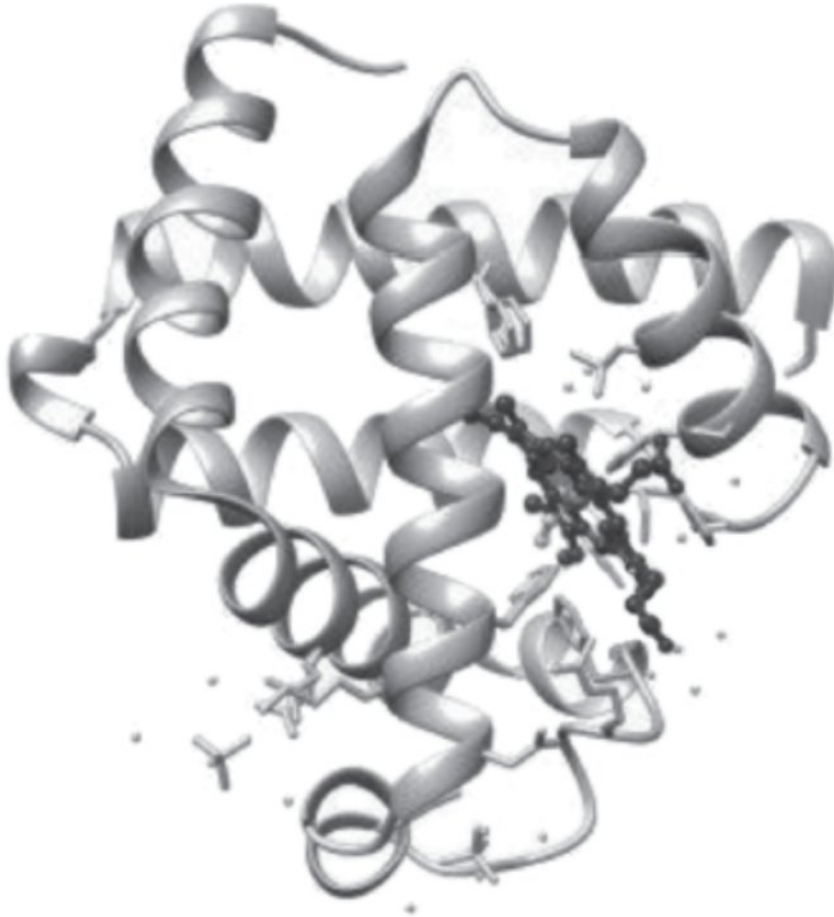
C The two cells have the same proteome.

D The two cells have different genomes.

Question 25/ 136

[VCAA 2022 SA Q1]

In the 1950s, scientist John Kendrew determined the structure of myoglobin. Myoglobin was found to be a single polypeptide chain with one heme group, as shown in the following diagram.



Source: Tuscany Diet, 'Definition, composition, and structure of the proteins',
<www.tuscany-diet.net/proteins/definition-composition-structure/>

The protein structure shown on the previous page would best be described as myoglobin's

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

Question 26/ 136

[VCAA 2020 SA Q8]

The primary structure of a protein is important because it

A is the active, functional form of the protein.

B has a very specific three-dimensional shape.

C influences the way that the polypeptide folds.

D directly controls the way proteins are transported into a cell.

Question 27/ 136

[VCAA 2019 SA Q5]

Which one of the following statements about proteins is correct?

A The activity of a protein may be affected by the temperature and pH of its environment.

B The primary structure of a protein refers to its three-dimensional protein shape.

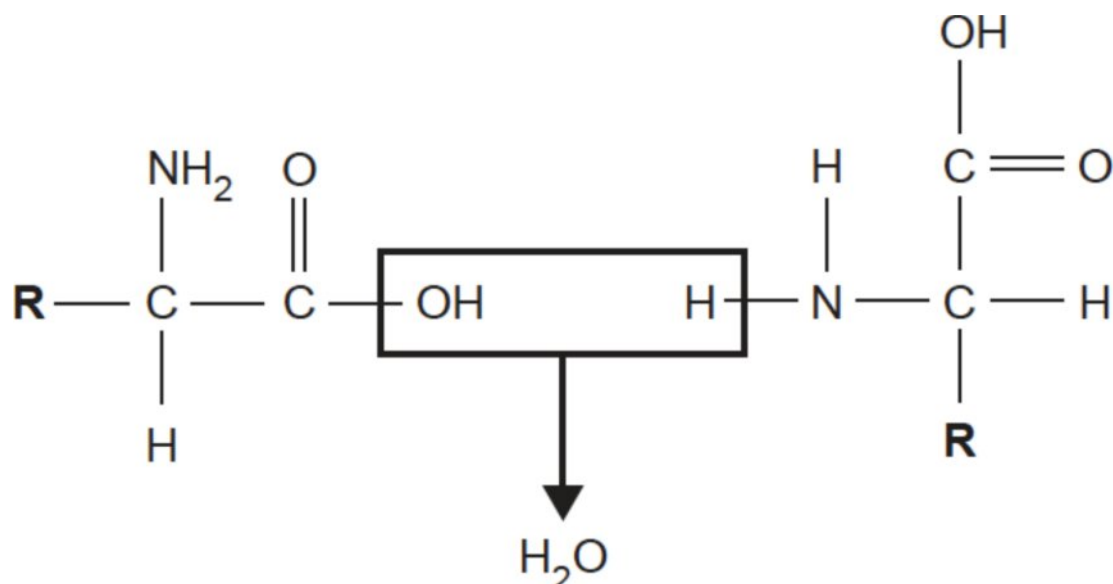
C Proteins are not involved in the human immune response.

D A protein with a quaternary structure will be an enzyme.

Question 28/ 136

[VCAA 2018 SA Q3]

The diagram below represents adjacent amino acids being joined together.



The joining of adjacent amino acids

A results in the formation of a nucleic acid.

B is an energy-releasing reaction.

C is catalysed by DNA ligase.

D is a condensation reaction.

Question 29/ 136

[VCAA 2017 SA Q1]

Consider the structure and functional importance of proteins. Which one of the following statements about proteins is correct?

A A change in the tertiary structure of a protein may result in the protein becoming biologically inactive.

B Proteins with a quaternary structure will be more active than proteins without a quaternary structure.

C Two different proteins with the same number of amino acids will have identical functions.

D Denaturation will alter the primary structure of a protein.

Question 30/ 136

[VCAA 2018 SA Q2]

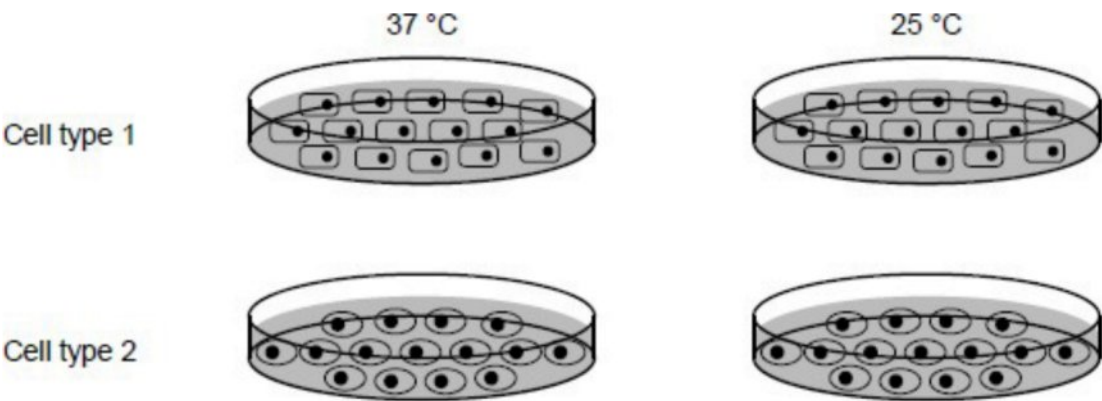
The proteome is

- A the total DNA content that is present within one cell of an organism.
- B a complete set of chromosomes found inside a cell of an organism.
- C the entire set of proteins expressed by an organism at a given time.
- D the four hierarchical levels of protein structure.

Question 31/ 136

[VCAA 2015 SA Q8]

In an investigation into the uptake of a protein by cells, scientists immersed two cell types in solutions of this protein. The investigation was carried out at two different temperatures and the percentage of the protein taken up by the two cell types was recorded over 10 minutes.



The data was presented in the table, as shown below.

	Cell type 1		Cell type 2	
	Percentage of protein taken up by cell		Percentage of protein taken up by cell	
Time (mins)	At 25 °C	At 37 °C	At 25 °C	At 37 °C
0	0	0	0	0

	Cell type 1		Cell type 2	
	Percentage of protein taken up by cell		Percentage of protein taken up by cell	
Time (mins)	At 25 °C	At 37 °C	At 25 °C	At 37 °C
2	2	5	5	10
4	4	10	10	20
6	6	12	12	24
8	8	16	16	32
10	8	16	16	36

Which one of the following conclusions is supported by the data?

- A The rate of uptake of this protein at 25°C is not affected by cell type.
 - B The percentage of this protein taken up by Cell type 1 is not affected by temperature.
 - C The rate of uptake of this protein by Cell type 2 is faster at 37°C than at 25°C.
 - D If the experiment continued for another 10 minutes, the percentage of this protein taken up by Cell type 1 would increase.
-

Question 32/ 136

[VCAA 2016 SA Q7]

In animal cells, tight junctions are multi-protein complexes that mediate cell-to-cell adhesion and regulate transport through the extracellular matrix. Proteins that form these complexes are made within the cell.

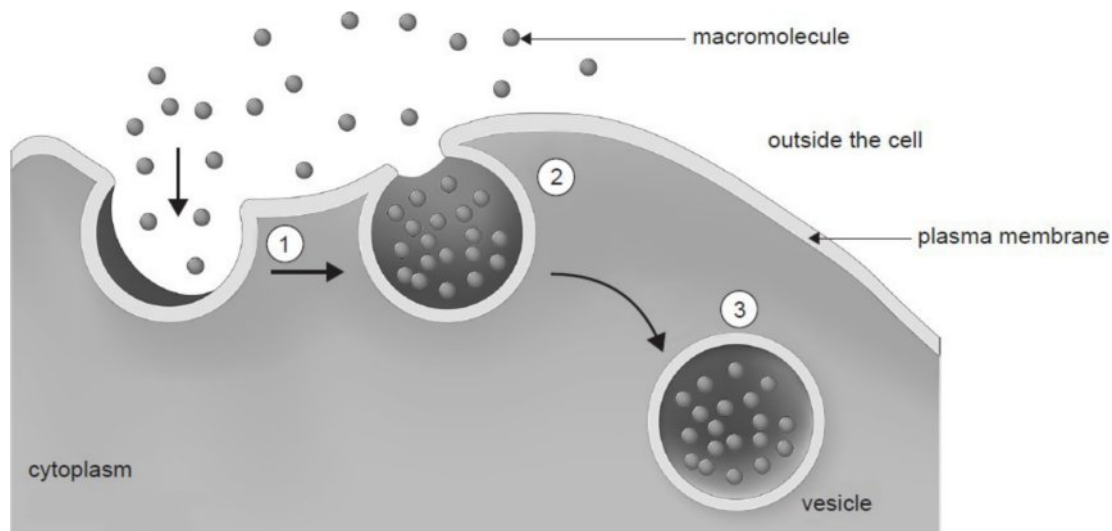
One pathway for the production of protein for these junctions is

- A nucleus – ribosome – Golgi apparatus – vesicle – endoplasmic reticulum.
- B nucleus – ribosome – endoplasmic reticulum – vesicle – Golgi apparatus.
- C nucleus – vesicle – endoplasmic reticulum – Golgi apparatus – ribosome.
- D nucleus – vesicle – Golgi apparatus – ribosome – endoplasmic reticulum.

Question 33/ 136

[VCAA 2019 SA Q1]

Consider the movement of macromolecules across the plasma membrane, as shown in the diagram below.



What type of transport is shown?

A facilitated diffusion

B simple diffusion

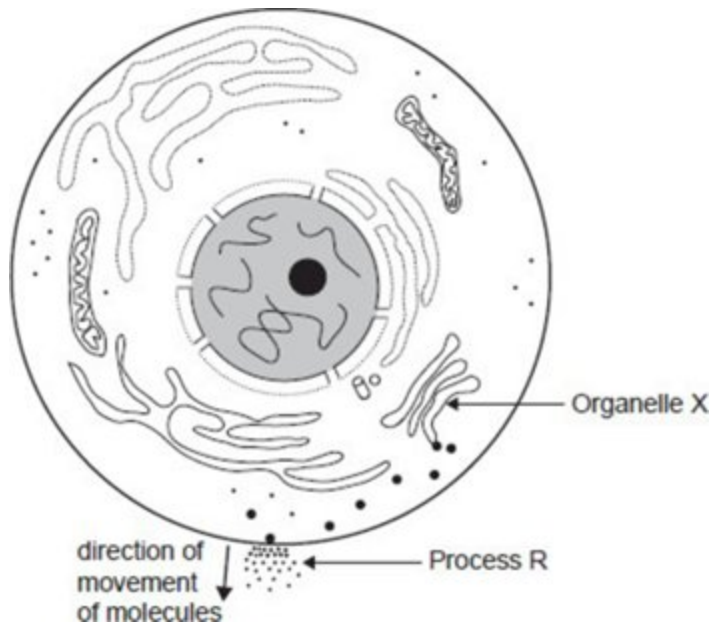
C endocytosis

D exocytosis

Question 34/ 136

Use the following information to answer Questions 35 and 36.

Consider the following cell diagram.



Question 35/ 136

[VCAA 2014 SA Q3]

Process R is an example of

- A exocytosis.
- B phagocytosis.
- C pinocytosis.
- D endocytosis.

Question 36/ 136

[VCAA 2014 SA Q4]

Organelle X

A is the site of cellular respiration.

B packages protein molecules for export from the cell.

C absorbs sunlight and produces carbohydrates.

D produces ribosomal RNA.

Question 37/ 136

[VCAA 2019 SA Q2]

Which one of the following organelles has the role of synthesising proteins from their monomers?

A Golgi apparatus

B ribosomes

C vesicles

D nucleus

Question 38/ 136

Use the following information to answer Questions 39 and 40.

Protein M, made by a particular cell type, is released for use by other cells.

Question 39/ 136

[VCAA 2013 SA Q6]

The site of synthesis of protein M is the

A vesicles.

B ribosomes.

C plasma membrane.

D smooth endoplasmic reticulum.

Question 40/ 136

[VCAA 2013 SA Q7]

The export of protein M by these cells would involve

A centrioles.

B lysosomes.

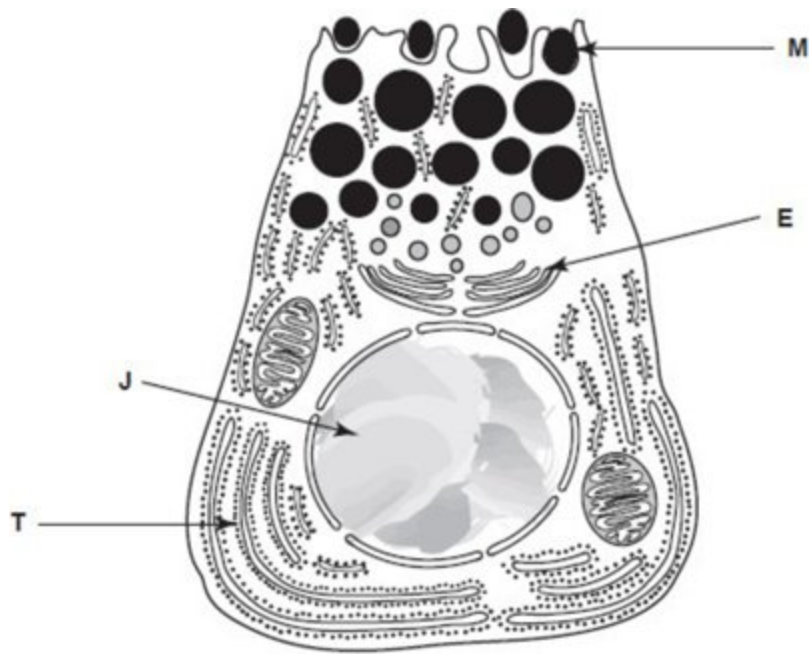
C the Golgi apparatus.

D chromosomes.

Question 41/ 136

[VCAA 2012 E1 SA Q7]

Examine the following diagram of a pancreatic cell.



The order in which the parts of the cell play a role in the production and secretion of proteins is

A M, E, J, T.

B T, J, M, E.

C J, T, E, M.

D E, M, T, J.

Question 42/ 136

[VCAA 2022 SA Q6]

An enzyme is used to manipulate DNA as shown in the diagram below.



- A This enzyme is an endonuclease.
 - B This enzyme could be used to join two DNA fragments together.
 - C The action of this enzyme produces blunt ends on the two new fragments.
 - D This enzyme breaks only hydrogen bonds between complementary base pairs.
-

Question 43/ 136

[VCAA 2019 SA Q38]

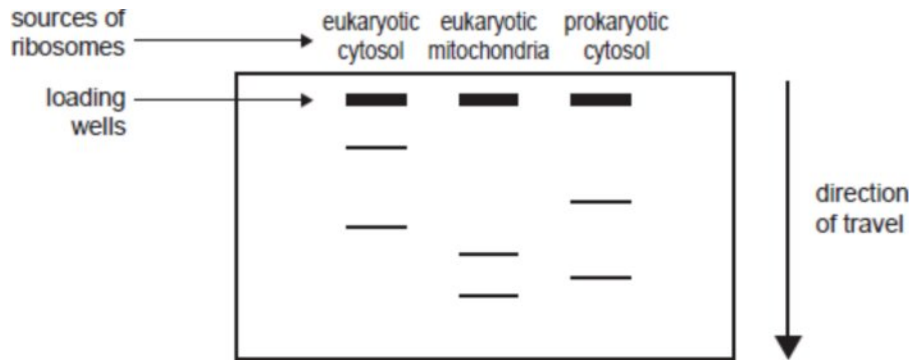
DNA ligase

- A joins two DNA fragments together by forming phosphodiester bonds between the two fragments.
 - B acts as molecular scissors, cutting DNA molecules at specific nucleotide sequences.
 - C separates two DNA strands during transcription so that a copy can be made.
 - D is an enzyme involved in protein synthesis.
-

Question 44/ 136

[VCAA 2015 SA Q28]

A ribosome contains two distinct sub-units: a large sub-unit and a small sub-unit. Ribosomes from prokaryotic and eukaryotic cells were isolated and subjected to gel electrophoresis. The results are shown in the diagram on the next page.



Which one of the following can be correctly concluded from the gel electrophoresis results?

- A Eukaryote cytosolic and mitochondrial ribosomes translate the same types of protein.
- B Eukaryote mitochondria contain the ribosomal sub-units of the smallest size.
- C Prokaryote ribosomal sub-units have opposing charges to each other.
- D Eukaryote cytosolic ribosomal sub-units travel at the greatest speeds.

Question 45/ 136

Use the following information to answer Questions 46 and 47.

Genetic engineers use restriction enzymes to cut DNA into smaller lengths. The recognition sequences of several restriction enzymes are shown in the table below. The symbol * denotes the restriction site (position of the cut).

Restriction enzyme	Recognition sequence (read in 5' to 3' direction)
EcoRI	$ \begin{array}{cccccc} \text{G}^* & & \text{A} & & \text{A} & & \text{T} & & \text{T} & & \text{C} \\ & & \text{---} & & \text{---} & & \text{---} & & \text{---} & & \\ \text{C} & & \text{T} & & \text{T} & & \text{A} & & \text{A} & & ^* \text{G} \end{array} $
HindIII	$ \begin{array}{cccccc} \text{A}^* & & \text{A} & & \text{G} & & \text{C} & & \text{T} & & \text{T} \\ & & \text{---} & & \text{---} & & \text{---} & & \text{---} & & \\ \text{T} & & \text{T} & & \text{C} & & \text{G} & & \text{A} & & ^* \text{A} \end{array} $
AluI	$ \begin{array}{ccccc} \text{A} & & \text{G}^* & & \text{C} & & \text{T} \\ \text{T} & & \text{C}^* & & \text{G} & & \text{A} \end{array} $
HaeIII	$ \begin{array}{ccccc} \text{G} & & \text{G}^* & & \text{C} & & \text{C} \\ \text{C} & & \text{C}^* & & \text{G} & & \text{G} \end{array} $

Question 46/ 136

[VCAA 2013 SA Q29]

Consider a length of double-stranded DNA with the sequence

5' T T A A G G A A T T C A A 3'

3' A A T T C C T T A A G T T 5'

Adding EcoRI to a solution containing one copy of this double-stranded DNA produces

A two fragments of double-stranded DNA, each with a sticky end.

B four fragments of single-stranded DNA, each with a sticky end.

C two fragments of double-stranded DNA, each with blunt ends.

D four fragments of single-stranded DNA, each with blunt ends.

Question 47/ 136

[VCAA 2013 SA Q30]

Now consider a different length of double-stranded DNA with the sequence

5' C T T A A G C T T C C A A A T T A C C G A 3'

3' G A A T T C G A A G G T T T A A T G G C T 5'

Which enzyme(s) will cut this piece of DNA?

A EcoRI only

B HindIII only

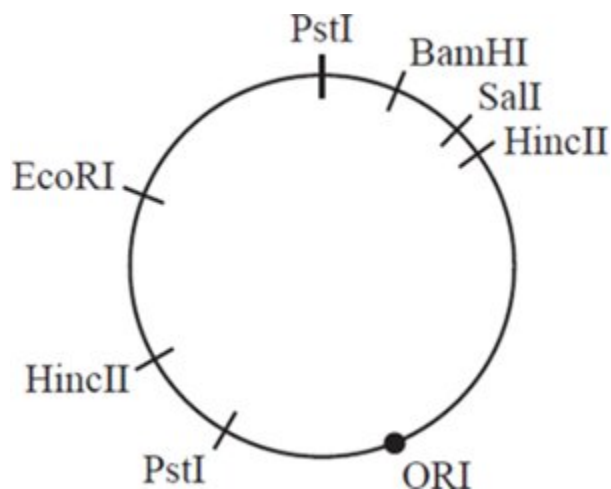
C AluI and HindIII only

D AluI, HindIII and HaeIII only

Question 48/ 136

[VCAA SA Q39 2019]

The diagram below is a map of a bacterial plasmid showing ORI, the origin of DNA replication, and selected restriction endonuclease sites.



One plasmid was mixed with the restriction enzymes EcoRI, BamHI and HincII. Which of the following shows the number of restriction sites that have been cut and the resulting number of DNA fragments produced?

Number of restriction sites cut	Number of DNA fragments produced

	Number of restriction sites cut	Number of DNA fragments produced
A	3	3
B	3	4
C	4	4
D	4	5

Question 49/ 136

[VCAA 2021 SA Q28]

Small amounts of DNA can be collected from items such as cigarette butts and hair follicles that are found at crime scenes. This DNA can be replicated for analysis and used as evidence in court cases.

	Method	Enzyme used
A	polymerase chain reaction	<i>Taq</i> polymerase
B	DNA profiling	DNA ligase
C	polymerase chain reaction	DNA ligase
D	DNA profiling	<i>Taq</i> polymerase

Which of the following identifies the method of DNA replication and the enzyme used?

Question 50/ 136

[VCAA 2020 SA Q29]

A small sample of DNA was obtained from a fossil. Polymerase chain reaction (PCR) was used to amplify the amount of DNA obtained from the sample.

Which one of the following is a correct statement regarding the PCR process?

A DNA polymerase catalyses the pairing of primers with complementary nucleotides.

B RNA polymerase catalyses the additions of nucleotides to a DNA strand.

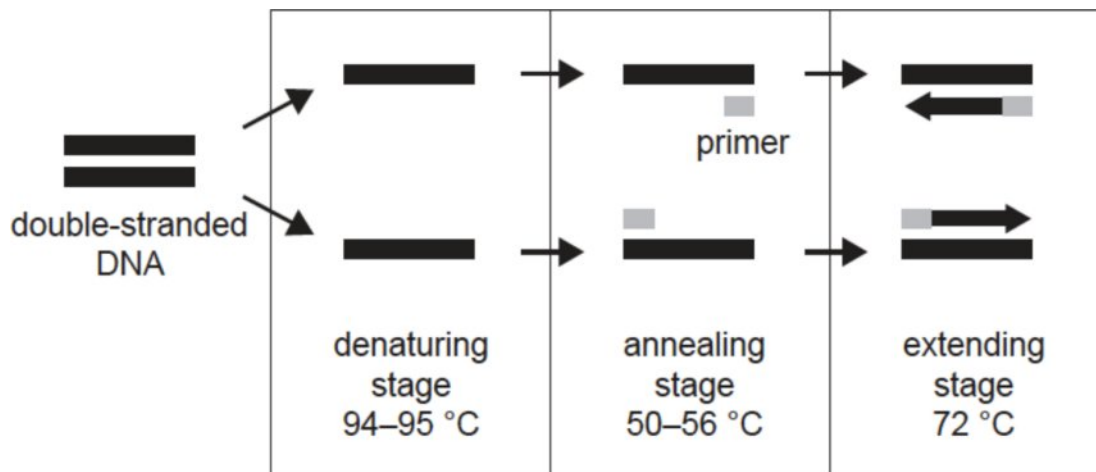
C Annealing and extension of the DNA occur at different temperatures.

D The number of copies of the DNA quadrupled in each cycle.

Question 51/ 136

[VCAA SA Q28 2018]

The diagram below represents a method of DNA manipulation.



Source: Genome Research Limited, in Your Genome, www.yourgenome.org

The method represented is

A gel electrophoresis.

B DNA transformation.

C bacterial transformation.

D polymerase chain reaction.

Question 52/ 136

Use the following information to answer Questions 53 and 54.

Four samples of DNA were loaded into four different wells in lanes W, X, Y and Z. A standard ladder was loaded into the well in lane S. The results of gel electrophoresis are shown below.



Question 53/ 136

[VCAA 2018 SA Q30]

Which lane represents a sample that was loaded with DNA fragments of four different lengths: 100 bp, 150 bp, 200 bp and 300 bp?

A W

B X

C Y

D Z

Question 54/ 136

[VCAA 2018 SA Q31]

Which lane contains the band that is closest to the negative electrode?

A W

B X

C Y

D Z

Question 55/ 136

[VCAA 2014 SA Q25]

Plasmids of bacteria are used to transfer selected genes from one species to another. The process can be represented as follows.

Bacterial plasmid cut → foreign gene and plasmid mixed → plasmid with inserted foreign gene

Enzymes are used to facilitate several of these steps.

	Cuts plasmid	Inserts genes
A	restriction enzyme	DNA ligase
B	restriction enzyme	DNA polymerase
C	DNA ligase	DNA polymerase
D	DNA polymerase	DNA ligase

Which one of the following shows the enzymes required for the first and last steps of the process?

Question 56/ 136

Use the following information to answer Questions 57 and 58.

A bacterial plasmid was modified by inserting a gene for an enzyme that provides resistance to the antibiotic ampicillin. A nutrient solution containing cells of the bacterium *Escherichia coli* was obtained. *E. coli* is naturally sensitive to the antibiotic ampicillin. The solution was divided into two equal volumes. The bacteria in one half of the solution were left untreated. Plasmids were added to the other half of the solution and the bacteria were treated to increase their chance of taking up the plasmids.

The next day, the bacterial cells were spread on agar plates as follows:

- Plate 1 – Untreated bacterial cells on nutrient agar
- Plate 2 – Untreated bacterial cells on nutrient agar with ampicillin
- Plate 3 – Treated bacterial cells on nutrient agar with ampicillin
- Plate 4 – Treated bacterial cells on nutrient agar

The plates were incubated overnight.

Question 57/ 136

[VCAA 2020 SA Q30]

In order to collect only bacterial cells that had taken up the plasmid successfully, a sample should be taken from

- A Plate 1.
 - B Plate 2.
 - C Plate 3.
 - D Plate 4.
-

Question 58/ 136

[VCAA 2020 SA Q31]

The process in which the bacterial cell takes up the plasmid is called

- A translation.
 - B transcription.
 - C translocation.
 - D transformation.
-

Question 59/ 136

[VCAA 2020 SA Q32]

Target DNA is to be inserted into a plasmid. For a recombinant plasmid to be produced

- A the plasmid sections and the target DNA must have blunt ends.
 - B the target DNA must come from the same species as the bacteria.
 - C the plasmid and the target DNA must be cut by a polymerase.
 - D DNA ligase is used to re-join the sugar-phosphate sections of the plasmid and the target DNA.
-

Question 60/ 136

Use the following information to answer Questions 61–63.

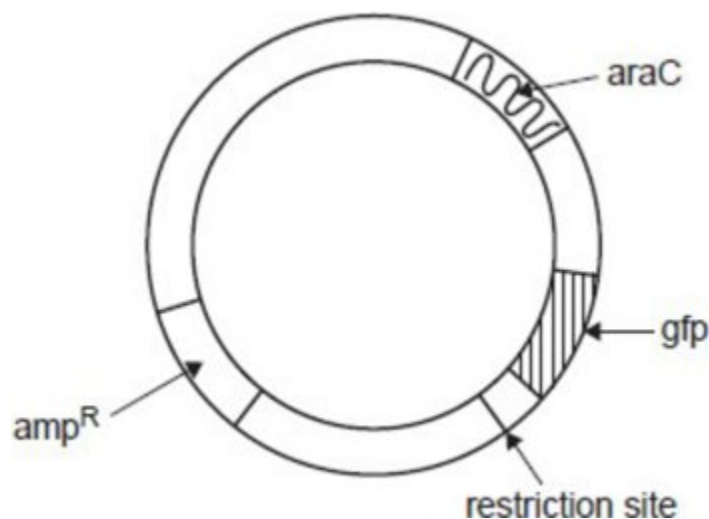
To clone a gene of interest, the following four steps are performed:

- 1 A plasmid is cut with a specific restriction enzyme.
- 2 The gene of interest is ligated into the plasmid.

3 Plasmids are transferred to bacteria.

4 Bacteria are grown on four nutrient agar plates (labelled W, X, Y and Z) that are coated with or without ampicillin and arabinose.

An example of a plasmid used in cloning is shown below.



This plasmid contains a restriction site and the following three genes:

- amp^R – confers resistance to the antibacterial agent ampicillin
- gfp – encodes the green fluorescent protein (GFP), which fluoresces under UV light
- araC – encodes a protein required to promote the expression of gfp when arabinose is present.

The results from a bacterial transformation experiment are shown in the table on the next page.

Plate	W	X	Y	Z
	untransformed bacteria only	untransformed bacteria only	transformed bacteria	transformed bacteria
Diagram of plate				
Added to plate	nutrient agar only	nutrient agar and ampicillin	nutrient agar, ampicillin and arabinose	nutrient agar and ampicillin
Description of result	lawn of bacteria	no growth	bacterial colonies present	bacterial colonies present

Question 61/ 136

[VCAA 2015 SA Q25]

Bacteria are used in gene cloning because they

A contain restriction enzymes that randomly cut chromosomes into fragments of varying size.

B can replicate non-bacterial sequences of DNA in a short time.

C replicate exponentially by undergoing mitotic divisions.

D allow the entry of foreign DNA into their nuclei.

Question 62/ 136

[VCAA 2015 SA Q26]

Which plate would contain bacteria that fluoresce under UV light?

A plate W

B plate X

C plate Y

D plate Z

Question 63/ 136

[VCAA 2015 SA Q27]

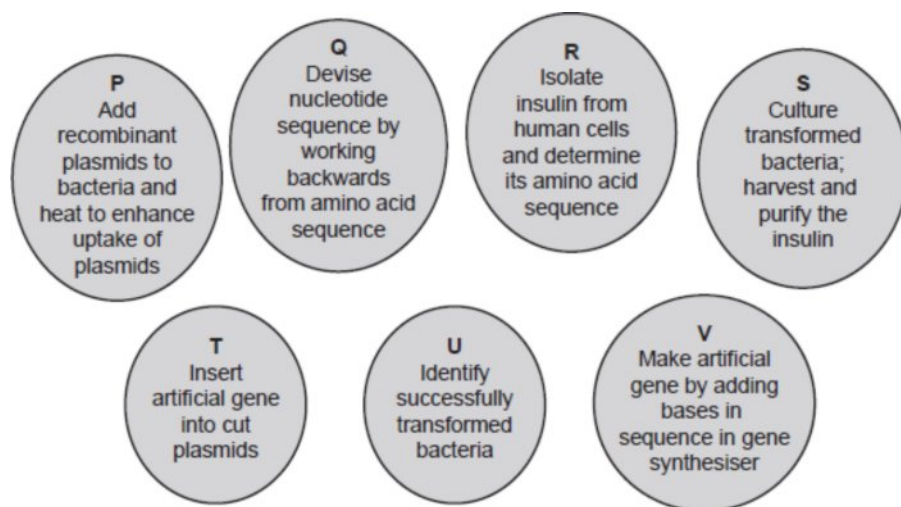
Which one of the following statements is an accurate description for the purpose of plate W or X?

- A Plate W shows that the plasmid was cut with a restriction enzyme.
- B Plate W shows that the percentage of transformed bacteria was high.
- C Plate X shows that the nutrient agar promoted the growth of viable bacteria.
- D Plate X shows that ampicillin was effective in killing the untransformed bacteria.
-

Question 64/ 136

Use the following information to answer Questions 65–67.

Bacteria can be transformed with an artificial insulin gene and cultured to make insulin in commercial quantities. The steps taken to produce genetically engineered insulin are summarised below. The order of the steps has been mixed up.



Question 65/ 136

[VCAA 2013 SA Q34]

The correct sequence of steps when producing the insulin is

A V, P, T, S, U, R, Q.

B V, T, P, U, S, Q, R.

C R, Q, V, T, P, U, S.

D R, V, Q, T, P, S, U.

Question 66/ 136

[VCAA 2013 SA Q35]

The tool used for joining the artificial gene to plasmid DNA at step T is

A a primer.

B DNA ligase.

C DNA polymerase.

D gel electrophoresis.

Question 67/ 136

[VCAA 2013 SA Q36]

The artificial insulin gene may have a different nucleotide sequence from the human insulin gene. This is because the DNA code is

A redundant.

B universal.

C mutated by heat shock.

D contaminated by bacterial DNA.

[VCAA 2013 SA Q28]

During a fight between a number of people, one was seriously injured. Blood samples were taken from the victim, the crime scene and four suspects. DNA was extracted from white blood cells in each of the blood samples and electrophoresis of the samples was carried out.

The results are shown in the diagram below.



The person most likely to have been at the crime scene is suspect

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

[VCAA 2019 SA Q36]

Certain yeast (*Saccharomyces cerevisiae*) can be modified and made to express a human gene, resulting in the production of insulin.

S. cerevisiae can most accurately be described as a

- A transgenic organism.
 - B yeast–human hybrid.
 - C genetically mutated organism.
 - D laboratory-produced organism.
-

Question 70/ 136

[VCAA 2022 SA Q7]

Genetically modified (GM) crops are engineered to introduce a new trait into a species. Traits chosen by scientists are ones that will benefit people either directly or indirectly.

An example of such a trait is one that

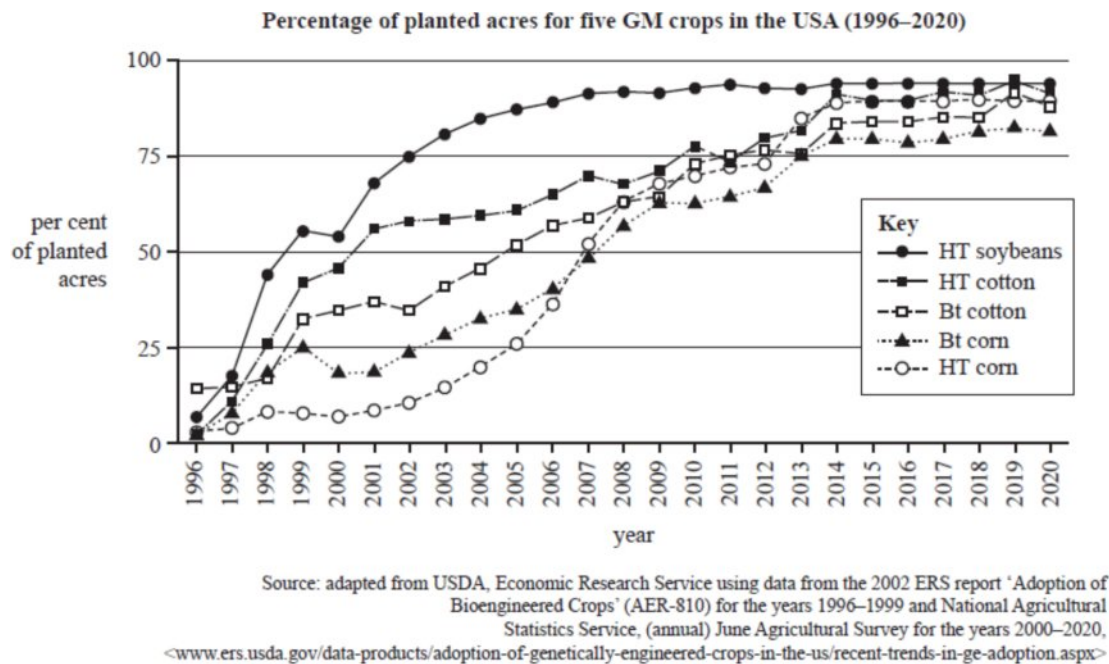
- A decreases the nutritional value of a crop.
 - B improves environmental conditions for crops.
 - C increases resistance to toxins produced by fungi.
 - D develops potential allergens that trigger a vigorous immune response.
-

Question 71/ 136

[VCAA 2022 SA Q8]

The extent to which GM crops were planted in the United States of America (USA) between 1996 and 2020 was investigated. The percentage of planted acres of GM crops out of the total planted acres of crops for five different types of crops – HT soybeans, HT cotton, Bt cotton, Bt corn and HT corn – is presented in the graph

below. 'HT' indicates herbicide-tolerant varieties and 'Bt' indicates insect-resistant varieties.



From the graph above, it can be concluded that

A in 1996, the percentage of planted acres of HT cotton crops was greater than 10 per cent.

B in 2007, the percentage of planted acres of Bt corn crops was greater than the percentage of planted acres of HT corn crops.

C in 2013, the percentage of planted acres of Bt cotton crops and the percentage of planted acres of Bt corn crops were similar.

D in 2020, the percentage of planted acres of HT soybean crops was the lowest that it had been for the duration of the investigation.

Question 72/ 136

What is the best explanation for the successful development of transgenic species?

A Artificial pollination works across the plant kingdom.

B Nuclear transplantation from cell to cell is easily achieved.

C DNA in the biosphere is composed of the same chemical components.

D Genes from different animals within the one species are easily combined.

Question 73/ 136

Use the following information to answer Questions 74 and 75.

Rice (*Oryza sativa*) is a staple food for billions of people worldwide, particularly in Asia. Although rice supplies energy, it is low in micronutrients, such as iron and zinc. Australian scientists created a strain of biofortified rice that has been trialled in the Philippines and has been recently introduced to Bangladesh.

The table below compares the iron and zinc content of normal white rice to that of biofortified rice in parts per million (ppm).

	Iron (ppm)	Zinc (ppm)
Normal white rice	2–5	16
Biofortified rice	15	46

The biofortified rice was created when two particular genes were inserted into normal rice. The biofortified rice plants responded as if they were iron deficient by permanently ‘switching on’ another gene to take up iron and zinc from the soil.

Details of the two inserted genes are given in the table below.

Inserted gene	Protein function	Source of gene
rice nicotianamine synthase (OsNAS2)	assists iron uptake by roots of rice plants	rice plants
soybean ferritin (Sfer-H1)	binds and stores large amounts of iron	soybean plants

Question 74/ 136

[VCAA 2020 SA Q36]

It is most likely that the main aim of this research and technology is to

A use knowledge from the research to develop treatments for human disease.

B enhance the flavour of rice to encourage greater rice consumption.

C increase the yield of rice crops to provide more food supplies.

D improve the nutrition of malnourished people.

Question 75/ 136

[VCAA 2020 SA Q37]

Which one of the following is the best description for this strain of biofortified rice?

A genetically screened

B genetically modified and transgenic

C genetically transformed by gene silencing

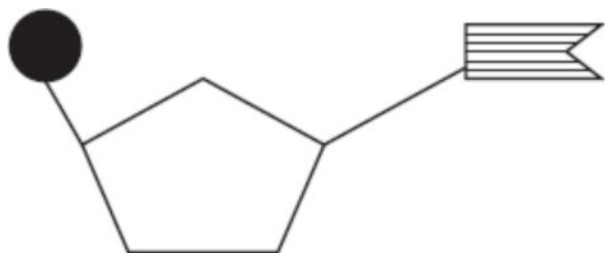
D genetically engineered by adding iron and zinc

Question 1/ 172

[VCAA 2020 SB Q2]

RNA molecules consist of long strands of joined nucleotides. Each nucleotide consists of three sub-units.

a Label the three sub-units on the diagram of the RNA nucleotide below. (1 mark)



b Complete the table below by describing the role in a cell of the two types of RNA listed. (2 marks)

Type of RNA

Role in a cell

Type of RNA	Role in a cell

tRNA	

mRNA	

c Outline two events that occur during RNA processing and the importance of each event in gene expression. (4 marks)

(Total 7 marks)

Question 2/ 172

[VCAA 2021 SB Q2]

Baker's yeast (*Saccharomyces cerevisiae*) is a unicellular, eukaryotic organism. Biologists have studied its proteome. A single yeast cell contains approximately 6000 different proteins.

a Consider the 6000 different proteins. The concentration of each protein may change with a change in environmental conditions. Give one example of a type of protein within a yeast cell that may change in concentration and explain why this change is necessary. (3 marks)

b There are several cellular activities that directly alter the number of proteins within a yeast cell. These include transcription, RNA processing, translation and breakdown of protein.

For each cellular activity listed in the table below, state the immediate end product of the activity. (2 marks)

Cellular activity	Immediate end-product

Transcription	

Cellular activity	Immediate end-product

RNA

processing

Translation

Breakdown of protein

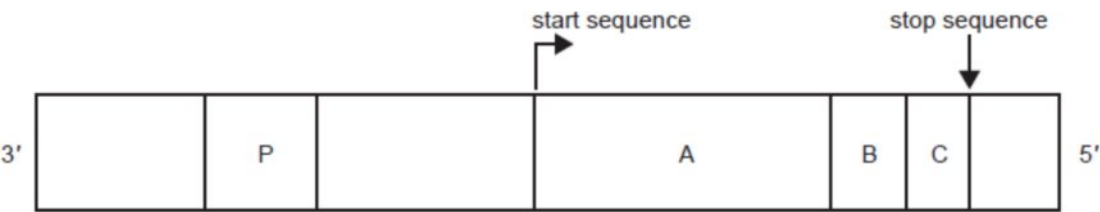
c Four *S. cerevisiae* genes and the functions of their gene products are outlined in Table 1 below. (2 marks)

Table 1. *S. cerevisiae* genes and the functions of their gene products

Gene	Function of gene product
HSP82	active on the plasma membrane to pump protons out of cell
ADR1	binds to DNA and acts as a transcriptional factor
GCN4	controls the activity of RNA polymerase
AQY1	a water channel in the plasma membrane

Identify the regulatory genes in Table 1 and justify your response.

d One in particular, the *S. cerevisiae* protein, PFY1, assists with the organisation of a cell's cytoskeleton. In the diagram below, the gene for the PFY1 protein is shown with a promoter region (labelled P), start and stop transcription sequences, and a single intron (labelled B).



Give the general name of the sections labelled A and C and outline the function of these sections. (2 marks)

(Total 9 marks)

Diagrams of two molecules that are required for the production of proteins within a cell are shown below.

Molecule 1



Molecule 2



a Complete the table below to describe two differences between the monomers of the two molecules. (2 marks)

	Molecule 1	Molecule 2
Difference 1		
Difference 2		

b Ten amino acids that form part of a protein are shown below.

-phe-val-asn-gln-his-leu-cys-gly-ser-his-

The section of an RNA molecule found in the nucleus of the cell associated with the translation of these 10 amino acids was found to contain over 300 monomers.

Explain how there can be over 300 monomers in this section of the RNA molecule but only 10 amino acids translated. (2 marks)

(Total 4 marks)

Question 4/ 172

[VCAA 2012 E1 SB Q3]

Human insulin is a macromolecule composed of two amino acid chains. The chains are connected by disulfide bonds.

a To what group of macromolecules does insulin belong? (1 mark)

Insulin found in other animals varies from human insulin. The following table compares all the differences seen in the primary structure of human, cow, pig and sheep insulin.

Amino acid position number within		
	Alpha Chain	Beta Chain
	-8 - 9 - 10-	-30-
human	-thre - ser - ile-	thr
cow	-ala - ser - val-	ala
pig	-thre - ser - ile-	ala
sheep	-ala - gly - val-	ala

b What is meant by the term ‘primary structure’ of the insulin macromolecule? (1 mark)

Humans with diabetes take insulin injections to maintain their health.

c If supplies of human insulin were not available, which one of the other three animals listed in the table would be the best source of insulin? Explain your reason for choosing this particular animal. (2 marks)

The table below contains the genetic code for protein production.

		Second letter					
		A	G	T	C		
First letter	A	AAA } phe AAG } AAT } leu AAC }	AGA } ser AGG } AGT } AGC }	ATA } tyr ATG } ATT } Stop ATC } Stop	ACA } cys ACG } ACT } Stop ACC } trp	Third letter	A G T C
	G	GAA } leu GAG } GAT } GAC }	GGA } pro GGG } GGT } GGC }	GTA } his GTG } GTT } gln GTC }	GCA } arg GCG } GCT } GCC }		A G T C
	T	TAA } ile TAG } TAT } met TAC } Start	TGA } thr TGG } TGT } TGC }	TTA } asn TTG } TTT } lys TTC }	TCA } ser TCG } TCT } arg TCC }		A G T C
	C	CAA } val CAG } CAT } CAC }	CGA } ala CGG } CGT } CGC }	CTA } asp CTG } CTT } glu CTC }	CCA } gly CCG } CCT } CCC }		A G T C

d Use the information in the table to explain:

i the different sequence of nucleotides in humans and cows with respect to the DNA coding for the amino acid at position 30. (1 mark)

ii whether the sequence of nucleotides in DNA coding for the amino acid at position 30 will be identical in cows, pigs and sheep. (1 mark)

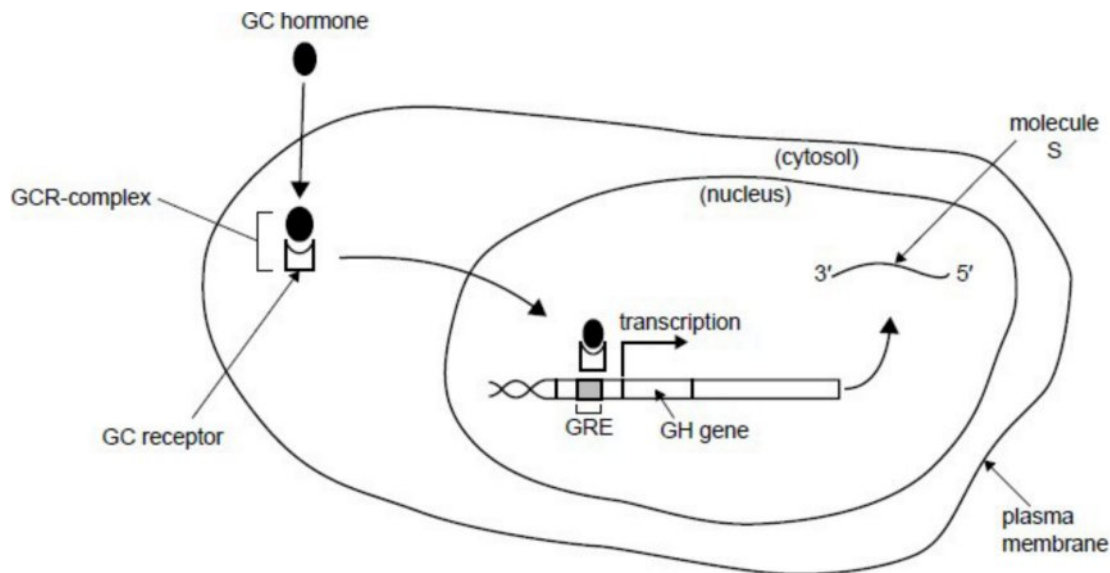
(Total 6 marks)

Question 5/ 172

[VCAA 2015 SB Q7]

Glucocorticoid (GC) is a hormone in rats that binds to a receptor, as shown in the diagram below. The glucocorticoid-receptor complex (GCR-complex) moves into the nucleus and attaches to the DNA, causing transcription to begin.

GC signal transduction in rat pituitary gland cells



The location where the GCR-complex attaches to the DNA is called the glucocorticoid response element (GRE). The GRE is located approximately 250 base-pairs upstream of the growth hormone (GH) gene. Following the attachment of the GCR-complex to the GRE, an enzyme catalyses the transcription of the gene.

a Name the enzyme that catalyses transcription. (1 mark)

b Name the transcription product, molecule S, and describe the processing that molecule S undergoes before it exits the nucleus. (3 marks)

c In the rat pituitary gland, GC stimulates the production of the growth hormone protein. However, in the rat liver, GC stimulates the production of the enzyme tryptophan oxygenase.

Given that the genetic sequence is identical in all somatic rat cells, explain how the production of distinct proteins in different cell types could occur. (2 marks)

d If a human gene is inserted into the DNA of rat pituitary gland cells, these genetically engineered cells can be used to produce human growth hormone.

What characteristic of the genetic code enables a human protein, such as human growth hormone, to be made by rat cells? (1 mark)

(Total 7 marks)

Question 6/ 172

[VCAA 2010 E1 SB Q6]

a List the three components of a DNA nucleotide. (1 mark)

In Tay–Sachs disease (TSD), the enzyme that breaks down glycolipid is faulty due to a genetic mutation. Examine the following two tables.

Table 1 – Portion of the genetic code

First letter	Second letter				Third letter
	A	G	T	C	
A	phe	ser	tyr	cys	A
G	leu	pro	his	arg	A
C	val	ala	glu	gly	T

Table 2 – Portion of DNA sequences

	DNA nucleotide sequence	Amino acid sequence
Normal Individual	--CTT GCA AAA--	glu - arg - phe
TSD Individual	--CTT GTA AAA--	

The amino acid sequence shown in **Table 1** for a normal individual, forms part of the enzyme hexosaminidase A (Hex A).

b What is the amino acid sequence for the TSD individual in **Table 2**?

Use the information in **Table 1** to explain how changing one amino acid in a polypeptide may adversely affect the function of a protein of which the amino acid is part. (1 + 2 = 3 marks)

(Total 4 marks)

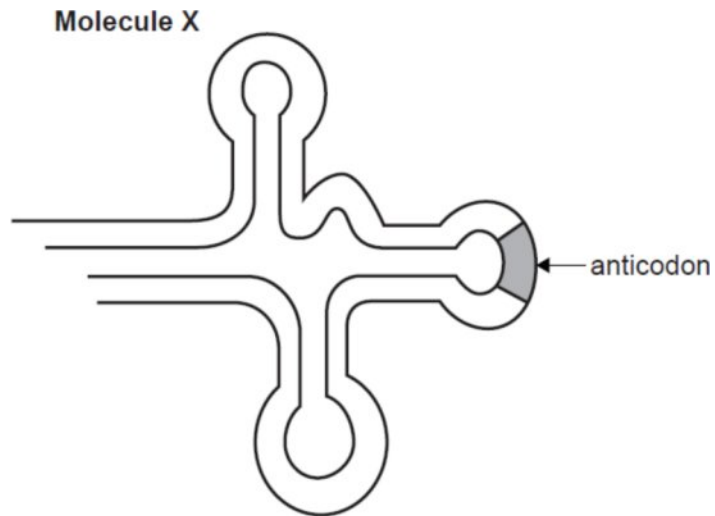
Question 7/ 172

[Adapted VCAA 2016 SB Q6]

The hormone insulin is a relatively small protein. Researchers studying the production of insulin in the cells of the pancreas noted that one of the early steps in this process was the formation of a polypeptide called preproinsulin.

Researchers noted that the formation of this polypeptide required repeated use of different types of Molecule

X, shown in the diagram below.



a i What is the name of Molecule X? (1 mark)

ii How does Molecule X play a role in the production of preproinsulin? (3 marks)

b The coding information in the DNA molecule for preproinsulin is initially transferred to another molecule (Molecule W). However, Molecule W has a different nucleotide sequence from the coding section of the DNA molecule.

Describe how Molecule W is synthesised. (3 marks)

(Total 7 marks)

Question 8/ 172

[VCAA 2012 E2 SB Q1]

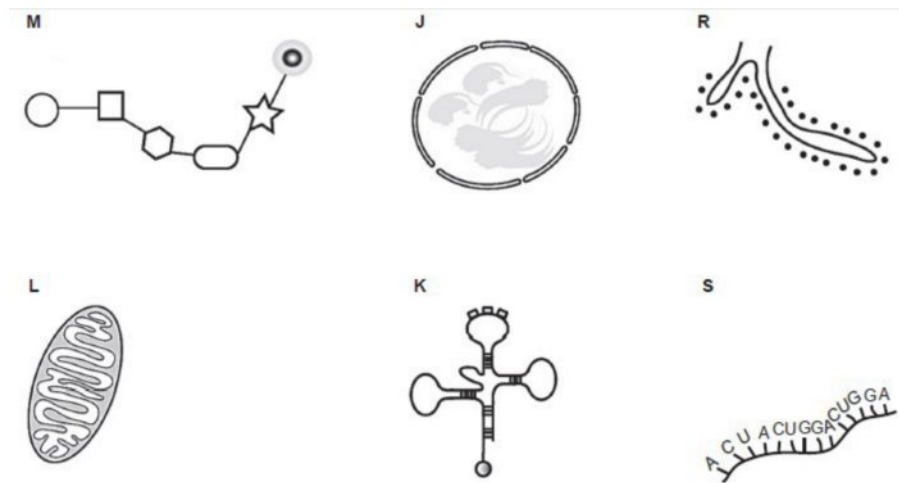
In Australia, Alzheimer's disease is the most common form of dementia. Alzheimer's disease is associated with the development of a toxic protein in the brain known as amyloid beta-protein. The amyloid beta-protein builds up to form plaques in the brain. This causes symptoms such as memory loss.

The synthesis of amyloid beta-protein occurs in two stages.

a Name the two stages of protein synthesis. (1 mark)

b Describe the main steps of the first stage of synthesis of amyloid beta-protein. (3 marks)

c Consider the diagrams of the following six structures.



Choose three of the structures shown above that are involved in the **second** stage of protein synthesis.

Explain the role of each in producing amyloid beta-protein.

Letter representing structure chosen	Role of structure in second stage of amyloid beta-protein synthesis

(3 marks)

(Total 7 marks)

Question 9/ 172

[VCAA 2014 SB Q7]

Scientists studying the nucleus of the fruit fly *Drosophila melanogaster* observed distinct types of nucleic acid chains.

These scientists noticed that one type of nucleic acid chain was able to pass through the nuclear membrane and move to a ribosome. After the nucleic acid chain attaches to the ribosome, a polymer is produced.

a Describe the steps occurring at the ribosome that resulted in the production of the polymer. (3 marks)

b One particular length of nucleic acid chain passed through the nuclear membrane and coded for the

production of a polymer that was 90 monomers long.

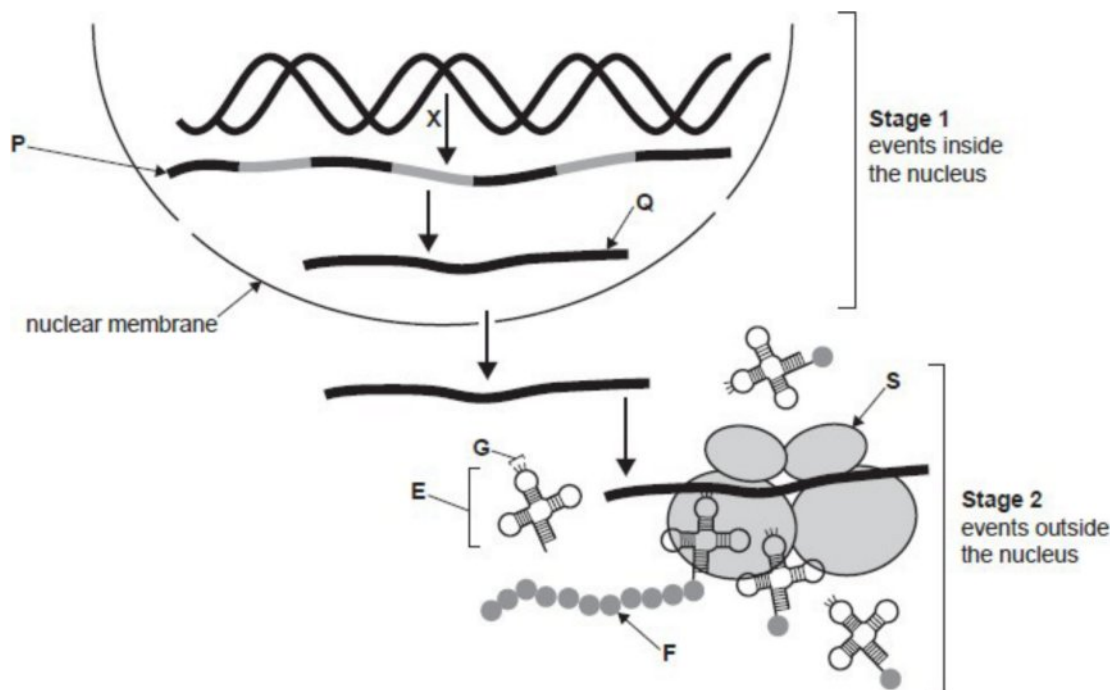
How many nucleotide bases on the nucleic acid chain were involved in the coding for this polymer? Explain your response. (2 marks)

(Total 5 marks)

Question 10/ 172

[VCAA 2013 SB Q6]

The diagram below outlines various events that occur in cells when DNA is activated.



a i Outline events that occur during action X. (2 marks)

ii Note that structure P consists of two different kinds of components. What are these two components called and what happens to each component? (2 marks)

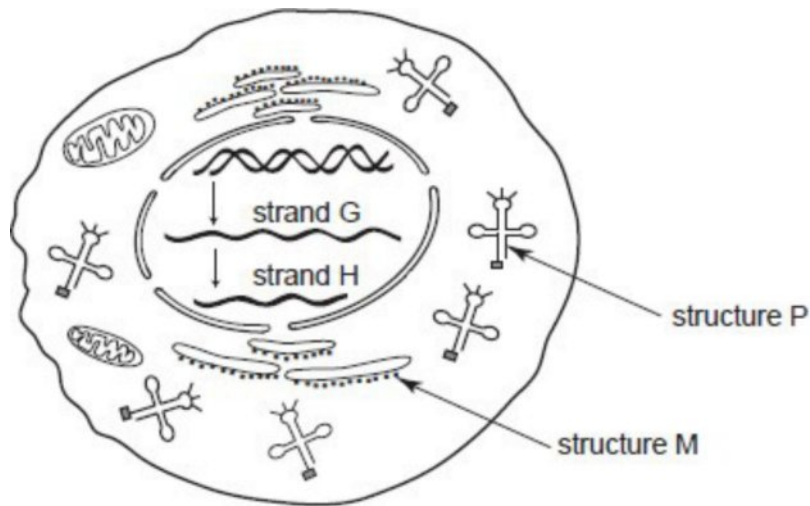
b Describe the events occurring in stage 2, including the role of each of the structures S, F, E and G. (4 marks)

(Total 8 marks)

Question 11/ 172

[VCAA 2011 E2 SB Q1]

Consider the following diagram of a cell. The parts of the diagram are not drawn to scale.



a In which structure would RNA polymerase be found? (1 mark)

b Describe the function of RNA polymerase. (2 marks)

c Strand **H** is shorter than strand **G**. Describe the process that results in this shortening, using appropriate names for both strands. (2 marks)

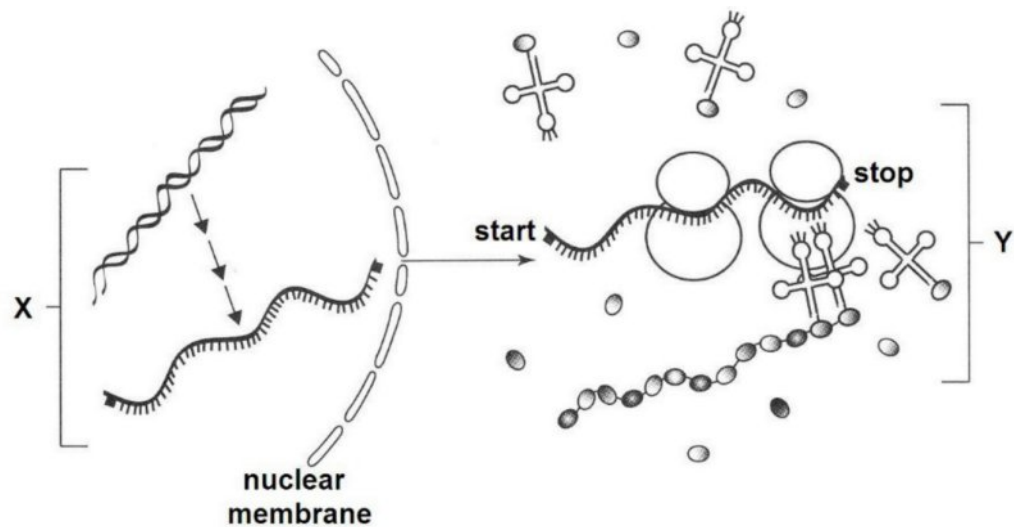
d Name strand **H** and structures **P** and **M**. Explain how each contributes to protein synthesis. (3 marks)

(Total 8 marks)

Question 12/ 172

[VCAA 2010 E2 SB Q2]

The following diagram outlines processes that occur in living cells.



a i Name the process represented at X. (1 mark)

ii Describe the sequence of events that occur during the process at X. (3 marks)

b i Name the process represented at Y. (1 mark)

ii Describe the sequence of events that occur during the process at Y. (3 marks)

(Total 8 marks)

Question 13/ 172

[VCAA 2022 SB Q1]

Tryptophan (trp) is the least abundant amino acid in eukaryotic cells.

Consider the genetic code below.

		Second letter				
		U	C	A	G	
First letter	U	UUU } phe UUC } UUA } leu UUG }	UCU } UCC } ser UCA } UCG }	UAU } tyr UAC } UAA STOP UAG STOP	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	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

a In terms of the genetic code, what feature shared by trp and met is not common to the other 18 amino acids? (1 mark)

b Using the genetic code above:

- write the next triplet in the sequence so that trp will be the next amino acid added to the polypeptide chain
- provide the corresponding mRNA strand
- provide the translated amino acid sequence.

DNA template strand	T	A	C	T	T	C	G	G	C	T	C	A	G	T	A	_____	_____	_____
																next triplet		

mRNA strand _____

Amino acid sequence _____

(3 marks)

c Unlike humans, the bacterium *Escherichia coli* does not need to rely on consuming tryptophan from the environment as these bacteria can synthesise their own. The trp operon regulates the production of tryptophan in *E. coli*. The diagram below shows the position of the five genes in the trp operon.

Annotate the diagram below to show how *E. coli* regulates the expression of genes through repression when tryptophan levels are high in the cell.

				<i>trpE</i>	<i>trpD</i>	<i>trpC</i>	<i>trpB</i>	<i>trpA</i>		

(3 marks)

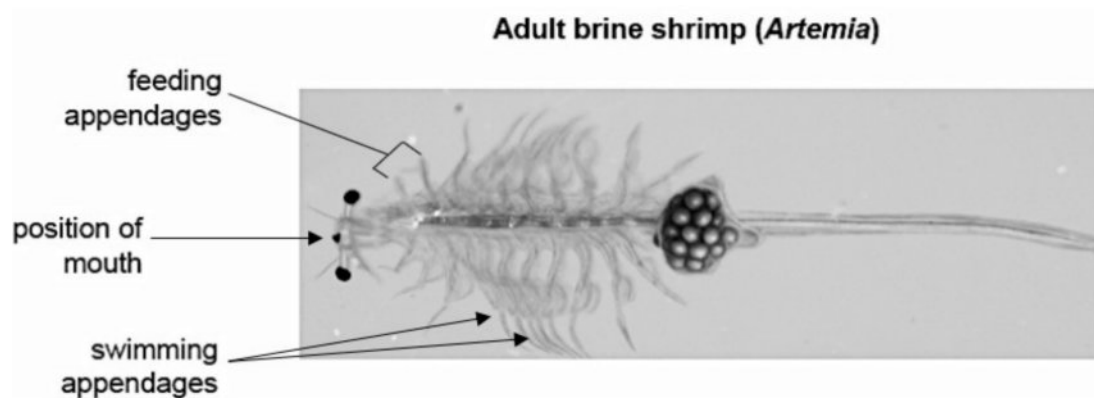
(Total 7 marks)

Question 14/ 172

[Adapted VCAA 2018 SB Q6]

a Describe the functional difference between a structural gene and a regulatory gene. (2 marks)

The *Hox* genes are master regulatory genes that influence cells in a particular location of an animal embryo in order to develop structures for that part of the body. In the brine shrimp, *Artemia*, the expression of the *Hox* genes *Ubx* and *Scr* results in the growth of either a swimming appendage or a feeding appendage, depending on whether the genes are expressed in cells that are in the mid-region of the body or that are near the mouth. These specialised appendages are labelled in the diagram below.



b Describe one way that genes are regulated so that the same genes can produce different appendages when the genes are expressed in different locations in the *Artemia* embryo. (1 mark)

(Total 3 marks)

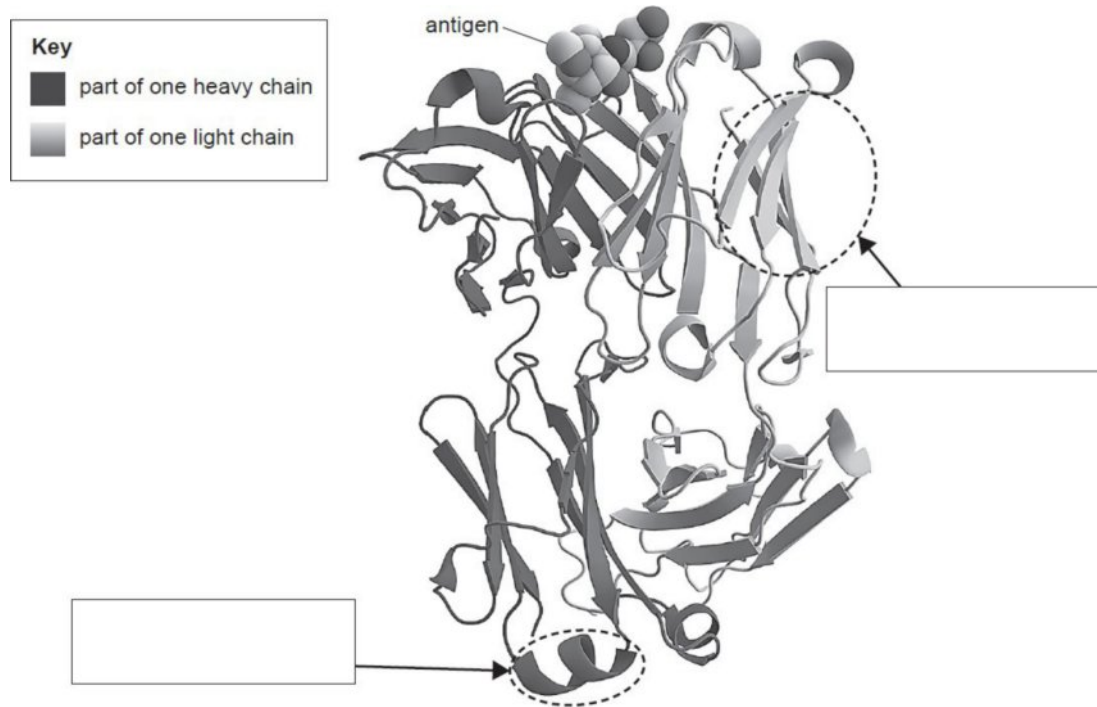
Question 15/ 172

[VCAA 2016 SB Q1]

Immunoglobulins, or antibody molecules, have an important role in the immune system. They are made up of two heavy chains and two light chains.

a Name the molecular monomer of these chains. (1 mark)

b Part of a mouse immunoglobulin molecule bound to an antigen is shown in the diagram below. Two arrows point to two different types of secondary structures of the immunoglobulin molecule.



Give the name of each structure in the boxes provided. (2 marks)

c Immunoglobulin molecules also display a tertiary structure and a quaternary structure.

Referring to the diagram, explain what quaternary means. (2 marks)

(Total 5 marks)

Question 16/ 172

[VCAA SB Q1 2018]

Tryptase is an enzyme that is released, along with histamine and other chemicals, from human mast cells.

Nucleic acids encode instructions for the synthesis of tryptase in a mast cell.

a Outline the steps of translation in the synthesis of tryptase. (3 marks)

b After being synthesised, trypase is released from mast cells via exocytosis.

Complete the table below by naming three different organelles directly associated with the transport of the synthesised trypase within or from mast cells and state the role of each organelle in this process. (3 marks)

Organelle

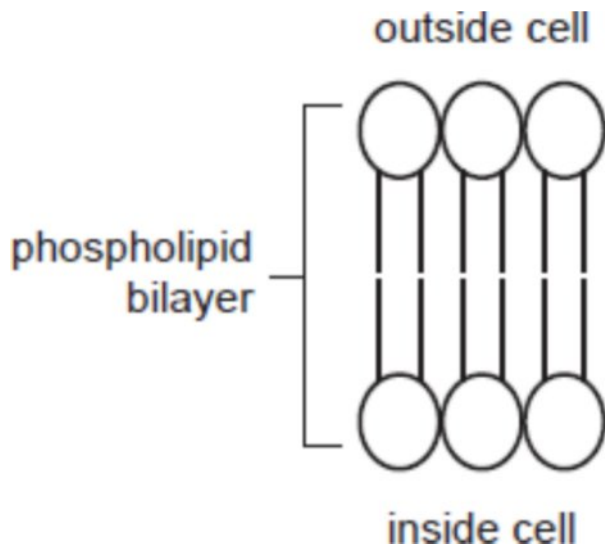
Role

(Total 6 marks)

Question 17/ 172

[Adapted VCAA 2021 SB Q1]

The diagram below shows a small part of a cross-section of the plasma membrane of a cell.



Some substances can move directly through the phospholipid bilayer.

Some very large substances and/or large particles that do not dissolve in the phospholipid bilayer can still move into or out of a cell.

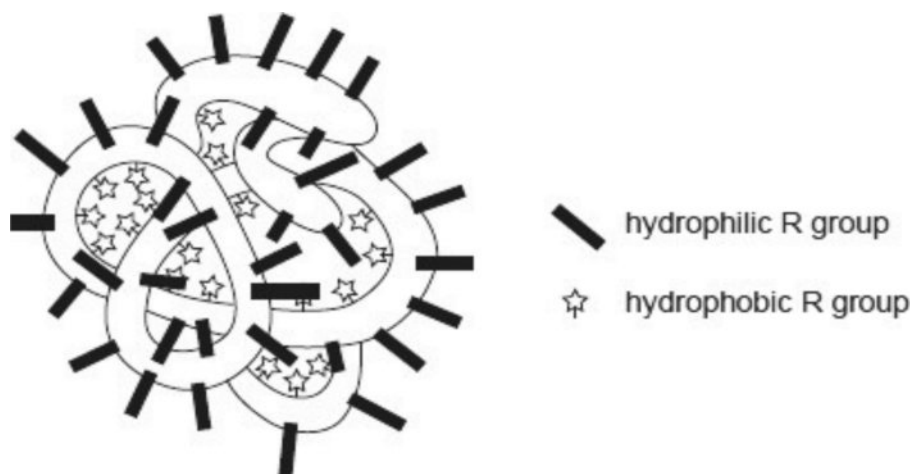
Using one example, explain how the phospholipid bilayer transports these very large substances and/or large particles without the use of channel or carrier proteins move out of a cell.

(Total 3 marks)

Question 18/ 172

[Adapted VCAA 2011 E1 SB Q1]

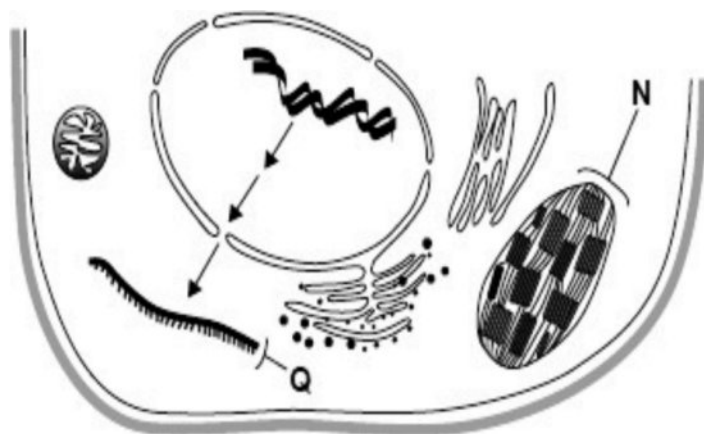
The following figure represents a globular protein.



This molecule is likely to be highly soluble in water.

a Outline why such a conclusion can be made about this molecule. (2 marks)

The following figure represents a portion of a plant cell.



b Examine the figure above and complete the following table.

Type of nucleic acid found in structure	Specific function of the nucleic acid

Type of nucleic acid found in structure

Specific function of the nucleic acid

Structure
N

Structure
Q

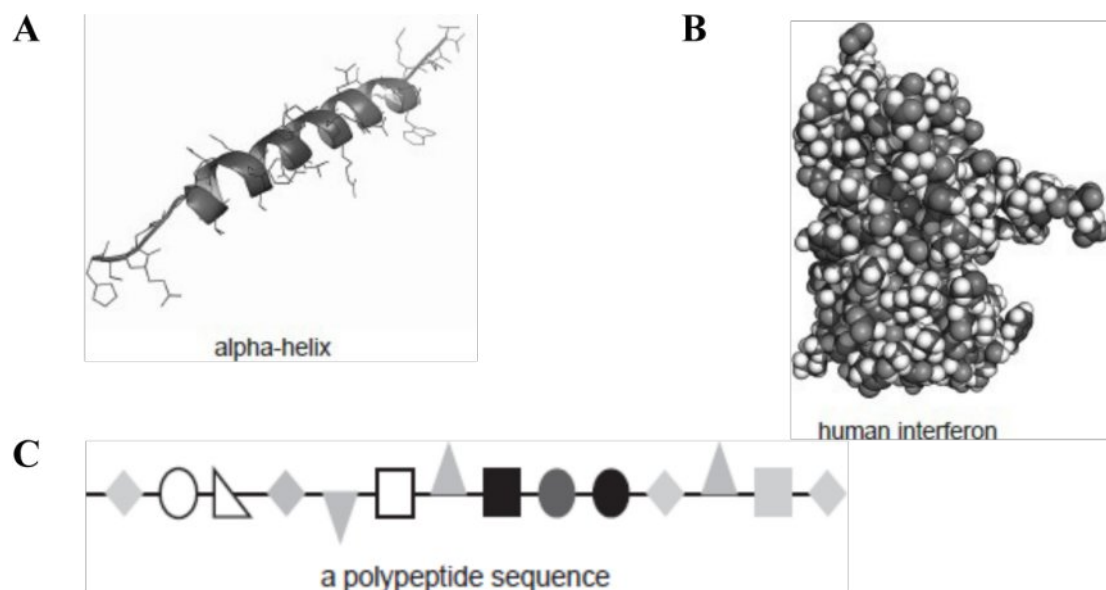
(4 marks)

(Total 6 marks)

Question 19/ 172

[VCAA 2015 SB Q1]

The diagrams below represent examples of three levels of structure with respect to the folding and assembly of a protein. The diagrams are not to scale.



a i Complete the table below to indicate the diagram that represents the structural level of the protein given.
(1 mark)

Structure level of protein Diagram (A, B or C)

primary

Structure level of protein Diagram (A, B or C)

secondary

tertiary

ii Name the molecular sub-unit of a protein. (1 mark)

The particular shape achieved by the folding of a protein is of great significance. Proteins sometimes fold incorrectly to form groups of joined, identical polypeptide sequences called aggregates. Sufferers of Alzheimer's disease have aggregates of various sizes in their brain tissue. Aggregates of amyloid beta protein are present in their brain tissue. These patients experience memory loss and have large areas of dead neurons in their brains.

Several hypotheses have been suggested as possible explanations for neuron death. One hypothesis is summarised below.

Hypothesis: Aggregates of amyloid beta protein could cause death of neurons.

Explanation: These aggregates have star-like shapes that pierce the plasma membrane.

b Suggest, by referring to cellular function, how aggregates of amyloid beta proteins could result in death of neurons. (2 marks)

c In healthy brain tissue, other proteins, called molecular chaperones, bind temporarily to a protein during its folding process to allow the correct folding and assembly of the protein. Researchers are trying rational drug design to mimic the action of molecular chaperones as a treatment for Alzheimer's disease.

Describe **one** structural characteristic of the molecular chaperone proteins that would need to be considered in order for this approach to provide a successful treatment. (1 mark)

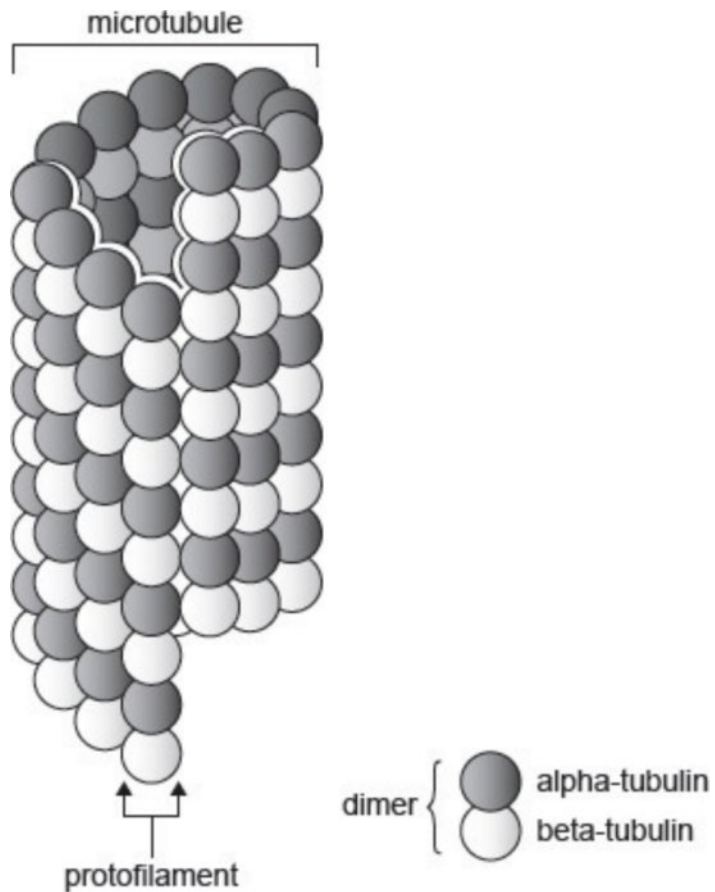
d Enzymes are protein catalysts. Use labelled diagrams to illustrate both **enzyme denaturation** and **enzyme inhibition**. Include both the enzyme and substrate in your diagrams. (3 marks)

(Total 8 marks)

Question 20/ 172

[VCAA 2013 SB Q2]

Microtubules are hollow structures composed of a protein, tubulin, which has two forms: alpha-tubulin and beta-tubulin. A tubulin dimer is formed when one alpha-tubulin molecule and one beta-tubulin molecule join. Tubulin dimers polymerise into long chains to form protofilaments. A microtubule can be formed when 13 protofilaments align side by side, as represented in the diagram below.



a With respect to the structure of a protofilament, explain what is meant by the term ‘polymerise’. (1 mark)

b Consider an alpha-tubulin molecule. Explain the difference between its primary structure and secondary structure. (2 marks)

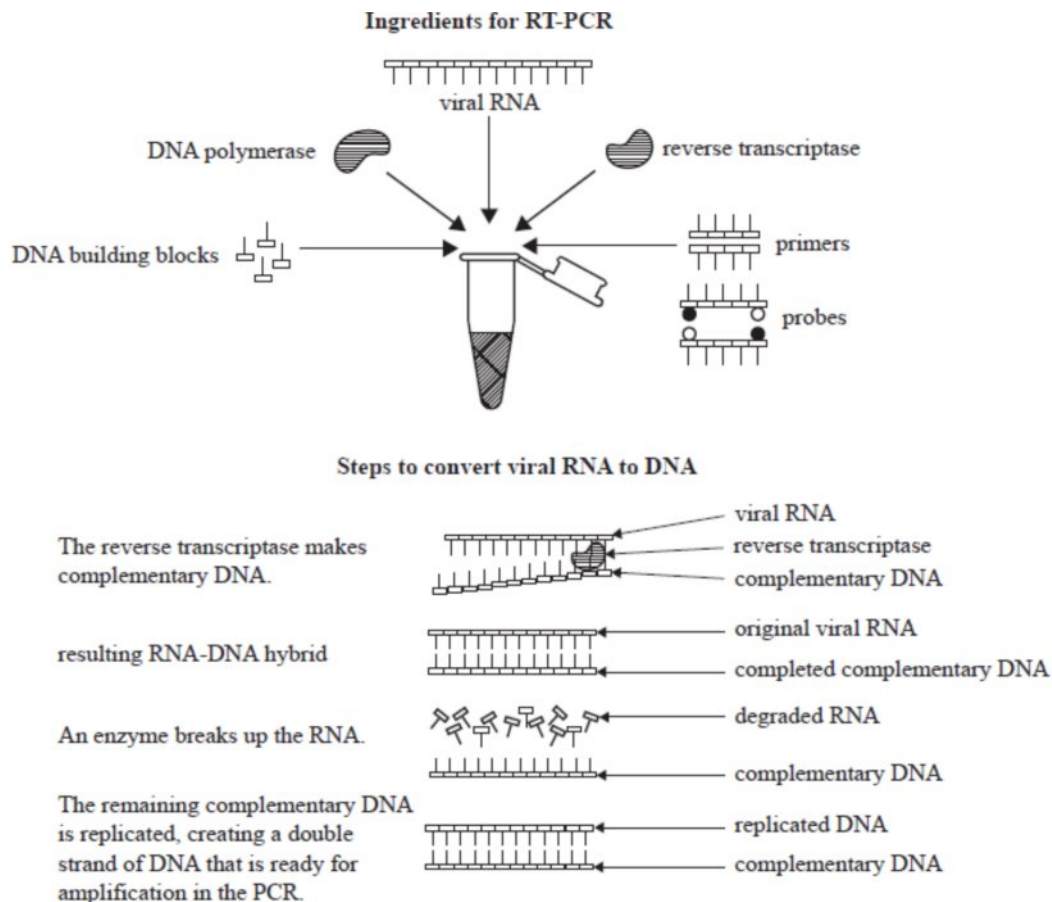
c Describe what is meant by tertiary and quaternary protein structures. (2 marks)

(Total 5 marks)

Question 21/ 172

[VCAA 2022 SB Q2]

The polymerase chain reaction (PCR) can be used to determine if a person is infected with a particular virus. Viral RNA must be converted to DNA before the PCR can occur. The process by which this occurs is called reverse transcription PCR (RT-PCR). The diagram on the next page shows the ingredients required and the steps that must be taken for viral RNA to be converted to DNA.



Source: adapted from S Tiner, 'The science behind the test for the COVID-19 virus',
Discovery's Edge (Mayo Clinic's research magazine), 27 March 2020,
<https://discoverysedge.mayo.edu/2020/03/27/the-science-behind-the-test-for-the-covid-19-virus/>

a i Explain why RNA must be converted to DNA in RT-PCR. (1 mark)

ii What is the purpose of DNA amplification in the PCR? (1 mark)

b There are different stages in the PCR, and each requires a different temperature.

Explain why each stage requires a different temperature. (3 marks)

c The probes shown in the diagram titled 'Ingredients for RT-PCR' in the above figure fluoresce (glow). They attach to complementary sequences only found in a particular virus. State two reasons why virus identification using RT-PCR cannot be used for all viruses. (2 marks)

(Total 7 marks)

A student wanted to investigate the effect of two different endonucleases (restriction enzymes) on a linear DNA fragment.

The student used three tubes containing a buffered solution of linear DNA fragments, each fragment being 9500 base pairs in length.

Two different endonucleases were available: BamHI and HindIII.

The student followed the steps below.

Step 1 – 2 μL of BamHI was added to the sample in Tube 1.

Step 2 – 2 μL of HindIII was added to the sample in Tube 2.

Step 3 – 2 μL of HindIII and 2 μL of BamHI were added to the sample in Tube 3.

Step 4 – All three tubes were incubated for one hour at a constant temperature of 37°C.

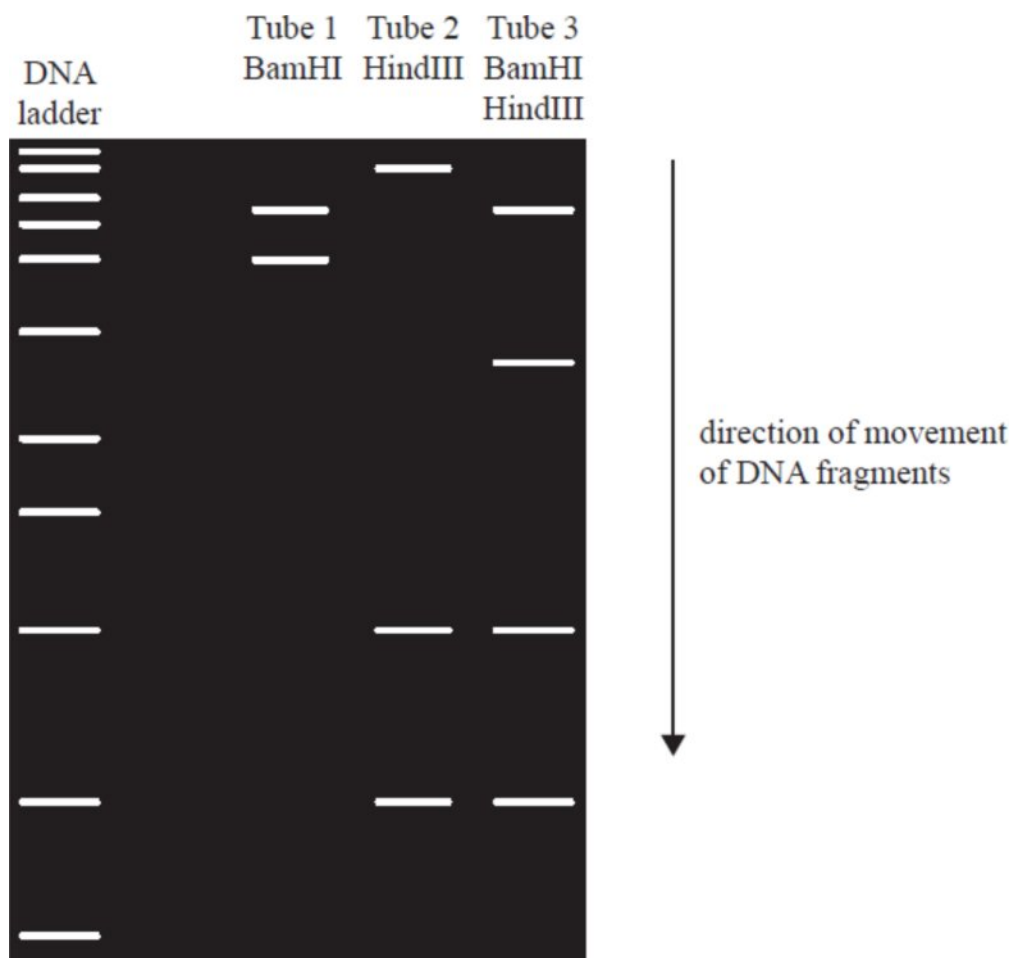
Step 5 – A 1% agarose gel was placed into an electrophoresis chamber and the gel was covered with buffer solution.

Step 6 – 40 μL of a DNA ladder with fragments of known sizes was added to the first well of the 1% agarose gel. The known sizes of the fragments were 10 000 bp, 8000 bp, 6000 bp, 5000 bp, 4000 bp, 3000 bp, 2000 bp, 1500 bp, 1000 bp, 500 bp and 250 bp.

Step 7 – 40 μL of the contents of each of the tubes was loaded into three separate wells of the 1% agarose gel.

Step 8 – An electric current of 100 V was run through the gel for 45 minutes.

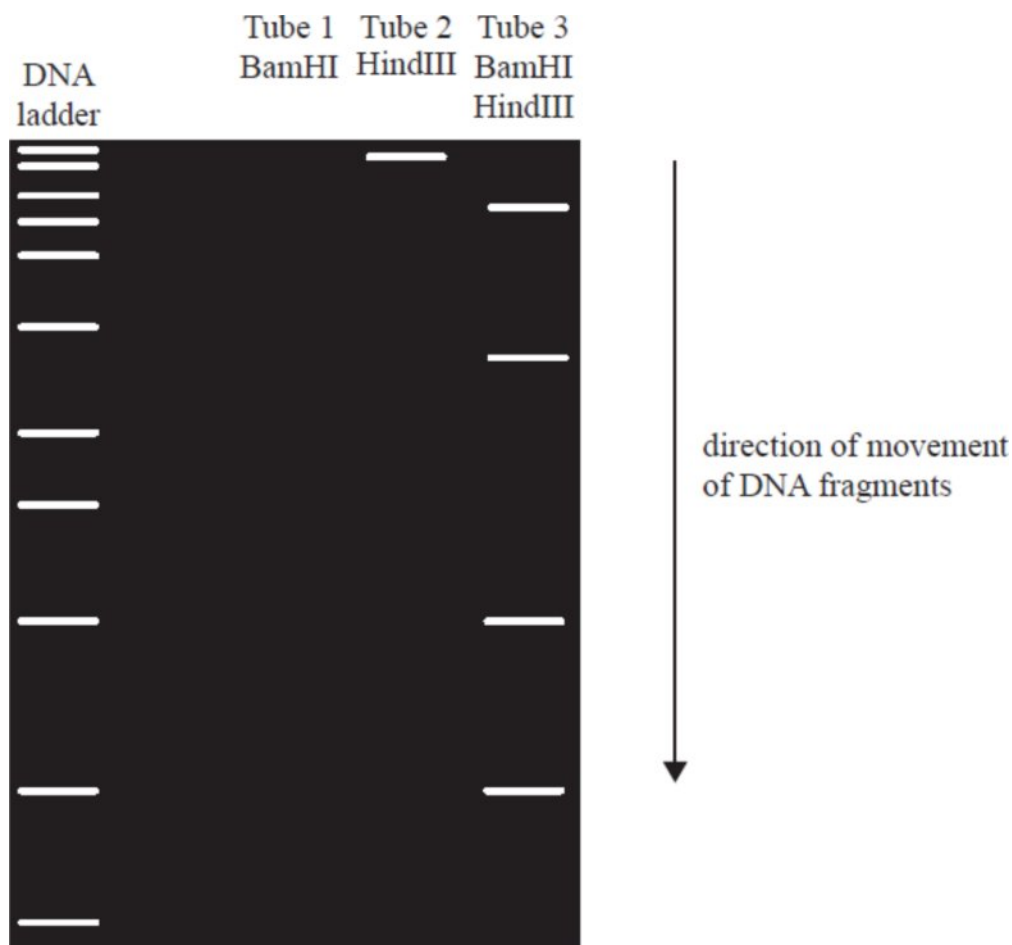
After 45 minutes the student obtained the results shown below.



Source: results based on 1 kb DNA ladder from
TEquipment, <www.tequipment.net>

a Analyse the results of the experiment performed by the student. (5 marks)

The student repeated the experiment the next day and obtained the following results.



b Identify **one** difference between the new results and the previous results, and suggest a possible reason for this difference. (2 marks)

c State **two** factors that will have an impact on the rate of movement of the DNA fragments through the agarose gel. (2 marks)

d Outline **two** safety guidelines that should have been followed by the student. (2 marks)

(Total 11 marks)

Question 23/ 172

[VCAA 2022 SB Q5]

Wheat is a cereal crop grown extensively in Australia. The starch found within the wheat grain is used to produce wheat flour. Wheat flour is used to make a variety of foods.

Scientists are investigating ways to improve wheat crop yields. It is known that both the weight and protein content of a wheat grain are under genetic control. The scientists designed a single guide RNA (sgRNA)

molecule and used CRISPR-Cas9 technology to edit the gene associated with grain weight. After editing, the gene was not expressed. When grown, the gene-edited wheat plants showed both an increase in grain weight and an increase in protein content.

a Explain how the scientists would have designed the sgRNA molecule and outline the function of sgRNA in the editing of the gene. (3 marks)

b The scientists noted that the lack of gene expression could have resulted in either the insertion of a nucleotide into the gene or the deletion of seven nucleotides from the gene.

Explain how each of these two different gene edits could have caused the lack of gene expression. (3 marks)

c Starch from the wheat grain can be used to manufacture bioethanol. In this process, *Zymomonas mobilis* bacteria and enzymes that break down starch into monosaccharides are added to the starch. *Z. mobilis* is a facultative anaerobic bacterium.

Explain how *Z. mobilis* is used in the manufacture of bioethanol. (2 marks)

(Total 8 marks)

Question 24/ 172

[VCAA 2019 SB Q8]

The Genomics Health Futures Mission will run a \ (32 million trial, starting in 2019, to screen over 10 000 couples who are in early pregnancy or who are planning to have a baby. Using a blood test, individuals will be screened for 500 severe or deadly recessive gene mutations.

Couples will be told they have a genetic mutation if both individuals in the couple carry the same mutation. The trial may lead to a population-wide carrier screening program. The researchers will evaluate cost effectiveness, psychological impact, ethics and barriers to screening. It is anticipated that future tests will be free of charge.

a Give an example of a disorder or disease that can be detected by genetic screening. (1 mark)

b The blood sample from an individual will provide researchers with only a small amount of DNA. Polymerase chain reaction (PCR) will be used to amplify the DNA.

Describe what happens in each of the three stages of PCR.

The stages must be given in the order in which they occur. (3 marks)

Stage	What is happening at this stage

Stage	What is happening at this stage

2

3

c Once the DNA has been amplified, it can be loaded into a well of an agarose gel. Discuss three factors that affect the migration of DNA fragments through the agarose gel during gel electrophoresis. (3 marks)

d The test may find that a couple who were planning to have a baby or who were already pregnant both carry the same severe or deadly mutation.

Describe one ethical and one social issue/implication that could arise from this finding. (2 marks)

(Total 9 marks)

Question 25/ 172

[VCAA 2022 SB Q4]

Increased protein consumption is a global trend. Chicken eggs are a good source of protein. Ovalbumin (egg white protein) is formed from chicken cells during egg production.

a Describe the role of organelles in the export of ovalbumin from a chicken's cells into an egg. (3 marks)

b To meet the growing demand for ovalbumin, more chickens are being bred for egg production using intensive farming methods. Animal welfare concerns have been raised, so alternative processes for making ovalbumin are being explored. Currently, recombinant technology can use a fungus to produce large quantities of ovalbumin. It has been suggested that scientists explore the option of using recombinant plasmids to transform bacterial cells for ovalbumin production.

c Discuss an ethical concern that could be raised about intensive farming methods or the use of recombinant technology to produce protein. Propose a feasible solution to this ethical concern. State the ethical concept or approach that has been addressed in your discussion. (4 marks)

(Total 7 marks)

Question 26/ 172

In 2020, Emmanuelle Charpentier and Jennifer Doudna were awarded the Nobel Prize in Chemistry for their work on developing the CRISPR-Cas9 genome editing technique.

a CRISPR-Cas9 is found naturally in bacteria. What is its role in bacteria? (1 mark)

b What is the role of the following key components of CRISPR-Cas9 RNA guide?

i guide RNA

ii Cas9 endonuclease (2 marks)

c Describe **two** ways CRISPR-Cas9 can be used to edit genes. (2 marks)

d What are the advantages of CRISPR-Cas9 over other gene editing techniques? (2 marks)

(Total 7 marks)

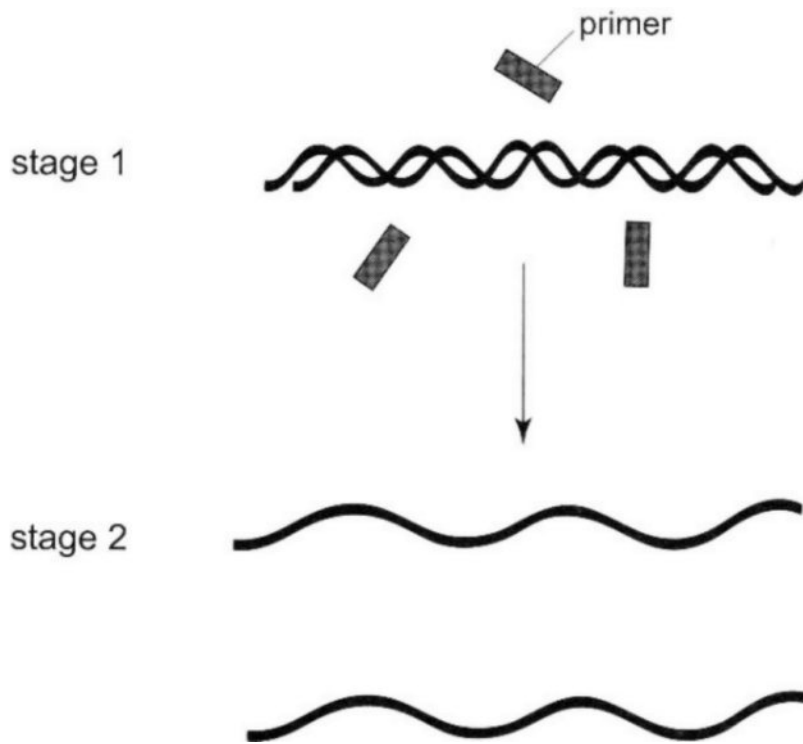
Question 27/ 172

[VCAA 2007 E2 SB Q2]

Victoria Police forensic scientists conduct DNA profiling using samples taken from crime scenes. Traces of DNA of less than 1 nanogram can be amplified and then profiled.

a Name the process which is used to amplify the DNA. (1 mark)

Below is a diagram showing part of this process.

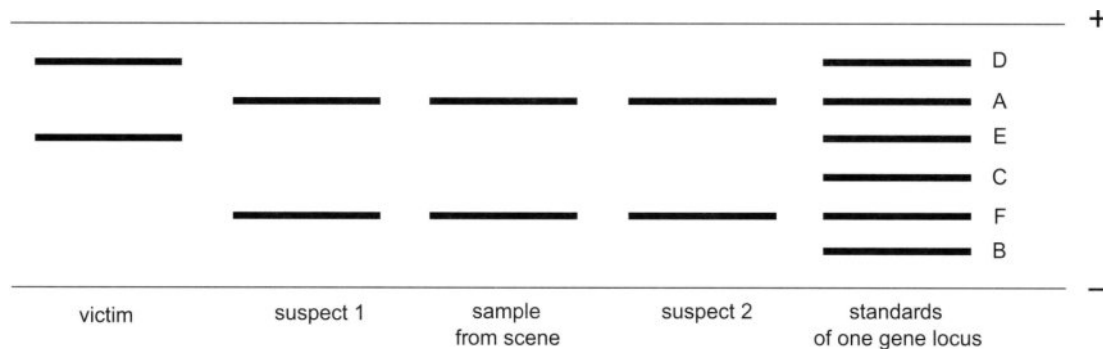


b What must be done between stages 1 and 2 to separate the strands of the DNA molecule? (1 mark)

c Complete and label the diagram at stage 2. (2 marks)

d Small pieces of DNA of differing length can be compared to determine whether a sample could have come from a particular person. In a case, samples of DNA from the victim and the crime scene were compared with samples from two suspects.

The DNA samples were treated with restriction enzymes, amplified and run through gel electrophoresis. The results for one gene locus are shown below.



e Draw an arrow on the right-hand side of the diagram to indicate the direction of movement of the DNA fragments. (1 mark)

f What do the standards consist of, and what is their purpose? (2 marks)

g From these results, give a conclusion which could be drawn about the sample taken from the crime scene. (1 mark)

h What further action would you recommend to the forensic scientists investigating this case? (1 mark)

(Total 9 marks)

Question 28/ 172

[VCAA 2012 E2 SB Q3]

Genetic information in humans can be obtained by DNA profiling. In DNA profiling, the polymerase chain reaction is used by a scientist to amplify a particular sequence of DNA.

a Briefly describe the steps of this technique. (4 marks)

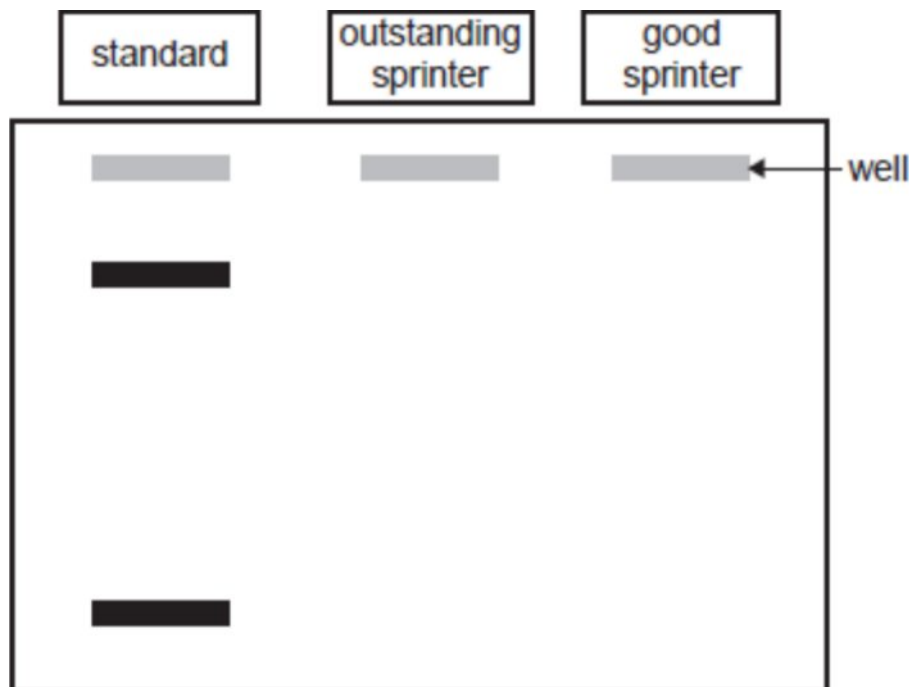
Scientists investigating the performance of athletes found that one gene contributing to the performance of sprinters is the ACTN3 gene. There are two alleles of the gene, the 577R allele and the 577X allele. The 577X allele codes for a very short protein fragment in muscle fibres due to a stop codon mutation.

The table below summarises the athletic potential for the three possible genotypes for the ACTN3 gene.

ACTN3 genotype	Athletic potential
577R/577R	outstanding sprinter
577R/577X	good sprinter or long- distance runner
577X/577X	very good long-distance runner

A scientist tested sprinters to see if they possessed the 577R allele. Samples were obtained from athletes' muscle fibres. A standard containing proteins of the same lengths as the proteins coded for by both alleles 577X and 577R was used as a comparison. The standard and the samples were exposed to gel electrophoresis. In gel electrophoresis, protein molecules separate according to size and charge in the same way as DNA molecules.

The result for the standard is shown below.



b On the diagram of the gel, draw the bands expected for an outstanding sprinter and for a good sprinter. Explain why you have placed the bands in these positions. (3 marks)

(Total 7 marks)

Question 29/ 172

[VCAA 2010 E2 SB Q8]

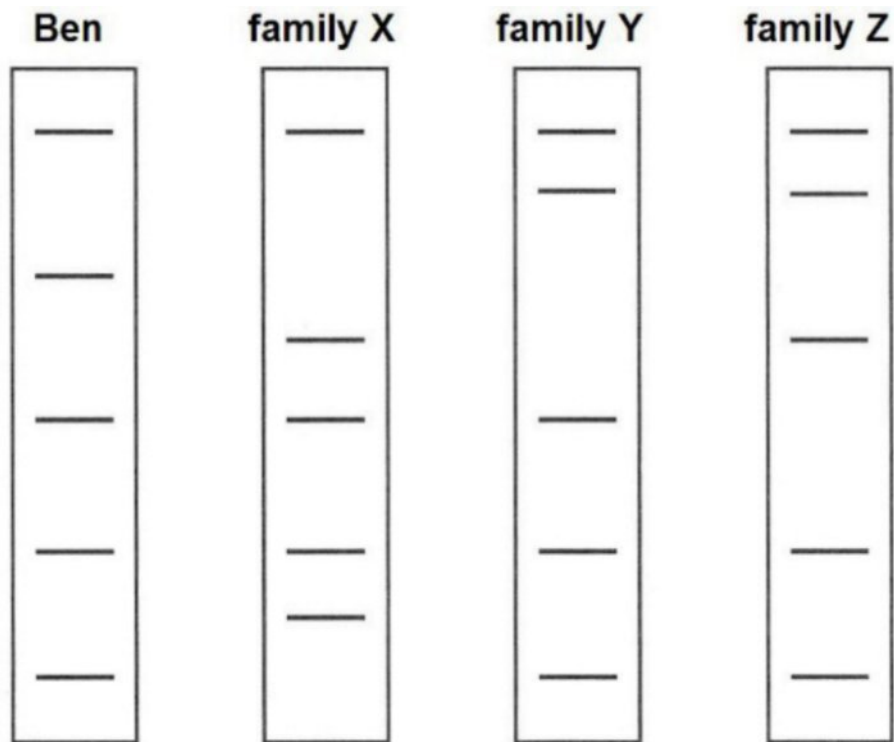
DNA includes sections that are called short tandem repeats (STR). Mutations in STRs occur, on average, every 500 generations. Different numbers of these repeats have no obvious effect on the individual.

a What is the likely reason for this? (1 mark)

A young man, Ben, wants to find out more about his genetic ancestry. He sends a sample of cells, obtained from a swab of his mouth, to a laboratory. On receipt of the sample, the laboratory treats the cells to release the DNA to enable identification of STR markers.

b Name the process used to produce many copies of the STR markers. (1 mark)

Each of the STR markers produced is labelled with a dye and subjected to gel electrophoresis. Five of Ben's STR markers were compared with three family groups who have the same surname as him. The following gels resulted.



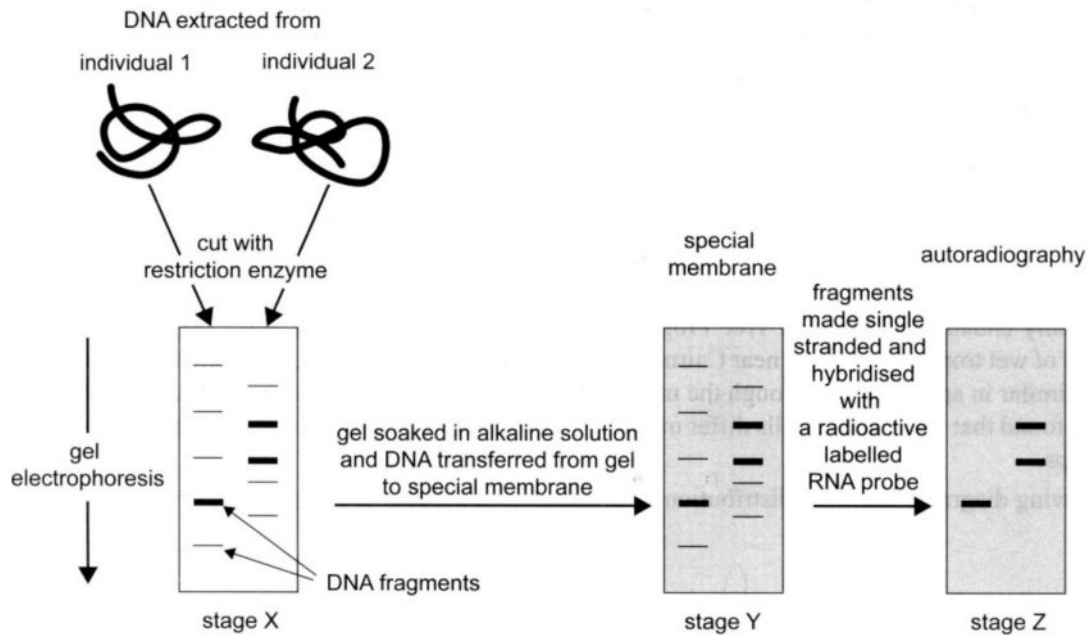
c Explain which family is Ben's most recent common ancestor. (2 marks)

(Total 4 marks)

Question 30/ 172

[VCAA 2008 E2 SB Q6]

RFLP (Restriction Fragment Length Polymorphism) analysis is commonly used to determine genetic variation between individuals. This procedure is summarised in the diagram on the next page.



In this procedure, scientists select a particular restriction enzyme from an available range.

a Explain the reason for their choice. (1 mark)

Electrophoresis uses electrical current to sort DNA fragments.

b i Describe one characteristic of this sorting process. (1 mark)

ii Explain why the DNA of each individual produces a different pattern of fragments after gel electrophoresis, even when the same restriction enzyme is used. (1 mark)

Examine stages Y and Z.

c Describe, at the molecular level, what is meant by the term ‘hybridised’. Why is it necessary to carry out hybridisation? (2 marks)

(Total 5 marks)

Question 31/ 172

[VCAA 2021 SB Q9]

The following table provides information on three commonly grown genetically modified (GM) crops in Australia.

Crop	Genetic modification	Characteristic given by modification
GM cotton	several bacterial genes inserted	insect resistance and herbicide tolerance
GM canola	two genes from two different bacterial species inserted	tolerance to several herbicides
GM safflower	a selection of genes silenced within the safflower genome	elevated levels of oleic acid in its seeds

a Select **one** of the GM crops in the table above and justify whether or not this crop could be described as transgenic. (1 mark)

b One issue with GM canola is the accidental release, during transport, of seeds along roadsides. Usually, unwanted plants that grow on the side of the road are killed using the herbicide glyphosate. However, GM canola is resistant to glyphosate.

Suggest **one** practical solution for treating GM canola that is found growing along roadsides. (1 mark)

c A new GM canola crop has been approved for use in Australia. It contains increased levels of omega-3 fatty acids, which are important, in humans, for building healthy cell membranes and for general growth and development, and also protect against a wide variety of diseases.

Omega-3 has traditionally been sourced from fish. Due to the growing demand for sources of omega-3, bioengineers have been encouraged to continue developing GM canola crops as a sustainable alternative.

Discuss **one social implication** and **one biological implication** of using GM canola with increased levels of omega-3. Use a different implication in each response. (4 marks)

(Total 6 marks)

Question 32/ 172

[VCAA 2021 SB Q10]

The path to insulin

In the 1970s, recombinant deoxyribonucleic acid methods for cloning and expressing genes in the bacteria *Escherichia coli* were under intense development. An important question that arose at the time was: Can humans design and chemically synthesise genes that function in bacteria? This question was

answered in the late 1970s with the successful expression of human insulin using *E. coli*. For the first time, this provided a practical source of recombinant human insulin for the treatment of diabetes. Prior to this, insulin was isolated from either cows or pigs.

When recombinant human insulin was first developed, researchers had knowledge of the amino acid sequence and the structure of insulin. Researchers investigated cloning the human insulin gene using plasmids found in *E. coli*. They knew of the presence of an EcoR1 recognition site (GAATTC) within these plasmids.

When research began, the safety of recombinant plasmids was being actively discussed. Safety regulations were put in place to identify, evaluate, minimise and manage the risks involved. Researchers tested the first recombinant human insulin in cell cultures in the laboratory and in live animals. This was followed by clinical trials where information was gained about the effectiveness and side effects of using this insulin to treat diabetes.

The first recombinant human insulin that was produced and tested established that the use of recombinant plasmids was successful. Facilities were built for recombinant plasmid research and the commercial production of recombinant human insulin. One of insulin's first researchers, Arthur Riggs, stated, 'It is interesting to think about how much progress has been made since [the 1970s]. For example, in 2020, the genes for insulin can be made in a few hours by automated instruments, then cloned and expressed by a single person in about a week'.

Reference: AD Riggs, 'Making, cloning, and the expression of human insulin genes in bacteria: The path to humulin', *Endocrine Reviews*, vol. 42, issue 3, June 2021, pp. 374–380, <https://doi.org/10.1210/endrev/bnaa029>

a What is meant by recombinant deoxyribonucleic acid in the context of this article? (1 mark)

b The article states that the researchers knew the structure of insulin and the amino acid sequence before they created the recombinant human insulin in the laboratory.

How would the researchers have used this information to genetically engineer a human insulin gene and how might this engineered insulin gene have differed from a natural insulin gene isolated from human DNA? (2 marks)

c Outline the steps that are required for the human insulin gene to be cloned and expressed in bacteria in 2020. (3 marks)

d What ethical response would have been expected from the researchers in the 1970s if, during their clinical trials, they discovered that the recombinant human insulin was significantly more effective than using insulin from either cows or pigs? (1 mark)

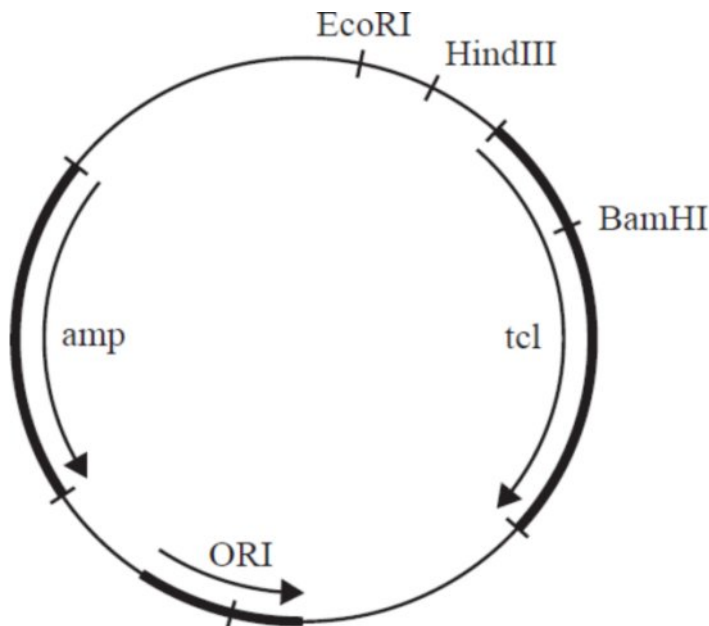
(Total 7 marks)

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

a What is meant by the term ‘vector’ in the context given? (1 mark)

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

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



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

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

i Describe how restriction enzymes such as BamHI are used to help insert a gene coding for a human protein into this plasmid. (2 marks)

ii Draw and label a diagram to show the position of the human gene in this plasmid when BamHI is used. Include the position of the recognition sites for the restriction enzymes EcoRI, HindIII and BamHI on the plasmid. (1 mark)

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

Explain how scientists use antibiotics to identify which of the bacterial cells have been successfully transformed with plasmids carrying the human gene. (3 marks)

(Total 7 marks)

Question 34/ 172

[VCAA 2006 E2 SB Q4]

a Describe the appearance of a bacterial plasmid. (1 mark)

A bacterial plasmid was modified in the laboratory so that it contained a gene for an enzyme which provided resistance to the antibiotic tetracycline.

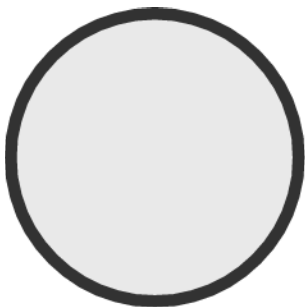
Bacterial cells, which in their natural environment were sensitive to the antibiotic tetracycline, were mixed with the modified plasmid. The bacterial cells were treated so that they could take up the plasmids.

b What is the name of the process in which a bacterial cell takes up a plasmid and expresses the genes of the plasmid? (1 mark)

The outcome of an experiment is shown below.

A

Bacterial cells only, spread on agar



B

Bacterial cells only, spread on agar with tetracycline



C

Bacterial cells exposed to the plasmid, spread on agar with tetracycline



With respect to the growth of bacteria, the results of plates A and C are shown. On plate A there is a continuous growth of bacteria over the surface of the agar. On plate C the colonies are distinguishable from each other.

c i What result would you expect on plate B with respect to the growth of the bacteria? (1 mark)

ii Explain your answer to **c.i.** (1 mark)

d Explain why there is a difference in the way the bacteria have grown on plates A and C. (2 marks)

(Total 6 marks)

Should we grow GM crops?

by Mary Nguyen

More than 25 years after genetically modified (GM) food first appeared, growing GM crops remains a hotly debated topic. Some people argue that GM crops are the only way to feed the growing world population and to minimise environmental harm. Other people express different views.

Bt cotton is a type of cotton that contains two genes from a soil bacterium, *Bacillus thuringiensis*, enabling it to produce insect-resistant proteins. Australian farmers of Bt cotton use only 15% of the quantity of the insecticide that was once needed to protect their cotton crops. However, Bt cotton is not as resistant to the main insect pest of cotton crops, *Helicoverpa*, as it has been in the past.

In Australia, Bt cotton is picked by machine, but in India, it is picked by hand. Workers in India have developed skin allergies, which have been attributed to Bt cotton proteins.

Traditionally, farmers have saved money by keeping seed from one year's crop to plant the following year. However, it is illegal for farmers to keep Bt cotton seeds because these seeds have been declared the legal property of the company Monsanto. Every year, cotton farmers must buy more seeds from Monsanto.

Unlike Monsanto, the company that produces the GM food crop Golden Rice allows farmers to replant the rice they harvested the previous year. By inserting a gene from the bacteria *Erwinia uredovora* and another from a daffodil, *Narcissus pseudonarcissus*, into white rice, scientists produced Golden Rice – a rice variety containing higher levels of vitamin A. People who eat Golden Rice avoid vitamin A deficiency. Trials conducted in several countries have shown that Golden Rice is safe to eat.

Question 35/ 172

[VCAA 2018 SB Q10]

a Bt cotton and Golden Rice are genetically modified organisms but are they also transgenic organisms? Support your response with evidence from the article above. (3 marks)

b How can planting a Bt cotton crop lead to an increase in crop yield? (1 mark)

c Using information from the article, complete the table below by describing one social and one biological implication relevant to the use of Bt cotton and Golden Rice. The same implication should not be used twice. (4 marks)

Social implications	Biological implications

Social implications

Biological implications

Bt cotton

Golden Rice

(Total 8 marks)

Question 36/ 172

Use an example of a named transgenic species to discuss the social and environmental impact of this technology. (Total 5 marks)

Chapter 3 How are biochemical pathways regulated?

Question 1/ 46

Is energy used by living organisms?

Question 2/ 46

Why do cells need energy?

Question 3/ 46

What is the difference between anabolic and catabolic reactions?

Question 4/ 46

What is the difference between exergonic and endergonic reactions? Give an example of each type.

Question 5/ 46

Define the term 'enzyme'.

Question 6/ 46

What is the 'lock-and-key' model and how does it differ from the induced fit?

Question 7/ 46

Use the terms 'substrate', 'enzyme' and 'product' to explain the role of enzymes in living organisms.

Question 8/ 46

Do enzymes increase the amount of product produced in a reaction?

Question 9/ 46

With respect to reactions involving enzymes, what is meant by the rate of reaction?

Question 10/ 46

What is an enzyme's active site and how is it formed?

Question 11/ 46

Enzymes can be denatured. How is this done and what are the consequences?

Question 12/ 46

Explain the difference between competitive and non-competitive enzyme inhibitors.

Question 13/ 46

What are coenzymes and what do they do?

Question 14/ 46

Complete the following table.

Loaded coenzyme	Unloaded form	Function	Involved in photosynthesis/cellular respiration
ATP			
NADH			
NADPH			

Question 15/ 46

What is ATP (adenosine triphosphate)? Explain its role in cells.

Question 16/ 46

Enzyme function is affected by

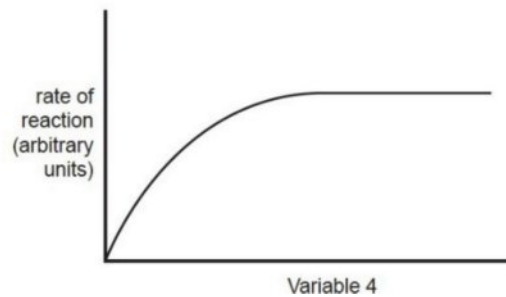
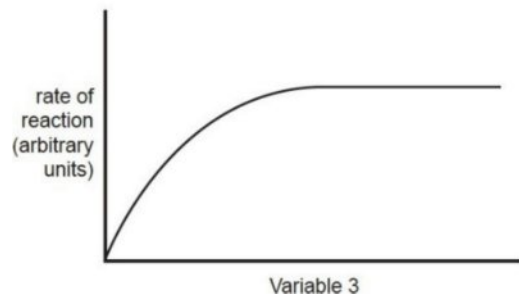
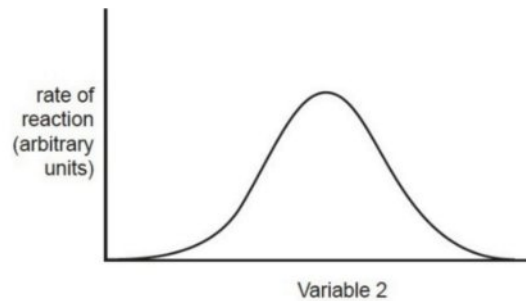
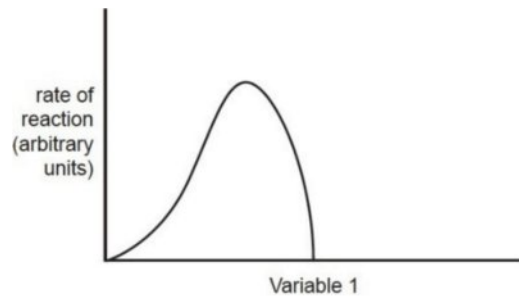
A: temperature

B: pH

C: substrate concentration

D: enzyme concentration

Match the above factors to the graphs below and explain the shape of the curve.



Variable

Factor

Explanation

1

2

3

4

Question 17/ 46

Do all enzymes work efficiently under the same conditions?

Question 18/ 46

What is the major difference between heterotrophic and autotrophic organisms?

Question 19/ 46

List the different sorts of organic compounds that heterotrophs require. What form is each type of compound in when moved into or out of cells? (No longer specifically on the course but useful background information.)

Question 20/ 46

Write down the word and chemical equations for photosynthesis.

Question 21/ 46

Where does photosynthesis occur?

Question 22/ 46

Draw a diagram of a leaf section. Use labels to show how various materials involved in photosynthesis move to and from the site of production.

Question 23/ 46

What is the role of pigments in photosynthetic organisms and why is there a range of different pigments?

Question 24/ 46

In eukaryotes, photosynthesis occurs in the chloroplast. Describe the structure of the chloroplast. Include in your description where light is absorbed and what wavelengths are involved.

Question 25/ 46

Use a table to explain what happens in the light-dependent and light-independent stages of photosynthesis.

Question 26/ 46

What is the role of NADP in photosynthesis?

Question 27/ 46

Complete the following table.

Stage	Location	Inputs	Outputs
light dependent reaction			
light independent reaction (Calvin)			

Question 28/ 46

What is Rubisco and what is its role in the Calvin cycle?

Question 29/ 46

Why is the rate of photosynthesis in C3 plants decreased on hot dry days?

Question 30/ 46

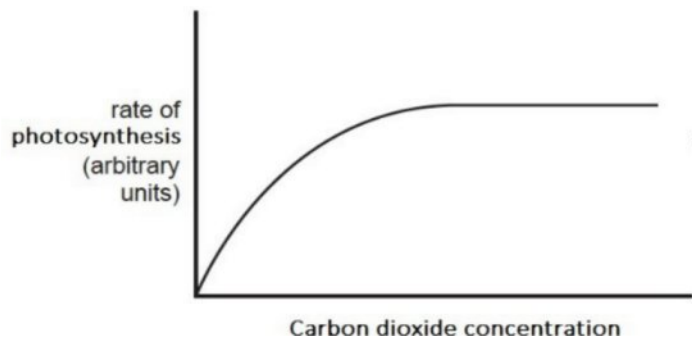
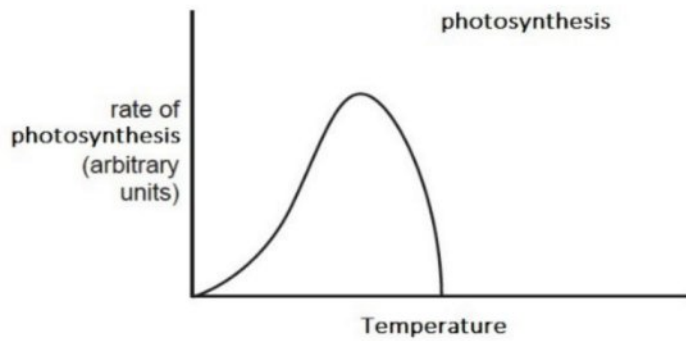
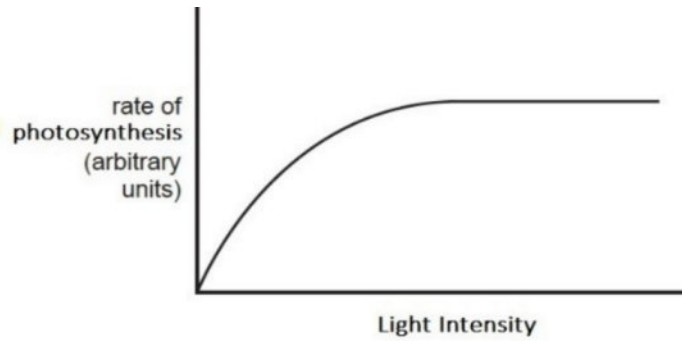
Explain how C4 and CAM plants are able to maintain a high rate of photosynthesis on hot dry days.

Question 31/ 46

Complete the following table.

Factor affecting photosynthesis

Explanation



Question 33/ 46

What other property of light, apart from intensity, affects the rate of photosynthesis?

Question 34/ 46

How might the availability of water affect the rate of photosynthesis in C3 plants?

Cellular respiration as an example of a biochemical pathway

Question 35/ 46

Write down the word equation for aerobic cellular respiration.

Question 36/ 46

Convert the above equation to a balanced chemical equation.

Question 37/ 46

In eukaryotes, aerobic respiration occurs in the mitochondrion. Describe the structure of a mitochondrion.

Question 38/ 46

Explain what happens in the three main stages of aerobic respiration.

Question 39/ 46

Write down the word equation for anaerobic respiration in:

a animals

b yeast.

Question 40/ 46

Aerobic respiration is said to be more efficient than anaerobic respiration. Explain this statement.

Question 41/ 46

Photosynthesis is similar to respiration. Do you agree?

Question 42/ 46

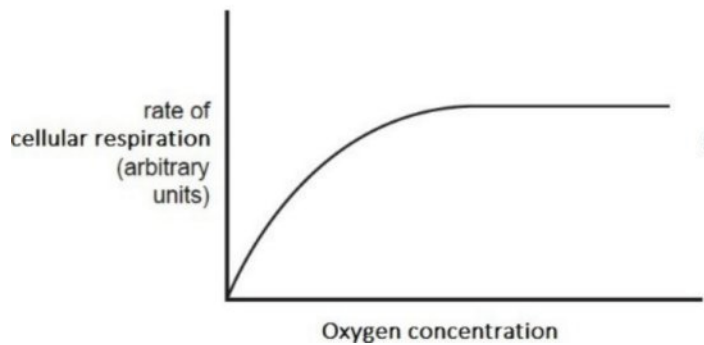
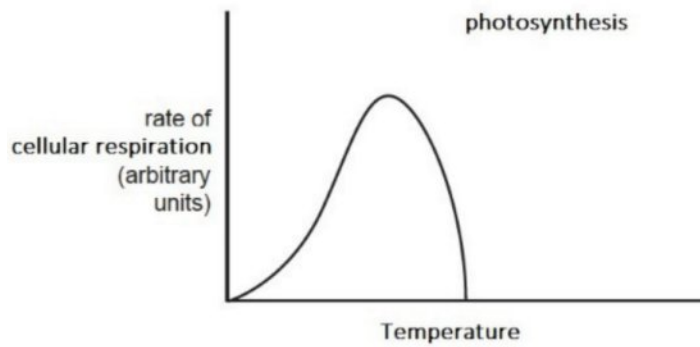
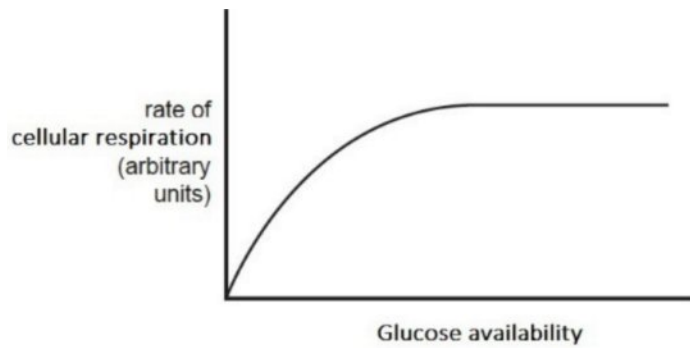
Mitochondria and chloroplasts contain many membranes embedded with enzymes. How would this increase efficiency?

Question 43/ 46

Explain the following graphs by completing the table.

Factor affecting photosynthesis

Explanation



Question 44/ 46

Describe how the CRISPR-Cas9 technologies may be used to improve photosynthesis efficiency and crop yields.

Question 45/ 46

What are meant by the terms 'biomass' and 'biofuel'?

Question 46/ 46

Explain how biomass can be used to make biofuel.

Question 1/ 115

[VCAA 2015 SA Q6]

An experiment was conducted to investigate enzyme activity. A small quantity of amylase solution was added to a solution of starch dissolved in water at 35°C. It was observed that maltose was produced.

Which one of the following is the substrate in this reaction?

A water

B starch

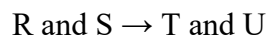
C maltose

D amylase

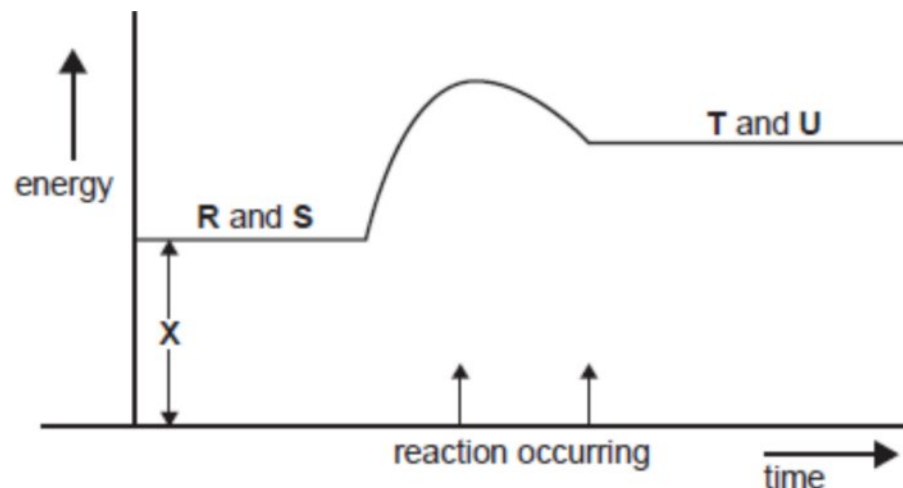
Question 2/ 115

[VCAA 2013 E1 SA Q8]

Consider the following reaction in which substrate molecule R and substrate molecule S are converted into product molecule T and product molecule U.



The graph below shows the energy available in the molecules against time.



Based on the information in the graph, a correct conclusion would be that

A this is an anabolic reaction.

B the reaction would release energy.

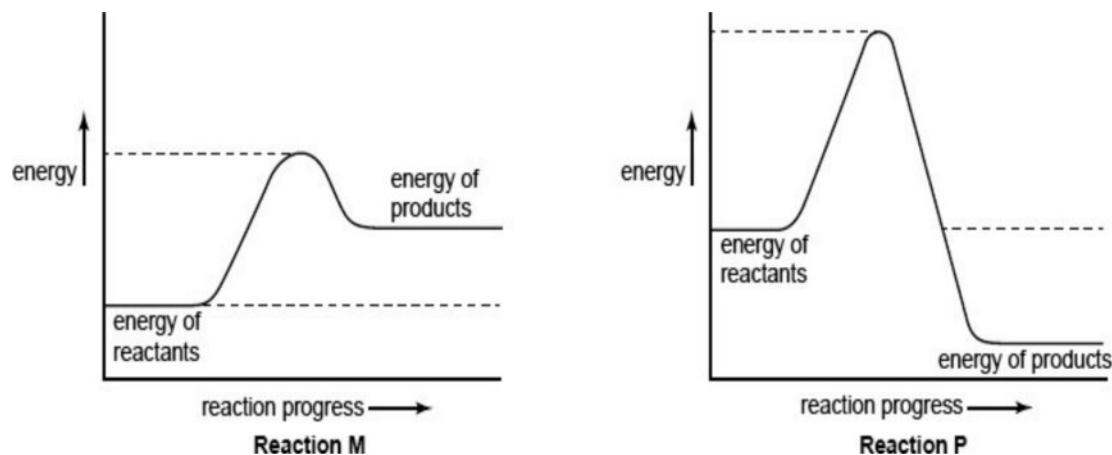
C value of the activation energy for the reaction is shown by X.

D product molecules T and U have less energy than substrate molecules R and S.

Question 3/ 115

[VCAA 2011 E1 SA Q23]

The following graphs depict two different reactions.



From the two graphs, it is reasonable to conclude that

A in reaction **P**, the energy level of the products is greater than that of the reactants.

B activation energy of reaction **M** is greater than that of reaction **P**.

C both graphs **M** and **P** represent endothermic reactions.

D energy is released in reaction **P** only.

Question 4/ 115

[VCAA 2020 SA Q4]

A group of Biology students set up an experiment with three test tubes. Each test tube contained the same enzyme and was kept under the same experimental conditions. All concentrations and volumes of substrate and enzyme placed in the test tubes were kept the same. The diagram below shows the initial contents of each test tube and the final contents of test tubes 1 and 2.

	Initial contents of each test tube			Final contents of each test tube	
Test tube 1	enzyme	+	Substrate A	→	enzyme + product
Test tube 2	enzyme	+	Substrate B	→	enzyme + Substrate B
Test tube 3	enzyme	+	Substrate A + Substrate B	→	?

Source: adapted from Chemistry LibreTexts,
<https://chem.libretexts.org>

An enzyme-substrate complex was formed in each of the three test tubes.

When compared to the final contents of Test tube 1, the concentration of product contained in the final contents of Test tube 3 will

A be the same because both Substrate A and Substrate B are able to bind to the enzyme at the same time.

B increase because Substrate A is a substrate that can bind to the enzyme's active site.

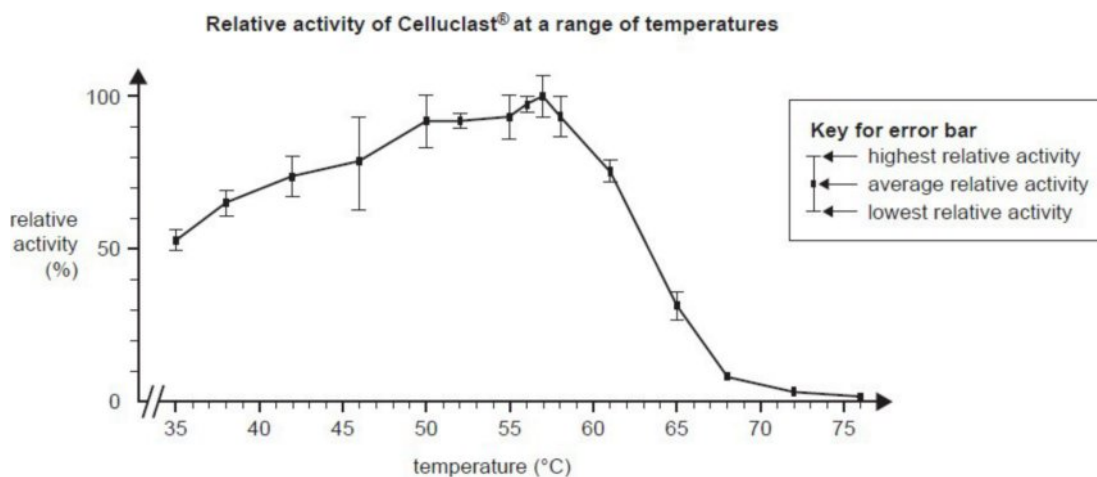
C decrease due to competitive reversible inhibition by Substrate B.

D be zero due to the presence of an irreversible inhibitor.

Question 5/ 115

Use the following information to answer Questions 6 and 7.

Celluclast® is an enzyme. The activity of Celluclast® at a range of temperatures and at a pH of 5 was measured. The experiment was repeated five times. The relative activity (%) of Celluclast® was calculated and plotted on a graph, as shown below. The range of the calculated measurements at each temperature is shown as an error bar on the graph below.



Source: J Herlet et al., 'A new method to evaluate temperature vs pH activity profiles for biotechnological relevant enzymes', *Biotechnology for Biofuels*, 10, 234 (2017), <<https://doi.org/10.1186/s13068-017-0923-9>>

Question 6/ 115

[VCAA 2020 SA Q13]

It is reasonable to conclude that

A Celluclast[®] is inactive at 61°C.

B Celluclast[®] is denatured at 35°C.

C the optimum pH for Celluclast[®] is pH 5.

D the optimum temperature for Celluclast[®] is around 57°C.

Question 7/ 115

[VCAA 2020 SA Q14]

The error bars on the graph indicate that the measurements taken at

A 38°C were more valid than at 35°C.

B 52°C were more precise than at 46°C.

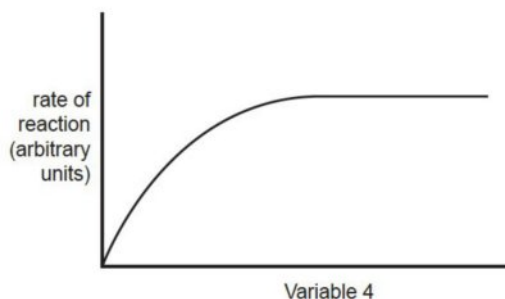
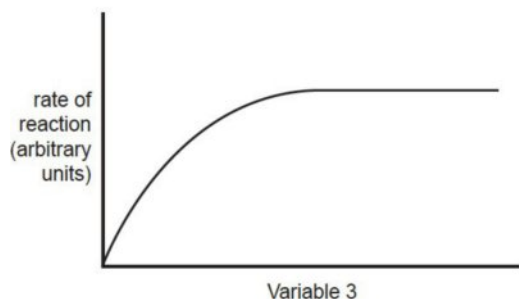
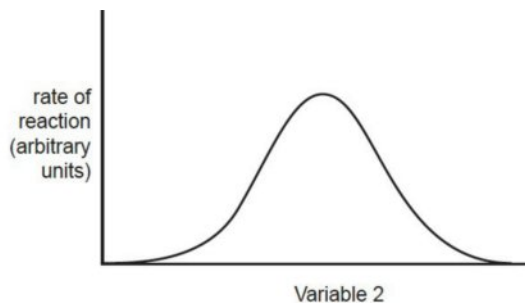
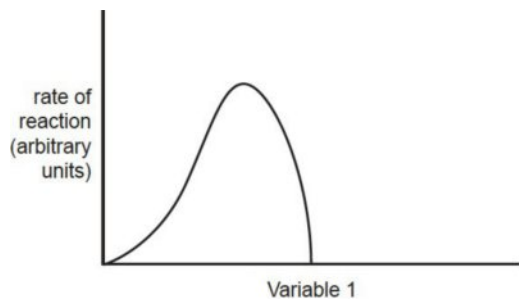
C 46°C were more accurate than at 55°C.

D 58°C had more random errors than at 42°C.

Question 8/ 115

[VCAA 2018 SA Q7]

Four students performed a series of experiments to investigate the effect of four different variables on the rate of an enzyme-catalysed reaction. In each experiment the students changed one of the following variables: substrate concentration, pH, temperature and enzyme concentration. After recording their data, the students displayed their results in a series of graphs, as shown below. Each graph is a line of best fit for their data.



The students did not label the horizontal axis on any of their graphs. The next day, the students could not agree on which variable should be labelled on the horizontal axis of each graph. The students made the suggestions on the following page as to what each variable could be.

Student	Variable 1	Variable 2	Variable 3	Variable 4
Marcus	substrate concentration	temperature	pH	enzyme concentration
Billy	temperature	substrate concentration	enzyme concentration	pH
Voula	enzyme concentration	temperature	substrate concentration	pH
Sheena	temperature	pH	enzyme concentration	substrate concentration

Which student correctly identified all four variables on the horizontal axes?

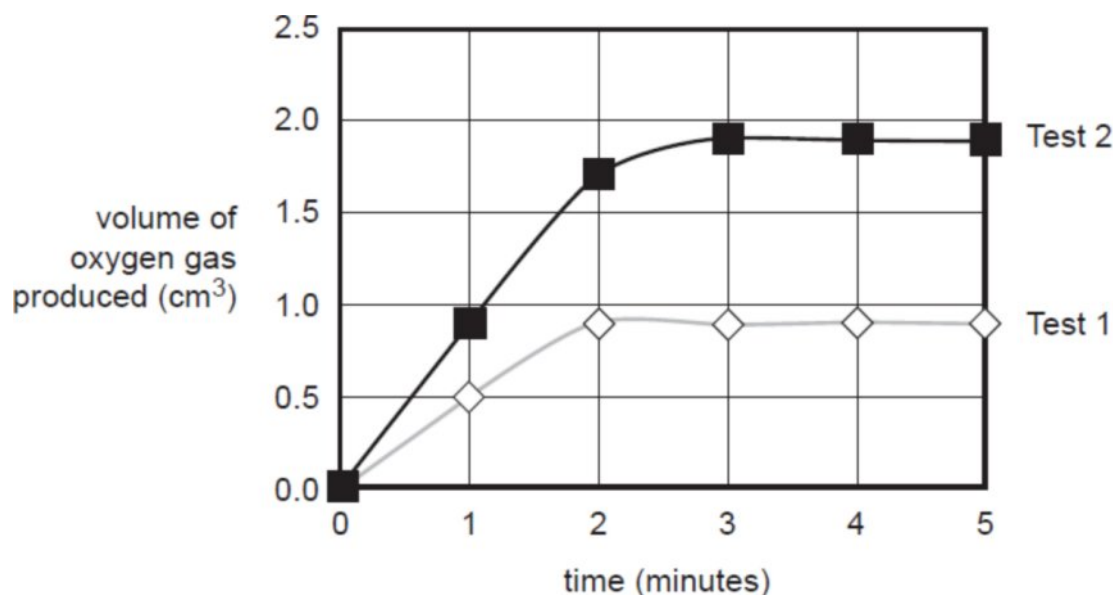
- A Marcus
- B Billy
- C Voula
- D Sheena

Question 9/ 115

Use the following information to answer Questions 10 and 11.

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

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



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

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

Question 10/ 115

[VCAA 2017 SA Q6]

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

A increased the concentration of catalase by adding less water to the ground potato.

B increased the temperature by placing the test tube in a water bath set at 30°C.

C used a hydrogen peroxide solution with a higher concentration.

D added a catalase suspension made from a cooked potato chip.

Question 11/ 115

[VCAA 2017 SA Q7]

The student then performed more tests by varying the pH of the buffer solution. It is expected that

A at pH 6 the reaction will cease.

B at pH 9 the reaction will be faster.

C at pH 2 and pH 10 very little oxygen will be produced.

D a greater volume of oxygen will be produced each time the pH is increased.

Question 12/ 115

[VCAA 2017 SA Q8]

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

The reason the student calibrated the pH meter was to

A ensure a random error would not influence the results.

B eliminate the effect of all uncontrolled variables.

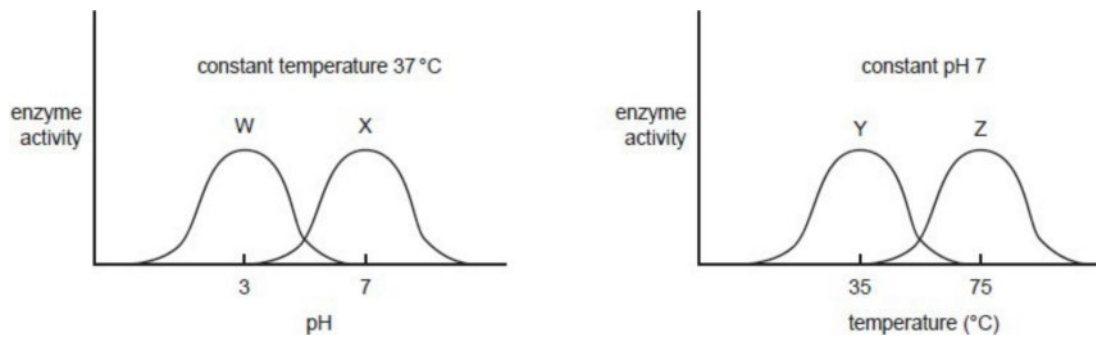
C enable the use of the instrument with precision.

D allow the pH to be measured accurately.

Question 13/ 115

[VCAA 2014 SA Q13]

The following graphs show the way four enzymes, W, X, Y and Z, change their activity in different pH and temperature situations.



Which one of the following statements about the activity of the four enzymes is true?

- A At pH 7, enzyme Y is denatured at temperatures below 20°C.
 - B Enzyme Z could be an intracellular human enzyme.
 - C At pH 3 and a temperature of 37°C, the active site of enzyme W binds well with its substrate.
 - D At pH 3 and a temperature of 37°C, enzyme X functions at its optimum.
-

Question 14/ 115

[VCAA 2012 E1 SA Q2]

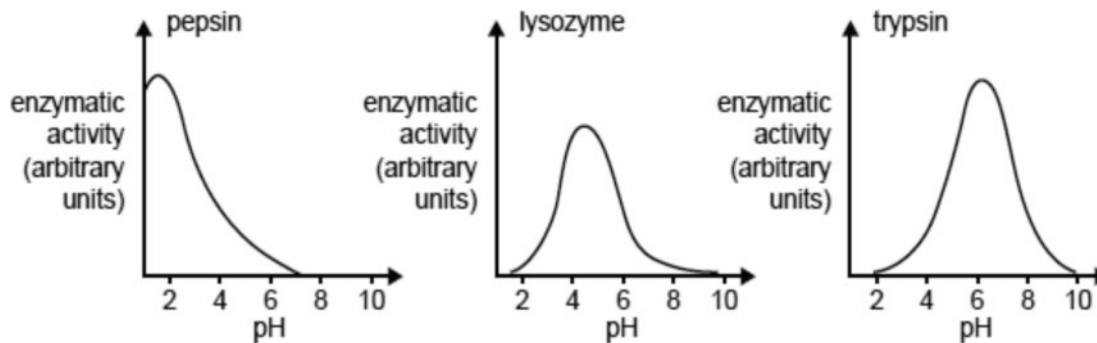
The activity of an enzyme is

- A decreased by the presence of an inhibitor.
- B unaffected by the pH of the cytosol of a cell.
- C reduced at very low temperatures due to denaturation.
- D increased as the temperature rises above the enzyme's optimum temperature.

Question 15/ 115

[VCAA 2011 E1 SA Q16]

Examine the following graphs.



From these graphs it is reasonable to infer that at a pH of 4

A trypsin would be inactive.

B all the pepsin would be denatured.

C all three enzymes would lack a functional active site.

D lysozyme has the highest activity of the three enzymes.

Question 16/ 115

[VCAA 2011 E1 SA Q22]

The following image is of a Siamese cat.



The colour produced in the fur of a Siamese cat is under the control of a tyrosinase enzyme that is sensitive to particular temperatures. A summary of the enzyme action is

pigment precursor $\xrightarrow{\text{body temperature at or above } 37^{\circ}\text{C}}$ no pigment produced

pigment precursor $\xrightarrow{\text{body temperature below } 37^{\circ}\text{C}}$ pigment produced

The core body temperature of a cat ranges from about 38°C to 39.2°C . It is likely that in Melbourne

A Siamese kittens have dark fur over their bodies when they are born.

B Siamese cats that live outside a house show an increase in pigment during summer.

C Siamese cats that live inside a house in winter have darker fur than those that live outside.

D Siamese cats that live outside in winter have darker fur than Siamese cats in tropical regions.

Question 17/ 115

[VCAA 2018 SA Q10]

Which pair of molecules contains the greatest amount of stored energy?

A NADH and ATP

B NAD^{+} and ATP

C NAD^{+} and ADP

D NADH and ADP

Question 18/ 115

[VCAA 2017 SA Q16]

A molecule that takes part in many biochemical reactions is NADP^+ . It is correct to state that

A NADP^+ becomes NADH when it is loaded.

B NADP^+ has a higher energy level when it is unloaded.

C energy is released when NADP^+ is converted to NADPH.

D NADP^+ carries additional energy when protons and electrons are added to it.

Question 19/ 115

[VCAA 2016 SA Q9]

ATP is important in living cells as it

A is required for osmosis.

B provides a supply of usable energy for the cell.

C provides one of the building blocks for lipid synthesis.

D is an important structural component of the plasma membrane.

Question 20/ 115

[VCAA 2015 SA Q7]

The production of adenosine triphosphate (ATP) is represented by the following equation.



The production of ATP

A is a catabolic reaction.

B requires an overall input of energy.

C only occurs in the absence of oxygen.

D occurs only in the mitochondria of a cell.

Question 21/ 115

[VCAA 2016 SA Q16]

Which one of the following is a catabolic process?

A the conversion of glycogen to glucose.

B the production of carbohydrates during photosynthesis.

C the synthesis of a polypeptide hormone from amino acids.

D the formation of a triglyceride from glycerol and fatty acids.

Question 22/ 115

[VCAA 2020 SA Q9]

The dependent variable in this experiment is the

A amount of sodium hydrogen carbonate added to the beaker.

B number of bubbles produced in one minute.

C time taken to count the bubbles produced.

D distance of the lamp from the beaker.

Question 23/ 115

[VCAA 2020 SA Q10]

The bubbles produced in this experiment are likely to contain

A oxygen.

B glucose.

C water vapour.

D carbon dioxide.

Question 24/ 115

[VCAA 2020 SA Q11]

Repeating the experiment three times and finding an average result at each distance increases the

A reliability of the data.

B accuracy of the data.

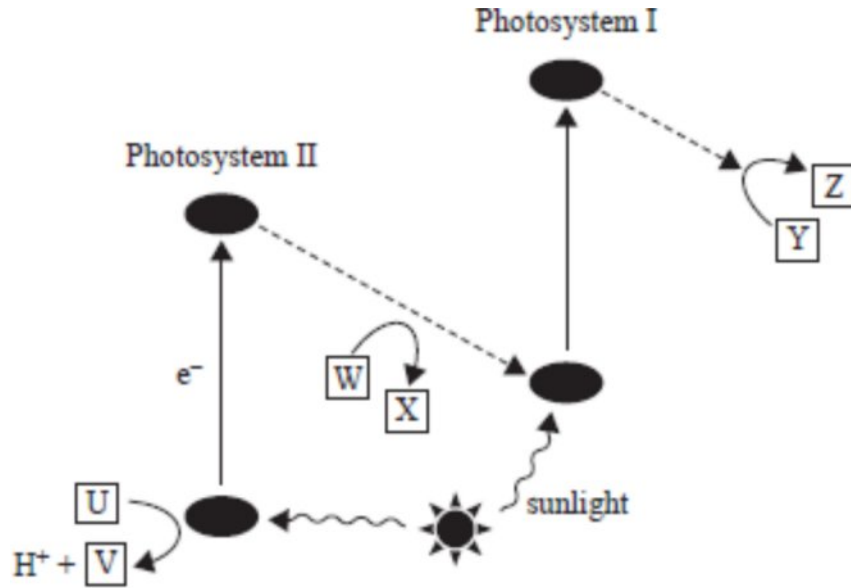
C precision of the data.

D validity of the data.

Question 25/ 115

Use the following information to answer Questions 26 and 27.

Photosynthesis is an important process that occurs in plants and in some bacteria. The diagram below represents one of the stages that occurs in the photosynthetic process.



Source: adapted from Arif Majid, SlideShare,
<<https://pt.slideshare.net/ArifMajid/light-reaction-of-photosynthesis/17>>

Question 26/ 115

[VCAA 2022 SA Q9]

Where in a plant cell would the stage of the photosynthetic process shown above be located?

- A mitochondria.
- B thylakoid membrane.
- C chloroplast inner membrane.
- D chloroplast outer membrane.

Question 27/ 115

[VCAA 2022 SA Q10]

In the diagram shown above, what do V, W and Z represent respectively?

- A water, ATP and NADP^+ .
 - B oxygen, ATP and NADPH.
 - C oxygen, ADP and NADPH.
 - D carbon dioxide, ADP and NADP^+ .
-

Question 28/ 115

[VCAA 2021 SA Q5]

Consider the process of photosynthesis.

Which of the following shows correct information about each of the two stages of photosynthesis?

	Light-dependent stage	Light-independent stage
A	produces oxygen	produces carbon dioxide
B	requires water	requires NADH
C	occurs in the stroma	occurs in the grana
D	energy is provided by light	energy is provided by ATP molecules

Question 29/ 115

[VCAA 2020 SA Q12]

During photosynthesis

A ATP and NADH created in the light-independent stage are transported to the chloroplasts' thylakoid membranes.

B ADP and NADH are used in the electron transport chain after being created in the light-dependent stage.

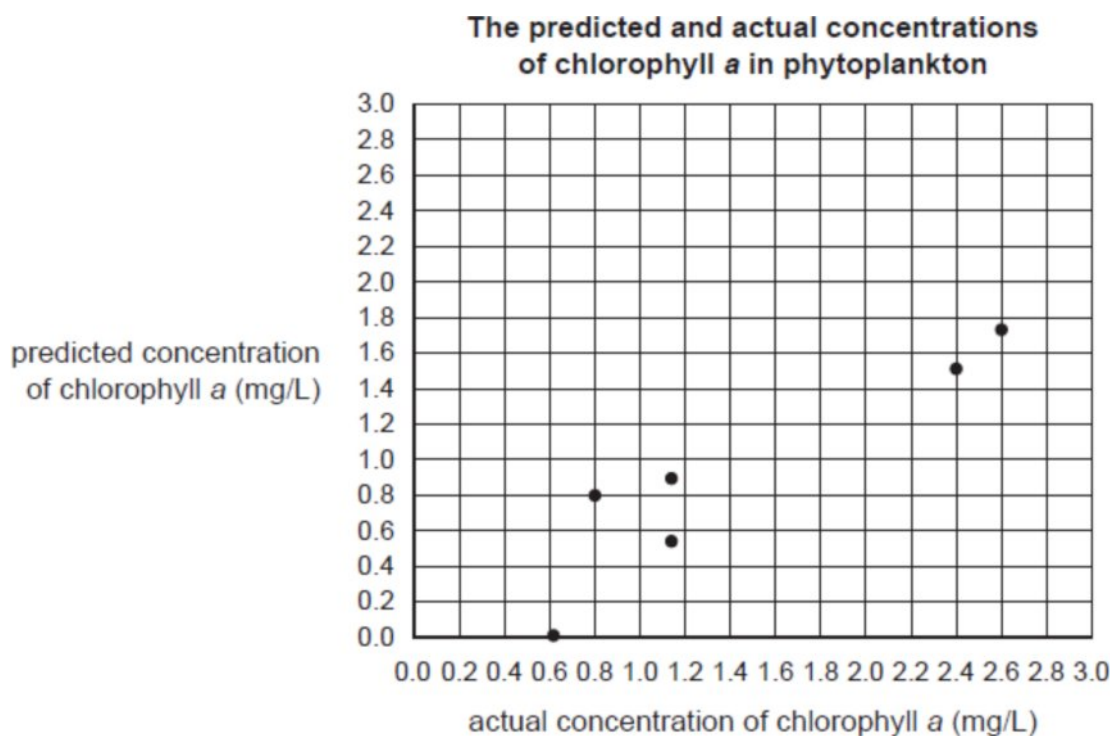
C ATP and NADPH are created in the grana of the chloroplasts and are used in the light-independent stage.

D ADP and NADPH are created during the Krebs cycle and carried to the stroma of the chloroplasts.

Question 30/ 115

[VCAA 2021 SA Q8]

The graph below shows the relationship between the predicted and actual concentrations of chlorophyll a in phytoplankton.



Source: Fairouz Binti Johan et al, 'Chlorophyll a concentration of fresh water phytoplankton analysed by algorithmic based spectroscopy', *Journal of Physics: Conference Series*, 1083 (2018) 012015, <https://iopscience.iop.org/article/10.1088/1742-6596/1083/1/012015/pdf>

From the graph, it can be inferred that

A the actual concentration of chlorophyll a was lower than the predicted concentration in all recorded measurements.

B at 2.4 mg/L actual concentration of chlorophyll a, the predicted concentration of chlorophyll a was 2 mg/L.

C at 0.8 mg/L, the predicted concentration and the actual concentration of chlorophyll a were the same.

D at zero predicted concentration of chlorophyll a, photosynthesis did not occur.

Question 31/ 115

[VCAA 2020 SA Q33]

A student completed an experiment to investigate how light is reflected from different leaves. The results were recorded qualitatively.

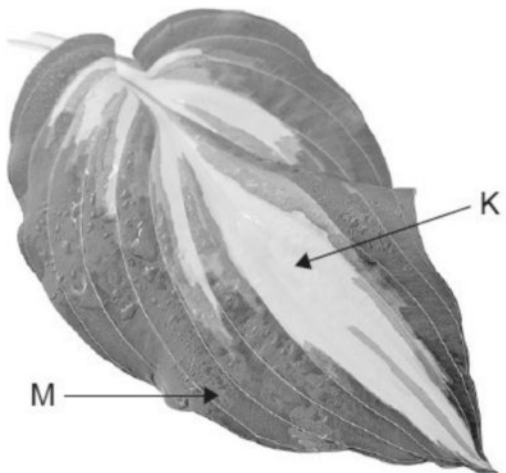
Which one of the following could be a correct statement about the qualitative data obtained by the student?

- A An average result for the data could be obtained.
 - B The same number would be recorded for each result.
 - C The data was obtained by measuring the wavelength of light.
 - D The data could be the names of the different colours of the reflected light.
-

Question 32/ 115

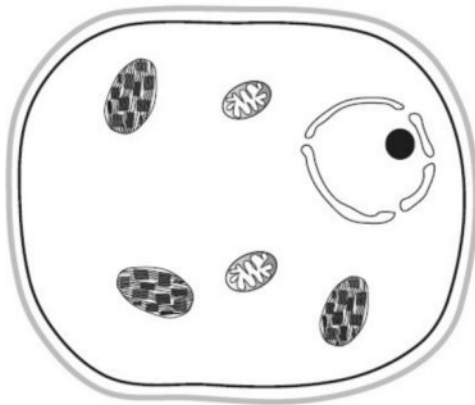
[VCAA 2017 SA Q15]

A variegated leaf from a plant is shown below.

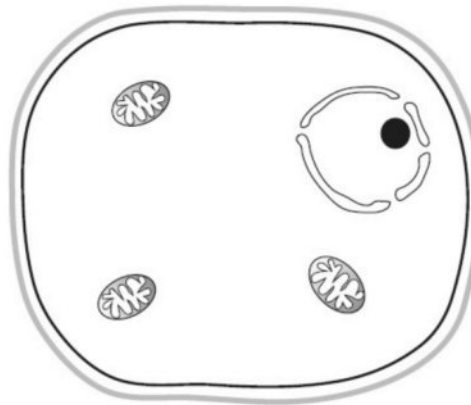


Cells from sections M and K were examined and simple sketches were produced.

A typical cell from section M



A typical cell from section K



From this information, it can be concluded that

A cells in section K would be unable to carry out aerobic respiration.

B light-independent reactions of photosynthesis can occur in cells from section K.

C there is chlorophyll present in cells from section K but not in cells from section M.

D glucose would be manufactured from carbon dioxide and water in cells from section M but not in cells from section K.

Question 33/ 115

[VCAA 2014 SA Q7]

During photosynthesis in chloroplasts, energy is used to split water, forming oxygen and hydrogen ions. The splitting of water occurs

A in the stroma during the light-independent reaction.

B in the grana during the light-dependent reaction.

C on the membrane of the thylakoids during the light-independent reaction.

D on the surface of the outer chloroplast membrane during the light-dependent reaction.

Question 34/ 115

[VCAA 2016 SA Q10]

Plants grown in light were supplied with water containing radioactive oxygen atoms. After four hours, an analysis of the chemicals in and around the plants was undertaken.

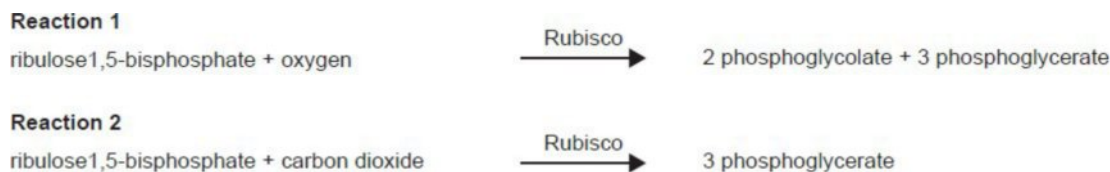
Which one of the following would contain the radioactive oxygen atoms after four hours?

- A protein
 - B glucose
 - C oxygen gas
 - D carbon dioxide gas
-

Question 35/ 115

[VCAA 2021 SA Q7]

Ribulose biphosphate carboxylase/oxygenase (Rubisco) is an enzyme found in green plants. Rubisco is important in two reactions. These reactions are shown below.



A Biology student hypothesised that the same active site on Rubisco is used in Reaction 1 and Reaction 2.

Which one of the following observations would support this hypothesis?

- A The rate of Reaction 2 increases when the temperature is increased.
 - B The rate of Reaction 2 decreases when the concentration of oxygen is increased.
 - C The rate of both reactions decreases when the concentration of Rubisco is increased.
 - D The rate of Reaction 1 increases when the concentration of carbon dioxide is increased.
-

Question 36/ 115

[VCAA 2016 SA Q11]

Which one of the following statements about photosynthesis in chloroplasts is correct?

- A The grana are the site of the light-independent stage.
 - B Chlorophyll found in the stroma traps light for use during the light-dependent stage.
 - C The light-dependent stage produces ATP for use during the light-independent stage.
 - D The light-independent stage captures carbon dioxide for use during the light- dependent stage to produce glucose.
-

Question 37/ 115

[VCAA 2014 SA Q8]

An increase in the atmospheric CO₂ level increases the rate of photosynthesis. The rate of photosynthesis increases because

- A the rate of the light-independent reactions on the thylakoid membranes of the chloroplasts increases.
 - B water loss from the leaf decreases, resulting in the availability of water for photosynthesis increasing.
 - C the increased CO₂ level lowers the pH inside the chloroplasts and increases the rate of enzyme-catalysed reactions.
 - D the rate of the light-independent reactions in the stroma increases with the increase in CO₂ level.
-

Question 38/ 115

[Adapted VCAA 2012 E1 SA Q22]

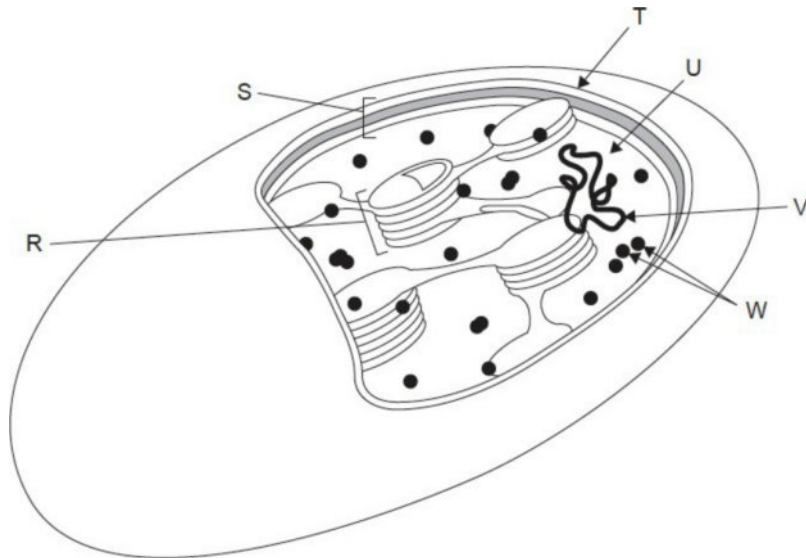
Carbon dioxide is an input in

- A synthesis of polypeptide molecules.
 - B breakdown of glucose during glycolysis.
 - C the light-independent reactions of photosynthesis.
 - D the electron transport chain in cellular respiration.
-

Question 39/ 115

Use the following information to answer Question 82.

The diagram that follows shows the structures of a chloroplast, labelled R–W.



Question 40/ 115

[VCAA 2018 SA Q14]

The light-independent reaction of photosynthesis occurs at

- A T.
- B U.

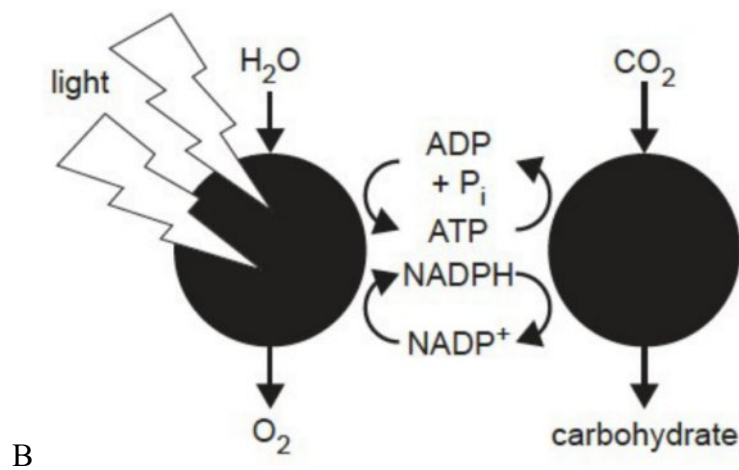
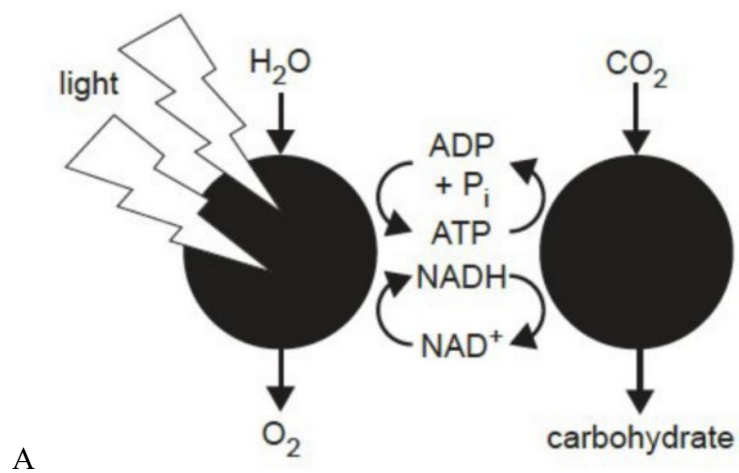
C V.

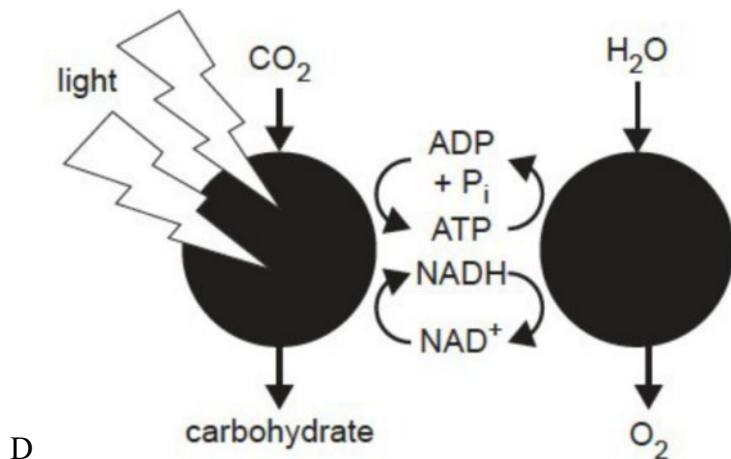
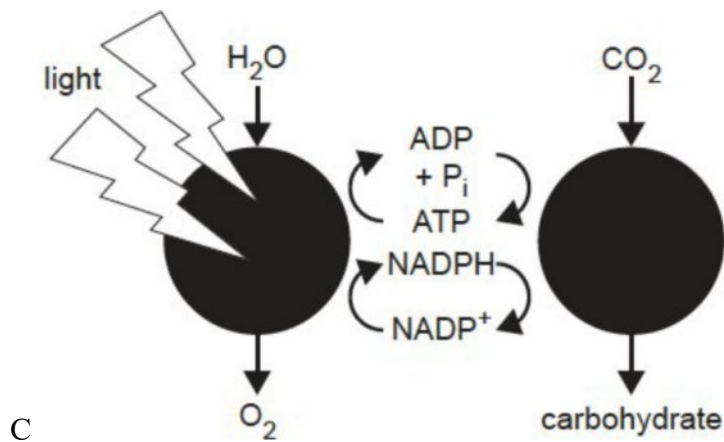
D W.

Question 41/ 115

[VCAA 2018 SA Q15]

Which one of the following diagrams correctly represents the inputs and outputs of photosynthesis?

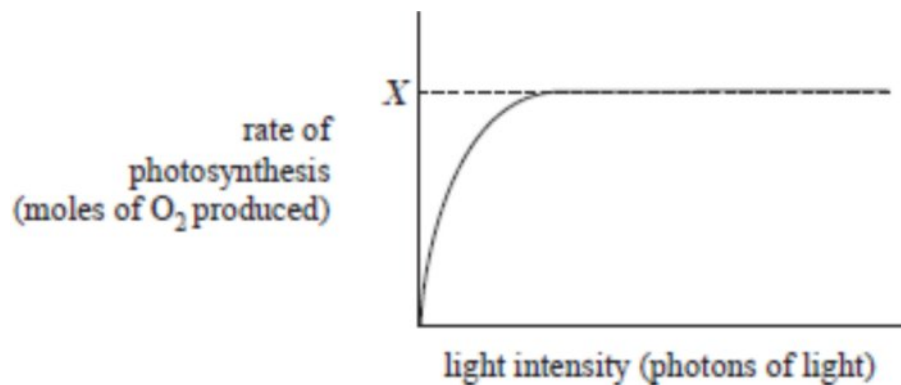




Question 42/ 115

[VCAA 2022 SA Q11]

A student shone a light on a green leaf and measured the rate of photosynthesis. The student varied the intensity of the light and graphed the findings as shown below. X was the maximum rate of photosynthesis detected by the student.



Which one of the following conditions will increase the value of X?

- A adding a filter to the light used
 - B using a leaf that contains more chloroplasts
 - C moving the light further away from the leaf
 - D decreasing the temperature of the leaf's environment
-

Question 43/ 115

[VCAA 2022 SA Q12]

A plant specialist was investigating the viability of producing a new plant variety. The plant specialist investigated the optimum time to grow the new plant variety in Brisbane, Queensland. This plant flourishes when the temperature is above 20°C, the precipitation is less than 50 mm per month and the number of daylight hours exceeds eight hours per day.

An example of qualitative data that the plant specialist may collect to assist their investigation of the viability of producing the new plant variety would be

- A recording the number of days per year that the temperature falls below 20°C in Queensland.
 - B determining the average number of hours of sunlight per day in Queensland.
 - C obtaining a list of the plant preferences from people living in Brisbane.
 - D calculating the mean monthly precipitation in Brisbane.
-

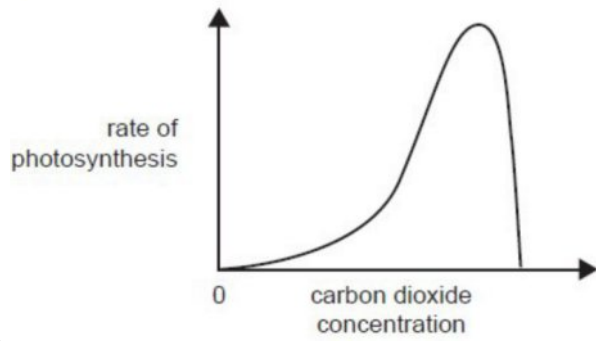
Question 44/ 115

[VCAA 2021 SA Q6]

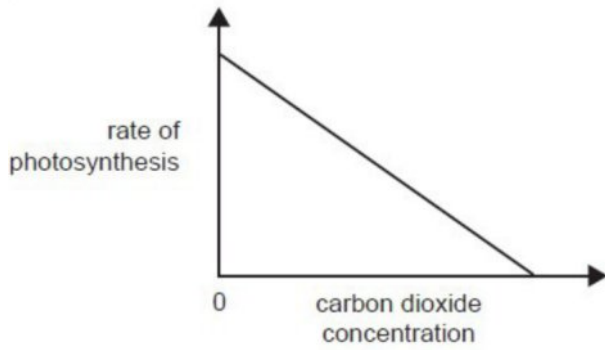
In a series of experiments, the rate of photosynthesis in plant cells was measured in environments with different concentrations of carbon dioxide. All other variables were kept constant.

Which one of the following graphs reflects the trend that would be shown by the results of these experiments?

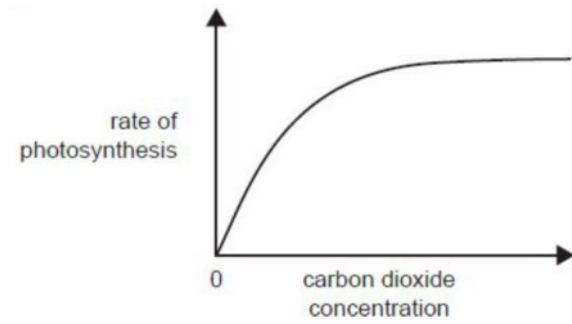
A



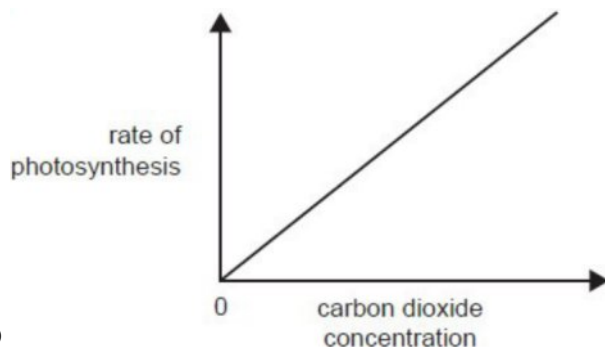
B



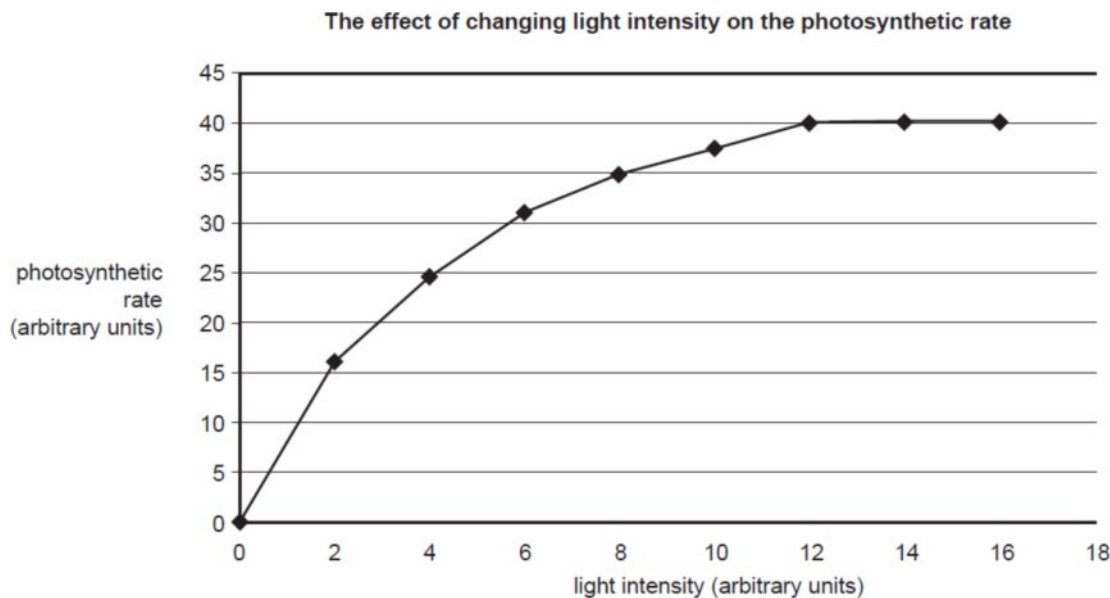
C



D



An experiment was carried out at a constant temperature and with a constant carbon dioxide concentration in order to determine the effect of changing light intensity on the photosynthetic rate. The following is a graph of the results.



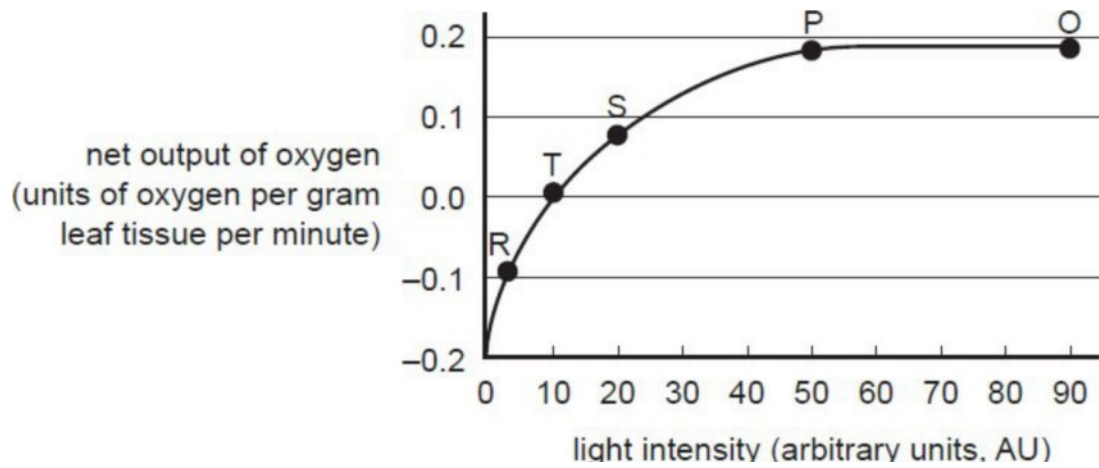
Based on your knowledge and the information in the graph on the previous page, which one of the following conclusions can be reached?

- A Photosynthesis ceases to occur at a light intensity of 14 arbitrary units.
- B Plants do not undergo photosynthesis at a light intensity of 1 arbitrary unit.
- C Light intensity is a limiting factor when the photosynthetic rate is less than 40 arbitrary units.
- D Increasing the amount of carbon dioxide at a light intensity of 16 arbitrary units would lead to a decrease in the photosynthetic rate.

Question 46/ 115

Use the following information to answer Questions 47 and 48.

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



Question 47/ 115

[VCAA 2017 SA Q13]

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

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

Question 48/ 115

[VCAA 2017 SA Q14]

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

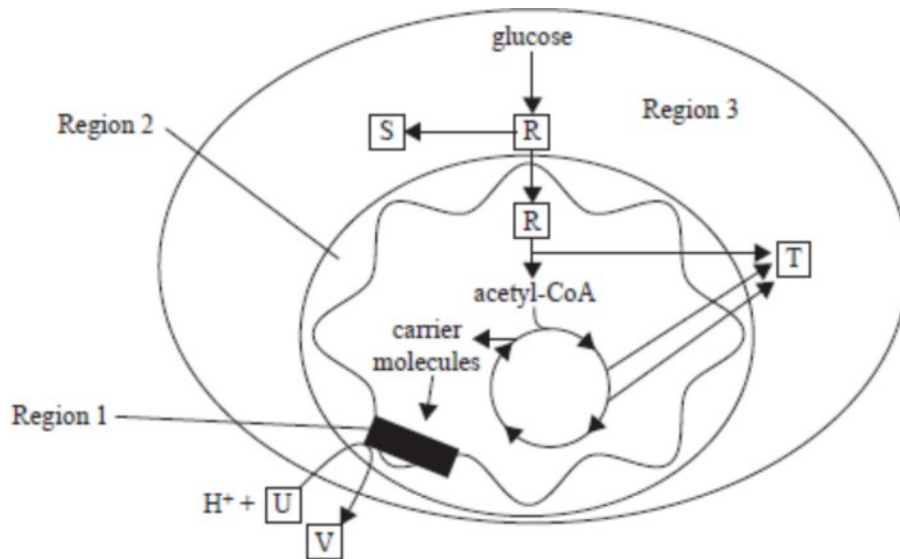
- A heat has denatured the enzymes involved in the photosynthesis reactions.
- B the concentration of available carbon dioxide limits the rate of photosynthesis.
- C the light intensity has damaged the chlorophyll molecules present in the spinach chloroplasts.

D high levels of oxygen produced at point P have accumulated around the spinach leaves, resulting in no more oxygen being produced.

Question 49/ 115

Use the following information to answer Questions 50 to 53.

There are a number of ways in which an animal cell is able to use compounds such as glucose to produce the energy that it needs to be able to function. The diagram below outlines the general metabolic pathways for cellular respiration in an animal cell.



Question 50/ 115

[VCAA 2022 SA Q13]

Which metabolic pathway is found in Region 3 of the cell?

A electron transport chain

B Calvin cycle

C Krebs cycle

Question 51/ 115

[VCAA 2022 SA Q14]

Which of the following gives the names of compounds R, T and V, shown in the diagram above?

	R	T
A	lactic acid	carbon dioxide
B	lactic acid	carbon dioxide
C	pyruvate	carbon dioxide
D	pyruvate	NADH

Question 52/ 115

[VCAA 2022 SA Q15]

The carrier molecules represented in the previous diagram are

A NAD^+ and water.

B FAD^+ and oxygen.

C NADH and FADH_2 .

D NAD^+ , carbon dioxide and FADH_2 .

Question 53/ 115

[VCAA 2022 SA Q16]

The last electron acceptor in cellular respiration is

A water.

B oxygen.

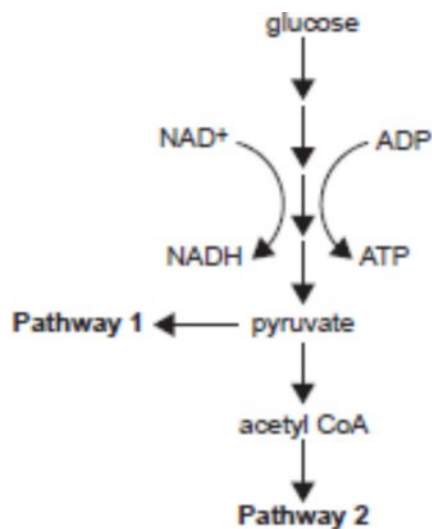
C NADH.

D carbon dioxide.

Question 54/ 115

Use the following information to answer Questions 55 and 56.

Shown below is a simplified diagram summarising a series of biochemical processes in a plant cell.



Source: adapted from MG Stovell et al., 'Assessing metabolism and injury in acute human traumatic brain injury with magnetic resonance spectroscopy: Current and future applications', *Frontiers in Neurology*, 12 September 2017, <<https://doi.org/10.3389/fneur.2017.00426>>

Question 55/ 115

[VCAA 2020 SA Q5]

Which one of the following is a correct statement?

A Pathway 2 releases oxygen as a by-product.

B Pathway 1 requires carbon dioxide as an input.

C ATP is produced in Pathway 1 and is used by the cell as an energy source.

D NADH created in Pathway 2 carries electrons into the electron transport chain.

Question 56/ 115

[VCAA 2020 SA Q6]

The final products of Pathway 1 are produced in the

A cristae.

B cytosol.

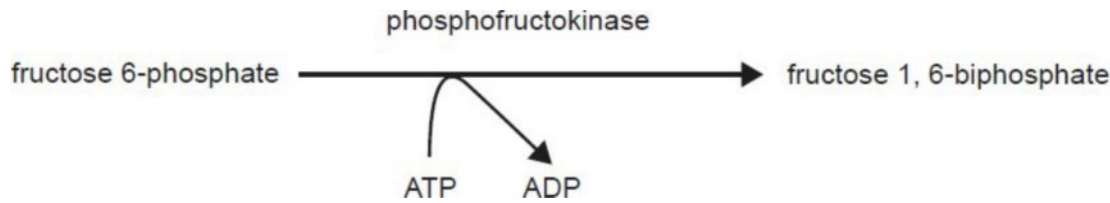
C mitochondrial matrix.

D chloroplast membranes.

Question 57/ 115

[VCAA 2017 SA Q5]

The biochemical pathway of glycolysis involves nine intermediate reaction steps. One of these steps is represented in the diagram below.



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

A acts as a coenzyme.

B increases the rate of reaction.

C is the substrate for the reaction.

D releases energy in the form of ADP.

Question 58/ 115

[VCAA 2019 SA Q14]

In glycolysis, the ATP yield per molecule of glucose is

A 4 ATP produced and 2 ATP used for a net gain of 2 ATP.

B 2 ATP produced and 4 ATP used for a net loss of 2 ATP.

C 36 to 38 ATP produced for a net gain of 2 ATP.

D 36 to 38 ATP used for a net loss of 2 ATP.

Question 59/ 115

Use the following information to answer Questions 60 and 61.

An experiment was carried out by students to test the effect of temperature on the growth of bacteria.

Bacterial cells were spread onto plates of nutrient agar that were then kept at three different temperatures: -10°C , 15°C and 25°C .

All other variables were kept constant. The experiment was carried out over four days. The nutrient agar was

observed every day at the same time and the percentage of nutrient agar covered by bacteria was recorded.

At the conclusion of the experiment, the results were recorded in a table, which follows.

Time (Days)	Percentage of nutrient agar covered by bacteria at three different temperatures		
	−10°C	15°C	25°C
0	0	0	0
1	0	5	10
2	0	10	20
3	0	15	40
4	0	20	60

Question 60/ 115

[VCAA 2019 SA Q7]

Which one of the following hypotheses is supported by the results?

A If the bacteria grow for four days, then the nutrient agar will be completely covered in bacteria.

B If the bacteria are kept in the dark, then the bacteria will grow more slowly.

C If the bacteria grow faster, then the temperature of the location will increase.

D If the temperature increases, then the bacteria will grow more quickly.

Question 61/ 115

[VCAA 2019 SA Q8]

In this experiment, the dependent variable is.

A time.

B temperature.

C the number of bacterial cells.

D the percentage of nutrient agar covered by bacteria.

Question 62/ 115

[VCAA 2019 SA Q9]

The students wanted to check the reliability of their data. The students should

A repeat the experiment several times to find out if they would obtain the same data.

B organise their data into a different format to help identify a trend.

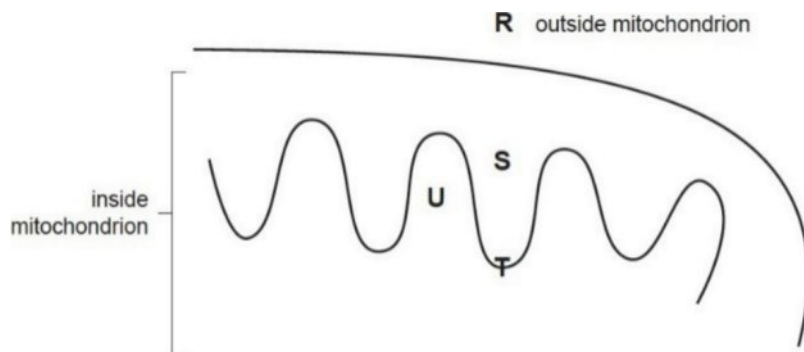
C change the independent variable in the experiment.

D rewrite the method for completing the experiment.

Question 63/ 115

[VCAA 2018 SA Q8]

The diagram that follows shows a section through a part of a mitochondrion.



The sites of the pathways in aerobic respiration are

A R – glycolysis, S – Krebs cycle, T – electron transport chain.

B U – glycolysis, T – Krebs cycle, R – electron transport chain.

C R – glycolysis, U – Krebs cycle, T – electron transport chain.

D D T – glycolysis, R – Krebs cycle, S – electron transport chain.

Question 64/ 115

[VCAA 2018 SA Q9]

Which one of the following statements best explains the effect of rotenone in causing death in insects and fish?

- A The rate of glycolysis would increase.
 - B ATP would accumulate in the mitochondria.
 - C Aerobic respiration in the mitochondria would be disrupted.
 - D The cell membrane would no longer be permeable to oxygen.
-

Question 65/ 115

[VCAA 2017 SA Q11]

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

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

Question 66/ 115

Use the following information to answer Questions 67 and 68.

Rotenone is a chemical compound that is used as an insecticide and a piscicide (a substance that kills fish). The rotenone molecule disrupts the electron transport chain in animal cells by interfering with one of the essential reactions within the electron transport chain.

Question 67/ 115

[VCAA 2015 SA Q9]

Which one of the following statements best explains the effect of rotenone in causing death in insects and fish?

- A The rate of glycolysis would increase.
 - B ATP would accumulate in the mitochondria.
 - C Aerobic respiration in the mitochondria would be disrupted.
 - D The cell membrane would no longer be permeable to oxygen.
-

Question 68/ 115

[VCAA 2015 SA Q10]

In the past, people sometimes put extracts containing rotenone into a river to poison the fish, allowing the fish to be more easily caught. When rotenone- poisoned fish are eaten by people, no poisonous effect is observed.

Which one of the following statements best explains this observation?

- A Rotenone is not absorbed through the cell membranes of people who have eaten poisoned fish.
- B Rotenone is not absorbed by fish tissue and remains dissolved in water.

C Human cell metabolism does not involve the electron transport chain.

D Rotenone only affects organisms that respire anaerobically.

Question 69/ 115

[VCAA 2015 SA Q12]

A student was investigating four cell types from different organisms. She recorded the results of her microscopic examination of the cells in the table below.

	Cell W	Cell X	Cell Y	Cell Z
Mitochondria	few	many	absent	few
Chloroplasts	present	absent	absent	present
Nucleus	present	present	absent	present

Which one of the following is the correct conclusion that can be drawn from this data?

A Cell W could be a muscle cell from an insect.

B Cell Y could be a living leaf cell from a corn plant.

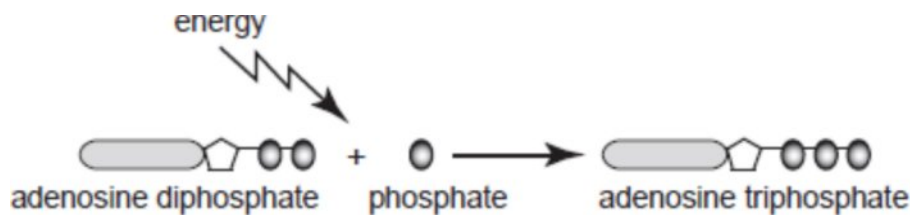
C Cell X could be a heart-muscle cell from a mammal.

D Cell Z could be an underground root cell from a pea plant.

Question 70/ 115

Use the following information to answer Questions 71 and 72.

Adenosine diphosphate (ADP) is an organic molecule found in large quantities in most cells. ADP is converted to adenosine triphosphate (ATP) by phosphorylation, as shown in the following diagram.



Question 71/ 115

[VCAA 2012 E1 SA Q21]

The original source of energy for this reaction is

- A ADP.
 - B glucose.
 - C sunlight.
 - D phosphate.
-

Question 72/ 115

[VCAA 2012 E1 SA Q22]

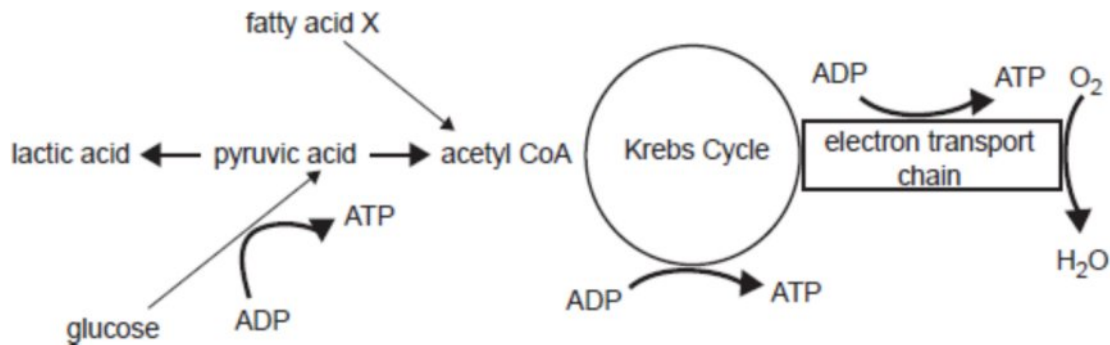
The process that produces the largest number of ATP molecules is

- A synthesis of polypeptide molecules.
 - B breakdown of glucose during glycolysis.
 - C the light-independent reactions of photosynthesis.
 - D the electron transport chain in cellular respiration.
-

Question 73/ 115

[VCAA 2014 SA Q12]

If there is insufficient glucose for cellular respiration, fatty acids can be changed to acetyl CoA. Each fatty acid X molecule produces eight molecules of acetyl CoA. The diagram below summarises the pathways for the breakdown of fatty acid X and glucose. The number of molecules produced in each step is not shown.



Referring to the information above and your knowledge of cellular respiration, which one of the following conclusions can be made?

- A Most of the ATP is made in the Krebs Cycle.
 - B Pyruvic acid is converted to acetyl CoA under anaerobic conditions.
 - C No ATP can be formed from the breakdown of glucose under anaerobic conditions.
 - D One fatty acid X molecule produces more ATP in aerobic conditions than one glucose molecule does.
-

Question 74/ 115

[VCAA 2019 SA Q12]

During which process would the production of lactic acid be observed?

- A aerobic cellular respiration.
- B fermentation in animals.
- C fermentation in yeasts.
- D photosynthesis

Question 75/ 115

[VCAA 2022 SA Q18]

A student investigated the effect of temperature and oxygen on the production of lactic acid by cultured human skin cells. At the start of this experiment, each test tube contained the same number of skin cells and the same concentration of glucose. The temperature of each test tube and the amount of oxygen supplied to each test tube are given in the table below. After 24 hours, the student measured the amount of lactic acid in the test tubes.

Temperature and oxygen content of each test tube in the experiment

Test Tube	Temperature (°C)	Oxygen content (%)
1	20	20
2	37	20
3	37	5
4	75	5

Which test tube would be expected to contain the highest concentration of lactic acid?

- A Test tube 1
 - B Test tube 2
 - C Test tube 3
 - D Test tube 4
-

Question 76/ 115

[VCAA 2020 SA Q40]

A student investigated the effect of the presence of four different molecules, R, S, T and U, on the rate of cellular respiration in human liver cells. The production of carbon dioxide by the cells was recorded over a

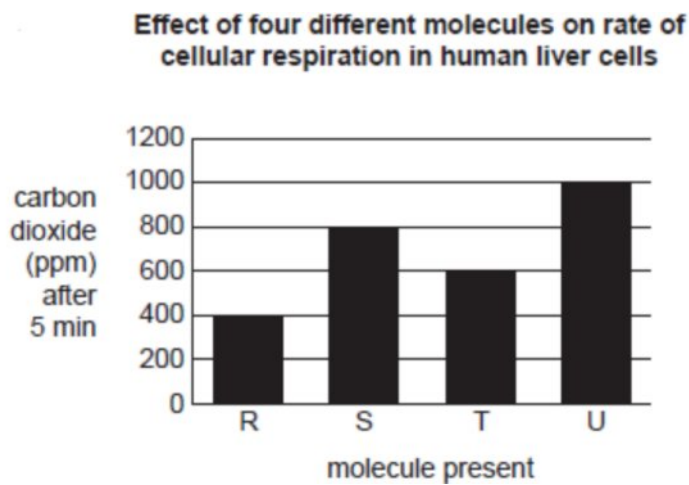
five-minute interval. The final concentration of carbon dioxide was recorded. The data collected is shown below.

Molecule present	Concentration of carbon dioxide (ppm) after five minutes

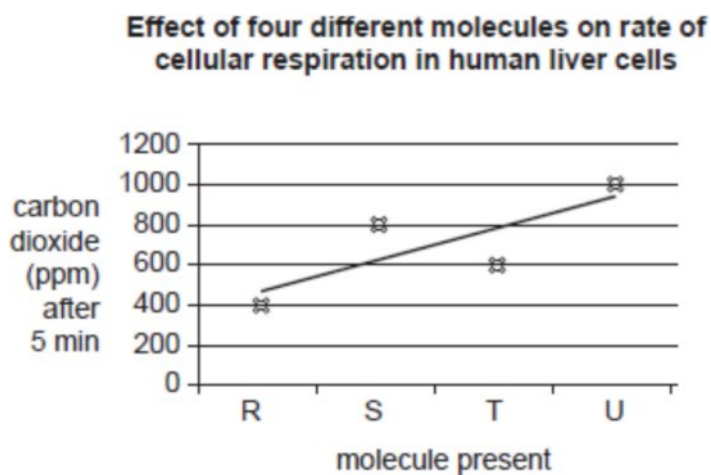
R	400
S	800
T	600
U	1000

The student presented the results as a graph.

Which one of the following graphs is the best representation of the results?

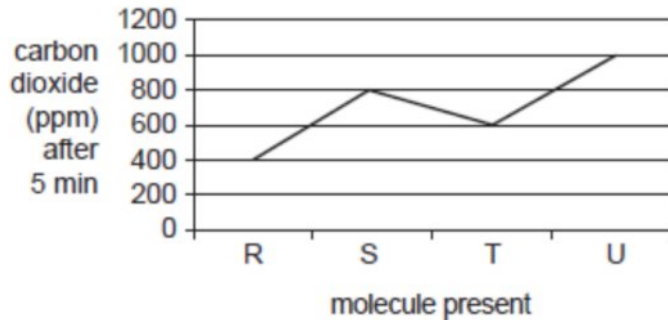


A



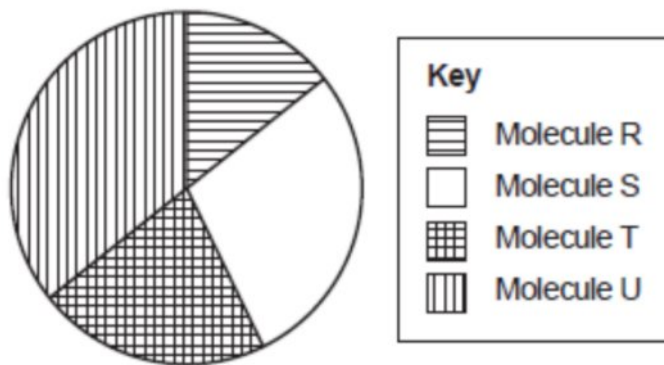
B

Effect of four different molecules on rate of cellular respiration in human liver cells



C

Effect of four different molecules on rate of cellular respiration in human liver cells



D

Question 77/ 115

[VCAA 2019 SA Q13]

The rate of aerobic cellular respiration in a human cell may increase if the

A temperature of the cell is lowered from 37°C to 35°C.

B oxygen concentration available to the mitochondria increases.

C carbon dioxide concentration in the cytosol of the cell increases.

D rate of facilitated diffusion of glucose into the cytosol of the cell decreases.

Question 78/ 115

Use the following information to answer Questions 79 and 80.

Four groups of students carried out an experiment in which the effect of glucose concentration on the fermentation rate of yeast was measured. The fermentation rate was determined by the rate of temperature change of the fermenting mixture.

Before beginning the experiment, each group practised measuring the temperature of water and checked the group's thermometer against an electronic thermometer that gave a true measure of temperature.

The following results were obtained during the practice.

Group	Each group's thermometer readings (°C)			Electronic thermometer reading (°C)
	1st measurement	2nd measurement	3rd measurement	
1	18.0	17.0	17.5	20.1
2	18.0	18.0	18.5	20.5
3	21.0	21.0	20.5	19.9
4	18.0	19.0	21.0	20.2

Question 79/ 115

[VCAA 2018 SA Q11]

Which one of the following statements is correct?

A Group 1's measurements are the most accurate but the least precise.

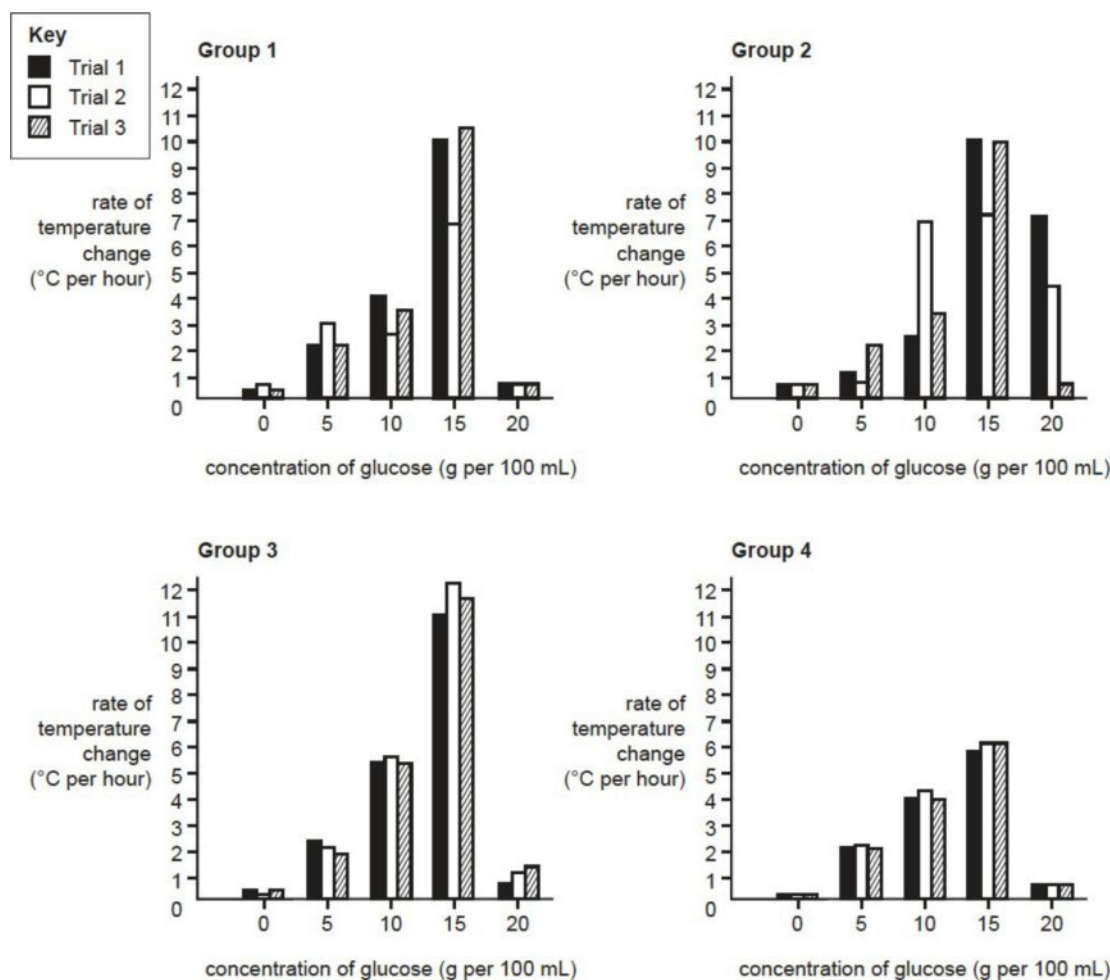
B Group 2's measurements are accurate but not precise.

C Group 3's measurements are precise but not accurate.

D Group 4's measurements are both accurate and precise.

[VCAA 2018 SA Q12]

Each group conducted the experiment three times (Trial 1, Trial 2, Trial 3). Five different concentrations of glucose were used in each trial. Each group plotted its results on a graph, as shown below. The black bar represents Trial 1, the white bar represents Trial 2 and the striped bar represents Trial 3.



Which one of the following statements about the experiment's results can be concluded from the graphs?

A Group 1's results are more valid than the other groups', but less reliable.

B Group 2's results are less reliable, but more precise and accurate.

C Group 3's results are the most accurate and reliable.

D Group 4's results are more reliable than the other groups'.

[VCAA 2019 SB Q11]

Three students wanted to investigate the activity of the enzyme lipase for a practical investigation. Student 1 made the following notes before designing her experiment.

Lipase catalyses the breakdown of fats into glycerol and fatty acids.

Fatty acids can neutralise an alkaline solution.

Sodium carbonate is an alkaline solution.

Student 1 set up four test tubes each containing 5 mL of a fatty solution and 10 mL of sodium carbonate solution. Each test tube was suspended in a water bath. Each water bath was set at a different temperature. pH probes were placed into each test tube. Each solution had a pH of 8.

After setting up the four test tubes in the water baths, Student 1 waited until the solution in the test tube was the same temperature as the water in the water bath. Student 1 then added 5 mL of lipase solution to each test tube. Student 1 timed how long it took for the pH of the solution to become neutral (pH of 7).

Student 1 repeated the experiment so that she had three measurements for each temperature. She obtained the data shown in Table 1.

Table 1. Results from Student 1

Temperature (°C)	Time taken for solution to become neutral (seconds)		
	Measurement 1	Measurement 2	Measurement 3
5	240	238	241
15	229	230	226
25	200	201	202
35	180	181	180

a Student 1 was concerned about the precision of her measurements. Analyse the data above and state the temperature at which the measurements are the most precise.

Justify your response. (2 marks)

b State whether Student 1 obtained qualitative or quantitative data. Outline a difference between the two types of data. (2 marks)

c Student 2 repeated the experiment designed by Student 1 the next day and obtained the data shown in Table 2.

Table 2. Results from Student 2

Temperature (°C)	Time taken for solution to become neutral (seconds)		
	Measurement 1	Measurement 2	Measurement 3
5	241	239	242
15	230	155	230
25	201	202	170
35	181	181	181

Student 2 indicated that he had errors in his measurements.

Identify which of his measurements have errors. Give two examples of sources of error for these measurements. (3 marks)

d Later that day, the third student performed the experiment. Student 3's data is shown in Table 3.

Table 3. Results from Student 3

Temperature (°C)	Time taken for solution to become neutral (seconds)		
	Measurement 1	Measurement 2	Measurement 3
5	141	139	142
15	130	130	130
25	101	102	102
35	81	81	81

After comparing his results with the other students' results, Student 3 realised he had made an error.

Name the type of error that was made by Student 3 and identify one source of error that may account for the results obtained by this student. (2 marks)

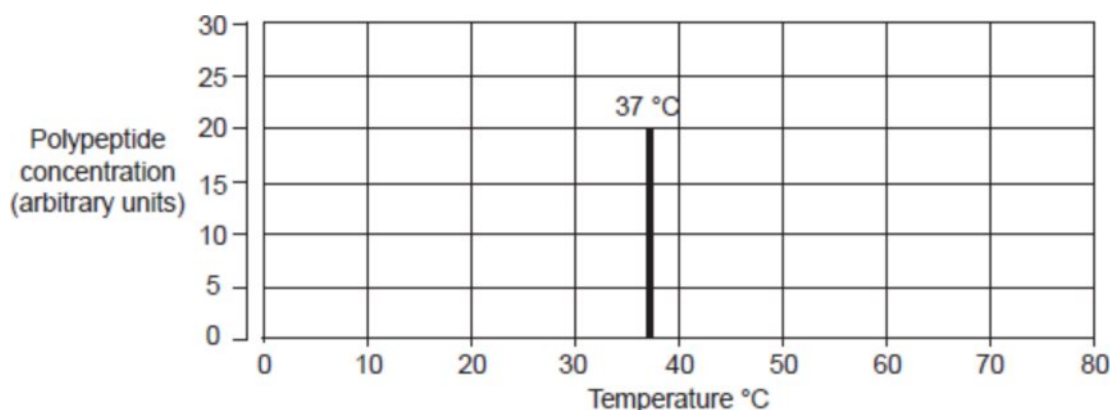
e Identify a limitation of the experiment that was carried out by all three students. What could the students do to address this limitation? (2 marks)

(Total 11 marks)

Question 2/ 133

[VCAA 2012 E1 SB Q5]

Half an hour after an adult person completed eating a protein-rich meal, a sample was taken of the contents of their stomach. This sample was divided into three equal parts in separate tubes. Each tube was incubated at a different temperature for 10 hours. After that time, each tube's contents was tested to determine its polypeptide concentration. The result for the sample incubated at 37°C is shown on the graph below.



a On the graph above, draw the results you would expect for the samples incubated at 10°C and 80°C. (2 marks)

b Explain your predicted results for the polypeptide concentrations at temperatures of 10°C and 80°C. (2 marks)

(Total 4 marks)

Question 3/ 133

Six students performed a trial experiment on enzyme activity. The enzyme they were studying acts on a cloudy suspension, breaking it down into a soluble form. The lesson ended, and students were asked to stop their experiment. They then recorded the time the experiment had run and their observations.

These data are collated in the following table.

Student	Volume of enzyme	Temperature (°C)	pH	Volume of cloudy	Time (minutes)	Observation at end of lesson

	solution (mL)		suspension (mL)		
1	5	37	2	10	9 Cloudy
2	5	37	2	10	20 Clear
3	5	37	4	10	35 Clear
4	5	37	4	10	20 Cloudy
5	5	37	6	10	8 Cloudy
6	5	37	6	10	40 Cloudy

a What is the purpose of this experiment? (1 mark)

b Describe two changes that would improve the validity of the data collected in the experiment. (2 marks)

c The experiment was repeated with all trials running for 40 minutes. Complete the table to predict the results. (1 mark)

Student	Volume of enzyme solution (mL)	Temperature (°C)	pH	Volume of cloudy suspension (mL)	Time (minutes)	Observation at end of lesson
1	5	37	2	10	40	
2	5	37	2	10	40	
3	5	37	4	10	40	
4	5	37	4	10	40	
5	5	37	6	10	40	
6	5	37	6	10	40	

(Total 4 marks)

[VCAA 2020 SB Q3]

Greenhouses have been used to generate higher crop yields than open-field agriculture. To encourage plant growth in greenhouses, the conditions required for photosynthesis are controlled. Commercial greenhouses, like the ones shown following, often use a lot of energy for heating, ventilation, lighting and water.



a Consider the reactions of photosynthesis. Why would it be important to maintain the temperature within narrow limits in a commercial greenhouse? Justify your answer. (2 marks)

b Scientists are developing a new material to cover greenhouses, which can split incoming light and convert the rays from green wavelengths into red wavelengths.

Explain how this new material increases crop yields. (2 marks)

c In plants and algae, photosynthesis is carried out in chloroplasts. It is thought that chloroplasts originated from bacteria.

Describe **two** features of chloroplasts that support the theory that chloroplasts originated from bacteria. (2 marks)

(Total 6 marks)

Question 5/ 133

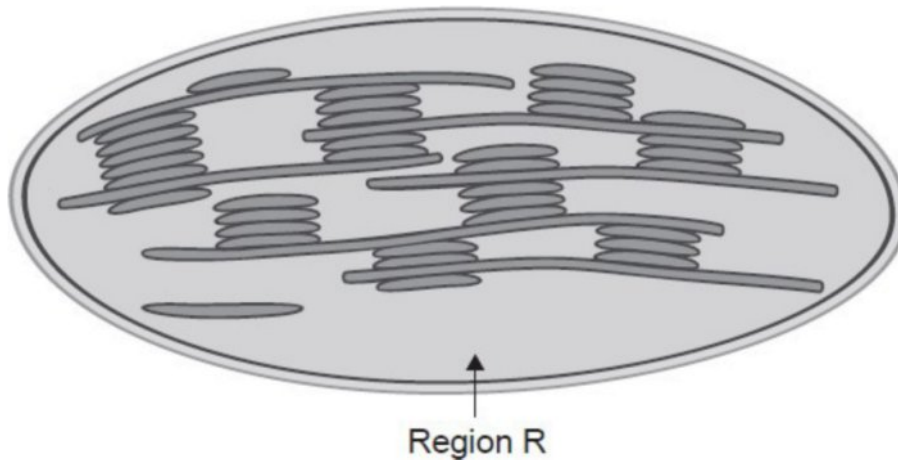
[VCAA 2019 SB Q2]

a A chloroplast is surrounded by a double membrane.

i Name **two** molecules, as inputs for photosynthesis, that would need to diffuse from the cytosol of the plant cell across the chloroplast membranes and into the chloroplast. (1 mark)

ii Under high magnification, the internal structure of a chloroplast is visible.

The diagram below shows part of this structure.



A higher concentration of oxygen is found in Region R when a plant is photosynthesising compared to when it is not photosynthesising.

Account for the differences in oxygen concentrations found in this region.

(2 marks)

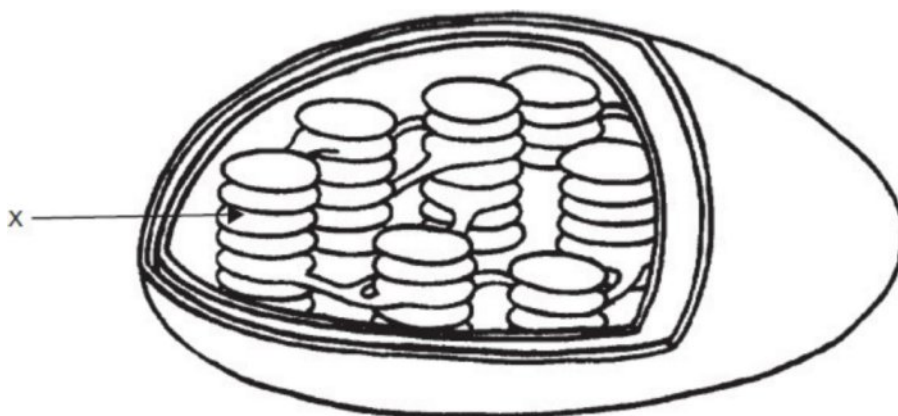
b Describe the role played by each of the coenzymes NADPH and ATP in photosynthesis. (2 marks)

(Total 5 marks)

Question 6/ 133

[VCAA 2015 SB Q3]

Below is a diagram of a chloroplast.



a Name the structure labelled X. (1 mark)

b Complete the table below by referring to the diagram above and your knowledge of photosynthesis. (3 marks)

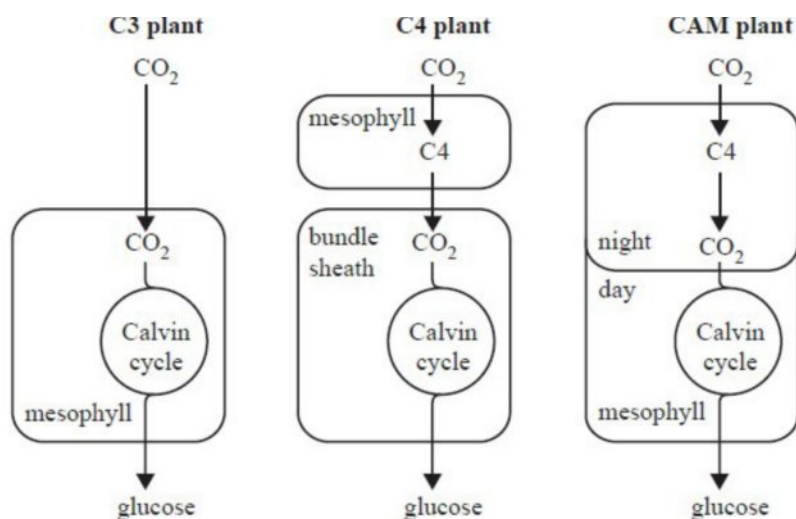
Name of the stage of photosynthesis that occurs at X		
Two input molecules that are required for reactions at X	1 	2
Two output molecules that result from reactions at X	1 	2

(Total 4 marks)

Question 7/ 133

[VCAA 2022 SB Q3]

Plants have the unique ability to photosynthesise and utilise sunlight. They are able to produce high-energy-containing molecules that fix carbon dioxide (CO_2) into forms of carbohydrates that can be stored or used by plant cells. Most plants use the C_3 pathway to fix CO_2 and some use the C_4 pathway. A small group of plants use a combination of both pathways. This smaller number of plants are called the CAM plants.



Source: adapted from H Kheyrodin and S Kheyrodin, 'CO₂ gas exchange in Crassulacean acid metabolism and C3 and C4 plants', *International Journal of Advanced Research in Biological Sciences*, vol. 4, issue 10, 2017, <<http://dx.doi.org/10.22192/ijarbs.2017.04.10.007>>

As part of their VCE Biology practical investigation, a group of students collected plant samples from their school grounds. While the students were able to identify most of the plants they collected, there was one they had not seen before. They performed a series of experiments with this plant in the laboratory. The observations they made, as well as documented information for C3, C4 and CAM plants, are shown in the table below.

Plant characteristic	Unknown plant	C3 plant	C4 plant	CAM plant
Ideal temperature for photosynthesis	25–35°C	15–25°C	30–40°C	> 40°C
Pathway to fix CO ₂	C4 pathway and Calvin cycle	only Calvin cycle	C4 pathway and Calvin cycle	C4 pathway and Calvin cycle
Stomata open during the day	yes	yes	yes	no
Photorespiration occurring	moderate to low	high	low	Only observed in the middle of the day
Water loss during the day	moderate	high	moderate	low
Plant growth rate	moderate	moderate	fast	very slow

a Based on the information provided, state whether the unknown plant is a C3, C4 or CAM plant. Justify your response. (5 marks)

b Outline three additional steps that could be carried out to extend the investigation and assist with identifying the unknown plant. (3 marks)

(Total 8 marks)

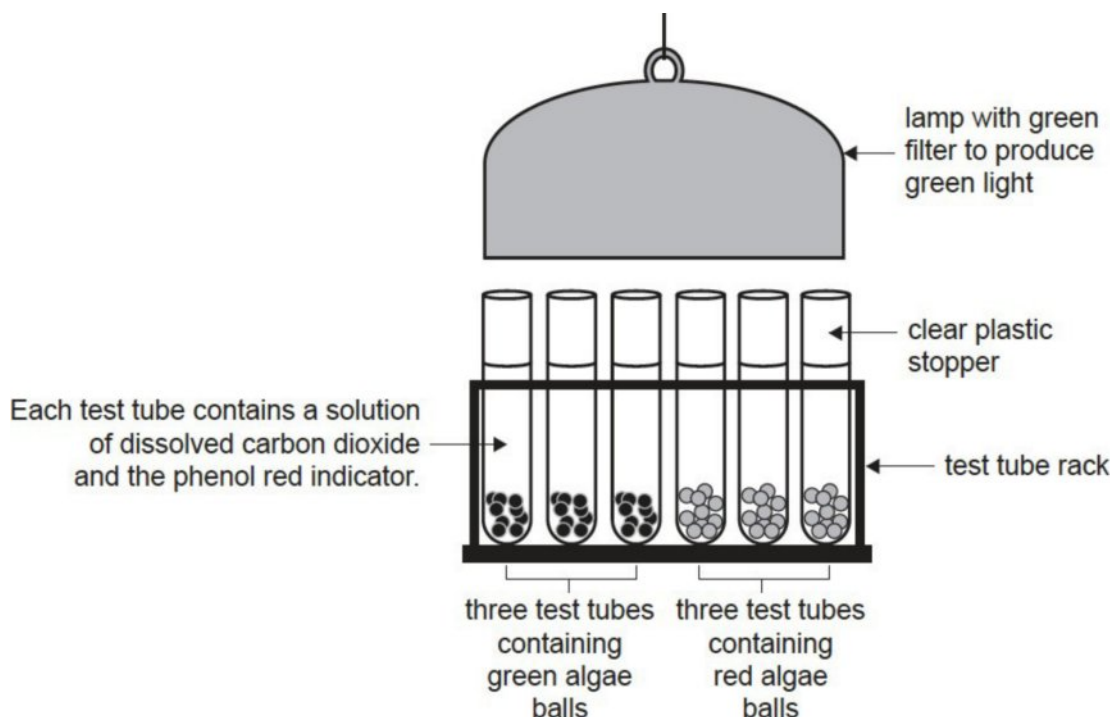
Question 8/ 133

[VCAA 2018 SB Q11]

Elsa read that red algae survive at greater water depths than green algae because of a pigment in the red algae called phycoerythrin. This pigment enables the algae to absorb more of the green light available at greater water depths. Elsa decided to investigate this by carrying out an experiment.

Using a standard technique, the single-celled algae were trapped in jelly balls. One set of balls contained green algae and another set contained red algae.

To measure the rate of photosynthesis, Elsa used a stopwatch and the pH indicator phenol red. Phenol red changes colour in solutions with different concentrations of carbon dioxide. In low carbon dioxide concentrations, phenol red is pink and in higher carbon dioxide concentrations it is yellow. Elsa placed the jelly balls into test tubes and covered them with a solution containing dissolved carbon dioxide. Phenol red indicator was added to each solution. The diagram on the following page shows the set-up of Elsa's experiment.



a State the hypothesis that Elsa was testing. (1 mark)

b List **three** variables that would need to be controlled to ensure the experiment produced valid results. (3 marks)

c State the independent variable and the dependent variable in this experiment. (2 marks)

d What results would disprove the hypothesis of Elsa's experiment? (2 marks)

e Elsa's laboratory partner suggested that they should also set up an identical experiment but keep the test tubes and their contents in the dark.

Explain why this is a good suggestion. (1 mark)

f Elsa's teacher said that even if the students completed the additional experiment in the dark and even if all of those results supported the hypothesis, there may still be other plausible explanations for their results.

Suggest **two** other explanations to which the teacher could be referring. (2 marks)

(Total 11 marks)

Question 9/ 133

[VCAA 2022 SB Q11]

A researcher was testing compounds for their effects on the activity of malate dehydrogenase (MDH), an enzyme in the Krebs cycle. One of the compounds the researcher tested, Compound A, yielded interesting results when the experiment was performed using malate as the substrate.

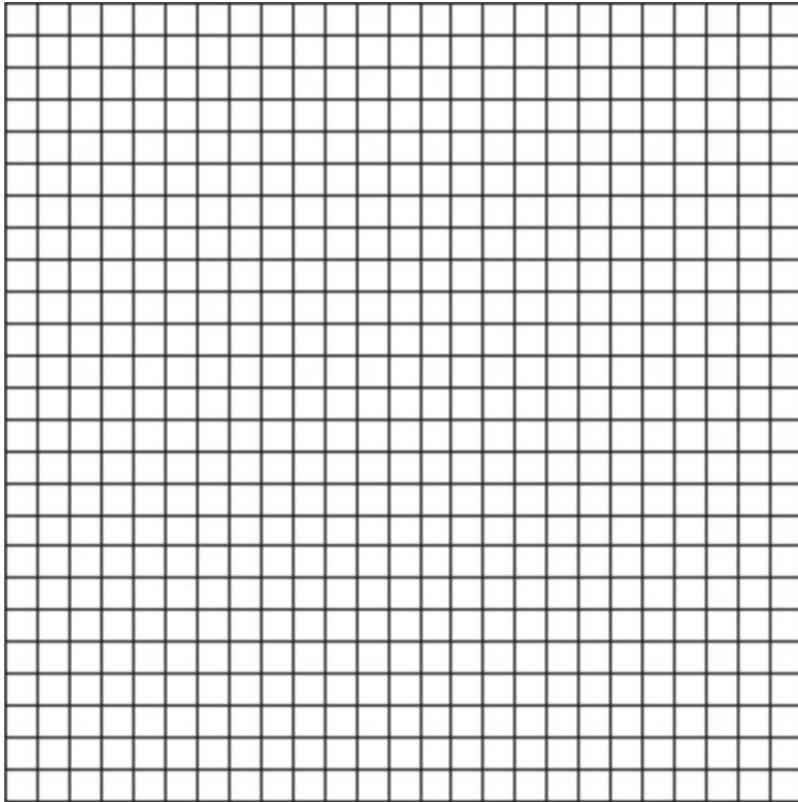
In the experiment, two sets of five test tubes were set up containing different amounts of malate, as shown in the table below. The same amount of enzyme was added to all the test tubes, but Compound A was added to only the experimental set of test tubes. The experiment was performed for one minute at 37°C.

The researcher found the rate at which the product formed, in millimoles per minute, and the results are shown in the table on the next page.

Amount of malate added (mmoles)	Rate of product formation (millimoles per minute)	
	Without Compound A	Without Compound B
0	0.00	0.00
5	3.30	1.00
10	3.80	2.00
15	3.90	3.00
25	4.00	3.80

a On the grid below, plot a graph representing the results and provide appropriate labels for the axes. (3

marks)



b Compound A was found to be a competitive inhibitor.

Briefly explain how competitive inhibitors affect the activity of an enzyme. (2 marks)

c The researcher repeated this experiment. However, when the researcher plotted the data, they noticed that while the shapes of the curves were similar, the results were different. On re-examination of the experimental set-up, the researcher noticed that the repeat experiment had been carried out at 20°C.

State the effect that this temperature change would have had on these results and explain the cause of this difference. (2 marks)

(Total 7 marks)

Question 10/ 133

[VCAA 2021 SB Q3]

Scientists measured the metabolic activity of mammalian cells by measuring the uptake of glucose into the cells. The cells were maintained at 37°C with a pH of 7.4 and suspended in a nutrient solution containing glucose. The uptake of glucose into the cells was recorded for the next 30 minutes.

a Explain why the uptake of glucose into the cells could be used to measure the metabolic activity of the cells. (2 marks)

b The scientists repeated the experiment. They kept all conditions the same as for the first experiment, except that the cells were kept in low-oxygen conditions.

Would the uptake of glucose into the cells be expected to be higher, lower or the same as for the first experiment? Justify your response. (4 marks)

(Total 6 marks)

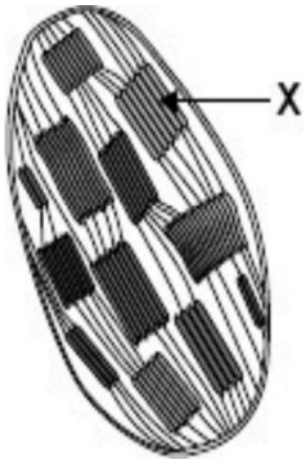
Question 11/ 133

[VCAA 2011 E1 SB Q7]

a Write the word or chemical equation for aerobic cellular respiration. (1 mark)

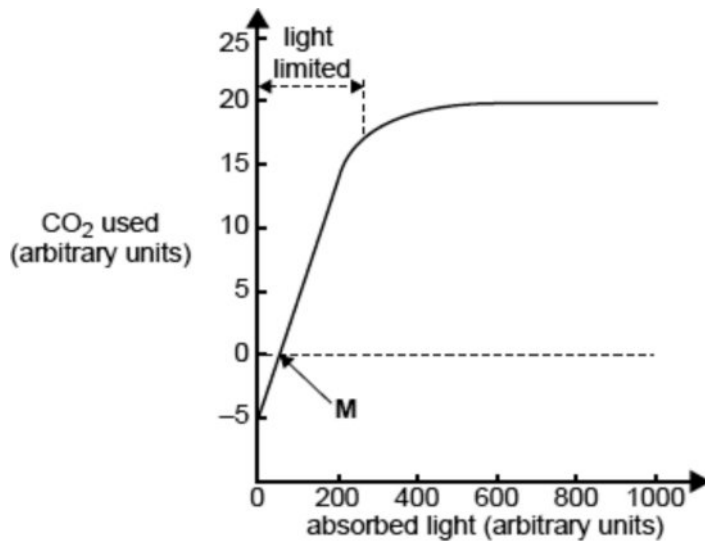
b Cyanide inactivates metabolic reactions at the cristae of mitochondria. Cyanide poisoning often results in death. Explain why. (2 marks)

The diagram that follows shows a chloroplast.



c Describe the chemical changes that occur at location X when light is present. (2 marks)

The graph below shows the rate of carbon dioxide exchange between a leaf and its external environment as light intensity is altered. All other variables are kept constant throughout the experiment.



d i Outline what is occurring at point M in terms of chemical reactions. (1 mark)

ii Explain why the graph line becomes nearly horizontal from about 600 units of absorbed light. (1 mark)

RuBisCo is an enzyme found in chloroplasts. Its normal function is to catalyse the reaction in which carbon dioxide is a substrate. In certain plants, when the level of carbon dioxide is low in the leaf, RuBisCo uses oxygen as the substrate and releases hydrogen peroxide and ammonia.

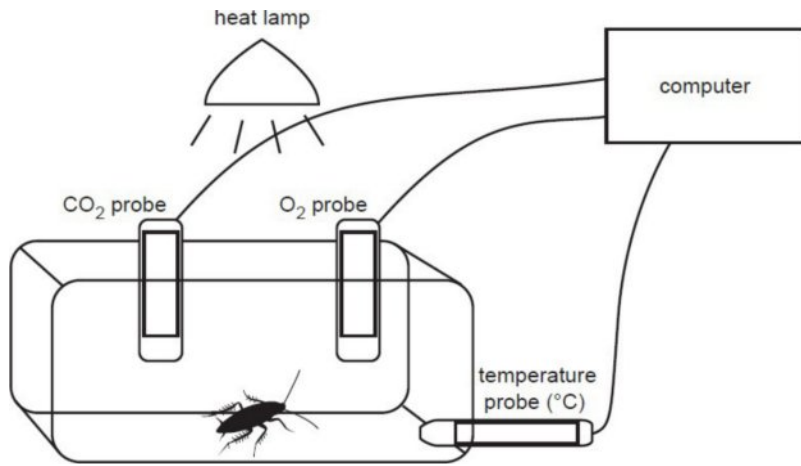
f Explain why it is beneficial for a plant to have a high level of carbon dioxide in its leaves. (2 marks)

(Total 9 marks)

Question 12/ 133

[VCAA 2017 SB Q11]

Matthew investigated how changes in environmental temperature affected oxygen (O₂) and carbon dioxide (CO₂) levels in the air around a cockroach. He used three digital probes linked to a computer, a closed animal chamber and a heat lamp in the experimental set-up shown in the diagram below.



a Name the cellular process being investigated in Matthew's experiment. (1 mark)

b Identify the:

- dependent variables
- independent variable. (2 marks)

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

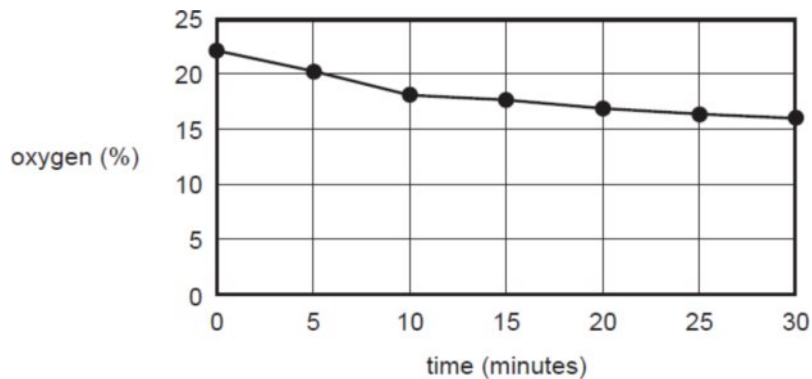
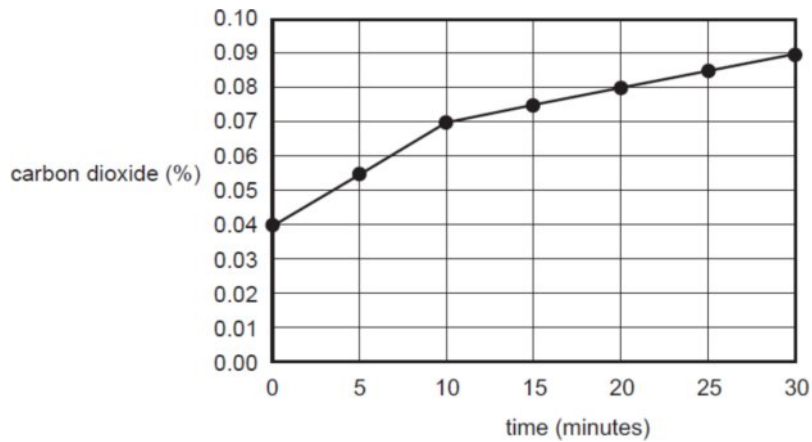
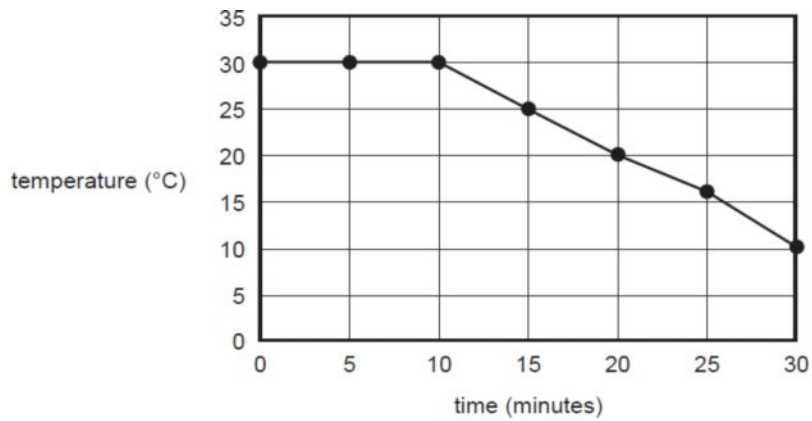
Time (minutes)	CO ₂ (%)	O ₂ (%)	Temperature (°C)
0	0.04	22.3	29.5
1	0.04	22.1	29.8
2	0.04	22.0	30.0
3	0.04	22.0	30.0
4	0.04	22.0	30.0

c Explain why Matthew recorded the data for four minutes and not just one minute. (1 mark)

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

d Other than repeating the entire experiment, identify two control measures Matthew should have included in his experimental design. Explain how each of these control measures could affect the results if not kept constant. (4 marks)

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



e i Using the graphical data, describe the changes in the levels of carbon dioxide and oxygen when the temperature in the chamber was kept constant compared to when the temperature was decreasing. (2 marks)

ii What conclusion do you think Matthew can draw from his investigation?

You should refer to each of the following in your response:

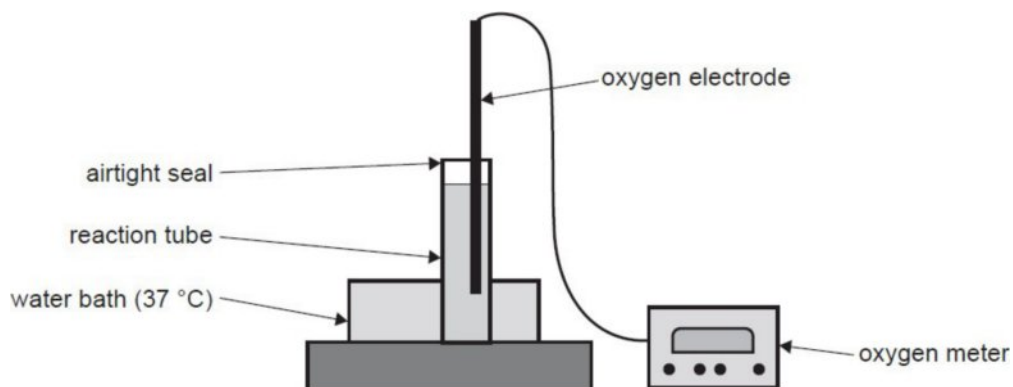
- the cellular process named in **part a**.
- the variables identified in **part b**.
- the evidence collected during Matthew's experiments. (4 marks)

(Total 14 marks)

Question 13/ 133

[Adapted VCAA 2016 SB Q4]

The apparatus shown in the diagram that follows was used in a series of experiments to study aerobic respiration.



In three different experiments, the reaction tube initially contained the following:

- 1 suspension of mitochondria
- 2 cytosol of cells from which the mitochondria had been removed
- 3 suspension of mitochondria and cytosol of cells.

The temperatures and pH of the mixtures within the reaction tubes were carefully controlled so as not to damage the mitochondrial structure or any of the enzymes.

In each experiment, a solution containing glucose was first added to the mixture in the reaction tube and the oxygen concentration was measured for three minutes. Then, a pyruvate solution was added and the oxygen concentration was measured again for three minutes.

Using your knowledge and understanding of aerobic respiration and mitochondria, give your **prediction** of the change in oxygen concentration of the mixture in the reaction tube after the addition of each substance in the three different experiments and give a **reason** for your prediction.

Experiment 1 – Suspension of mitochondria

Experiment 2 – Cytosol of cells from which the mitochondria had been removed

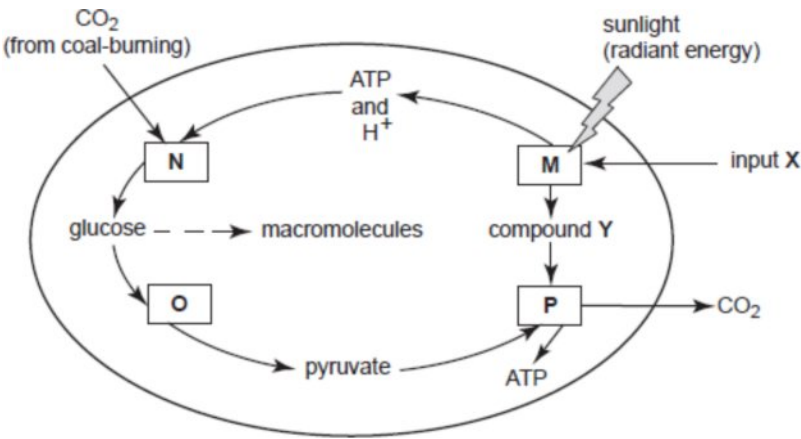
Experiment 3 – Suspension of mitochondria and cytosol of cells

(Total 6 marks)

[VCAA 2012 E1 SB Q8]

Climate change has been linked to an excess of carbon dioxide in the atmosphere. The burning of coal is a major contributor to this excess of carbon dioxide. Microalgae such as *Chlorella* can use greater amounts of carbon dioxide than land plants and they do not require prime soil, reliable rainfall and a particular climate. *Chlorella* can be grown cheaply in existing or engineered ponds which are supplied with carbon dioxide from a coal-burning power station nearby.

The diagram below represents a summary of the processes (labelled M, N, O, P) occurring in a *Chlorella* cell.



a Name:

i input X (1 mark)

ii compound Y. (1 mark)

b With reference to the diagram of processes in a *Chlorella* cell, complete the following table.

Process	Name of process	Site of process
M		Grana of chloroplast
O	Glycolysis	
P	Stages of cellular respiration	

(3 marks)

Chlorella pond farms could reduce 50% of the carbon dioxide that is produced by coal-burning power stations. Consider the summary of processes occurring in a *Chlorella* cell.

c Given that carbon dioxide is an output of process P, explain how *Chlorella* farming could prevent 50% of the carbon dioxide emitted by coal-burning power stations from entering the atmosphere. (2 marks)

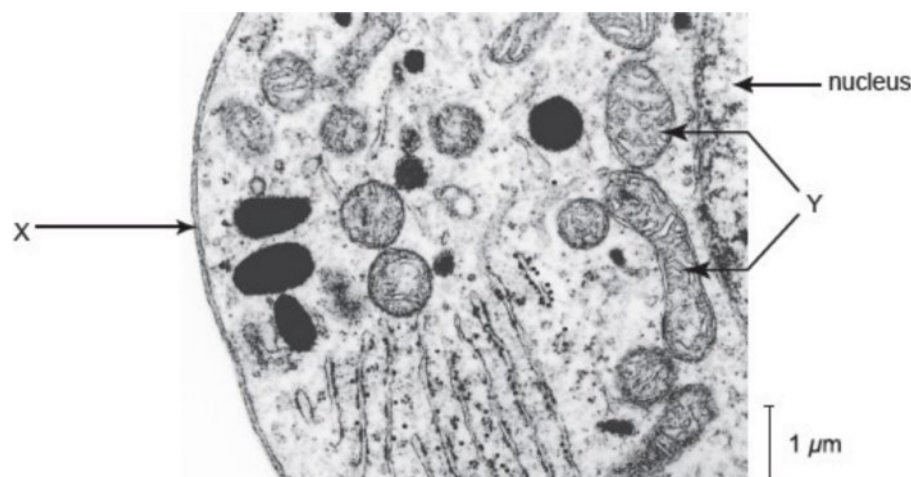
d What are **two** conditions, other than carbon dioxide supply, that an engineer or biologist maintaining a *Chlorella* pond farm would need to control to keep the growing conditions at an optimum level? (1 mark)

(Total 8 marks)

Question 15/ 133

[VCAA 2012 E1 SB Q1]

The electron-micrograph below shows a portion of a cell.



a Name and describe structure X. (2 marks)

b It has been suggested that as humans age the structures labelled Y become less efficient. Explain the consequence of this for an elderly person. (2 marks)

(Total 4 marks)

Question 16/ 133

[VCAA 2013 SB Q1]

Yeast is a single-celled, microscopic fungus that uses sucrose as a food source. An experiment was carried out to investigate cellular respiration by a particular species of yeast. Yeast cells were placed in a container and a sucrose solution was added. An airtight lid was placed on the container. The percentages of oxygen and ethanol in the container were recorded over a one-hour period.

The experiment was carried out at room temperature. The results are shown in the following table.

	Percentage of oxygen	Percentage of ethanol
at the start of the experiment	21	0
at the end of the experiment	18	4

a Explain any changes that have been observed in oxygen and ethanol levels within the airtight container. (2 marks)

Levels of carbon dioxide were also monitored during the experiment.

b Predict whether the carbon dioxide concentration inside the airtight container would increase, stay the same or decrease within the time the experiment was carried out. Explain the reasoning behind your prediction. (2 marks)

Scientists are looking at ways to increase the efficiency of photosynthesis in plants, including the way in which carbon dioxide is captured.

c i Name the stage of photosynthesis in which carbon dioxide is captured. (1 mark)

ii The stage of photosynthesis in which carbon dioxide is captured requires other inputs. Name two other inputs, and describe the role played by each in this stage of photosynthesis. (2 marks)

(Total 7 marks)

Question 17/ 133

[VCAA 2016 SB Q2]

Plant materials containing cellulose and other polysaccharides are reacted with acids to break them down to produce glucose. This glucose is then used by yeast cells for fermentation.

a Why is fermentation important for yeast cells? (1 mark)

b What are the products of fermentation in yeast cells? (1 mark)

A by-product of the acid treatment of plant materials is a group of chemical compounds called furans. It has

been observed that as the concentration of furans increases, the rate of fermentation decreases. The enzyme alcohol dehydrogenase is required for the process of fermentation.

c Design an experiment to test the hypothesis that one of the furans, called furfural, is an inhibitor of the enzyme alcohol dehydrogenase. Assume that the experiment will be repeated many times and that environmental factors are kept constant. (4 marks)

d Scientists have proposed that furfural is a competitive inhibitor of the enzyme alcohol dehydrogenase.

Explain how furfural could act as a competitive inhibitor of the enzyme alcohol dehydrogenase. (2 marks)

(Total 8 marks)

Chapter 4 How do organisms respond to pathogens?

Question 1/ 55

How do organisms determine which cells are theirs and which cells are foreign?

Question 2/ 55

Distinguish between the following terms: pathogen, antigen, antibody and allergen.

Question 3/ 55

What is disease? Are all diseases infectious?

Question 4/ 55

Explain the relationship between infectious diseases and pathogens.

Question 5/ 55

In terms of pathogens, what is meant by the term 'host'?

Question 6/ 55

Pathogens can be non-cellular or cellular. Give three examples of each.

Question 7/ 55

What physical and chemical barriers do plants have against infection?

Question 8/ 55

The human body has a number of levels of defence against disease. What is the first line of defence?

Question 9/ 55

Complete the following table.

Component of the innate immune response	Role in the innate immune response
Macrophage	
Neutrophil	
Dendritic cells	
Eosinophil	
Natural killer cell	
Mast cell	
Complement protein	
Interferon	

Question 10/ 55

What are the functions of inflammation?

Question 11/ 55

Describe the stages of inflammation.

Question 12/ 55

Explain whether the features described above provide specific defence.

Question 13/ 55

Give two roles of fever in the immune response.

Question 14/ 55

Complete the following table.

Examples

Primary lymphoid organs

Secondary lymphoid organs

Question 15/ 55

What are the two main functions of lymph vessels?

Question 16/ 55

What is the function of lymph nodes?

Question 17/ 55

What is the role of the adaptive immune response?

Question 18/ 55

Distinguish between T lymphocytes and B lymphocytes. Where is each sort of cell formed and matured?

Question 19/ 55

What is the difference between antibodies and antigens? How do they relate to each other?

Question 20/ 55

What are antibodies made of and by what cells are they made?

Question 21/ 55

Why is the shape/structure of antibodies so important?

Question 22/ 55

List the major steps involved in humoral immunity.

Question 23/ 55

List the major steps involved in cell-mediated immunity.

Question 24/ 55

Describe the different ways that T cells are involved in specific defence.

Question 25/ 55

How does natural immunity differ from artificial immunity?

Question 26/ 55

What is the principle behind active immunity?

Question 27/ 55

How does active immunity differ from passive immunity? Which is best?

Question 28/ 55

Explain why most people get mumps or measles once only. (Assume they were not vaccinated!)

Question 29/ 55

What are the differences between infectious and non-infectious diseases?

Question 30/ 55

Explain the relationship between infectious diseases and pathogens.

Question 31/ 55

Give two explanations as to why new diseases emerge.

Question 32/ 55

Why is scarlet fever considered to be a re-emerging disease?

Question 33/ 55

Give two reasons why diseases re-emerge.

Question 34/ 55

Distinguish between an epidemic and a pandemic by completing the table below.

	Epidemic	Pandemic
Definition		
Cause		
Death rates		
Example		

Question 35/ 55

What diseases did the first European settlers bring to the Aboriginal and Torres Strait Islanders?

Question 36/ 55

Why did the diseases brought to Australia with the European settlers have such a devastating effect on the Aboriginal and Torres Strait Islander peoples?

Question 37/ 55

Apart from the introduction of pathogens, how has the health of Aboriginal and Torres Strait Islander peoples been affected by European settlement?

Question 38/ 55

Complete the following table.

Method	Explanation	Type of pathogen
Morphology		
Genetic		
Immunology		

Question 39/ 55

In terms of disease, what is meant by the term 'vector'?

Question 40/ 55

Explain why cleanliness in food, water and personal hygiene practices assist in control of disease.

Question 41/ 55

What are the major ways in which pathogens are transmitted from host to host?

Question 42/ 55

Complete the following table summarising procedures that reduce the spread of disease.

Procedure	How it stops spread	Examples of diseases that are stopped
Personal hygiene		
Community hygiene		
Quarantine		
Vaccination		

Procedure	How it stops spread	Examples of diseases that are stopped
Public health programs		
Pesticides		
Genetic engineering		

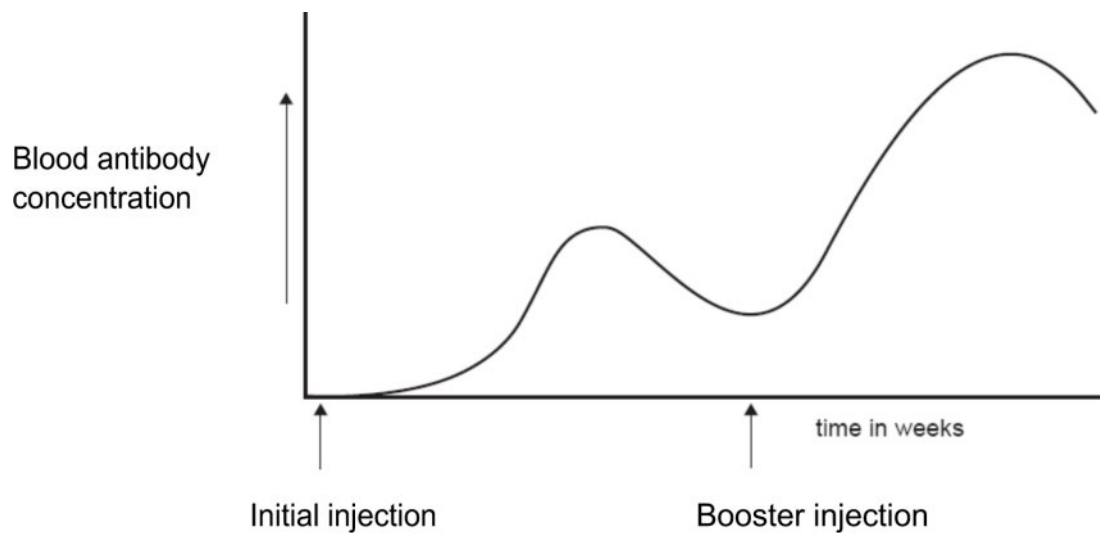
Question 43/ 55

Complete the following table.

Type of vaccine	Description
Live attenuated vaccine	
Inactivated or killed vaccines	
Inactivated bacterial toxin	
Pathogen sub-unit	

Question 44/ 55

The graph below shows antibody levels after initial immunisation followed by a booster injection. Explain the shape of the graph.



Question 45/ 55

The hepatitis B vaccine is given at birth 2 months, 4 months and 6 months. Why?

Question 46/ 55

Explain why both quarantine and vaccination are used to stop the spread of disease.

Question 47/ 55

Why does herd immunity rely on the immunisation of most of the population?

Question 48/ 55

What is multiple sclerosis?

Question 49/ 55

How is cancer related to cell division?

Question 50/ 55

How do tumour cells evade the immune response?

Question 51/ 55

What is immunotherapy?

Question 52/ 55

What are monoclonal antibodies and how can they be used to treat cancer?

Question 53/ 55

How can monoclonal antibodies be used to treat autoimmune diseases?

Question 54/ 55

Explain how conjugated monoclonal antibodies can directly deliver drugs and or radiation to tumour cells.

Question 55/ 55

Complete the following table:

Type of cancer vaccine	Antigens contained in the vaccine	How the vaccine works
Preventive		
Therapeutic		
Personalised		

Question 1/ 145

[VCAA 2022 SA Q20]

During their lifetime, plants are exposed to both pathogenic and beneficial microorganisms. Some plants provide shelter within their bodies for beneficial microorganisms. These beneficial microorganisms help plants that have not been genetically modified to resist pathogenic microorganisms.

The beneficial microorganisms may be providing protection by

- A synthesising toxins that kill pathogenic microorganisms.
 - B providing a permeable physical barrier to pathogenic microorganisms.
 - C stimulating the production of antibodies against pathogenic microorganisms.
 - D mobilising the cells of the third line of defence against pathogenic microorganisms.
-

Question 2/ 145

[VCAA 2015 SA Q17]

Which one of the following is an example of a plant defence against a pathogen?

- A production of antibodies
 - B an active immune system
 - C extensive cell death throughout the plant
 - D waxy leaf surfaces acting as physical barriers
-

Question 3/ 145

[VCAA 2014 SA Q15]

The first line of defence against pathogens includes the

- A activation of helper T cells.
 - B presence of acid in the stomach.
 - C release of histamine from mast cells.
 - D production of interferon from virus-infected cells.
-

Question 4/ 145

[VCAA 2013 SA Q14]

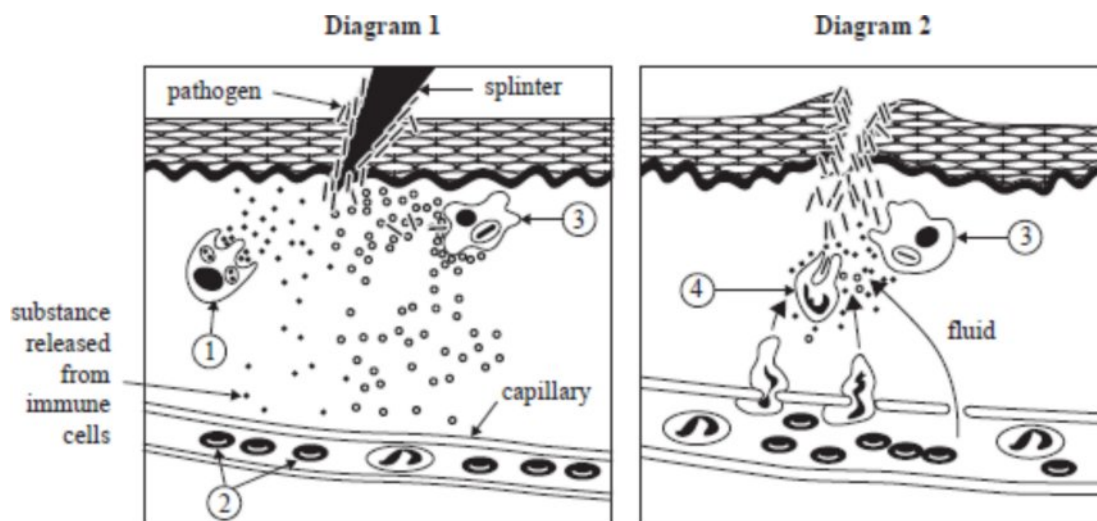
As part of the first line of defence in the human immune system, naturally occurring barriers to invading pathogens include

- A lysozymes in tears.
- B the production of antibodies.
- C the engulfing of pathogens by phagocytes.
- D inflammation at the site of infection.

Question 5/ 145

[VCAA 2022 SA Q21]

The diagrams below illustrate the inflammatory response that may occur when a pathogen enters the human body.



Source: adapted from NA Campbell, JB Reece et al., *Biology*, 8th edition, Pearson Education Australia, 2009, p. 949

Which of the following correctly identifies one of the cells labelled 1 to 4 in the diagrams above and their role in the inflammatory response?

Cell Number	Name of cell	Role

	Cell Number	Name of cell	Role
A	1	T cell	releases cytokines
B	2	dendritic cell	presents antigens to helper T cells
C	3	mast cell	releases histamines
D	4	neutrophil	acts as a phagocyte

A 1: T cell

B 2: dendritic cell

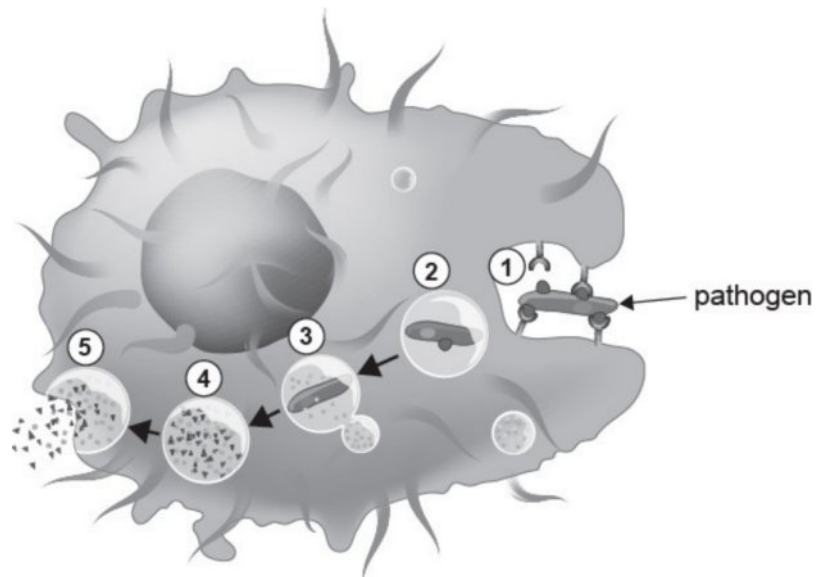
C 3: mast cell

D 4: neutrophil

Question 6/ 145

[VCAA 2019 SA Q20]

The diagram that follows shows the process of phagocytosis. This process is vital for immunity against extracellular infections.



What is happening at position 3?

A Enzymes that break down the microorganism are released into the vesicle.

B Antibodies are added to the vesicle to kill the microorganism.

C The cell is sampling the vesicle for antigen presentation.

D Intracellular microbes are attacking the microorganism.

Question 7/ 145

[VCAA 2021 SA Q15]

Neutrophils

A secrete complement proteins.

B migrate to the site of infection and engulf invading pathogens.

C increase the diameter of blood vessels to make them more permeable.

D release histamine following the binding of the antigen to receptors on the neutrophil's surface.

Question 8/ 145

[VCAA 2021 SA Q16]

In humans, an example of a chemical barrier that prevents the entry of pathogens into the internal environment would be

A histamine.

B interferons.

C lysozymes.

D complement proteins.

Question 9/ 145

[VCAA 2016 SA Q20]

The inflammatory response is a defence mechanism that evolved in higher organisms to protect them from infection and injury.

This response

A includes phagocyte migration to the site of the injury.

B is part of the adaptive immune system.

C is specific to the type of foreign body.

D involves the production of lymphocytes.

Question 10/ 145

[VCAA 2015 SA Q18]

A girl is carrying a piece of wood. A small piece breaks off and becomes embedded in her finger. The next day, she notices an inflammatory response occurring in her finger.

In the region around the small piece of wood embedded in her finger

A mast cells would release antibodies.

B the skin tissue would become pale and cold.

C the capillaries would become more permeable.

D red blood cells would leave the blood vessels and engulf foreign material.

Question 11/ 145

[VCAA 2014 SA Q16]

An example of a non-specific response by the immune system is

A phagocytes engulfing non-self-material.

B cytotoxic T cells releasing chemicals into infected cells.

C production of memory T cells.

D cloning of B cells to produce plasma cells.

Question 12/ 145

[VCAA 2013 SA Q15]

Defence mechanisms against bacterial pathogens include:

A the production of interferon.

B neutralisation by histamines.

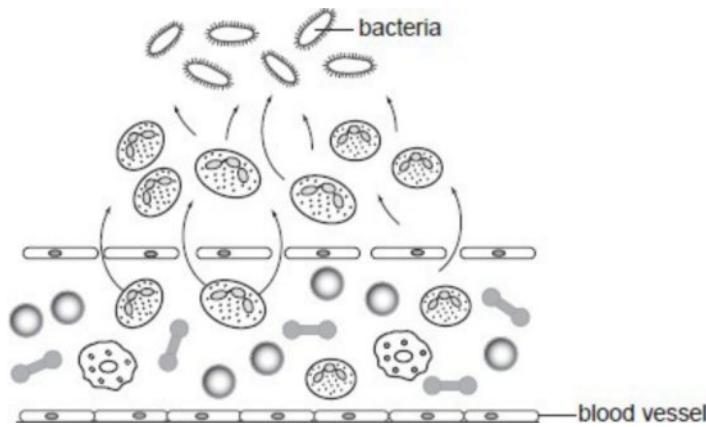
C destruction by complement proteins.

D agglutination by cytotoxic T cells.

Question 13/ 145

[VCAA 2012 E1 SA Q10]

Consider the following diagram showing a bacterial infection within a human.



Cells moving from the blood vessel towards the bacteria

A are natural killer cells.

B would act as phagocytes.

C cause vasodilation of the blood vessel.

D release histamine in response to tissue damage.

Question 14/ 145

[VCAA 2012 E1 SA Q23]

Interferon is a chemical that

A kills bacteria by producing holes in the bacterial wall.

B protects uninfected cells from viral attack.

C suppresses the immune response.

D is produced by T cells.

Question 15/ 145

[VCAA 2011 E1 SA Q6]

It is reasonable to infer that an infection has occurred if

- A histamine is released by cells.
 - B a scab has formed on a cut in the skin.
 - C bacteria are found in the large intestine.
 - D pathogens are found in leg muscle tissue.
-

Question 16/ 145

[VCAA 2011 E1 SA Q8]

Nonspecific defences of the immune system that act against bacteria include

- A antibodies.
 - B phagocytes.
 - C interferons.
 - D plasma cells.
-

Question 17/ 145

[VCAA 2015 SA Q15]

Which one of the following is true of prions?

- A They have an outer wall made of cellulose.
- B They cause some brain diseases.
- C They contain nucleic acids.
- D They are unicellular.

Question 18/ 145

[VCAA 2022 SA Q22]

The human body does not normally produce an immune response against self-cells. Cells in the human immune system can distinguish self-cells from non-self-cells

A because non-self-cells have a faster reproduction rate.

B due to the presence of different antigens on non-self-cells.

C only when antibodies are attached to the surface of non-self-cells.

D because non-self-cells are always smaller in size than self-cells.

Question 19/ 145

[VCAA 2014 SA Q14]

An example of ‘self’ material in an adult human female is

A pollen inhaled from flowers in her garden.

B sperm cells present in her reproductive tract.

C cells lining her nose and trachea.

D malarial parasites inside her red blood cells.

Question 20/ 145

[VCAA 2012 E1 SA Q9]

Major Histocompatibility Complex (MHC) class 1 molecules

A release complement proteins.

B are found only on B and T cells.

C present foreign antigens to B and T cells.

D produce antibodies that are specific to each antigen.

Question 21/ 145

[VCAA 2021 SA Q17]

The role of the lymphatic system in an immune response includes

A carrying mast cells to the site of infection.

B activation of platelets to help heal wounds.

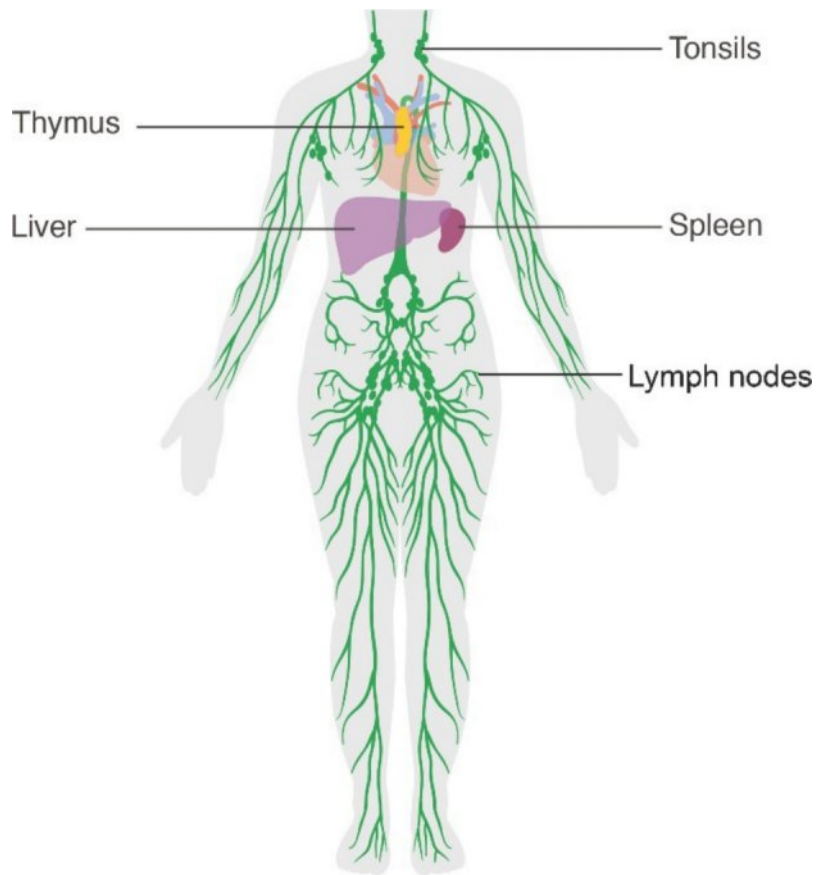
C transport of antigen-presenting cells, including dendritic cells.

D delivery of injected monoclonal antibodies to specific target cells.

Question 22/ 145

[VCAA 2017 SA Q23]

The human lymphatic system



The lymphatic system includes the lymph nodes, spleen and tonsils. In these particular organs

A clotting factors are inactivated to help seal a wound.

B clonal selection and proliferation of B cells occurs.

C non-self-antigens are identified by red blood cells.

D the initial response to an allergen is triggered.

Question 23/ 145

[VCAA 2013 SA Q18]

Di George syndrome is a rare, congenital disease that can disrupt the normal development of the thymus gland. This disease would result in the

A swelling of lymph nodes.

B overproduction of B cells.

C reduced production of T cells.

D release of histamines from mast cells.

Question 24/ 145

[VCAA 2013 SA Q20]

In the lymphatic system

A clonal selection occurs.

B mast cells are produced.

C vessels have thick, muscular walls.

D lymph is pumped by the heart.

Question 25/ 145

[VCAA 2011 E1 SA Q7]

The lymphatic system contains

A B cells only.

B T cells only.

C B cells and T cells.

D neither B cells nor T cells.

Question 26/ 145

[VCAA 2018 SA Q17]

Antigen-presenting cells deliver antigens to lymphocytes found within lymphoid tissue. These lymphocytes recognise these antigens as being non-self, causing the lymphocytes to become activated and increase in number.

Which of the following lymphocytes are activated by antigen-presenting cells?

A T helper cells

B dendritic cells

C plasma cells

D neutrophils

Question 27/ 145

[VCAA 2019 SA Q19]

In adaptive immunity, which cells, directly destroy virally infected cells?

A B cells

B plasma cells

C T helper cells

D T cytotoxic cells

Question 28/ 145

[VCAA 2013 SA Q19]

Cytotoxic T cells are

A antibodies.

B able to kill virus-infected cells.

C part of the humoral response.

D part of the second line of the immune defence.

Question 29/ 145

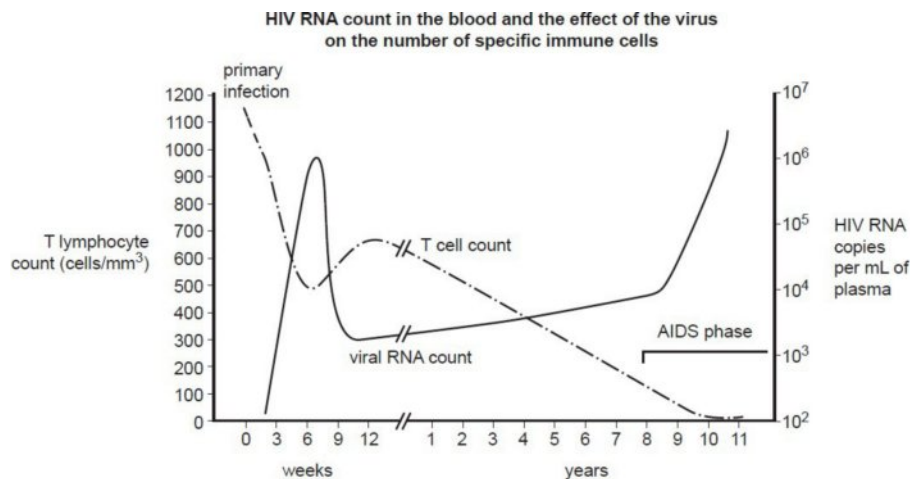
[VCAA 2017 SA Q22]

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

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

Question 30/ 145

[VCAA 2019 SA Q23]



The graph above shows the HIV RNA count in the blood and the effect of the virus on the number of specific immune cells in an untreated patient.

Based on your knowledge and the information in the graph above, what is the effect of the change in the number of T cells over time?

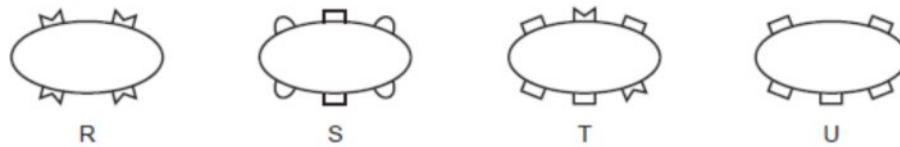
- A a decrease in the viral RNA count during the AIDS phase.
 - B loss of effective function of the adaptive immune system.
 - C failure of macrophages to engulf HIV.
 - D failure of complement proteins.
-

Question 31/ 145

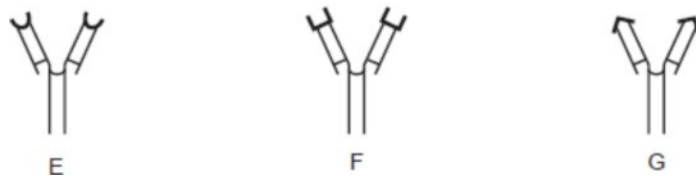
[VCAA 2015 SA Q16]

Consider the following diagram of four pathogens and three antibodies.

Pathogen



Antibody



Which one of the following statements is correct?

- A Antibody E would be effective against both pathogen S and pathogen R.
 - B Antibody F is effective against three of the pathogens.
 - C There are no antibodies effective against pathogen U.
 - D Antibody G is only effective against pathogen R.
-

Question 32/ 145

[VCAA 2012 E1 SA Q16]

The ABO blood group system has four main groups. Consider the following table.

Blood group samples				
	O	A	B	AB
Antigens on red blood cells	Neither	A	B	Both
	A nor B		A and B	

Agglutination of blood cells would occur if

A antibodies of type A were added to a sample of group O blood.

B antibodies of type A were added to a sample of group B blood.

C antibodies of type B were added to a sample of group A blood.

D antibodies of type B were added to a sample of group AB blood.

Question 33/ 145

[VCAA 2011 E1 SA Q13]

This diagram shows a group of antigens.



An appropriate antibody to use against these antigens would be type



A



B



C



Question 34/ 145

[VCAA 2020 SA Q19]

The role of T helper cells is to

A destroy cells that are infected with bacteria.

B control the adaptive immune response.

C generate antibodies.

D engulf parasites.

Question 35/ 145

[VCAA 2020 SA Q20]

Which one of the following describes a feature common to both T cells and B cells?

A having immunological memory

B rapidly responding to pathogens on first exposure

C providing a physical barrier to the entry of pathogens

D being able to attach to both microorganisms and viruses

Question 36/ 145

[VCAA 2020 SA Q21]

The property of the immune system that enables it to fight infections and destroy cancer cells is the

A ability to kill all invading organisms.

B ability to adapt to donor tissue, facilitating transplants.

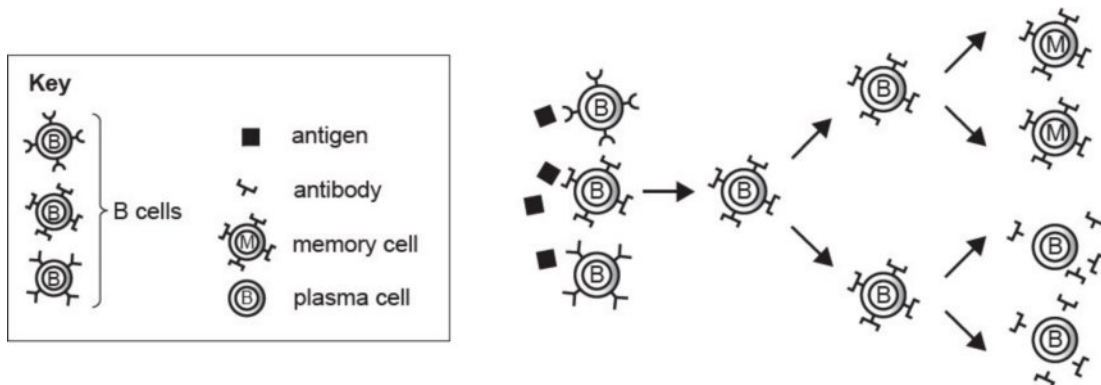
C ability to distinguish self from non-self-biological molecules.

D generation of complement proteins and other chemical barriers.

Question 37/ 145

[VCAA 2019 SA Q21]

Consider the diagram below of clonal selection in B cells.



In adaptive immunity, which part of this process allows long-term (sometimes lifetime) protection against pathogens?

A recognition of one antigen by one B cell clone.

B production of specific antibodies.

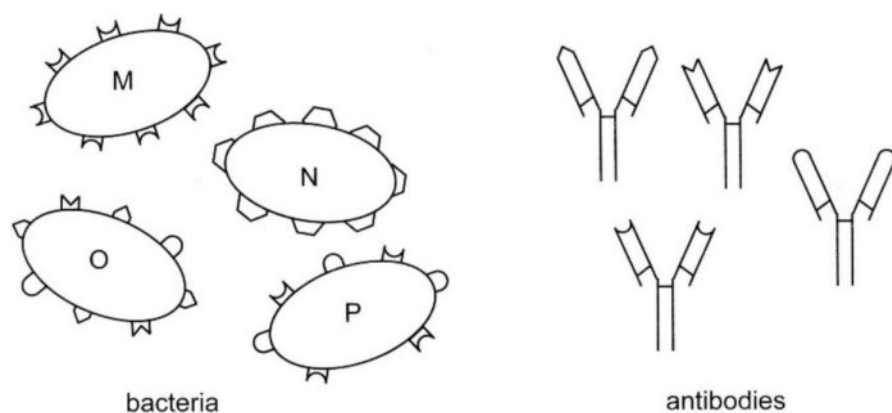
C generation of memory cells.

D production of plasma cells.

Question 38/ 145

[VCAA 2009 E1 SA Q20]

A young woman stood on a dirty, rusty nail. The following diagrams show bacteria isolated from the wound and a range of antibodies that were already present in her body.



The microorganism most likely to cause a severe infection is

A M.

B N.

C O.

D P.

Question 39/ 145

[VCAA 2018 SA Q23]

Rabies is a viral disease spread to people by infected animals. A person bitten by an infected animal should be given an injection of specific antibodies.

Following the injection, this person should have

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

Question 40/ 145

[VCAA 2016 SA Q23]

A park ranger was injected with an antivenom serum to treat a snakebite. The treating doctor explained that the injection would not protect him against future snakebites.

This is because antivenom serum is used to achieve

- A active and natural immunity.
 - B passive and natural immunity.
 - C active and induced (artificial) immunity.
 - D passive and induced (artificial) immunity.
-

Question 41/ 145

[VCAA 2011 E1 SA Q9]

Antibodies passed from a mother to her baby during breast-feeding would be best described as

- A naturally acquired, passive immunity.
- B naturally acquired, active immunity.

C artificially acquired, passive immunity.

D artificially acquired, active immunity.

Question 42/ 145

The following information relates to Questions 43 and 44.

People that have been infected with one or more different respiratory viruses develop antibodies in response to each kind of virus in their blood. The blood of four patients was tested to diagnose which viruses each patient had previously been infected with. The results are shown in the following table.

Key: ++ agglutination

0 no agglutination

Blood from	Antibody to			
	Rhinovirus	Influenza A	Influenza B	RSV
Becky	++	++	0	0
Emily	0	++	++	++
Mary	++	++	0	0
Stella	0	0	++	0

Question 43/ 145

[VCAA 2011 E1 SA Q24]

From the information in the table, it is reasonable to infer that

A Stella has been infected with RSV.

B Mary has been infected with three kinds of virus.

C Emily has been infected with the greatest number of different viruses.

D Becky and Stella have each been infected with the same set of viruses.

D Once the antibody distribution was known, doctors vaccinated the four patients against viruses for which each patient had no immunity.

Question 44/ 145

[VCAA 2011 E1 SA Q25]

From the information given in the table it is reasonable to infer that Becky would be given

A vaccines for Rhinovirus and influenza A.

B vaccines for influenza B and RSV.

C the same vaccines as Emily.

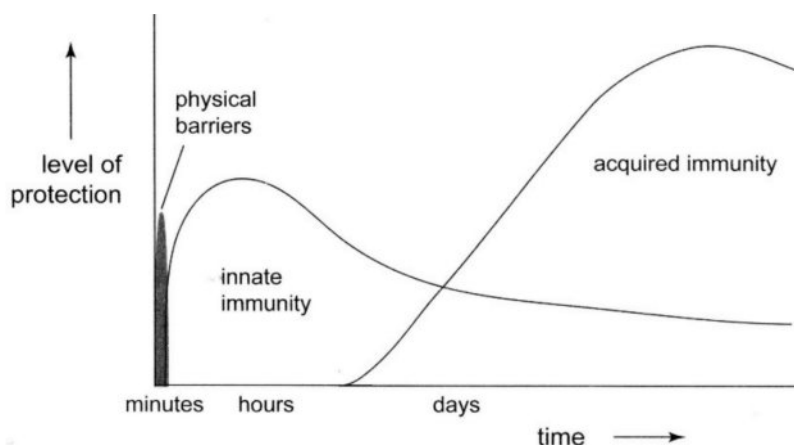
D vaccines for influenza A.

Question 45/ 145

[VCAA 2009 E1 SA Q21]

After an individual is exposed to a microbial infection, the immune system increases its activities.

The graph below summarises the timeline of the level of those activities.



It is reasonable to conclude that

A physical barriers involve macrophages.

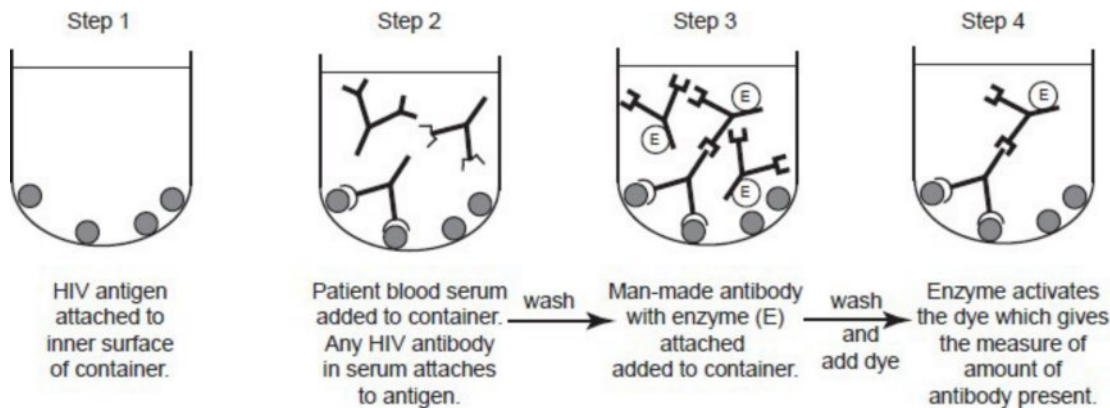
B innate immunity lacks involvement of living cells.

C lymph nodes are involved in the acquired immunity phase.

D the protection developed against the disease ceases at the end of the infection.

Question 46/ 145

Use the following information to answer Questions 47 and 48.



A diagnostic test for HIV infection includes the following steps.

Question 47/ 145

[VCAA 2012 E1 SA Q24]

This test for HIV is reliable because the

A dye reacts with the patient's blood serum.

B enzyme has an active site for the HIV antigen.

C man-made antibody has the same shape as the HIV antigen.

D HIV antigen has a complementary shape specific to the HIV antibody.

Question 48/ 145

[VCAA 2012 E1 SA Q25]

The results of the tests of three patients are given in the following table.

Positive control	Negative control	Patient R	Patient S	Patient T
1.689	0.153	0.155	0.675	1.999

Numbers are expressed as optical density at 450 nm. The more intense the dye is, the higher the optical density. The cut-off value indicating a positive result is 0.500.

Values below 0.300 are considered to be negative.

The results of these tests suggest that

A patient T has not been exposed to HIV.

B patient R has been exposed to the HIV antigen.

C patient S has responded to exposure to HIV by developing antibodies.

D the positive control contained fewer HIV antibodies than the negative control.

Question 49/ 145

Use the following information to answer Questions 50 to 55.

MEASLES:

Important considerations



suspect



report



confirm



prevent

- In 2019, outbreaks of measles have occurred across the United States, with over 1,000 cases reported from 30 states.
- In 2018, Europe experienced a large measles outbreak with over 69,000 cases reported.
- The last case of measles reported in Montana was in 1990.

WHO'S AT RISK → INCUBATION → SYMPTOMS



- Babies who are too young for vaccine (<12 months)
- Immunocompromised
- Pregnant women
- Unvaccinated

Average: 14 days
(range 7-21 days)

- High fever
- Runny nose
- Cough
- Red, watery eyes
- Rash (spreads from head to toe)
- Koplik spots (sometimes)



Measles complications can include: pneumonia, encephalitis, and/or death

How infectious is measles?

One person can infect 12-18 susceptible people

RISK FACTORS



Travel to a place where measles is endemic



Contact with someone who has measles



Not receiving a measles vaccine (MMR)



Visitors from areas where measles is occurring

SUSPECT



Evaluate signs and symptoms and risk factors to determine if measles is high on the suspicion list.

REPORT



Measles is immediately reportable to local public health. Reporting should not wait until lab results are available. If you suspect measles, report it ASAP.

CONFIRM



A diagnosis of measles is confirmed by prompt laboratory testing. The gold standard is PCR and can be performed as soon as possible following rash onset. Blood tests for IgM and IgG antibody production may also be helpful.

PREVENT



The measles vaccine (MMR) is extremely effective against preventing the disease in those who are >12 months of age. Two doses of MMR are 97% effective.

For more information, contact your local health department



Montana
Department of Public Health
1-800-455-4556
www.mt.gov/health

Source: adapted from Montana Official State Website, measles infographic,
<<https://dphhs.mt.gov/assets/publichealth/CDEpi/Infographics/measles2019ADA.pdf>>

There are many countries where measles is endemic and the vaccination rate for measles is low. Assuming that an unvaccinated person from the state of Montana, USA, travelled home by plane from one of these countries, what is the minimum number of days that this person should be kept in quarantine so that they are not at risk of spreading the disease if they were infected?

A 30

B 21

C 14

D 7

Question 51/ 145

[VCAA 2022 SA Q24]

Testing a traveller for IgM antibodies would let a health official know if the traveller

A is no longer infectious.

B has had red, watery eyes.

C has recovered from measles.

D has been infected with the measles virus.

Question 52/ 145

[VCAA 2022 SA Q25]

The R_0 is defined as the average number of secondary cases of an infectious disease arising from one case.

According to the infographic provided on the previous page, what is the R_0 for measles?

A 0–7

B 3–97.

C 7–21

D 12–18

Question 53/ 145

[VCAA 2022 SA Q26]

There are 200 people aged more than 12 months old in a population. This population is exposed to the measles virus. If the population was fully vaccinated, how many of these 200 people could be expected to be infected with the measles virus?

A 0

B 3

C 6

D 9

Question 54/ 145

[VCAA 2022 SA Q27]

Which of the following cells responds first when a person receives the MMR vaccination?

A helper T cells

B memory T cells

C cytotoxic T cells.

D antigen-presenting cells.

Question 55/ 145

[VCAA 2022 SA Q28]

Hendra virus is a disease that can affect horses and human beings. Available evidence implicates fruit bats as the natural reservoir of the Hendra virus, which is transmitted in bodily fluids.

One practical way of controlling the spread of the Hendra virus to horses is to

A stop horses from eating fruit.

B cover the feed and water containers for horses.

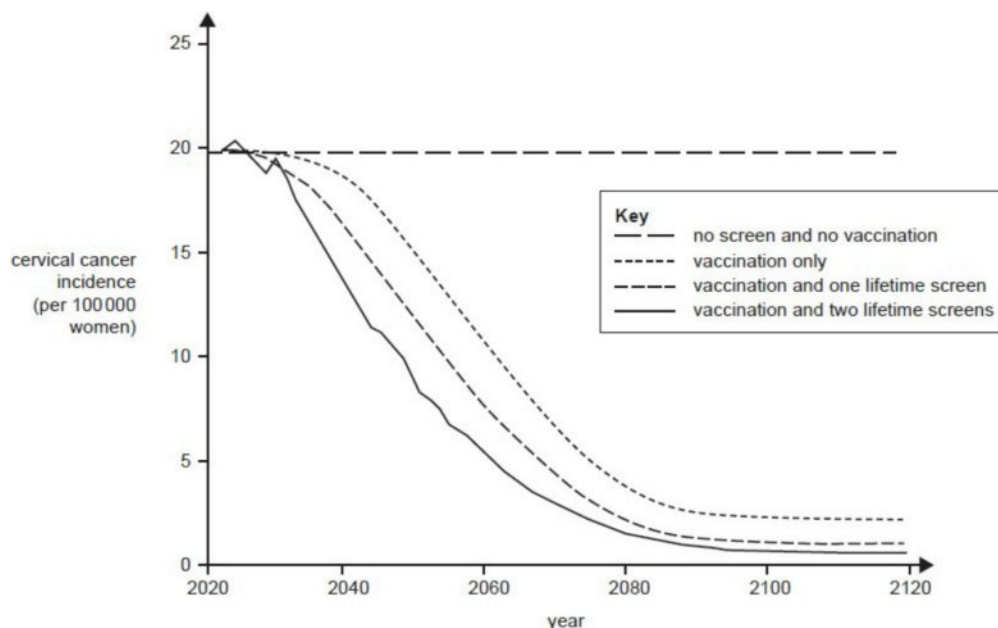
C inject all fruit bats with a vaccine against the virus.

D minimise the number of fruit trees that bats rely on for food.

Question 56/ 145

[VCAA 2021 SA Q34]

The World Health Organization (WHO) runs a campaign to eliminate cervical cancer globally. In response to this campaign, a study was conducted to model the impact of cervical cancer screening along with a human papillomavirus (HPV) vaccination program in low-income and lower-middle-income countries. HPV is the cause of most cervical cancers. The results of the modelling are shown below.



Source: adapted from M Brisson et al, 'Impact of HPV vaccination and cervical screening on cervical cancer elimination: A comparative modelling analysis in 78 low-income and lower-middle-income countries', *The Lancet*, vol. 395 22 February 2020, [https://doi.org/10.1016/S0140-6736\(20\)30068-4](https://doi.org/10.1016/S0140-6736(20)30068-4)

Which one of the following conclusions is supported by the data in the graph?

A The incidence of cervical cancer would be unaffected by a cervical cancer screening program.

B The largest factor in reducing the incidence of cervical cancer in the long term is vaccination.

C With vaccination only, it is possible to achieve fewer than 10 cervical cancer cases per 100 000 women by 2050.

D Vaccination and one lifetime screen would be more effective than vaccination and two lifetime screens by 2070.

Question 57/ 145

Use the following information to answer Questions 58 and 59.

Ross River fever is caused by a virus that lives in kangaroos and wallabies. When a female mosquito bites an infected animal, it picks up viral particles. When the mosquito bites a human, the virus enters the bloodstream. The virus then reproduces in blood cells, resulting in fever, rashes and joint pain.

Question 58/ 145

[VCAA 2013 SA Q16]

Using the information given, it can be concluded that

A the viral vector is a mosquito.

B the virus is a cellular pathogen.

C Ross River water transmits the virus.

D many kangaroos and wallabies would be killed.

Question 59/ 145

[VCAA 2013 SA Q17]

The most effective way to reduce the incidence of Ross River fever in Australia would be to

A prevent humans from living near the Ross River.

B use an attenuated form of the virus to create a human vaccine.

C increase spending on anti-inflammatory drugs to treat the symptoms.

D isolate kangaroos and wallabies in nature reserves near the Ross River.

Question 60/ 145

Use the following information to answer Questions 61 and 62.

In early 2016, there was an outbreak of food poisoning in Victoria linked to the consumption of pre-packaged lettuce. In investigations carried out by the Department of Health and Human Services, several products tested positive for the prokaryote *Salmonella anatum*.

Question 61/ 145

[VCAA 2016 SA Q21]

It is reasonable to say that *S. anatum* is

A a virus.

B a prion.

C an insect.

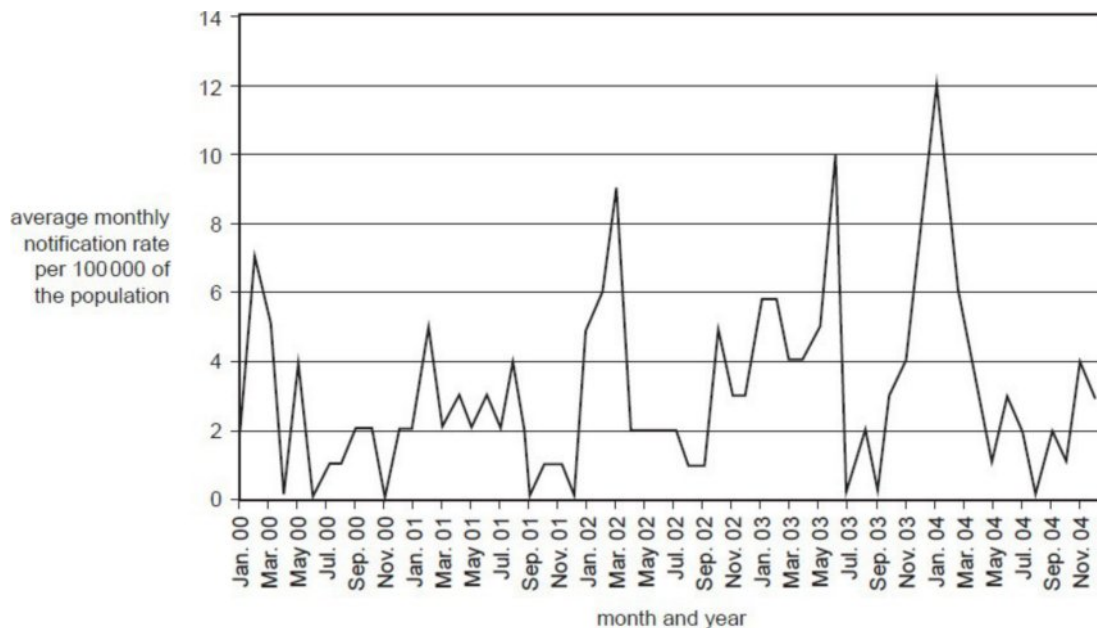
D a bacterium.

Question 62/ 145

[VCAA 2016 SA Q22]

S. anatum is not a common cause of food poisoning. Data has been collected and analysed for the occurrence of illness caused by this organism in Queensland over a five-year period.

The graph that follows displays the average monthly notification rate per 100 000 of the population for the illness caused by *S. anatum*.



It can be concluded from the data that

A there are four periods in which the notification rate is greater than six per 100 000.

B the notification rate is always lowest during September of each year.

C the notification rate is fairly steady over the five-year period.

D the notification rate in 2001 was highest in May.

Question 63/ 145

A four-month investigation was undertaken in the classrooms of a large number of Year 2 and Year 3 students from four primary schools. For the first two months, half of the classes from each school used an antimicrobial gel hand sanitiser, while the other half used soap and water for regular hand hygiene. The students then switched hand-cleaning methods for the final two months. No significant differences in illness were observed between the groups.

The purpose of this investigation was most likely to

A reduce water use in schools.

B encourage students to wash their hands more often.

C reduce the number of students who are away from school due to illness.

D decide if purchasing antimicrobial gel hand sanitiser for students was worthwhile.

Question 64/ 145

Use the following information to answer Questions 65 to 68.

The short-beaked echidna (*Tachyglossus aculeatus*) can be found in Australia and New Guinea. This species is sometimes a target of the illegal wildlife trade.



A university Biology student set out to compare DNA from four different short-beaked echidnas living in four different locations. The student aimed to determine the country of origin of each echidna. This was achieved using primers that amplified a 430-base pair (bp) sequence from the echidna's mitochondrial

genome.

A flow chart of the steps taken by the student is shown below.

Step 1 – Isolate mitochondrial DNA (mtDNA) from the short-beaked echidna's quills (spines).



Step 2 – Amplify the mtDNA at a precise location.



Step 3 – Verify that mtDNA amplification was successful using gel electrophoresis.



Step 4 – Sequence the mtDNA fragments from the gel and compare the samples.

Question 65/ 145

[VCAA 2021 SA Q30]

Which one of the following would be a requirement of either Step 1 or Step 2?

A Step 2 would require the use of a thermocycling machine to maintain the temperature at 37°C.

B Step 1 would require the quill samples to have been stored at a very high temperature.

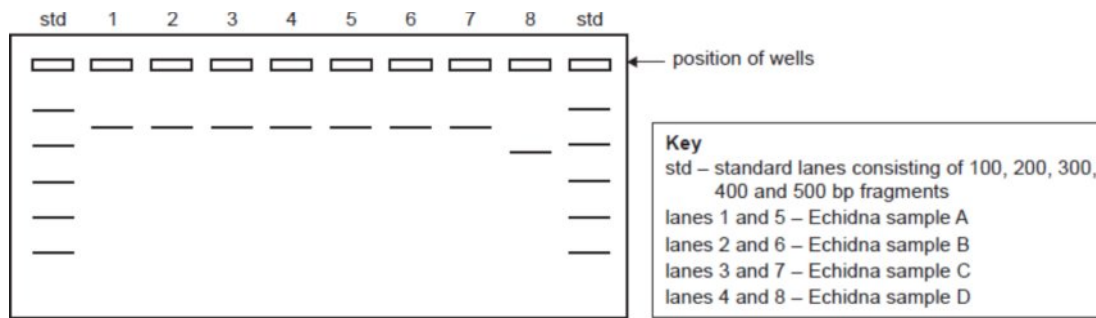
C Step 1 would require the extraction of DNA from the nuclei of quill epithelial cells.

D Step 2 would usually require a reaction mixture containing two primers.

Question 66/ 145

Use the following additional information to answer Questions 67 and 68.

Results from Step 3 – Verification that DNA amplification was successful



Question 67/ 145

[VCAA 2021 SA Q31]

In order for the student's experiment to be valid, the student would need to

A ensure the amplified DNA region is from the correct locus of the echidna's mitochondrial genome.

B be able to have the same set of results replicated by a different observer at a different time.

C demonstrate that the results from the amplified samples were precise.

D repeat the experiment a minimum of three times.

Question 68/ 145

[VCAA 2021 SA Q32]

Attempts to reach a conclusion based on these electrophoresis results may be affected by

A an unidentified systematic error.

B the presence of several outliers in the results.

C a degree of uncertainty in the results for Echidna sample D.

D a random error causing the position of the DNA sample in lane 7.

Question 69/ 145

[VCAA 2021 SA Q33]

The results from Step 4 are shown in the table below. They compare a sequence of 20 bases between the echidna samples. Of the four samples, three were determined to be from Australia and one was determined to be from New Guinea.

Echidna sample	Mitochondrial DNA sequence
A	... ATAGGCATTGCTCTGGGAAT ...
B	... ATTGGCATGGCTCTCGGATT
C	... ATAGGCATTGCTCTGGCAAT ...
D	... ATAGGCATTGCTCTGAGAAT ...

Considering the information provided, which echidna sample is most likely to be from New Guinea?

- A Echidna sample A
 - B Echidna sample B
 - C Echidna sample C
 - D Echidna sample D
-

Question 70/ 145

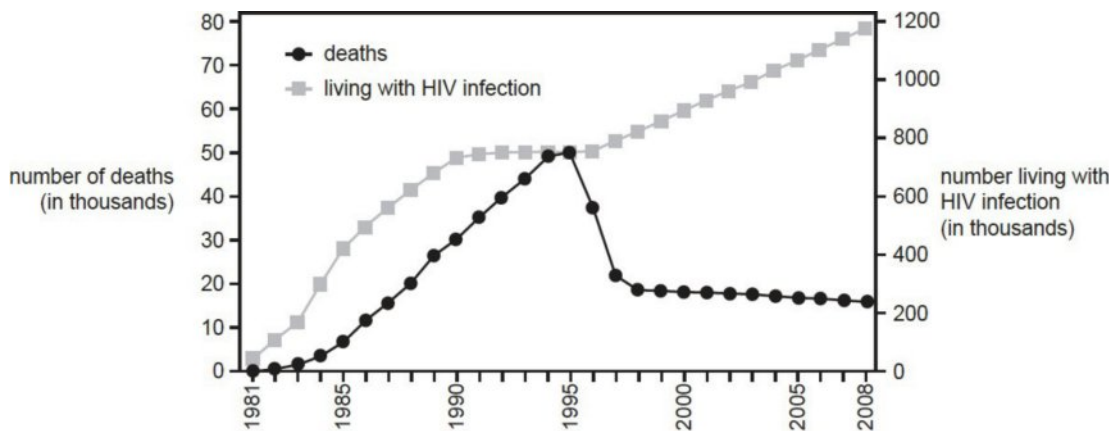
Why are quarantine measures needed when there is an outbreak of an infectious disease in Australian farm animals?

- A To prevent the spread of the disease to food imported into Australia
- B To prevent Australian animals from becoming immune to the disease
- C To prevent introduced plants threatening the survival of Australian farm animals
- D To prevent the disease from spreading to farm animals in different regions of Australia

Question 71/ 145

[VCAA 2018 SA Q29]

The graph below shows the death rates from acquired immune deficiency syndrome (AIDS) and also the number of people infected with the human immunodeficiency virus (HIV). Before 1995 many people infected with the virus went on to develop AIDS, which led to their deaths.



Based on the information in the graph on the previous page, what is the most likely reason for the change in death rates, even though infection rates continued to climb after 1995?

- A People had access to new antiviral drugs.
- B People were educated about what caused HIV infection.
- C People infected with HIV were isolated from the rest of the public.
- D A widespread vaccination program for HIV was introduced within a targeted population.

Question 72/ 145

[VCAA 2021 SA Q36]

A study assessed the effectiveness and safety of a drug called doxycycline. One hundred and fifty adults hospitalised with malaria were involved. These adults were randomly placed into two groups of equal size. One group received doxycycline in addition to standard care. The other group received standard care only.

The group receiving standard care only was the

A control group.

B variable group.

C unsupported group.

D experimental group.

Question 73/ 145

[VCAA 2021 SA Q37]

Viruses can be detected in sewage. Human faecal matter is the main source of pathogenic viruses in sewage. Infected individuals shed viral particles in their faeces.

Which one of the following is an advantage of testing sewage for viral particles in order to control possible virus outbreaks?

A Infected individuals can be prevented from shedding the virus.

B Infection in a community can be rapidly identified.

C Infected individuals can be located quickly.

D Sewage can be treated for the virus.

Question 74/ 145

Use the following information to answer Questions 75 and 76.

The table below compares how eight diseases spread and the number of people likely to be infected by one other infected person.

Disease	measles	whooping cough	rubella	polio	smallpox	mumps	severe acute respiratory syndrome	Ebola

	(SARS)							
How it spreads	airborne droplets	airborne droplets	airborne droplets	fecal–oral route	airborne droplets	airborne droplets	airborne droplets	bodily fluids
No. of people infected from one other person	12 to 18	12 to 17	6 to 7	5 to 7	5 to 7	4 to 7	2 to 4	1 to 4

Question 75/ 145

[VCAA 2018 SA Q32]

What would be the most effective method of preventing the spread of measles during an outbreak?

- A Wash hands thoroughly after going to the toilet.
 - B Establish a ‘clean needle’ exchange program.
 - C Vaccinate all infected people.
 - D Isolate all infected people.
-

Question 76/ 145

[VCAA 2018 SA Q33]

Based on the information in the table, which one of the following statements is correct?

- A Ebola is the most contagious disease.
- B Polio and smallpox have a similar infection rate.
- C More people would die from measles than any other disease shown.
- D The fecal–oral route is the most effective means of spreading pathogens.

Question 77/ 145

[VCAA 2017 SA Q37]

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

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

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

A This outbreak of yellow fever is considered to be a pandemic.

B Infected individuals who travel to other areas of Brazil will not increase the spread of the disease.

C This outbreak of yellow fever is occurring in populations with high vaccination rates for yellow fever.

D Elimination of mosquito breeding sites in areas with yellow fever will reduce the number of individuals affected.

Question 78/ 145

[VCAA 2020 SA Q34]

Bovine spongiform encephalopathy (BSE) is a prion disease of cattle. It is sometimes called mad cow disease. It is caused by feeding cattle food that contains prions from other infected animals. The time between infection and symptoms appearing can be up to five years. There are concerns that variant Creutzfeldt–Jakob disease (vCJD) in humans could be caused by eating infected cattle meat.

Yellow fever is a viral disease that affects humans. The yellow fever virus can cause symptoms three to six days after infection. The virus is carried by a mosquito vector.

Which combination of approaches would be most effective at controlling the risk of outbreaks of both vCJD and yellow fever?

vCJD

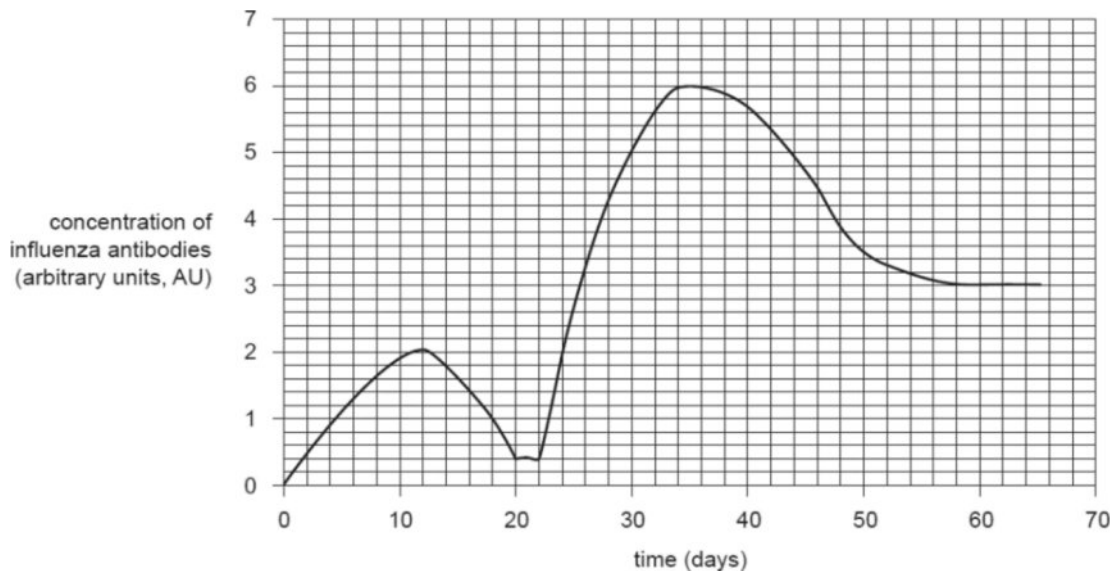
Yellow Fever

A Prevent all cattle that show symptoms of mad cow disease from reproducing.	Remove breeding grounds for mosquitoes.
B Test all cattle for the presence of the prions.	Ensure that all healthcare professionals wear gloves when working with infected patients.
C Destroy all cattle that have been fed infected food containing the prions.	Ensure that people take measures to reduce their chances of being bitten by mosquitoes.
D Stop selling cattle meat.	Instruct people who are infected with yellow fever to wear masks in public places.
-

Question 79/ 145

[VCAA 2017 SA Q26]

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



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

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

Question 80/ 145

[VCAA 2016 SA Q24]

In the search for a malaria vaccine, scientists have focused on a protein called circumsporozoite protein (CSP).

CSP is secreted by the malaria parasite and is present on its surface. For the vaccination to work, the scientists want CSP to act as

A an antigen.

B an allergen.

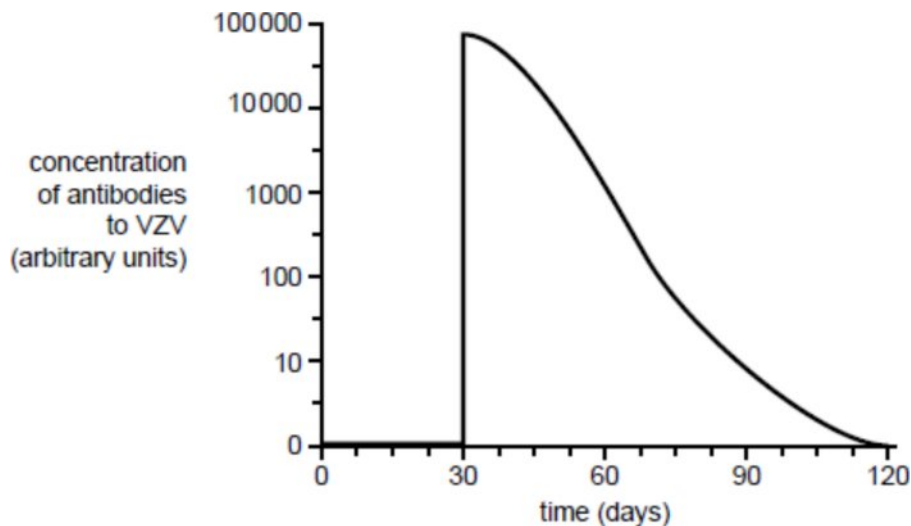
C an antibody.

D a complement protein.

Question 81/ 145

[VCAA 2015 SA Q14]

Chickenpox (varicella) is a highly contagious viral disease caused by the varicella-zoster virus (VZV). A technician measured the concentration of antibodies to VZV in a person's blood over a 120-day period. An event occurred on day 30 that significantly altered the concentration of antibodies. The concentration of antibodies over the 120 days is displayed in the graph below.



Which one of the following events could have occurred on day 30?

- A an exposure of the person to VZV
 - B a booster vaccination against VZV for the person
 - C an injection of antibodies to VZV into the person
 - D an oral dose of antibiotics was given to the person
-

Question 82/ 145

[VCAA 2012 E1 SA Q18]

Rubella is a virus that causes a highly contagious infection. When infected with rubella, humans initially produce IgM antibodies and then IgG antibodies. IgM antibodies do not cross the placenta.

Tests for the presence of IgM and IgG antibodies are carried out on a newborn baby if its mother has been diagnosed with a rubella infection during pregnancy. The results from tests carried out on four newborn babies before they had been fed are shown in the following table.

Antibodies for the rubella virus found in the baby's blood

Baby 1	none
Baby 2	IgG
Baby 3	IgM
Baby 4	IgM

Using your knowledge and the information given, it would be correct to conclude that

- A the mother of baby 1 has immunity to the rubella virus.
 - B baby 2 will have about two years of passive immunity to the rubella virus.
 - C baby 3 received IgM antibodies to the rubella virus from its mother.
 - D baby 4 was exposed to the rubella virus during fetal development.
-

Question 83/ 145

[VCAA 2012 E1 SA Q19]

At about 12 months of age a baby is immunised against measles, mumps and rubella.

The immunity the baby acquires as a result of this vaccination is called

- A active and natural.
 - B active and induced (artificial).
 - C passive and natural.
 - D passive and induced (artificial).
-

Question 84/ 145

[VCAA 2021 SA Q19]

A new treatment for some cancers includes the use of conjugated monoclonal antibodies, which have an anti-cancer drug attached.

The main advantage of using conjugated monoclonal antibodies in this new cancer treatment is that they

- A decrease the amount of the anti-cancer drug delivered to cancerous cells.
- B reduce the effects of the anti-cancer drug on non-cancerous cells.

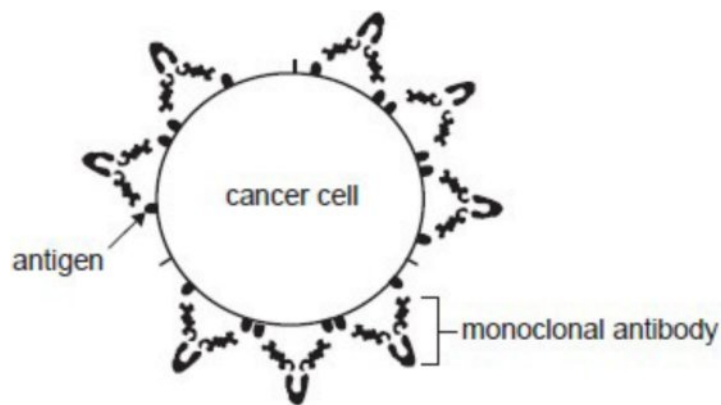
C cause an increase in the number of memory T cells.

D stimulate B cells to produce antibodies.

Question 85/ 145

[VCAA 2020 SA Q35]

Monoclonal antibodies attaching to antigens on a cancer cell are shown in the diagram below.



Source: adapted from N Halim, 'Monoclonal antibodies:
A 25-year roller coaster ride', *The Scientist*, 20 February 2000,
<www.the-scientist.com>

Monoclonal antibodies

A are used to suppress B cells acting on cancer cells.

B make it easier for cells of the immune system to detect cancer cells.

C can bind to dendritic cells to stimulate them to destroy cancer cells.

D can attach to many structurally different proteins found on the surface of cancer cells.

Question 86/ 145

[VCAA 2020 SA Q25]

DOCK8 syndrome is a disorder in which both B cells and T cells are defective. Patients with DOCK8 syndrome face a range of health issues, including repeated bacterial and viral infections, as well as an increased risk of cancer.

DOCK8 syndrome could be classified as

- A acquired immunity.
 - B an allergic reaction.
 - C an autoimmune disease.
 - D an immune deficiency disease.
-

Question 87/ 145

[VCAA 2021 SA Q18]

One method of assessing the progress of multiple sclerosis (MS) in patients detects fragments of the protein NfL. These protein fragments are released into spinal fluid and blood when nerves are damaged.

It can be expected that patients with progressive MS will have

- A an increased number of T helper lymphocytes.
 - B lower levels of the NfL protein in the blood.
 - C thicker myelin sheaths around nerves.
 - D levels of antibodies.
-

Question 88/ 145

[VCAA 2019 SA Q22]

In multiple sclerosis, which specific part of the nervous system do immune cells attack?

- A the receptors of post-synaptic nerve cells.

B the myelin sheath around nerve cells.

C the nuclei of nerve cells.

D the neurotransmitters.

Question 89/ 145

[VCAA 2018 SA Q16]

Lupus is a condition that results in the increased secretion of antibodies that attach themselves to healthy cells in a patient's body. The accumulation of these antibodies causes inflammation, joint pain, rash, fatigue and fever.

Lupus is an example of

A an allergic reaction.

B an autoimmune disease.

C an immune deficiency disease.

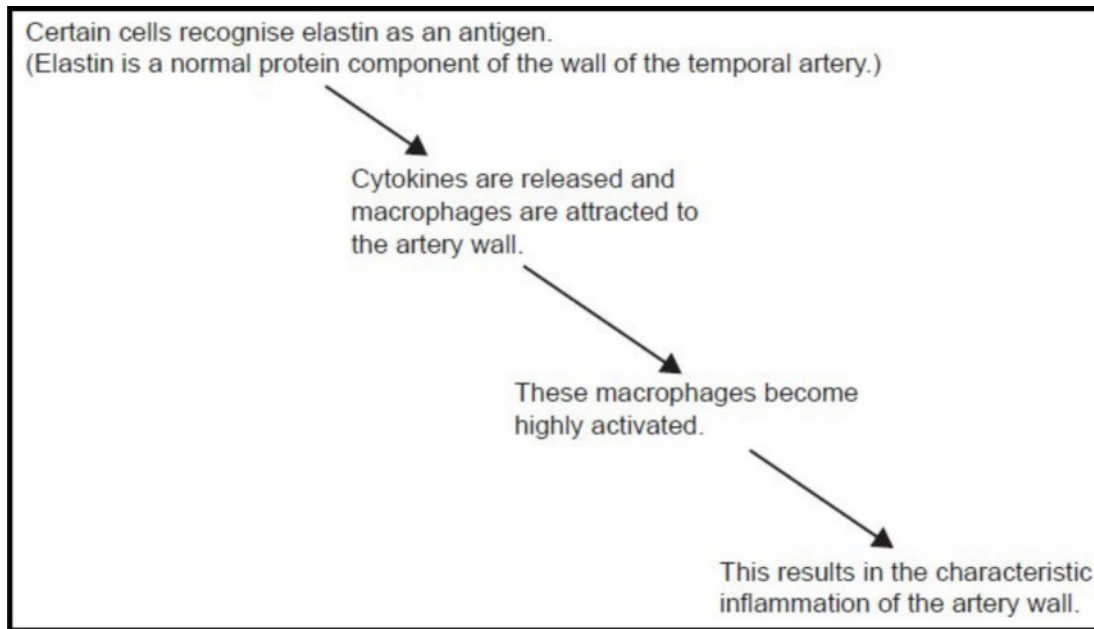
D a complement protein response.

Question 90/ 145

[VCAA 2016 SA Q25]

Temporal arteritis is a human disease in which the temporal arteries become inflamed. This causes headaches and may result in blindness or stroke.

The sequence of responses in this disease is as shown in the diagram below.



Considering the information on the previous page, temporal arteritis is

- A an immunodeficiency disease.
 - B a pathogenic disease.
 - C an allergic response.
 - D an autoimmune disease.
-

Question 91/ 145

[VCAA 2015 SA Q19]

Autoimmune diseases are different from diseases caused by pathogens because in all autoimmune diseases

- A certain self-tissues are not recognised as ‘self’ and this causes an immune response to the tissues.
 - B histamine is released from mast cells to cause an inflammatory response.
 - C complement protein causes the breakdown of healthy cells.
 - D interferon is released to kill infected tissue.
-

Question 92/ 145

[VCAA 2017 SA Q24]

Researchers investigating MS have analysed various tissue samples from patients. In these samples they would expect to find

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

Question 93/ 145

[VCAA 2017 SA Q25]

Scientists are investigating factors that increase the likelihood of developing MS. Recently, the ‘hygiene theory’ has been considered a possible factor. This theory proposes that, if a child's environment is overly hygienic and does not allow sufficient exposure to a wide range of non-self-antigens, an overactive immune system will result later in life.

A recent study tested for the presence of antibodies to the bacteria that cause stomach ulcers, *Helicobacter pylori*, in the blood of 550 MS patients and 299 healthy people. Both groups of people had the same proportion of each gender and were of similar age. Exposure to *H. pylori* usually occurs by the age of two years. The results of the antibody testing showed that the rate of *H. pylori* infection was 30% lower in the women with MS than in the healthy women or healthy men.

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

Question 94/ 145

[VCAA 2014 SA Q10]

In the disease multiple sclerosis, the myelin sheath surrounding the axons of neurons is broken down. One of the symptoms of multiple sclerosis is weakening of the muscles.

A possible cause for this weakening could be

A the transmission of electrical impulses along the axons of neurons is slowed.

B the size of the electrical impulses travelling along the axons is smaller.

C neurotransmitter receptors on the muscle cells have become less sensitive.

D neurotransmitters are inhibited from travelling along the neurons.

Question 95/ 145

[VCAA 2018 SA Q24]

Monoclonal antibodies can be produced and used to treat different types of cancers. Which one of the following is a correct statement about monoclonal antibodies?

A Monoclonal antibodies are carbohydrate molecules.

B Monoclonal antibodies produced from the same clone of a cell are specific to the same antigen.

C Monoclonal antibodies pass through the plasma membrane of a cancer cell and attach to an antigen within the cell.

D Monoclonal antibodies produced to treat stomach cancer will be identical to monoclonal antibodies produced to treat breast cancer.

Question 96/ 145

[VCAA 2018 SA Q35]

The emergence of antibiotic-resistant diseases in humans means that

A antibiotics are causing resistance mutations in bacteria.

B some bacteria are less sensitive to antibiotics.

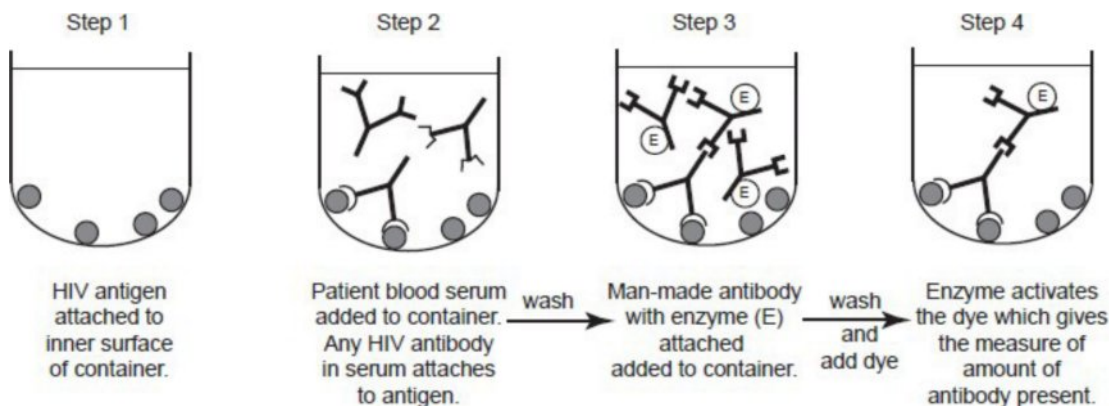
C viruses are becoming resistant to antibiotics.

D humans are less sensitive to antibiotics.

Question 97/ 145

Use the following information to answer Questions 98 and 99.

A diagnostic test for HIV infection includes the following steps.



Question 98/ 145

[VCAA 2012 E1 SA Q24]

This test for HIV is reliable because the

A dye reacts with the patient's blood serum.

B enzyme has an active site for the HIV antigen.

C man-made antibody has the same shape as the HIV antigen.

D HIV antigen has a complementary shape specific to the HIV antibody.

Question 99/ 145

[VCAA 2012 E1 SA Q25]

The results of the tests of three patients are given in the following table.

Positive control	Negative control	Patient R	Patient S	Patient T
1.689	0.153	0.155	0.675	1.999

Numbers are expressed as optical density at 450 nm. The more intense the dye is, the higher the optical density. The cut-off value indicating a positive result is 0.500. Values below 0.300 are considered to be negative. The results of these tests suggest that

A patient T has not been exposed to HIV.

B patient R has been exposed to the HIV antigen.

C patient S has responded to exposure to HIV by developing antibodies.

D the positive control contained fewer HIV antibodies than the negative control.

Question 1/ 166

[VCAA 2019 SB Q3]

The human immune system consists of a series of defensive barriers that protect the body from infection. When bacteria come into contact with the body, they immediately encounter these defences and must bypass each barrier if they are to survive and infect the body.

a When bacteria come into contact with the body, they must gain access to living tissues to become pathogens.

List **two** possible routes the bacteria could use to access the living tissues of the body. (2 marks)

b Once bacteria are within or have access to the living tissues of the body, before cells are aware of their presence, the bacteria will encounter chemical barriers.

List **one** of these chemical barriers and explain its function. (2 marks)

c When an inflammatory response starts, the first cellular responders will be cells from the innate immune system. One of these cells releases histamine.

How does histamine contribute to the inflammatory response? (1 mark)

d If bacteria are not destroyed by innate immune responses, adaptive immune responses become involved.

Describe how an adaptive immune response is initiated during a bacterial infection. (2 marks)

(Total 7 marks)

Question 2/ 166

[VCAA 2018 SB Q3]

Plants are a rich source of nutrients for many organisms, including bacteria, fungi and viruses. Although plants lack an immune system that is comparable to animals, plants have evolved chemical barriers to stop invading pathogens from causing significant damage.

a Describe **two** chemical barriers that could be present in a plant that is protecting itself from an invading pathogen. (2 marks)

b Humans have a sophisticated immune response to invading pathogens. State **two** ways that pathogens are prevented from entering the internal environment of the human body. (2 marks)

c Outline how complement proteins and natural killer cells protect the human body once a pathogen has gained entry to the internal environment. (2 marks)

(Total 6 marks)

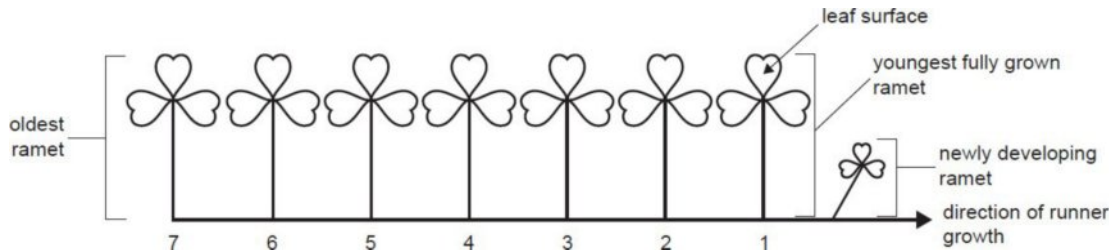
Question 3/ 166

[Adapted VCAA 2017 SB Q2]

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

a Describe **one** example of a physical method of defence in a plant. (2 marks)

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



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

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

Stage 1 – Leaf damage preparation

Runner A

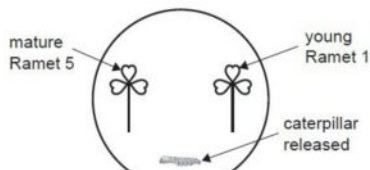
Ramets 6 and 7 were each enclosed in a separate, plastic mesh cage for four days.

Runner B

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

Stage 2 – Food choice test

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



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



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

b What was the role of Runner A ramets? (1 mark)

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

White clover (*T. repens*) leaf surface area eaten by caterpillars (*S. exigua*) in food choice test ($n = 40$)



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

c Referring to the data, compare the average leaf surface area of young ramets eaten by the caterpillars in Runner A and Runner B. (1 mark)

(Total 4 marks)

Question 4/ 166

[Adapted VCAA 2011 E1 SB Q5]

Neisseria meningitidis is a bacterium that causes meningitis. This disease causes inflammation of tissue surrounding the brain and spinal cord in humans. Bacteria enter through plasma membranes as shown in the figure below.



a Name the process shown in the figure. (1 mark)

In an attempt to prevent the spread of the bacteria, the immune system releases antibodies and macrophages to an area of infection.

b Describe how antibodies and macrophages inhibit the spread of *N. meningitidis*. (2 marks)

N. meningitidis can protect itself from the immune system by releasing a protease that breaks the subunits of the antibody.

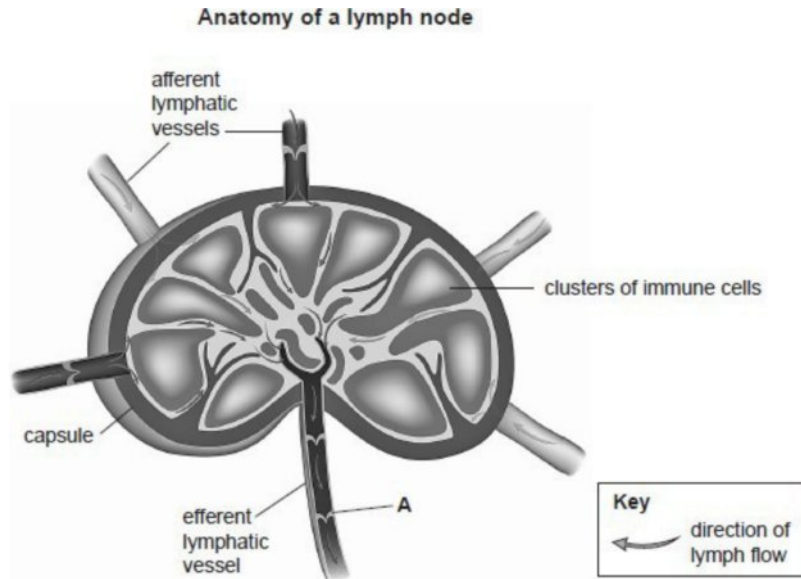
c Why is this enzyme named a protease? (1 mark)

(Total 4 marks)

Question 5/ 166

[VCAA 2015 SB Q5]

Consider the following diagram of a lymph node.



a Describe the role of the structure labelled A, found within the efferent lymphatic vessel. (1 mark)

Immune cells are clustered within the lymph node (see diagram). There is more than one type of immune cell within each of these clusters.

b Name and describe the role of one type of immune cell found within these clusters that plays a role in the innate immune response. (2 marks)

c Another of the immune cell types found within these clusters has a large nucleus and extensive rough endoplasmic reticulum, and plays an important role in an adaptive immune response.

Name this cell type and explain how the extensive rough endoplasmic reticulum assists this cell to perform its function. (2 marks)

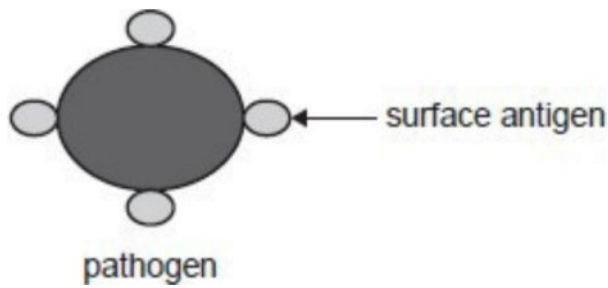
(Total 5 marks)

Question 6/ 166

[VCAA 2014 SB Q4]

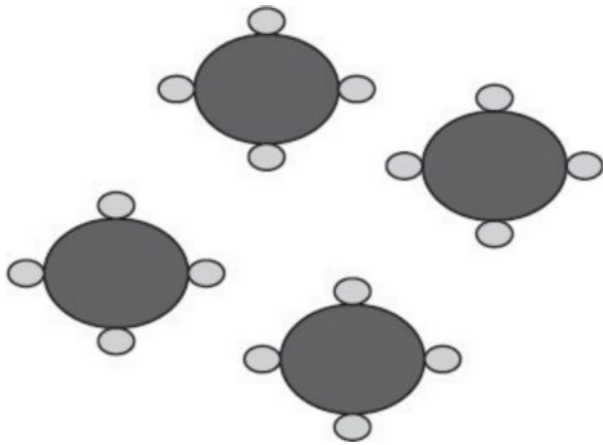
a Define the term 'pathogen'. (1 mark)

The diagram below shows a generalised pathogen with antigens on its surface. The immune system responds to antigens by making antibodies.



b Draw an antibody that would be effective against this pathogen. Label the different parts of the antibody. (2 marks)

One way that antibodies work is by forming antigen–antibody complexes. The diagram below shows four pathogens.



c i Illustrate on the diagram above how the antigen–antibody complex forms, using at least four antibodies in your drawing. (2 marks)

ii Explain how an antigen–antibody complex provides protection against these pathogens. (2 marks)

(Total 7 marks)

Question 7/ 166

[VCAA 2016 SB Q5]

Yellow fever is a potentially fatal, mosquito-borne, viral disease that occurs in many countries in Africa, the Caribbean, and Central and South America. An effective and safe vaccine has been available since 1938.

a What is a vaccine? (1 mark)

b For the vaccine to be effective, it is recommended that travellers to these regions have the vaccination approximately two to four weeks before travelling.

Why is this time frame recommended? (2 marks)

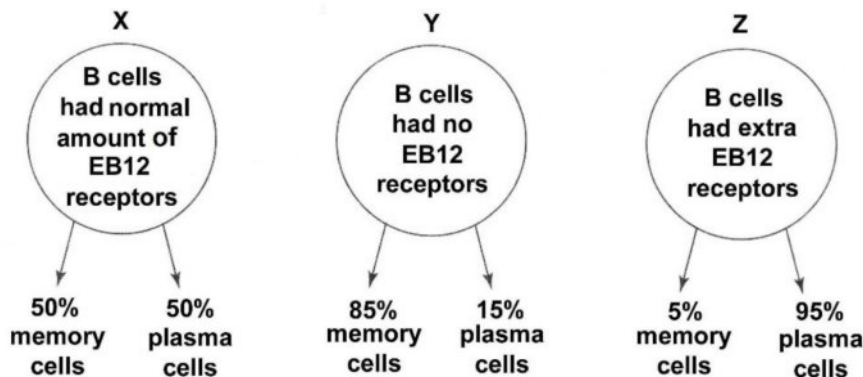
c Recent research shows that the vaccine gives lifelong immunity.

Name **two** different cell types that would be important in providing lifelong immunity and explain the **role** of each in providing lifelong immunity. (4 marks)

(Total 7 marks)

Question 8/ 166

[VCAA 2010 E1 SB Q4]



EB12 is a receptor on the B cells of mice that helps determine if a cell becomes a plasma or a memory cell. Scientists used three different strains of mice to investigate B cell immunity. None of the strains had been exposed to the influenza virus. The strains were as follows.

The three mice strains were infected with the influenza virus.

a Explain which strain, X, Y or Z, would be best at destroying the fast-acting influenza virus. (2 marks)

b Explain how blocking the action of EB12 receptors could result in the production of a more efficient vaccine. (2 marks)

(Total 4 marks)

Question 9/ 166

[VCAA 2020 SB Q5]

a The human immune system uses several different types of cells to eliminate virally infected cells.

Name **one** of these cells and outline how it eliminates virally infected cells. (2 marks)

b i State the role played by the lymphatic system in an immune response. (1 mark)

ii Describe the sequence of events that occurs in the secondary lymphoid tissue that results in the production of antibodies. (4 marks)

(Total 7 marks)

Question 10/ 166

[VCAA 2017 SB Q4]

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

a i What is meant by the term 'sterile' in the context given? (1 mark)

ii Consider a hospital environment. Give two examples of how sterile conditions can be achieved in a hospital. (2 marks)

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

b Describe at a molecular level how antibodies perform their function. (2 marks)

c Name the type of immunity that the joey obtains from the antibodies in the milk and explain how this form of immunity is beneficial to the joey. (3 marks)

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

d i Name the part of the immune system to which these peptides and the other listed chemicals belong. (1 mark)

ii Circle one of the chemicals below, found in Tammar wallaby milk, and describe its role in protecting the

joey against pathogens.

lysozyme complement proteins cytokines venom inhibitors

(1 mark)

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

Suggest what the scientists would hope to achieve as a result of further testing of these peptides with antibiotic properties. (1 mark)

(Total 11 marks)

Question 11/ 166

[VCAA 2021 SB Q4]

Varicella (chickenpox) is a highly contagious disease caused by the varicella zoster virus. A live, attenuated varicella zoster virus vaccine is recommended for children at age 18 months. In Australia, this vaccine is provided free of charge under the National Immunisation Program.

a Once the varicella zoster virus vaccine is injected into the arm of a child, an immune response occurs.

Summarise the immune response that occurs within the child to result in long-term protection from chickenpox. (5 marks)

b If a person has not been vaccinated and is older than 14 years, it is recommended that this person has two doses of the varicella zoster virus vaccine. The second dose should be given at least four weeks after the first dose. What is the benefit of having two doses instead of one dose? Justify your response. (2 marks)

c Outline similarities and/or differences in active and passive ways of acquiring immunity. (3 marks)

(Total 10 marks)

Question 12/ 166

A vaccine for cancer

Scientists are investigating whether it is possible to produce a vaccine that will work against cancer cells. Currently there are vaccines available against certain viruses that are known to cause cancer. For example, the human papillomavirus vaccine is highly effective in preventing cervical cancer. The vaccine contains virus-like particles that have antigens that are found on the surface of the human papillomavirus. These antigens stimulate an immune response when injected into the individual but do not cause disease. The vaccine is very effective as the immune response produces high levels of antibodies.

This example is considered a conventional vaccine. Conventional vaccines contain either a dead or inactivated version of a pathogen, or a protein from that pathogen. Conventional vaccines can take many months to produce.

As most cancers are not caused by viruses, scientists investigated whether a non-conventional vaccine could be developed. A vaccine containing mRNA was produced. mRNA codes for the production of a protein that must be produced by the cells of the individual injected with the vaccine. This protein manufactured by the cells acts as an antigen and, when released from the cells, results in an immune response within the individual.

The scientists determined the genetic code of an antigen found on the surface of a particular cancer cell. They assembled a molecule of mRNA that would code for this antigen. Many copies of this mRNA molecule were then incorporated into a vaccine. In December 2019, a clinical trial to test for a new type of vaccine took place. Individuals injected with the mRNA vaccine produced an immune response that resulted in antibodies that acted against the antigen found on the surface of the cancer cells.

Scientists realised that they could potentially quickly produce vaccines for many different cancers by changing the nucleotide sequence of the mRNA molecule. However, designing vaccines for cancers is not that simple. Cancer cells can easily evade immune cells and continue to reproduce. Mutations can cause changes to the target antigens on the surface of cancer cells. A vaccine designed for one person may not work for another person as their cancers have different mutations.

Reference: N Pardi, MJ Hogan, FW Porter and D Weissman, ‘mRNA vaccines – A new era in vaccinology’, *Nature Reviews Drug Discovery*, vol. 17, April 2018, <https://doi.org/10.1038/nrd.2017.243>

a i According to the article, what are the contents of conventional vaccines and how do they lead to an improved immune response when a person encounters a pathogen? (2 marks)

ii Explain how mRNA vaccines are different from conventional vaccines. (2 marks)

b Using the information in the article above, identify the advantages of developing mRNA vaccines for the treatment of cancer. Outline an ethical concept that should be taken into account when developing mRNA vaccines. (4 marks)

(Total 8 marks)

Question 13/ 166

Captain Arthur Phillip accompanied by about 1500 convicts, soldiers and civilians arrived in Sydney Cove in 1788. Within 10 years the indigenous population was reduced by 90%. Name and explain **two** reasons for this decrease.

Reason

Explanation

(Total 4 marks)

Question 14/ 166

[VCAA 2020 SB Q10]

Measles in Samoa

Measles is one of the most contagious viruses affecting humans. Measles spreads when an infected person coughs or sneezes and the virus is breathed in by another person, or by direct contact with bodily fluids. In a susceptible population – people who have neither been vaccinated nor had measles previously – one person with measles could infect 12 to 18 other people.

The Pacific Island nation of Samoa had a significant measles outbreak in 2019. This started when a person who had measles arrived in Samoa by plane in August 2019. In the following months over 5000 measles cases were recorded and more than 70 people died.

A measles outbreak was declared by the Samoan Government in October 2019. On 15 November the Samoan Government declared a 30-day state of emergency as the number of measles cases continued to rise and more people died. Ninety per cent of the deaths were among children less than five years old.

More than one in five Samoan babies aged six to 11 months contracted measles during this outbreak and more than one in 150 babies in this age group died. Fewer deaths occurred in babies who were less than

six months old.

Prior to the measles outbreak in Samoa, the vaccination rate for measles for five-year-old children in the country had fallen to 31% in 2018. One of the responses of the government to the outbreak was a mandatory vaccination program for all people. By early December 2019 over 90% of the population had been vaccinated.

In Australia a measles-containing vaccine (MMR vaccine) is recommended for children aged 12 months of age or older. A single dose of the measles vaccine provides protection for between 95% and 98% of recipients, while two doses protect 99% of vaccinated people. In 2018 in Australia, 95% of five-year-old Australian children were fully vaccinated.

Reference: K Gibney, 'Measles in Samoa: How a small island nation found itself in the grips of an outbreak disaster', *The Conversation*, 12 December 2019, <<https://theconversation.com/au>>

a Is the measles outbreak discussed in the article above best described as an epidemic or a pandemic? Give your reasoning. (2 marks)

b Consider the Samoan children who were less than five years old during the measles outbreak. Of this group, what age were the children who were least likely to die from measles? Explain why children of this age would be less likely to die. (2 marks)

People who are vaccinated are unlikely to be affected by the measles virus.

c i What is the percentage difference between vaccinated five-year-old children in Samoa and Australia in 2018? (1 mark)

ii The MMR vaccine contains antigens for measles, mumps and rubella. What form of immunity is given when a person is vaccinated with the MMR vaccine? (1 mark)

iii Some children, for example those undergoing chemotherapy, cannot be vaccinated. Explain how high vaccination rates can also protect unvaccinated individuals. (2 marks)

d Describe two strategies, other than vaccination, that could reduce the transmission of measles. (2 marks)

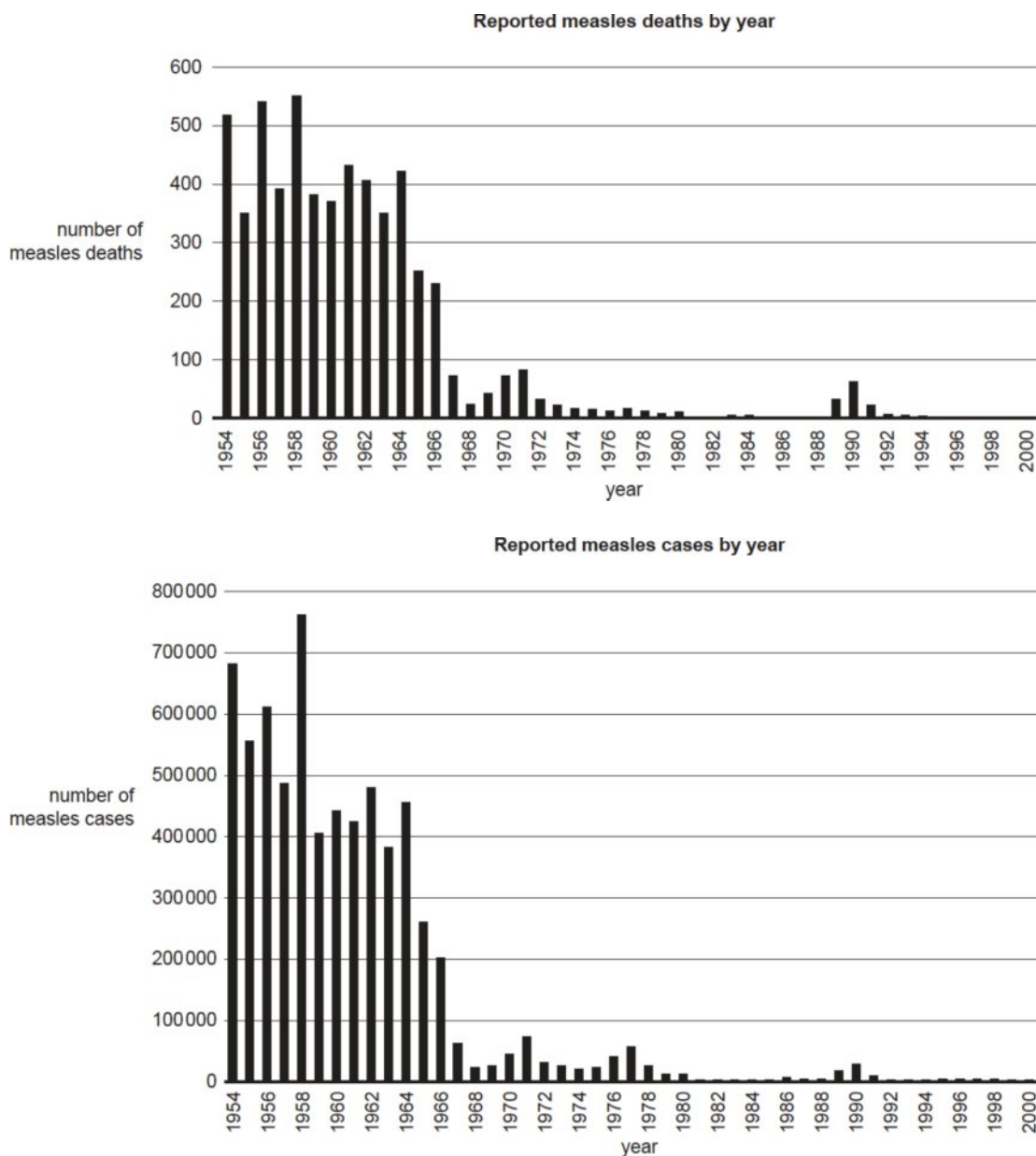
(Total 10 marks)

Question 15/ 166

[VCAA 2018 SB Q5]

Measles is a highly infectious and dangerous disease. Young children and individuals with impaired immunity are especially susceptible to measles.

Analyse the graphs below and on the next page that show the number of people in the United States of America (USA) who were infected with measles during the period 1954–2000 and the number of people who died as a result of having measles during the same period.



Data: ProCon.org

a i Which year had the greatest number of reported measles cases? (1 mark)

ii What trends can be observed when the two graphs are compared? (2 marks)

b Controlling the number of measles cases in a population relies on herd immunity.

What is herd immunity and how does it help control the number of cases of this disease? (2 marks)

(Total 5 marks)

Question 16/ 166

[VCAA 2022 SB Q7]

Before the chickenpox vaccine was developed, many people used ‘chickenpox parties’ as a way to infect their children with the virus. The idea was to enable the children to become immune to the virus before reaching adulthood, when the symptoms of the infection can be more severe. Some people continue to hold ‘chickenpox parties’ as an alternative to receiving the vaccine. However, the Center for Disease Control and Prevention (CDC) in the United States of America (USA) warns against this practice, saying that chickenpox can have severe and sometimes unpredictable or life-threatening consequences. The CDC recommends vaccination as a safe way to develop immunity to chickenpox.

a What is the name given to the type of immunity that would develop in children who became infected at the ‘chickenpox parties’? (1 mark)

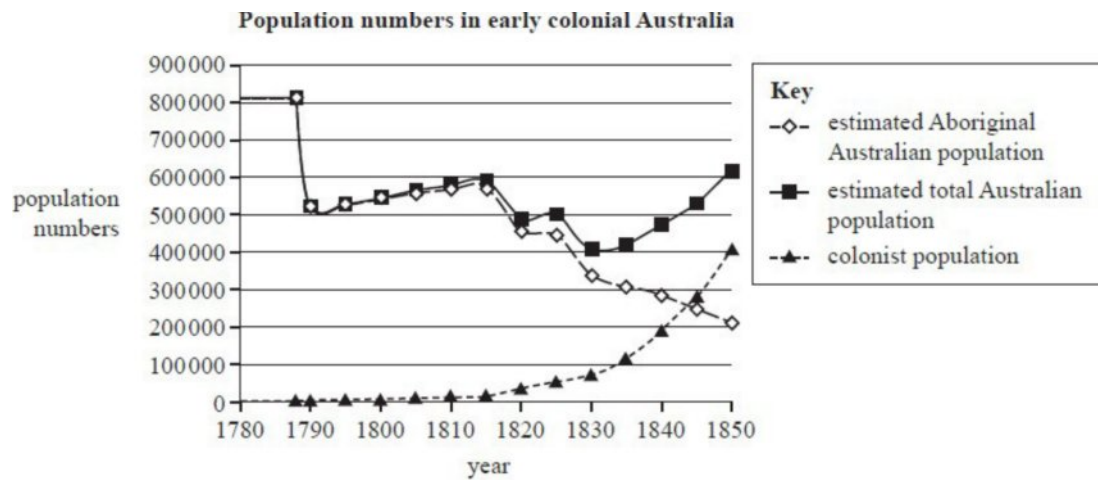
b A summary of case-control studies conducted from 1997 to 2003 and analysed by the Australian National University showed that a single dose of varicella (chickenpox) vaccine was 97% effective in the first year after vaccination and 86% effective in the second year. From the second to eighth year after vaccination, the vaccine's effectiveness remained stable at 81% to 86%. Most vaccinated children who developed chickenpox during the eight years after vaccination had a mild case of the disease.

Why do most vaccinated individuals, if they are infected, show only a mild case of the disease? (2 marks)

c Smallpox is widely believed to be the cause of the significant population decline in Indigenous populations during early European arrival in Australia. Recent research suggests that it may have been chickenpox that caused the change in population numbers rather than smallpox. It is thought that chickenpox did not exist in Aboriginal and Torres Strait Islander communities before European arrival. Chickenpox is fairly mild in young children and is easily transmitted. It can be a fatal disease in adults who were not infected as children.

The graph below shows population numbers during the period 1780–1850:

- the estimated Aboriginal Australian population
- the colonist population
- the estimated total Australian population.



Source: adapted from BH Hunter and J Camody, 'Estimating the Aboriginal population in early colonial Australia: The role of chickenpox reconsidered', *Australian Economic History Review*, vol. 55, no. 2, July 2015, <<https://doi.org/10.1111/aeht.12068>>

With reference to chickenpox, explain how infection may have caused such a large impact on the Aboriginal Australian population and yet did not affect the population numbers of the colonists significantly, and why the Aboriginal population increased from 1790 to 1810. (3 marks)

(Total 6 marks)

Question 17/ 166

[VCAA 2015 SB Q4]

In 2014, an outbreak of Ebola virus disease (EVD) occurred in West Africa. Humans may contract the virus from infected animals or from an infected person.

In 2014, there was no safe and effective vaccine available to prevent EVD.

a Explain how an effective vaccine could provide long-term immunity to EVD. (4 marks)

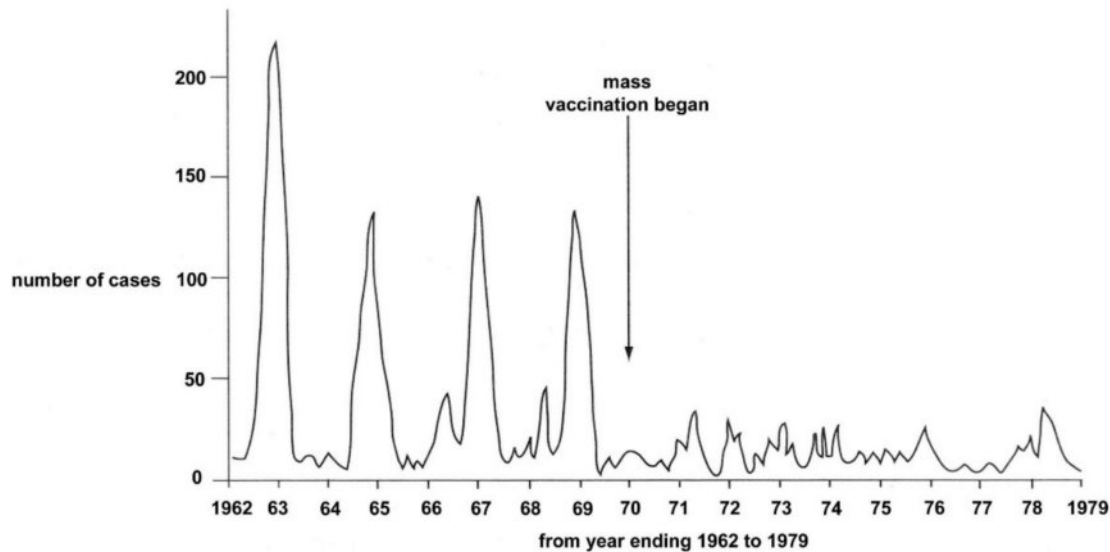
b Scientists developing new vaccines for EVD are conducting trials in animal subjects. To evaluate the effectiveness of a new vaccine, both humoral and cell-mediated responses are measured in the animal subjects.

Explain how these two immune responses are different. Give differences in your answer. (2 marks)

(Total 6 marks)

[VCAA 2010 E1 SB Q8]

Measles is a highly contagious, serious disease caused by an RNA virus. There were regular epidemics of the disease until the introduction of mass vaccination. The following graph indicates the incidence of measles in Victoria from 1962 to 1979.



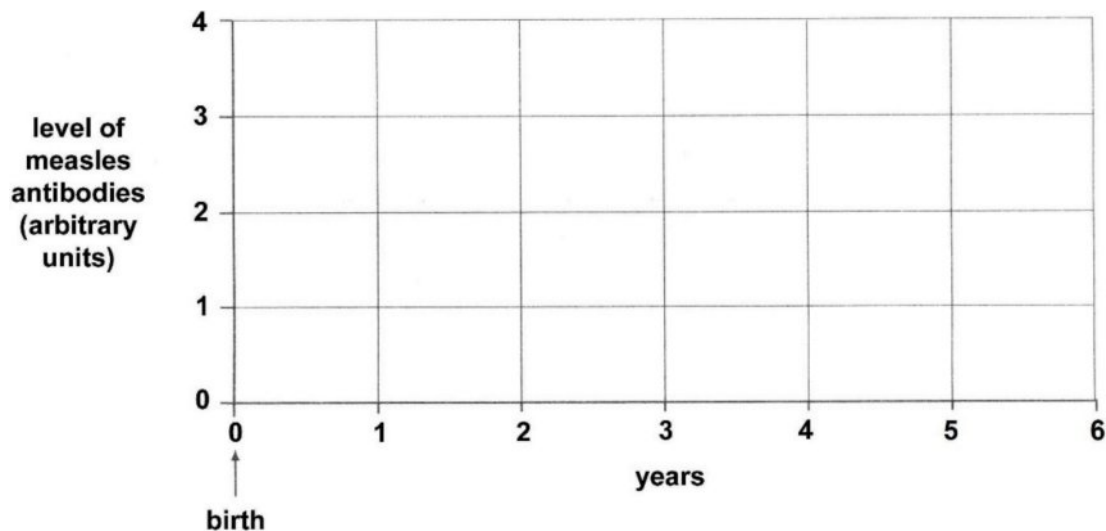
a What was the time period between successive epidemics? (1 mark)

An unaffected person without immunity has a 90 per cent chance of catching the disease if they live in the same house as a person with the disease. If a child is suspected of having measles, a serum sample is taken and tested for measles-specific IgM and IgG antibodies.

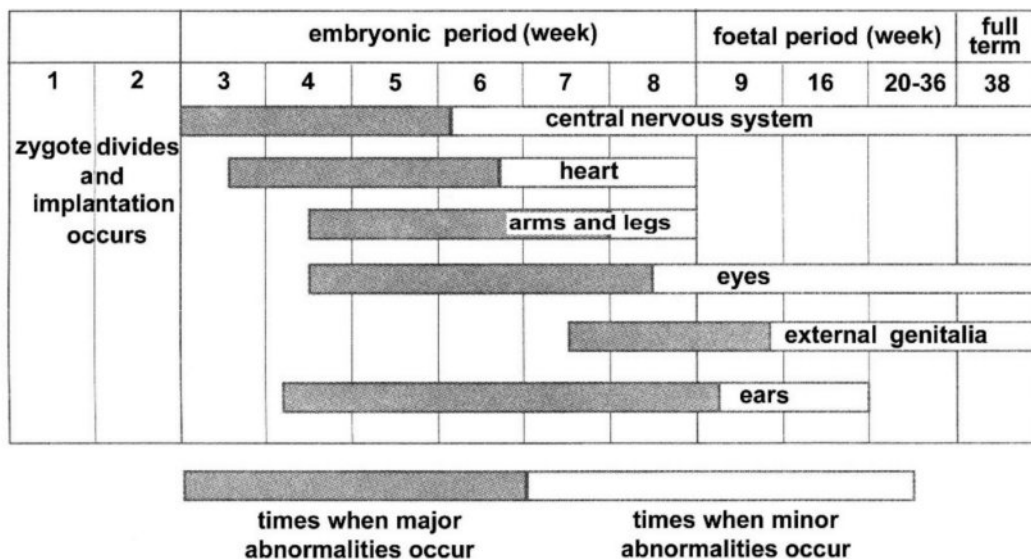
b What conclusion could be made if high levels of these antibodies were found and what action would be taken? (2 marks)

In Australia, vaccination against measles is a two-dose schedule. The first dose is generally given at age 12 months and the second dose at 4 years.

c On the grid below, graph the level of measles antibodies you would expect in a vaccinated child. The child's mother is known to have had measles as a child. (2 marks)



Rubella is a contagious viral disease. An individual may have the disease for two or more weeks before it is diagnosed. If a pregnant woman is infected with Rubella, the developing baby may develop serious defects. The diagram below outlines the development of various organs of a baby in utero.



Each bar shows the time over which a particular organ develops. Two pregnant women are diagnosed with Rubella. Mrs Smith is 6 weeks pregnant, and Mrs Jones is 28 weeks pregnant.

d Which embryo or foetus is at greater risk of developing a major defect? Refer to at least two areas of development to support your answer. (2 marks)

(Total 7 marks)

[VCAA 2013 SB Q4]

In 1995, the Australian Bureau of Statistics released a report showing that only 53 per cent of children aged between three months and six years had completed the immunisation schedule.

a Is childhood immunisation an active or passive form of protection against a disease? Justify your answer. (2 marks)

After a major advertising campaign by the government, the immunisation rate increased to 92 per cent.

b Complete the following flow chart to show the immune response in a person receiving their first vaccination. The following words must appear in your flow chart.

plasma cells memory cells B cells antibodies cytokines

The first step has been completed. (3 marks)

Step 1

antigens detected by T-helper cells



Step 2



Step 3



Step 4

Many immunisation schedules include regular booster injections.

c Explain how these work, and why they are necessary. (2 marks)

(Total 7 marks)

Question 20/ 166

[VCAA 2012 E1 SB Q4]

Australia is currently experiencing an epidemic of pertussis. Pertussis is a highly contagious respiratory infection caused by the bacteria *Bordetella pertussis* (whooping cough). Pertussis vaccine is offered as part of

an immunisation program for children at two months, four months, six months, four years and in Year 10 of secondary school.

a i Name the cells that are responsible for the production of antibodies. (1 mark)

Two children have been immunised according to the schedule. One is two months old and the other is four months old.

ii What difference would there be in the children's levels of antibodies against *Bordetella pertussis*? (1 mark)

Consider a Year 10 student. Memory cells will have been produced during the periods of immunisation when the student was younger.

b What are **two** advantages of having these memory cells when the student receives their immunisation in Year 10? (2 marks)

In Victoria in the past two years the number of cases of pertussis has increased dramatically. In 2010 there were over 6500 reported cases of pertussis; 66 per cent of these cases were adults and most of these adults had been immunised in childhood.

c i Outline a likely reason for the high percentage of adults with pertussis in 2010. (1 mark)

ii Describe one process that could be introduced by the Department of Health, Victoria, to reduce the number of adults being infected with pertussis. (1 mark)

The human immune response to antigens of *Bordetella pertussis* can be measured by the level of antibodies in the blood.

d Is this test a measure of cell-mediated immunity? Explain your answer. (1 mark)

(Total 7 marks)

Question 21/ 166

[VCAA 2013 SB Q5]

Sufferers of autoimmune diseases produce autoantibodies.

a What role do these autoantibodies play in causing the symptoms of an autoimmune disease? (1 mark)

A teenager with a family history of an autoimmune disease underwent a genetic screen for the disease. After receiving a positive result for the genetic screen, she had an additional autoantibody test. The result of this autoantibody test was negative.

b Explain why the autoantibody test could be negative even though the genetic screen was positive. (2 marks)

(Total 3 marks)

Chapter 5 How are species related over time?

Question 1/ 83

Why is meiosis significant to sexually reproducing organisms? You should be able to make several points.

Question 2/ 83

What is the difference between allele and a gene? Are they the same thing?

Question 3/ 83

Distinguish between the terms 'homologous', 'homozygous' and 'heterozygous'.

Question 4/ 83

What is the difference between the terms 'genotype' and 'phenotype'? What factors determine each?

Question 5/ 83

What is meant by variation when looking at members of a population?

Question 6/ 83

List the major types of variation that exist between organisms.

Question 7/ 83

List the various sources and processes that provide genetic variation in a population. Start with variation that arises during gamete production.

Question 8/ 83

Point mutations are minor alterations to base sequences in genes. Describe the three major types of point mutation.

Question 9/ 83

Explain why mutations are usually harmful. Which of the three types of point mutation are the least harmful?

Why? Refer to frameshift in your answer.

Question 10/ 83

What are block mutations?

Question 11/ 83

Give an example of a condition that arises as a result of non-disjunction. Explain what must have happened during meiosis.

Question 12/ 83

How do aneuploidy and polyploidy differ?

Question 13/ 83

List some causes of mutation.

Question 14/ 83

Distinguish between germline and somatic mutations.

Question 15/ 83

Which sorts of mutation can be beneficial to a species' long-term survival? Explain.

Question 16/ 83

Which is the more important source of variation – recombination during meiosis or mutation? Justify your opinion explaining the significance of each.

Question 17/ 83

What is meant by the terms 'gene pool' and 'allele frequency'?

Question 18/ 83

How is allele frequency calculated?

Question 19/ 83

In terms of the gene pool and allele frequency, what is the difference between gene flow and genetic drift? When will the two processes have the greatest effect on allele frequency?

Question 20/ 83

Complete the following table.

	Bottleneck	Founder effect
Definition		
Genetic diversity		

Question 21/ 83

What is biological evolution? Is evolution a process or a result? Explain.

Question 22/ 83

Is biological evolution a theory or fact?

Question 23/ 83

How are 'Natural Selection' and 'Biological Evolution' related?

Question 24/ 83

If natural selection is to occur, what must exist in a population?

Question 25/ 83

Is selection at the phenotypic or genotypic level? Explain what sorts of individuals are most likely to survive in a particular environment.

Question 26/ 83

Does the 'fitness' of an individual vary and if so, what determines an individual's fitness?

Question 27/ 83

Which individuals in a population are most likely to survive in a particular environment?

Question 28/ 83

Which individuals in a population are most likely to reproduce in a particular environment?

Question 29/ 83

If an individual is to pass on its alleles (genetic information) to the next generation, how long must it live?

Question 30/ 83

Darwin proposed the theory of 'Evolution by Natural Selection'. Since then, developments in genetics have led to its modification. Summarise the modern view of evolution by natural selection.

Question 31/ 83

Using the Darwin/Wallace theory of natural selection, explain how peppered moths in polluted forests are mainly black whereas populations of these moths in unpolluted forests are mainly pale. This is an example of how physical conditions can affect populations.

Question 32/ 83

Using the Darwin/Wallace theory of natural selection, explain how mosquitoes have become resistant to

DDT. This is an example of how chemical conditions can affect populations.

Question 33/ 83

Explain whether or not individuals with a dominant phenotype will become more frequent in a population than individuals with the recessive phenotype for the same characteristic. In other words, does 'dominance' in numbers have much to do with 'dominance' in phenotype? (HINT – in genetics only use the word 'dominant' when referring to phenotype.)

Question 34/ 83

Complete the following table.

Environment

Genetic diversity advantage

Explanation

Question 35/ 83

Is there any real difference in the process of 'Natural Selection' when compared with 'Selective Breeding'?

Question 36/ 83

How does selective breeding affect genetic diversity and what are the advantages and disadvantages of this?

Question 37/ 83

Explain how bacteria can become resistant to antibiotics.

Question 38/ 83

Where are the genes for antibiotic resistance located within a bacterium?

Question 39/ 83

Describe two ways that plasmids are passed on to daughter cells.

Question 40/ 83

Explain why it is dangerous to overuse antibiotics.

Question 41/ 83

Compare antigenic drift and antigenic shift by completing the following table.

Similarities	antigenic drift	antigenic shift
Differences		

Question 42/ 83

What is palaeontology?

Question 43/ 83

What is faunal succession and how does it provide evidence to support evolution?

Question 44/ 83

Is it always true to say that fossils are the remains of dead organisms?

Question 45/ 83

Under what environmental conditions are fossils formed? What conditions reduce the chances of good fossils forming?

Question 46/ 83

What information can fossils provide about the lifestyle of once living organisms?

Question 47/ 83

Why is it difficult to identify different species using only fossil evidence?

Question 48/ 83

Describe the difference between absolute dating (radioactive isotope dating) and relative dating (stratigraphy).

Question 49/ 83

What role do index fossils have in dating rocks?

Question 50/ 83

Different radioactive isotopes have different half-lives. What does this mean?

Question 51/ 83

Different radioisotopic methods are used to date fossils of different ages. List some commonly used isotopes and state their use. Is it always the fossil that is dated?

Question 52/ 83

What is the significance of fossils like *Archaeopteryx*?

Question 53/ 83

What is meant by the term 'species'?

Question 54/ 83

What is the most important test used to distinguish members of a species?

Question 55/ 83

What is the significance of geographical barriers in the evolution of new species? Describe features that act as geographical barriers.

Question 56/ 83

Summarise the important steps that lead to allopatric speciation.

Question 57/ 83

How can you determine if you have one species or two distinct species in an area?

Question 58/ 83

If two closely related species live in the same area, what are the possible isolating mechanisms that might prevent interbreeding?

Question 59/ 83

Use the finches of the Galapagos Islands to explain what is meant by adaptive radiation. What type of evolution is this?

Question 60/ 83

Name two features that characterise adaptive radiation.

Question 61/ 83

How do allopatric speciation of sympatric speciation differ?

Question 62/ 83

How did sympatric speciation of *Howea* plants on Lord Howe Island occur?

Question 63/ 83

Complete the following table.

	Evidence for evolution	Example

Palaeontology		

-transitional forms		

Comparative anatomy		

-homologous structures		

-vestigial organs		

Evidence for evolution Example

Molecular homology

- Universal genetic code
 - similar DNA sequences
 - similar amino acid sequences
-

Question 64/ 83

What is molecular homology and how can it be used to determine the relatedness between species?

Question 65/ 83

Draw a phylogenetic tree based on the following hybridisation results.

Human and chimpanzee: 97.7%

Human and gibbon: 94.7%

Question 66/ 83

List the major characteristics that distinguish mammals from other animals.

Question 67/ 83

Humans are primates. Describe the major features that distinguish primates from other mammals.

Question 68/ 83

Why are opposable digits important to primates? In particular, how is an opposable digit important to humans?

Question 69/ 83

Why do netballers and footballers require good stereoscopic vision?

Question 70/ 83

What features distinguish hominins from other primates?

Question 71/ 83

Distinguish between the terms 'hominoid' and 'hominin'.

Question 72/ 83

Describe the location changes of the foramen magnum.

Question 73/ 83

What changes in jaw and tooth structure have occurred during human evolution? How might behaviour have changed during this evolution?

Question 74/ 83

Skull shape and size have changed during human evolution. Describe their changes and their significance.

Question 75/ 83

What has been the limiting factor to a further increase in skull size?

Question 76/ 83

What selective pressures might have led to increased brain size?

Question 77/ 83

Is it true to say that man has evolved from chimps and gorillas? If not, rephrase the statement.

Question 78/ 83

Complete the following table.

Homo neanderthalensis

When did they live?

Where did they live?

Features of their skull

Brain size

Culture

Disappeared from the fossil record

Question 79/ 83

How is mitochondrial DNA different from nuclear DNA?

Question 80/ 83

Why is mitochondrial DNA useful for tracking human evolution?

Question 81/ 83

What does the comparison of mitochondrial DNA indicate about *Homo sapiens*, *Homo neanderthalensis* and *Homo denisovan*?

Question 82/ 83

Complete the following table summarising two theories of human migration.

Hypothesis	Description	Evidence
Out of Africa		
Multi-Regional		

Question 83/ 83

There is debate about when humans first arrived in Australia. What is the evidence that arrival was at least 65 000 years ago?

Question 1/ 170

Use the following information to answer Questions 2–4.

Populations of the koala (*Phascolarctos cinereus*) can be found along the eastern coast of Australia. In the late 1800s, habitat destruction and hunting reduced the number of koalas dramatically. In an effort to save the koala from extinction, a small number of individual koalas were introduced to French Island, Victoria. The number of koalas on the island quickly grew. Scientists measured the genetic diversity within the island population and found it to be low when compared to populations of koalas in New South Wales and Queensland.

Question 2/ 170

[VCAA 2022 SA Q29]

The low genetic diversity within the French Island koala population can be explained by

A the bottleneck event.

B the founder effect.

C gene flow.

D mutations.

Question 3/ 170

[VCAA 2022 SA Q30]

The population of koalas on French Island

A will show more variation in traits than the populations in New South Wales.

B will have the same number of alleles per trait as the populations in Queensland.

C may be vulnerable to future changes in selective pressures acting on the population.

D will have more harmful mutations than the populations in New South Wales and Queensland.

Question 4/ 170

[VCAA 2022 SA Q31]

When completing the research on the French Island koalas, the scientists would have needed to take into account bioethical issues. The scientists were aware that they would need to communicate all results, whether favourable or unfavourable.

Which one of the following principles of bioethics would the scientists be addressing?

A non-maleficence

B beneficence

C integrity

D respect

Question 5/ 170

Use the following information to answer Questions 6 and 7.

		Second letter				
		U	C	A	G	
First letter	U	UUU } phe UUC } UUA } leu UUG }	UCU } UCC } ser UCA } UCG }	UAU } tyr UAC } UAA STOP UAG STOP	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	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

Consider the following sequence of six amino acids that make up part of a polypeptide.

---- [phe] ---- [leu] ---- [pro] ---- [val] ---- [tyr] ---- [ala] ----

A mutation within the gene coding for this sequence of six amino acids resulted in the following six amino acids in the same position.

---- [phe] ---- [leu] ---- [ala] ---- [val] ---- [tyr] ---- [ala] ----

Question 6/ 170

[VCAA 2018 SA Q20]

This change in the sequence of amino acids was caused by

- A a deletion of a nucleotide.
 - B an insertion of a nucleotide.
 - C a substitution of a nucleotide.
 - D an inversion of adjacent nucleotides.
-

Question 7/ 170

[VCAA 2018 SA Q21]

Another mutation within the original gene resulted in a shortened protein. The protein was truncated (cut short) after the amino acid valine, as shown below.

---- [phe] ---- [leu] ---- [pro] ---- [val] ----

This truncated protein resulted from the codon

- A UAU changing to UAA.
- B UAC changing to UGC.
- C GUA changing to UGA.

D GUG changing to UGG.

Question 8/ 170

[VCAA 2018 SA Q22]

In humans, Duchenne muscular dystrophy (DMD) is caused by mutations in the dystrophin encoding DMD gene. The DMD gene contains 79 exons. In some patients, duplication of one exon occurs.

If the number of nucleotides in the duplicated exon is divisible by three, the

A transcribed mRNA will contain many stop codons.

B length of each of the 79 exons will increase by three nucleotides.

C translated protein will be longer than the dystrophin protein found in a person without DMD.

D dystrophin of these patients will show one amino acid change in the sequence compared to normal dystrophin.

Question 9/ 170

[VCAA 2014 SA Q23]

In populations of fruit flies, there are individuals that are resistant to the effects of insecticides. Insecticide-resistant fruit flies arose as a result of a mutation. In normal insecticide-susceptible fruit flies, a specific section of mRNA has the sequence GCU, whereas in the insecticide-resistant fruit flies, the sequence is UCU.

This mutation is an example of a

A chromosomal deletion during the formation of a gamete.

B nucleotide substitution during the formation of a gamete.

C chromosomal deletion during the formation of a somatic cell.

D nucleotide substitution during the formation of a somatic cell.

Question 10/ 170

Use the following information to answer Questions 11 and 12.

The codon table below can be used to determine the sequence of amino acids coded for by a nucleotide sequence.

1st position (5' end)	2nd position				3rd position (3' end)
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

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

AAA GCT ACC TAT CGG TTA

Question 11/ 170

[VCAA 2017 SA Q27]

In a mutation, the eighth nucleotide in this sequence was changed from C to T. What would be the result of this mutation?

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

Question 12/ 170

[VCAA 2017 SA Q28]

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

The result of this mutation would be that

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

Question 13/ 170

[VCAA 2012 E2 SA Q25]

Biological evolution

A includes changes in the learnt behaviour of individuals in a population.

B involves inherited change in a population over many generations.

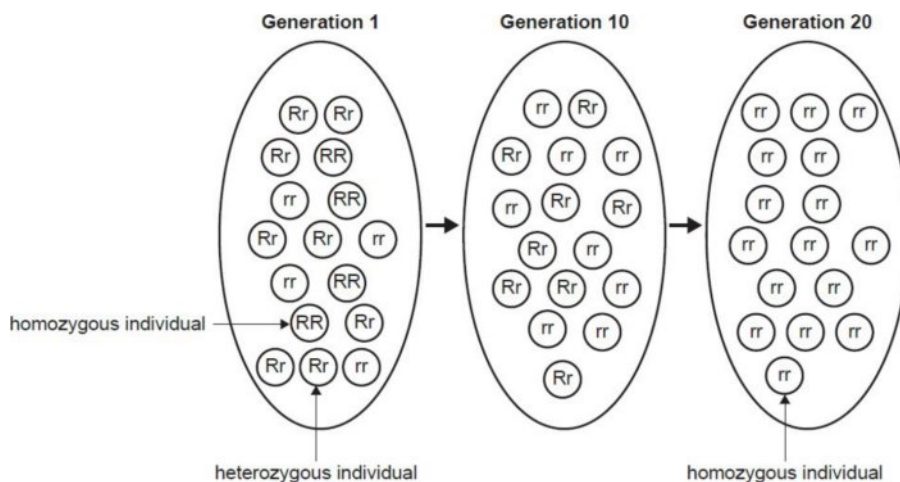
C occurs faster than technological evolution.

D is defined as simply change over time.

Question 14/ 170

[VCAA 2019 SA Q26]

Consider the diagram below showing the gene pool of a population over 20 generations.



It would be correct to conclude that, over the 20 generations

A genetic diversity is increasing in this population.

B individuals with the genotype RR had a selective advantage in this population.

C the frequency of each allele is equal in Generation 1 but not in other generations.

D new advantageous alleles for this gene were introduced as individuals joined this population.

Question 15/ 170

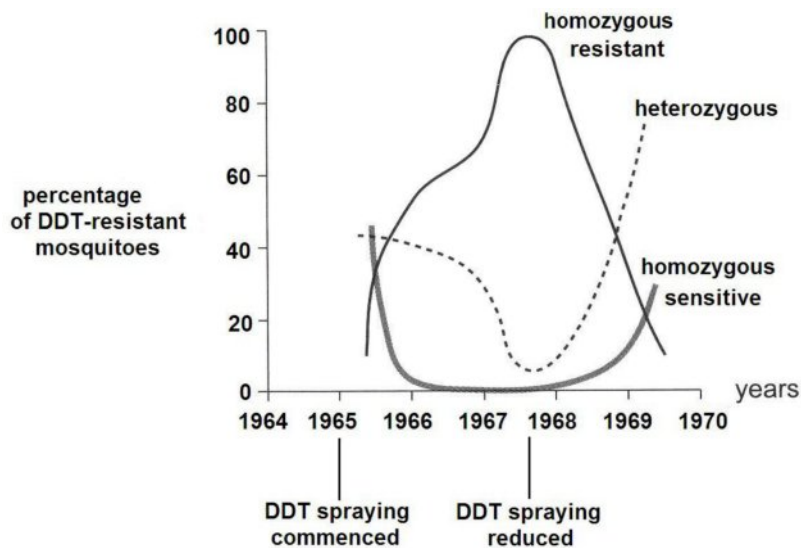
[VCAA 2010 E2 SA Q23]

In the mid-1960s, DDT was widely used as an insecticide against mosquitoes. The sensitivity to insecticide in mosquitoes is determined by a single gene that has two alleles.

allele 1 : resistant to DDT

allele 2 : sensitive to DDT

Over several years genotypic frequencies were measured in a population of mosquito larvae. The graph on the next page shows the results.



Analysis of the graph reveals that in the population

A when spraying levels declined, heterozygous advantage occurred.

B there were no alleles for sensitivity present in the population in 1967.

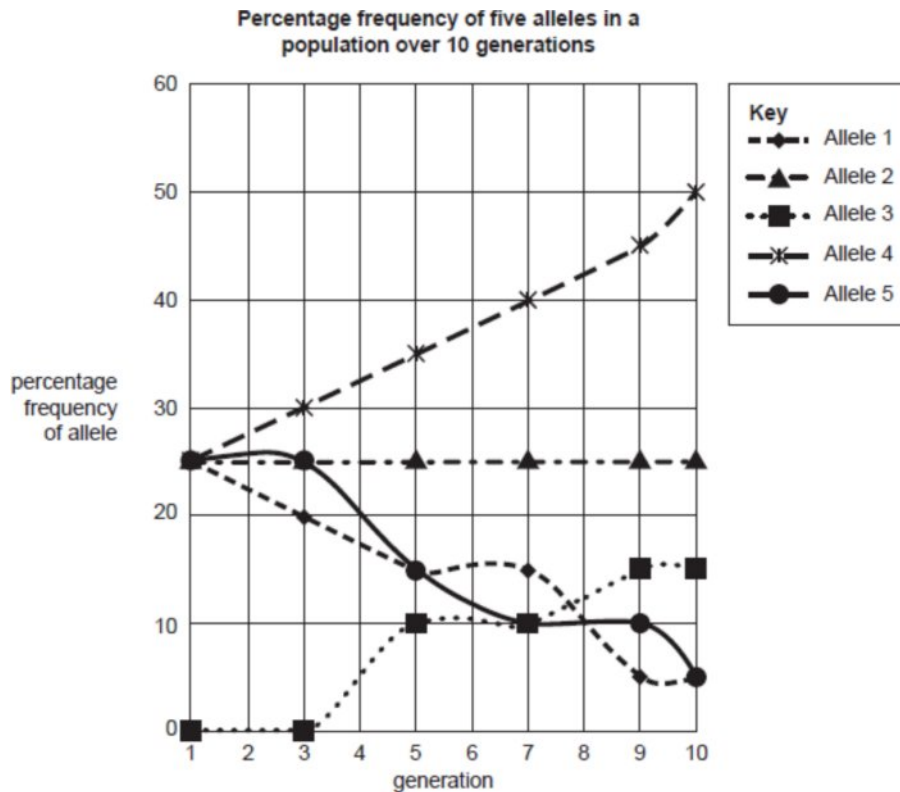
C the number of alleles for resistance was equal to the number for sensitivity in 1966.

D the homozygous resistant genotype was unable to produce offspring at low spraying levels.

Question 16/ 170

[VCAA 2020 SA Q28]

The graph below shows the frequency of five alleles in a population over 10 generations. The change in allele frequency is represented as a percentage of the frequency of the five alleles.



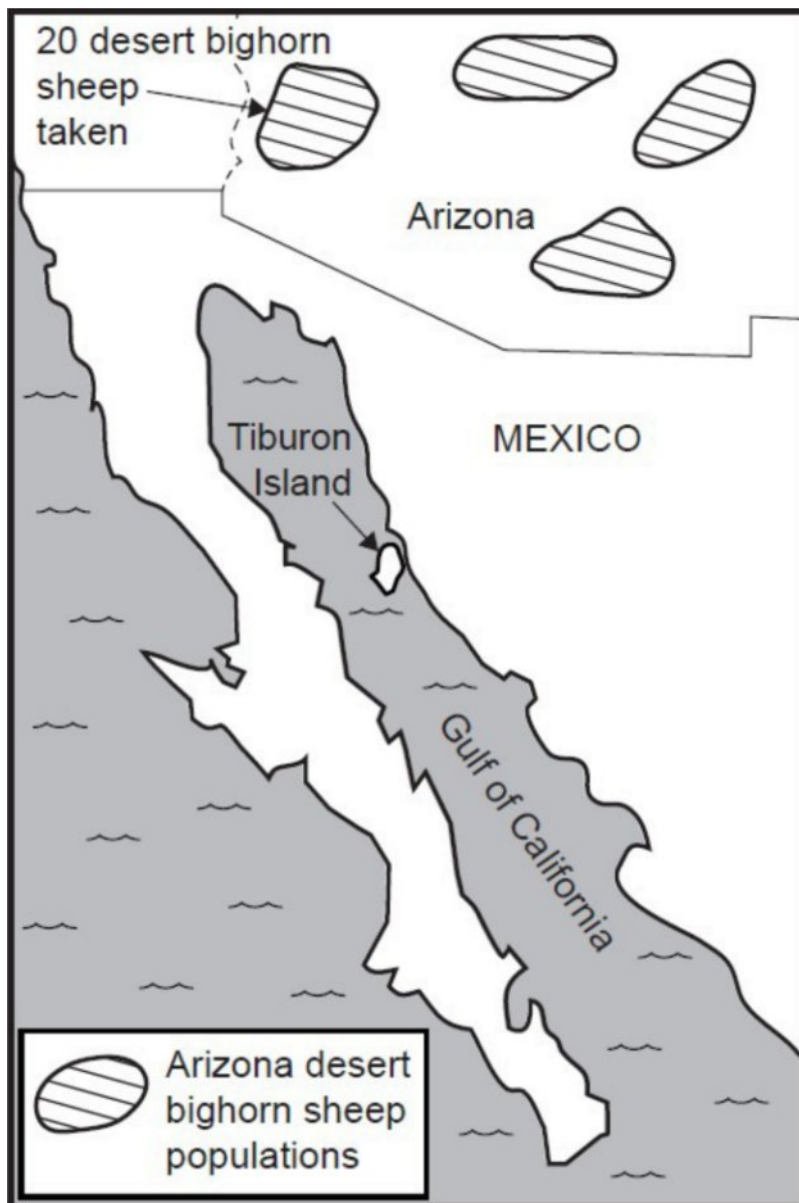
Based on the information in the graph, which one of the following is most likely?

- A The founder effect can explain the change in allele frequency in the first three generations.
- B Genetic diversity within the population remains unchanged over the 10 generations.
- C The appearance of Allele 3 after Generation 3 may be explained by gene flow.
- D A bottleneck event occurred between Generation 7 and Generation 9.

Question 17/ 170

[VCAA 2016 SA Q37]

Tiburon is an isolated island off the coast of Mexico. Desert bighorn sheep became extinct on this island hundreds of years ago. In 1975, 20 desert bighorn sheep were taken from a population in the American state of Arizona (shown on the map below) and were re-introduced to Tiburon Island. By 1999, the population of desert bighorn sheep on Tiburon Island had risen to 650.



Which one of the following statements about this 1999 population of desert bighorn sheep on Tiburon Island is correct?

- A The gene pool of this population will be identical to the gene pool of the Arizona populations.
 - B This population has less genetic variation than the Arizona populations and is an example of the founder effect.
 - C This population will have become a new species because the mutation rate on Tiburon Island will be much higher than in Arizona.
 - D Having been through a population bottleneck, the current population will now show increased genetic variation compared to the Arizona populations.
-

Question 18/ 170

[VCAA 2015 SA Q40]

Northern elephant seals, *Mirounga angustirostris*, were nearly hunted to extinction in the 1890s, with only about 20 individuals left at the end of the century. The population has now grown to more than 120 000. In the 1890s, southern elephant seals, *Mirounga leonina*, were not as severely hunted and currently there are estimated to be 600 000 southern elephant seals.

Based on this information, it is true to say that

A northern elephant seals have evolved as a result of the ‘founder effect’.

B northern elephant seals would show less genetic variation than southern elephant seals.

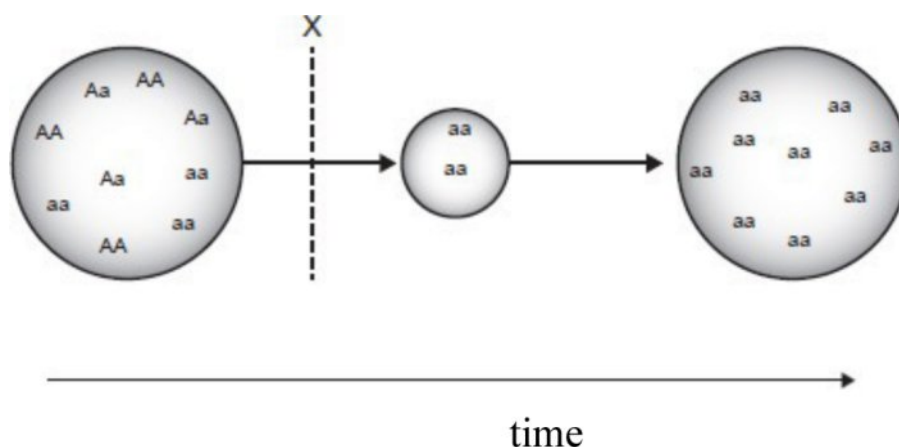
C southern elephant seals would have experienced greater genetic drift than northern elephant seals.

D the mutation rate in northern elephant seals would have been greater than in southern elephant seals.

Question 19/ 170

[VCAA 2014 SA Q33]

Consider the diagram below that models the changes in allele frequencies for one trait in a population over two generations. The original population is shown on the left.



If the diagram above models the founder effect, then event X is

A migration.

- B a natural disaster.
 - C random mating.
 - D a random assortment of alleles.
-

Question 20/ 170

[VCAA 2012 E2 SA Q21]

Retinitis pigmentosa (RP) is an autosomal recessive trait that results in progressive blindness in humans. On the island of Tristan da Cunha in the Atlantic Ocean, the frequency of the allele causing RP is four times greater in its population of a few hundred individuals than in the original British population from which it was colonised in the early 1800s. No natural disasters have occurred on the island since it was colonised.

The process that is most likely responsible for this observation related to allele frequency is

- A genetic drift.
 - B founder effect.
 - C bottleneck effect.
 - D natural selection.
-

Question 21/ 170

[VCAA 2010 E2 SA Q13]

In populations

- A genetic drift will have less effect in a large population compared to a small population.
- B bottlenecks enable a population to become better equipped for future changes in the environment.
- C some organisms develop mutations in order to better suit them to their environment compared to other members of the population.
- D allele frequencies remain constant if the number of individuals leaving the population equals the number of individuals entering it.

Question 22/ 170

[VCAA 2012 E2 SA Q23]

Early in 2012, biologists announced the discovery of a new lizard species.

To claim that the lizards belong to a new species, the biologists must show that the lizards

A look different from one another.

B look different from known species.

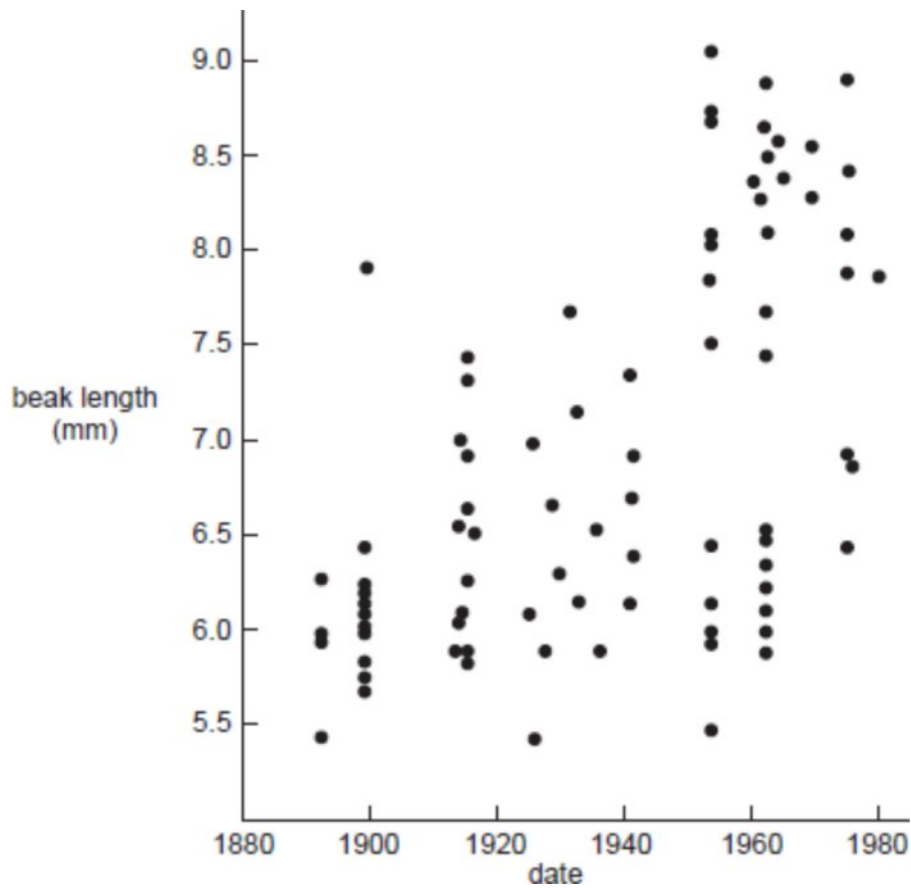
C have similar genetic sequences to known species.

D do not produce fertile offspring with members of known species.

Question 23/ 170

Use the following information to answer Questions 24 and 25.

The soapberry bug (*Jadera haematoloma*) uses its long beak to penetrate the fleshy fruit of plants to feed on the seeds at the centre. The bug feeds on the native soapberry tree. The bug also feeds on the fruit of the introduced golden rain tree. Investigators measured the average beak length of the soapberry bug over eighty years. The results are shown below.



Question 24/ 170

[VCAA 2011 E2 SA Q19]

From this information it would be reasonable to conclude that

A the golden rain tree was introduced around 1970.

B no long-beaked bugs existed prior to the introduction of the golden rain tree.

C the diameter of the golden rain tree fruit acted as a selection pressure on beak length.

D the response of an individual golden rain tree to predation by soapberry bugs would be to grow larger fruit.

Question 25/ 170

[VCAA 2011 E2 SA Q20]

In neighbouring regions, the fruits of other introduced plants have also been used by the soapberry bug. Male and female soapberry bugs from different regions can interbreed. Evidence indicates that genetic isolation of some of these populations is gradually occurring.

The situation that would lead to an increase in genetic isolation would be if

A different types of host plants have fruiting seasons which do not overlap.

B pheromones of female soapberry bugs attract soapberry males from neighbouring populations.

C the soapberry tree is common throughout the distribution and each tree produces large amounts of fruit.

D male soapberry bugs new to a region are reproductively active, whereas female bugs need to feed before becoming reproductively active.

Question 26/ 170

[VCAA 2020 SA Q27]

Tasmanian devils (*Sarcophilus harrisii*) were originally broadly distributed across Australia. When sea levels rose 12 000 years ago, an island, now referred to as Tasmania, was formed. The small number of Tasmanian devils on Tasmania was cut off from the Australian mainland populations. The population in Tasmania showed less genetic variation than the mainland populations. Mainland populations became extinct approximately 3000 years ago.

Over the last 20 years, the total Tasmanian devil population on Tasmania has halved. Many of the deaths have been the result of Tasmanian devil facial tumour disease (DFTD). Scientists have taken some Tasmanian devils that do not have DFTD to mainland Australia to set up a conservation program. The scientists have shown that greater genetic diversity among offspring in this program is observed when the Tasmanian devils are kept in isolated male–female pairs rather than in larger groups.

The conservation program for Tasmanian devils is an example of

A a population bottleneck.

B allopatric speciation.

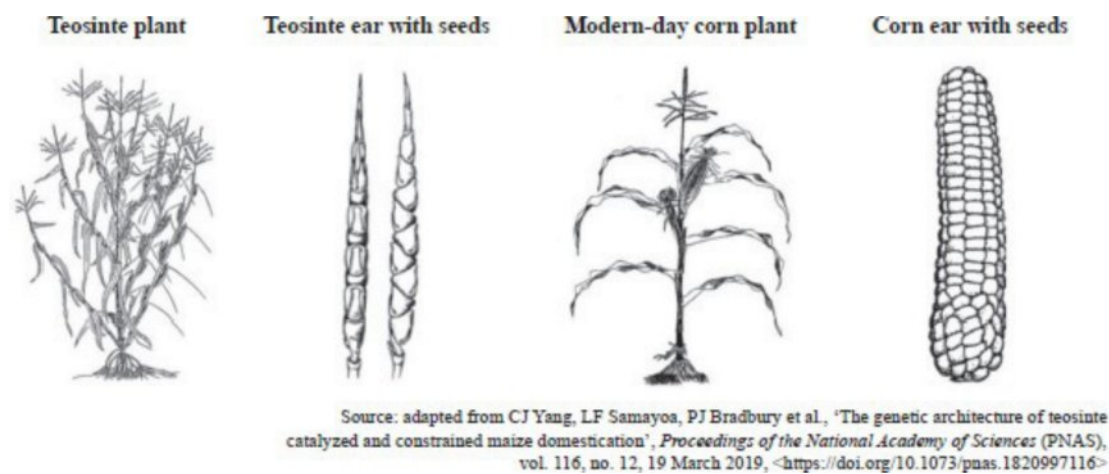
C selective breeding.

D natural selection.

Question 27/ 170

[VCAA 2022 SA Q35]

Corn (*Zea mays* subsp. *mays*) is a crop grown in Australia. The direct ancestor of corn is widely believed to be a wild grass known as teosinte (*Zea mays* subsp. *parviglumis*). Approximately 9000 years ago, farmers in Mexico began selecting for more favourable traits in teosinte. Further selective breeding has resulted in the current form of the corn plant. Some of the traits of both the ancestral teosinte plant and the modern-day corn plant are shown in the diagram that follows.



In the selective breeding to produce modern-day corn, a trait that has been selected for is an increase in the number of

- A branches per plant.
- B leaves on the plant.
- C seeds in the ear.
- D ears per plant.

Question 28/ 170

[VCAA 2019 SA Q27]

Farmers and supermarkets agree that green beans are bought more frequently than yellow beans. A

supermarket has asked a farmer to produce only green beans.

One way this could be achieved is by

E condensation polymerisation.

F DNA hybridisation.

G selective breeding.

H adaptive radiation.

Question 29/ 170

[VCAA 2017 SA Q30]

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

A genetic fitness.

B natural selection.

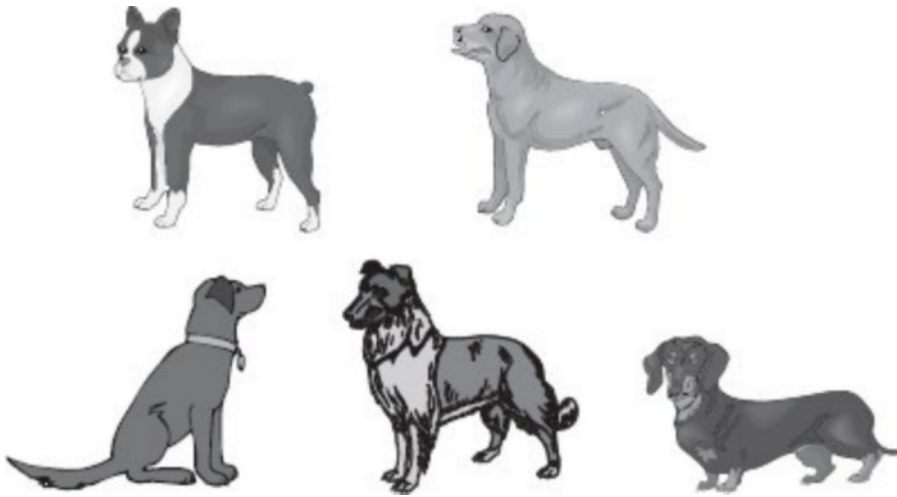
C selective breeding.

D allopatric speciation.

Question 30/ 170

[VCAA 2014 SA Q38]

The diagram that follows shows five different breeds of dog that now exist within the *Canis lupus familiaris* species.



The development of variant breeds within *Canis lupus familiaris* is an example of

- A natural selection occurring in geographically isolated populations.
- B gene-transfer technology transforming the genotype of a species.
- C convergent evolution occurring in a range of similar habitats.
- D human intervention through artificial selection.

Question 31/ 170

[VCAA 2011 E2 SA Q22]

Selective breeding over many generations has produced gradual changes in farm animals.

It is reasonable to state that such gradual changes in a herd of cattle

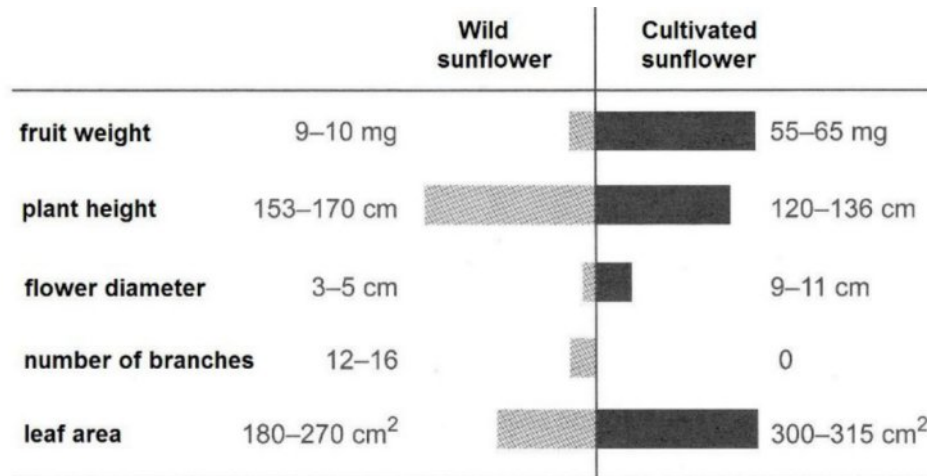
- A result from random mating in the herd in each generation.
 - B are due to the occurrence of gene mutations in each generation.
 - C will improve traits that enhance survival of the animals in the wild.
 - D result from the restriction of breeding to chosen animals in the herd.
-

Question 32/ 170

[VCAA 2010 E2 SA Q20]

The wild sunflower plant has been cultivated by humans over several generations. During that time, selection for or against particular sunflower traits has been carried out.

A comparison of some of the traits in wild and cultivated sunflowers is given the diagram that follows.



From the information on the previous page, we can assume that humans have selected against large

A leaf area.

B plant height.

C fruit weight.

D flower diameter.

Question 33/ 170

Use the following information to answer Questions 34 and 35.

Health professionals are concerned about the over-prescription of antibiotics. Many antibiotics have become ineffective against certain species of bacteria.

Question 34/ 170

[VCAA 2013 SA Q39]

Any rise in incidence of antibiotic-resistant bacteria is due to

A these bacteria having acquired immunity to antibiotics.

B the overuse of antibiotics causing mutations in bacteria.

C the introduction of selectively bred, antibiotic-resistant bacteria.

D antibiotic-resistant phenotypes being favoured through natural selection.

D Up to 80 per cent of bacterial diseases are caused by bacteria living in biofilms. Biofilms are large communities of bacteria encased in extra-cellular coverings that attach to slippery surfaces, such as teeth and contact lenses. Special features of biofilms include the following.

- Some regions of cells form spores for reproduction and dispersal.
 - Other regions of cells grow flagella for movement.
 - Cells can detect others of their own species through cell-to-cell signalling (so they can sense when sufficient numbers are present to invade new areas successfully).
-

Question 35/ 170

[VCAA 2013 SA Q40]

Researchers are trying to develop therapies that avoid the use of antibiotics. These therapies could include

A using drugs that stop spindle fibres forming during mitosis.

B providing amino acid supplements to promote flagella development.

C preventing biofilm bacteria from detecting others of their own species.

D targeting the biofilm's covering to make it more permeable to antibiotics.

Question 36/ 170

Use the following information to answer Questions 37 and 38.

Due to copyright restrictions, this image is not supplied.

To view the original image, please visit the VCAA website.

Victoria's fossil emblem *Koolasuchus cleelandi*, shown on the stamp above, was chosen in January 2022. *K. cleelandi* fossils have been found in Boonwurrung country in Gippsland. Studies of *K. cleelandi* fossils have revealed many interesting findings. Several of these findings are summarised below.

K. cleelandi findings

1. It was an amphibian that lived 125 million years ago.
 2. It had a jaw, a skull, vertebrae and ribs made of bone.
 3. It was covered in scales and had fangs on the roof of its mouth.
 4. It lived in rivers carrying many sediments.
 5. It lived in Victoria for 50 million years after its closest relatives in the rest of the world became extinct.
 6. It fed on small dinosaurs, turtles and fish.
 7. It was the size of a small car, 4 m long and weighed 500 kg.
-

Question 37/ 170

[VCAA 2022 SA Q32]

Which combination of findings from the list above is most likely to be associated with an increased chance of formation of *K. cleelandi* fossils?

- A findings 1 and 6.
 - B findings 2 and 4.
 - C findings 3 and 5.
 - D findings 2 and 7.
-

Question 38/ 170

[VCAA 2022 SA Q33]

It is most likely that scientists determined the absolute age of *K. cleelandi* fossils

A through mtDNA analysis of *K. cleelandi* scales and fangs.

B through carbon-14 dating of jaw bones, skull, vertebrae and ribs.

C by finding index fossils nearby, such as those of small dinosaurs and turtles.

D through radioisotope dating of rock surrounding the fossils.

Question 39/ 170

[VCAA 2021 SA Q21]

Which of the following shows some of the organisms on the fossil record in the correct order in which they first appear?

A fish, green algae, mammals, flowering land plants

B green algae, fish, flowering land plants, mammals

C fish, mammals, green algae, flowering land plants

D green algae, fish, mammals, flowering land plants

Question 40/ 170

[VCAA 2021 SA Q24]

Sea stars are soft-bodied marine animals that have survived periods of mass extinction. The oldest sea star fossils have been dated to 480 million years ago. The number of sea star fossils found is relatively low.

One reason why the number of sea star fossils found is relatively low is that sea stars

D have bodies that decompose quickly.

The two photographs that follow (Image A and Image B) are of arthropod fossils found in tree resin (amber) and a drawing of an arthropod (Image C). Each image has a scale in micrometres (μm).

From the images shown, it can be concluded that the arthropod

A fossils are examples of trace fossils.

B in Image C is less than 90 μm in height.

C fossil in Image A is greater than 100 μm in length.

D that was fossilised in Image B was buried in sediment before it was surrounded by amber.

Question 42/ 170

[VCAA 2019 SA Q28]

Consider the close-up image that follows of a dinosaur footprint discovered by scientists.



This type of fossil is best described as

A preserved remains.

B a petrified fossil.

C a trace fossil.

D a cast.

Question 43/ 170

[VCAA 2018 SA Q25]

It is most probable that the two stratigraphically younger fossils would have been found in a layer of rock that

A was closer to the present-day ground surface than the rock surrounding the *D. pickeringi* fossil.

B contained a smaller quantity of carbon-14 than the rock surrounding the *D. pickeringi* fossil.

C was located at a depth of 2.3 m below the ancient riverbed.

D was formed from extremely hot, volcanic lava flow.

Question 44/ 170

[VCAA 2018 SA Q26]

Palaeontologists believe that the Victorian ornithopods shared a close common ancestor with several ornithopod fossils found in Antarctica, South America and Africa.

Which one of the following is the most likely explanation for the distribution of these fossils?

A Antarctica, South America and Africa were joined to Australia in the distant past.

B The strong tails of the ornithopods enabled them to swim for sustained periods of time.

C The small forelimbs of the ornithopods suggest that they were evolving wings for flight.

D Seagoing, scavenger birds carried the fossil bones of the ornithopods to other continents.

Question 45/ 170

[VCAA 2016 SA Q38]

In India, a group of scientists was studying fossils from a coal deposit formed during the Permian period (290–245 million years ago). They found three fossil species from the same genus in different levels (strata) of the coal. When radiocarbon dating on these fossils was performed, it showed exactly the same levels of

carbon-14 in all three fossil species.

The data is summarised in the table below.

Fossil species	Depth at which fossil was found in the coal deposit (m)	Proportion of carbon-14 (%)
<i>Gangamopteris major</i>	6.2	0.0001
<i>Gangamopteris obliqua</i>	8.1	0.0001
<i>Gangamopteris clarkeana</i>	4.7	0.0001

Which one of the following is the correct conclusion to draw from these findings?

A There is no evolutionary relationship between these three fossil species.

B *G. clarkeana* is the common evolutionary ancestor of *G. major* and *G. obliqua*.

C As carbon dating is a more reliable dating technique than analysis of strata in coal deposits, the fossils of *G. major*, *G. obliqua* and *G. clarkeana* are all of the same age.

D An analysis of strata in coal deposits is a more reliable dating technique than carbon dating for Permian fossils; the fossil of *G. major* is younger than the fossil of *G. obliqua*.

Question 46/ 170

[VCAA 2015 SA Q35]

Potassium-40 has a half-life of 1.25 billion years. In igneous rocks closely associated with a fossil layer, the ratio of potassium-40 to its radioactive breakdown product, argon-40, is approximately 1:1.

The age of the fossils in the fossil layer will be close to

A 125 million years.

B 310 million years.

C 1.25 billion years.

D 2.5 billion years.

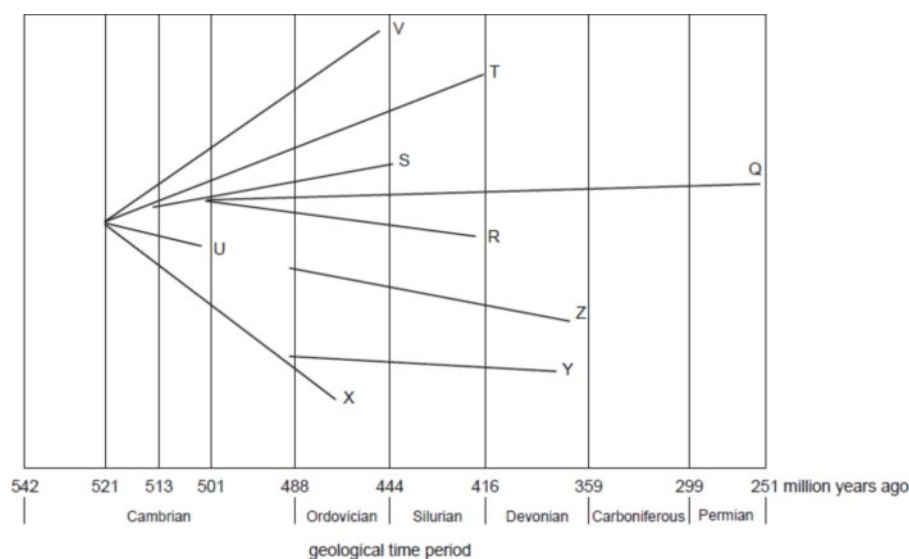
Question 47/ 170

Use the following information to answer Questions 48 and 49.

Trilobites existed from the Early Cambrian period (521 million years ago) until the end of the Permian period (251 million years ago). The chart below and the next page, based on fossil evidence, shows the phylogeny of some trilobite orders present in Earth's oceans over this time.



A trilobite fossil
order: Ptychopariida



Question 48/ 170

[VCAA 2014 SA Q34]

Trilobite fossils in a particular layer of rock were used to date a fossil shell in the same layer. A palaeontologist dated the fossil shell to 328–359 million years old. It is most likely that the trilobite fossils present were of the order

A Y.

B U.

C Q.

D T.

Question 49/ 170

[VCAA 2014 SA Q35]

The absolute age of the trilobite fossils was most likely determined by using

A carbon dating.

B transition fossils.

C index fossils.

D potassium-argon dating.

Question 50/ 170

[VCAA 2014 SA Q36]

The geological time periods shown on the chart differ in duration because the time periods reflect

A the diversity of fossils and mass extinction events.

B the absence of trilobite fossils in the Late Cambrian period.

C different rates of radioactive decay.

D different rates of fossilisation.

Question 51/ 170

[VCAA 2014 SA Q37]

The chance of a trilobite becoming fossilised is increased by

- A slow burial of its remains in dry sediment.
 - B large temperature variations in the sediment containing its remains.
 - C the presence of hard body parts.
 - D the presence of scavengers at the time of its death.
-

Question 52/ 170

[VCAA 2013 SA Q31]

The thylacine (*Thylacinus cynocephalus*) was a large, dog-like marsupial that was declared extinct in 1986. A mummified carcass of a thylacine was found in a cave on the Nullarbor Plain. The carcass was dated about 5000 years old.

The most likely method used to date the mummified carcass would involve

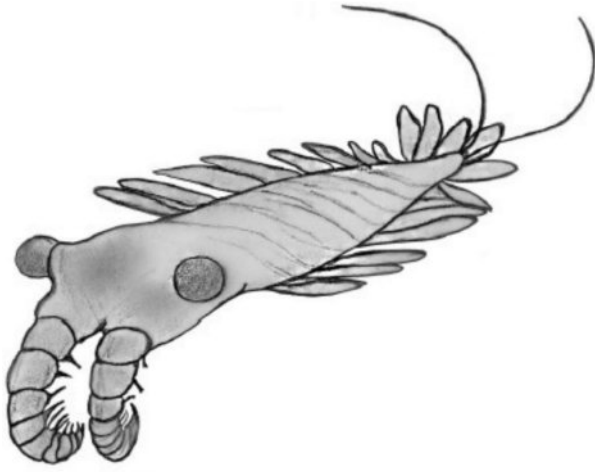
- A dating the layers of rocks within the cave.
 - B potassium–argon dating of the mummified remains.
 - C measuring the proportion of carbon-14 atoms in the carcass.
 - D comparing the teeth in the mummified carcass to the teeth of other dog-like marsupials.
-

Question 53/ 170

Use the following information to answer Questions 54 and 55.

Anomalocaris fossils have been found at Emu Bay in South Australia. *Anomalocaris* was a predatory,

shrimp-like invertebrate measuring 60 cm in length. It had long, spiny, frontal appendages and a powerful, disc-shaped mouth made of overlapping, hard plates. The Emu Bay fossils were found in layers of shale and dated back to about 520 million years ago. *Anomalocaris* fossils that have been found around the world suggest that this genus existed for at least 50 million years.



Question 54/ 170

[VCAA 2012 E2 SA Q16]

Factors that would have contributed to the fossilisation of this animal include

- A its predatory way of life.
- B the action of waves and currents.
- C the salt content of the water in which it lived.
- D its hard-plated mouth and spiny appendages.

Question 55/ 170

[VCAA 2012 E2 SA Q17]

In order to estimate the age of *Anomalocaris* fossils, paleontologists would have most likely used

- A index fossils.
 - B carbon-14 dating.
 - C a molecular clock.
 - D DNA hybridisation.
-

Question 56/ 170

[VCAA 2012 E2 SA Q18]

- A likely explanation for the extinction of *Anomalocaris* is that
- A its populations had high genetic diversity.
 - B its disc-shaped mouth was unsuitable for ingesting prey.
 - C it produced offspring that were suited to their environment.
 - D selection pressures changed dramatically due to rapid climate change.
-

Question 57/ 170

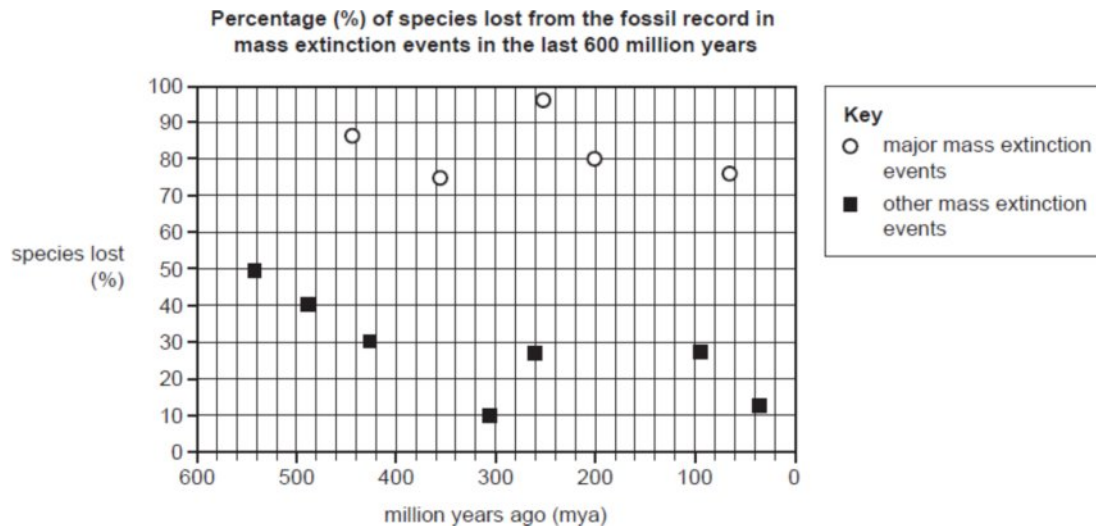
[VCAA 2011 E2 SA Q12]

- The technique of carbon dating would be most suitable for dating organic remains that are aged
- A 4 000 000 000 years and beyond.
 - B 4 000 000 years.
 - C 400 000 years.
 - D 40 000 years.
-

Question 58/ 170

[VCAA 2021 SA Q22]

The graph below shows when the five major mass extinction events and several other mass extinction events occurred. It also shows the percentage of species that were lost in each event.



According to the graph above, to be classified as a major mass extinction event, the percentage of species that are lost has to be at least

- A 10%
- B 50%
- C 74%
- D 97%

Question 59/ 170

[VCAA 2021 SA Q23]

Mass extinction events

- A allow new species to evolve to occupy available niches.
- B allow all species that survive to recover and diverge.

C result from a constant global climate.

D affect all species equally.

Question 60/ 170

[VCAA 2015 SA Q36]

Biologists have found evidence for mass extinction events in Earth's history at approximately 65 million years ago (mya) and at approximately 200 mya. The fossil record indicates a rapid increase in diversity of species after these mass extinction events.

This increased diversity of species can be explained by

A decreased mutation rates associated with the extinction event.

B increased numbers of fossils produced by the extinction event.

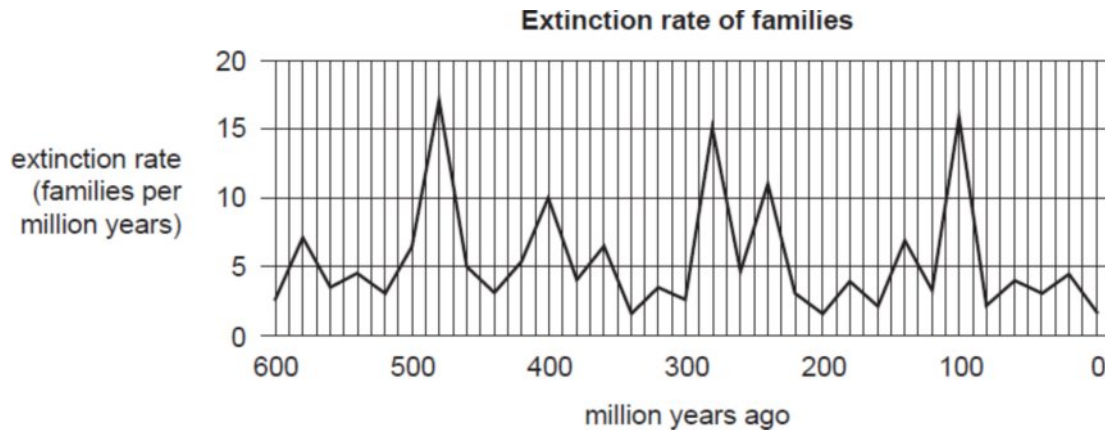
C populations of species returning to their pre-extinction event size.

D the extinction of many species providing many unoccupied niches.

Question 61/ 170

[VCAA 2019 SA Q29]

Refer to the following graph that shows the extinction rate of families.



A scientist stated that a mass extinction occurred when the extinction rate was eight families per million years or greater.

The number of mass extinction events recorded on the graph above is

A eight.

B seven.

C six.

D five.

Question 62/ 170

[VCAA 2017 SA Q33]

Mass extinctions

A kill all but the most primitive species.

B are caused by the introduction of competing species.

C are followed by a period of rapid divergent evolution.

D have been caused by continental drift and earthquakes.

Question 63/ 170

[VCAA 2022 SA Q34]

Consider a hypothetical animal species, Species X, that can neither fly nor swim. Separate populations of Species X live in the same geographical area and often interbreed. After a period of time, a new species, Species Z, arises from Species X.

The following list describes some barriers that may have contributed to the formation of Species Z:

1. A newly formed river separated one population of Species X from the other populations.
2. One population of Species X developed a new mating ritual that was not recognised by members of the other populations of Species X.
3. One population of Species X began to breed several weeks later than the other populations of Species X.
4. A volcanic eruption created a mountain that separated one population of Species X from the other populations of Species X.

The barrier(s) that could have led to the formation of Species Z by sympatric speciation is

A either barrier 1 or barrier 4.

B either barrier 2 or barrier 3.

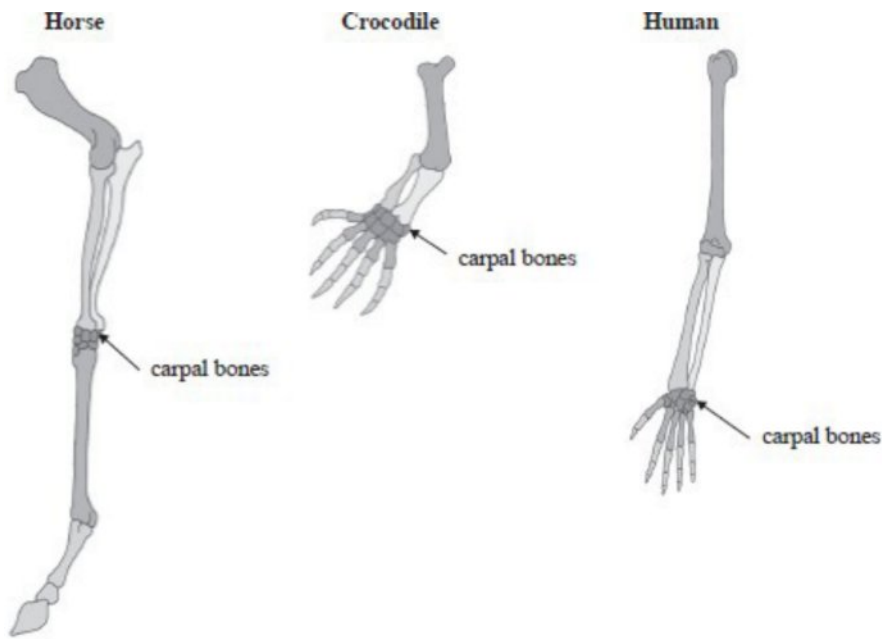
C barrier 1 only.

D barrier 2 only.

Question 64/ 170

Use the following information to answer Questions 65 and 66.

The images below show the bones in the forelimbs of three vertebrates. The carpal bones of a human are located in the wrist. Note that the three images are not shown at the same scale.



Source: adapted from Amadeu Blasco/Shutterstock.com

Question 65/ 170

[VCAA 2022 SA Q36]

The arrangement of bones in the forelimbs of these vertebrates can be described as

- A putative.
- B vestigial.
- C analogous.
- D homologous.

Question 66/ 170

[VCAA 2022 SA Q37]

Based on your knowledge of evolution and the images above, which one of the following is a reasonable

conclusion?

- A The earliest ancestors of horses had only one digit on their forelimbs.
 - B The crocodile is a transitional form between horses and humans.
 - C Humans are more closely related to crocodiles than to horses.
 - D Humans, crocodiles and horses share a common ancestor.
-

Question 67/ 170

[VCAA 2015 SA Q24]

The genome of the northern white-cheeked gibbon, *Nomascus leucogenys*, has been sequenced and compared to other primate species.

The *N. leucogenys* genome would

- A include only the non-coding DNA sequences.
 - B be an uninterrupted, circular sequence of DNA base pairs.
 - C be identical to the genome of the black-crested gibbon, *Nomascus concolor*.
 - D consist of all the genetic sequences within the haploid cells of individuals of the species.
-

Question 68/ 170

Use the following information to answer Questions 69 and 70.

Cytochrome c is a protein that consists of 104 amino acids. Many of these 104 sites on cytochrome c contain exactly the same amino acid across a large range of organisms. There are, however, some differences at certain sites. It is hypothesised that different organisms, all containing cytochrome c proteins, descended from a primitive microbe that lived over 2 billion years ago.

The table below uses the three-letter codes for various amino acids found at specific sites for each organism.

Molecular homology of cytochrome c

Organism	Site 1	Site 4	Site 11	Site 15	Site 22
human	Gly	Glu	Ile	Ser	Lys
pig	Gly	Glu	Val	Ala	Lys
dogfish	Gly	Glu	Val	Ala	Asn
chicken	Gly	Glu	Val	Ser	Lys
<i>Drosophila</i>	Gly	Glu	Val	Ala	Ala
yeast	Gly	Lys	Val	Glu	Lys
wheat	Gly	Asp	Lys	Ala	Ala

Question 69/ 170

[VCAA 2016 SA Q39]

Using only the data for the molecular homology of cytochrome c, which one of the following organisms is most closely related to the dogfish?

A *Drosophila*

B chicken

C human

D yeast

Question 70/ 170

[VCAA 2016 SA Q40]

Using only the data for the molecular homology of cytochrome c, which pair of organisms is most distantly related to wheat?

A dogfish and *Drosophila*

B *Drosophila* and yeast

C *Drosophila* and pig

D human and yeast

Question 71/ 170

Use the following information to answer Questions 72 and 73.

Chimpanzees are the closest living relatives of humans. Less than 1 per cent of our DNA has changed in the 6 million years or so since the human and chimpanzee lineages diverged.

Question 72/ 170

[VCAA 2013 SA Q37]

The measurement of the rate of accumulation of random genetic changes in the genomes of chimpanzees and humans is called

A stratigraphy.

B a molecular clock.

C radiometric dating.

D relative dating.

Question 73/ 170

[VCAA 2013 SA Q38]

Research has shown that in a number of genes the sequence of nucleotides is unique to humans and is not found in chimpanzees.

Gene with sequence unique to humans

Functional role of gene with sequence unique to humans

HAR1	active in the brain necessary for development of the cerebral cortex
FOXP2	facilitates formation of words by the mouth
AMY1	facilitates digestion of starch
ASPM	controls brain size
LCT	permits digestion of milk sugar in adulthood
HAR2	drives gene activity in the wrist and thumb during development

Using the information in the table, it is reasonable to conclude that humans

A can digest milk sugar only in infancy.

B have less-opposable thumbs than chimpanzees.

C are able to walk on two feet in an upright position.

D process and remember more complex information than chimpanzees.

Question 74/ 170

[VCAA 2012 E2 SA Q20]

Another source of DNA that could be used to determine evolutionary relationships among eucalypts would be

A plasmids.

B ribosomes.

C mitochondria.

D reverse copy DNA.

Question 75/ 170

[VCAA 2022 SA Q38]

Which one of the following statements is correct?

A Phylogeny I shows the evolutionary relationships between groups of vertebrates more accurately than Phylogeny II.

B Phylogeny I and Phylogeny II use different features of vertebrates as evidence to draw evolutionary relationships.

C Phylogeny II shows the same evolutionary relationships between groups of vertebrates as Phylogeny I.

D The most advanced groups in Phylogeny II are the hagfishes and lampreys.

Question 76/ 170

[VCAA 2022 SA Q39]

Which one of the following is a correct conclusion from Phylogeny I?

A Frogs arose more recently than coelacanths.

B The common ancestor of all vertebrates is animal Q.

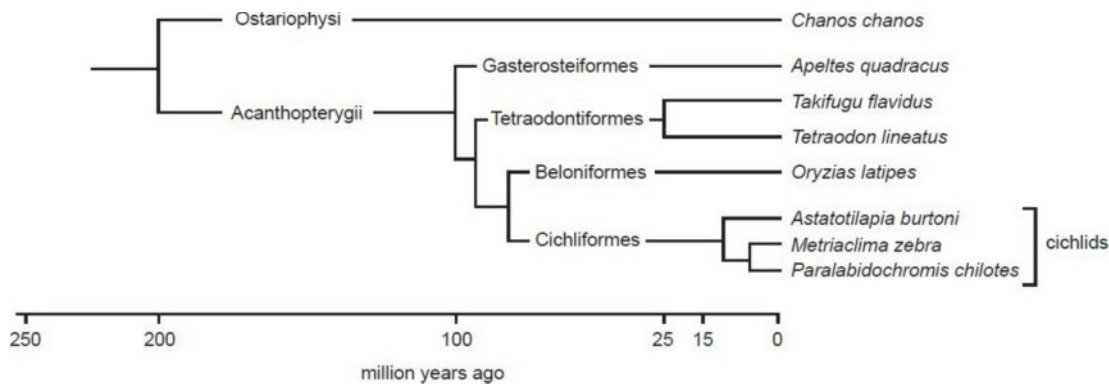
A The most closely related groups are lampreys and hagfishes.

B Animal R is the most recent common ancestor of ray-finned fishes and sharks.

Question 77/ 170

Use the following information to answer Questions 78 and 79.

Consider the following phylogenetic tree, which summarises the evolutionary relationships between certain fish species.



Question 78/ 170

[VCAA 2019 SA Q24]

O. latipes is most closely related to

A *A. quadracus*.

B *T. lineatus*

C *P. chilotes*.

D *T. flavidus*.

Question 79/ 170

[VCAA 2019 SA Q25]

Which one of the following statements is correct?

A Cichlids diverged to form three distinct species 100 million years ago.

B *C. chanos* was the last species to diverge from the most distant common ancestor.

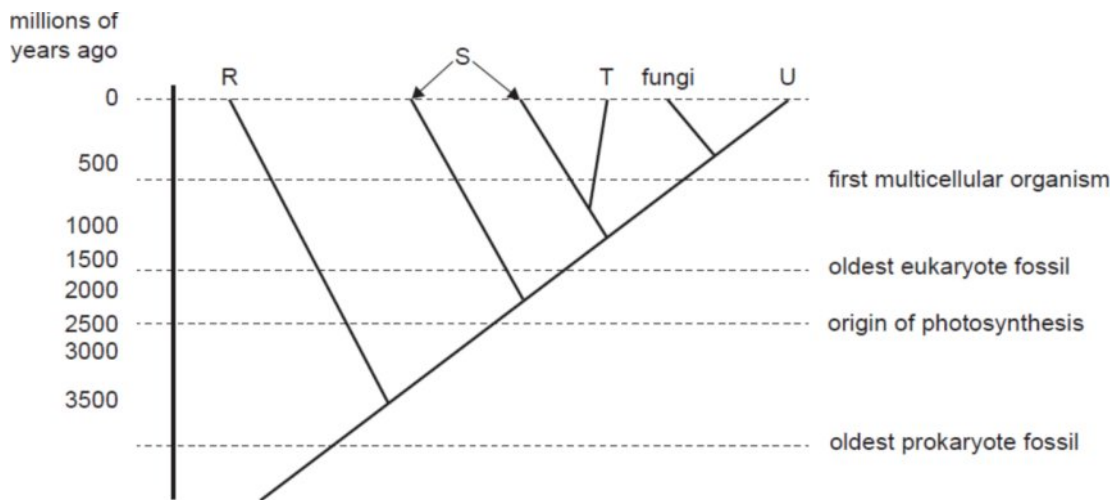
C Gasterosteiformes, Beloniformes and Cichliformes do not share a common ancestor.

D *T. flavidus* and *T. lineatus* diverged to form two distinct species 25 million years ago.

Question 80/ 170

[VCAA 2017 SA Q32]

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



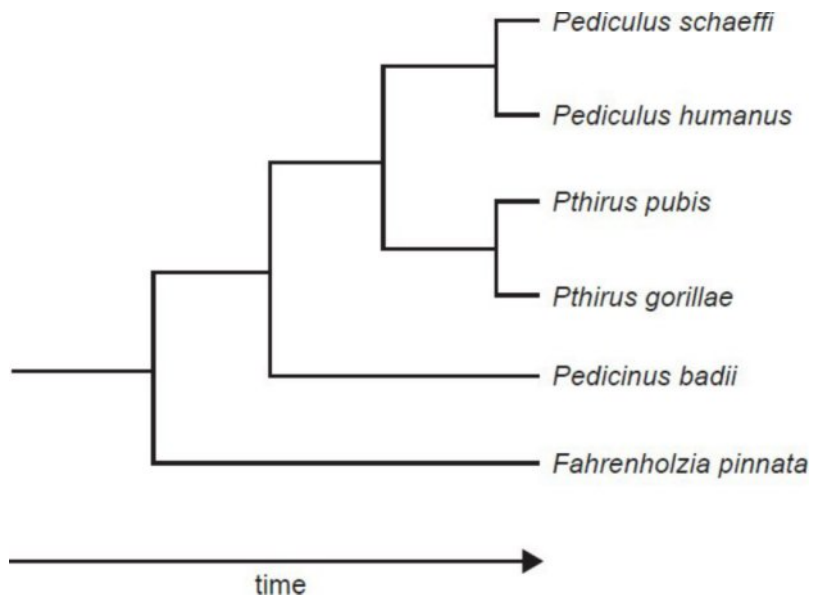
Which of the following shows the correct placement of the organisms on the phylogenetic tree?

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

Question 81/ 170

[VCAA 2016 SA Q29]

Consider the following phylogenetic tree for different species of lice. The tree has been constructed based on molecular and morphological data.



This information suggests that

A *Pedicinus badii* shares a more recent common ancestor with *Pthirus gorilla* than with *Fahrenholzia pinnata*.

B *Pediculus humanus* is more closely related to *Pedicinus badii* than it is to *Pthirus pubis*.

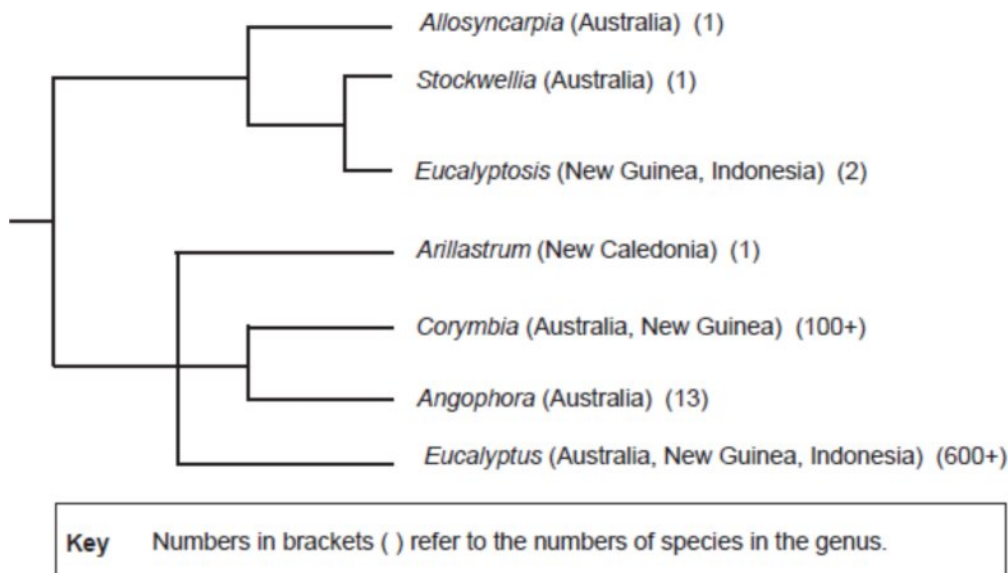
C the six species of lice would have evolved by convergent evolution.

D *Pediculus schaeffi* is the ancestor of *Pediculus humanus*.

Question 82/ 170

[VCAA 2012 E2 SA Q19]

A proposed phylogeny for the seven genera is shown in the diagram below, along with the countries in which they are found.



It would be reasonable to conclude that

A DNA sequences in *Eucalyptosis* would be more similar to those in *Allosyncarpia* than to those in *Stockwellia*.

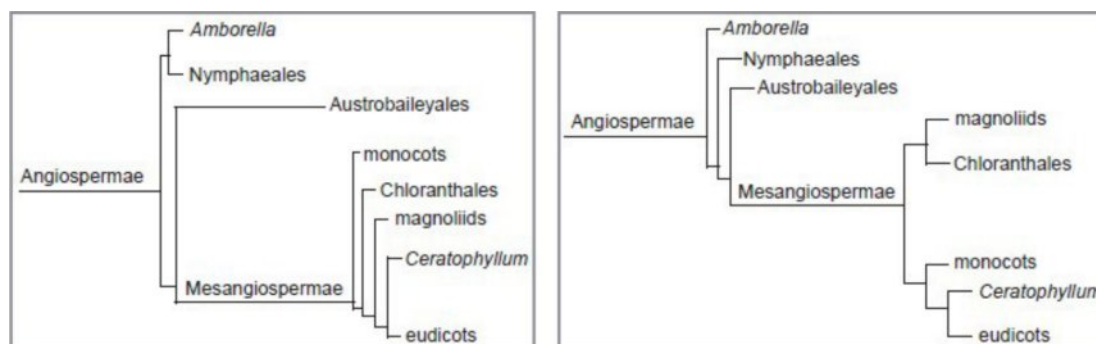
B speciation in *Eucalyptus* was assisted by different selecting pressures.

C the greater the number of species in a genus, the younger the genus.

D the genus that evolved most recently was *Angophora*.

Question 83/ 170

[VCAA 2011 E2 SA Q23]



Two possible phylogenetic relationships between eight groups of flowering plants are shown in the following diagrams.

One similarity between the alternatives is

A monocots diverged before Chloranthales.

B *Ceratophyllum* and eudicots diverged from monocots.

C *Amborella* and Nymphaeales diverged first from Angiospermae.

D magnoliids were the first group to diverge from Mesangiospermae.

Question 84/ 170

[VCAA 2019 SA Q40]

What evidence in the image below enables the primate shown to be classified as a hominoid?



A the presence of an opposable thumb

B the absence of claws on the toes

C the presence of hair

D the absence of a tail

Question 85/ 170

[VCAA 2018 SA Q37]

Members of the order Primates are mammals.

Which combination of features is common to all primates and distinguishes them from other mammals?

	Feature 1	Feature 2	Feature 3
A	forward-facing eyes	sloping forehead	fur or hair
B	binocular vision	opposable thumbs	fully rotating shoulder joints
C	parabolic jaw	tail	nails instead of claws
D	even-sized teeth	arms longer than legs	bipedal stance

Question 86/ 170

[VCAA 2021 SA Q26]

Until May 2019, Denisovan fossils had been found in only two locations: Siberia and Tibet. Since then, Denisovan DNA has been discovered in some present-day populations. These populations are found on several continents, including Australia.

This suggests that the ancient Denisovan hominin group was, or its descendants were

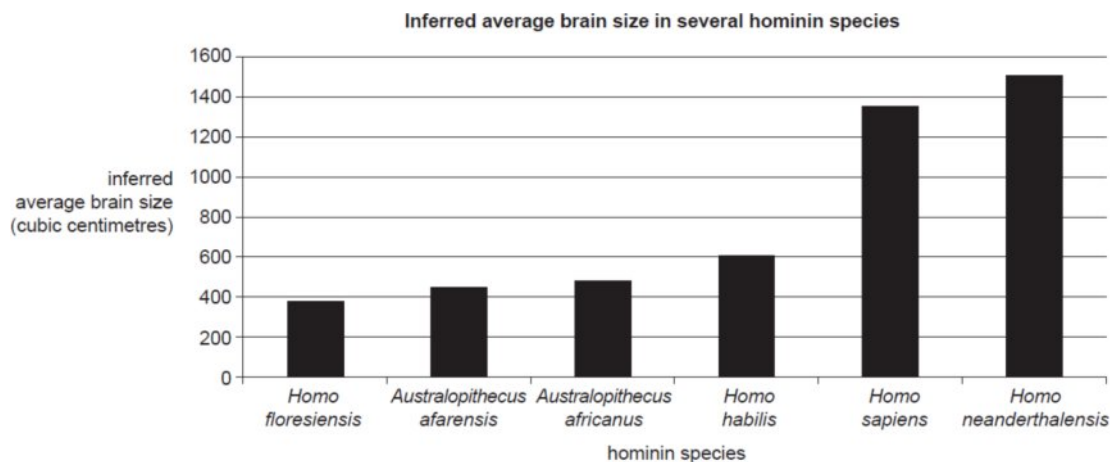
A only fossilised in Siberia and Tibet.

B genetically identical to *Homo sapiens*.

C extinct prior to the presence of Neanderthals.

D more widespread than fossil evidence suggests.

Question 87/ 170



The graph above shows the inferred average brain size of a number of hominin species.

Based on your knowledge and using the information in the graph, which one of the following species does not follow the general trend in inferred brain size seen in hominin evolution?

- A *H. habilis*
- B *H. sapiens*
- C *A. afarensis*
- D *H. floresiensis*

Question 88/ 170

Which row shows the group of characteristics that best reflects the trends in hominin evolution from the *Australopithecus* species to the *Homo* species?

Characteristics

- A decreasing tooth size, increasing size of brow ridges, increasingly bowl-shaped pelvis, increasing size of zygomatic arch
- B decreasing tooth size, decreasing size of brow ridges, decreasing arch of feet, more-opposable big toe
- C increasing jaw size, decreasing size of zygomatic arch, increasing arch of feet, decreasing tooth size

Characteristics

- D** decreasing size of canines, decreasing size of zygomatic arch, increasingly bowl-shaped pelvis, increasing arch of feet
-

Question 89/ 170

[VCAA 2018 SA Q38]

Consider the evolution of hominins.

Which one of the following statements about hominin evolution is correct?

A *Homo sapiens* and *Homo neanderthalensis* are the only present-day hominin species.

B Members of the *Australopithecus* genus are not classified as hominins.

C *Homo erectus* was a bipedal primate.

D All hominoids are also hominins.

Question 90/ 170

[VCAA 2018 SA Q39]

Which general trend is shown by hominin fossils?

A The older the fossil, the more central the position of the foramen magnum in the skull.

B The older the fossil, the smaller the braincase that surrounds the cerebral cortex.

C The more recent the fossil, the less bowl-shaped the pelvis.

D The more recent the fossil, the larger the jaw bones.

Question 91/ 170

[VCAA 2018 SA Q40]

Biologists have suggested that the development of bipedalism was a factor contributing to cultural evolution in hominins.

The advantage of bipedalism that had the greatest impact on cultural evolution was that it allowed

A improved teamwork and social bonding during ritual dances.

B food sources to be seen from long distances.

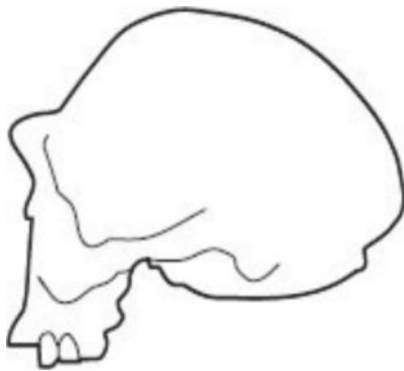
C the free use of hands to manipulate objects.

D fast escape from predators.

Question 92/ 170

[VCAA 2015 SA Q37]

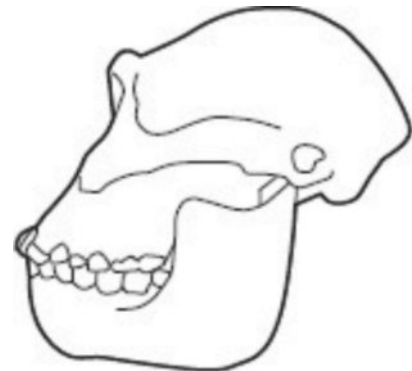
Below are three images of fossil hominin skulls.



Skull 1



Skull 2



Skull 3

Which sequence best shows the order from the most ancient fossil skull to the most modern fossil skull?

A Skull 3, Skull 1, Skull 2

B Skull 1, Skull 2, Skull 3

C Skull 3, Skull 2, Skull 1

D Skull 1, Skull 3, Skull 2

Question 93/ 170

[VCAA 2015 SA Q38]

Fossil remains of a number of individuals from the genus *Australopithecus* were found at various sites in the eastern half of Africa and have been dated to between three and four million years old.

These fossil remains

A are descendants of *Homo erectus*.

B represent the oldest evidence found of primates.

C show early evidence that hominins were bipedal.

D represent the earliest examples of the hominoid super-family

Question 94/ 170

[VCAA 2011 E2 SA Q25]

Consider the following hominin (previously called hominid) species.

M *Homo erectus*

N *Homo neanderthalensis*

O *Australopithecus africanus*

P *Australopithecus afarensis*

The order of oldest to youngest hominin species is

A M N O P.

B P O M N.

C N O P M.

D O M P N.

Question 95/ 170

[VCAA 2017 SA Q35]

Modern African *Homo sapiens* do not contain Neanderthal DNA. Modern non- African *H. sapiens* contain a small percentage of Neanderthal DNA because of interbreeding between Neanderthals and *H. sapiens*. This interbreeding is thought to have occurred within the time period 65 000 to 47 000 years ago.

A recent study has found *H. sapiens* DNA in the genomes of 100 000-year-old Neanderthal remains.

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

A modern Africans are the descendants of Neanderthals.

B there was an early migration of *H. sapiens* out of Africa before 100 000 years ago.

C the ancestors of modern Africans migrated from Europe to Africa between 65 000 and 47 000 years ago.

D approximately 100 000 years ago, Neanderthals bred with *H. sapiens* in Africa before the Neanderthals spread to the rest of the world.

Question 96/ 170

[VCAA 2022 SA Q40]

Scientists are investigating the mitochondrial genomes of different Aboriginal Australian populations. A purpose of these investigations is to reveal the pathways of migration of Aboriginal Australians who arrived from Sahul.

Mitochondrial DNA can be used for this purpose because it

A contains genes that code for enzymes.

B is always the same in specific populations.

C is conserved through the maternal lineage.

D is more structurally stable than nuclear DNA.

Question 97/ 170

[VCAA 2013 SA Q22]

You have the same mitochondrial DNA as your

A paternal grandfather.

B paternal grandmother.

C maternal grandfather.

D maternal grandmother.

Question 98/ 170

Use the following information to answer Questions 99 and 100.

A hominin species, *Homo floresiensis*, was identified from fossils found on an isolated Indonesian island. These fossils were dated to be 18 000 years old.

The adult skull of this upright bipedal hominin had a cranial volume less than one- third of the average cranial volume of a modern adult human. It had harder, thicker eyebrow ridges than *Homo sapiens*, a sharply sloping forehead and no chin.

H. floresiensis was just over one metre tall and their arm-to-leg ratio was slightly larger than modern humans. They weighed approximately 16 kg.

The fossils were found in sediment that also contained stone tools and fireplaces for cooking. The fireplaces contained the burnt bones of animals, each animal weighing more than 350 kg. The stone tools included blades, spearheads, and cutting and chopping tools.

Question 99/ 170

[VCAA 2014 SA Q39]

This evidence and current theories of hominin evolution indicate that

A the very small stature of *H. floresiensis* is unexpected in a species that is geographically isolated on a small island.

B *H. floresiensis* was a species that showed considerable social cooperation and methods for passing on knowledge.

C the sloping forehead and absence of chin of members of the *H. floresiensis* species suggest they were members of the first migration of hominins into Australia over 50 000 years ago.

D the skull shape and size of *H. floresiensis* suggest a close relationship to the *Homo neanderthalensis* species.

Question 100/ 170

[VCAA 2014 SA Q40]

The fossils of *H. floresiensis* showed that they had opposable thumbs. The development of an opposable thumb in primate evolution

A is used to distinguish members of the genus *Homo* from the other great apes.

B was a necessary step in the development of bipedalism in hominins.

C was an important anatomical development that assisted tool-making in hominins.

D is a significant factor in determining the arm-to-leg ratio of modern humans.

Question 1/ 205

[VCAA 2020 SB Q7]

Only 35% of the world's adult human population can digest lactose, which is found in milk. These people continue to produce the enzyme lactase throughout their lives. Most people who can digest lactose have European ancestry. There is evidence that people kept animals for milk in Europe 10 500 years ago. About 7500 years ago in central Europe, a gene mutation occurred in the lactase gene, where cytosine was replaced by thymine. The allele produced by this mutation allows individuals to produce lactase and to digest lactose throughout their lives.

Researchers have estimated that populations in Europe with this mutation produced more offspring than populations who did not have this mutation.

a Name the type of mutation that occurred 7500 years ago in central Europe. (1 mark)

b i The increase in frequency of the allele for lactase persistence happened relatively quickly in some populations. Explain why the frequency of this allele increased relatively quickly. (3 marks)

ii In some present-day populations there are no individuals with the mutation. Give **two** reasons for the absence of the mutation in these populations. (2 marks)

c Cows are the main source of milk in Europe. Modern dairy cow breeds can produce 25 L of milk each day – much more than their wild ancestors.

Describe how an increase in production of cow's milk could be achieved by farmers over many generations of cows. (2 marks)

(Total 8 marks)

Question 2/ 205

[VCAA 2019 SB Q6]

From 10 weeks into pregnancy, a woman can decide to have a non-invasive prenatal test that detects fetal aneuploidies. A blood sample is taken from the woman for the test.

a i What does aneuploidy refer to? (1 mark)

ii What would scientists examine in the woman's blood sample? (1 mark)

If there is a requirement to look for other genetic abnormalities, such as block mutations, different procedures can be conducted.

b Describe **two** different types of block mutations. (2 marks)

Some procedures can detect single gene mutations. Sickle-cell anaemia is produced by a single gene mutation that affects the production of the beta chain of the haemoglobin protein (the oxygen-carrying protein that makes blood cells red). Beta haemoglobin is a single chain consisting of 147 amino acids.

5'	AUG	GUG	CAC	CUG	ACU	CCU	GAG	GAG	3'

Shown below is a small section of the mRNA nucleotide sequence found in an individual without the mutation.

The codon table below can be used to determine amino acids coded for by a nucleotide sequence.

1st position (5' end)	2nd position				3rd position (3' end)
	U	C	A	G	
U	phe	ser	tyr	cys	U
	phe	ser	tyr	cys	C
	leu	ser	STOP	STOP	A
	leu	ser	STOP	trp	G
C	leu	pro	his	arg	U
	leu	pro	his	arg	C
	leu	pro	gln	arg	A
	leu	pro	gln	arg	G
A	ile	thr	asn	ser	U
	ile	thr	asn	ser	C
	ile	thr	lys	arg	A
	met	thr	lys	arg	G
G	val	ala	asp	gly	U
	val	ala	asp	gly	C
	val	ala	glu	gly	A
	val	ala	glu	gly	G

c Use the section of mRNA provided above and the codon table above to complete the table below. (2 marks)

Translated sequence

d i The gene for sickle-cell anaemia produces misshapen red blood cells that do not carry oxygen efficiently. In an individual with sickle-cell anaemia, the twentieth nucleotide has changed to uracil in the transcribed

mRNA provided after part **b**.

How would this alter the amino acids coded for in this sequence? (1 mark)

ii If this twentieth nucleotide was deleted, how could this mutation alter the structure and function of the haemoglobin protein produced? (2 marks)

(Total 9 marks)

Question 3/ 205

[VCAA 2021 SB Q11]

Two students designed an experiment to investigate antibiotic resistance in *Escherichia coli* bacteria. They began with an *E. coli* culture. The following procedure was conducted in a filtered air chamber using aseptic techniques:

- On Day 0, spread 1 mL of *E. coli* culture onto a nutrient agar plate containing 0 µg/mL (micrograms per millilitre) of the antibiotic ampicillin. Spread 1 mL of the *E. coli* culture onto a separate nutrient agar plate containing 1 µg/mL of ampicillin. Cover each plate with an airtight lid.
- On Day 1, transfer a sample of bacteria from one of the Day 0 plates to one of the Day 1 plates containing 2 µg/mL of ampicillin. Transfer a sample of bacteria from the other Day 0 plate to the other Day 1 plate, which also contains 2 µg/mL of ampicillin. Cover as before.
- On Day 2, transfer a sample of bacteria from one of the Day 1 plates to one of the Day 2 plates containing 4 µg/mL of ampicillin. Transfer a sample of bacteria from the other Day 1 plate to the other Day 2 plate, which also contains 4 µg/mL of ampicillin. Cover as before.
- On Day 3, transfer a sample of bacteria from one of the Day 2 plates to one of the Day 3 plates containing 6 µg/mL of ampicillin. Transfer a sample of bacteria from the other Day 2 plate to the other Day 3 plate, which also contains 6 µg/mL of ampicillin. Cover and seal the plates.

All plates were incubated at 37°C for each 24-hour period. Used plates were refrigerated until the end of the experiment. They were then photographed to compare the amount of bacterial growth and disposed of safely.

The students drew a diagram (Figure 1 on the next page) to help explain the experimental design and to show their predicted results in each condition at the end of each day.

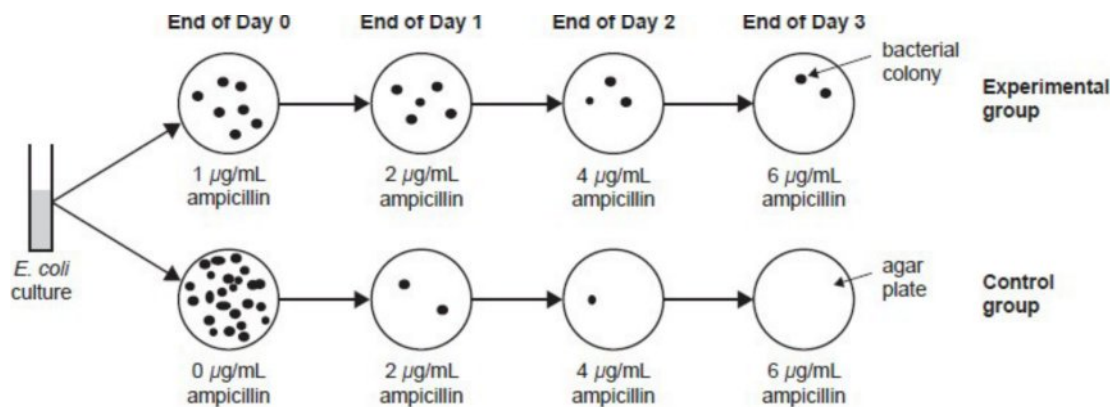


Figure 1

a Identify any **two** controlled variables for this experiment. (2 marks)

b Write a suitable hypothesis for this experiment. (2 marks)

The refrigerated plates kept from Days 0, 1, 2 and 3 of the experiment were photographed. The diagrams in Figure 2 on the following page represent the bacterial growth seen in the photographs.

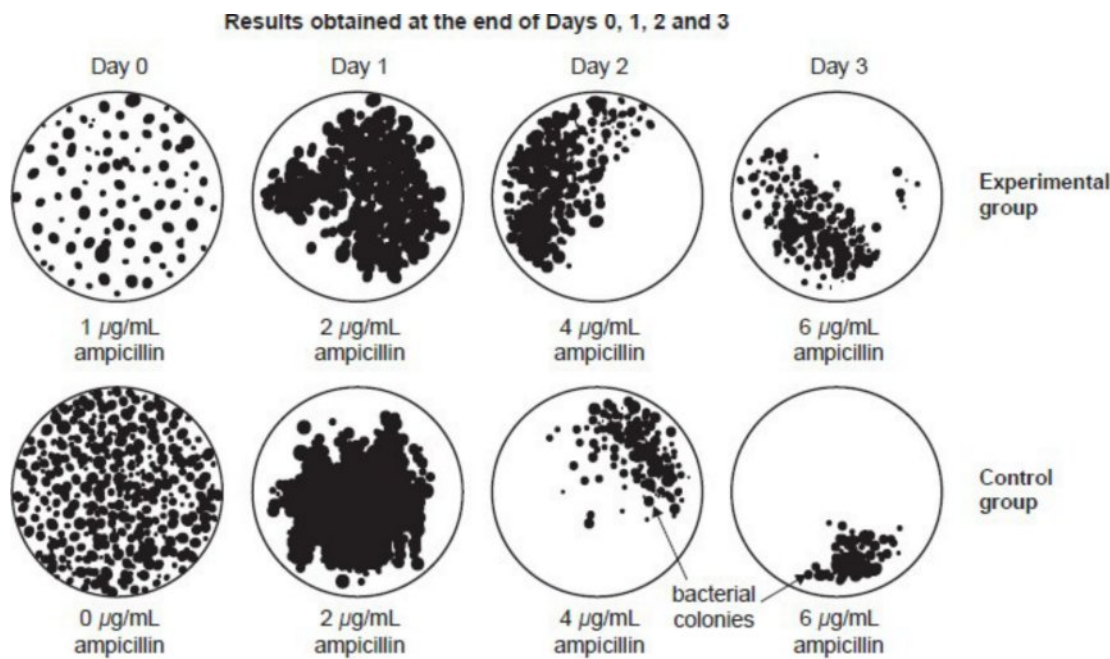


Figure 2

c i Analyse the results of the experiment shown in Figure 2. (3 marks)

ii Explain whether the results of the students' experiment shown in Figure 2 support the predicted results shown in Figure 1. (2 marks)

(Total 9 marks)

Question 4/ 205

[VCAA 2018 SB Q7]

Populations of the lizard species *Anolis sagrei* are found on the many islands of the Bahamas. There is natural variation between the phenotypes of individuals within each population.

a Explain how natural variation can exist between individuals within a lizard population. (3 marks)

In 2004 a hurricane killed all populations of *A. sagrei* lizards on seven of the smaller islands. Scientists randomly chose seven males and seven females from a remaining population on a large island. They introduced one male and one female to each of the seven smaller islands. Over the next three years, the scientists noted that the size of the populations increased on each of the seven smaller islands. The scientists measured the genetic diversity within each of the populations and found there was lower genetic diversity in each new population compared with the population on the large island.

b Explain the reasons for the lower genetic diversity of the new populations on the smaller islands compared with the population on the large island. (2 marks)

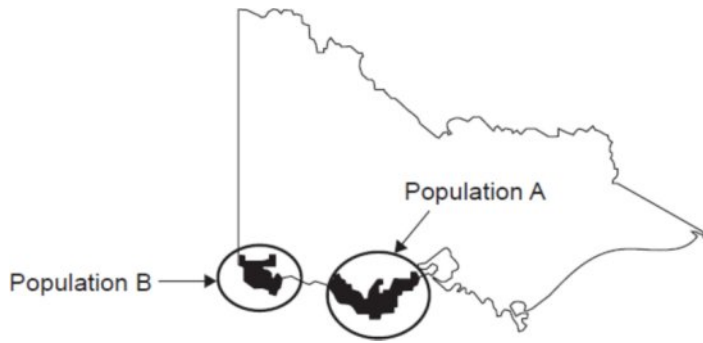
c The scientists noted that after three years there was a significant decrease in the average length of the hind legs of the lizards living on the smaller islands compared with those on the large island. Explain what may have happened on the smaller islands to produce this decrease in the average length of hind legs. (2 marks)

(Total 7 marks)

Question 5/ 205

[VCAA 2017 SB Q5]

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



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

a Define the term ‘gene flow’ and explain whether gene flow is likely to occur between these two populations. (3 marks)

b Both of the rufous bristlebird populations in Victoria are small. Referring to the theory of natural selection, explain why the rufous bristlebird is at risk of extinction. (3 marks)

(Total 6 marks)

Question 6/ 205

[VCAA 2017 SB Q10]

Aboriginal Australians co-existed with the megafauna for at least 17 000 years

Australia was once home to giant reptiles, marsupials and birds known as megafauna. Many researchers have suggested a rapid extinction model to account for the extinction of megafauna thought to have occurred soon after the arrival of the First Australians¹.

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

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

If it can be shown that megafauna disappeared soon after the arrival of the First Australians, then there is

support for the rapid extinction model. On the other hand, proof that megafauna and people co-existed suggests that other explanations for their extinction need to be proposed.

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

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

¹First Australians – the ancestors of Aboriginal Australians

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

a Using the information in the text, explain how the rapid extinction model may account for the extinction of Australia's megafauna. (3 marks)

b Complete the following table by identifying three pieces of evidence in the text that cast doubt on the rapid extinction model. Justify how each piece of evidence can be used to reject the rapid extinction model. (6 marks)

Evidence	Justification

1	

2	

3	

(Total 9 marks)

Question 7/ 205

[VCAA 2013 SB Q9]

The southern brush-tailed rock wallaby (*Petrogale penicillata*) is threatened with extinction in Victoria. Since European settlement, it has suffered from hunting for its fur, clearing of habitat and predation by foxes. Early

in 2012, the population of brush-tailed rock wallabies in the Grampians National Park numbered only four individuals.



Source: Richard Lydekker, A Hand-book to the Marsupialia and Monotremata, R Bowdler Sharpe (ed.), W.H. Allen & Co. Limited, London, 1894

a What is meant by extinction? (1 mark)

Eighteen brush-tailed rock wallabies were released into the Grampians in late 2012. The wallabies had been bred in captivity in zoos and nature reserves in Victoria, South Australia, New South Wales and the Australian Capital Territory. Care was taken to ensure that the gene pool of the released wallabies was as diverse as possible.

b i What is a gene pool? (1 mark)

ii Using your knowledge of natural selection, explain why it is an advantage to have a diverse gene pool among the released wallabies. (2 marks)

Wildlife officers are hoping that the Grampians population will increase to at least 50 wallabies in five years and that it will be maintained over time. A small population of wallabies could be affected by **genetic drift** and, possibly, a genetic **bottleneck effect**.

c Explain the meaning of each of these terms with reference to allele frequencies. (2 marks)

The Grampians wallabies will be closely monitored by surveillance cameras and radio collars after their release.

d Suggest one further measure that wildlife officers should carry out to help maintain the population over time. (1 mark)

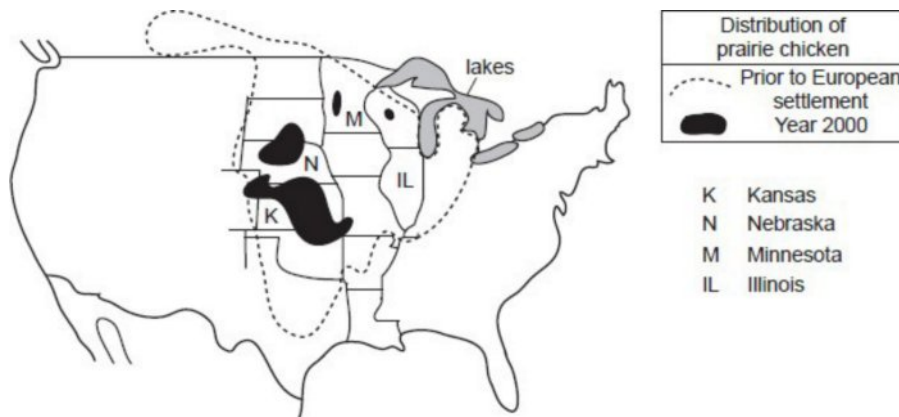
(Total 7 marks)

Question 8/ 205

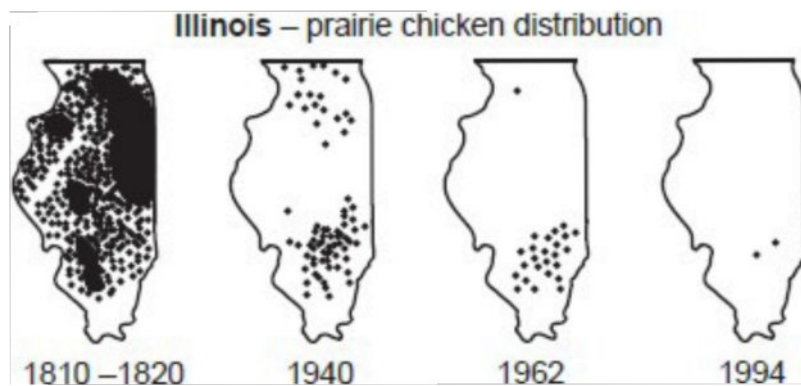
[VCAA 2011 E2 SA Q6]

a Define 'genetic drift'. (1 mark)

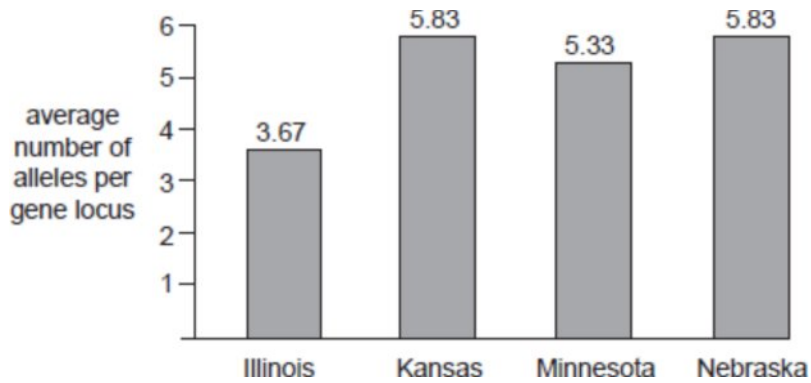
The prairie chicken (*Tympanuchus cupido pinnatus*) is a grassland bird native to North America. A prairie chicken spends its entire life within several kilometres of its birthplace. Prior to European settlement, prairie chickens numbered in the millions across the Midwest of the United States of America. As a result of the grasslands being replaced by plant food crops, the distribution of prairie chickens has diminished, as shown in the diagram on the next page.



By 1994, Kansas, Nebraska and Minnesota still supported large and widespread populations; however, in the state of Illinois, the number of prairie chickens fell to less than fifty individuals isolated in two separate geographical areas.



Representative samples of prairie chickens from the four states were selected for testing. Each prairie chicken had six gene loci tested. The average number of alleles at each gene locus for each prairie chicken group is shown in graph below.



b i Explain the significance of the results for the Illinois birds compared to the results of the birds from the three other states. (2 marks)

ii Explain why the results for the Kansan birds and Nebraskan birds are similar to each other. (1 mark)

Measures were taken in the 1990s to prevent the Illinois prairie chicken from dying out completely.

c i Explain why low genetic diversity in a population threatens the survival of the population. (2 marks)

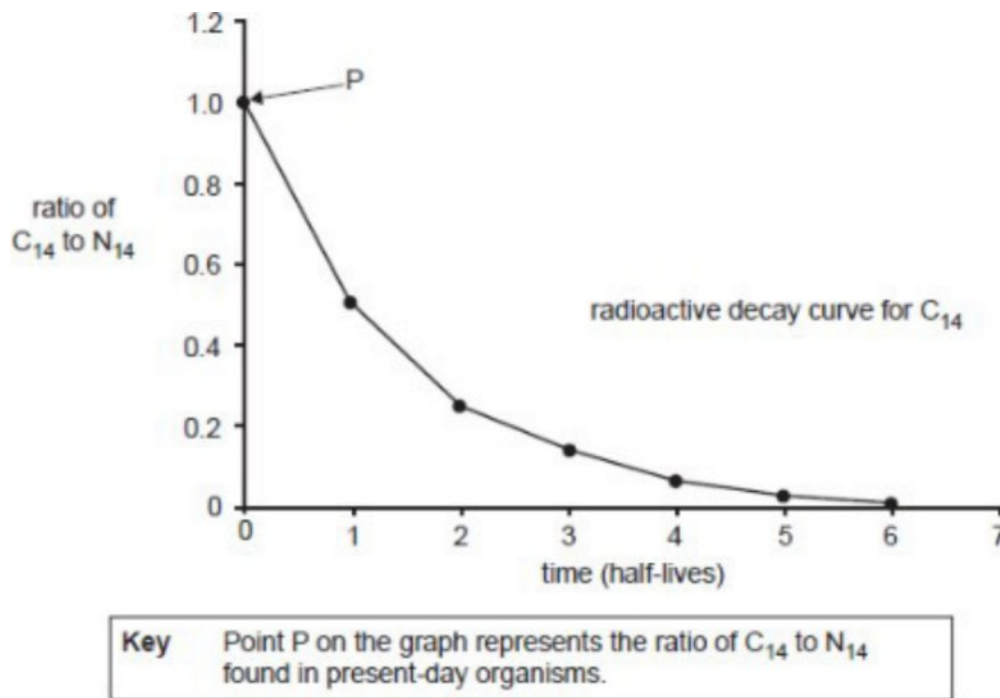
ii Describe one measure that could be used to prevent the Illinois prairie chicken from dying out. (1 mark)

(Total 7 marks)

Question 9/ 205

[VCAA 2012 E2 SB Q6]

One form of dating the age of a fossil is by radioactive carbon dating. The ratio of carbon-14 to nitrogen-14 ($C_{14} : N_{14}$) in the fossil is analysed and compared with the ratio of these elements in an organism living today. The following graph shows the rate of decay for carbon-14.



A fossil kangaroo skull was found in a limestone cave. The skull's $C_{14} : N_{14}$ ratio was analysed and found to contain one-quarter ($\frac{1}{4}$) of the carbon-14 of a kangaroo that died in 2012.

a i Place an X on the curve to show the fossil's $C_{14} : N_{14}$ ratio. (1 mark)

ii Given the half-life of carbon is approximately 6000 years, what is the approximate age, in years, of the kangaroo skull? (1 mark)

Carbon-dating analysis is not always possible, and the age of the fossil can be estimated by dating the rock in which it is found.

b i Why is carbon-dating analysis not always possible? (1 mark)

ii Name another absolute dating technique that can determine the age of the rock surrounding a fossil. (1 mark)

(Total 4 marks)

Question 10/ 205

[VCAA 2022 SB Q6]

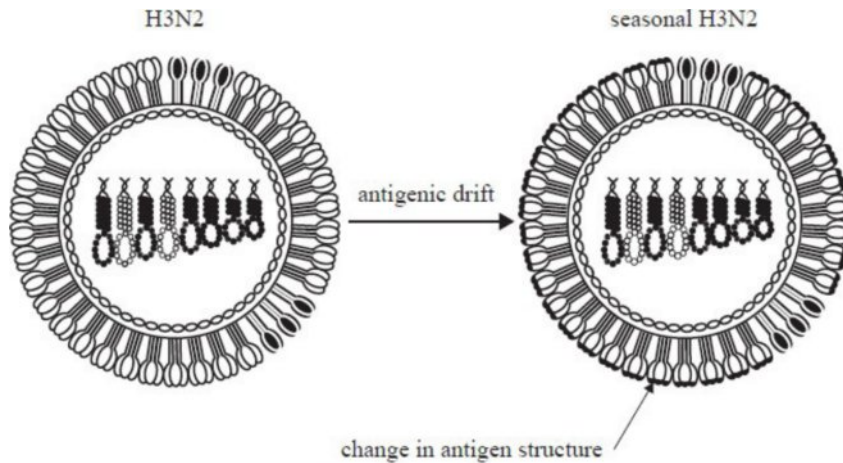
Influenza is an infectious respiratory disease. In humans, it can be caused by the influenza A or influenza B viruses.

a Natural killer cells and cytotoxic T cells both play an important part in the human immune response to the

virus causing influenza.

Compare the roles played by each of these two types of cells in the immune response to the influenza virus. (4 marks)

Antigenic drift can result in small changes to the structure of the antigens on the surface of the influenza virus, as shown in the diagram on the next page.



Source: adapted from F Krammer, GJD Smith, RAM Fouchier et al., 'Influenza', *Nature Reviews Disease Primers*, 4:3 (2018), <<https://doi.org/10.1038/s41572-018-0002-y>>

b i What change would have occurred within the virus to bring about the change in the structure of the antigen? (1 mark)

ii Vaccines against influenza are available and it is recommended that people are vaccinated each year.

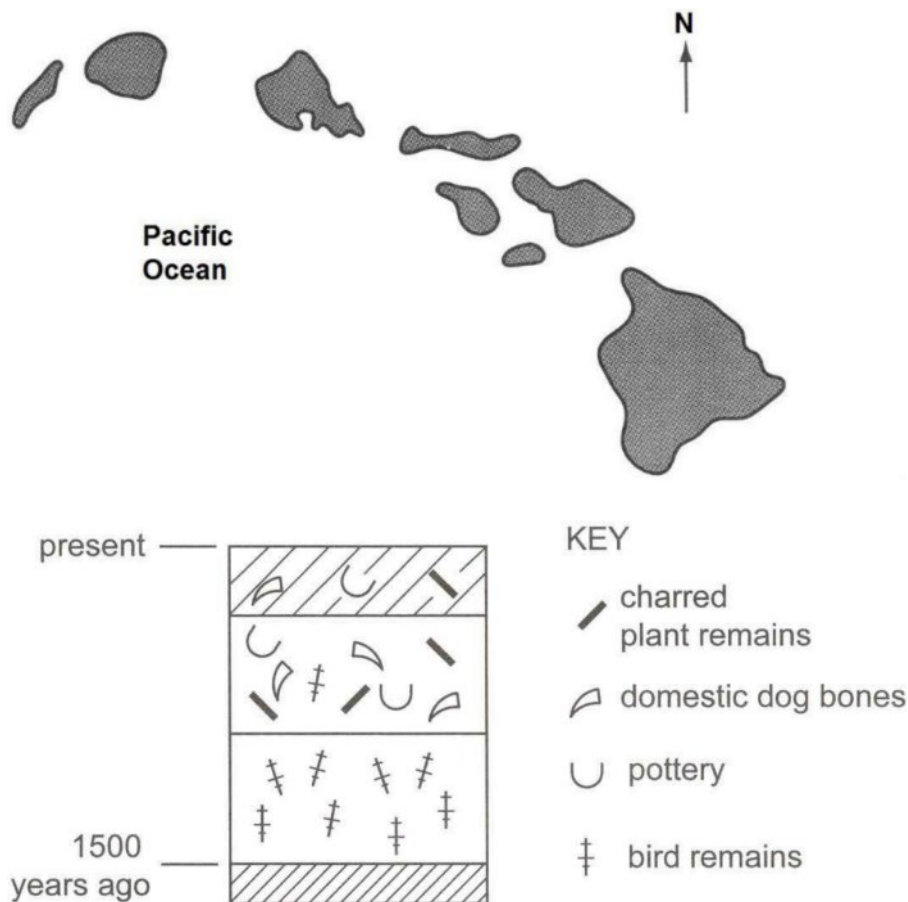
Explain, in terms of antigenic drift, why vaccinations are recommended yearly for influenza rather than once every few years. (2 marks)

(Total 7 marks)

Question 11/ 205

[VCAA 2010 E2 SB Q7]

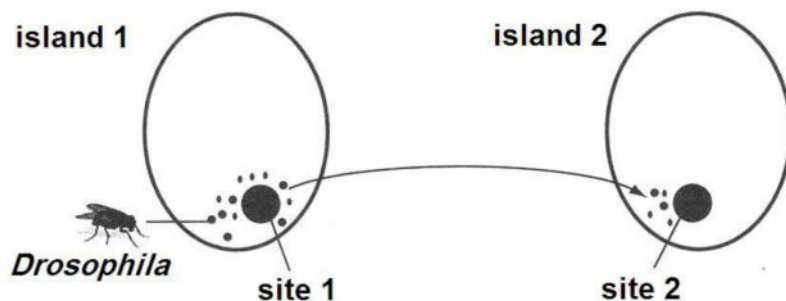
The islands of Hawaii in the Pacific Ocean were formed as a result of volcanic action in which small land masses were thrown up by submarine volcanoes. The youngest of the islands lies to the east of the oldest.



A similar pattern of deposition has been found across all islands, shown by the profile below.

- a** What assumption is made about the formation of strata when interpreting profiles such as this? (1 mark)
- b i** State a hypothesis to account for the disappearance of many of the bird species from the groups of islands. (1 mark)
- ii** Provide evidence to support your hypothesis. (1 mark)

Biologists studied many species of the fruit fly, *Drosophila*, living on the Hawaiian Islands. The species vary widely in appearance, behaviour and habitat. The diversity of *Drosophila* can be explained by the successive colonisation of newly formed islands by a small number of individuals 'island-hopping' from the neighbouring westerly island. This is represented in the diagram below.



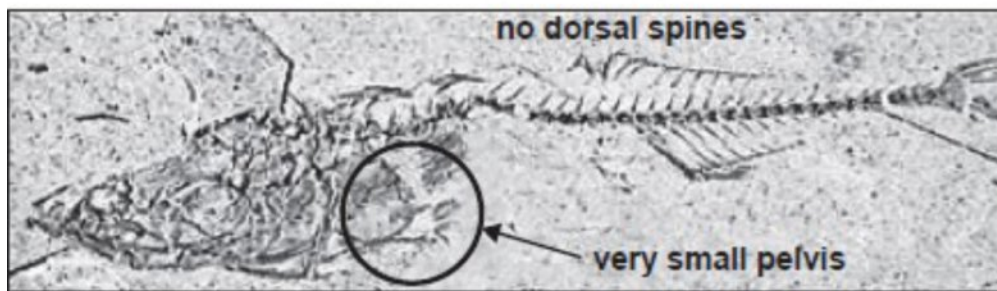
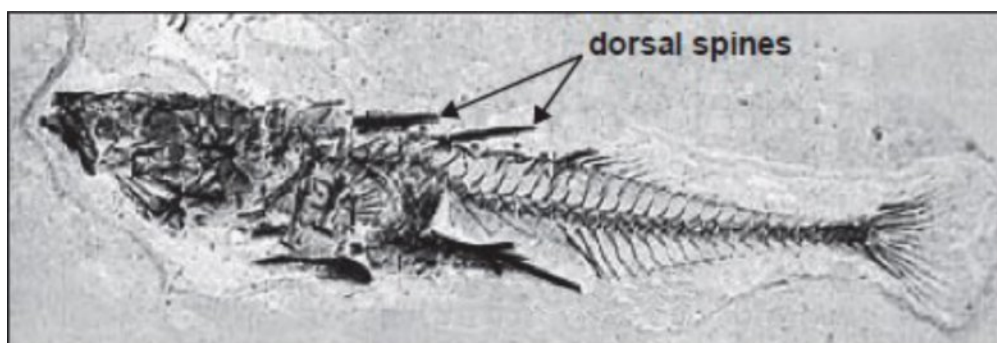
- c i** What name is given to this small group of colonising individuals? (1 mark)
- ii** Explain how the new and old colonies became separate species. (3 marks)

(Total 7 marks)

Question 12/ 205

[VCAA 2015 SB Q10]

Scientists studying the fossils in an ancient lakebed have an almost perfect fossil record ranging more than 25 000 years. In this fossil record, there are two forms of a fish called a 'stickleback'. One form has large spines on the back of the fish (dorsal spines) and large pelvic bones. The other form has smaller or no spines and smaller pelvic bones. Modern-day stickleback fish with large dorsal spines are common in the ocean, while the stickleback fish with small spines are more common in fresh water.



The table below contains a summary of some structural features of the fossils found in different sediment layers in the ancient lake bed.

Sediment layer	Pelvis	Dorsal spines
top	small	small or absent
middle	large	large
lower	small	small or absent

a i Suggest a hypothesis that could explain the change in the structural features seen in the different sediment

layers. (1 mark)

ii Give evidence from the information provided to support your hypothesis. (2 marks)

b Scientists studying modern-day sticklebacks taken from freshwater lakes have discovered that young fish that grow to have small pelvises and small or no dorsal spines grow more quickly and move faster as young fish than those that grow into fish that have larger pelvises and dorsal spines.

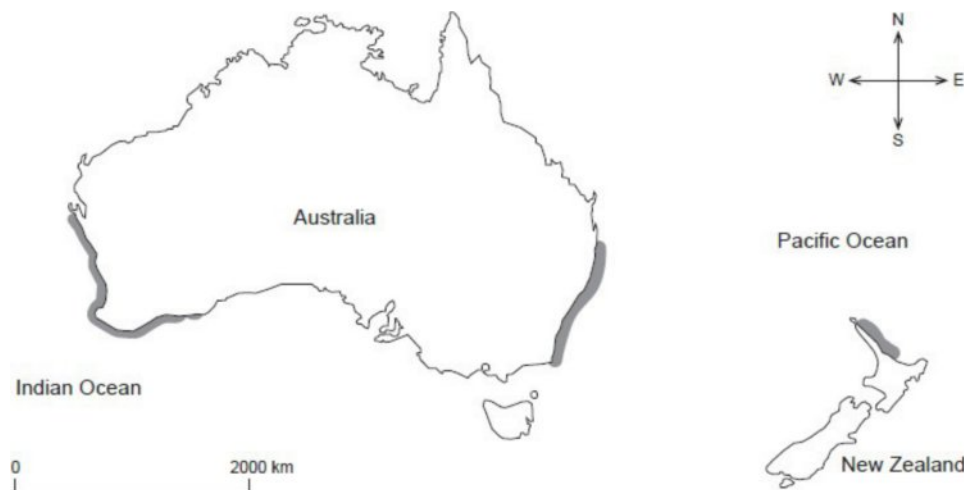
Outline how the sticklebacks with small pelvises have become more common over time in fresh water. (2 marks)

(Total 5 marks)

Question 13/ 205

[VCAA 2021 SB Q6]

Many species of octopus can be found in the oceans surrounding Australia and New Zealand. Populations of octopus can be found on both the east and west coasts of Australia and on the north coast of New Zealand. The distribution of the populations is shown shaded on the map below.



Source: adapted from MD Amor, MD Norman, HE Cameron and JM Strugnell,
‘... within a cryptic species complex of Australasian octopuses’,
PLOS ONE, vol. 9, issue 6, e98982, June 2014,
<<https://doi.org/10.1371/journal.pone.0098982>>

a Scientists investigated whether the octopus populations on Australia's east coast are a separate species from the populations on the west coast. After analysing both molecular and morphological results, the scientists concluded that all populations share a distant common ancestor. They also concluded that the populations of octopus on the east coast of Australia are a distinct species from the populations of octopus on the west coast of Australia.

Describe the process that may have led to the formation of the two distinct species of octopus from the distant common ancestor. (4 marks)

b The scientists also compared the populations of east Australian octopus with the populations of the New Zealand octopus. No significant genetic differences between these populations of the New Zealand octopus and east Australian octopus were found. It is known that young octopi can be carried long distances by water currents. Occasionally, adult octopi have been seen on pieces of floating wood.

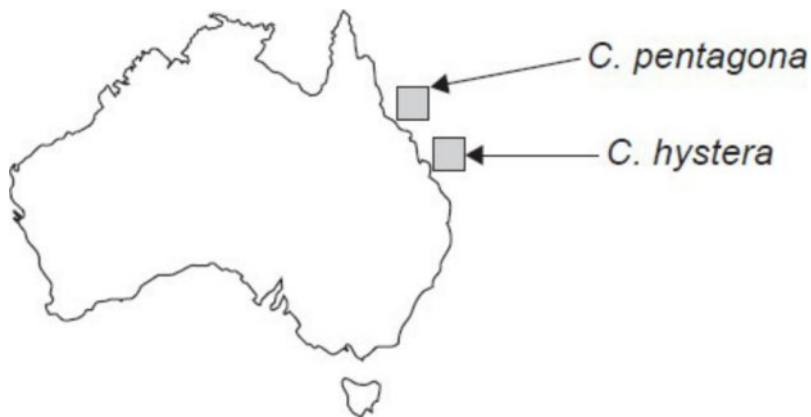
Give **two** reasons that may account for the lack of genetic diversity between the populations. (2 marks)

(Total 6 marks)

Question 14/ 205

[VCAA 2016 SB Q8]

Two species of *Cryptasterina* sea stars are found in coastal Queensland. *Cryptasterina pentagona* is found in warmer water further north, while *Cryptasterina hystera* is found further south in cooler water.



Researchers have concluded that these two species arose from a recent common ancestor via natural selection. They believe that, over thousands of years, the sea environment has changed, with the boundary line between cold water and warm water moving further north. They have found that water temperature and predation of sea star larvae by cold-water predators are important selection pressures for these sea stars.

a Using the information above, explain how natural selection can lead to differences in phenotypes between these two sea star species. (4 marks)

b One of the phenotypic differences between these two species of sea stars is their method of reproduction. *C. pentagona* reproduces sexually and its sperm and eggs are free-floating in the ocean.

C. hystera self-fertilises and its fertilised eggs are kept within the sea star until maturity. The researchers found that one species of *Cryptasterina* has a significantly higher diversity of alleles in its gene pool than the other species.

Using this information about reproduction strategies, which species of *Cryptasterina* would you expect to have the highest diversity of alleles? Explain your answer. (2 marks)

(Total 6 marks)

Question 15/ 205

[VCAA 2016 SB Q9]

Galápagos tortoises (*Chelonoidis* spp.) can be found on many of the islands that make up the Galápagos Islands. Originally, 14 different species were identified based on the islands on which they lived and on their morphology.

Santa Cruz, the second largest of the Galápagos Islands, has two isolated tortoise populations. Population A contains more than 2000 individuals covering an area of 156 square kilometres. Population B is a small population of 250 individuals covering an area of 40 square kilometres.

The position of the two populations on the island of Santa Cruz is shown below. The two populations are separated by a distance of 20 kilometres.



In 2015, scientists investigated whether the individuals of the two populations belong to the same species or whether they are two different species.

Average measurements of skull size were calculated for tortoises belonging to both populations A and B. The skulls were measured in six different places. The six measurements were also compared to average measurements taken from skulls of other Galápagos tortoise species. The results are shown in the table below.

Comparisons have been made with three other Galápagos tortoise species.

Measurement position	Average skull measurement (mm)				
	Population B	Population A	<i>Chelonoidis vicina</i>	<i>Chelonoidis chathamensis</i>	<i>Chelonoidis ephippium</i>
1	118	98	86	80	74
2	40	37	28	27	25
3	21	18	16	14	12
4	26	23	21	18	17
5	10	9	8	7	6
6	19	17	16	14	13

a Consider the data given.

Does the data support the hypothesis that individuals in Population A belong to a different species from individuals in Population B? Explain your answer. (2 marks)

b Scientists have carried out genetic studies on the two populations.

Give an example of genetic evidence that may be produced by scientists to support the hypothesis that individuals of the two populations belong to different species. Explain your answer. (2 marks)

c Some scientists thought that allopatric speciation may have occurred on the island of Santa Cruz.

i Name a feature that scientists would look for in the island environment to support the occurrence of allopatric speciation. (1 mark)

ii Explain how the feature named in **part c.i.** could contribute to allopatric speciation. (2 marks)

(Total 7 marks)

Question 16/ 205

[VCAA 2019 SB Q7]

Consider the information provided on the three species shown in the table that follows.

Species	rock hyrax	elephant	dugong



Size

small terrestrial mammal
(2–5 kg)

large terrestrial mammal
(4500–6000 kg)

mid-sized marine mammal
(150–300 kg)

a These three species are closely related, sharing a relatively recent common ancestor, but have different features.

Identify the type of evolution involved. Justify your response. (2 marks)

In 2014 palaeontologists discovered a frozen, well-preserved, complete specimen of an extinct species, the steppe bison, in Siberia. The intact specimen was dated at 9300 years old.

b Scientists are debating the cause of the steppe bison's extinction. Give **one** possible cause of its extinction. (1 mark)

c Though steppe bison are extinct, palaeontologists know a lot about them as they have found several frozen, intact steppe bison bodies.

Describe what would have occurred to lead to the preservation of the animal from when the steppe bison died to when the frozen, well-preserved remains were discovered. (4 marks)

(Total 7 marks)

Question 17/ 205

[VCAA 2021 SB Q7]

Lemurs belong to the order Primates and are found in the wild only on the African island of Madagascar.

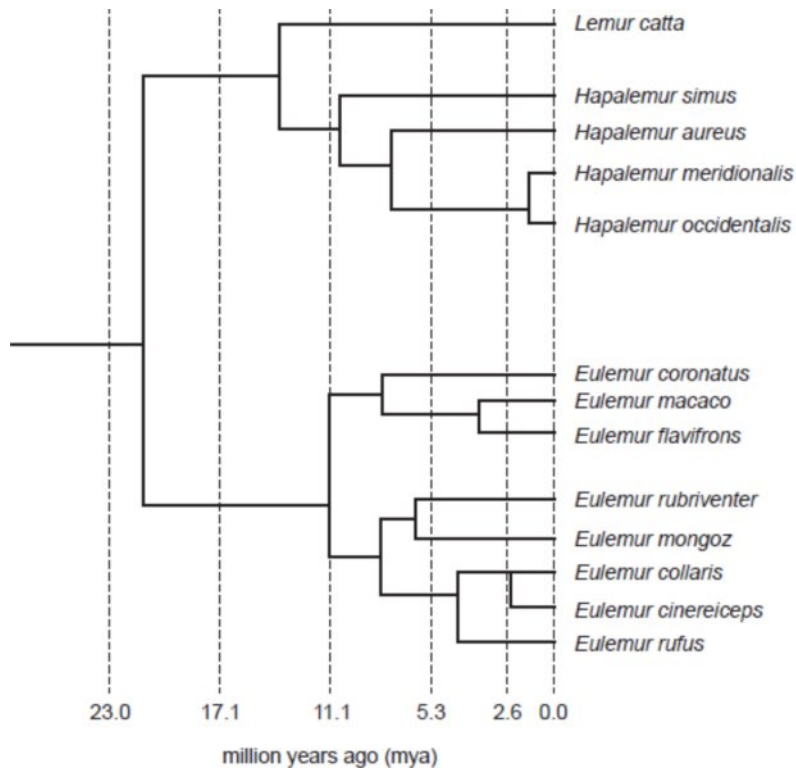
a Identify **two** structural features that are common to most primates and that distinguish them from other mammal groups. (2 marks)

A team of biologists combined morphological data from extinct and living lemur species, along with genetic data, to produce a phylogenetic tree for lemurs. The biologists used published sequences from mitochondrial

DNA (mtDNA) as a molecular clock.

b Give **two** advantages of using mtDNA as a molecular clock. (2 marks)

A small part of the phylogenetic tree for lemurs, constructed by the biologists, is shown below.



Source: adapted from JP Herrera and LM Dávalos, 'Phylogeny and divergence times of lemurs inferred with recent and ancient fossils in the tree', *Systematic Biologists*, 65(5), 2016, p. 781

c Describe the phylogenetic relationships between *Lemur catta*, *Eulemur coronatus* and *Eulemur flavifrons*, as shown in the phylogenetic tree shown. (2 marks)

d Biologists isolated DNA from different species of present-day lemurs and performed DNA hybridisation.

Outline the main steps in the process of DNA hybridisation and explain how DNA hybridisation supports the relationships shown in the phylogenetic tree above. (4 marks)

(Total 10 marks)

Question 18/ 205

[VCAA 2022 SB Q8]

There are 13 species of small birds commonly known as Darwin's finches, found only on the Galápagos

Islands in the Pacific Ocean, 1000 km west of South America. Their closest living relative is the dull-coloured grassquit, *Asemospiza obscura*, which is found on mainland South America. It is believed that Darwin's finches evolved from *A. obscura* or from its ancestor on the mainland. The different finch species are similar in colour but vary in beak size and shape, habitat and diet.

a Discuss how the different species of Darwin's finches arose from an ancestral population on the mainland. In your response, name the type of speciation that occurred, identify the main selection pressure that has acted on finch populations and explain how the Galápagos Islands enabled rapid speciation. (6 marks)

The table that follows shows the distribution of Darwin's finch species on the Galápagos Islands.

The species of Darwin's finches found on each island of the Galápagos

Species	Abbreviated name of island															
	Esp.	Fern.	Flor.	D. Maj.	Gen.	Isa.	Pint.	Mar.	N. Sey.	Pinz.	Rab.	S. Cris.	S. Cruz.	S. Fe	Santi.	W. & Dar.
<i>Certhidea olivacea</i>	✓	✓	✓		✓	✓			✓	✓	✓		✓		✓	
<i>Certhidea fusca</i>	✓		✓		✓		✓	✓				✓		✓		
<i>Geospiza scandens</i>			✓	✓	✓	✓	✓		✓	?	✓	✓	✓	✓	✓	
<i>Geospiza conirostris</i>	✓															
<i>Geospiza magnirostris</i>		✓	extinct	✓	✓	✓	✓	✓		✓	✓	extinct	✓	extinct	✓	
<i>Geospiza psittacula</i>		✓	extinct			✓	✓	✓		extinct	✓		✓	✓	✓	
<i>Geospiza heliobates</i>						✓										
<i>Geospiza fortis</i>		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
<i>Geospiza pauper</i>			✓													
<i>Geospiza difficilis</i>		✓	extinct				✓						extinct			✓
<i>Geospiza fuliginosa</i>	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
<i>Geospiza parvula</i>		✓	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	
<i>Geospiza pallida</i>		?				✓				?		✓	✓		✓	

Source: Galapagos Conservation Trust, 'Darwin's finches', <<https://galapagosconservation.org.uk/wildlife/darwins-finches/>>

b Using the table above, identify the species of Darwin's finches that is currently the most widely distributed. (1 mark)

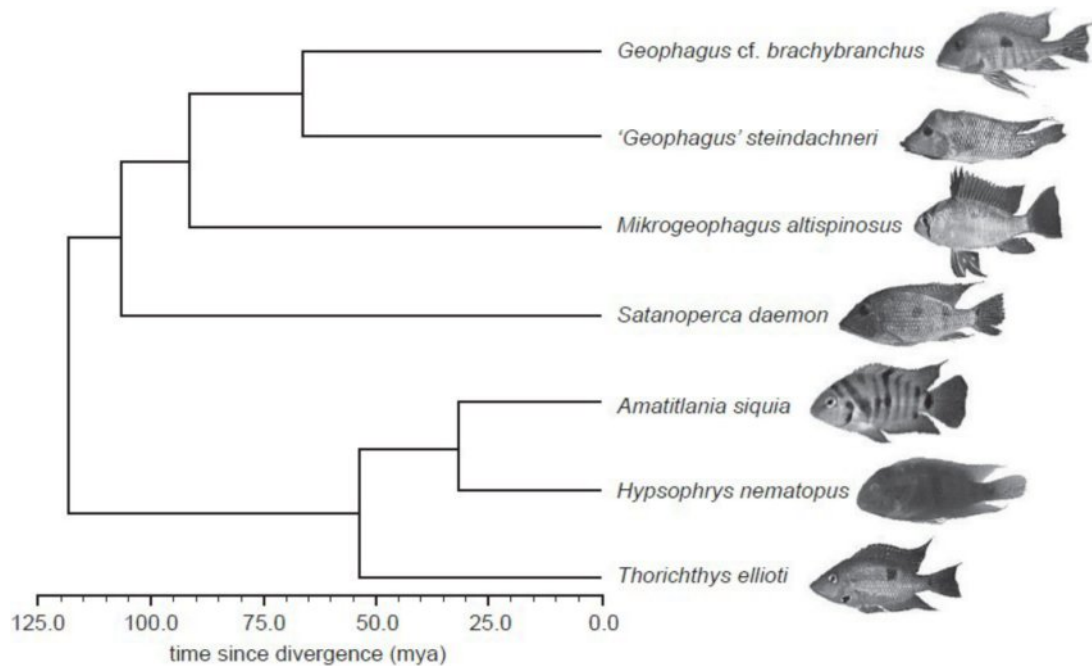
c The species *G. magnirostris*, *G. psittacula* and *G. difficilis* are listed as 'extinct' on several islands. Describe two types of evidence that would allow biologists to classify a species as extinct on a particular island. (2 marks)

(Total 9 marks)

Question 19/ 205

[VCAA 2020 SB Q8]

The phylogenetic tree below shows the evolutionary relationship between seven species of cichlid fish.



Source: H López-Fernández et al.,
'Morphology and efficiency of a specialized foraging behavior, sediment sifting,
in neotropical cichlid fishes', *PLoS ONE*, 9(3): e89832,
6 March 2014, <<https://doi.org/10.1371/journal.pone.0089832>>

a Molecular homology can be used to construct a phylogenetic tree. Based on the information above, state which two species of cichlid fish would be expected to have the most similar amino acid sequences in their proteins. Justify your answer. (3 marks)

b Fossils of species of fish are more likely to be found than fossils of land-dwelling animals. Explain why this is the case with reference to two conditions required for the fossilisation of an organism. (2 marks)

c A group of scientists stated that a particular fossilised fish was 5000 years old. Outline a dating technique that could have been used by the scientists to determine the age of the fossil. (2 marks)

(Total 7 marks)

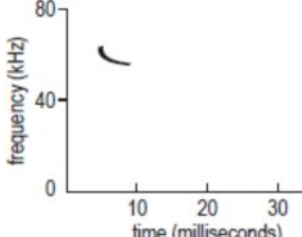
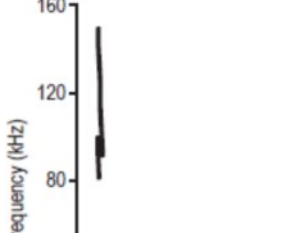
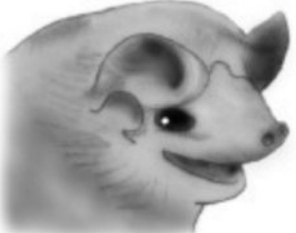
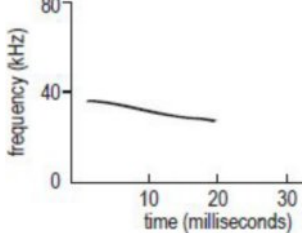
Question 20/ 205

[VCAA 2012 E2 SB Q5]

Barro Colorado Island is a small island covered by tropical forest in Central America. Seventy-four different species of bats live in the forest.

Bats are nocturnal, flying mammals. To find their way around in darkness, many bat species emit high-frequency sound pulses that bounce off obstacles and prey. These pulses enable them to judge the distance to an object. This behaviour is called echolocation.

Three of the Barro Colorado Island species are described in the table on the next page.

Species name	Facial appearance of bat	Diet	Feeding location	Echolocation signal
Black myotis bat (<i>Myotis nigricaris</i>)		insects	around trees at forest's edge and in clearings	
Mexican long-tongued bat (<i>Choeronyct eris mexicana</i>)		Nectar and pollen flowers that open at night, for example cactus, agave	narrow gaps and small spaces	
Velvety free-tailed bat (<i>Molossus molossus</i>)		Insects	above trees, in open spaces	

a From the information provided, state **one** selection pressure operating on the bats of Barro Colorado Island. (1 mark)

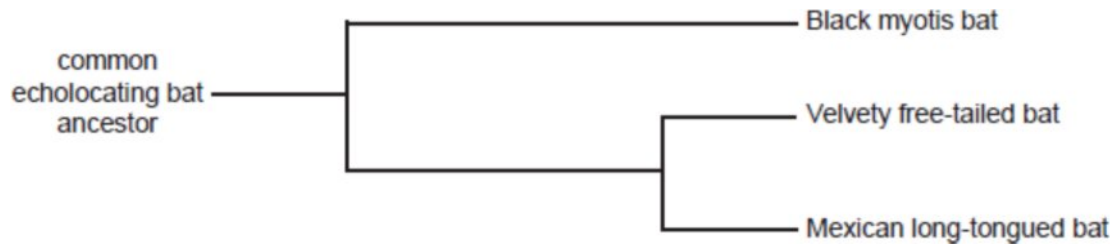
b i In terms of time, which of the three species emits the longest echolocation signal? (1 mark)

ii Explain how this could be a selective advantage for this bat species. (1 mark)

c A biologist suggested that the three species shown evolved from a recent common ancestor. What is this type of evolution called? (1 mark)

The biologist wanted to establish the order in which each species had evolved from the common ancestor. DNA hybridisation between the various species was carried out.

After analysing the results, the scientist drew the following phylogenetic tree.



d What results would have been obtained from the DNA hybridisation that led the biologist to construct this phylogeny? (2 marks)

e A student suggested that the evolution of the three species was an example of allopatric speciation. Explain why you agree or disagree with the student. (2 marks)

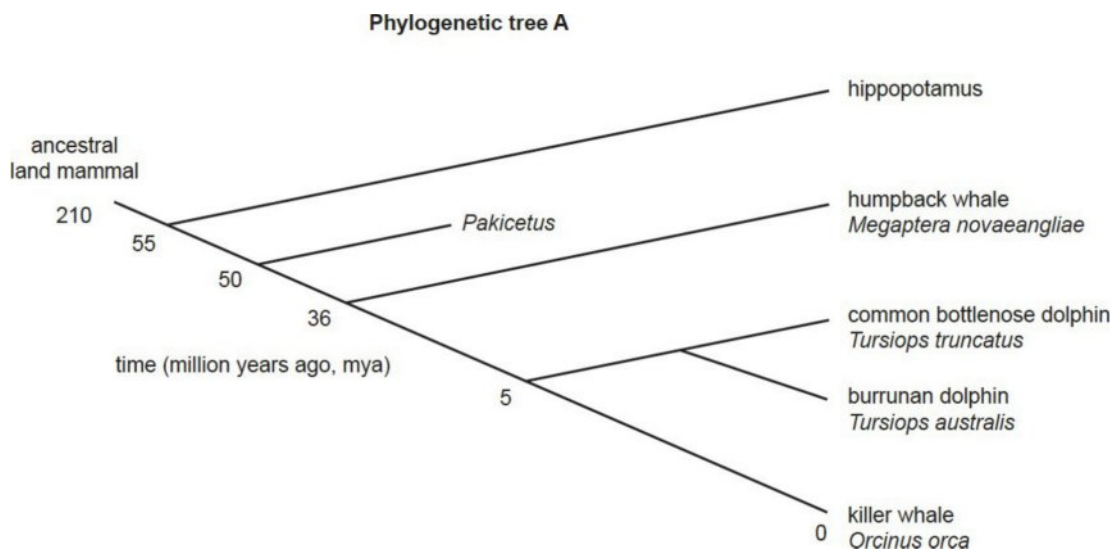
(Total 8 marks)

Question 21/ 205

[VCAA 2018 SB Q9]

Cetaceans (whales, porpoises and dolphins) are marine mammals belonging to the order Artiodactyla (even-toed hoofed mammals). The closest living relatives of cetaceans are the hippopotamuses.

Phylogenetic tree A summarises the evolutionary relationships of four present-day cetacean species and the hippopotamus.



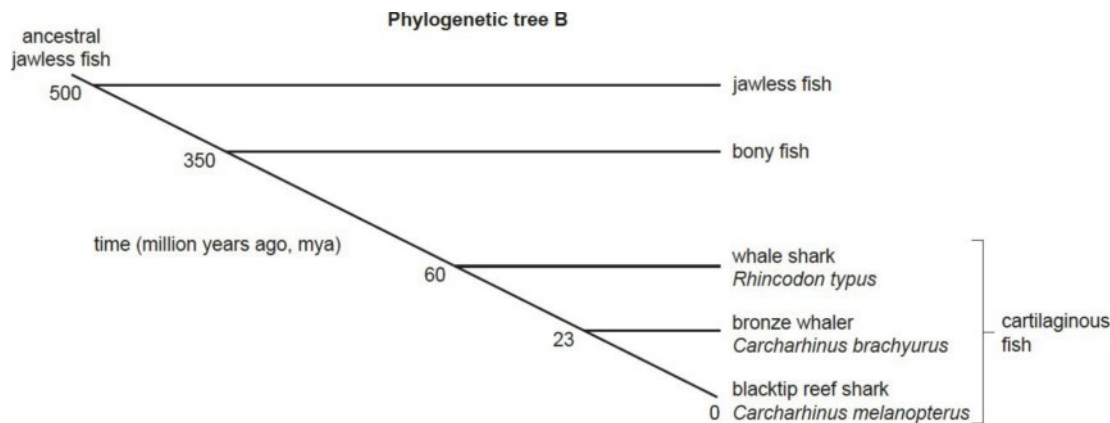
a What does the length of the line that represents the evolution of *Pakicetus* suggest? (1 mark)

b A fossil named *Ambulocetus* was found in 1992 and dated at 49 million years old. Some palaeontologists believe that it is a transitional fossil between the ancestral land mammal shown in Phylogenetic tree A and present-day cetaceans.

Predict **two** structural features of the *Ambulocetus* fossil that would provide evidence to support the hypothesis that it is a transitional fossil and suggest a survival advantage of each feature. (3 marks)

Sharks are marine fish of the order Chondrichthyes (cartilaginous fish).

Phylogenetic tree B summarises the evolutionary relationships of three present-day shark species and main fish classes.



The table below provides information about the present-day species shown in phylogenetic trees A and B.

Marine animal		Average length (m)	Diet
	Humpback whale <i>Megaptera novaeangliae</i>	16	filters plankton and krill by sucking water into mouth through baleen plates
	common bottlenose dolphin <i>Tursiops truncatus</i>	4	hunts fish, squid and crustaceans
	burrunan dolphin <i>Tursiops australis</i>	3	hunts fish and squid
	killer whale <i>Orcinus orca</i>	10	hunts sea birds, squid, seals, baleen whales, dolphins, fish, sharks and sea turtles depending on location
	whale shark <i>Rhincodon typus</i>	12	filters plankton, small squid and fish through filter pads and 300 rows of teeth
	bronze whaler <i>Carcharhinus brachyurus</i>	3	hunts squid, bony fish and other cartilaginous fish
	blacktip reef shark <i>Carcharhinus melanopterus</i>	2	hunts small bony fish, squid and shrimp

c i Give a specific example of **divergent** evolution using two animals from the information provided in Phylogenetic trees A & B and the table above and justify your response. (2 marks)

ii Give a specific example of **convergent** evolution using **two** animals from the information provided in Phylogenetic trees A and B, and the table above and justify your response. (2 marks)

In 2011, Australian scientists identified the burrunan dolphin as a separate species from the common bottlenose dolphin. They gathered evidence from living dolphin populations as well as museum specimens.

d Briefly describe **two** types of evidence that the scientists would have used to establish whether the burrunan dolphin is a separate species from the common bottlenose dolphin. (2 marks)

e Burrunan dolphins are found only in Port Phillip Bay and the Gippsland Lakes in Victoria. There are only 150 burrunan dolphins alive today. The Port Phillip Bay population is very isolated and rarely mixes with dolphins outside the bay. Port Phillip Bay is impacted by the human population and industry of Melbourne and surrounding towns, and is used heavily for recreation, fishing and shipping.

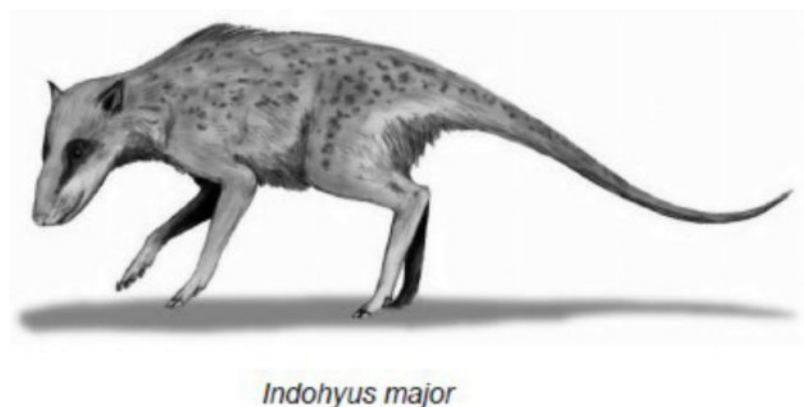
Suggest **two** possible future outcomes for the Port Phillip Bay population of burrunan dolphins. Justify each outcome. (2 marks)

(Total 12 marks)

Question 22/ 205

[VCAA 2015 SB Q9]

A fossil of an extinct species called *Indohyus major*, found in northern India, is thought to share a recent common ancestor with the group of living organisms called cetaceans. Cetaceans include dolphins and whales.



a Name the type of evolution that describes the relationship between *I. major* and cetaceans. (1 mark)

For a long time, scientists have believed that cetaceans are related to the group of terrestrial mammals classified as artiodactyls, which includes pigs and hippopotami. The name ‘artiodactyl’ refers to the shape of the feet or hooves of these animals.

To work out the evolutionary relationships between *I. major* and living animals, scientists closely studied their bones and skeletal structures.

b What name is given to the study of the similarities and differences between the bones and skeletal structures of animals, including fossils of extinct species? (1 mark)

The table below shows a summary of the scientists’ findings.

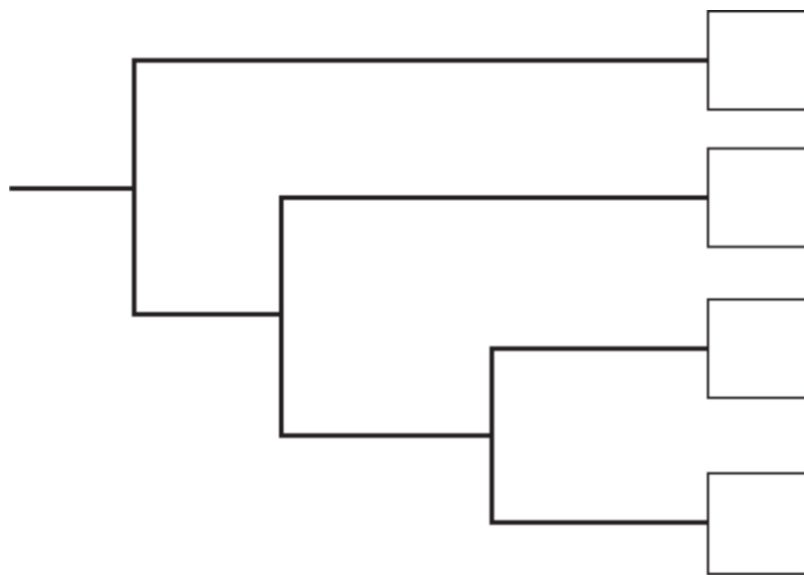
Animal	Feet	Limb bones	Inner-ear bones
cetaceans (e.g. whales)	artiodactyl	thick	thick
suids (e.g. pigs)	artiodactyl	thin	thin
hippopotamids (e.g. hippopotami)	artiodactyl	thick	thin
<i>I. major</i>	artiodactyl	thick	thick

c i Using all the information provided, complete the diagram that follows to show the evolutionary relationships between the following animals:

A cetaceans (e.g. whales and dolphins) **B** suids (e.g. pigs)

C hippopotamids (e.g. hippopotami) **D** *I. major*

Write the corresponding letter of the animal (A.–D.) in the boxes provided. (2 marks)



ii Explain the reasoning behind your response to **part c.i.** (2 marks)

(Total 6 marks)

Question 23/ 205

[VCAA 2010 E2 SB Q6]

DNA sequencing is often performed to help produce phylogenetic trees or to classify organisms. Sections of nuclear DNA from similar organisms are sequenced and compared for similarities.

a **Name** and **describe** another DNA method that is used to determine how closely related two species are. (2 marks)

Scientists use a specific mitochondrial gene called *cox1* in comparative studies in fish. The *cox1* gene lacks introns and is only 654 bp long, making it economical and easy to sequence. The sequenced gene appears like a ‘barcode’ found on grocery products, for example:



A worldwide database has over 45 000 *cox1* gene sequences obtained from different kinds of fish. Illegal fishing occurs in Australian waters. Often only a small portion, such as a fin, is kept by the fishermen and the remainder is thrown overboard.

b How would the barcode database be used to identify the fish species that had been caught by the fishermen? Provide an example of a situation (other than illegal fishing) when humans would want to identify the fish species. (2 marks)

Scientists using the *cox1* gene have seen that even within the same species of fish, differences within the DNA sequence can occur. The scientists believe this is often due to the redundancy in the genetic code.

c Explain what redundancy in the genetic code means. (1 mark)

As the database grows it is hoped that at least five samples for each species will be collected and analysed. The species samples will be taken from as many different locations as possible.

d Why is it important to sequence multiple samples from the same species? (1 mark)

(Total 6 marks)

Question 24/ 205

[VCAA 2013 SB Q10]

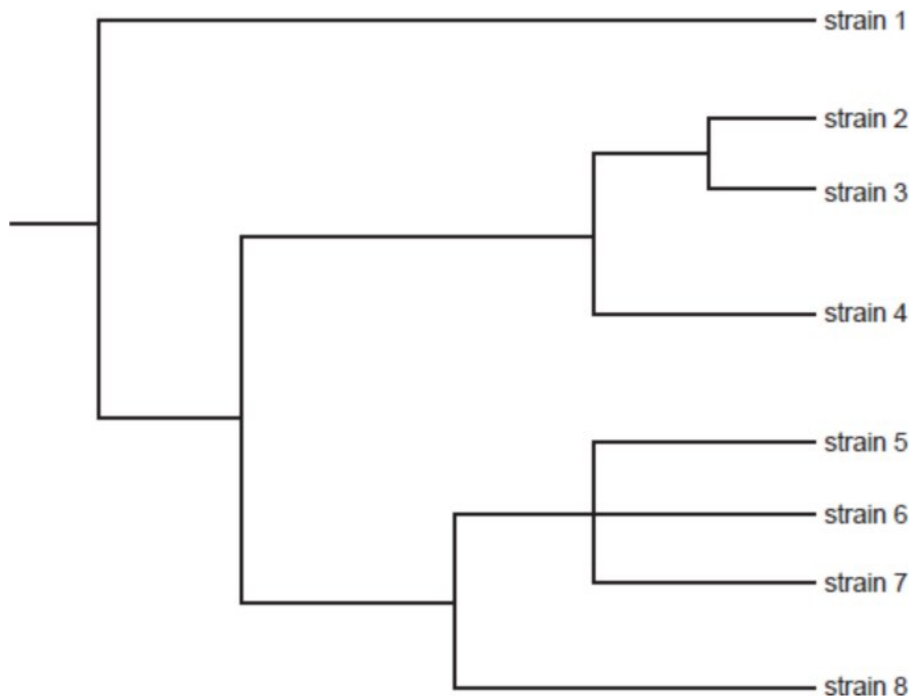
In humans, severe acute respiratory syndrome (SARS) is a serious form of pneumonia. SARS is caused by a coronavirus that was first identified in 2003.

Scientists suspected that the virus had been transmitted to humans from some other animal. Testing was completed on several animal species. Strains of the coronavirus similar to those found in humans were identified in different species of horseshoe bats (genus *Rhinolophus*) and palm civets (*Paguma larvata*).

Samples were taken from the different sources and the virus's RNA from each sample was sequenced.

a What molecular information would the scientists obtain from sequencing RNA? (1 mark)

The molecular information enabled the scientists to draw an evolutionary tree for different strains of the coronavirus. The following evolutionary tree was drawn.



b Coronavirus strains 2 and 3 are the most similar of the strains. Using your knowledge and the information given in the evolutionary tree, give **two** possible explanations as to why they are the most similar of the strains. (2 marks)

Strain 7 is found in palm civets, and strains 5 and 6 in humans. All other strains are found in different species of horseshoe bats.

c What conclusion can be drawn about the origin of the strain of virus that causes SARS in humans? (1 mark)

(Total 4 marks)

Question 25/ 205

[VCAA 2020 SB Q9]

In 1931 a team of Dutch archaeologists unearthed 12 skulls and two leg bones at a site in Ngandong, Indonesia.

a Describe **two** key structural features of these fossils that would suggest that the skulls were from *Homo erectus* rather than from *Homo sapiens*. (2 marks)

Figure 1 and Figure 2 below show *Homo* evolutionary trees that were created in 1997 and 2013 respectively.

1997 *Homo* evolutionary tree

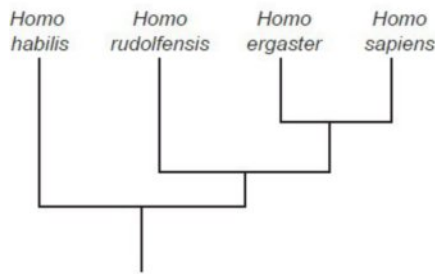


Figure 1

2013 *Homo* evolutionary tree

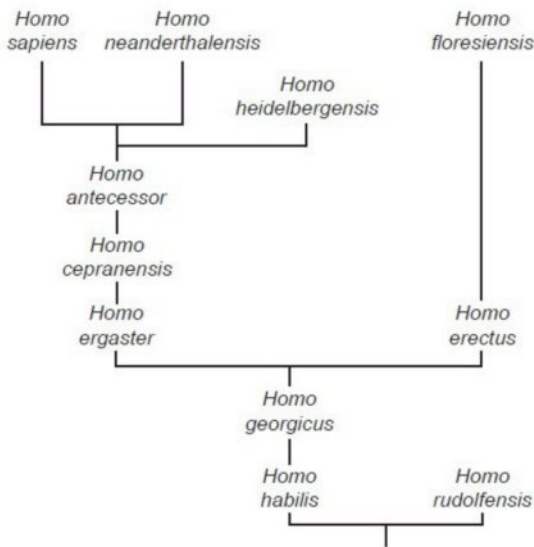


Figure 2

Sources (from left): adapted from DS Strait, FE Grine and MA Moniz, 'A reappraisal of early hominid phylogeny', *Journal of Human Evolution*, volume 32, issue 1, January 1997, pp. 17–82; C Schultz, 'Homo Sapiens' family tree may be less complicated than we thought', *Smithsonian Magazine*, 18 October 2013, <www.smithsonianmag.com>

b State **one** difference between Figure 1 and Figure 2 with respect to the evolutionary relationships between *Homo ergaster* and *Homo sapiens*. (1 mark)

Homo denisovan is one species that is missing from both evolutionary trees shown in the previous figures.

c Draw a branch on Figure 2, the 2013 *Homo* evolutionary tree, that represents where you think *Homo denisovan* should be placed. Justify why you have put the branch in that position. (2 marks)

d Scientists do not always agree on the position of each *Homo* species on evolutionary trees. Explain why this is the case. (2 marks)

(Total 7 marks)

Question 26/ 205

[VCAA 2022 SB Q9]

Homo sapiens are the only species of hominin alive today. The table below gives estimated ranges of existence for several hominin species, based on fossil evidence.

Species Name	Earliest date found (number of years ago)	Latest date found (number of years ago)	Location

Species Name	Earliest date found (number of years ago)	Latest date found (number of years ago)	Location
<i>Australopithecus anamensis</i>	4 200 000	3 800 000	East Africa
<i>Australopithecus afarensis</i>	3 850 000	2 950 000	East Africa
<i>Australopithecus africanus</i>	3 300 000	2 100 000	South Africa
<i>Homo habilis</i>	2 400 000	1 400 000	East and South Africa
<i>Homo rudolfensis</i>	1 900 000	1 800 000	East Africa
<i>Homo floresiensis</i>	700 000	50 000	South-East Asia (Indonesia)
<i>Homo neanderthalensis</i>	400 000	40 000	Europe South-West and Central Asia
<i>Homo sapiens</i>	300 000	present	earliest in North Africa, now worldwide

Data: Smithsonian National Museum of Natural History, ‘What does it mean to be human?’,
<https://humanorigins.si.edu/evidence/human-evolution-interactive-timeline>

- a** Describe two trends that would be observed in fossils of these hominin species, with respect to brain size and limb structure, from the most ancient to the most recent species. (2 marks)
- b** Several times during hominin evolution, different hominin species lived in the same locations, and it is possible that they interbred. There is evidence to support the theory that *H. sapiens* and *H. neanderthalensis* interbred in some parts of Europe.
- i** Using the table above, apart from interbreeding between *H. sapiens* and *H. neanderthalensis*, identify two other occasions when interbreeding may have occurred between two different species of hominin and name the species involved. (2 marks)
- ii** Discuss the limitations of the evidence that supports your response to part **b. i.** (2 marks)

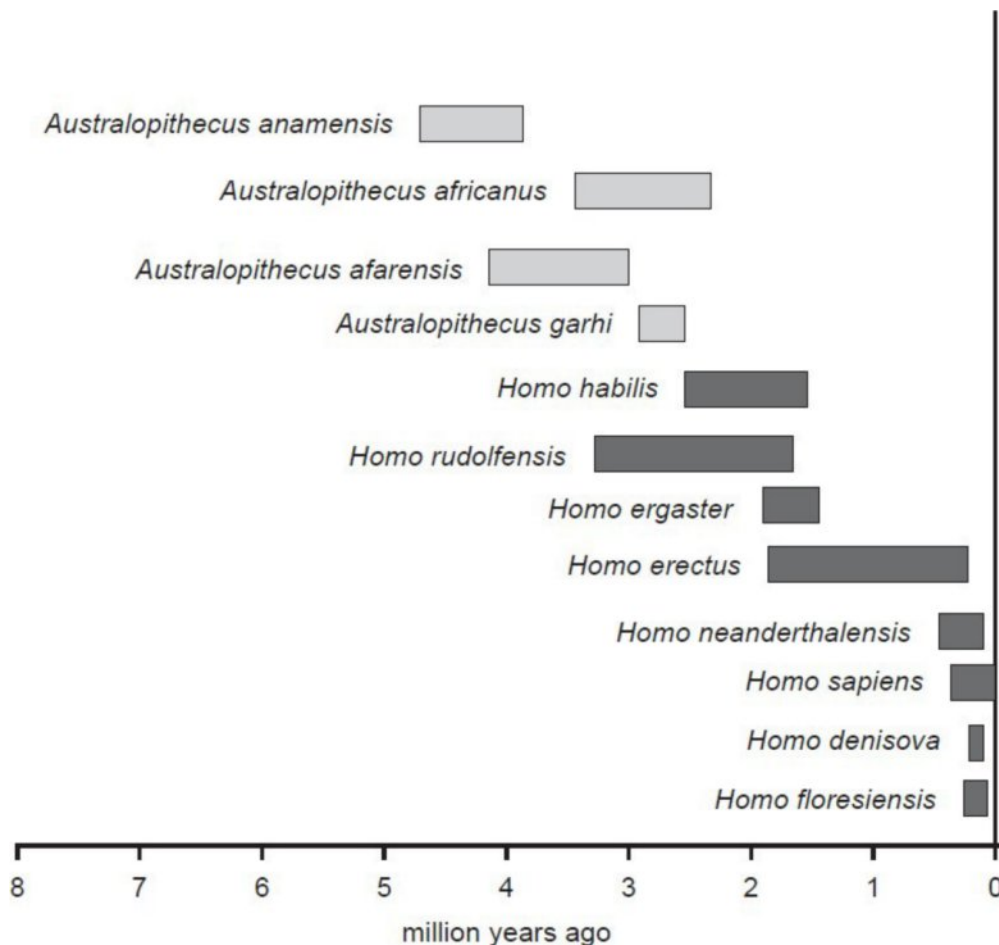
(Total 6 marks)

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

a What are **two** features that the fossil skeleton would need to have in order to be classified in the genus *Homo* and not in the genus *Australopithecus*? (2 marks)

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

The diagram that follows indicates the time periods for different *Australopithecus* and *Homo* species.



b If the second group of scientists has correctly dated the *H. naledi* fossils, what evidence from the diagram above supports this group's claim that *H. naledi* cannot be the 'link' between *Australopithecus* and *Homo*? (1 mark)

(Total 3 marks)

Question 28/ 205

[Adapted VCAA 2016 SB Q10]

Over the past 20 years, a number of new hominin fossils have been discovered. *Homo erectus georgicus* was found near the banks of the Black Sea in Georgia and *Homo naledi* was found in a cave in South Africa.

a Consider the conditions that may have led to the fossilisation of members of these species.

Complete the table below by identifying one condition in the environment of each species that will have made fossilisation possible. The same answer cannot be used for both species. (2 marks)

Species	Environment	Condition
<i>H. erectus georgicus</i>	Near the banks of the Black Sea	
<i>H. naledi</i>	Cave in South Africa	

Shown below is a photograph of a skull of *H. erectus georgicus*. Scientists compared this skull to that of modern humans (*Homo sapiens sapiens*).



b Describe any two features of the skull shown in the photograph above that allowed scientists to determine that this was a much earlier species of the genus *Homo* than modern humans (*H. sapiens sapiens*). (2 marks)

c Describe one structural feature (other than skull structure) of *H. naledi* that would indicate it is a more modern species than members of the genus *Australopithecus*. (1 mark)

(Total 5 marks)

Question 29/ 205

[Adapted VCAA 2012 E2 SB Q8]

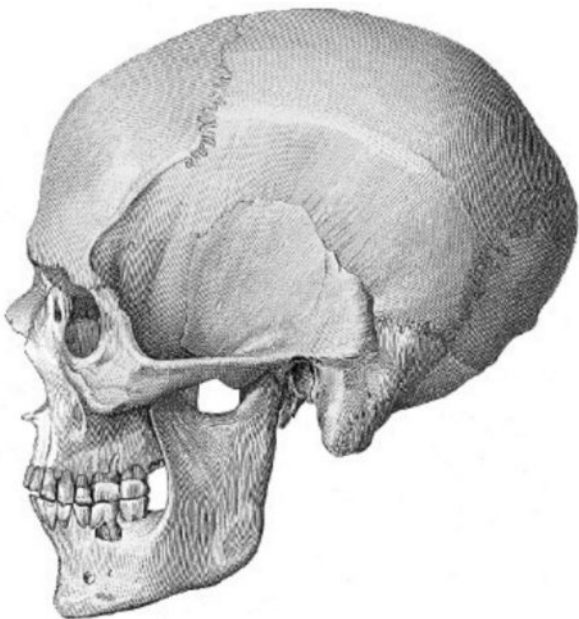
In 2008, two incomplete, fossilised skeletons were found in cave deposits in South Africa. The scientists compared the newly discovered bones with those of members of the genus *Australopithecus*, early *Homo*, modern humans and apes. The fossilised skeletons, named *Australopithecus sediba*, displayed an unusual mix of characteristics. They partly resembled primitive, ape-like animals.

Like the apes, *A. sediba* was of small stature. Scientists determined that *A. sediba*, like apes, was suited to climbing in trees.

a What feature of the *A. sediba* skeleton allowed scientists to reach this conclusion? (1 mark)

A. sediba was found to have many characteristics in common both with the members of the genus *Australopithecus* and with the genus *Homo*. Two characteristics shared with the genus *Homo* included a projecting nose and hands with a precision grip.

b Explain how each of these characteristics may have given *A. sediba* an advantage over other *Australopithecus* species. (2 marks)



Below is a drawing of the skull of a modern-day human.

c Using the drawing, suggest one feature of modern-day humans that makes humans more advanced than other *Homo* species. Explain the significance of this feature to the evolution of modern humans. (2 marks)

(Total 7 marks)

Question 30/ 205

[VCAA 2019 SB Q10]

Neanderthal or Denisovan?

When *Homo sapiens* left Africa about 60 000 years ago, they were not alone. At least two other hominin groups made the same journey – Neanderthals and Denisovans.

Neanderthals left Africa about 300 000 years ago, settling in Europe and parts of western Asia.

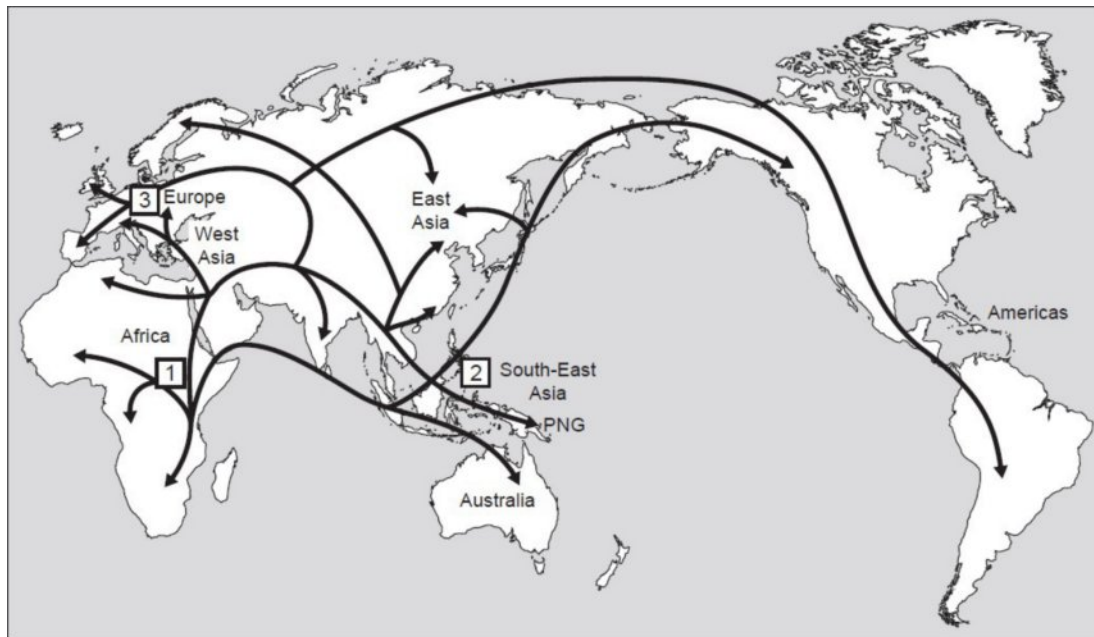
Anthropologists in southern Siberia unearthed a 40 000-year-old adult tooth and a well-preserved fossilised finger bone that had belonged to a young girl. Nuclear DNA analysed from the finger bone showed that the girl was closely related to Neanderthals but could be classified as a new species of ancient humans, which scientists named ‘Denisovan’.

The scientists found similarities between the Denisovan genome and that of some present-day Pacific Islanders living in Papua New Guinea (PNG), known as the Melanesians. It appears the Denisovans contributed between 3–5% of their genetic material to the genomes of the Melanesians. The scientists think the most likely explanation is that Denisovans living in eastern Eurasia interbred with the modern human ancestors of the Melanesians. When those humans crossed the ocean to reach PNG around 45 000 years ago, they brought their Denisovan DNA with them.

Studies of modern human DNA concluded that most humans with European ancestry have 1–3% Neanderthal DNA. According to one theory, Neanderthals, Denisovans and modern humans are all descended from the ancient human *Homo heidelbergensis*. Between 400 000 and 300 000 years ago, an ancestral group of *H. heidelbergensis* left Africa and then split shortly after. One branch ventured north-west into West Asia and Europe and became the Neanderthals. The other branch moved east, becoming the Denisovans. By 130 000 years ago, *H. heidelbergensis* in Africa gave rise to *H. sapiens*, who did not leave Africa until about 60 000 years ago.

a Based on the information given in the article, would it be possible to classify Denisovans as a separate group from Neanderthals without using DNA analysis? Justify your response. (2 marks)

b Scientists could have extracted mitochondrial DNA from the young girl's finger bone sample but, instead, extracted and sequenced nuclear DNA. Explain why the scientists chose to sequence the nuclear DNA for this sample. (2 marks)



c Using the information in the article and by referring to the map above, name which hominin group would most likely have been found living at each site between 300 000 and 60 000 years ago. Justify your response.

Site	Name of hominin group	Justification
1 – Africa		
2 – South-East Asia and Papua New Guinea		
3 – Europe		

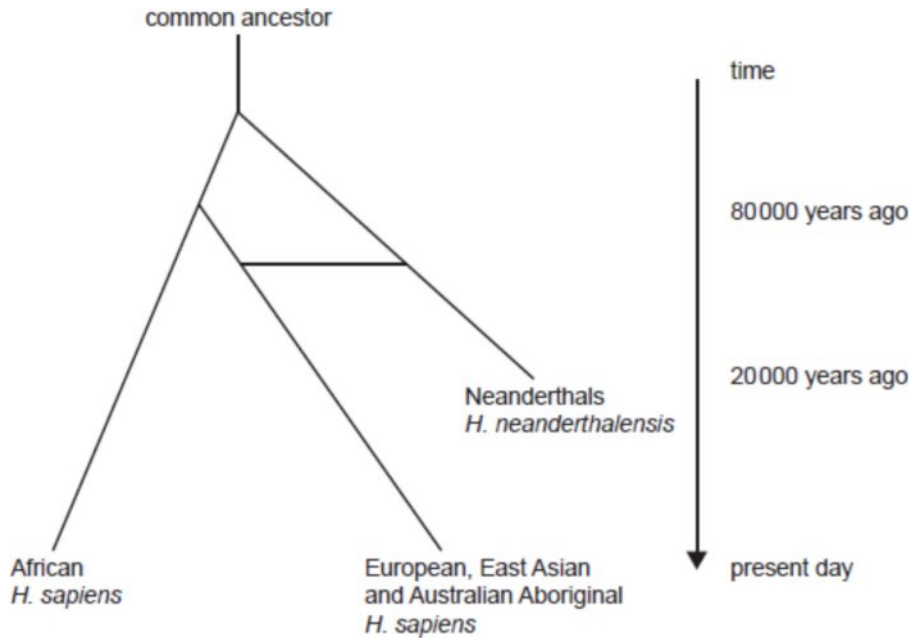
(3 marks)

(Total 7 marks)

Question 31/ 205

[VCAA 2015 SB Q11]

Fossil evidence indicates that between 30 000–80 000 years ago, populations of the two hominin species – modern humans (*Homo sapiens*) and the extinct Neanderthals (*Homo neanderthalensis*) – lived close to one another in parts of the Middle East, Europe and Asia.



Researchers have constructed a theory about the relationships between ancient populations. This is represented in the diagram below.

Recent DNA evidence has shown that:

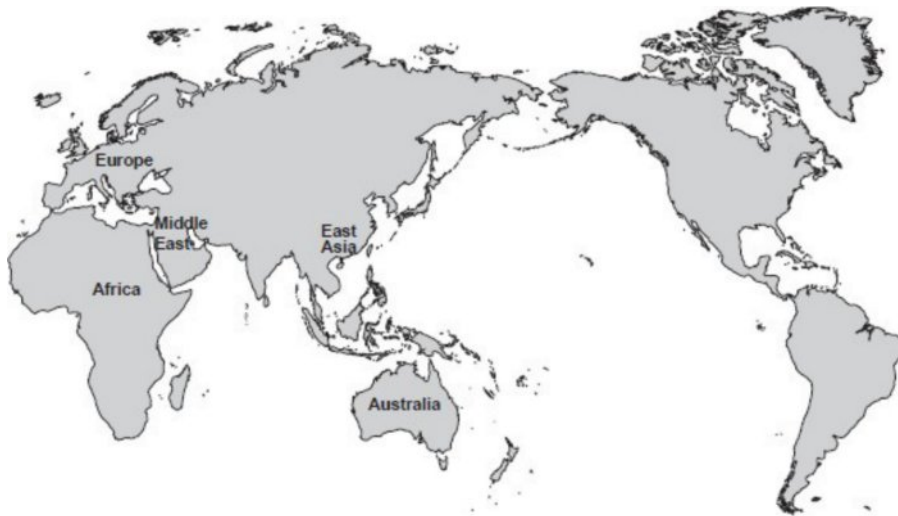
- the genome of living humans of African descent does not contain Neanderthal DNA
- the genomes of living humans of European, East Asian and Australian Aboriginal descent all contain small amounts of Neanderthal DNA (1–4%).

a i Suggest how DNA from *H. neanderthalensis* entered the genome of present-day European, East Asian and Australian Aboriginal *H. sapiens*, and continues to be found in modern populations. (2 marks)

ii What implication does this DNA evidence have for the classification of the two hominin species, *H. sapiens* and *H. neanderthalensis*, according to the common definition of a species? (1 mark)

b There are several theories about the geographical origins of *H. sapiens*. Scientists consider that the absence of Neanderthal DNA in present-day African *H. sapiens* lends support to one theory about the geographical origins of *H. sapiens*. Name this theory and explain how the recent DNA evidence provided supports it. (3 marks)

c Consider the map provided below.



What does the DNA evidence provided on the previous page suggest about the route and timing of the migration of the first Australian Aboriginals to arrive in Australia? (2 marks)

(Total 8 marks)

Question 32/ 205

[VCAA 2014 SB Q11]

In 1991, the body of a man was found frozen beneath a glacier in Italy. Researchers named him Ötzi. It was determined that Ötzi died 5300 years ago and that his body is the oldest mummified human body ever found. Scientists have successfully extracted DNA from the nucleus of his frozen cells.

a Describe the process scientists would use on a small sample of Ötzi's DNA to obtain larger quantities of identical DNA. (3 marks)

Using gel electrophoresis, scientists discovered that there were four different types of blood on Ötzi's clothes. Their results were as shown on the next page.

Ötzi's blood taken from his blood vessels	Blood sample 1 from Ötzi's clothes	Blood sample 2 from Ötzi's clothes	Blood sample 3 from Ötzi's clothes	Blood sample 4 from Ötzi's clothes
				

b i Which blood sample on Ötzi's clothes belongs to Ötzi? (1 mark)

ii Propose one hypothesis that would explain the presence of the other blood samples on Ötzi's clothes. (1 mark)

c Analysis of mammalian proteins provides evidence of evolutionary relationships.

Explain how amino acid differences in a protein can indicate evolutionary relationships. (2 marks)

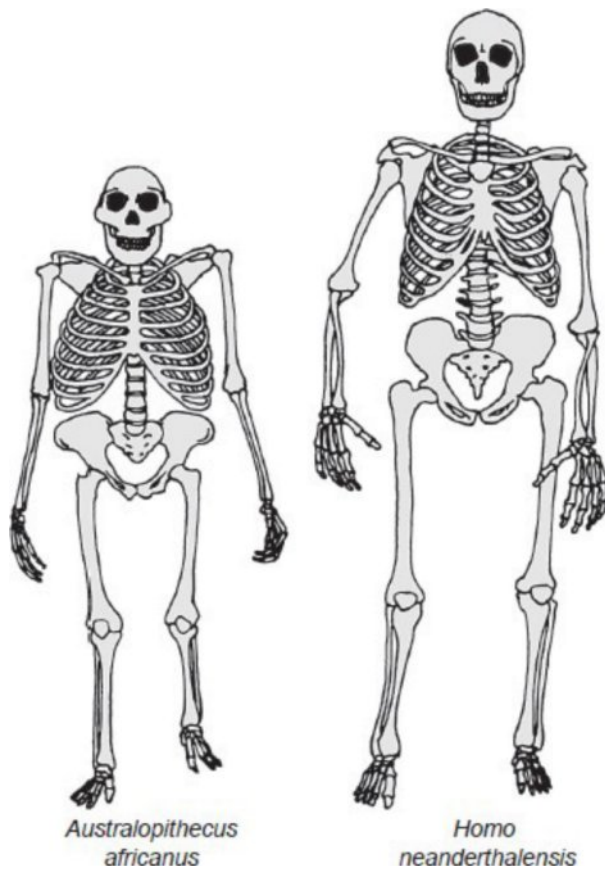
d The development of bipedalism in hominins is believed to have had a very significant effect on human evolution.

Describe **two** effects of bipedalism on hominin behaviour. (2 marks)

(Total 9 marks)

[Adapted VCAA 2013 SB Q11]

The skeletal structures of two extinct members of the hominin family tree, *Australopithecus africanus* and *Homo neanderthalensis*, are shown in the diagram that follows.



a Examine the skeletal structures. For each of the features listed in the table below, describe the difference between the two species and state the significance of the difference. (4 marks)

Feature	Description of difference	Significance of difference
Pelvic structure		
Arm to leg length ratio		

Neanderthals lived in the cold climate of Europe and Asia from 200 000 to 30 000 years ago. Modern humans and Neanderthals coexisted for around 10 000 years. Fossil evidence indicates Neanderthals shared much behaviour with modern humans. Scientists are undertaking research to find reasons why Neanderthals became extinct, but modern humans survived. Fossil evidence of the use of sewing needles and the division of labour between men and women was found only for modern humans, but not for Neanderthals.

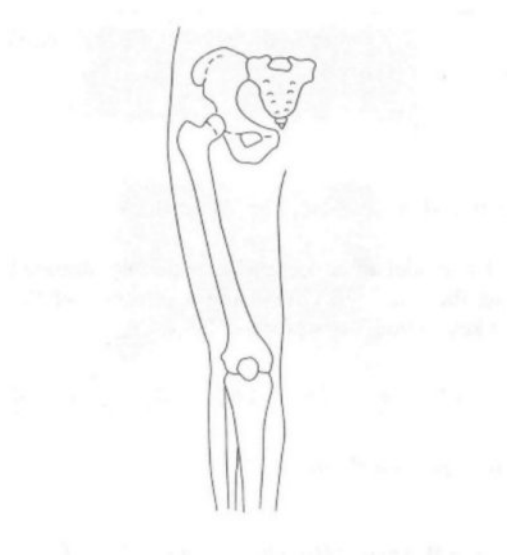
People today with non-African heritage carry some Neanderthal DNA.

b State a hypothesis to account for these findings. (1 mark)

(Total 5 marks)

Question 34/ 205

a i Using the diagram, name TWO features of the *Homo sapiens* skeleton that make it unique among the primates. (2 marks)



ii Outline how ONE named non-skeletal characteristic has assisted primates in their evolution. (2 marks)

b Examine the data collected on *Homo neanderthalensis* fossils found in recent years.

Date	Data
2008	• Full sequence of mitochondrial DNA of a range of Neanderthal fossils from within and between different fossil sites. • The sequence is nearly identical within one fossil site. • The sequence is very different between fossil sites.
2010	• Full sequence of Neanderthal nuclear DNA. • 1%–4% of genes in European modern humans are specific Neanderthal genes. • No identifiable specific Neanderthal genes in modern sub-Saharan African humans. • No specific modern human genes in nuclear DNA of Neanderthal fossils.

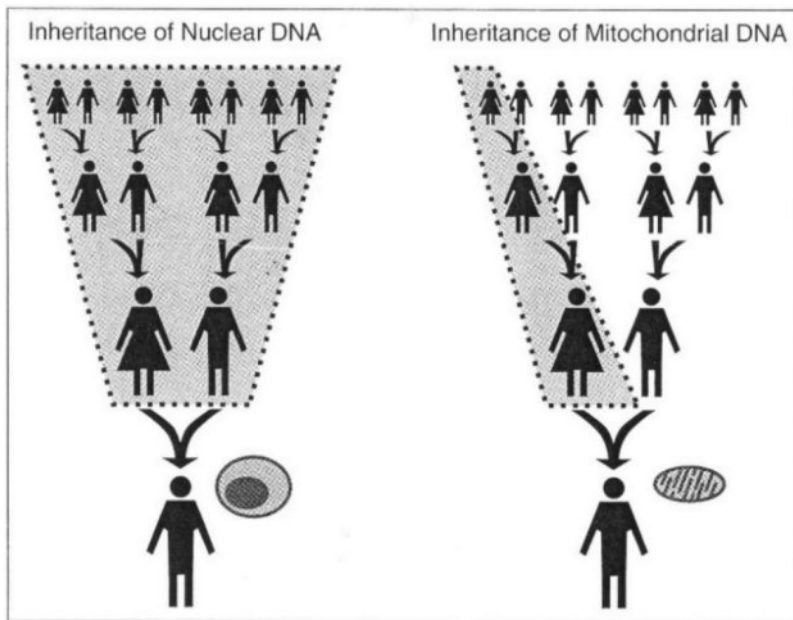
i What inferences can be made about Neanderthal populations, based on the data collected in 2008? (3 marks)

ii What inferences can be made about migration and breeding, based on the data collected in 2010? (3 marks)

(Total 10 marks)

Question 35/ 205

a The diagram below compares the inheritance of nuclear DNA with mitochondrial DNA.

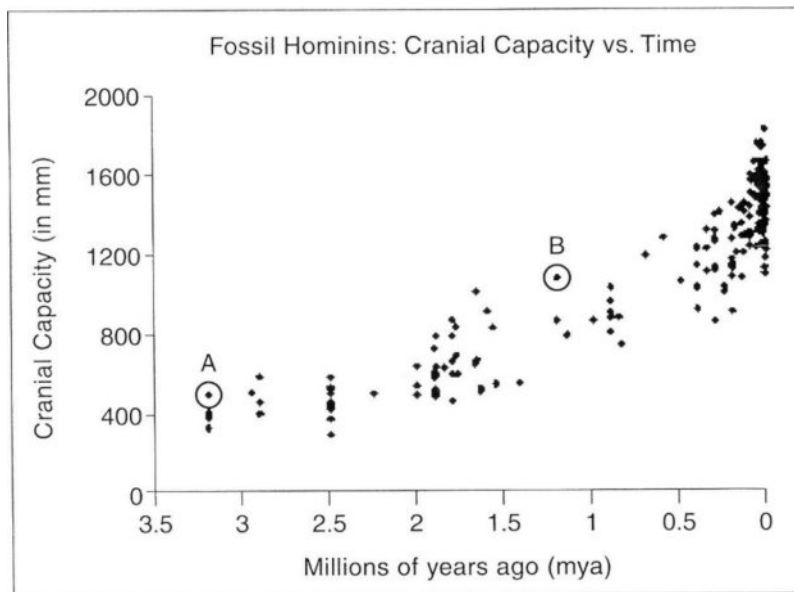


i Compare the pattern of inheritance of nuclear DNA with mitochondrial DNA. (1 mark)

ii Assess whether the analysis of nuclear DNA or mitochondrial DNA is more useful to evolutionary biology. (4 marks)

b The graph below shows the results of an investigation into cranial capacity of fossil hominins.

- Data were obtained from measurements of hominin cranial capacity published in scientific journals.
- Each data point on the graph represents the average cranial capacity of the adult skull at a single archaeological dig.
- The results from 215 archaeological digs are represented.



- i Justify the methods used to collect and present the data. (4 marks)
- ii For either data point A or B, propose the name of the hominin species and its regional location. (2 marks)
- (Total 11 marks)
-

Chapter 7 VCE Examination Paper Units 3 & 4 2023

This chapter contains the questions from the Unit 3 & 4 VCE October 2023 Examination Paper. When you sit the external examination, you should note the following instructions:

- You must write your student number in the space provided.
- The paper consists of two sections: Section A and Section B.
- Answer **all** questions from Section A. Section A is worth 40 marks.
- You should spend approximately 55 minutes answering Section A.
- In Section A, you choose the response that is **correct** or that **best answers the question**.
- In Section A, a correct answer is worth 1 mark, an incorrect answer is worth no marks. No mark will be given if more than one answer is shown for any one question. Marks will not be deducted for incorrect

answers. You should **attempt every question**.

- In the examination, Section A questions should be answered on the answer sheet provided for multiple-choice questions.
- Answer all questions from Section B. Section B is worth 80 marks.
- In the examination, Section B questions should be answered in the spaces provided in the examination booklet.
- The paper is worth 120 marks. Allocate time appropriate to the number of marks.
- Check that you answer each page.
- You have 15 minutes reading time followed by 150 minutes to write your answers.
- Write in legible English using an ink or ballpoint pen. (Examiners find it hard to read and mark messy answers – especially when written in pencil.)

Question 1/ 40

[VCAA SA Q1 2023]

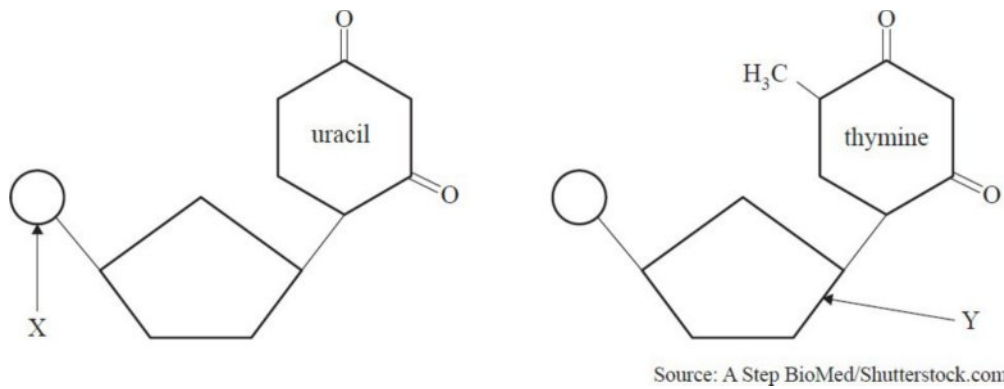
Which one of the following correctly matches the nucleic acid molecule with its role?

Molecule	Role
DNA	carries genetic information to ribosomes
tRNA	carries amino acids to ribosomes
mRNA	structural component of ribosomes
rRNA	contains genetic information that is transcribed

Question 2/ 40

[VCAA SA Q2 2023]

The basic structure of two nucleotides is in the diagram that follows. Each nucleotide has three subunits.



It can be concluded that the

A subunit labelled X is a nitrogen base.

B subunit labelled Y is a ribose sugar.

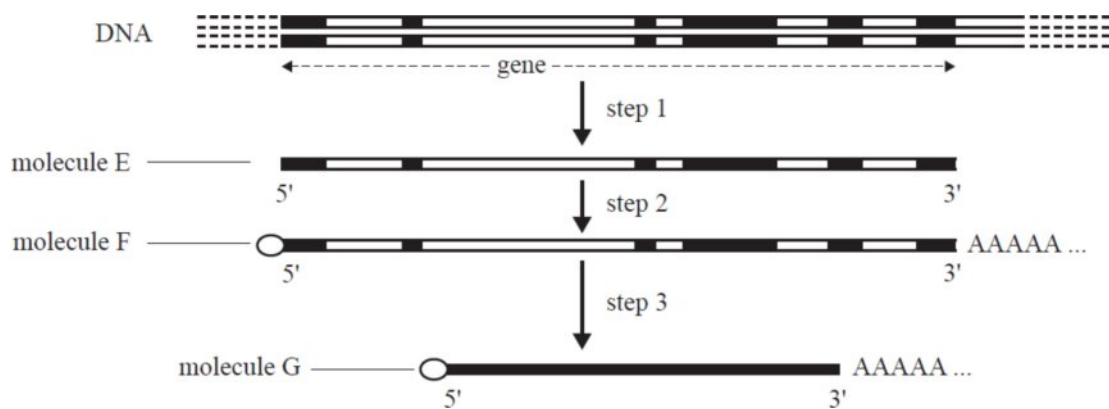
C nucleotide with the subunit labelled uracil can be found in DNA.

D nucleotide with the subunit labelled thymine will have a pentose sugar subunit.

Question 3/ 40

Use the following information to answer Questions 4 and 5.

The following diagram shows some of the steps in the production of a protein within a cell.



Question 4/ 40

[VCAA SA Q3 2023]

Which one of the following is a correct statement?

A Step 1 represents translation.

B There are six introns in the gene.

C RNA polymerase is required for Step 3.

D The circle on molecule F represents a modified guanine molecule.

Question 5/ 40

[VCAA SA Q3 2023]

Molecule G codes for a protein containing 100 amino acids that form a single polypeptide chain.

The number of codons required to code for these 100 amino acids is

A 33.

B 66.

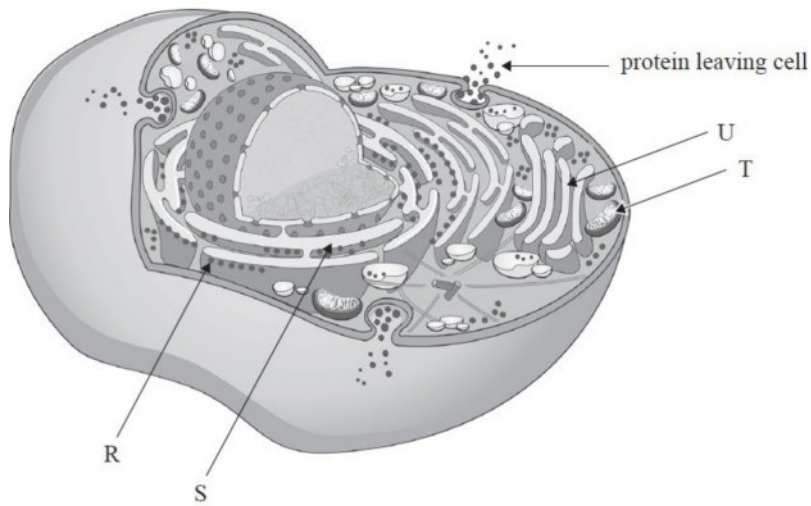
C 100.

D 300.

Question 6/ 40

[VCAA SA Q5 2023]

The diagram below represents a mammalian cell undergoing the process of exocytosis.



Source: adapted from Soleil Nordic/Shutterstock.com

In the process of exocytosis, the role of

A organelle R is to carry the protein to the plasma membrane.

B organelle S is to enable folding and transport of the protein.

C organelle T is to synthesise the protein.

D organelle U is to produce energy for the synthesis of the protein.

Question 7/ 40

Use the following information to answer Questions 8 and 9.

Students investigated the proteins found in several different types of human cells.

Question 8/ 40

[VCAA SA Q6 2023]

In their investigation, the students would have expected

A all proteins within each cell type to be identical.

B that proteins within the same cell could differ in structure and function.

C all proteins to consist of multiple polypeptide chains.

D gene expression for each protein in each cell to be occurring continuously.

Question 9/ 40

[VCAA SA Q7 2023]

Students completed their investigation and analysed their results. They suggested their results were affected by systematic errors.

Systematic errors

A result in a spread of readings.

B affect the precision of a measurement.

C are easy to identify and eliminate.

D cause readings to differ from the true value by a consistent amount each time.

Question 10/ 40

Use the following information to answer Questions 11–13.

Wheat plants can be affected by rust disease, which is caused by a number of different fungal pathogens.

Wheat plants without rust disease



Wheat plants with rust disease



Sources (from left): naor/Shutterstock.com; Photomusk/Shutterstock.com

Question 11/ 40

[VCAA SA Q8 2023]

Plants have a number of barriers and mechanisms to prevent entry of pathogens.

The most likely route of entry of the fungal pathogen to the wheat plants above is via the

A stomata.

B waxy cuticle.

C leaf receptors.

D external layer of small hairs.

Question 12/ 40

[VCAA SA Q9 2023]

Some plants, such as rye and wild grasses, have genes that code for proteins that make them resistant to rust disease.

Recently, scientists have taken genes coding for resistance to rust disease and transferred them into a variety of wheat plants susceptible to rust disease.

Wheat plants with transferred genes for resistance to rust disease are known as

A recombinant.

B transgenic.

C polyploid.

D vectors.

Question 13/ 40

[VCAA SA Q10 2023]

To determine the uptake of resistance genes by the wheat plants, scientists investigate gene fragments using electrophoresis to

A cut the DNA.

B amplify the DNA.

C separate the DNA.

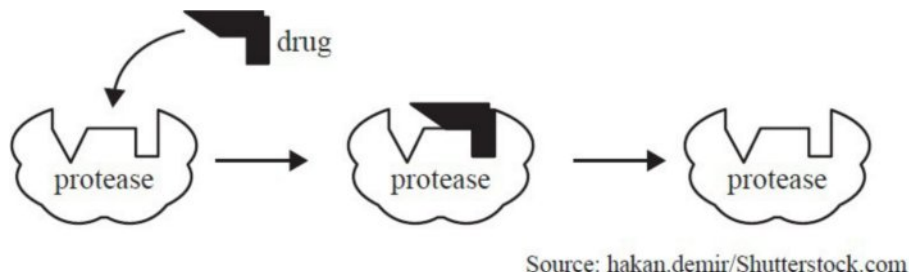
D denature the DNA.

Question 14/ 40

Use the following information to answer Questions 15 and 16.

A new drug for the treatment of specific cancers has been developed and was assessed in clinical studies. A number of participants were recruited for the study and monitored to determine the effectiveness of the drug in the treatment of the cancer.

The drug has been designed to interact with protease as in the diagram that follows.



Question 15/ 40

[VCAA SA Q11 2023]

The interaction with the drug will result in the protease being

- A denatured.
- B activated.
- C catalysed.
- D inhibited.

Question 16/ 40

[VCAA SA Q12 2023]

After the research was concluded, the results of the study, whether favourable or unfavourable, were published.

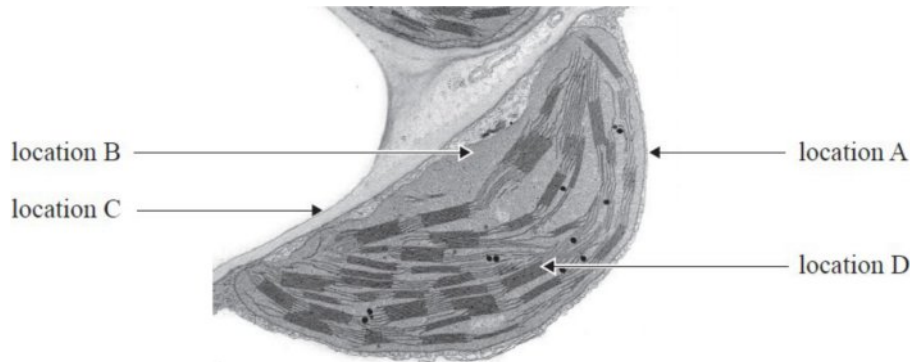
The publishing of all of the results would most closely align to the ethical concept of

- A non-maleficence.
- B beneficence.
- C integrity.
- D justice.

Question 17/ 40

Use the following information to answer Questions **18–21**.

The following image is an electron micrograph of a chloroplast.



Source: adapted from Eldon Newcomb, University of Wisconsin
<<https://search.library.wisc.edu/digital/ADJFWJEB7OGBAB85>>

Question 18/ 40

[VCAA SA Q13 2023]

Where in this chloroplast would you find the Calvin cycle occurring?

A location A

B location B

C location C

D location D

Question 19/ 40

[VCAA SA Q14 2023]

Which one of the following statements about the Calvin cycle is correct?

- A It is light-independent.
 - B It requires glucose as an input.
 - C It only occurs in complete darkness.
 - D It only occurs when the humidity is high.
-

Question 20/ 40

[VCAA SA Q15 2023]

Which molecules are involved in a light-independent reaction?

- A oxygen, ADP and NADH
 - B oxygen, ADP and NADPH
 - C carbon dioxide, ATP and NADH
 - D carbon dioxide, ATP and NADPH
-

Question 21/ 40

[VCAA SA Q16 2023]

Where in a plant leaf cell does a light-dependent reaction occur?

- A stroma
- B mitochondrion
- C thylakoid membrane

Question 22/ 40

[VCAA SA Q17 2023]

The enzymes involved in glucose metabolism are what type of biological molecule?

A carbohydrates

B nucleotides

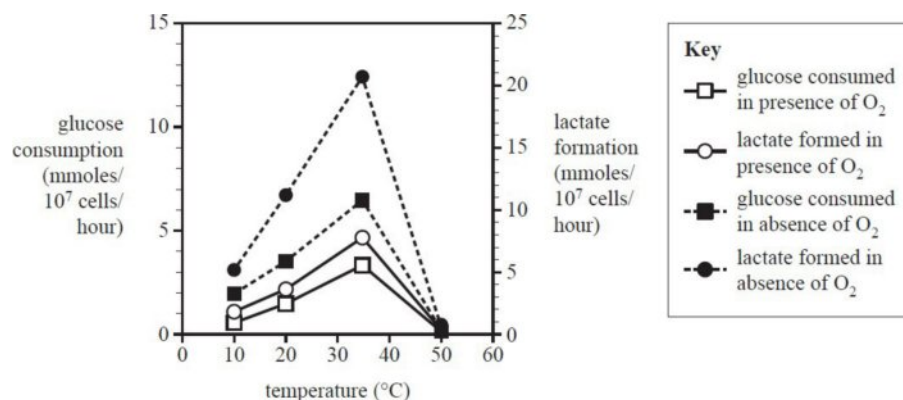
C proteins

D lipids

Question 23/ 40

Use the following information to answer Questions 24–26.

The graph on the next page shows the effect of temperature and oxygen on the rate of consumption of glucose and the corresponding rate of production of lactate in white blood cells at four different temperatures (10 °C, 20 °C, 35 °C and 50 °C).



Question 24/ 40

[VCAA SA Q18 2023]

Under which of the following conditions is the rate of lactate formation highest?

- A 10 °C in the absence of oxygen
 - B 20 °C in the absence of oxygen
 - C 35 °C in the presence of oxygen
 - D 50 °C in the presence of oxygen
-

Question 25/ 40

[VCAA SA Q19 2023]

Why is the rate of consumption of glucose higher in the absence of oxygen than in its presence at 35 °C?

- A Oxygen stimulates lactate formation.
 - B Oxygen inhibits the uptake of glucose by the cell.
 - C Glycolysis reactions require the presence of oxygen.
 - D Less ATP is formed from glucose in the absence of oxygen.
-

Question 26/ 40

[VCAA SA Q20 2023]

Why are the rates of consumption of glucose and formation of lactate at 50 °C the same irrespective of oxygen levels?

- A Most of the enzymes involved in glycolysis have become denatured.

B Glucose is converted to ATP by a single chemical reaction.

C At 50 °C the cell uses heat as a source of energy.

D At 50 °C metabolic pathways are very efficient.

Question 27/ 40

[VCAA SA Q21 2023]

Hay fever (allergic rhinitis) is caused by a range of allergens, including pollen, animal fur, dust mites and moulds entering the body via the eyes, nose or mouth.

The cells that release histamine in the allergic response are

A mast cells.

B eosinophils.

C macrophages.

D natural killer cells.

Question 28/ 40

[VCAA SA Q22 2023]

Allergens are presented by antigen-presenting cells to specific T cells using which of the following?

A IgE antibodies

B complement proteins

C dendritic cell receptors

D major histocompatibility complex proteins

Question 29/ 40

[VCAA SA Q23 2023]

Tea-tree oil is derived from the leaves of *Melaleuca alternifolia*, which is endemic to Australia and native to Bundjalung country located in northern New South Wales.

Bundjalung people have used tea-tree oil as a traditional medicine. It is typically used as a topical medication for the treatment of skin conditions. It has anti-inflammatory properties and reduces skin inflammation caused by insect bites or hives.

It is reasonable to conclude that tea-tree oil inhibits the

A physical barrier of the skin.

B innate immune response.

C proliferation of B cells.

D lymphatic system.

Question 30/ 40

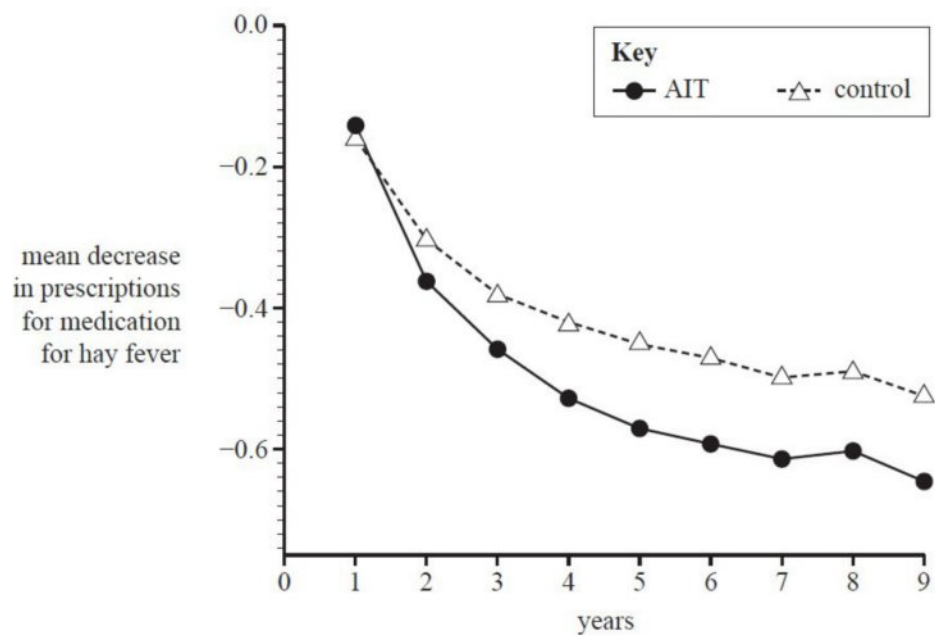
Use the following information to answer Questions 39 and 40.

A study was conducted over nine years to determine the effectiveness of allergen immunotherapy treatment (AIT).

Participants in the study had been diagnosed with hay fever and were receiving prescriptions for medication to reduce the symptoms of hay fever. The experimental group comprised over 40 000 participants who received AIT. The control group received no AIT.

Over the course of the study, both groups were still able to take their hay fever medication to treat their symptoms as required. The following graph shows the mean change in number of prescriptions issued for hay fever medication in the experimental group and control group over the study, compared to the mean number of prescriptions at the beginning of the study.

Mean change in number of prescriptions for hay fever medication over time



Source: adapted from B Fritzsche et al, 'Results from the REACT study, a retrospective cohort study', *The Lancet*, vol 13, February 2022

Question 31/ 40

[VCAA SA Q24 2023]

It is most reasonable to conclude that AIT

A demonstrates long-term and sustained effects.

B was not administered correctly in the first year.

C is most effective between the first and second year.

D is not effective, as both the experimental group and control group reduced the number of prescriptions required.

Question 32/ 40

[VCAA SA Q25 2023]

It is reasonable to conclude that, compared to the experimental group, the control group

A was randomly selected from the general population.

B participants were unable to leave the study.

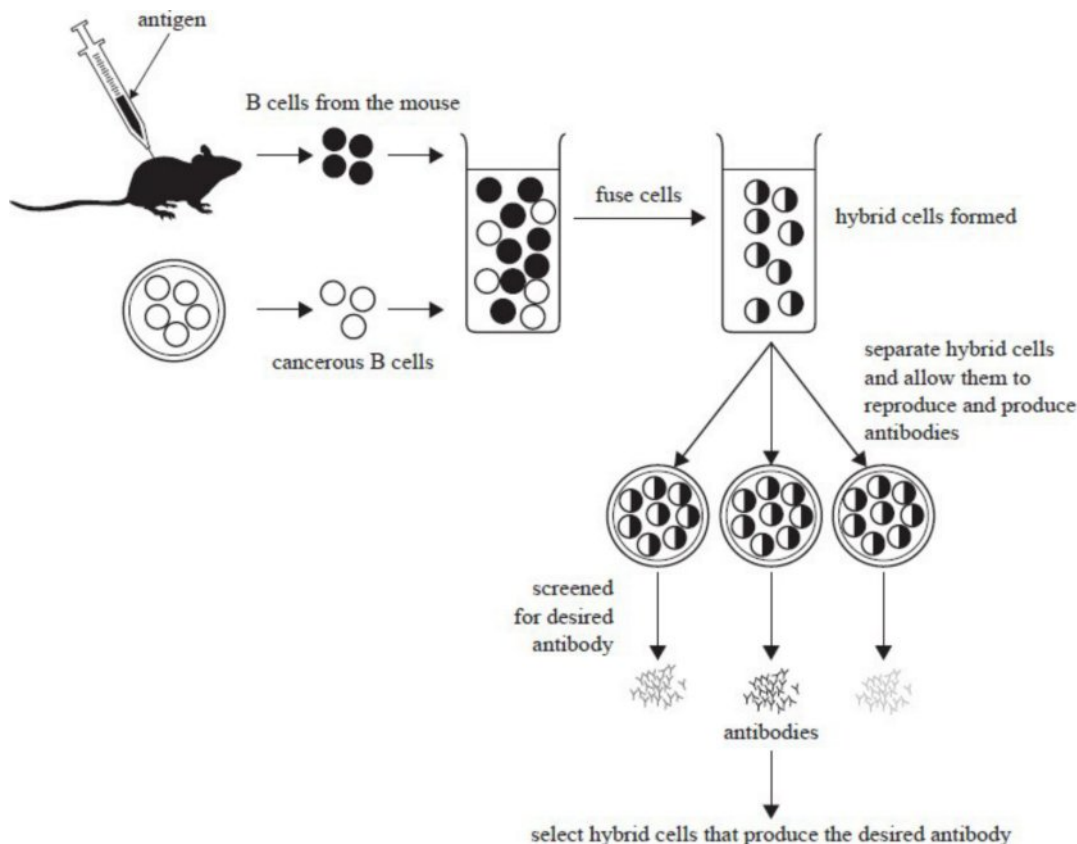
C had a similar number of participants.

D had double the number of participants.

Question 33/ 40

[VCAA SA Q26 2023]

Monoclonal antibodies (mAbs) have been the focus of much attention in the fight against cancer. The basic process of monoclonal antibody production is summarised in the diagram that follows, beginning with a mouse being injected with cancer antigens.



Source: adapted from <<https://openstax.org/books/microbiology/pages/20-1-polyclonal-and-monoclonal-antibody-production>>

Which one of the following statements regarding the production of monoclonal antibodies is correct?

- A The monoclonal antibodies produced by one hybrid cell are identical to each other.
 - B The monoclonal antibodies are specific to the antigens on mouse skin cells.
 - C The cancerous B cells are extracted from the mouse.
 - D The antigens are combined with cancerous B cells.
-

Question 34/ 40

[VCAA SA Q27 2023]

Bevacizumab is a humanised monoclonal antibody that is used to treat several different cancers. Humanising involves removing part of the constant region of a mouse monoclonal antibody and replacing it with the constant region from a human antibody. Therefore, the humanised antibody has both human-derived and mouse-derived components.

An advantage of humanising monoclonal antibodies such as bevacizumab would be to

- A decrease the binding strength between bevacizumab and the cancer cell antigens.
 - B reduce the chances of an immune response against bevacizumab.
 - C allow greater destruction of cancerous and non-cancerous cells.
 - D deliver toxic substances less effectively to the cancer cells.
-

Question 35/ 40

[VCAA SA Q28 2023]

Mosunetuzumab is a bispecific monoclonal antibody. Bispecific antibodies are designed to simultaneously bind to two different targets, such as a cancer cell antigen and a cytotoxic T cell. The T cell then destroys the cancer cell.

Mosunetuzumab bispecificity would arise from the fact that it

- A lacks a constant region.

B contains only heavy chains.

C contains both a light and a heavy chain.

D has two different-shaped variable regions.

Question 36/ 40

[VCAA SA Q29 2023]

Which one of the following correctly describes an event that may occur in the lymphatic system?

A antigen presentation by a dendritic cell to helper T cells

B valves moving lymph fluid in two different directions

C histamine triggering the release of IgE antibodies

D phagocytosis of eosinophils

Question 37/ 40

[VCAA SA Q30 2023]

Atlantic salmon (*Salmo salar*) are fish that are farmed in the waters of Tasmania. A selective breeding program was introduced that focused on increasing the growth of the fish, increasing the resistance of the fish to disease and maintaining the colour and oil content of the fish meat.

The selective breeding program resulted in at least a 10% increase in growth of the fish in each generation. Increased resistance to disease has been noted as fewer fish in each generation have required treatment for disease.

In this selective breeding program

A offspring will be produced by random mating of parents.

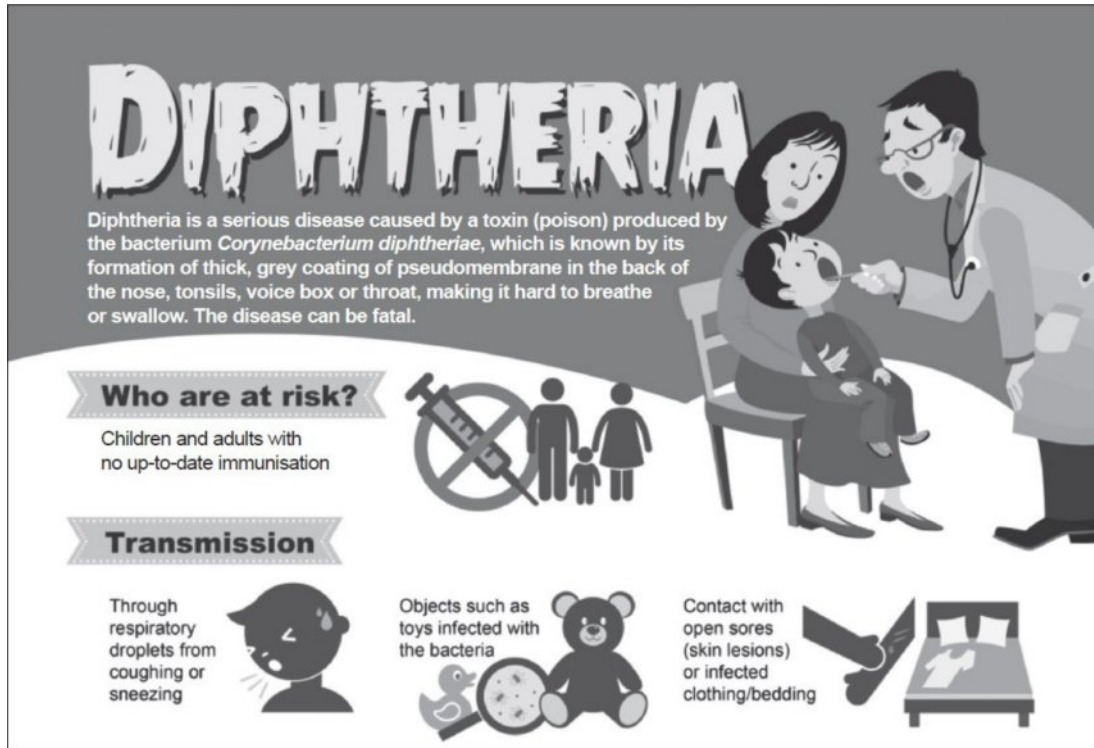
B genetic variation within the fish population will increase.

C the frequency of alleles for the desired phenotypes will increase over generations.

D maintaining the colour and oil content of the fish meat will be advantageous for the fish.

Question 38/ 40

Use the following information and your own knowledge to answer Questions 31 and 32.



DIPHTHERIA

Diphtheria is a serious disease caused by a toxin (poison) produced by the bacterium *Corynebacterium diphtheriae*, which is known by its formation of thick, grey coating of pseudomembrane in the back of the nose, tonsils, voice box or throat, making it hard to breathe or swallow. The disease can be fatal.

Who are at risk?
Children and adults with no up-to-date immunisation

Transmission

- Through respiratory droplets from coughing or sneezing
- Objects such as toys infected with the bacteria
- Contact with open sores (skin lesions) or infected clothing/bedding

The infographic includes illustrations of a doctor examining a child, a family with a crossed-out vaccine syringe, a person coughing, a teddy bear and a rubber duck, and a bed with a hand reaching towards it.

Source: adapted from 'Diphtheria', *Positive Parenting*, July 28, 2016, <<https://mypositiveparenting.org/2016/07/28/diphtheria>>

Question 39/ 40

[VCAA SA Q31 2023]

The diphtheria vaccine contains an inactivated form of the diphtheria toxin.

Which type of immunity will be acquired by individuals who receive this vaccine?

A artificial active

- B natural active
 - C natural passive
 - D artificial passive
-

Question 40/ 40

[VCAA SA Q32 2023]

Outbreaks of diphtheria occasionally occur.

Which statement is the most likely explanation for outbreaks of diphtheria?

- A Mutations produce a new strain, which means the bacteria are less able to enter cells in the nose and throat.
 - B Herd immunity is lost due to parents choosing not to vaccinate their children.
 - C Free genetic testing to identify individuals who are at risk is not provided.
 - D There was a failure to use antiviral medication to treat individuals quickly
-

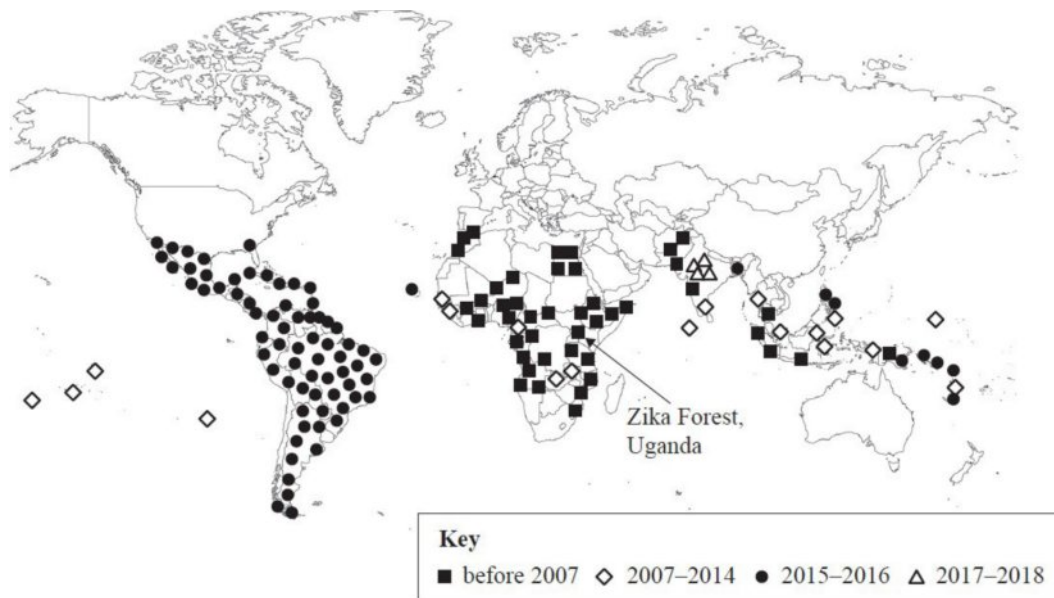
Question 41/ 40

Use the following information to answer Questions 42 and 43.

Zika virus is an emerging infectious disease that was first identified in Uganda in 1947. The virus is mainly transmitted when mosquitoes bite an infected person. The mosquitoes then go on to bite other people, infecting them.

Most infected people develop no symptoms. Those that do generally have mild symptoms including a rash, fever, and muscle and joint pain that usually lasts two to seven days. There is currently no treatment or vaccination available.

The map on the next page shows the geographical distribution of Zika virus cases during various outbreaks between 1947 and 2018.



Source: V Sharma, M Sharma, D Dhull, Y Sharma, S Kaushik and S Kaushik,
 'Zika virus: an emerging challenge to public health worldwide', *Canadian Journal of Microbiology*, vol 66, No 2,
<https://cdnsiencepub.com/doi/10.1139/cjm-2019-0331>

Question 42/ 40

[VCAA SA Q33 2023]

The World Health Organization declared that the outbreak of Zika virus in 2015 and 2016 was an epidemic rather than a pandemic because

- A the cases were confined to specific geographic regions.
 - B no vaccination was available for the pathogen.
 - C cases were confirmed in different countries.
 - D people of all ages were affected.
-

Question 43/ 40

[VCAA SA Q34 2023]

Which one of the following measures would be least effective in controlling the spread of Zika virus?

- A using television and radio advertisements to educate people on how Zika virus spreads
 - B providing free face masks and encouraging people to wear them in public
 - C quarantining infected individuals inside their homes
 - D wearing clothing that covers arms and legs
-

Question 44/ 40

[VCAA SA Q35 2023]

Students designed a controlled experiment. After they had performed the experiment, another group of students gave them feedback suggesting that they should modify the experiment to improve the accuracy of their results.

A change that the first group of students could make to improve the accuracy of their results could include

- A ignoring outlying results.
 - B repeating the experiment many times.
 - C carefully calibrating the equipment used.
 - D having many people take the measurements.
-

Question 45/ 40

[VCAA SA Q36 2023]

An evolutionary biologist used several methods to construct a phylogenetic tree for a group of mammals.

Which one of these methods would have been least useful?

- A amino acid sequences
- B protein sequences

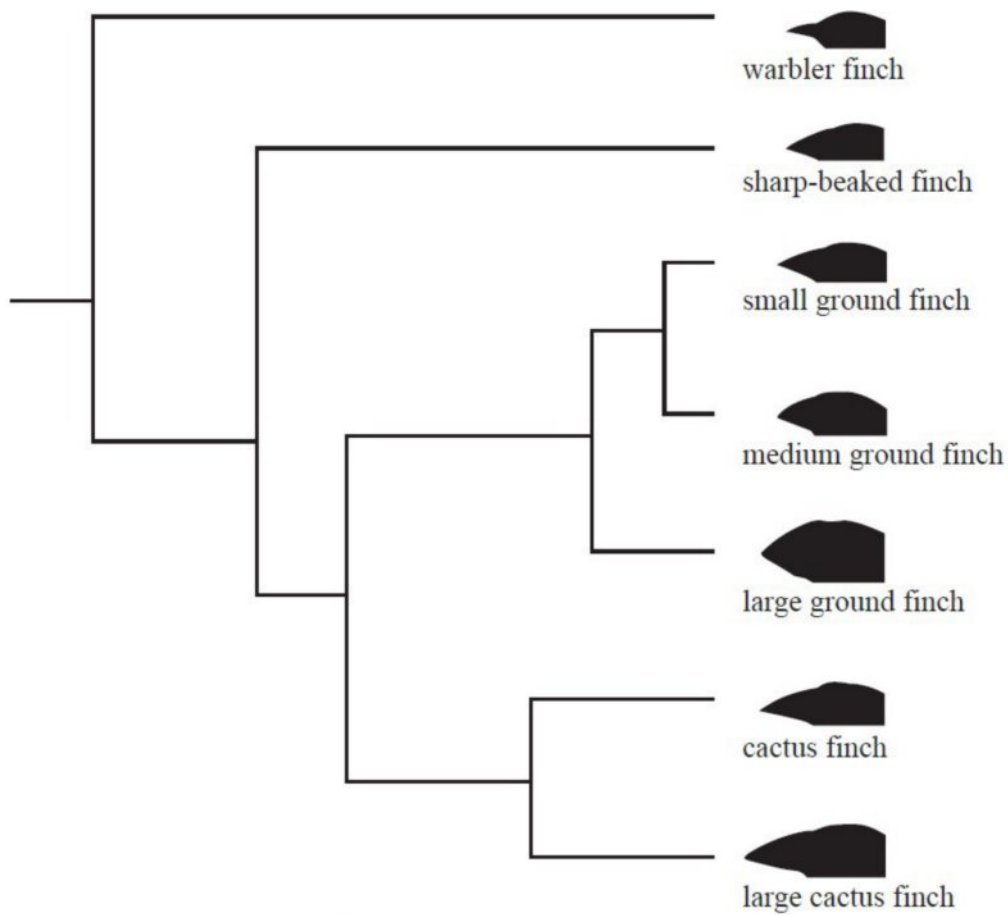
C bone structure

D presence of hair

Question 46/ 40

[VCAA, SA, Q37, 2023]

The phylogenetic tree below shows the evolutionary relationship between several species of finches.



Source: adapted from WJ Cromie, 'How Darwin's finches got their beaks', *The Harvard Gazette*, 24 July 2006, <https://news.harvard.edu/gazette/story/2006/07/how-darwins-finches-got-their-beaks>

Which pair of finches has the most recent common ancestor?

A large cactus finch and cactus finch

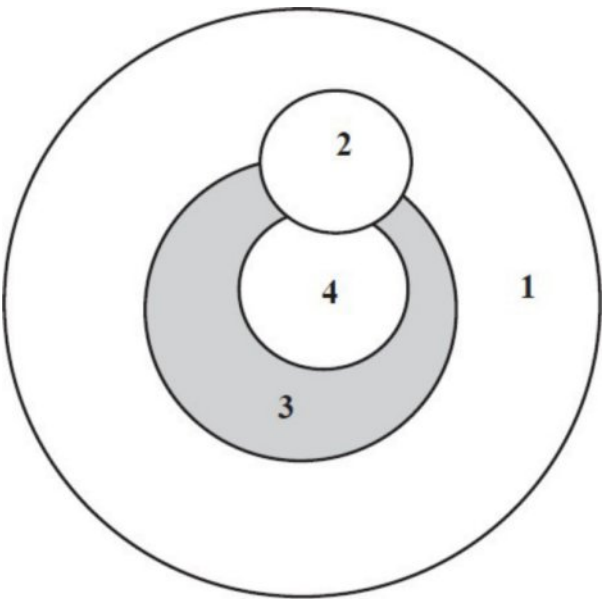
B sharp-beaked finch and warbler finch

C large ground finch and medium ground finch

Question 47/ 40

[VCAA SA Q38 2023]

Students constructed a diagram to illustrate the relationships between hominins and other groups. They produced the diagram on the next page.



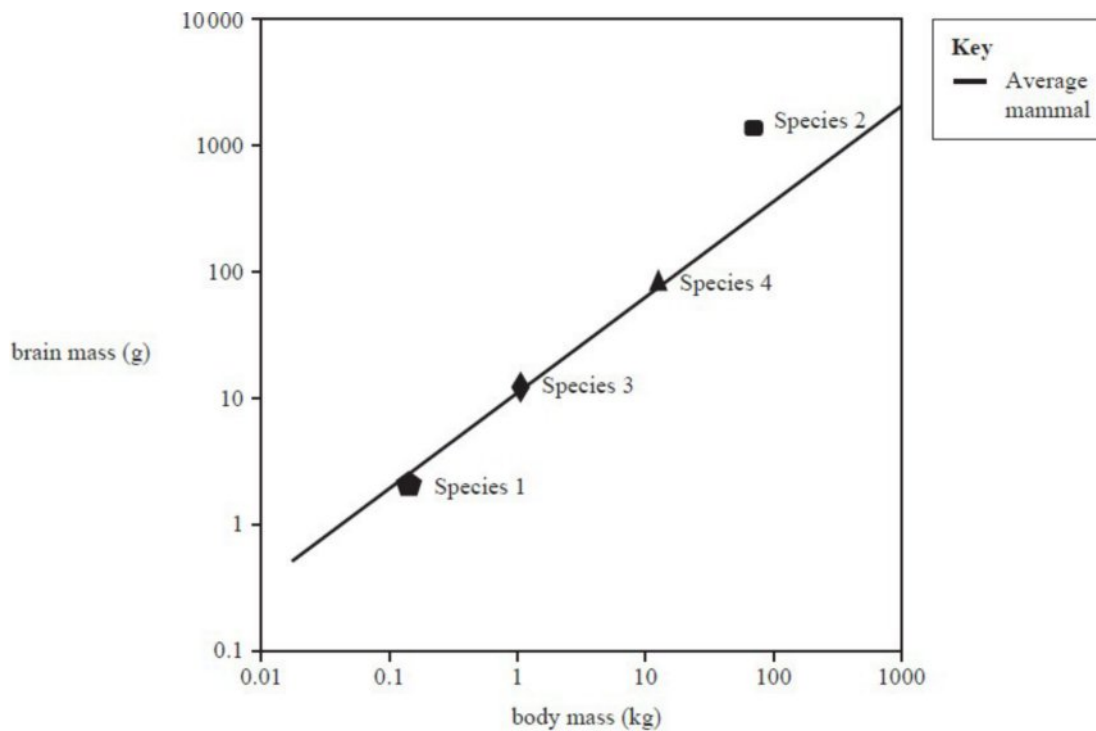
Which one of the following options correctly represents each group?

Circle 1	Circle 2	Circle 3	Circle 4
mammals	primates	hominoids	hominins
mammals	primates	hominins	hominoids
primates	hominins	hominoids	mammals
hominins	hominoids	primates	mammals

[VCAA SA Q39 2023]

Scientists investigated the relationship between body mass and brain mass in primate species. The graph below shows the data for several primate species including *Homo sapiens*.

Both the body mass (kg) and brain mass (g) of each species have been plotted using a logarithmic scale.



Source: adapted from P Schoenemann (2008), 'Evolution of the Size and Functional Areas of the Human Brain', *Annual Review of Anthropology* 35(1), <<https://www.researchgate.net/publication/228173421>>

Based on the information in the graph on the previous page, which species is most likely to represent *Homo sapiens*?

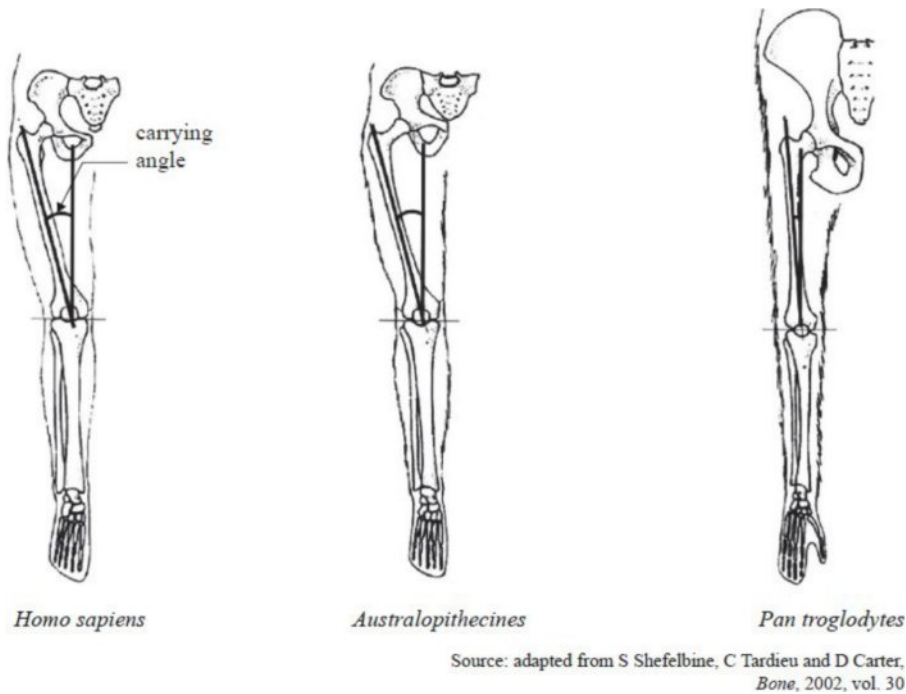
- A Species 1
- B Species 2
- C Species 3
- D Species 4

Question 49/ 40

[VCAA SA Q40 2023]

The diagram below shows the position of the pelvis and leg bones of *Homo sapiens*, *Australopithecines* and

chimpanzees (*Pan troglodytes*). The carrying angle for each is shown.



Which one of the following statements is correct?

A *Homo sapiens* have the smallest carrying angle of the skeletons shown.

B The carrying angle in *Australopithecines* allows their centre of gravity to be shifted forward.

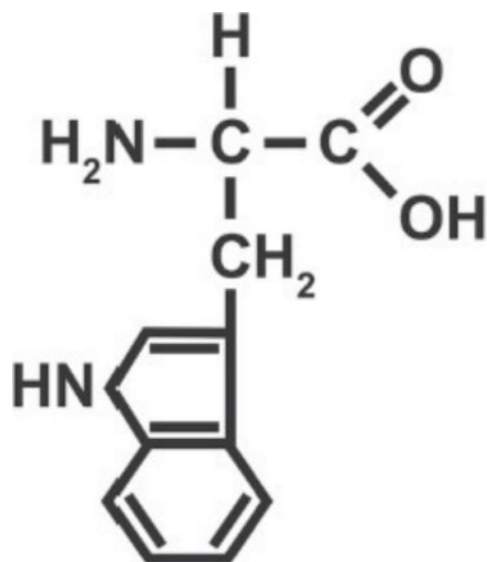
C The carrying angle of the *Pan troglodytes* suggests that, of the three species, it is the best suited to bipedalism.

D The large carrying angle of *Australopithecines* supports bipedalism.

Question 1/ 11

[VCAA SB Q1 2023]

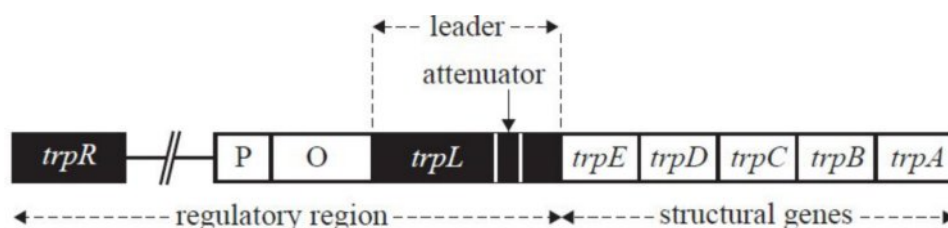
The diagram below shows the structure of tryptophan.



Source: Ali DM/Shutterstock.com

a To what group of biological monomers does tryptophan belong? Use the information in the diagram to justify your response. [2 marks]

b The synthesis of tryptophan in prokaryotic cells such as *Escherichia coli* is regulated. The positions of both the regulatory region and the structural genes are shown in the diagram below.



Source: adapted from Trp operon, <<https://en.wikipedia.org/wiki/File:Trpoperon.svg> licensed CC-BY SA 3.0>

E. coli has two mechanisms that regulate the expression of the structural genes for the synthesis of tryptophan: repression and attenuation.

Compare the two mechanisms of regulation. Refer to the diagram in your answer.

[6 marks]

[Total 8 marks]

A student found an unusual plant species growing in the local park. Without knowing what type of plants they were, the student undertook experiments to identify the photosynthetic output of the plants as measured by the rate of starch formed per day. Plants of the same size were exposed to different environmental conditions, and the rate of starch formed per day was measured.

The results are shown in the table that follows.

Effect of different environmental conditions on starch production per day

Temperature (°C)	Light Source	Carbon Dioxide (%)	Relative Humidity (%)	Rate of starch formed (mg/day)
20	white	5	70	1.5
20	white	1	70	1.2
20	white	5	30	1.8
20	green	5	30	0.3
20	blue	5	30	1.4
40	white	5	70	2.8
40	white	1	70	2.4
40	white	5	30	3.0
40	green	5	30	0.4
40	blue	5	30	2.7

a To which plant group (C3, C4 or CAM) would this unusual plant species most likely belong? Justify your answer.

Justify your answer. [3 marks]

b Why does exposing the plants to green or blue light as opposed to white light affect the formation of starch? Justify your answer.

[4 marks]

[Total 7 marks]

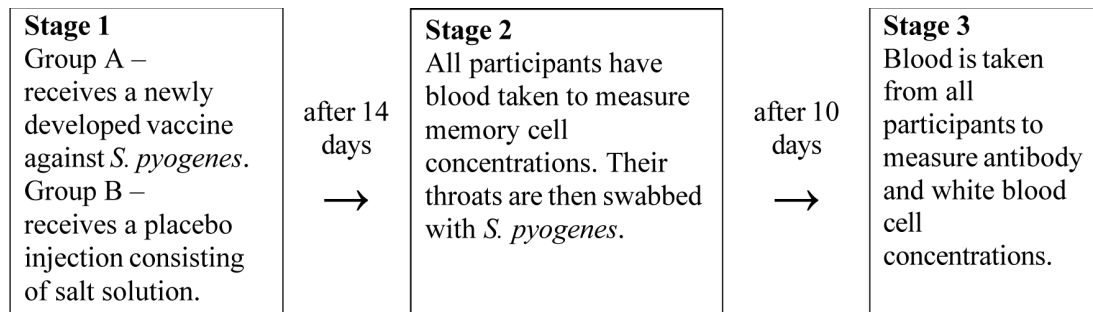
Streptococcus pyogenes is a pathogenic bacterium that can cause a range of diseases including a sore throat. People infected by *S. pyogenes* produce specific antibodies against the bacterium that normally enable them to recover after several days.

a Describe the functions of these specific antibodies during an *S. pyogenes* infection and how this leads to recovery. [3 marks]

In 2021, researchers from Melbourne's Nucleus Network were involved in the early stages of developing a vaccine against *S. pyogenes*. Part of their investigation involved determining the bacterial concentration needed to cause a sore throat in at least 60% of people whose throats were deliberately infected with *S. pyogenes*.

b Some scientists suggest that this study may have violated a principle of bioethics. Suggest which **principle** this may be and **explain** why. [2 marks]

In a follow-up study, the participants were divided into two groups (A and B) of equal size and put through a three-stage trial, as shown below.



Participants also indicated whether they suffered from a sore throat at any point during the study. The data in the table that follows shows the results from four participants at the end of the study.

	Participant			
	1	2	3	4
Sore throat during study?	yes	no	no	yes
Blood memory cell concentration at stage 2	low	high	medium	high
Blood memory cell concentration at stage 3	medium	high	high	high
Blood antibody concentration at stage 3	medium	high	high	high
Blood cytotoxic T cell concentration at stage 3	low	low	low	high

c Explain which participant is the most likely to have received the placebo injection. [3 marks]

d Another example of a pathogenic bacteria is *Mycobacterium tuberculosis*. This bacterium causes the disease tuberculosis (TB). Some strains of this bacterium have become resistant to many of the common

drugs used in the treatment of TB.

Outline two ongoing challenges for treatment strategies as a result of this resistance. [2 marks]

[Total 10 marks]

Question 4/ 11

[VCAA SB Q4 2023]

In most mammalian cells the ATP produced from the complete breakdown of glucose occurs by a series of chemical reactions. Coenzymes also play an important role in glucose metabolism.

a Describe the roles of coenzymes in the formation of ATP. [3 marks]

A student measured the effect of oxygen on the metabolism of glucose in red blood cells at 37 °C and observed the results shown in the table below.

Effect of oxygen availability on the metabolism of glucose by red blood cells

Oxygen	Glucose consumed (nmoles/ 10^7 cells/hour)	Lactate produced (nmoles/ 10^7 cells/hour)
absent	1.6	3.2
present	1.6	3.2

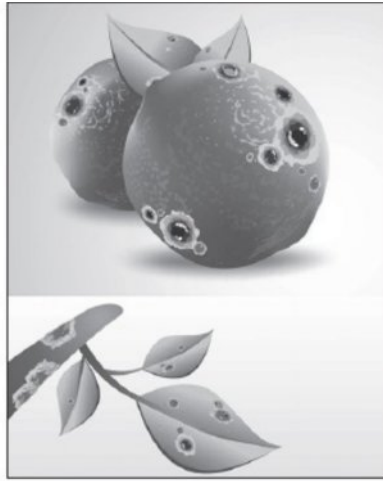
b Why are the results the same irrespective of the presence of oxygen? Explain your answer. [3 marks]

[Total 6 marks]

Question 5/ 11

[VCAA SB Q5 2023]

Citrus canker is a disease that affects citrus plants such as lime and orange trees, reducing fruit yield and quality by causing the development of dark spots on the fruit and leaves. It is caused by several different bacteria species, including *Xanthomonas axonopodis*. There have been several outbreaks in Australia.



Source: adapted from kaew409/Shutterstock.com

Scientists have recently tried to use CRISPR-Cas9 technology to inactivate genes involved in the citrus canker pathway. This pathway for citrus canker disease is summarised below:

Xanthomonas axonopodis bacteria enter a citrus plant.



CsWRKY22 gene in citrus plant cells is activated by the bacteria.



CsWRKY22 gene is transcribed producing *CsWRK22* protein.



CsWRKY22 protein then binds to *CsLOB1* gene.



Transcription of *CsLOB1* gene produces proteins that result in citrus canker development.

a Using the information in the flow chart above, explain how CRISPR-Cas9 technology could be used to produce citrus-canker-resistant plants.

[4 marks]

During outbreaks of citrus canker, the infected trees and fruit are removed and burned. Recently it has been proposed that instead of being burned, the trees could be used to produce biofuel.

The first stage in the production of biofuel from infected trees could involve a technique known as steam explosion. This involves using very hot steam at high pressures inside a pressure chamber to break open the cells from the trees.

An investigation was conducted to determine the relationship between temperature and the percentage of cells broken open during the steam explosion technique. The results are shown below.

Temperature inside pressure chamber (°C)	Percentage of cells broken open

80	47
150	57
200	85
250	94

b Scientists decided to use the steam explosion technique at 250 °C. The temperature was then lowered to 35 °C and yeast was added to the ruptured cell mixture.

Why did the scientists decide to do each of the following?

i Use 250°C [1 mark]

ii Lower to 35°C and add yeast [1 mark]

[Total 6 marks]

Question 6/ 11

[VCAA SB Q6 2023]

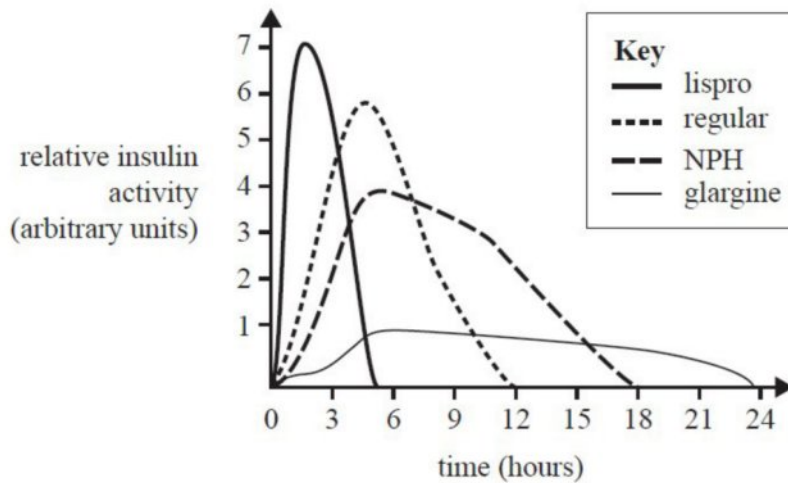
Diabetes can be an autoimmune condition where the body is activated to destroy the beta cells in the pancreas that produce insulin. Human insulin is a polypeptide hormone. Insulin consists of two polypeptide chains, chain A (21 amino acids) and chain B (30 amino acids), connected by two disulfide bridges. Human insulin can be made using recombinant plasmids.

a Outline how human insulin is made using recombinant plasmids.

[5 marks]

There are different types of insulin available for use. The activity profile of each of these insulins is shown in the graph below.

Activity profiles of different types of insulin



Source: adapted from 'Types of Insulin', Diabetes Education Online, <<https://dtc.ucsf.edu/types-of-diabetes/type2/treatment-of-type-2-diabetes/medications-and-therapies/type-2-insulin-rx/types-of-insulin/>>

b Identify which type of insulin is rapid acting compared to regular insulin. Use data from the graph to justify your response. [3 marks]

Insulin contains 2 polypeptide chains.

c i What hierarchical level of organisation is insulin? [1 mark]

Scientists alter the primary structure of insulin to create different types of insulin.

ii What should scientists consider when altering the primary structure of insulin? Justify your response. [2 marks]

[Total 11 marks]

Question 7/ 11

[VCAA SB Q7 2023]

The helmeted honeyeater (*Lichenostomus melanops cassidix*) can be found in forest to the east of Melbourne. There are only three small wild populations. The bird has been listed as critically endangered.

a Explain how the genetic diversity of helmeted honeyeaters may change over time as a result of genetic drift. [3 marks]

b Since 1989, Zoos Victoria has run a captive-breeding program for the helmeted honeyeater. More than 250 helmeted honeyeaters have been released into the wild and the total number of birds in the wild has tripled since 1989.

Each year, eggs are swapped between the wild populations and the captive-bred population.

How is genetic diversity within the wild populations being maintained?

[2 marks]

c Define a consequence-based approach to bioethics and outline how this relates to the work by Zoos Victoria to prevent extinction of the helmeted honeyeater.

[3 marks]

[Total 8 marks]

Question 8/ 11

[VCAA SB Q8 2023]

Neanderthals and early *Homo sapiens* share a common ancestor that originated in Africa. By the time modern humans left Africa around 300 000 years ago, Neanderthals had been living in Europe and Asia for approximately 100 000 years.

Early genetic studies identified around 0.02% of Neanderthal DNA in genomes of modern Africans. New research has identified that those with African ancestry have closer to 0.5% Neanderthal DNA. The same study found that Neanderthal DNA contributed 1.7% to European genomes and 1.8% in Asian genomes.

a Suggest two possible ways in which people with African ancestry could have some Neanderthal DNA in their genomes. [2 marks]

b Suggest why it is reasonable that modern Europeans and Asians show greater percentages of Neanderthal DNA than people who originated in Africa.

[2 marks]

[Total 4 marks]

Question 9/ 11

[VCAA SB Q9 2023]

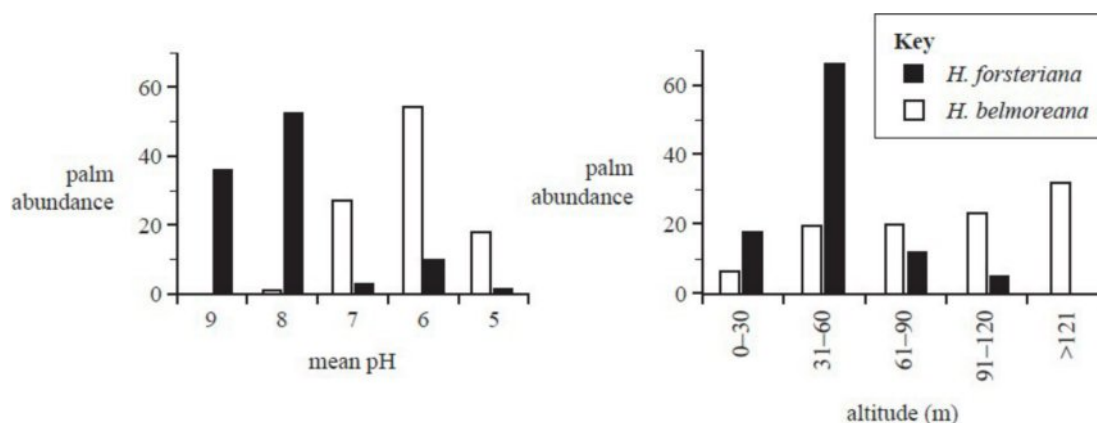
Scientists recorded flowering information for two *Howea* palm species found on Lord Howe Island. The information recorded is presented in the following table.

Palm species	Flowering frequency each week over 13 weeks												
	1	2	3	4	5	6	7	8	9	10	11	12	13
male <i>H. forsteriana</i>	0.16	0.25	0.27	0.16	0.05	0.02	0.01	0.01	0.01	0	0	0	0
female <i>H. forsteriana</i>	0.04	0.06	0.15	0.25	0.26	0.15	0.03	0	0	0	0	0	0
male <i>H. belmoreana</i>	0	0	0	0	0.03	0.04	0.05	0.17	0.25	0.17	0.14	0.1	0.02
female <i>H. belmoreana</i>	0	0	0	0	0.01	0.04	0.15	0.16	0.21	0.14	0.16	0.11	0.05

Source: adapted from V Savolainen, MC Anstett, C Lexer, I Hutton, J Clarkson, M Norup, M Powell, D Springate, N Salamin, & W Baker, *Nature*, 2006, <<https://www.researchgate.net/publication/7306249>>

a Using the information in the table, identify two factors that may have contributed to speciation in these two palms. [2 marks]

Scientists also recorded the pH of the soil in which the palm species were growing and the altitude where the plants could be found.



Source: adapted from V Savolainen, MC Anstett, C Lexer, I Hutton, J Clarkson, M Norup, M Powell, D Springate, N Salamin, & W Baker, *Nature*, 2006, <<https://www.researchgate.net/publication/7306249>>

b i Referring to the graphs above, complete the table below, listing the most ideal environment for *H. forsteriana* and *H. belmoreana*. [1 mark]

pH Altitude range (m)

H. forsteriana

H. belmoreana

b ii Evidence suggests that a common ancestor of the two palm species colonised acidic (pH below 7) volcanic soils on the island around 6 million years ago. Much more recently (2 million to 500 000 years ago),

H. forsteriana diverged from the common ancestor.

Explain how these differences between pH and altitude could have led to speciation. [2 marks]

[Total 5 marks]

Question 10/ 11

[VCAA SB Q10 2023]

The platypus (*Ornithorhynchus anatinus*) is a semi-aquatic animal, historically present in rivers throughout Victoria.



Source: John Carnemolla/Shutterstock.com

Platypuses usually occur in areas that have stable banks for burrowing, invertebrates for food, and reliable water flows. The platypus is potentially vulnerable to a range of natural and human-induced threats that degrade aquatic ecosystems, including drought, predators, habitat destruction, poor water quality and altered river flows. The Victorian Government listed the platypus as vulnerable in 2021.



Source: metha1819/Shutterstock.com

An innovative detection technique using environmental DNA (eDNA) allowed scientists to develop a detailed map of platypus populations across the state. eDNA is comprised of traces of DNA that wildlife shed into their environment. Volunteers were provided with water-sampling kits and collected water samples from over 1500 selected sampling sites on Victorian rivers.

At each sampling site, six water samples were collected and tested in the laboratory using the Polymerase Chain Reaction (PCR) method. The PCR results were analysed using a platypus-specific DNA probe. At least two positive PCR results (out of six water samples) were required to classify the site as positive for the presence of platypus DNA.

a Give two examples of possible sources of eDNA from the platypus.

[2 marks]

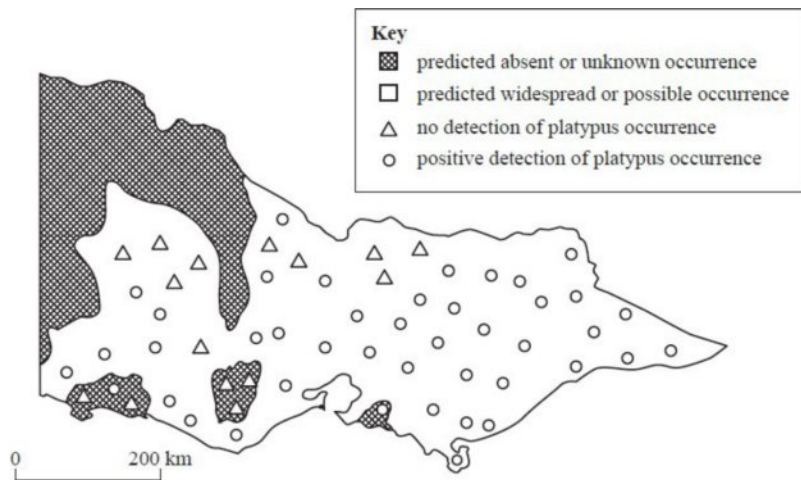
b Explain two factors to consider when sampling the water to reduce sources of error. [4 marks]

c State why PCR was used in the test of the water samples.

[4 marks]

Prior to the project, state-wide data on the occurrence of platypuses across Victorian rivers was collated. Refer to the shading on the map below for predicted platypus occurrences.

The project detected platypuses at 19–25% of sampled Victorian rivers. Refer to the icons on the map below for the results from eDNA surveys for detection of platypus occurrence at a range of sampling sites.



Source: adapted from 'eDNA tells story of platypus distribution throughout Victoria', EnviroDNA,

<https://www.envirodna.com/news/edna-tells-story-of-platypus-distribution-throughout-victoria>

d Referring to the map on the previous page, describe one difference between predicted platypus occurrence and detection of platypus occurrence from the eDNA survey results. Justify your response.

[2 marks]

[Total 8 marks]

Question 11/ 11

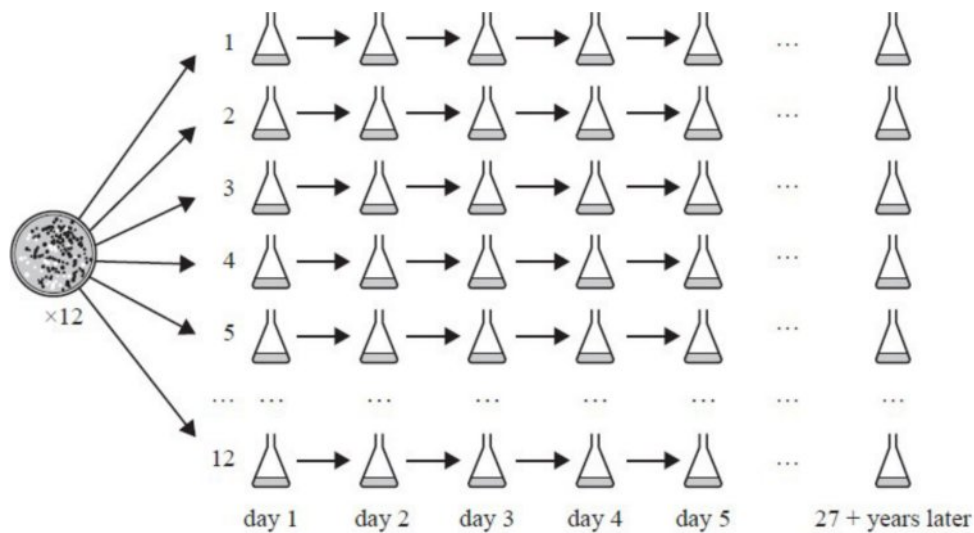
[VCAA SB Q11 2023]

In 1988 a scientist called Richard Lenski and his group used a single ancestral genome of *Escherichia coli* to put 12 genetically identical populations in 12 identical environments. Each environment consisted of a flask filled with 10 mL of bacterial growth medium, a nutrient broth containing glucose and citrate. Citrate is a potential food source that *E. coli* cannot use.

The group was interested in observing the evolution of diversification and adaptation as they happened in the laboratory.

The method of their experiment involves a simple serial transfer protocol: As the populations grow over the course of every 24 hours, they use up the resources in their flasks, so every day a 0.1 mL sample of each population is transferred to a flask of 9.9 mL of fresh growth medium and thus allowed to keep reproducing.

The method is shown in the diagram below.



Source: E Parke, 'Experiments, Simulations, and Lessons from Experimental Evolution',
Publicly Accessible Penn Dissertations, 1114, 2015, <<https://repository.upenn.edu/edissertations/1114>>

The experiment had been running for 27 years at the time the results were shown.

This was equivalent to 65 000 generations of bacteria. A generation is the time between when an organism is formed and when it reproduces.

a State **two** factors that were controlled in this experiment. [2 marks]

b At about 30 000 generations, a mutation was seen that allowed the mutant bacteria to use citrate as an energy source.

What effect would you expect this mutation to have on subsequent generations of this group of bacteria and why? [2 marks]

c Assume that you are a scientist looking to further this research and you have access to the bacteria from a generation after 30 000.

Describe how you would conduct an experiment to investigate the effect of different glucose concentrations on the frequency of the mutant citrate phenotype. [2 marks]

[Total 7 marks]

Solutions

Chapter 2 What is the role of nucleic acids and proteins in maintaining life?

Key science skills

What is meant by 'independent' and 'dependent' variables?

Solution

2-1 The independent variable is the factor the scientist deliberately changes. The dependent variable is the factor the scientist measures.

Compare categorical and numerical variables by completing the following table.

Variable	Categorical		Numerical	
qualitative/quantitative				
description/number				
graphed by				
types	Nominal	Ordinal	Discrete	Continuous
example				

Solution

2-2

Variable	Categorical	Numerical
qualitative/quantitative	qualitative	quantitative
description/number	description	number

Variable	Categorical		Numerical	
graph	bar charts/pie graphs		scatter plots/line graphs	
types	Nominal cannot be logically ordered	Ordinal can be logically ordered	Discrete	Continuous
example	gender of children in a family	birth order	number of children in a family	height of children in a family

Question 3/ 73

The table below summarises the ‘If-then-when’ hypothesis construction process.

If	Relationship phrase	Then	Trend indicator	When	Trend indicator
(the DV)	(to the IV)		(effect on the DV)		(action by the IV)
	...depends		...show an		...increased/decreased
	on...				...
	...results		increase/decrease		
	from...		...		...greater/lesser...
	...is affected		...to be greater		...larger/smaller...
	by...		than/less than...		
	...is directly		...be		
	related to...		larger/smaller...		

Use the table to write a hypothesis for the research question ‘Do bananas ripen faster in the dark?’.

Solution

2-3 If the rate of ripening of bananas is directly related to lack of light, then bananas will ripen faster when they are kept in the dark.

Question 4/ 73

Why is it important to have a control group in an experiment?

Solution

2-4 The results of the control group allow the scientist to be confident that the results obtained by the experimental group are due to the independent variable only and not some other factor.

Note: It is not good enough to say that the control is there as a 'standard of comparison'.

Question 5/ 73

What is the difference between the control group and controlled variables?

Solution

2-5 The control group is a set-up that is used to ensure that the results are due to the independent variable only, whereas controlled variables are the factors that are the same for the control group and the experimental group.

Question 6/ 73

Is experimental accuracy the same as experimental precision?

Solution

2-6 No. Experimental accuracy refers to how close the result is to the value obtained if the quantity could be measured perfectly, whereas precision refers to how close in value are repeated measurements.

Question 7/ 73

How can experimental precision be improved?

Solution

2-7 Experimental precision can be improved by repeating the experiment many times and by practising experimental techniques.

Question 8/ 73

Why is a large number of individuals usually included in a treatment group?

Solution

2-8 A large number of individuals in a treatment group minimises the effect on the results of natural variation in the tested organisms.

Question 9/ 73

When are experimental results considered to be valid and reliable?

Solution

2-9 Valid results are those obtained from controlled experiments where there is only one independent variable. Reliable results are close results obtained when the experiment is reproduced by other scientists.

Question 10/ 73

Complete the following comparison of systemic and random errors.

Errors

	Systematic	Random

Sources		

Affect		

Improved by repeating		

Solution

2-10

Errors		
	Systematic	Random
Sources	• calibration of measuring instruments • poorly maintained instruments • faulty readings by the user, e.g. parallax error	• estimates of readings between lines on a measuring instrument • fluctuations whilst measuring
Affect	• accuracy • measurements are shifted in one direction from the true value	• precision • increase spread of readings
Improved by repeating	No	Yes

Question 11/ 73

State two ethical principles that must be considered when using live organisms.

Solution

2-11 Ethical principles to be considered when using live organisms are:

- Where possible use other methods that don't involve live animals.
 - Reduce the number of animals used.
 - Ensure that the impact on the organisms is reduced by refining methods.
-

Question 12/ 73

Nucleic acids

What is the basic building block of DNA?

Solution

2-12 The basic building block of DNA (or RNA) is the nucleotide.

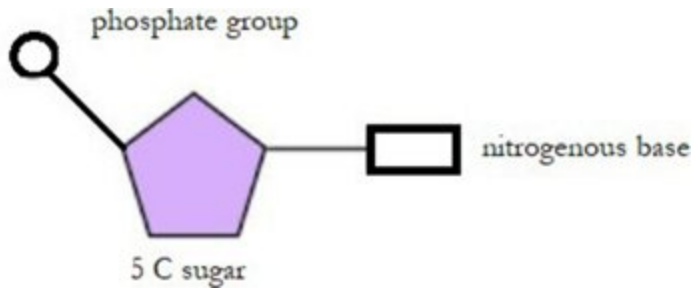
Question 13/ 73

Draw and label a DNA nucleotide.

Solution

2-13 The three major components of DNA nucleotides are:

- sugar (deoxyribose)
- phosphate (link sugars to form uprights of the DNA ladder)
- nitrogen base (pair to form rungs of the DNA ladder).



Question 14/ 73

Which two components of a DNA nucleotide are constant?

Solution

2-14 The sugar and phosphate parts are constant in DNA.

Question 15/ 73

The third component's chemical makeup can vary. Name the four variations.

Solution

2-15 The nitrogen base component is variable. Four bases are found in DNA: Adenine (A), Thymine (T), Guanine (G), Cytosine (C). Difference in base sequences is the basis of the genetic code.

Question 16/ 73

What are complementary base pairs?

Solution

2-16 Bonds will only form between complementary base pairs. The following are the complementary base pairs of DNA: Adenine and Thymine, Guanine and Cytosine.

Question 17/ 73

What type of chemical bond holds the base pairs together?

Solution

2-17 Hydrogen bonds hold the bases together. Two hydrogen bonds hold adenine and thymine together while three hydrogen bonds hold guanine and cytosine together.

Question 18/ 73

How are the above bonds broken?

Solution

2-18 Heating to about 90°C causes hydrogen bonds to break and the bases to separate. In heating, the sugar-phosphate bonds are unaffected. Thus, if DNA is heated, two long chains of nucleotides will result. If allowed to cool, hydrogen bonds will reform between complementary bases and the chains will rejoin.

Question 19/ 73

How do RNA and DNA differ?

Solution

2-19 RNA is a single chain of nucleotides whereas DNA is composed of two chains running in opposite directions and held together by hydrogen bonds. At the nucleotide level, they differ in the pentose sugar present. DNA has deoxyribose whereas RNA has ribose. They also vary in that a DNA nucleotide may contain thymine. This is replaced in RNA with uracil.

Question 20/ 73

In simple terms, explain how DNA codes for proteins.

Solution

2-20 The order of bases in DNA determines the order that amino acids are assembled at the ribosomes.

Question 21/ 73

Describe the relationship between DNA, genes and chromosomes.

Solution

2-21 A chromosome is a long molecule of DNA. Chromosomes can be divided into sub-units called genes. Each gene is a section of DNA that codes for the production of a particular protein or form of RNA. Genes are made of DNA and a series of linked genes forms a chromosome.

Question 22/ 73

What are triplets, codons and anticodons?

Solution

2-22 The DNA code is a three-letter (or base) code. Three bases code for a particular amino acid. A sequence of three bases in DNA coding for one amino acid is called a triplet. In messenger RNA, a sequence of three bases coding for one amino acid is called a codon. In transfer RNA, a sequence of three bases coding for one amino acid is called an anticodon. The codon is the complement of the triplet and the anticodon is the complement of the codon.

Question 23/ 73

In terms of nucleotides and triplets, what is a gene?

Solution

2-23 A gene is a piece of double-stranded DNA that codes information for a particular function. Most genes code for the production of a protein. Genes vary in length, from thousands to millions of nucleotides. The order of nucleotides and thus, the order of bases, determines the type of protein formed. Three bases or a triplet code for a particular amino acid. If a gene is three thousand bases long, it can be described as consisting of one thousand triplets. (*Note: Not all triplets in eukaryotic genes code for amino acids. Non-coding sections or introns are edited out during transcription.*)

Question 24/ 73

What information is encoded by a gene?

Solution

2-24 A gene codes for the production of a protein and forms of RNA. All proteins consist of building blocks called amino acids. Individual triplets code for particular amino acids. Therefore, a gene is a plan to construct a sequence of amino acids that form a protein.

Question 25/ 73

Approximately how many genes does a human have in a cell?

Solution

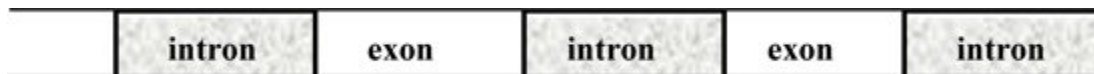
2-25 It is thought that humans have about twenty thousand genes per cell.

Question 26/ 73

Introns and exons are parts of eukaryotic gene sequences. Which parts seem to have the more important function?

Solution

2-26 Exons are the coding part of genes and seem to have the most importance. The role of introns is less clear, but they may have a role in controlling the decoding process. During the production of a finished piece of mRNA, the introns are edited out.



Question 27/ 73

How many different codons are possible in the genetic code?

Solution

2-27 Answer the following question with some mathematics. There are four bases. To form a triplet or codon, they are chosen three at a time. Any base can be chosen for any of the three positions in the codon.

$$= \begin{array}{|c|c|c|} \hline 4 & 4 & 4 \\ \hline \end{array} \quad \begin{array}{|c|} \hline 64 \\ \hline \end{array}$$

Codon base positions

There are 64 possibilities for codons.

Question 28/ 73

Are all codons needed? How many amino acids are there?

Solution

2-28 There are twenty different amino acids used to synthesise proteins. Sixty-four codons are more than sufficient to specify the amino acids. In a number of cases, several different codons specify the same amino acid.

Question 29/ 73

Do all codons code for amino acids?

Solution

2-29 Not all codons specify amino acids. Four codons act as punctuation – there is one start and three different stop codons.

Question 30/ 73

Describe the production of a finished piece of mRNA in eukaryotes. Include the role of enzymes.

Solution

2-30 Production of a finished piece of mRNA in eukaryotes involves:

1. RNA polymerase attaches to DNA at the region where the gene to be transcribed starts (the promoter).
 2. The double-stranded DNA unwinds and unzips to expose the template strand's bases.
 3. Complementary RNA nucleotides are added to exposed bases on the DNA template under the control of RNA polymerase.
 4. The chain gradually lengthens to form a single-stranded pre-mRNA molecule.
 5. The pre-mRNA detaches from the template DNA.
 6. The pre-mRNA's introns are removed and mRNA 5' cap and poly-A tail to form the final mRNA product.
-

Question 31/ 73

List the major steps in protein synthesis.

Solution

2-31 Major steps in protein synthesis:

1 Transcription

- RNA polymerase locates the gene by recognising the promoter.
- The DNA unwinds and unzips.
- Controlled by **RNA polymerase**, complementary RNA nucleotides are added to the exposed **DNA template**.
- This continues until a termination sequence is reached.
- **Pre-mRNA** is formed.

2 Editing

- Pre-mRNA is edited, introns are removed and a 5' cap and poly A tail is added.
- The final product is mRNA.
- mRNA moves out of the nucleus to the **ribosome**.

3 Translation

- The start codon is read.
 - Each charged **tRNA** molecules brings a **specific amino acid** to the complementary mRNA in the order determined by the mRNA.
 - Three mRNA bases or a **codon** codes for one amino acid.
 - The complementary bases on the tRNA area called an **anticodon**.
 - Peptide bonds form between adjacent amino acids.
 - tRNA molecules detach and translation ceases when a stop codon is reached.
 - The **final product** is an amino acid chain or **polypeptide**.
-

Question 32/ 73

Gene structure and regulation

Name two types of functions of genes. Explain whether all genes are responsible for the production of a protein.

Solution

2-32 Genes can have one of two major functions. '**Structural genes**' are directly responsible for a protein that is part of an organism's structure or has a function. The products of '**regulator genes**' control the action of other genes by determining whether a gene is active or not. In this way, the rate of production of particular materials can be controlled.

Question 33/ 73

Complete the following summary of the structure of a eukaryotic gene.

	Name	Function
a	Promoter	
b	Start triplet	
c	Coding region	
d	Stop triplet	

Solution

2-33

	Name	Function
A	Promoter	Binding site for RNA polymerase to begin transcription
B	Start triplet	First triplet transcribed
C	Coding region	Region that is transcribed and translated to produce a protein
D	Stop triplet	Where transcription stops

Question 34/ 73

How do eukaryotic and prokaryotic genes differ?

Solution

2-34

Prokaryote

One promoter may initiate the transcription of a number of polypeptide coding regions (genes)

No introns present

Eukaryote

One promoter for each polypeptide coding region (gene)

Introns present

Question 35/ 73

Explain how the trp operon switches genes on and off in prokaryotes.

Solution

2-35 When tryptophan is present in high concentration, it binds to a repressor protein coded for by a regulatory gene. The resulting molecule binds to the operator of the trpE, trpD, trpC, trpB and trpA genes. This stops RNA polymerase binding with the promoter and therefore the genes are not transcribed, and tryptophan is not synthesised. When tryptophan is present in low concentrations the repressor cannot bind to the operator, RNA can bind to the promoter and the genes coding for tryptophan synthesis are expressed resulting in the synthesis of tryptophan.

Question 36/ 73

How are transcriptional factors made and what is their role?

Solution

2-36 Transcription factors are coded for by regulatory genes and are made when a specific regulatory gene is expressed. Their function is to regulate the transcription of other genes. They do this by binding to the DNA sequence near the promoter region of the gene or to the RNA polymerase to either to induce or repress the transcription of other genes.

Question 37/ 73

Nucleic acids and proteins

What are the three parts of an amino acid and which part determines the type and its properties?

Solution

2-37 Amino acids consist of a carboxylic acid group, an amine group and an R group. The R group determines the properties and type of amino acid.

Question 38/ 73

Explain in terms of protein structure what is meant by primary, secondary, tertiary and quaternary structure.

Solution

2-38 Primary structure is the specific sequence of amino acids joined together by peptide bonds in a polypeptide chain. Secondary structure refers to the repeating 3-dimensional structure of the twisted and folded polypeptide chain resulting from hydrogen bonding. Tertiary structure refers to the final folded 3-dimensional shape. Hydrogen bonds, ionic bonds, disulphide bonds, van der Waals forces and hydrophobic interactions bring this about. Where there is more than one polypeptide chain, quaternary structure refers to how these chains are bonded to make a complete protein.

Question 39/ 73

What type of reaction links amino acids together?

Solution

2-39 Condensation and peptide bonds.

Question 40/ 73

How is denaturing caused and what types of bonds are broken?

Solution

2-40 Denaturing may be caused by high temperatures. High temperatures break hydrogen bonds and van der Waals forces, destroying the quaternary and tertiary structure. Denaturing can be caused by extremes of pH, which break ionic bonds again destroying quaternary and tertiary structure. Denaturing may also be caused

by solvents such as alcohol, by solutes such as urea and by detergents.

Question 41/ 73

Complete the following table.

	Types of proteins	
	Fibrous	Globular
Example		
Role		
Solubility		
Structure		

Solution

2-41

	Types of proteins	
	Fibrous	Globular
Example	Collagen, myosin, actin	Enzymes, some hormones, antibodies, haemoglobin
Role	Structural	Functional
Solubility	Water insoluble	Water soluble
Structure	Chains or sheets of polypeptide chains	Folded polypeptide chains. Shape important and determined by tertiary structure.

Question 42/ 73

With respect to nucleic acids and proteins, complete the following table.

	monomer	polymer
nucleic acid		
protein		

Solution

2-42

	monomer	polymer
nucleic acid	nucleotide	DNA or RNA
protein	amino acid	polypeptide

Question 43/ 73

DNA manipulation techniques and applications

Where is DNA found in prokaryotic and eukaryotic cells?

Solution

2-43 In prokaryotic cells, DNA is found in the cytosol. In eukaryotic cells, DNA is found in the nucleus, mitochondria and chloroplasts.

Question 44/ 73

How do eukaryotic and prokaryotic genes differ?

Solution

2-44

Prokaryote genes

One promoter may initiate the transcription of a number of polypeptide coding regions (genes)

No introns present

Eukaryote genes

One promoter for each polypeptide coding region (gene)

Introns present

Question 45/ 73

Complete the following table to summarise how eukaryotic and prokaryotic chromosomes differ.

Chromosome

	Prokaryote	Eukaryote

shape

presence of histone

number per cell

location in the cell

Solution

2-45

Chromosome

	Prokaryote	Eukaryote
shape	circular	linear
presence of histone	not present	present
number per cell	one	many
location in the cell	cytosol	nucleus

Question 46/ 73

The genetic code is universal. What does this mean and why is this important in genetic engineering?

Solution

2-46 The genetic code is universal. This means that the same DNA triplet/tRNA anticodon/mRNA codon codes for the same amino acid in all living organisms. This is important in genetic engineering in that DNA can be inserted into other species and still express the same protein.

Question 47/ 73

Complete the following table.

Enzyme	Function
Endonuclease	
DNA ligase	
Polymerase	
DNA polymerase	

Enzyme	Function
RNA polymerase	

Solution

2-47

Enzyme	Function
endonuclease	Break DNA into small pieces. Cut the DNA evenly creating blunt ends or unevenly creating sticky ends that can then be used in genetic engineering
DNA ligase	Joins pieces of double stranded DNA together. Important in DNA replication joining Okazaki fragments together (lagging strand) and DNA repair
polymerase	Joins many monomers together to form a polymer
DNA polymerase	Joins DNA nucleotides together. Important in DNA replication
RNA polymerase	Joins RNA nucleotides together. Important in protein synthesis in transcription and the production of tRNA and rRNA

Question 48/ 73

What are endonucleases (restriction enzymes) and how are they used?

Solution

2-48 Endonucleases are used to cut DNA into pieces by breaking DNA phosphodiester bonds. There are a range of restriction enzymes, and they differ in the places they cut DNA. A particular restriction enzyme will only cut DNA at a specific cutting site or recognition sequence. The DNA may cut both strands evenly resulting in blunt ends or unevenly resulting in sticky ends.

Question 49/ 73

Endonucleases were originally isolated from bacteria. What is their role in bacteria and how is this reflected in the name of the endonuclease?

Solution

2-49 Endonucleases are used by bacteria to breakdown viral DNA. They are named after the bacteria from which they were originally isolated. For example, Bgl II is the second endonuclease isolated from *Bacillus globigii*.

Question 50/ 73

What is the function of CRISPR-Cas9 in bacteria?

Solution

2-50 CRISPR-Cas9 is used by bacteria to edit DNA of infecting viruses.

Question 51/ 73

Complete the following table.

CRISPR-Cas9 compound	Function
RNA Guide	
Cas9 endonuclease	

Solution

2-51

CRISPR-Cas9 Compound	Function
RNA Guide	Locates and binds to targeted viral DNA
Cas9 endonuclease	Unwinds & cuts the viral DNA

Question 52/ 73

What are the **potential** applications of CRISPR-Cas9 technology?

Solution

2-52 CRISPR-Cas 9 technology could be used to:

- correct mutations that result in disease.
- add new genes to an organism. switch faulty genes off.

Question 53/ 73

Explain the steps in the polymerase chain reaction (PCR) and give examples of its use.

Solution

2-53 The polymerase chain reaction (PCR) is used to make multiple copies of a DNA sample. This is useful for forensic tests when small tissue samples may remain. It is also used in prenatal diagnosis to produce enough DNA to analyse for genetic abnormalities.

Steps involved in PCR:

- DNA is **denatured** by heating to around 95°C.
 - The sample is cooled to approximately 50°C. Primers – synthetic single strand pieces of DNA (usually) that are complementary to the DNA sequence either side of the target sequence are added and anneal to the exposed DNA strands.
 - DNA nucleotides are added.
 - The sample is heated to approximately 72°C. Taq polymerase is added (heat tolerant enzyme from *Taq* bacteria). This joins nucleotides together starting at the primer and continuing until the end of the template DNA.
 - The cycle is repeated many times resulting in a mixture of DNA strands, including many copies of the desired sequence of DNA.
-

Question 54/ 73

Give two reasons for performing gel electrophoresis on DNA.

Solution

2-54 Gel electrophoresis is used to sort out pieces of DNA into different lengths. The results allow the use of DNA fingerprinting for forensics or paternity testing, examine DNA for evolutionary relationships, and testing for different genetic diseases.

Question 55/ 73

Use three words to summarise the steps in each PCR cycle.

Solution

2-55 Three words that summarise the PCR cycle are: denature, anneal and extend.

Question 56/ 73

Why is Taq polymerase, the restriction enzyme, often used in PCR?

Solution

2-56 Taq polymerase has been isolated bacteria that live in hot springs. Therefore, it is not denatured by high temperatures and therefore does not have to be added during the PCR process.

Question 57/ 73

Complete the following table summarising the use of gel electrophoresis in the separation of DNA of unknown lengths.

Component	Function
Agarose gel	
Electric field	
Line of wells	
Dye in the samples	
Buffer	
Ethidium bromide	
Standard	

Solution

2-57

Component	Function
Agarose gel	To provide a differential barrier to DNA movement. Smaller DNA segments move faster through the gel.
Electric field	Attracts molecules forcing them to move through the gel. DNA is negative so is attracted to the positive pole.
Line of wells	Where the samples are placed using a micropipette.
Dye in the samples	Indicate where molecules smaller than the sample have moved through the gel. Indicate to the scientist when to stop the run.
Buffer	Carry the current and maintain pH.
Ethidium bromide	Binds with DNA and fluoresces under UV light allowing the bands to be seen.

Component	Function
Standard	A solution of known DNA segments that is placed in a separate well and run at the same time as the sample under investigation. It is used to compare with the sample under investigation and determine the size of the sample DNA.

Question 58/ 73

What two features of DNA allow it to be sorted using gel electrophoresis?

Solution

2-58 DNA is negatively charged, and the sample must contain DNA of different lengths.

Question 59/ 73

What are short tandem repeats (STRs)?

Solution

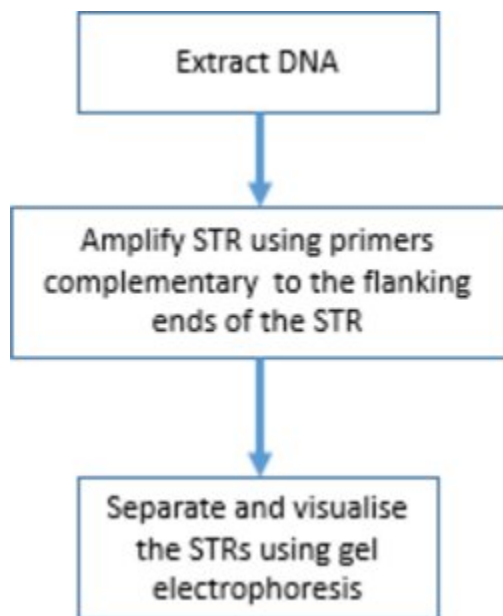
2-59 STRs are non-coding chromosomal regions of repeated 2–6 base pairs. The number of repeats varies between individuals.

Question 60/ 73

Using a flow chart, summarise the main steps in DNA profiling.

Solution

2-60 Steps in DNA profiling:



Question 61/ 73

Why are up to 10 different STR sites commonly used in DNA profiling?

Solution

2-61 The greater the number of different STR sites used the greater the chance of a result that is unique to the

person in question.

Question 62/ 73

Complete the following table summarising the differences between plasmids and prokaryotic chromosomes.

	Plasmid	Prokaryotic chromosome
Size		
Shape		
Number per cell		
Replication		
Number of gene loci		
Can be transformed (transferred to another bacterial cell)		
Solution		

2-62

	Plasmid	Prokaryotic chromosome
Size	Small	Large
Shape	Circular	Circular
Number per cell	Many	One
Replication	Self-replicating	During binary fission
Number of gene loci	Less genes Include genes coding for antibiotic resistance	All the genes for normal functioning
Can be transformed (transferred to another bacterial cell)	No	Yes

Question 63/ 73

What is a recombinant plasmid?

Solution

2-63 A recombinant plasmid is a plasmid that has been genetically engineered to contain DNA from another organism.

Question 64/ 73

What role do recombinant plasmids play in DNA manipulation?

Solution

2-64 Recombinant plasmids are used as a vector to transport (transform) DNA into other bacterial cells.

Question 65/ 73

Outline the steps in producing human insulin using bacteria.

Solution

2-65

1. Plasmid is extracted from bacteria.
 2. A section of DNA is constructed containing the following genes: gene coding for insulin protein, gene coding for antibiotic resistance, and regulatory gene.
 3. PCR is used to make more copies.
 4. The copied DNA and plasmids are mixed.
 5. A restriction enzyme is added resulting in sticky ended fragments.
 6. Ligase is added to join the fragments together.
 7. The plasmids are taken up by the bacterial cells.
 8. The bacteria are grown on antibiotic.
 9. Only bacteria containing the plasmid can grow.
 10. The regulatory gene is turned on.
 11. Insulin is produced.
-

Question 66/ 73

What is a common technique used to determine which bacterial cells have been transformed?

Solution

2-66 To determine which bacterial cells have been transformed when making the recombinant DNA an antibiotic resistance gene is inserted into the plasmid with the target gene. When the bacterial cells are cultured, an antibiotic is added and only those bacteria with the resistance gene will survive.

Question 67/ 73

Give advantages and disadvantages of using recombinant DNA technology by completing this table.

Advantages

Disadvantages

Solution

2-67

Advantage

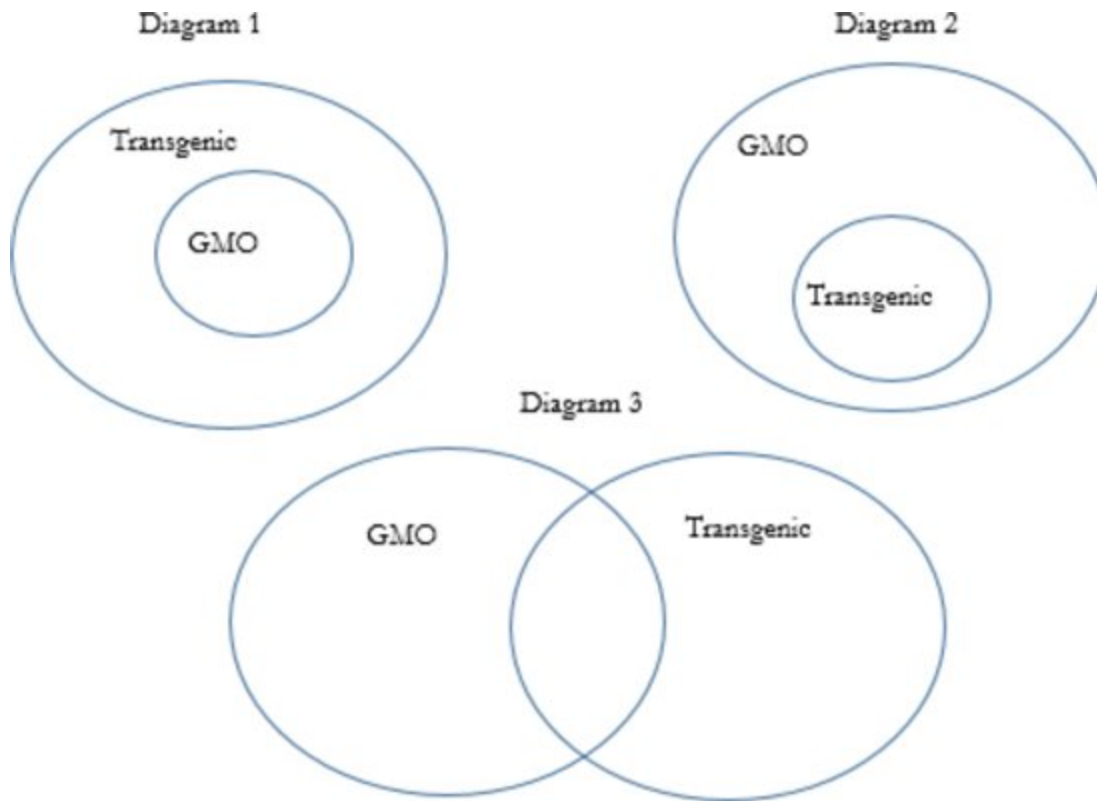
- Ability to produce large quantities of proteins/peptides that can't be produced by other means.
- Production of useful bacteria that can yield valuable products such as insulin.
- The exact protein required is produced so no rejection problems.

Disadvantage

- Complicated and expensive on a commercial scale.
 - Hard to identify useful genes in a large genome.
 - Not all eukaryotic genes will be expressed in bacterial plasmids.
 - Use of restriction enzymes with DNA produces millions of useless fragments.
-

Question 68/ 73

Which of the diagrams below best shows the relationship between genetically modified organisms (GMOs) and transgenic organisms? Explain your choice.



Solution

2-68 Diagram 2.

A genetically modified organism (GMO) is an organism whose genome has been altered by genetic engineering. The alteration maybe an addition of a gene or the silencing of a gene. Transgenic organisms are a subset of GMOs. Transgenic organisms are GMOs that have gained DNA from a different species.

Question 69/ 73

What is the difference between transformation and transfection?

Solution

2-69 Transformation is when foreign DNA is incorporated into a prokaryotic cell whereas transfection is when foreign DNA is incorporated into a eukaryotic cell.

Question 70/ 73

List the ways foreign DNA can be inserted into a cell.

Solution

2-70 Ways foreign DNA can be inserted into host cells:

- liposomes
 - plasmid vectors
 - viral vectors
 - pronuclear injection
 - ballistic DNA injection.
-

Question 71/ 73

Explain how the Ti plasmid is used to transfer genes into plants.

Solution

2-71 The Ti plasmid is found naturally in *Agrobacterium*. *Agrobacterium* infect plants and cause disease by inserting their T_i plasmids into plant cells. The T_i plasmid then inserts tumour-forming genes into the plant's chromosomes. When these genes are expressed, a tumour or gall forms. In genetic engineering, the tumour forming genes are replaced with genes the scientist wants the plant to express. In this way, the introduced genes are inserted into the plant's genome.

Question 72/ 73

Complete the following table.

Use of GMO	Example	Advantage
To provide resistance to insect predation		
To provide resistance to disease		

Solution

2-72

Use of GMO	Example	Advantage
To provide resistance to insect predation	The introduction of the Bt toxin gene from <i>Bacillus thuringiensis</i> into cotton. The cotton produces the Bt toxin protecting the cotton from insect pests.	Less use of pesticides.
To provide resistance to disease	The introduction of the R gene from peppers into tomatoes. The tomatoes produce the R protein, which breaks down the toxin causing Bacterial spot.	Less use of chemical sprays and increased productivity.

Question 73/ 73

Complete the following table by stating three reasons why we should use GMOs and three reasons why we shouldn't.

For

Against

Solution

2-73

For

Against

Increase crop yields/food production

May have unknown effects

Promote efficient land use

Recombinant plasmids are usually genetically engineered to contain genes coding for antibiotic resistance. The recombinant plasmids are selected by growing bacteria on antibiotics.

There is a risk that these recombinant plasmids could be taken up by disease-causing bacteria. These would then be resistant to antibiotics and therefore treatment of infections would be less.

Reduce the use of pesticides/herbicides

Risk of GMOs escaping into the natural environment where they may out-compete native species reducing biodiversity.

Question 1/ 136

Use the following information to answer Questions 1–3.

A scientist identified a single-stranded molecule with the structure shown below.

exon	intron	exon	intron	exon	intron
50 bases	150 bases	70 bases	80 bases	120 bases	40 bases

[VCAA 2022 SA Q2]

It would be reasonable for the scientist to conclude that this molecule is

A mature mRNA.

B pre-mRNA.

C copy DNA.

D DNA.

Solution

2-74 [VCAA 2022 SA Q2]

It would be reasonable for the scientist to conclude that this molecule is

B pre-mRNA. (The molecule cannot be DNA as it is single-stranded. Introns are present, so it must be pre-mRNA.)

Question 2/ 136

[VCAA 2022 SA Q3]

In which part of a cell would this molecule be found?

A nucleus.

B ribosome.

C Golgi apparatus.

D endoplasmic reticulum.

Solution

2-75 [VCAA 2022 SA Q3]

In which part of a cell would this molecule be found?

A nucleus. (Introns are present, so the mRNA is from a eukaryote. Editing of pre-mRNA occurs in the nucleus.)

Question 3/ 136

[VCAA 2022 SA Q4]

The scientist would expect the length of the molecule that is translated into a protein to be

A 240 bases.

B 270 bases.

C 480 bases.

D 510 bases.

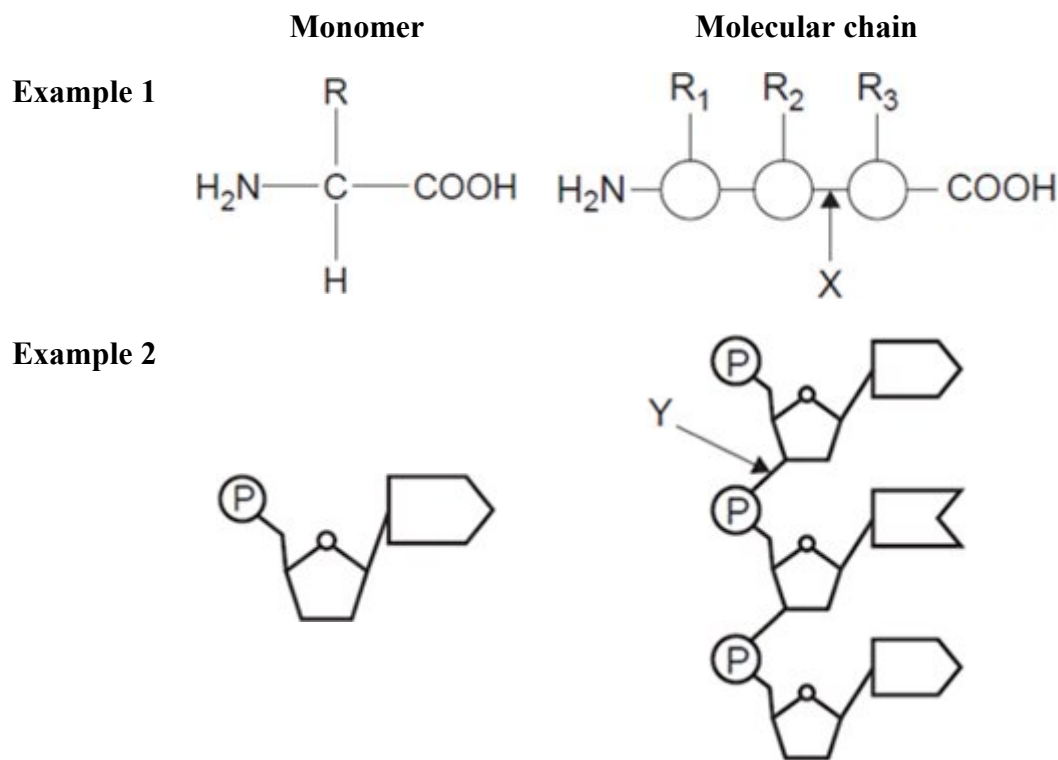
Solution

2-76 [VCAA 2022 SA Q4]

The scientist would expect the length of the molecule that is translated into a protein to be

A 240 bases. (During editing, introns are removed, leaving the exons. $50 + 70 + 120 + 40 = 240$ bases.)

Cells synthesise different molecular chains using distinct monomers, as shown in the two examples below.



The formation of chemical bonds X and Y

A requires a water molecule as a reactant.

B involves condensation polymerisation.

C releases energy for use in the cell.

D occurs in the Calvin cycle.

Solution

2-77 [VCAA 2021 SA Q1]

The formation of chemical bonds X and Y.

B involves condensation polymerisation. (X and Y are large molecules built from smaller monomers. The

joining of monomers to form larger molecules is by condensation polymerisation. This type of reaction produces water and requires energy. The Calvin cycle results in the formation of glucose, not proteins or nucleic acids as shown in the examples.)

Question 6/ 136

[VCAA 2015 SA Q3]

A single DNA nucleotide is shown by sub-unit(s)

A X alone.

B X and Y together.

C Y and Z together.

D X, Y and Z together.

Solution

2-78 [VCAA 2015 SA Q3]

A single DNA nucleotide is shown by sub-unit(s)

D X, Y and Z together. (A nucleotide consists of a nitrogenous base, a phosphate and a sugar subunit.)

Question 7/ 136

[VCAA 2015 SA Q4]

A feature of DNA that can be seen in the diagram above is

A the anti-parallel arrangement of the two strands of nucleotides.

B the process of semi-conservative replication.

C its ribose sugar–phosphate backbone.

D its double-helix structure.

Solution

2-79 [VCAA 2015 SA Q4]

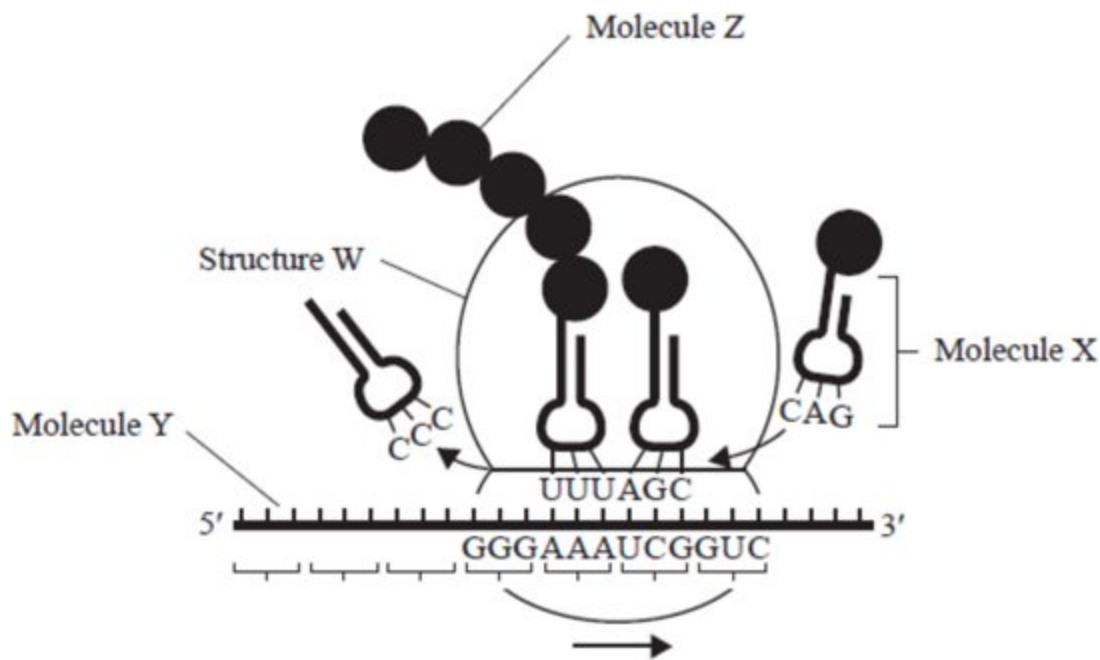
A feature of DNA that can be seen in the diagram is

A the anti-parallel arrangement of the two strands of nucleotides. (One chain runs 5' to 3' and the other 3' to 5' – hence anti-parallel.)

Question 8/ 136

[VCAA 2022 SA Q5]

Consider the diagram shown on the next page, with molecules X, Y and Z, and Structure W labelled. All arrows depict the movement of molecules or structures.



Source: adapted from H Lodish, A Berk, P Matsudaira et al.,
Molecular Cell Biology, 5th edition, WH Freeman and Company, New York, 2003, p. 119

Which one of the following is a correct statement about the diagram?

A Structure W is a copy of template DNA found in the nucleus.

B Molecule X carries an amino acid that will be added to the growing polypeptide.

C Molecule Y is being read in the 3' to 5' direction.

D Molecule Z contains a codon.

Solution

2-80 [VCAA 2022 SA Q5]

Which one of the following is a correct statement about the diagram?

B Molecule X carries an amino acid that will be added to the growing polypeptide. (The diagram is of translation. Structure W is the ribosome, molecule Y is read in the 5' to 3' direction and molecule Z is the growing polypeptide chain. Molecule X is transfer RNA. Transfer RNA carries specific amino acids to the ribosome.)

Question 10/ 136

[VCAA 2021 SA Q2]

To make the mRNA molecule containing the target sequence, a cell must

A synthesise DNA polymerase.

B attach a poly-A tail to the 3' end of the gene.

C create a nucleotide chain with a ribose–phosphate backbone.

D have a ready supply of the N-containing bases adenine, thymine, guanine, and cytosine.

Solution

2-81 [VCAA 2021 SA Q2]

To make the mRNA molecule containing the target sequence, a cell must

C create a nucleotide chain with a ribose–phosphate backbone. (RNA polymerase, not DNA polymerase, is involved in mRNA synthesis. The poly-A tail is attached to the RNA, not the gene and uracil, not thymine, is present in RNA.)

Question 11/ 136

[VCAA 2021 SA Q3]

The mRNA molecule identified by FISH is used by the cell to produce a new type of molecule.

Which one of the following statements correctly describes one aspect of the production of this new molecule?

A The rRNA and its associated proteins create a binding site for the mRNA.

B The tRNA delivers and attaches a nucleotide to the new growing molecule.

C The mRNA anticodons are complementarily matched with the tRNA codons.

D The mRNA attaches to the smaller sub-unit of the ribosome to initiate transcription.

Solution

2-82 [VCAA 2021 SA Q3]

Which one of the following statements correctly describes one aspect of the production of this new molecule?

A The rRNA and its associated proteins create a binding site for the mRNA. (The new type of molecule is a protein and is the translation product. In translation, the mRNA binds to rRNA and tRNA delivers amino acids, not nucleotides.)

Question 12/ 136

[VCAA 2021 SA Q4]

Using the information provided in the diagram in question 9 and your own knowledge of genetic coding, which of the following (in the table that follows) is correct? Assume that there are no STOP codons in the target mRNA sequence.

Probe sequence	Number of amino acids coded by the mRNA target sequence
A 3' GCAGGCAUUCCGAUCCGA 5'	5
B 3' CGGAGCGGAATGCCTGCA 5'	5
C 3' CGGAGCGGAAUGCCUGCA 5'	6
D 3' CGGAGCGGAATGCCTGCA 5'	6

Solution

2-83 [VCAA 2021 SA Q4]

Using the information provided in the diagram on the previous page and your own knowledge of genetic

coding, which of the following is correct? Assume that there are no STOP codons in the target mRNA sequence.

Probe sequence	Number of amino acids coded by the mRNA target sequence
D 3' CGGAGCGGAATGCCTGCA 5'	6

(18 nucleotides are in the sequence and 3 nucleotides code for one amino acid; therefore, 6 amino acids are coded for. D is incorrect as thymine is not present in mRNA.)

Question 13/ 136

[VCAA 2018 SA Q4]

The genetic code is described as a degenerate code. This means that

A in almost all organisms the same DNA triplet is translated to the same amino acid.

B some amino acids may be encoded by more than one codon.

C a single nucleotide cannot be part of two adjacent codons.

D three codons are needed to specify one amino acid.

Solution

2-84 [VCAA 2018 SA Q4]

The genetic code is described as a degenerate code. This means that

B some amino acids may be encoded by more than one codon. (Fact: in a number of cases it is just that the first 2 bases of a codon that determine an amino acid – so coding for some amino acids is not unique.)

Question 15/ 136

[VCAA 2020 SA Q7]

The codon table that follows can be used to determine amino acids coded for by a nucleotide sequence.

1st position (5' end) ↓	2nd position				3rd position (3' end) ↓
	U	C	A	G	
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	STOP	STOP	A
	Leu	Ser	STOP	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

It is correct to state that

A identical amino acid sequences are found in all organisms.

B the genetic code is degenerate with respect to Met.

C the codon GGU adds Trp to a polypeptide chain.

D the DNA template sequence GAA codes for Leu.

Solution

2-85 [VCAA 2020 SA Q7]

It is correct to state that

D the DNA template sequence GAA codes for Leu. (Identical amino acid sequences are found in all organisms is not true. The genetic code for Met is not degenerate as only one codon codes for MET. GGU codes for Gly, not Trp. The RNA codon is the complement of the DNA triplet; therefore, the complement of CUU is GAA.)

Question 16/ 136

[VCAA 2015 SA Q23]

The following is a sequence of amino acids located within a polypeptide:

Asn – Gly – Pro – Arg – Ser –

Using the table on the previous page, the DNA template sequence that could code for this amino acid sequence is

A TTG / CCC / GGT / GCT / TCG

B TTG / GTT / GGT / GCT / TCG

C TTG / CCC / GGT / GCT / TCT

D UUG / CCC / GGU / CGU / UGC

Solution

2-86 [VCAA 2015 SA Q23]

Using the table provided, the DNA template sequence that could code for this amino acid sequence is

A TTG / CCC / GGT / GCT / TCG (To answer the question determine the mRNA sequence –therefore – AAU or C, GG_, CC_, CG_, and AGU or C. The complement with T replacing U gives the DNA template sequence.)

Question 17/ 136

[VCAA 2014 SA Q5]

The part of a molecule referred to as an anticodon can be found in

A DNA.

B transfer RNA.

C ribosomal RNA.

D messenger RNA.

Solution

2-87 [VCAA 2014 SA Q5]

The part of a molecule referred to as an anticodon can be found in

B transfer RNA. (Triplets are found in DNA and codons in mRNA.)

Question 18/ 136

[VCAA 2011 E2 SA Q24]

The first step of gene expression is

A translation of DNA.

B transcription of DNA.

C modification of RNA.

D packaging of proteins.

Solution

2-88 [VCAA 2011 E2 SA Q24]

The first step of gene expression is

B transcription of DNA. (You need a detailed understanding of protein synthesis and the location of each step. The order for the steps given is transcription, translation, modification and then packaging of proteins.)

Question 19/ 136

[VCAA 2011 E1 SA Q44]

A molecule of transfer RNA could include the nucleotide sequence

A CTCGAUTAC

B GGCUUUAAA

C CCUUTUGAG

D AAAATACCG

Solution

2-89 [VCAA 2011 E1 SA Q44]

A molecule of transfer RNA could include the nucleotide sequence

B GGCUUUAAA (In RNA T (thymine) is replaced by U (uracil).)

Question 20/ 136

[Adapted VCAA 2020 SA Q26]

The trp operon in prokaryotes illustrates the switching off and on of genes. The operator within the trp operon

- A is a regulatory gene.
- B attaches RNA polymerase.
- C codes for the production of an enzyme.
- D is the binding site for the repressor protein and tryptophan.

Solution

2-90 [Adapted VCAA 2020 SA Q26]

The trp operon in prokaryotes illustrates the switching off and on of genes. The operator within the trp operon

D is the binding site for the repressor protein and tryptophan. (The regulatory gene codes for the production of a repressor protein. The repressor protein binds to tryptophan and the resulting molecule binds to the operator stopping RNA polymerase from reading the gene.)

Question 22/ 136

[Adapted VCAA 2019 SA Q3]

Transcription of the structural genes within the trp operon will occur when

- A a repressor molecule is attached to the operator.
- B RNA polymerase is attached to the promoter.
- C tryptophan is in high concentration in the prokaryotic cell.
- D transcription of the regulatory gene is optimal.

Solution

2-91 [Adapted VCAA 2019 SA Q3]

Transcription of the structural genes within the trp operon will occur when

B RNA polymerase is attached to the promoter. (When tryptophan is present in high concentration it binds to the repressor protein. The resulting molecule binds to the operator stopping transcription.)

Question 23/ 136

[Adapted VCAA 2019 SA Q4]

Transcription of the structural genes within the trp operon results in the production of molecules of

A a transcription factor.

B a repressor protein.

C tryptophan.

D mRNA

Solution

2-92 [Adapted VCAA 2019 SA Q4]

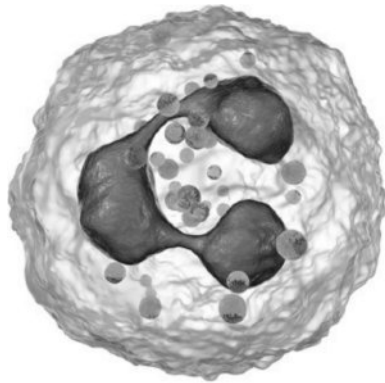
Transcription of the structural genes within the trp operon results in the production of molecules of

D mRNA. (The transcription of the structural genes results in mRNA complements of the trp E, trp D, trp B and trp A genes. Translation of the mRNA molecules results in the production of enzymes that result in the production of tryptophan.)

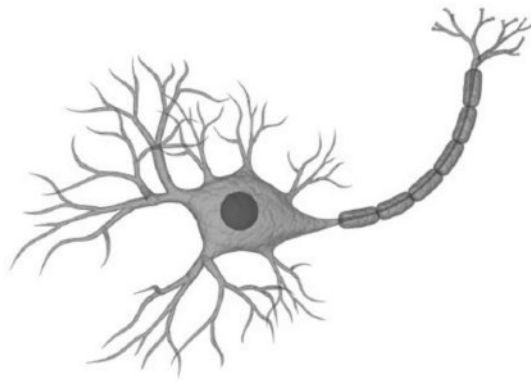
Question 24/ 136

[VCAA 2019 SA Q11]

Two different cells taken from the same human were viewed using a microscope. The diagrams below show the structure of the two cells, not drawn to the same scale.



a neutrophil



a neuron

Which one of the following is a correct conclusion to reach when comparing the two cells?

A At any given time, the genes expressed in each cell may be different.

B All proteins in each cell will have similar tertiary structures.

C The two cells have the same proteome.

D The two cells have different genomes.

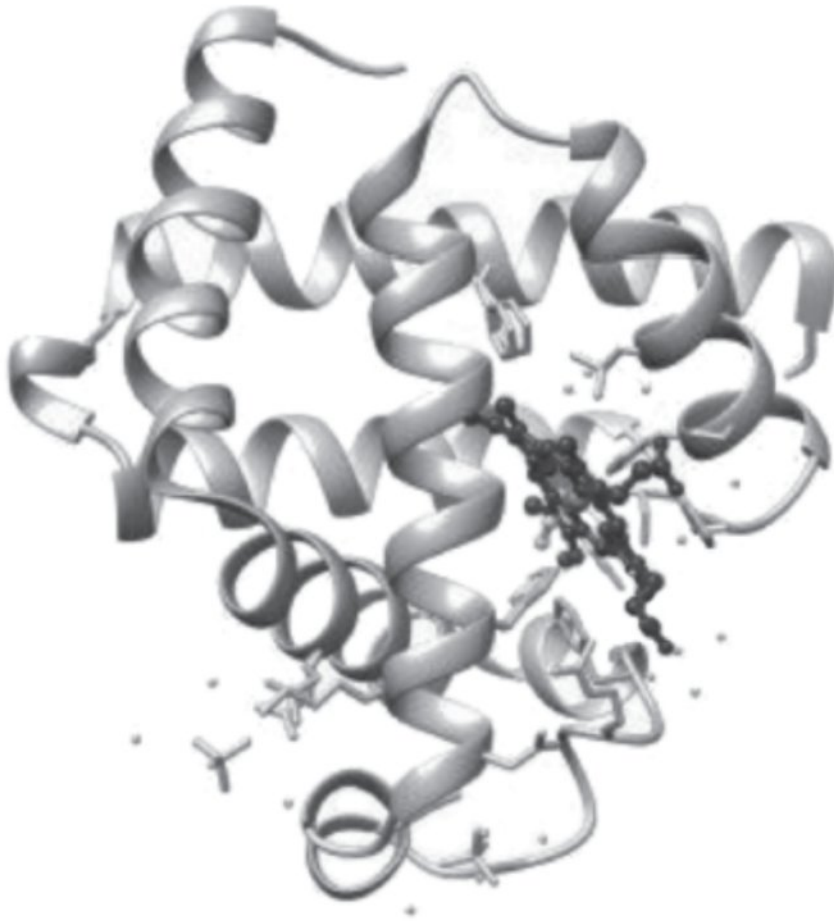
Solution

2-93 [VCAA 2019 SA Q11]

Which one of the following is a correct conclusion to reach when comparing the two cells?

A At any given time, the genes expressed in each cell may be different. (Within an organism, all somatic cells have the same genome. In different cells, the differences in function and structure are determined by which genes have been switched on as this determines what proteins are produced.)

In the 1950s, scientist John Kendrew determined the structure of myoglobin. Myoglobin was found to be a single polypeptide chain with one heme group, as shown in the following diagram.



Source: Tuscany Diet, 'Definition, composition, and structure of the proteins',
<www.tuscany-diet.net/proteins/definition-composition-structure/>

The protein structure shown on the previous page would best be described as myoglobin's

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

Solution

The protein structure shown above would best be described as myoglobin's

C tertiary structure. (It says in the question's stem that myoglobin is found to be a single polypeptide chain and the diagram clearly shows a three-dimensional shape; therefore, myoglobin has a tertiary structure.)

Question 26/ 136

[VCAA 2020 SA Q8]

The primary structure of a protein is important because it

A is the active, functional form of the protein.

B has a very specific three-dimensional shape.

C influences the way that the polypeptide folds.

D directly controls the way proteins are transported into a cell.

Solution

2-95 [VCAA 2020 SA Q8]

The primary structure of a protein is important because it

C influences the way that the polypeptide folds. (The functional form of the protein is due to the tertiary and quaternary structure which gives the protein its three-dimensional shape.)

Question 27/ 136

[VCAA 2019 SA Q5]

Which one of the following statements about proteins is correct?

A The activity of a protein may be affected by the temperature and pH of its environment.

B The primary structure of a protein refers to its three-dimensional protein shape.

C Proteins are not involved in the human immune response.

D A protein with a quaternary structure will be an enzyme.

Solution

2-96 [VCAA 2019 SA Q5]

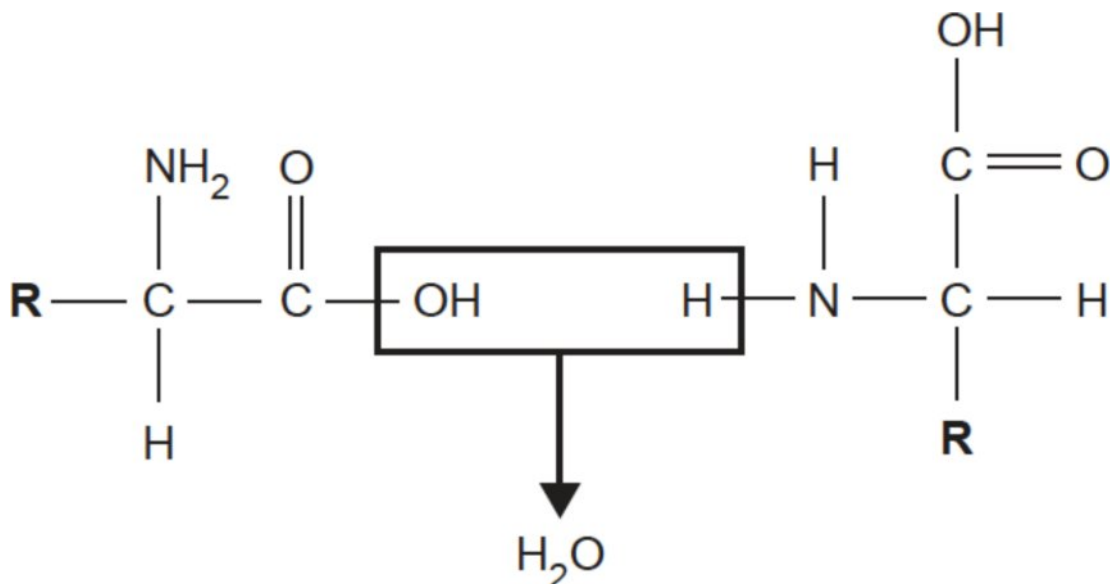
Which one of the following statements about proteins is correct?

A The activity of a protein may be affected by the temperature and pH of its environment. (Proteins are affected by temperature and pH. Primary structure refers to the amino acid order in a chain before folding so is not 3-dimensional. Proteins, e.g. immunoglobulins, are involved in the immune response and not all proteins with quaternary structure are proteins.)

Question 28/ 136

[VCAA 2018 SA Q3]

The diagram below represents adjacent amino acids being joined together.



The joining of adjacent amino acids

A results in the formation of a nucleic acid.

B is an energy-releasing reaction.

C is catalysed by DNA ligase.

D is a condensation reaction.

Solution

2-97 [VCAA 2018 SA Q3]

The joining of adjacent amino acids

D is a condensation reaction. (The reaction results in the production of water therefore condensation. Nucleic acids are not produced, and the reaction requires energy rather than releasing it. Ligase join pieces of DNA.)

Question 29/ 136

[VCAA 2017 SA Q1]

Consider the structure and functional importance of proteins. Which one of the following statements about proteins is correct?

A A change in the tertiary structure of a protein may result in the protein becoming biologically inactive.

B Proteins with a quaternary structure will be more active than proteins without a quaternary structure.

C Two different proteins with the same number of amino acids will have identical functions.

D Denaturation will alter the primary structure of a protein.

Solution

2-98 [VCAA 2017 SA Q1]

Which one of the following statements about proteins is correct?

A A change in the tertiary structure of a protein may result in the protein becoming biologically inactive. (The tertiary structure of a protein determines its shape, and the shape of a protein determines its function. Two different proteins may have the same amino acid sequence, but the chains maybe folded in different ways therefore they will have different shapes and different functions.)

Question 30/ 136

[VCAA 2018 SA Q2]

The proteome is

A the total DNA content that is present within one cell of an organism.

B a complete set of chromosomes found inside a cell of an organism.

C the entire set of proteins expressed by an organism at a given time.

D the four hierarchical levels of protein structure.

Solution

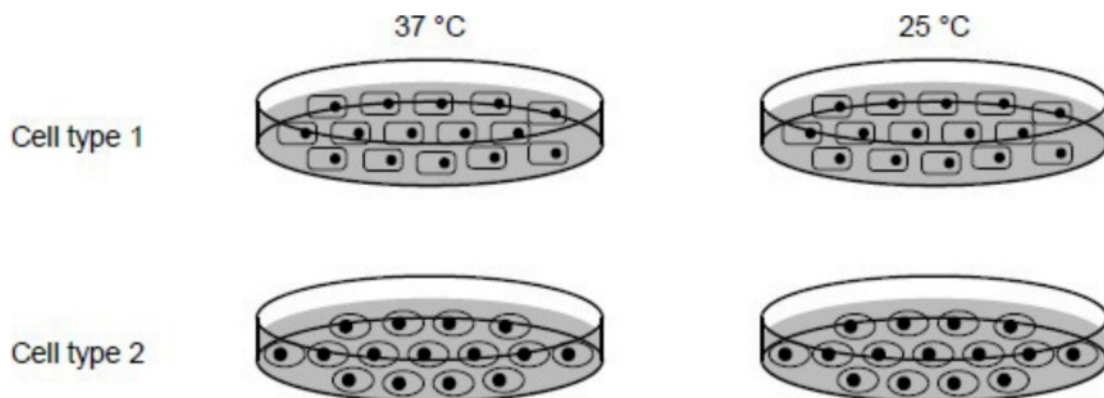
2-99 [VCAA 2018 SA Q2]

The proteome is

C the entire set of proteins expressed by an organism at a given time. (Fact. A and B refer to the DNA content rather than protein.)

Question 31/ 136

In an investigation into the uptake of a protein by cells, scientists immersed two cell types in solutions of this protein. The investigation was carried out at two different temperatures and the percentage of the protein taken up by the two cell types was recorded over 10 minutes.



The data was presented in the table, as shown below.

	Cell type 1		Cell type 2	
	Percentage of protein taken up by cell		Percentage of protein taken up by cell	
Time (mins)	At 25 °C	At 37 °C	At 25 °C	At 37 °C
0	0	0	0	0
2	2	5	5	10
4	4	10	10	20
6	6	12	12	24
8	8	16	16	32
10	8	16	16	36

Which one of the following conclusions is supported by the data?

A The rate of uptake of this protein at 25°C is not affected by cell type.

B The percentage of this protein taken up by Cell type 1 is not affected by temperature.

C The rate of uptake of this protein by Cell type 2 is faster at 37°C than at 25°C.

D If the experiment continued for another 10 minutes, the percentage of this protein taken up by Cell type 1 would increase.

Solution

2-100 [VCAA 2015 SA Q8]

Which one of the following conclusions is supported by the data?

C The rate of uptake of this protein by Cell type 2 is faster at 37°C than at 25°C. (A is incorrect as cell type does influence rate as shown by Cell type 1 at 25°C compared with Cell type 1 at 37°C. B is incorrect as temperature in Cell type 1 does influence uptake as shown by Cell type 1 at 25°C and at 37°C. There is evidence that uptake has levelled off as shown by last two measurements for Cell type 1 at 37°C. C is supported by the data.)

Question 32/ 136

[VCAA 2016 SA Q7]

In animal cells, tight junctions are multi-protein complexes that mediate cell-to-cell adhesion and regulate transport through the extracellular matrix. Proteins that form these complexes are made within the cell.

One pathway for the production of protein for these junctions is

A nucleus – ribosome – Golgi apparatus – vesicle – endoplasmic reticulum.

B nucleus – ribosome – endoplasmic reticulum – vesicle – Golgi apparatus.

C nucleus – vesicle – endoplasmic reticulum – Golgi apparatus – ribosome.

D nucleus – vesicle – Golgi apparatus – ribosome – endoplasmic reticulum.

Solution

2-101 [VCAA 2016 SA Q7]

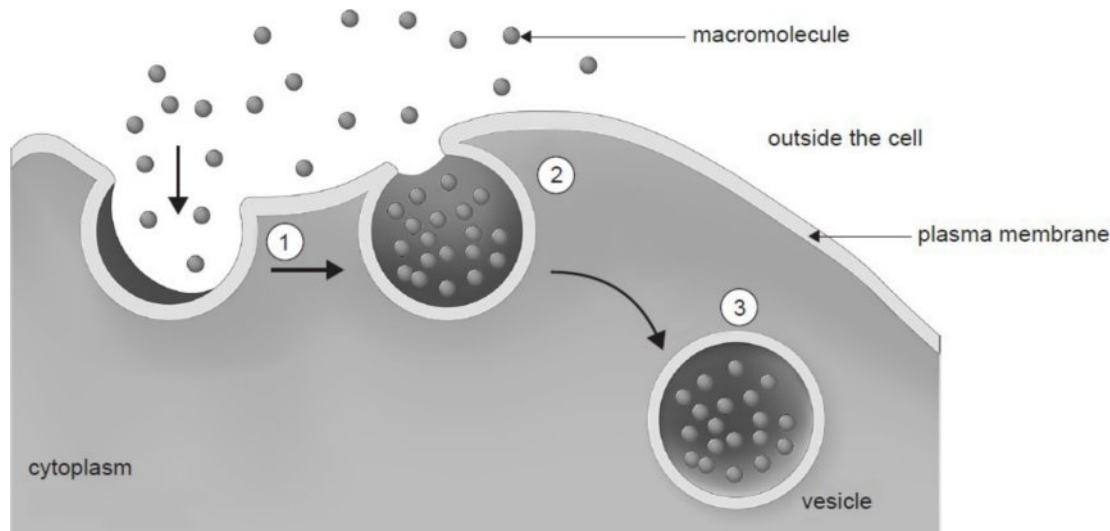
One pathway for the production of protein for these junctions is

B nucleus – ribosome – endoplasmic reticulum – vesicle – Golgi apparatus. (The question asks for an understanding of protein production. The nucleus is involved in coding for proteins, the ribosomes on the ER are the site of protein production and the vesicles and Golgi apparatus are involved in export from the cell.)

Question 33/ 136

[VCAA 2019 SA Q1]

Consider the movement of macromolecules across the plasma membrane, as shown in the diagram below.



What type of transport is shown?

A facilitated diffusion

B simple diffusion

C endocytosis

D exocytosis

Solution

2-102 [VCAA 2019 SA Q1]

What type of transport is shown?

C endocytosis. (The process shown shows bulk materials being taken into a cell by an active process so is not an example of diffusion.)

Question 35/ 136

[VCAA 2014 SA Q3]

Process R is an example of

A exocytosis.

B phagocytosis.

C pinocytosis.

D endocytosis.

Solution

2-103 [VCAA 2014 SA Q3]

Process R is an example of

A exocytosis. (The bulk release of molecules from a cell is called exocytosis. Phagocytosis and pinocytosis are forms of endocytosis where molecules are taken into a cell.)

Question 36/ 136

[VCAA 2014 SA Q4]

Organelle X

A is the site of cellular respiration.

B packages protein molecules for export from the cell.

C absorbs sunlight and produces carbohydrates.

D produces ribosomal RNA.

Solution

2-104 [VCAA 2014 SA Q4]

Organelle X

B packages protein molecules for export from the cell. (Organelle X is a Golgi Apparatus. Mitochondria are the sites of aerobic respiration and chloroplasts are the sites of photosynthesis.)

Question 37/ 136

[VCAA 2019 SA Q2]

Which one of the following organelles has the role of synthesising proteins from their monomers?

A Golgi apparatus

B ribosomes

C vesicles

D nucleus

Solution

2-105 [VCAA 2019 SA Q2]

Which one of the following organelles has the role of synthesising proteins from their monomers?

B ribosomes. (Fact – ribosomes are the site of protein synthesis.)

Question 39/ 136

[VCAA 2013 SA Q6]

The site of synthesis of protein M is the

A vesicles.

B ribosomes.

C plasma membrane.

D smooth endoplasmic reticulum.

Solution

2-106 [VCAA 2013 SA Q6]

The site of synthesis of protein M is the

B ribosomes. (Proteins are assembled at ribosomes, transported by the smooth endoplasmic reticulum and vesicles.)

Question 40/ 136

[VCAA 2013 SA Q7]

The export of protein M by these cells would involve

A centrioles.

B lysosomes.

C the Golgi apparatus.

D chromosomes.

Solution

2-107 [VCAA 2013 SA Q7]

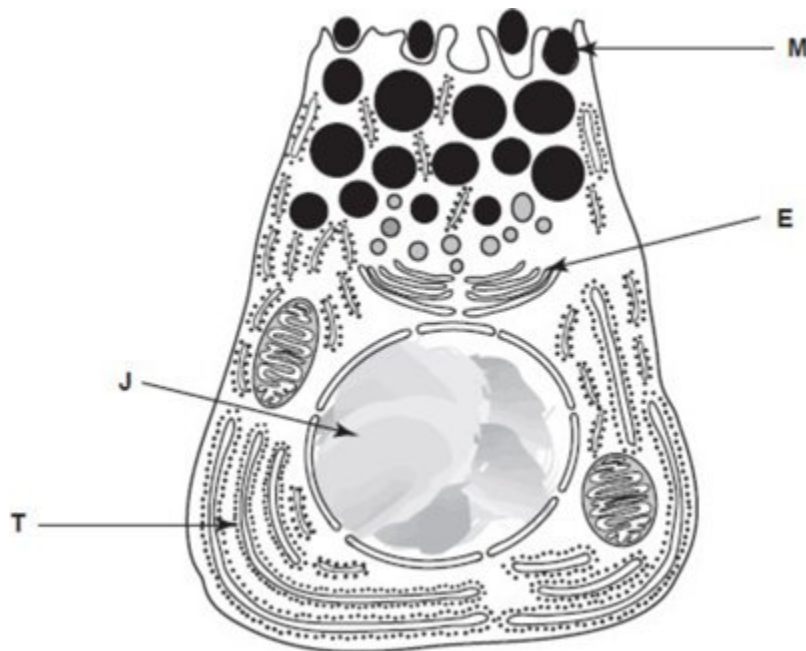
The export of protein M by these cells would involve

C the Golgi apparatus. (Chromosomes store genetic information, centrioles are involved in cell division and lysosomes contain digestive enzymes.)

Question 41/ 136

[VCAA 2012 E1 SA Q7]

Examine the following diagram of a pancreatic cell.



The order in which the parts of the cell play a role in the production and secretion of proteins is

A M, E, J, T.

B T, J, M, E.

C J, T, E, M.

D E, M, T, J.

Solution

2-108 [VCAA 2012 E1 SA Q7]

The order in which the parts of the cell play a role in the production and secretion of proteins is

C J, T, E, M. (The instructions for the production of the protein are found in J, the nucleus. mRNA carries these instructions to T, the ribosome. The protein is packaged for secretion at E, the Golgi body. M – vesicles bud off the Golgi body and carry the secretion to the cell membrane.)

Question 42/ 136

[VCAA 2022 SA Q6]

An enzyme is used to manipulate DNA as shown in the diagram below.



A This enzyme is an endonuclease.

B This enzyme could be used to join two DNA fragments together.

C The action of this enzyme produces blunt ends on the two new fragments.

D This enzyme breaks only hydrogen bonds between complementary base pairs.

Solution

2-109 [VCAA 2022 SA Q6]

An enzyme is used to manipulate DNA as shown in the diagram below.

A This enzyme is an endonuclease. (Ligases are used to join two DNA fragments; the diagram shows sticky ends rather than blunt ends, and the enzyme breaks hydrogen bonds between the nitrogenous bases and the DNA backbone.)

Question 43/ 136

[VCAA 2019 SA Q38]

DNA ligase

A joins two DNA fragments together by forming phosphodiester bonds between the two fragments.

B acts as molecular scissors, cutting DNA molecules at specific nucleotide sequences.

C separates two DNA strands during transcription so that a copy can be made.

D is an enzyme involved in protein synthesis.

Solution

2-110 [VCAA 2019 SA Q38]

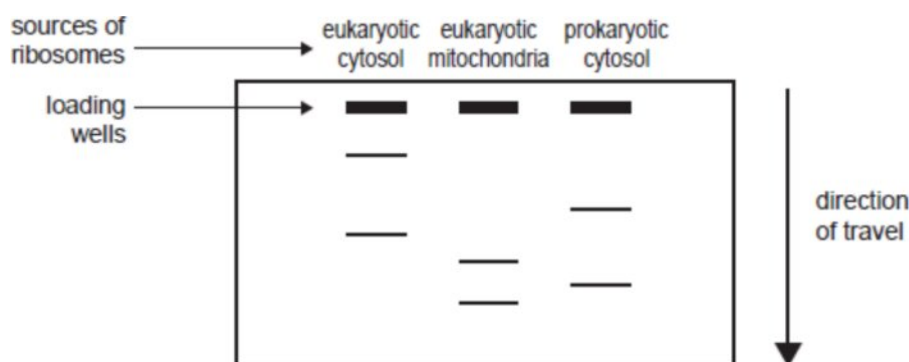
DNA ligase

A joins two DNA fragments together by forming phosphodiester bonds between the two fragments.
(Definition. Ligases are enzymes that join pieces of DNA together.)

Question 44/ 136

[VCAA 2015 SA Q28]

A ribosome contains two distinct sub-units: a large sub-unit and a small sub-unit. Ribosomes from prokaryotic and eukaryotic cells were isolated and subjected to gel electrophoresis. The results are shown in the diagram on the next page.



Which one of the following can be correctly concluded from the gel electrophoresis results?

A Eukaryote cytosolic and mitochondrial ribosomes translate the same types of protein.

B Eukaryote mitochondria contain the ribosomal sub-units of the smallest size.

C Prokaryote ribosomal sub-units have opposing charges to each other.

D Eukaryote cytosolic ribosomal sub-units travel at the greatest speeds.

Solution

2-111 [VCAA 2015 SA Q28]

Which one of the following can be correctly concluded from the gel electrophoresis results?

B Eukaryote mitochondria contain the ribosomal sub-units of the smallest size. (Movement in gel electrophoresis depends on size – small units travel further. The sub-units of the eukaryote mitochondria have travelled the greatest distances and must be the smallest.)

Question 46/ 136

[VCAA 2013 SA Q29]

Consider a length of double-stranded DNA with the sequence

5' T T A A G G A A T T C A A 3'

3' A A T T C C T T A A G T T 5'

Adding EcoRI to a solution containing one copy of this double-stranded DNA produces

A two fragments of double-stranded DNA, each with a sticky end.

B four fragments of single-stranded DNA, each with a sticky end.

C two fragments of double-stranded DNA, each with blunt ends.

D four fragments of single-stranded DNA, each with blunt ends.

Solution

2-112 [VCAA 2013 SA Q29]

Adding EcoRI to a solution containing one copy of this double-stranded DNA produces

A two fragments of double-stranded DNA, each with a sticky end. (There is only one recognition sequence for EcoRI in the sample, therefore one cut and two pieces. EcoRI cuts the DNA unevenly, therefore sticky ends will be produced.)

Question 47/ 136

[VCAA 2013 SA Q30]

Now consider a different length of double-stranded DNA with the sequence

5' C T T A A G C T T C C A A A T T A C C G A 3'

3' G A A T T C G A A G G T T T A A T G G C T 5'

Which enzyme(s) will cut this piece of DNA?

A EcoRI only

B HindIII only

C AluI and HindIII only

D AluI, HindIII and HaeIII only

Solution

2-113 [VCAA 2013 SA Q30]

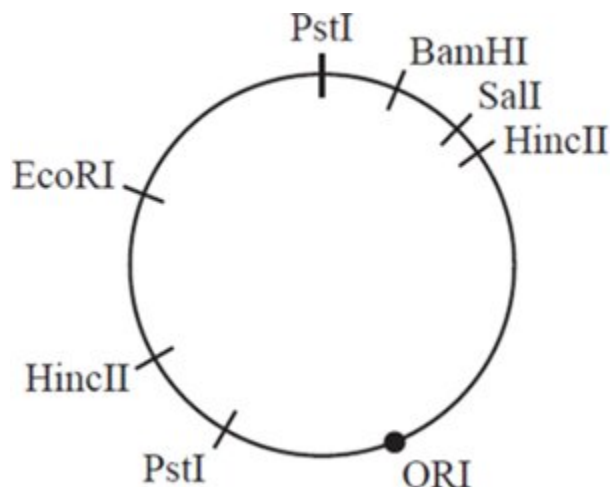
Which enzyme(s) will cut this piece of DNA?

C AluI and HindIII only. (Only the recognition sequences for these restriction enzymes are present in the sequence.)

Question 48/ 136

[VCAA SA Q39 2019]

The diagram below is a map of a bacterial plasmid showing ORI, the origin of DNA replication, and selected restriction endonuclease sites.



One plasmid was mixed with the restriction enzymes EcoRI, BamHI and HincII. Which of the following shows the number of restriction sites that have been cut and the resulting number of DNA fragments produced?

	Number of restriction sites cut	Number of DNA fragments produced
A	3	3
B	3	4
C	4	4
D	4	5

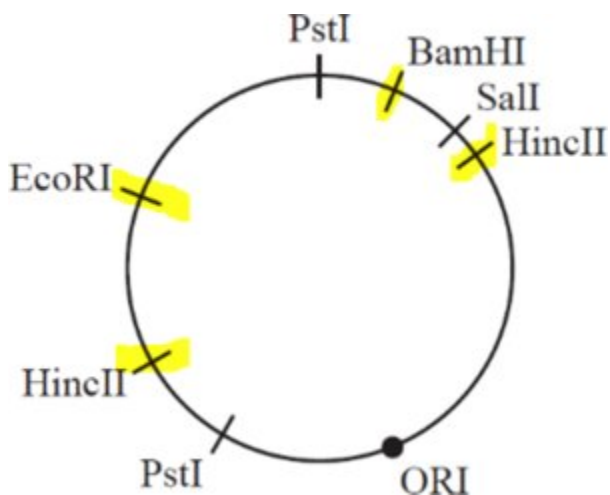
Solution

2-114 [VCAA 2019 SA Q39]

Which of the following shows the number of restriction sites that have been cut and the resulting number of DNA fragments produced?

Number of restriction sites cut	Number of DNA fragments produced
4	4

C



(Note the yellow mark – representing 4 restriction sites where a cut will occur – resulting in 4 DNA fragments.)

Question 49/ 136

[VCAA 2021 SA Q28]

Small amounts of DNA can be collected from items such as cigarette butts and hair follicles that are found at crime scenes. This DNA can be replicated for analysis and used as evidence in court cases.

	Method	Enzyme used
A	polymerase chain reaction	<i>Taq</i> polymerase
B	DNA profiling	DNA ligase
C	polymerase chain reaction	DNA ligase
D	DNA profiling	<i>Taq</i> polymerase

Which of the following identifies the method of DNA replication and the enzyme used?

Solution

2-115 [VCAA 2021 SA Q28]

Small amounts of DNA can be collected from items such as cigarette butts and hair follicles that are found at crime scenes. This DNA can be replicated for analysis and used as evidence in court cases.

Which of the following identifies the method of DNA replication and the enzyme used?

Method	Enzyme used
polymerase chain reaction	<i>Taq</i> polymerase

A (The problem with collecting DNA for analysis is that the samples are small. PCR or the polymerase chain reaction allows the sample DNA to be replicated many times to allow for analysis.)

Question 50/ 136

[VCAA 2020 SA Q29]

A small sample of DNA was obtained from a fossil. Polymerase chain reaction (PCR) was used to amplify the amount of DNA obtained from the sample.

Which one of the following is a correct statement regarding the PCR process?

A DNA polymerase catalyses the pairing of primers with complementary nucleotides.

B RNA polymerase catalyses the additions of nucleotides to a DNA strand.

C Annealing and extension of the DNA occur at different temperatures.

D The number of copies of the DNA quadrupled in each cycle.

Solution

2-116 [VCAA 2020 SA Q29]

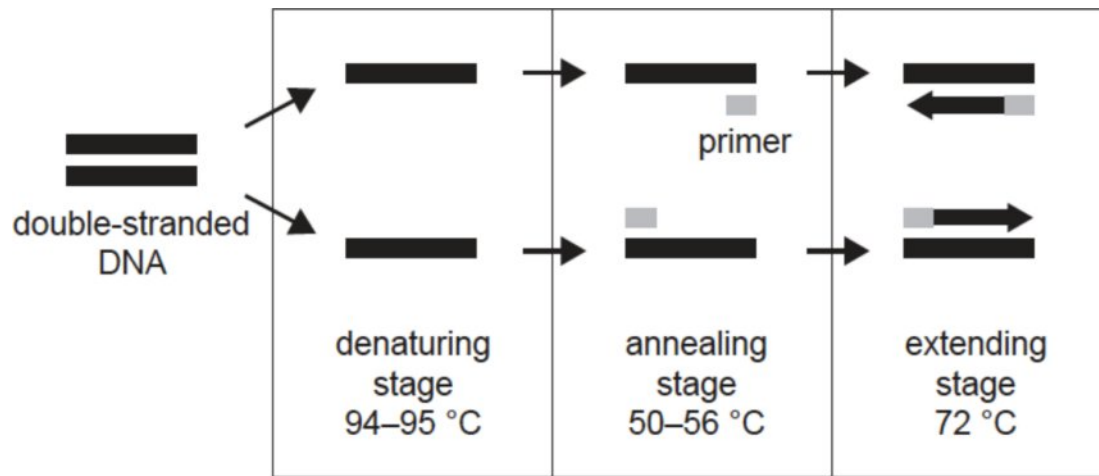
Which one of the following is a correct statement regarding the PCR process?

C Annealing and extension of the DNA occur at different temperatures. (Fact. Taq polymerase joins DNA nucleotide together and the number of copies of DNA double each cycle.)

Question 51/ 136

[VCAA SA Q28 2018]

The diagram below represents a method of DNA manipulation.



Source: Genome Research Limited, in Your Genome, www.yourgenome.org

The method represented is

A gel electrophoresis.

B DNA transformation.

C bacterial transformation.

D polymerase chain reaction.

Solution

2-117 [VCAA 2018 SA Q28]

The diagram represents a method of DNA manipulation. The method represented is

D polymerase chain reaction. (The diagram represents the polymerase chain reaction used to make multiple copies of a piece of DNA. It is not bacterial transformation as bacterial DNA is single stranded.)

Question 53/ 136

[VCAA 2018 SA Q30]

Which lane represents a sample that was loaded with DNA fragments of four different lengths: 100 bp, 150 bp, 200 bp and 300 bp?

A W

B X

C Y

D Z

Solution

2-118 [VCAA 2018 SA Q30]

Which lane represents a sample that was loaded with DNA fragments of four different lengths: 100 bp, 150 bp, 200 bp and 300 bp?

C Y (Useful to use a ruler to add in the missing figures. Doing so makes it easy to see that lane Y satisfies the criteria. All other lanes have samples of much greater length – 350 base pairs and greater.)

Question 54/ 136

[VCAA 2018 SA Q31]

Which lane contains the band that is closest to the negative electrode?

A W

B X

C Y

D Z

Solution

2-119 [VCAA 2018 SA Q31]

Which lane contains the band that is closest to the negative electrode?

B X (The DNA fragments are negatively charged. The negative electrode is at the loading well end. Fragments will move towards the opposite/positive end of the gel plate. Note the 500-base piece near the X well. S could have been answer but was not an alternative.)

Question 55/ 136

[VCAA 2014 SA Q25]

Plasmids of bacteria are used to transfer selected genes from one species to another. The process can be represented as follows.

Bacterial plasmid cut → foreign gene and plasmid mixed → plasmid with inserted foreign gene

Enzymes are used to facilitate several of these steps.

	Cuts plasmid	Inserts genes
A	restriction enzyme	DNA ligase
B	restriction enzyme	DNA polymerase
C	DNA ligase	DNA polymerase
D	DNA polymerase	DNA ligase

Which one of the following shows the enzymes required for the first and last steps of the process?

Solution

2-120 [VCAA 2014 SA Q25]

Cuts plasmid	Inserts genes

restriction enzyme DNA ligase

Which one of the following shows the enzymes required for the first and last steps of the process?

A (Restriction enzymes cut plasmids and ligase joins double stranded DNA segments together. DNA polymerase joins DNA nucleotides together to form a single chain of nucleotides.)

Question 57/ 136

[VCAA 2020 SA Q30]

In order to collect only bacterial cells that had taken up the plasmid successfully, a sample should be taken from

A Plate 1.

B Plate 2.

C Plate 3.

D Plate 4.

Solution

2-121 [VCAA 2020 SA Q30]

In order to collect only bacterial cells that had taken up the plasmid successfully, a sample should be taken from

C Plate 3. (The aim of the process to produce cells that are resistant to ampicillin. Therefore, we need to look at a treated plate with ampicillin. Any bacterial cells that grow will have taken up the gene and be resistant.)

Question 58/ 136

[VCAA 2020 SA Q31]

The process in which the bacterial cell takes up the plasmid is called

A translation.

B transcription.

C translocation.

D transformation.

Solution

2-122 [VCAA 2020 SA Q31]

The process in which the bacterial cell takes up the plasmid is called

D transformation. (Fact. The other three processes are involved in normal cell processes – for example, preparation for cell division or production of proteins.)

Question 59/ 136

[VCAA 2020 SA Q32]

Target DNA is to be inserted into a plasmid. For a recombinant plasmid to be produced

A the plasmid sections and the target DNA must have blunt ends.

B the target DNA must come from the same species as the bacteria.

C the plasmid and the target DNA must be cut by a polymerase.

D DNA ligase is used to re-join the sugar-phosphate sections of the plasmid and the target DNA.

Solution

2-123 [VCAA 2020 SA Q32]

Target DNA is to be inserted into a plasmid. For a recombinant plasmid to be produced.

D DNA ligase is used to re-join the sugar-phosphate sections of the plasmid and the target DNA.

(Ligase is used to join pieces of DNA with sticky ends. The DNA to be used can, in theory, come from any source. Blunt ends would not be useful – the pieces would not join.)

Question 61/ 136

[VCAA 2015 SA Q25]

Bacteria are used in gene cloning because they

A contain restriction enzymes that randomly cut chromosomes into fragments of varying size.

B can replicate non-bacterial sequences of DNA in a short time.

C replicate exponentially by undergoing mitotic divisions.

D allow the entry of foreign DNA into their nuclei.

Solution

2-124 [VCAA 2015 SA Q25]

Bacteria are used in gene cloning because they

B can replicate non-bacterial sequences of DNA in a short time. (Bacteria do not have nuclei or divide by mitosis.)

Question 62/ 136

[VCAA 2015 SA Q26]

Which plate would contain bacteria that fluoresce under UV light?

A plate W

B plate X

C plate Y

D plate Z

Solution

2-125 [VCAA 2015 SA Q26]

Which plate would contain bacteria that fluoresce under UV light?

C plate Y (Only transformed bacteria can grow in the presence of ampicillin and the 'gfp' gene is only expressed if arabinose is present.)

Question 63/ 136

[VCAA 2015 SA Q27]

Which one of the following statements is an accurate description for the purpose of plate W or X?

A Plate W shows that the plasmid was cut with a restriction enzyme.

B Plate W shows that the percentage of transformed bacteria was high.

C Plate X shows that the nutrient agar promoted the growth of viable bacteria.

D Plate X shows that ampicillin was effective in killing the untransformed bacteria.

Solution

2-126 [VCAA 2015 SA Q27]

Which one of the following statements is an accurate description for the purpose of plate W or X?

D Plate X shows that ampicillin was effective in killing the untransformed bacteria. (Untransformed bacteria cannot grow in the presence of ampicillin therefore any growth on Y and Z must be of transformed bacteria.)

Question 65/ 136

[VCAA 2013 SA Q34]

The correct sequence of steps when producing the insulin is

A V, P, T, S, U, R, Q.

B V, T, P, U, S, Q, R.

C R, Q, V, T, P, U, S.

D R, V, Q, T, P, S, U.

Solution

2-127 [VCAA 2013 SA Q34]

The correct sequence of steps when producing the insulin is

C, R, Q, V, T, P, U, S. (The code for the amino acid sequence must be known before the gene can be synthesised therefore R must be first. The code can be worked out from the amino acid sequence in the protein therefore Q before V.)

Question 66/ 136

[VCAA 2013 SA Q35]

The tool used for joining the artificial gene to plasmid DNA at step T is

A a primer.

B DNA ligase.

C DNA polymerase.

D gel electrophoresis.

Solution

2-128 [VCAA 2013 SA Q35]

The tool used for joining the artificial gene to plasmid DNA at step T is

B DNA ligase. (Gel electrophoresis is used to separate different lengths of DNA, a primer is used as an anchor to start the addition of DNA nucleotides and DNA polymerase joins DNA nucleotides into a single chain. DNA ligase is used to join doubled stranded DNA (plasmid) together.)

Question 67/ 136

[VCAA 2013 SA Q36]

The artificial insulin gene may have a different nucleotide sequence from the human insulin gene. This is because the DNA code is

A redundant.

B universal.

C mutated by heat shock.

D contaminated by bacterial DNA.

Solution

2-129 [VCAA 2013 SA Q36]

This is because the DNA code is

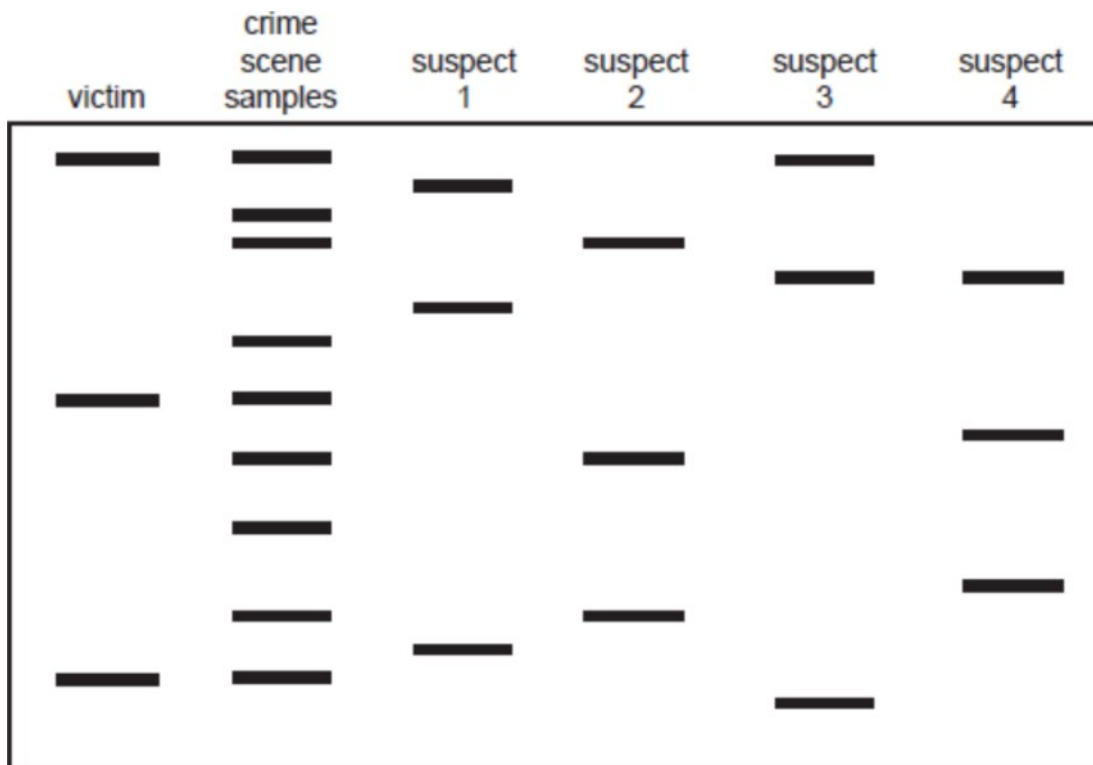
A redundant. (Redundant refers to the fact that a number of DNA triplets may code for the same amino acid.)

Question 68/ 136

[VCAA 2013 SA Q28]

During a fight between a number of people, one was seriously injured. Blood samples were taken from the victim, the crime scene and four suspects. DNA was extracted from white blood cells in each of the blood samples and electrophoresis of the samples was carried out.

The results are shown in the diagram below.



The person most likely to have been at the crime scene is suspect

A 1.

B 2.

C 3.

D 4.

Solution

2-130 [VCAA 2013 SA Q28]

The person most likely to have been at the crime scene is suspect

B 2. (Only the bars for Suspect 2 sample match the bars for the sample found at the crime scene.)

Question 69/ 136

[VCAA 2019 SA Q36]

Certain yeast (*Saccharomyces cerevisiae*) can be modified and made to express a human gene, resulting in the production of insulin.

S. cerevisiae can most accurately be described as a

A transgenic organism.

B yeast–human hybrid.

C genetically mutated organism.

D laboratory-produced organism.

Solution

2-131 [VCAA 2019 SA Q36]

S. cerevisiae can most accurately be described as a

A transgenic organism. (Definition. If a yeast is modified to include a human gene, it is a changed organism – that is transgenic.)

Question 70/ 136

[VCAA 2022 SA Q7]

Genetically modified (GM) crops are engineered to introduce a new trait into a species. Traits chosen by scientists are ones that will benefit people either directly or indirectly.

An example of such a trait is one that

A decreases the nutritional value of a crop.

B improves environmental conditions for crops.

C increases resistance to toxins produced by fungi.

D develops potential allergens that trigger a vigorous immune response.

Solution

2-132 [VCAA 2022 SA Q7]

An example of such a trait is one that

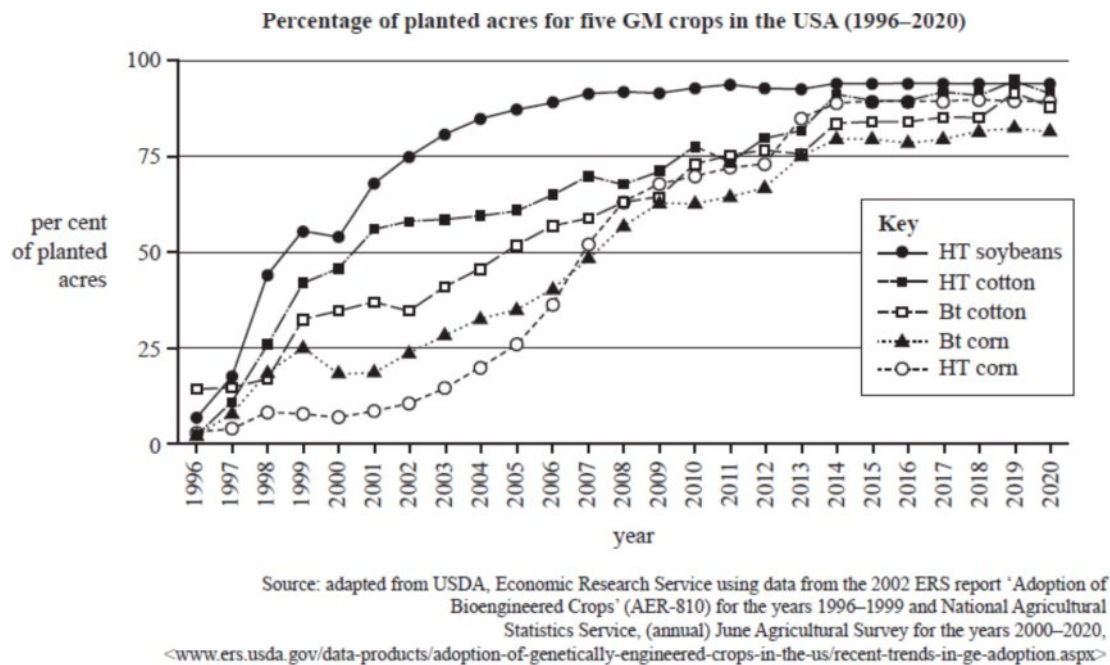
C increases resistance to toxins produced by fungi. (Decreasing nutritional value and the development of allergens will not benefit people.)

Question 71/ 136

[VCAA 2022 SA Q8]

The extent to which GM crops were planted in the United States of America (USA) between 1996 and 2020

was investigated. The percentage of planted acres of GM crops out of the total planted acres of crops for five different types of crops – HT soybeans, HT cotton, Bt cotton, Bt corn and HT corn – is presented in the graph below. ‘HT’ indicates herbicide-tolerant varieties and ‘Bt’ indicates insect-resistant varieties.



From the graph above, it can be concluded that

A in 1996, the percentage of planted acres of HT cotton crops was greater than 10 per cent.

B in 2007, the percentage of planted acres of Bt corn crops was greater than the percentage of planted acres of HT corn crops.

C in 2013, the percentage of planted acres of Bt cotton crops and the percentage of planted acres of Bt corn crops were similar.

D in 2020, the percentage of planted acres of HT soybean crops was the lowest that it had been for the duration of the investigation.

Solution

2-133 [VCAA 2022 SA Q8]

From the graph, it can be concluded that

C in 2013, the percentage of planted acres of Bt cotton crops and the percentage of planted acres of Bt corn crops were similar. (You need to read the graph carefully – we would suggest you use a ruler. On looking, it can be seen in 2013 the percentage Bt cotton and Bt corn planted are similar.)

Question 72/ 136

What is the best explanation for the successful development of transgenic species?

A Artificial pollination works across the plant kingdom.

B Nuclear transplantation from cell to cell is easily achieved.

C DNA in the biosphere is composed of the same chemical components.

D Genes from different animals within the one species are easily combined.

Solution

2-134

What is the best explanation for the successful development of transgenic species?

C DNA in the biosphere is composed of the same chemical components. (Transgenic species contain and express genes from another species. If DNA/the genetic code was not universal, the genes from another species could not be expressed.)

Question 74/ 136

[VCAA 2020 SA Q36]

It is most likely that the main aim of this research and technology is to

A use knowledge from the research to develop treatments for human disease.

B enhance the flavour of rice to encourage greater rice consumption.

C increase the yield of rice crops to provide more food supplies.

D improve the nutrition of malnourished people.

Solution

2-135 [VCAA 2020 SA Q36]

It is most likely that the main aim of this research and technology is to

D improve the nutrition of malnourished people. (Use the data! Look at the increase in iron and zinc levels in the biofortified rice – large increases. Also, in the question stem, there is a hint – rice supplies energy but is low in micronutrients such as iron and zinc.)

Question 75/ 136

[VCAA 2020 SA Q37]

Which one of the following is the best description for this strain of biofortified rice?

A genetically screened

B genetically modified and transgenic

C genetically transformed by gene silencing

D genetically engineered by adding iron and zinc

Solution

2-136 [VCAA 2020 SA Q37]

Which one of the following is the best description for this strain of biofortified rice?

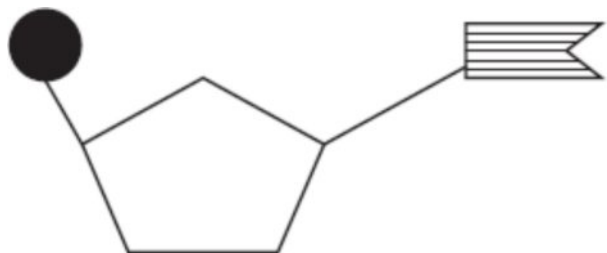
B genetically modified and transgenic (The new strain is genetically modified because it has new genes inserted. It is transgenic because it contains genetic material from other species, i.e.: soybeans.)

Question 1/ 172

[VCAA 2020 SB Q2]

RNA molecules consist of long strands of joined nucleotides. Each nucleotide consists of three sub-units.

a Label the three sub-units on the diagram of the RNA nucleotide below. (1 mark)



b Complete the table below by describing the role in a cell of the two types of RNA listed. (2 marks)

Type of RNA	Role in a cell

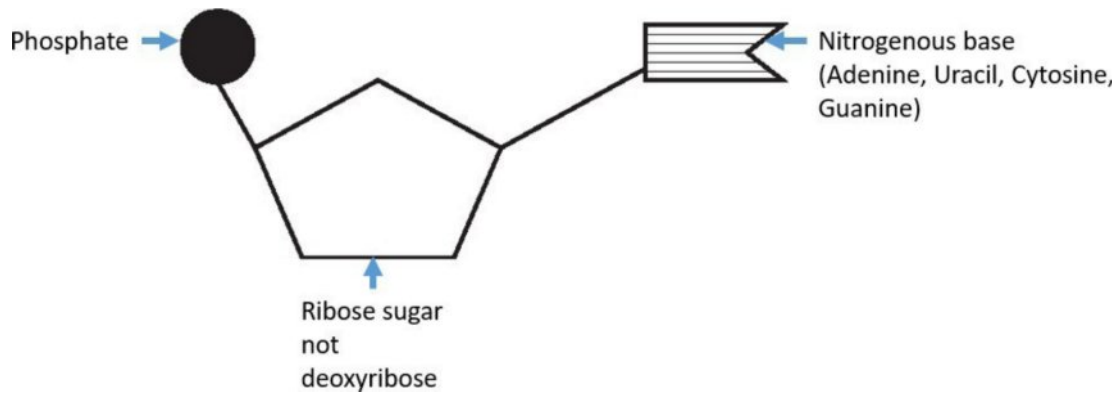
tRNA	

mRNA	

c Outline two events that occur during RNA processing and the importance of each event in gene expression. (4 marks)

(Total 7 marks)

Solution



a

b

Type of RNA

Role in a cell

tRNA	tRNA carries specific amino acids to the ribosome. Its anticodon is complementary to the mRNA codon.
mRNA	mRNA carries a transcript of the DNA template strand to the ribosome and therefore determines the order amino acids are assembled into a polypeptide chain at the ribosome.

c Any **two** of:

- Introns are removed.

Importance: only coding nucleotides remain in the mRNA. Only these are transcribed; therefore, the correct polypeptide chain is translated.

- Exons are spliced together: only coding nucleotides remain in the mRNA. Only these are transcribed; therefore, the correct polypeptide chain is translated.
- Exon shuffling.

Importance: allows many slightly different proteins to be coded for by one gene. This increases the variety of proteins produced by the cell.

- A 5' methyl cap is added to the RNA.

Importance: this protects the mRNA from degradation as it moves from the nucleus to the ribosome and allows the mRNA to bind to the ribosome.

- A poly-A tail is added to the RNA.

Importance: this protects the mRNA from degradation as it moves from the nucleus to the ribosome.

Question 2/ 172

[VCAA 2021 SB Q2]

Baker's yeast (*Saccharomyces cerevisiae*) is a unicellular, eukaryotic organism. Biologists have studied its proteome. A single yeast cell contains approximately 6000 different proteins.

a Consider the 6000 different proteins. The concentration of each protein may change with a change in environmental conditions. Give one example of a type of protein within a yeast cell that may change in concentration and explain why this change is necessary. (3 marks)

b There are several cellular activities that directly alter the number of proteins within a yeast cell. These include transcription, RNA processing, translation and breakdown of protein.

For each cellular activity listed in the table below, state the immediate end product of the activity. (2 marks)

Cellular activity	Immediate end-product
Transcription	
RNA	
processing	
Translation	
Breakdown of protein	

c Four *S. cerevisiae* genes and the functions of their gene products are outlined in Table 1 below. (2 marks)

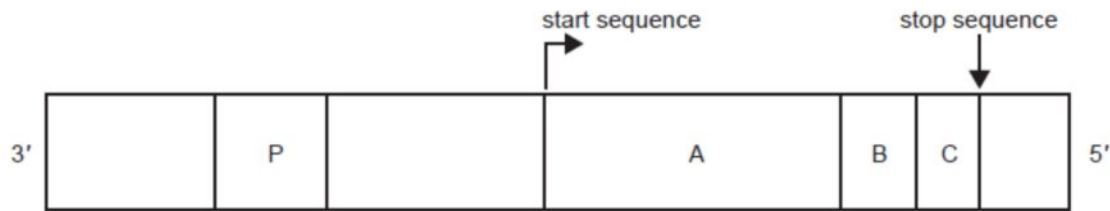
Table 1. *S. cerevisiae* genes and the functions of their gene products

Gene	Function of gene product
HSP82	active on the plasma membrane to pump protons out of cell
ADR1	binds to DNA and acts as a transcriptional factor
GCN4	controls the activity of RNA polymerase
AQY1	a water channel in the plasma membrane

Identify the regulatory genes in Table 1 and justify your response.

d One in particular, the *S. cerevisiae* protein, PFY1, assists with the organisation of a cell's cytoskeleton. In the diagram below, the gene for the PFY1 protein is shown with a promoter region (labelled P), start and stop

transcription sequences, and a single intron (labelled B).



Give the general name of the sections labelled A and C and outline the function of these sections. (2 marks)

(Total 9 marks)

Solution

2-138 [VCAA 2021 SB Q2]

a Any **one** of the following:

- Enzyme. If there is an increase (decrease) in substrate concentration, then more (less) enzymes will be produced to break down the substrate.
- Enzymes involved in respiration. If there is an increase (decrease) in respiration rate, then more (less) enzymes involved in respiration will be produced.
- Structural proteins. If the cell is damaged/replicating, then structural proteins will be produced to repair the cell.
- Transcription factors. If environmental conditions change requiring more/fewer transcription factors to increase/decrease transcription and therefore protein synthesis.

b

Cellular activity	Immediate end product
transcription	Pre-mRNA
RNA processing	mRNA
translation	a polypeptide chain
Breakdown of protein	amino acids

c Regulatory genes code for proteins that control the transcription of other genes. ADR1 is a regulatory gene as it binds to DNA and increases transcription. GCN4 is a regulatory gene as it controls the activity of RNA polymerase. RNA polymerase binds to the promoter region of genes, the gene unwinds and unzips, and

RNA polymerase joins RNA nucleotides together to form pre-mRNA complementary to the DNA template strand.

d A and C are exons. Exons are transcribed and, therefore, code for the order of amino acids assembled at the ribosome.

Question 3/ 172

[VCAA 2019 SB Q1]

Diagrams of two molecules that are required for the production of proteins within a cell are shown below.

Molecule 1



Molecule 2



a Complete the table below to describe two differences between the monomers of the two molecules. (2 marks)

Molecule 1

Molecule 2

Difference 1

Difference 2

b Ten amino acids that form part of a protein are shown below.

-phe-val-asn-gln-his-leu-cys-gly-ser-his-

The section of an RNA molecule found in the nucleus of the cell associated with the translation of these 10 amino acids was found to contain over 300 monomers.

Explain how there can be over 300 monomers in this section of the RNA molecule but only 10 amino acids translated. (2 marks)

(Total 4 marks)

Solution

2-139 [VCAA 2019 SB Q1]

a Any **two** of:

	Molecule 1	Molecule 2
Difference	The pentose sugar present is ribose.	The pentose sugar present is deoxyribose.
Difference	The nitrogenous bases present are adenine, cytosine, guanine and uracil.	The nitrogenous bases present are adenine, cytosine, guanine and uracil.
Difference	Ribose sugar contains more oxygen.	Deoxyribose sugar contains less oxygen.

Note: The question asks for differences in the monomers, i.e. RNA nucleotide and DNA nucleotide **not** the molecules transfer RNA and DNA.

b Genes consist of introns and exons. These are both transcribed into pre-mRNA. Pre-mRNA introns are removed to form mRNA. 3 mRNA molecules code for one amino acid.

Question 4/ 172

[VCAA 2012 E1 SB Q3]

Human insulin is a macromolecule composed of two amino acid chains. The chains are connected by disulfide bonds.

a To what group of macromolecules does insulin belong? (1 mark)

Insulin found in other animals varies from human insulin. The following table compares all the differences seen in the primary structure of human, cow, pig and sheep insulin.

Amino acid position number within

	Alpha Chain	Beta Chain
	-8 - 9 - 10-	-30-
human	-thre - ser - ile-	thr
cow	-ala - ser - val-	ala
pig	-thre - ser - ile-	ala
sheep	-ala - gly - val-	ala

b What is meant by the term ‘primary structure’ of the insulin macromolecule? (1 mark)

Humans with diabetes take insulin injections to maintain their health.

c If supplies of human insulin were not available, which one of the other three animals listed in the table would be the best source of insulin? Explain your reason for choosing this particular animal. (2 marks)

The table below contains the genetic code for protein production.

		Second letter					
		A	G	T	C		
First letter	A	AAA } phe AAG } AAT } leu AAC }	AGA } AGG } ser AGT } AGC }	ATA } tyr ATG } ATT } Stop ATC } Stop	ACA } cys ACG } ACT } Stop ACC } trp	A G T C	
	G	GAA } leu GAG } GAT } GAC }	GGA } GGG } pro GGT } GGC }	GTA } his GTG } GTT } gln GTC }	GCA } arg GCG } GCT } GCC }	A G T C	
	T	TAA } ile TAG } TAT } met TAC } Start	TGA } TGG } thr TGT } TGC }	TTA } asn TTG } TTT } lys TTC }	TCA } ser TCG } TCT } arg TCC }	A G T C	
	C	CAA } val CAG } CAT } CAC }	CGA } CGG } ala CGT } CGC }	CTA } asp CTG } CTT } glu CTC }	CCA } gly CCG } CCT } CCC }	A G T C	

d Use the information in the table to explain:

i the different sequence of nucleotides in humans and cows with respect to the DNA coding for the amino acid at position 30. (1 mark)

ii whether the sequence of nucleotides in DNA coding for the amino acid at position 30 will be identical in cows, pigs and sheep. (1 mark)

(Total 6 marks)

Solution

2-140 [VCAA 2012 E1 SB Q3]

a proteins

b 'Primary structure' of the insulin macromolecules refers to the specific order of amino acids in each of the two polypeptide chains making up insulin.

c Animal: pig

Explanation: The order of amino acids in the alpha chain of the pig is more similar (identical) to humans than the other animals therefore its shape will be more similar to human insulin and it will be more likely to fit human insulin receptors on cells.

d i Human: thr Coding triplets: TGA TGG TGT TGC

Cow: ala Coding triplets: CGA CGG CGT CGC

The DNA triplets coding for the amino acid at position 30 differ in the first base. For humans the first nucleotide is T, whereas for cows it is C.

ii The sequence of nucleotides in DNA coding for the amino acid at position 30 will not necessarily be identical in cows, pigs and sheep. The amino acid at position 30 is the same (ala) but there are 4 possible triplets (CGA, CGG, CGT and CGC) that code for this amino acid therefore any of these could be present and still result in the same amino acid at position 30.

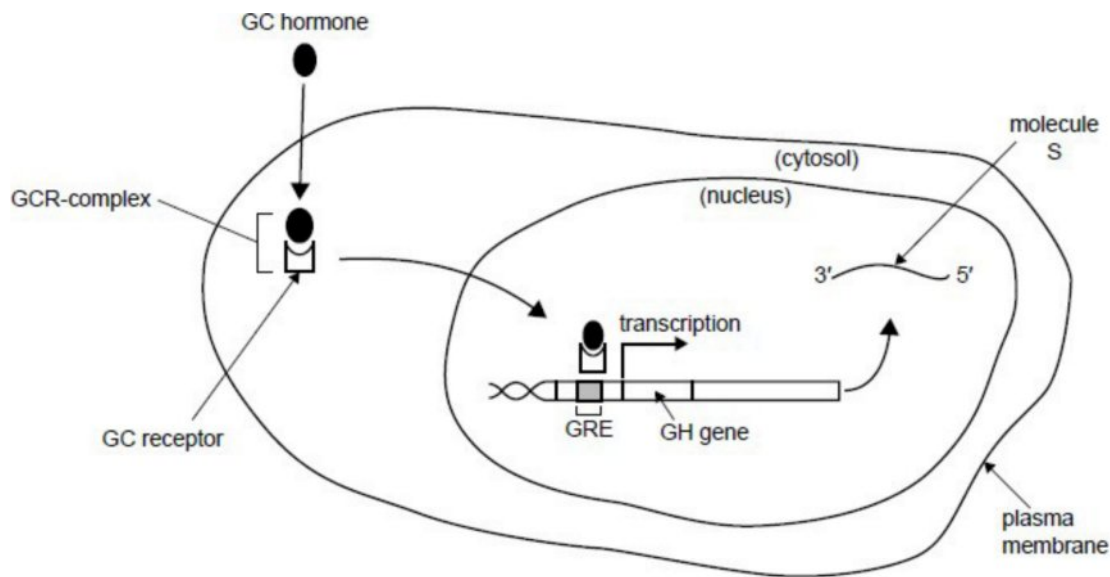
Question 5/ 172

[VCAA 2015 SB Q7]

Glucocorticoid (GC) is a hormone in rats that binds to a receptor, as shown in the diagram below. The glucocorticoid-receptor complex (GCR-complex) moves into the nucleus and attaches to the DNA, causing

transcription to begin.

GC signal transduction in rat pituitary gland cells



The location where the GCR-complex attaches to the DNA is called the glucocorticoid response element (GRE). The GRE is located approximately 250 base-pairs upstream of the growth hormone (GH) gene. Following the attachment of the GCR-complex to the GRE, an enzyme catalyses the transcription of the gene.

a Name the enzyme that catalyses transcription. (1 mark)

b Name the transcription product, molecule S, and describe the processing that molecule S undergoes before it exits the nucleus. (3 marks)

c In the rat pituitary gland, GC stimulates the production of the growth hormone protein. However, in the rat liver, GC stimulates the production of the enzyme tryptophan oxygenase.

Given that the genetic sequence is identical in all somatic rat cells, explain how the production of distinct proteins in different cell types could occur. (2 marks)

d If a human gene is inserted into the DNA of rat pituitary gland cells, these genetically engineered cells can be used to produce human growth hormone.

What characteristic of the genetic code enables a human protein, such as human growth hormone, to be made by rat cells? (1 mark)

(Total 7 marks)

Solution

a RNA polymerase

b Molecule S is pre-mRNA. Before it leaves the nucleus, introns are removed and a methyl cap and poly-A tail are added.

c The genetic sequence is identical but when expressed different proteins are produced because when pre-mRNA is edited different introns are spliced out. Therefore, the resulting mRNA is different and when translated a different protein is produced.

d The genetic code is universal. This means that the same three DNA bases code for the same amino acid in all living organisms.

Question 6/ 172

[VCAA 2010 E1 SB Q6]

a List the three components of a DNA nucleotide. (1 mark)

In Tay–Sachs disease (TSD), the enzyme that breaks down glycolipid is faulty due to a genetic mutation. Examine the following two tables.

Table 1 – Portion of the genetic code

First letter	Second letter				Third letter
	A	G	T	C	
A	phe	ser	tyr	cys	A
G	leu	pro	his	arg	A
C	val	ala	glu	gly	T

Table 2 – Portion of DNA sequences

	DNA nucleotide sequence	Amino acid sequence
Normal Individual	--CTT GCA AAA--	glu - arg - phe
TSD Individual	--CTT GTA AAA--	

The amino acid sequence shown in **Table 1** for a normal individual, forms part of the enzyme

hexosaminidase A (Hex A).

b What is the amino acid sequence for the TSD individual in **Table 2**?

Use the information in **Table 1** to explain how changing one amino acid in a polypeptide may adversely affect the function of a protein of which the amino acid is part. (1 + 2 = 3 marks)

(Total 4 marks)

Solution

2-142 [VCAA 2010 E1 SB Q6]

a The three components of a DNA nucleotide are a phosphate, deoxyribose and a nitrogenous base.

b TSD amino acid sequence: glu-his-phe

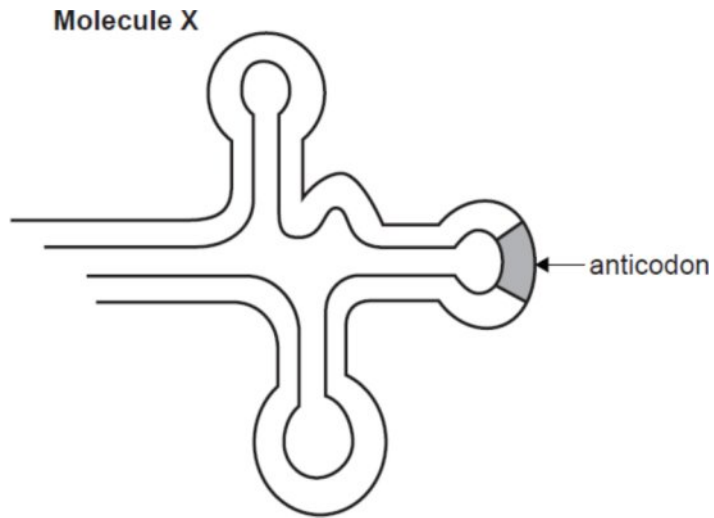
Explanation: a different amino acid sequence will change the primary structure of the protein, which will then affect how the protein chain folds and therefore the final shape of the enzyme. The shape of the active site of the enzyme is specific to the reactants it catalyses. If the active site is altered, the enzyme will no longer be able to catalyse the reaction.

Question 7/ 172

[Adapted VCAA 2016 SB Q6]

The hormone insulin is a relatively small protein. Researchers studying the production of insulin in the cells of the pancreas noted that one of the early steps in this process was the formation of a polypeptide called preproinsulin.

Researchers noted that the formation of this polypeptide required repeated use of different types of Molecule X, shown in the diagram below.



a i What is the name of Molecule X? (1 mark)

ii How does Molecule X play a role in the production of preproinsulin? (3 marks)

b The coding information in the DNA molecule for preproinsulin is initially transferred to another molecule (Molecule W). However, Molecule W has a different nucleotide sequence from the coding section of the DNA molecule.

Describe how Molecule W is synthesised. (3 marks)

(Total 7 marks)

Solution

2-143 [Adapted VCAA 2016 SB Q6]

a i Transfer RNA

ii tRNA carries specific amino acids to the ribosome. The anticodon on the tRNA attaches to a complementary to the mRNA codon. In this way, the amino acids are assembled and joined according to the order of bases on the mRNA that was formed from the transcription of the preproinsulin gene.

b Molecule W is mRNA and is formed when the preproinsulin gene is transcribed. Transcription begins when RNA polymerase binds to the preproinsulin gene promoter. The DNA unwinds and unzips. RNA polymerase then joins RNA nucleotides that are complementary (adenine with uracil, thymine with adenine, cytosine with guanine and guanine with cytosine) to the exposed DNA template, together to form pre-mRNA. This continues until the terminator sequence is reached. The single-stranded pre-mRNA is complementary to the DNA and contains uracil instead of thymine. The pre-mRNA dissociates from the template strand and is edited. Introns are removed and a cap and a tail are added to form mRNA coding for preproinsulin.

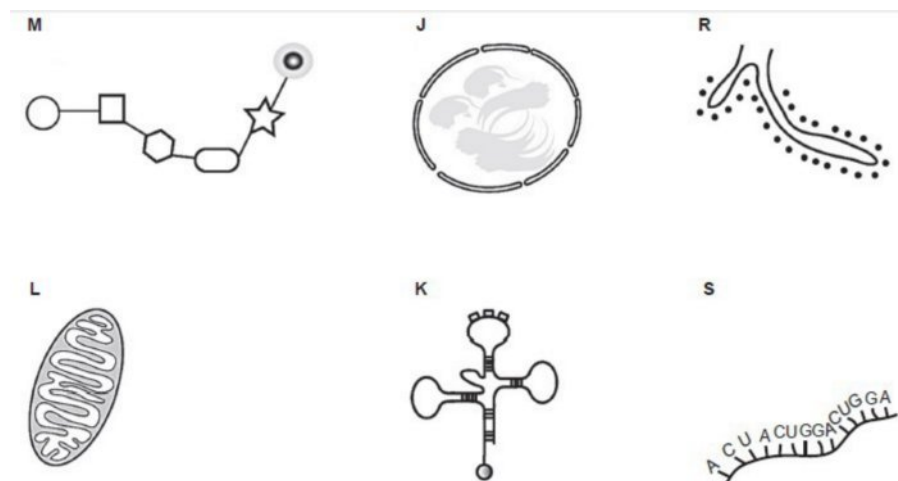
Question 8/ 172

[VCAA 2012 E2 SB Q1]

In Australia, Alzheimer's disease is the most common form of dementia. Alzheimer's disease is associated with the development of a toxic protein in the brain known as amyloid beta-protein. The amyloid beta-protein builds up to form plaques in the brain. This causes symptoms such as memory loss.

The synthesis of amyloid beta-protein occurs in two stages.

- a** Name the two stages of protein synthesis. (1 mark)
- b** Describe the main steps of the first stage of synthesis of amyloid beta-protein. (3 marks)
- c** Consider the diagrams of the following six structures.



Choose three of the structures shown above that are involved in the **second** stage of protein synthesis.

Explain the role of each in producing amyloid beta-protein.

Letter representing structure chosen	Role of structure in second stage of amyloid beta-protein synthesis

(3 marks)

(Total 7 marks)

Solution

2-144 [VCAA 2012 E2 SB Q1]

a Stage 1: Transcription Stage 2: Translation

b RNA polymerase initiates transcription by binding to the promoter of the gene coding for the amyloid beta-protein gene. The DNA unwinds and unzips. RNA polymerase then joins RNA nucleotides that are complementary (adenine with uracil, thymine with adenine, cytosine with guanine and guanine with cytosine) to the exposed DNA template, together to form pre-mRNA. This continues until the terminator sequence is reached. The pre-mRNA dissociates from the template strand and is edited. Introns are removed and a cap and tail are added to form mRNA.

c Any **three** of the following:

Letter representing structure chosen	Role of structure in second stage of amyloid beta-protein synthesis
M	A chain of amino acids, when folded will form the Amyloid beta-protein. (It is not correct to write amyloid beta-protein as the diagram shows a chain of amino acids not the final folded molecule.)
J	Nucleus Site of transcription where an mRNA complement of the gene for amyloid beta-protein is synthesised. This mRNA carries the information that determines the order amino acids are joined during translation to make the amyloid beta-protein.
R	Rough Endoplasmic Reticulum Site of translation where amino acids are assembled into a polypeptide. The order is determined by mRNA. tRNA brings specific amino acids to the ribosome where bonds form between the adjacent amino acids forming the chain of amino acids that will form the amyloid beta-protein.
L	Mitochondrion Site of aerobic respiration. Provides the energy required to assemble the amino acids together in translation.
K	Transfer RNA (tRNA) tRNA carries specific amino acids to the ribosome. The anticodon on the tRNA is complementary to the mRNA codon. In this way, the amino acids are assembled according to the order of bases on the mRNA.

**Letter
representing
structure chosen**

Role of structure in second stage of amyloid beta-protein synthesis

S

Messenger RNA (mRNA)

The order of bases on the mRNA is determined by the order of bases in DNA. Therefore, mRNA carries the instructions for assembling amino acids into the amyloid beta-protein from the nucleus to the ribosome.

Question 9/ 172

[VCAA 2014 SB Q7]

Scientists studying the nucleus of the fruit fly *Drosophila melanogaster* observed distinct types of nucleic acid chains.

These scientists noticed that one type of nucleic acid chain was able to pass through the nuclear membrane and move to a ribosome. After the nucleic acid chain attaches to the ribosome, a polymer is produced.

a Describe the steps occurring at the ribosome that resulted in the production of the polymer. (3 marks)

b One particular length of nucleic acid chain passed through the nuclear membrane and coded for the production of a polymer that was 90 monomers long.

How many nucleotide bases on the nucleic acid chain were involved in the coding for this polymer? Explain your response. (2 marks)

(Total 5 marks)

Solution

2-145 [VCAA 2014 SB Q7]

a Translation occurs at the ribosome. mRNA attaches to the ribosome. The start codon is read. tRNA molecules bring specific amino acids to the complementary mRNA in the order determined by the mRNA. Three mRNA bases or a codon, code for one amino acid. The complementary bases on the tRNA are called an anticodon. The anticodon determines the type of amino acid carried to the ribosome and the order the amino acids are assembled as the anticodon pairs with the codon at the ribosome. Peptide bonds form between adjacent amino acids, tRNA molecules detach and translation ceases when a stop codon is reached. The chain of amino acids produced forms the polymer.

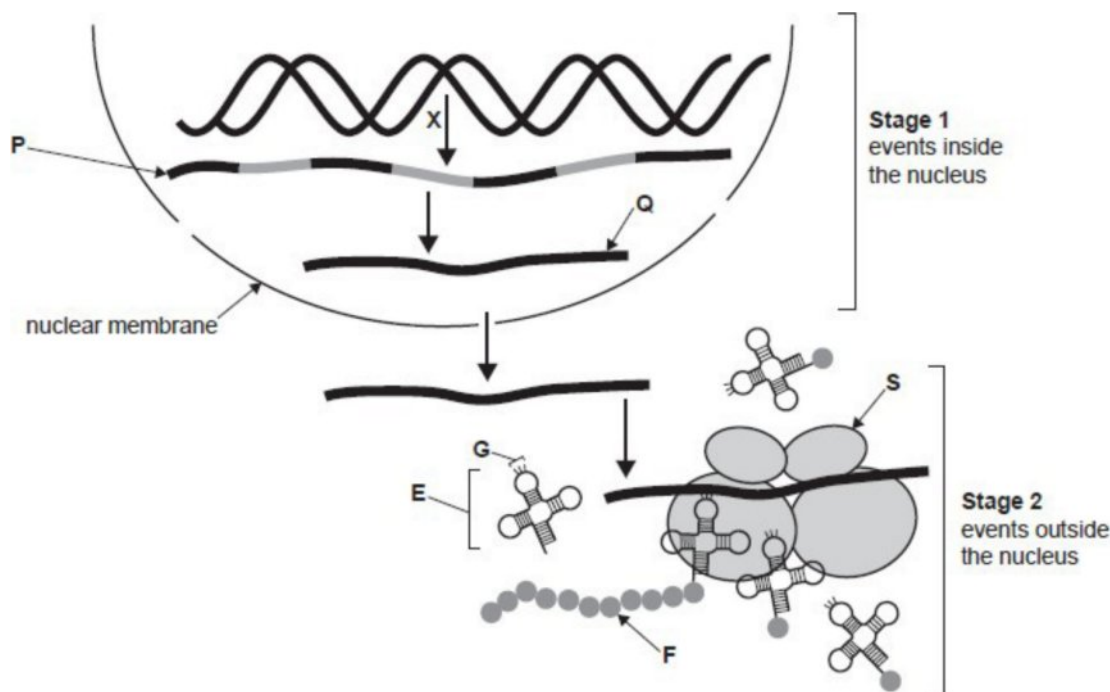
b Each monomer is coded for by three nucleotide bases therefore $3 \times 90 = 270$ nucleotide bases were involved in the coding of this polymer.

Or 3×90 plus 3 for the start codon and 3 for the stop codon = 276

Question 10/ 172

[VCAA 2013 SB Q6]

The diagram below outlines various events that occur in cells when DNA is activated.



a i Outline events that occur during action X. (2 marks)

ii Note that structure P consists of two different kinds of components. What are these two components called and what happens to each component? (2 marks)

b Describe the events occurring in stage 2, including the role of each of the structures S, F, E and G. (4 marks)

(Total 8 marks)

Solution

2-146 [VCAA 2013 SB Q6]

a i Action X is transcription. RNA polymerase locates the gene by recognising the promoter. The DNA unwinds and unzips. Controlled by RNA polymerase, complementary RNA nucleotides (adenine and uracil, thymine and adenine, cytosine and guanine, guanine and cytosine) are added to the exposed DNA template. This continues until a termination sequence is reached. Pre-mRNA is formed. This separates from the DNA and the DNA joins back together again.

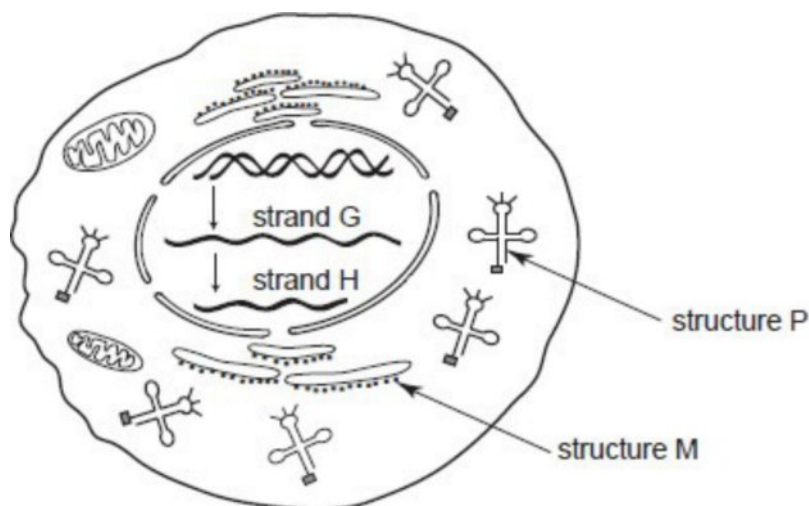
ii P consists of exons (dark sections) and introns (pale sections). Introns are non-coding and are cut out. The exons are coding and join together to form mRNA. The mRNA then leaves the nucleus and moves to the ribosome for translation.

b mRNA moves out of the nucleus to the ribosome, structure S and site of translation. The start codon is read. Structure E is tRNA. tRNA molecules bring specific amino acids to the complementary mRNA in the order determined by the mRNA. Three mRNA bases or a codon, code for one amino acid. The complementary bases on the tRNA are called an anticodon, structure G. The anticodon determines the type of amino acid carried to the ribosome and the order the amino acids are assembled as the anticodon pairs with the codon at the ribosome. Peptide bonds form between adjacent amino acids, tRNA molecules detach and translation ceases when a stop codon is reached. The final product F is an amino acid chain or polypeptide. This forms the primary structure of a protein.

Question 11/ 172

[VCAA 2011 E2 SB Q1]

Consider the following diagram of a cell. The parts of the diagram are not drawn to scale.



a In which structure would RNA polymerase be found? (1 mark)

b Describe the function of RNA polymerase. (2 marks)

c Strand **H** is shorter than strand **G**. Describe the process that results in this shortening, using appropriate names for both strands. (2 marks)

d Name strand **H** and structures **P** and **M**. Explain how each contributes to protein synthesis. (3 marks)

(Total 8 marks)

Solution

2-147 [VCAA 2011 E2 SB Q1]

a Nucleus

b RNA polymerase initiates transcription by binding to the promoter. The DNA unwinds and unzips. RNA polymerase then joins RNA nucleotides that are complementary to the exposed DNA template, together to form pre-mRNA.

c Strand **G** is pre-mRNA. It is an RNA complement of the template strand of the DNA for a gene including both introns and exons. The sections complementary to the introns are removed from the RNA, shortening the strand. A cap and tail is added to form the shorter mRNA which is strand **H**.

d Strand **H**: messenger RNA (mRNA)

The order of bases on the mRNA is determined by the order of bases in DNA. Therefore, mRNA carries the instructions for assembling amino acids into proteins from the nucleus to the ribosome.

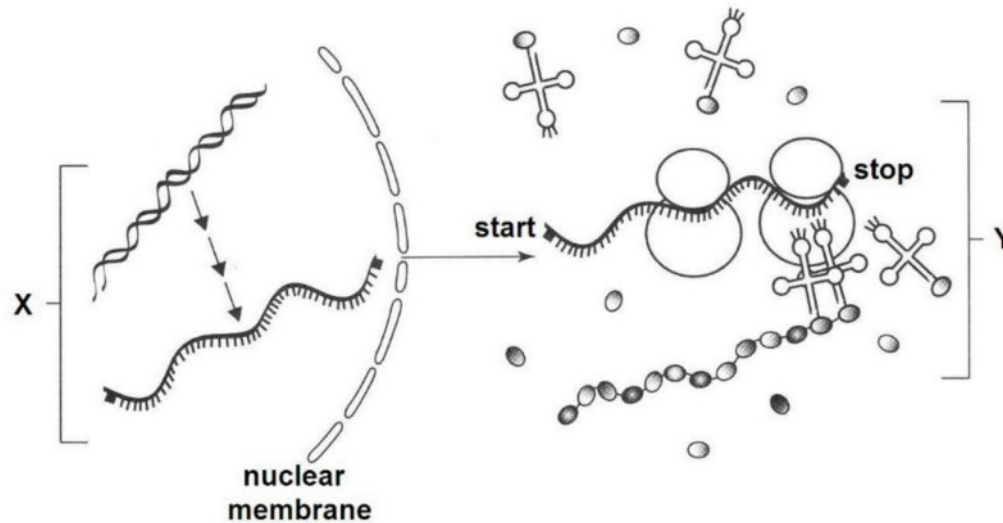
Structure **P**: transfer RNA (tRNA)

tRNA carries specific amino acids to the ribosome. The anticodon of the tRNA is complementary to the mRNA codon. In this way, the amino acids are assembled according to the order of bases on the mRNA.

Structure **M**: ribosome

Site where amino acids are assembled into a polypeptide. The order is determined by mRNA. tRNA brings the amino acids to the ribosome where bonds form between the adjacent amino acids.

The following diagram outlines processes that occur in living cells.



a i Name the process represented at X. (1 mark)

ii Describe the sequence of events that occur during the process at X. (3 marks)

b i Name the process represented at Y. (1 mark)

ii Describe the sequence of events that occur during the process at Y. (3 marks)

(Total 8 marks)

Solution

2-148 [VCAA 2010 E2 SB Q2]

a i Transcription

ii RNA polymerase locates the gene by recognising the promoter. The DNA unwinds and unzips. Controlled by **RNA polymerase**, complementary RNA nucleotides (adenine and uracil, thymine and adenine, cytosine and guanine, guanine and cytosine) are added to the exposed **DNA template**. This continues until a termination sequence is reached.

Pre-mRNA is formed. This is **edited**, introns are removed and a cap and tail added. The final **product** is **mRNA**.

b i Translation

ii mRNA moves out of the nucleus to the **ribosome**.

The start codon is read. Charged tRNA molecules bring **specific amino acids** to the complementary mRNA in the order determined by the mRNA. Three mRNA bases or a **codon** codes for one amino acid. The

complementary bases on the tRNA are called an **anticodon**.

Peptide bonds form between adjacent amino acids. tRNA molecules detach and translation ceases when a stop codon is reached. The **final product** is an amino acid chain or **polypeptide**.

Question 13/ 172

[VCAA 2022 SB Q1]

Tryptophan (trp) is the least abundant amino acid in eukaryotic cells.

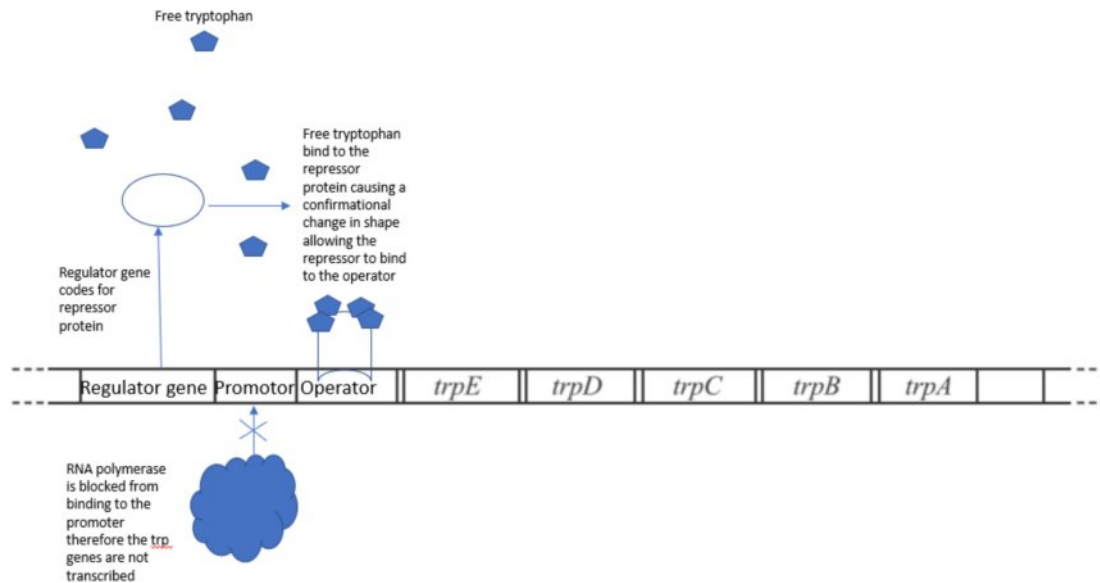
Consider the genetic code below.

		Second letter					
		U	C	A	G		
First letter	U	UUU } phe UUC } UUA } leu UUG }	UCU } UCC } ser UCA } UCG }	UAU } tyr UAC } UAA STOP UAG STOP	UGU } cys UGC } UGA STOP UGG trp	U C A G	Third letter
	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	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	

a In terms of the genetic code, what feature shared by trp and met is not common to the other 18 amino acids? (1 mark)

b Using the genetic code above:

- write the next triplet in the sequence so that trp will be the next amino acid added to the polypeptide chain
- provide the corresponding mRNA strand
- provide the translated amino acid sequence.



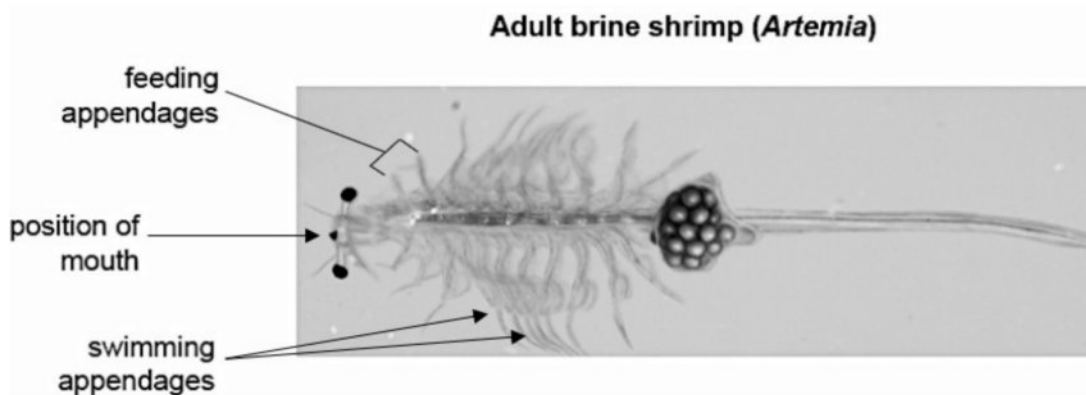
c

Question 14/ 172

[Adapted VCAA 2018 SB Q6]

a Describe the functional difference between a structural gene and a regulatory gene. (2 marks)

The *Hox* genes are master regulatory genes that influence cells in a particular location of an animal embryo in order to develop structures for that part of the body. In the brine shrimp, *Artemia*, the expression of the *Hox* genes *Ubx* and *Scr* results in the growth of either a swimming appendage or a feeding appendage, depending on whether the genes are expressed in cells that are in the mid-region of the body or that are near the mouth. These specialised appendages are labelled in the diagram below.



b Describe one way that genes are regulated so that the same genes can produce different appendages when the genes are expressed in different locations in the *Artemia* embryo. (1 mark)

(Total 3 marks)

Solution

2-150 [Adapted VCAA 2018 SB Q6]

- a** Structural genes code for a protein that is part of an organism's structure whereas regulatory genes code for proteins that control the action of other genes by determining whether a gene is active or not.
- b** Any **one** of the following ways genes are regulated in different locations:
- different regulatory genes are expressed at different times at the different sites
 - different regulatory sequences of on/off times at different sites
 - different introns are removed during the production of mRNA from pre-RNA resulting in different regulatory proteins at each site.
-

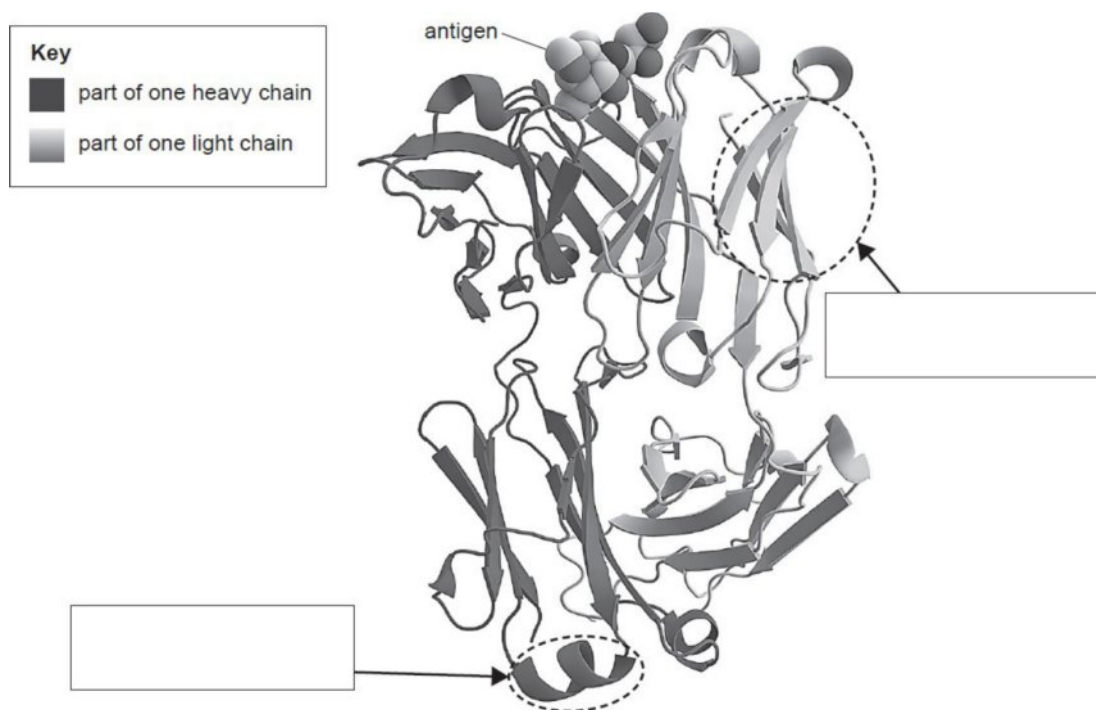
Question 15/ 172

[VCAA 2016 SB Q1]

Immunoglobulins, or antibody molecules, have an important role in the immune system. They are made up of two heavy chains and two light chains.

a Name the molecular monomer of these chains. (1 mark)

b Part of a mouse immunoglobulin molecule bound to an antigen is shown in the diagram below. Two arrows point to two different types of secondary structures of the immunoglobulin molecule.



Give the name of each structure in the boxes provided. (2 marks)

c Immunoglobulin molecules also display a tertiary structure and a quaternary structure.

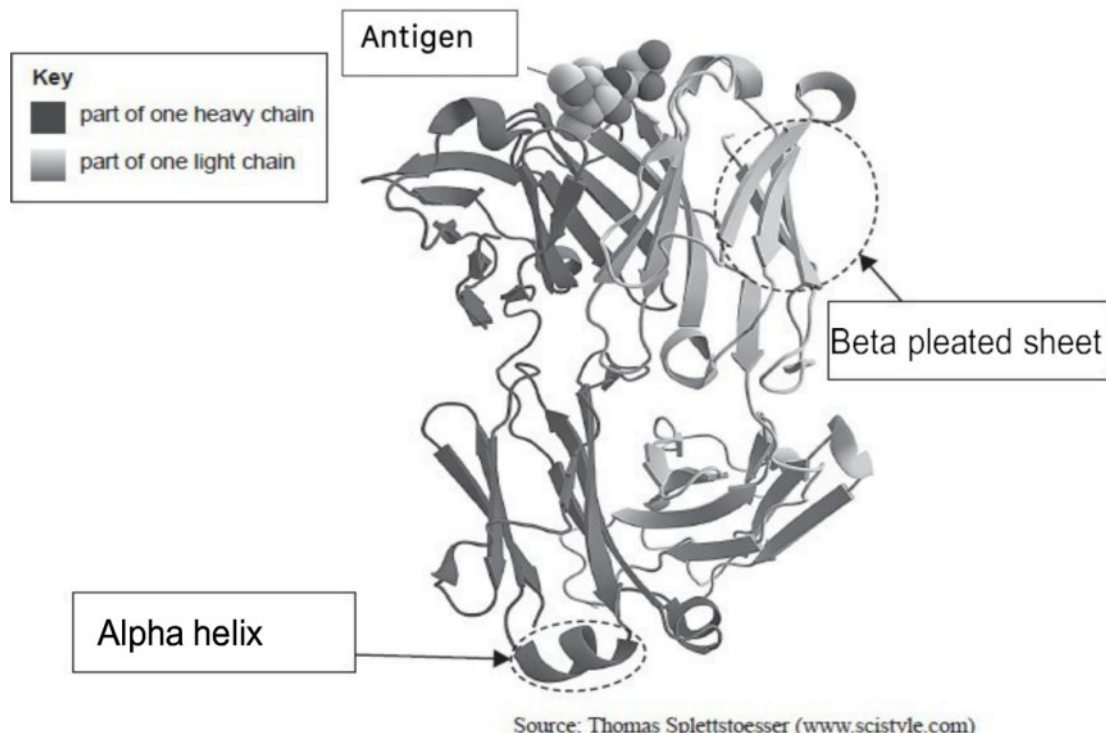
Referring to the diagram, explain what quaternary means. (2 marks)

(Total 5 marks)

Solution

2-151 [VCAA 2016 SB Q1]

a amino acid



b

c Quaternary structure refers to the structure that is formed by two or more polypeptide chains joined together. In this example, there are two polypeptide chains – one heavy and one light, therefore it is a quaternary structure.

Question 16/ 172

[VCAA SB Q1 2018]

Tryptase is an enzyme that is released, along with histamine and other chemicals, from human mast cells.

Nucleic acids encode instructions for the synthesis of tryptase in a mast cell.

a Outline the steps of translation in the synthesis of tryptase. (3 marks)

b After being synthesised, tryptase is released from mast cells via exocytosis.

Complete the table below by naming three different organelles directly associated with the transport of the synthesised tryptase within or from mast cells and state the role of each organelle in this process. (3 marks)

Organelle

Role

Organelle**Role**

(Total 6 marks)

Solution**2-152 [VCAA SB Q1 2018]**

a mRNA that is the complement of the DNA coding for trypsin moves from the mast cell nucleus to the ribosome where it is read, and translation begins. The start codon is read. Charged tRNA molecules bring specific amino acids to the complementary mRNA in the order determined by the mRNA. Three mRNA bases or a codon codes for one amino acid. The complementary bases on the tRNA are called an anticodon. Peptide bonds form between adjacent amino acids. tRNA molecules detach and translation ceases when a stop codon is reached. The final product is the specific order of amino acids in a polypeptide chain of trypsin.

b

Organelle**Role**

Rough endoplasmic reticulum or ribosome

Site where the trypsin-polypeptide chain, is folded and carbohydrates added and provides channels for movement of the trypsin through the cytoplasm within the cell.

Golgi apparatus

Site where the trypsin is packaged into vesicles ready for export out of the cell.

Vesicles

Vesicles containing trypsin bud off from the Golgi apparatus and transport the trypsin to the plasma membrane where they fuse with the membrane, releasing the trypsin into the extracellular fluid.

Plasma membrane

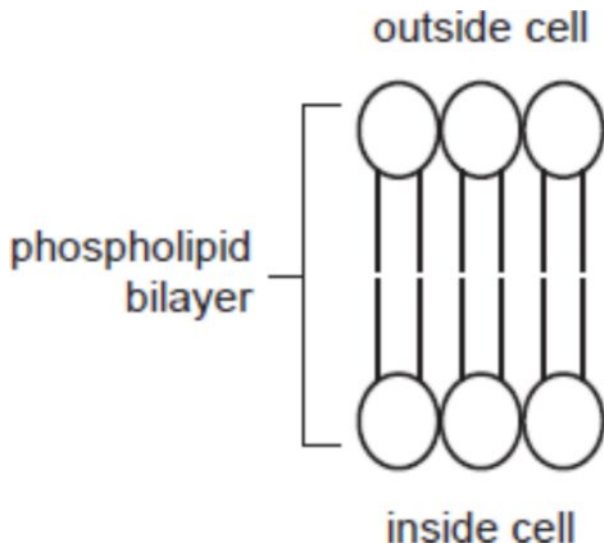
Vesicles fuse with the plasma membrane, releasing the trypsin into the extracellular fluid.

Mitochondria

Site of aerobic respiration which provides ATP (energy) for exocytosis of trypsin.

[Adapted VCAA 2021 SB Q1]

The diagram below shows a small part of a cross-section of the plasma membrane of a cell.



Some substances can move directly through the phospholipid bilayer.

Some very large substances and/or large particles that do not dissolve in the phospholipid bilayer can still move into or out of a cell.

Using one example, explain how the phospholipid bilayer transports these very large substances and/or large particles without the use of channel or carrier proteins move out of a cell.

(Total 3 marks)

Solution

2-153 [Adapted VCAA 2021 SB Q1]

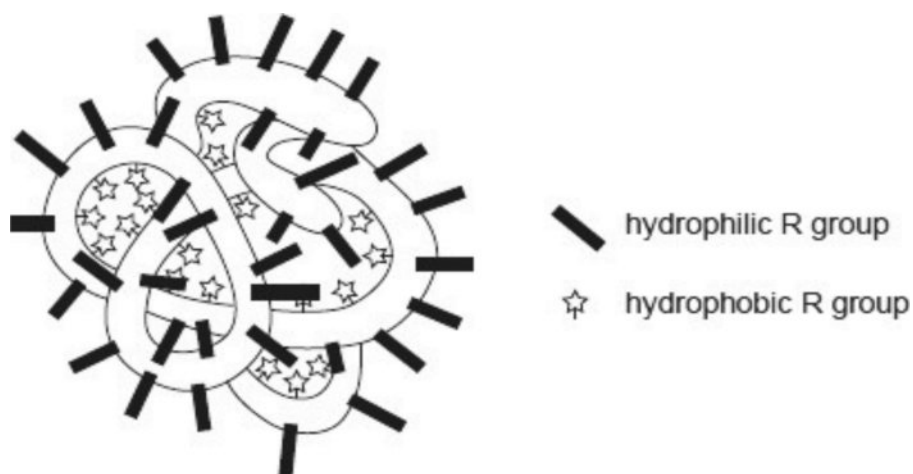
Movement out of a cell by the following means:

- Exocytosis
- Secretion of adrenaline (other possible answers include antibodies/histamine/neurotransmitter/enzyme)
- Adrenaline is packaged and moved into secretory vesicles in the Golgi apparatus. The secretory vesicles move through the cytoplasm to the plasma membrane, where they fuse with the cell membrane releasing their adrenaline contents into the extracellular fluid. Mitochondria provide energy for the process to occur.

Question 18/ 172

[Adapted VCAA 2011 E1 SB Q1]

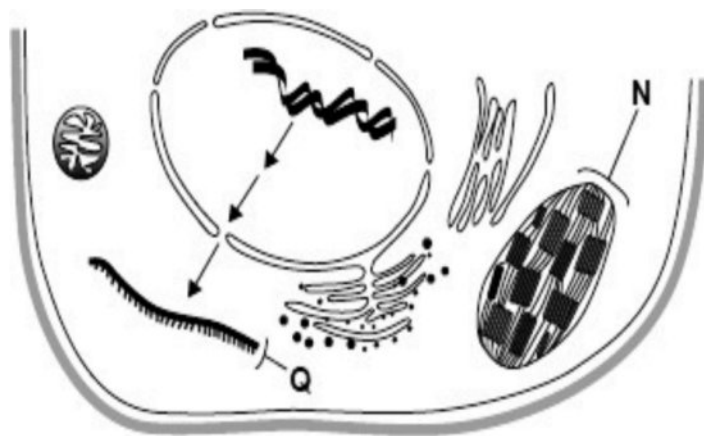
The following figure represents a globular protein.



This molecule is likely to be highly soluble in water.

a Outline why such a conclusion can be made about this molecule. (2 marks)

The following figure represents a portion of a plant cell.



b Examine the figure above and complete the following table.

	Type of nucleic acid found in structure	Specific function of the nucleic acid
Structure		
N		

Type of nucleic acid found in structure**Specific function of the nucleic acid**

**Structure
Q**

(4 marks)

(Total 6 marks)

Solution**2-154 [Adapted VCAA 2011 E1 SB Q1]**

a Hydrophilic molecules readily dissolve in water. In this molecule, the amino acid hydrophilic R groups are on the outside and are in close association with water whilst the amino acid hydrophobic R groups are on the inside of the molecule away from the surrounding water.

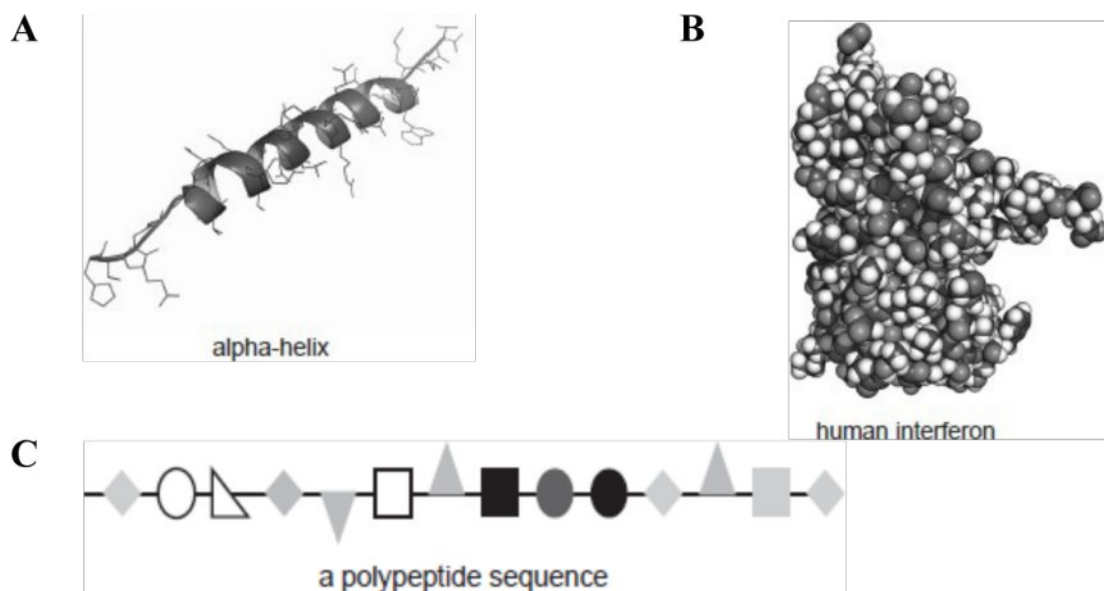
b

	Type of nucleic acid found in structure	Specific function of the nucleic acid
Structure N	DNA	Codes for the proteins/enzymes that are produced inside the chloroplast
	or	or
	mRNA	Carries a RNA complement of the DNA found in the chloroplast to the ribosomes where proteins/enzymes are produced in the chloroplast
	or	or
	rRNA	Site where proteins/enzymes are produced in the chloroplasts
Structure Q	or	or
	tRNA	Carry amino acids to the ribosomes in the chloroplast so that proteins/enzymes used in the chloroplast can be produced
Structure Q	mRNA	Carries a RNA complement of the DNA found in the nucleus to the ribosomes where protein/enzymes are produced

Question 19/ 172

[VCAA 2015 SB Q1]

The diagrams below represent examples of three levels of structure with respect to the folding and assembly of a protein. The diagrams are not to scale.



a i Complete the table below to indicate the diagram that represents the structural level of the protein given. (1 mark)

Structure level of protein	Diagram (A, B or C)

primary	

secondary	

tertiary	

ii Name the molecular sub-unit of a protein. (1 mark)

The particular shape achieved by the folding of a protein is of great significance. Proteins sometimes fold incorrectly to form groups of joined, identical polypeptide sequences called aggregates. Sufferers of Alzheimer's disease have aggregates of various sizes in their brain tissue. Aggregates of amyloid beta protein are present in their brain tissue. These patients experience memory loss and have large areas of dead neurons in their brains.

Several hypotheses have been suggested as possible explanations for neuron death. One hypothesis is summarised below.

Hypothesis: Aggregates of amyloid beta protein could cause death of neurons.

Explanation: These aggregates have star-like shapes that pierce the plasma membrane.

b Suggest, by referring to cellular function, how aggregates of amyloid beta proteins could result in death of neurons. (2 marks)

c In healthy brain tissue, other proteins, called molecular chaperones, bind temporarily to a protein during its folding process to allow the correct folding and assembly of the protein. Researchers are trying rational drug design to mimic the action of molecular chaperones as a treatment for Alzheimer's disease.

Describe **one** structural characteristic of the molecular chaperone proteins that would need to be considered in order for this approach to provide a successful treatment. (1 mark)

d Enzymes are protein catalysts. Use labelled diagrams to illustrate both **enzyme denaturation** and **enzyme inhibition**. Include both the enzyme and substrate in your diagrams. (3 marks)

(Total 8 marks)

Solution

2-155 [VCAA 2015 SB Q1]

a **i**

Structure level of protein	Diagram (A, B or C)

primary	C

secondary	A

tertiary	B

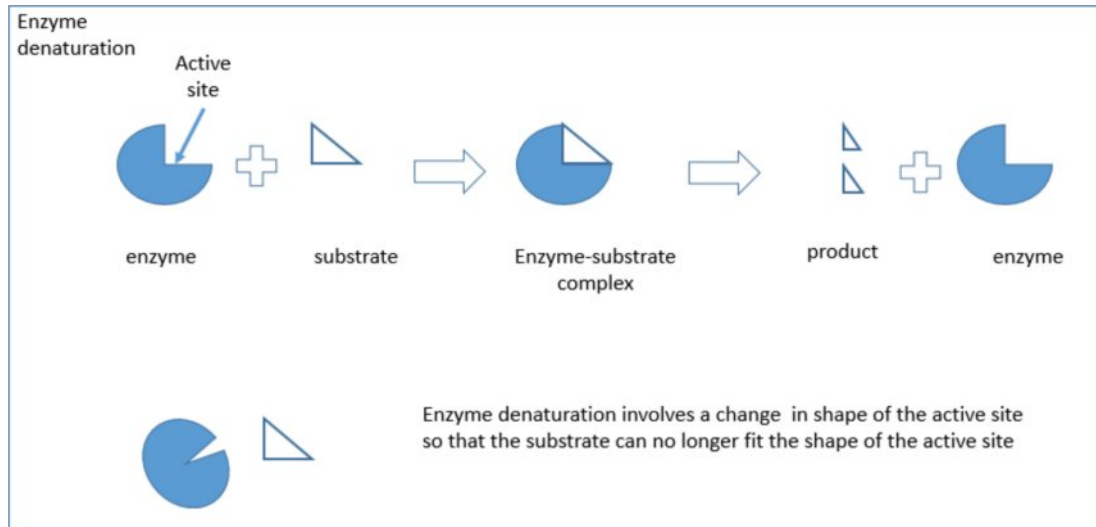
ii Amino acid

b Any **two** of the following:

- Piercing the membrane results in loss of cell contents disrupting metabolic reactions.
- Mitochondria are lost; therefore, the cell has reduced aerobic respiration/ATP available to maintain life.
- Ribosomes are lost, translation and therefore protein synthesis will be reduced. The cell will not be able to produce enough enzymes to catalyse metabolic reactions at the speed required to maintain life.
- Piercing the membrane initiates apoptosis.

- Loss of contents/damage to membrane results in disruption of the cell's osmotic gradient.

c The specific shape of the molecular chaperone would need to be considered. The shape of the molecular chaperone determines its ability to bind to the protein and allow correct folding. The molecular chaperone must have a complementary shape to the protein it binds to. The rational drug must have the same shape as the molecular chaperone if it is to have the same function.

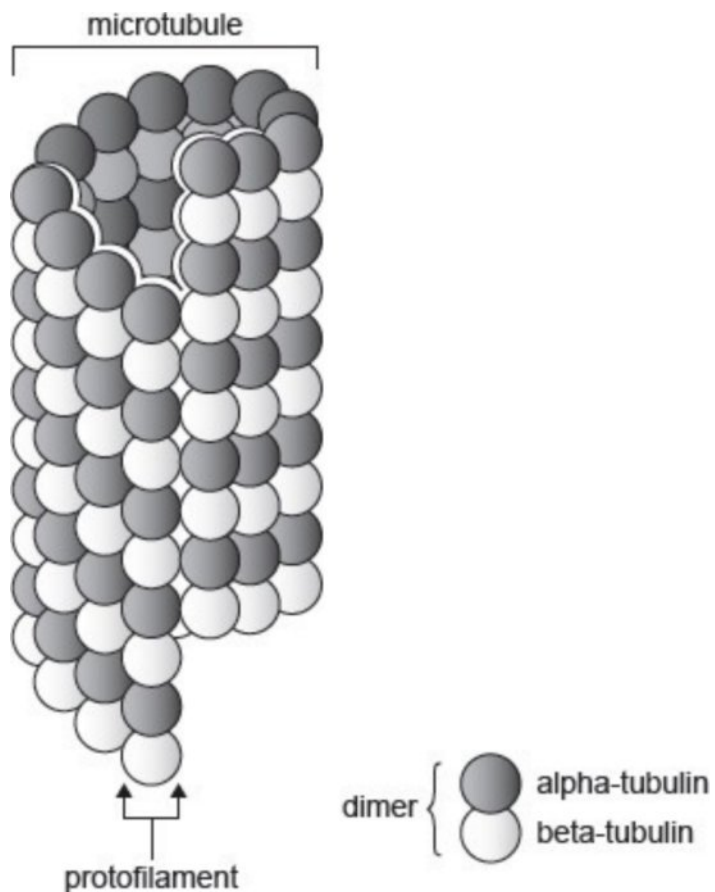


d

Question 20/ 172

[VCAA 2013 SB Q2]

Microtubules are hollow structures composed of a protein, tubulin, which has two forms: alpha-tubulin and beta-tubulin. A tubulin dimer is formed when one alpha-tubulin molecule and one beta-tubulin molecule join. Tubulin dimers polymerise into long chains to form protofilaments. A microtubule can be formed when 13 protofilaments align side by side, as represented in the diagram below.



a With respect to the structure of a protofilament, explain what is meant by the term ‘polymerise’. (1 mark)

b Consider an alpha-tubulin molecule. Explain the difference between its primary structure and secondary structure. (2 marks)

c Describe what is meant by tertiary and quaternary protein structures. (2 marks)

(Total 5 marks)

Solution

2-156 [VCAA 2013 SB Q2]

a Polymerise refers to the production of a large molecule from many repeating smaller units by condensation reactions. The protofilament molecule is formed from many repeating units of smaller alpha-tubulin and beta-tubulin.

b The primary structure of alpha-tubulin refers to the set/specific order of amino acids in its polypeptide chain whereas the secondary structure refers to the folding and twisting of the polypeptide chain (alpha helices/beta-pleated sheets) due to the formation of hydrogen bonds between amino acids within the chain.

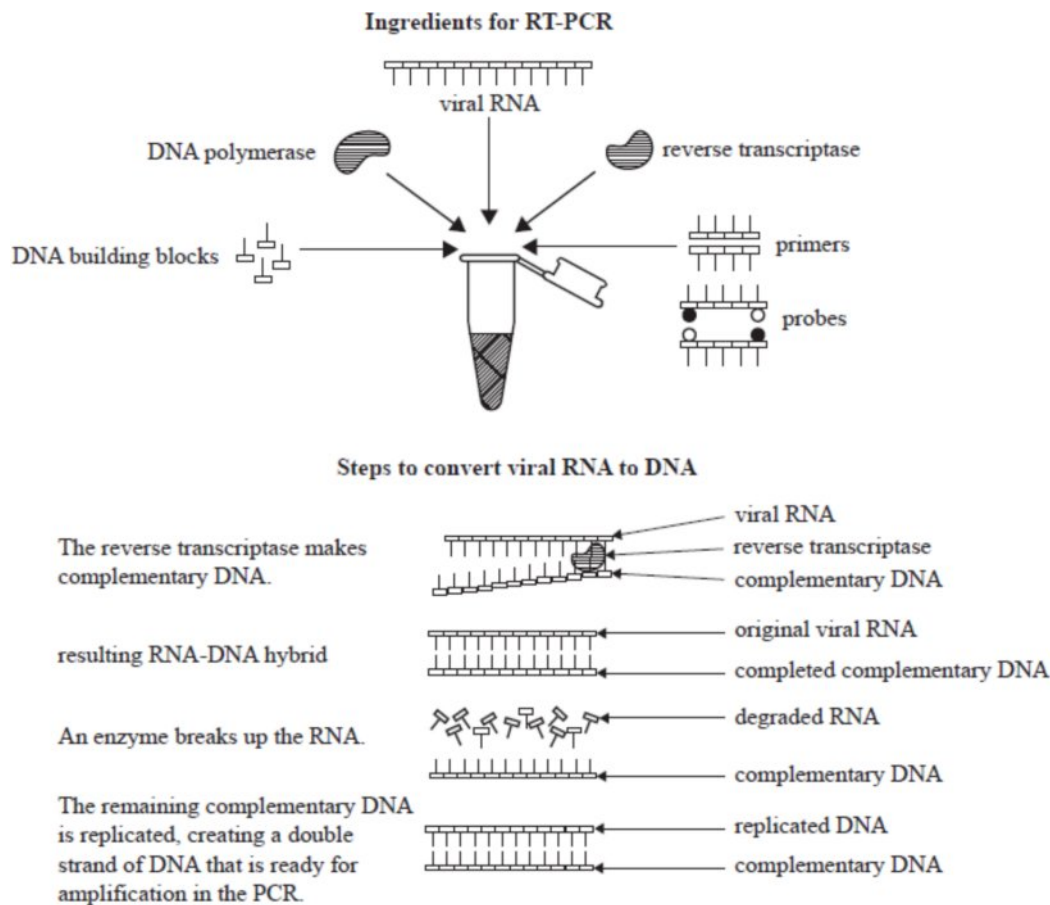
c Tertiary structure refers to the folded 3-dimensional shape of the secondary structures of the protein

molecule. In this example, this refers to the long chains that form the protofilaments. Quaternary structure refers to the structure that is formed by two or more polypeptide chains joined together. In this example, this refers to the microtubule made of 13 protofilaments.

Question 21/ 172

[VCAA 2022 SB Q2]

The polymerase chain reaction (PCR) can be used to determine if a person is infected with a particular virus. Viral RNA must be converted to DNA before the PCR can occur. The process by which this occurs is called reverse transcription PCR (RT-PCR). The diagram on the next page shows the ingredients required and the steps that must be taken for viral RNA to be converted to DNA.



Source: adapted from S Tiner, 'The science behind the test for the COVID-19 virus', *Discovery's Edge* (Mayo Clinic's research magazine), 27 March 2020, <<https://discoverysedge.mayo.edu/2020/03/27/the-science-behind-the-test-for-the-covid-19-virus/>>

a i Explain why RNA must be converted to DNA in RT-PCR. (1 mark)

ii What is the purpose of DNA amplification in the PCR? (1 mark)

b There are different stages in the PCR, and each requires a different temperature.

Explain why each stage requires a different temperature. (3 marks)

c The probes shown in the diagram titled 'Ingredients for RT-PCR' in the above figure fluoresce (glow). They attach to complementary sequences only found in a particular virus. State two reasons why virus identification using RT-PCR cannot be used for all viruses. (2 marks)

(Total 7 marks)

Solution

2-157 [VCAA 2022 SB Q2]

a i PCR is used to make many copies of DNA. Many viruses have RNA and not DNA; therefore, the RNA must be used as a template to make DNA that PCR can then amplify.

ii The purpose of DNA amplification is to make many copies of DNA. Many copies of the DNA are needed so that there is enough to be analysed.

c In stage 1 denaturation of DNA, DNA strands must be separated to expose the DNA nucleotides that can then be used as a template. The two chains in double-stranded DNA are held together by hydrogen bonds that can be broken by heating the DNA to 94°C. Once the strands are separated in stage 2 annealing, primers –synthetic single-strand pieces of DNA complementary to the DNA sequences on either side of the target sequence must form hydrogen bonds with the DNA. The primers provide a 3' end to which DNA nucleotides can be added. For this to happen, the DNA must be cooled to 50°C. In stage 3 extension, DNA nucleotides are added to the primers. The enzyme that catalyses the formation of bonds between DNA nucleotides is Taq polymerase and the optimum temperature for Taq polymerase is 72°C.

c Any **two** of the following:

- The sequence of viral nucleotides may be common to many other viruses; therefore, the presence of the probe will not distinguish between them.
 - The sequence of viral nucleotides has not been determined yet; therefore, a complementary probe cannot be made.
 - The genetic material of some viruses is DNA, not RNA.
-

[VCAA 2020 SB Q11]

A student wanted to investigate the effect of two different endonucleases (restriction enzymes) on a linear DNA fragment.

The student used three tubes containing a buffered solution of linear DNA fragments, each fragment being 9500 base pairs in length.

Two different endonucleases were available: BamHI and HindIII.

The student followed the steps below.

Step 1 – 2 μL of BamHI was added to the sample in Tube 1.

Step 2 – 2 μL of HindIII was added to the sample in Tube 2.

Step 3 – 2 μL of HindIII and 2 μL of BamHI were added to the sample in Tube 3.

Step 4 – All three tubes were incubated for one hour at a constant temperature of 37°C.

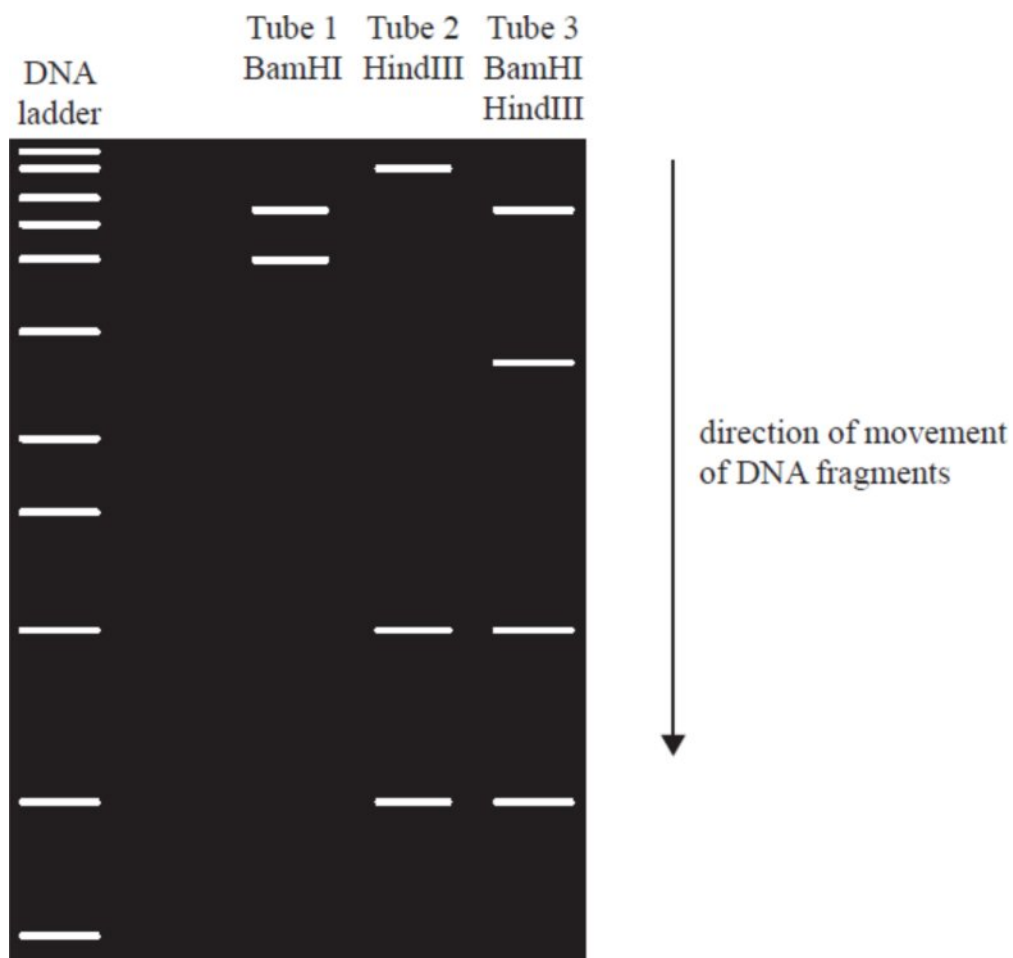
Step 5 – A 1% agarose gel was placed into an electrophoresis chamber and the gel was covered with buffer solution.

Step 6 – 40 μL of a DNA ladder with fragments of known sizes was added to the first well of the 1% agarose gel. The known sizes of the fragments were 10 000 bp, 8000 bp, 6000 bp, 5000 bp, 4000 bp, 3000 bp, 2000 bp, 1500 bp, 1000 bp, 500 bp and 250 bp.

Step 7 – 40 μL of the contents of each of the tubes was loaded into three separate wells of the 1% agarose gel.

Step 8 – An electric current of 100 V was run through the gel for 45 minutes.

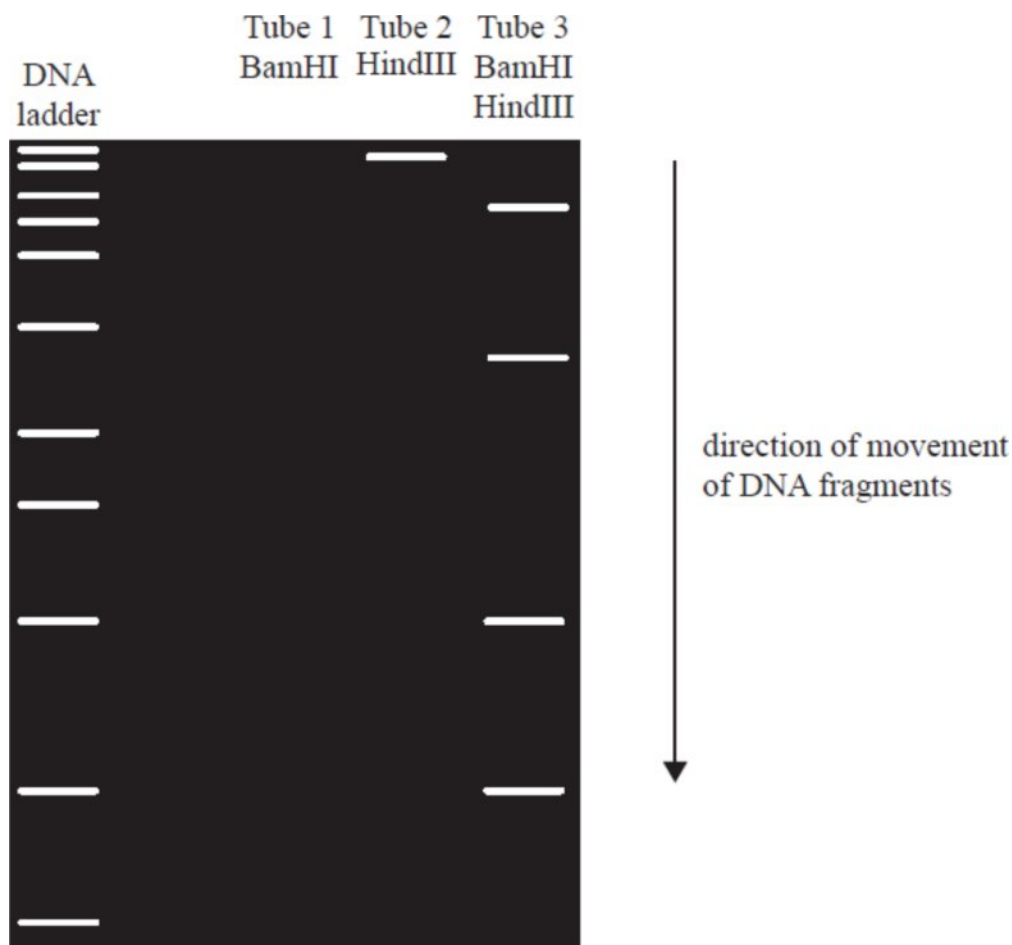
After 45 minutes the student obtained the results shown below.



Source: results based on 1 kb DNA ladder from
TEquipment, <www.tequipment.net>

a Analyse the results of the experiment performed by the student. (5 marks)

The student repeated the experiment the next day and obtained the following results.



b Identify **one** difference between the new results and the previous results, and suggest a possible reason for this difference. (2 marks)

c State **two** factors that will have an impact on the rate of movement of the DNA fragments through the agarose gel. (2 marks)

d Outline **two** safety guidelines that should have been followed by the student. (2 marks)

(Total 11 marks)

Solution

2-158 [VCAA 2020 SB Q11]

a The results indicate the linear DNA:

- has one recognition site for BamHI cutting the DNA into 2 pieces, one 5500bp and one 4000bp long
- has 2 recognition sites for HindIII cutting the DNA into 3 pieces, one 500bp, one 1000bp and one 8000bp long

- when cut with both BamHI and HindIII, the DNA was cut into 4 pieces, one 500bp, one 1000bp, one 2500bp and one 5500bp long
- the recognition site for BamHI is located within the 8000bp piece produced by HindIII.

b Any **one** of the following:

- No bands are present in Tube 1. This suggests that no DNA is present due to the student not loading the buffered DNA correctly into the well.
- Only 1 band not 3 bands are present in Tube 2. This suggests that the restriction enzymes have been denatured.

c Any **two** of the following:

- the length of the DNA fragment
- the density of the agarose gel
- the type of agarose gel
- the voltage applied to the gel

Note: not charge as all fragments are DNA and will therefore have the same charge.

d Any **two** of the following safety guidelines:

- wear gloves to stop the contact of chemicals with the body
- wear glasses to stop chemical contact with eyes
- correct disposal of chemicals
- avoiding electrocution by ensuring the equipment is not touched when the current is turned on.

Question 23/ 172

[VCAA 2022 SB Q5]

Wheat is a cereal crop grown extensively in Australia. The starch found within the wheat grain is used to produce wheat flour. Wheat flour is used to make a variety of foods.

Scientists are investigating ways to improve wheat crop yields. It is known that both the weight and protein content of a wheat grain are under genetic control. The scientists designed a single guide RNA (sgRNA) molecule and used CRISPR-Cas9 technology to edit the gene associated with grain weight. After editing, the gene was not expressed. When grown, the gene-edited wheat plants showed both an increase in grain weight and an increase in protein content.

a Explain how the scientists would have designed the sgRNA molecule and outline the function of sgRNA in the editing of the gene. (3 marks)

b The scientists noted that the lack of gene expression could have resulted in either the insertion of a nucleotide into the gene or the deletion of seven nucleotides from the gene.

Explain how each of these two different gene edits could have caused the lack of gene expression. (3 marks)

c Starch from the wheat grain can be used to manufacture bioethanol. In this process, *Zymomonas mobilis* bacteria and enzymes that break down starch into monosaccharides are added to the starch. *Z. mobilis* is a facultative anaerobic bacterium.

Explain how *Z. mobilis* is used in the manufacture of bioethanol. (2 marks)

(Total 8 marks)

Solution

2-159 [VCAA 2022 SB Q5]

a The scientist would first identify the gene associated with grain weight in wheat. This would be used as a template to form a complementary chain of RNA nucleotides resulting in sgRNA. Cas9 enzyme would be added to the sgRNA to form a CRISPR-Cas9 complex.

Function: sgRNA guides Cas9 to the site to be cut within the gene associated with grain weight in wheat.

b One triplet or three DNA nucleotides code for one amino acid. If one nucleotide or seven nucleotides are deleted, all triplets from then on will be altered (a frameshift). This will change the sequence of amino acids from this point on, leading to the production of a non-functional protein.

Or

One triplet or three DNA nucleotides code for one amino acid. The insertion or deletion may result in a triplet that codes for a stop codon. The amino acid sequence translated from this would be shorter and non-functional.

c Ethanol is a product of anaerobic fermentation where glucose in the absence of oxygen, is broken down to ethanol, carbon dioxide and 2 ATP. *Zymomonas mobilis* bacteria produce enzymes that break down the starch in wheat into glucose. This is then used as a substrate in anaerobic fermentation.

[VCAA 2019 SB Q8]

The Genomics Health Futures Mission will run a \ (32 million trial, starting in 2019, to screen over 10 000 couples who are in early pregnancy or who are planning to have a baby. Using a blood test, individuals will be screened for 500 severe or deadly recessive gene mutations.

Couples will be told they have a genetic mutation if both individuals in the couple carry the same mutation. The trial may lead to a population-wide carrier screening program. The researchers will evaluate cost effectiveness, psychological impact, ethics and barriers to screening. It is anticipated that future tests will be free of charge.

a Give an example of a disorder or disease that can be detected by genetic screening. (1 mark)

b The blood sample from an individual will provide researchers with only a small amount of DNA. Polymerase chain reaction (PCR) will be used to amplify the DNA.

Describe what happens in each of the three stages of PCR.

The stages must be given in the order in which they occur. (3 marks)

Stage	What is happening at this stage
1	
2	
3	

c Once the DNA has been amplified, it can be loaded into a well of an agarose gel. Discuss three factors that affect the migration of DNA fragments through the agarose gel during gel electrophoresis. (3 marks)

d The test may find that a couple who were planning to have a baby or who were already pregnant both carry the same severe or deadly mutation.

Describe one ethical and one social issue/implication that could arise from this finding. (2 marks)

(Total 9 marks)

Solution

2-160 [VCAA 2019 SB Q8]

a Many possible answers including: sickle cell anaemia, Huntington's disease, cystic fibrosis.

b

Stage What is happening at this stage

- 1** Denaturing: the DNA is denatured by heating to around 95°C.
- 2** Annealing: the sample is cooled to approximately 50°C. Primers – synthetic single strand pieces of DNA (usually) that are complementary to the DNA sequence either side of the target sequence are added and anneal to the exposed DNA strands. DNA nucleotides are added.
- 3** Extension: the sample is heated to approximately 72°C. Taq polymerase is added (heat tolerant enzyme from Taq bacteria). This joins nucleotides together starting at the primer and continuing to the end of the template DNA. The cycle is repeated many times resulting in a mixture of DNA strands including many copies of the desired sequence of DNA.

c Three factors affecting the migration of DNA fragments through agarose gel:

- the length of the DNA fragment. The shorter the fragment the easier the movement, therefore the greater distance travelled.
- the charge on the DNA fragment. DNA has a negative charge, so it is attracted to the positive end of the gel.
- the consistency of the gel. Gels vary in density. The denser the gel the shorter the distance the DNA travels.

d Any **one from each category.**

Issue/implication

Ethical Should the pregnancy be terminated?

If only one parent carries the mutation, should they be told? Does the foetus have a right to live?

Social Who should pay for the testing?

May lead to increased costs for psychological therapy for known carriers

Question 25/ 172

[VCAA 2022 SB Q4]

Increased protein consumption is a global trend. Chicken eggs are a good source of protein. Ovalbumin (egg white protein) is formed from chicken cells during egg production.

a Describe the role of organelles in the export of ovalbumin from a chicken's cells into an egg. (3 marks)

b To meet the growing demand for ovalbumin, more chickens are being bred for egg production using intensive farming methods. Animal welfare concerns have been raised, so alternative processes for making ovalbumin are being explored. Currently, recombinant technology can use a fungus to produce large quantities of ovalbumin. It has been suggested that scientists explore the option of using recombinant plasmids to transform bacterial cells for ovalbumin production.

c Discuss an ethical concern that could be raised about intensive farming methods or the use of recombinant technology to produce protein. Propose a feasible solution to this ethical concern. State the ethical concept or approach that has been addressed in your discussion. (4 marks)

(Total 7 marks)

Solution

2-161 [VCAA 2022 SB Q4]

a Ribosomes are the site where amino acids are assembled to form the polypeptide chains in ovalbumin. The ovalbumin is moved into the endoplasmic reticulum, where the polypeptide chains are further folded. Transport vesicles containing the ovalbumin, bud off the endoplasmic reticulum and move to the Golgi Apparatus, where the ovalbumin is packaged into secretory vesicles. The secretory vesicles move through the cytoplasm to the plasma membrane, where they fuse with the cell membrane releasing their ovalbumin contents into the extracellular fluid. Mitochondria provide energy for the process to occur.

b The answer to this question should focus on the ethical concerns of intensive farming or the ethical concerns of using recombinant technology, not both. It should include a discussion of the cause and effect of intensive farming/use of recombinant technology, specific reference to the ethical approach and a suggested solution.

Example 1 Ethical concern about intensive farming methods

Cause: Many chickens are housed in a small space leading to poor quality of life for the chickens.

Effect: The chickens cannot move freely, maintain their social behaviour and have an increased chance of disease.

Consequence approach: The positives of intensive farming (increased production of ovalbumin) must be compared with the negatives (chicken welfare).

Any **one** of the following associated ethical concepts:

Beneficence: benefits should be maximised, and risks minimised. The benefit of intensive farming is increased ovalbumin production/efficient land use does not outweigh the risk to the health of the chickens.

Non-maleficence: Harm should be avoided or not be disproportionate to the benefits. The harm caused by intensive farming is disproportionate to the harm.

Respect: consideration of the rights of the individual, welfare, liberty, beliefs, and culture. Intensive farming does not respect chickens as they are not free to roam, are harmed and cannot establish social behaviour.

Justice: a moral obligation to provide fair treatment. Intensive farming is not fair to chickens as they are confined to a small area or harmed.

Integrity: All information and communication of results should be honestly reported whether favourable or unfavourable. Intensive farming conditions should be honestly reported. How ovalbumin should be labelled so that the consumer knows how it is produced.

Solution: Provide more room/improved housing for the chickens. Other examples could include:

Duty/rules-based approach: The government sets and enforces minimum guidelines for intensive farming.

Plus, an ethical concept

Solution: Farmers follow the government guidelines.

Or

Virtues-based approach: How would a good farmer/consumer approach the problem?

Plus, an ethical concept

Solution: Free-range farming is practised by farmers or consumers choose to buy ovalbumin produced on free-range farms.

Example 2 Ethical concern about the use of recombinant technology to produce protein

Cause: Recombinant technology involves inserting the ovalbumin gene found in chickens into the genome of bacteria or fungi. It involves the use of plasmids containing genes for antibiotic resistance.

Effect: This process may be unsafe. Modified plasmids may be transformed into disease-causing bacteria, resulting in a decreased effectiveness of antibiotics in treating disease.

Or

This is man 'playing God' or is considered by some to be unnatural or is against cultural beliefs, or the cost to the consumer may increase/decrease.

Consequence approach: The positives of recombinant technology (increased production of ovalbumin) must be compared with the negatives (effectiveness of antibiotics/beliefs/cost).

Any **one** of the following associated ethical concepts:

- **Beneficence:** benefits should be maximised, and risks minimised. The benefit of recombinant technology is increased ovalbumin production/land can be better used, which does not outweigh the risk of using antibiotics/costs/conscious.
- **Non-maleficence:** Harm should be avoided or not be disproportionate to the benefits. The harm caused by using recombinant technology is disproportionate to the possible benefits.
- **Respect:** consideration of the rights of the individual, welfare, liberty, beliefs and culture. Using recombinant technology does not respect the cultural beliefs of the consumer.

- Justice: a moral obligation to provide fair treatment. The use of recombinant technology may increase the price of ovalbumin; therefore, only wealthy people will have access. Alternatively, recombinant technology may decrease the cost of ovalbumin, decreasing chicken farmers' income.
- Integrity: All information and communication of results should be honestly reported whether favourable or unfavourable. Information regarding recombinant technologies should be honestly reported. Ovalbumin should be labelled so that the consumer knows how it is produced.

Possible solutions:

- Use free-range farming of chickens.
- Governments subsidise free-range farmers/production of ovalbumin. Extensive labelling of products, so consumers know what they are buying. Comprehensive government regulations regarding the production of ovalbumin by recombinant technologies.

Other examples could include:

- Duty/rules-based approach: The government sets and enforces minimum guidelines for recombinant technology.
- Plus, an ethical concept and a solution.

Or

- Virtues-based approach: How would a good scientist/consumer approach the problem?
 - Plus, an ethical concept and a solution.
-

Question 26/ 172

In 2020, Emmanuelle Charpentier and Jennifer Doudna were awarded the Nobel Prize in Chemistry for their work on developing the CRISPR-Cas9 genome editing technique.

a CRISPR-Cas9 is found naturally in bacteria. What is its role in bacteria? (1 mark)

b What is the role of the following key components of CRISPR-Cas9 RNA guide?

i guide RNA

ii Cas9 endonuclease (2 marks)

c Describe **two** ways CRISPR-Cas9 can be used to edit genes. (2 marks)

d What are the advantages of CRISPR-Cas9 over other gene editing techniques? (2 marks)

(Total 7 marks)

Solution

2-162

- a** CRISPR-Cas9 defends bacteria from invading viruses by cutting the viral DNA into pieces.
- b** (i) RNA guide: guides the Cas9 endonuclease to the target site.
- (ii) Cas9 endonuclease unwinds the DNA and cuts both strands at a specific site.
- c** CRISPR-Cas9 can edit genes by:
- gene knock in – where a new sequence of DNA is inserted into the DNA.
 - gene knock out – where a sequence of DNA is removed from the DNA.
- d** Any **two** of the following:
- more precise
 - fast
 - low cost.
-

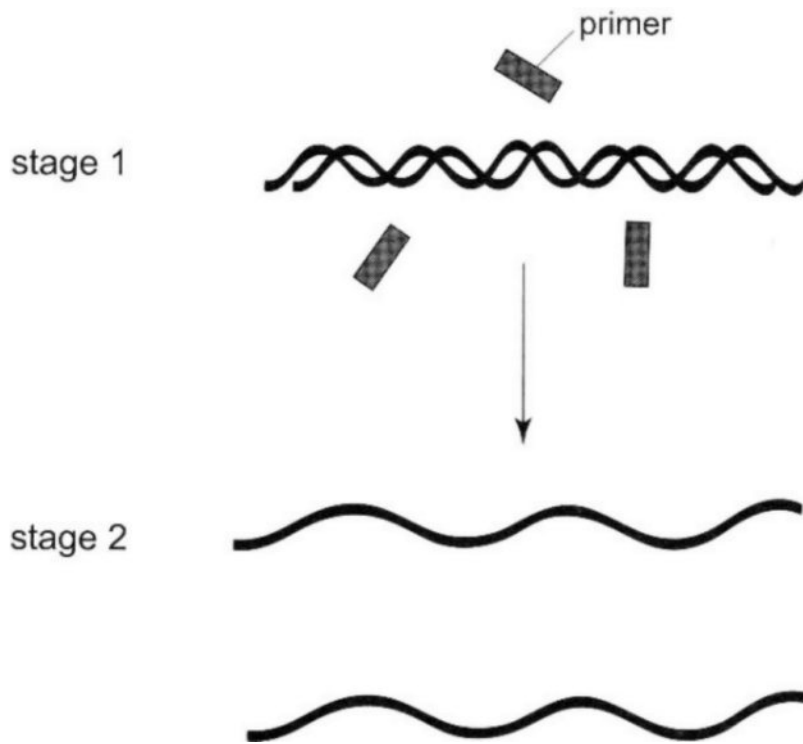
Question 27/ 172

[VCAA 2007 E2 SB Q2]

Victoria Police forensic scientists conduct DNA profiling using samples taken from crime scenes. Traces of DNA of less than 1 nanogram can be amplified and then profiled.

a Name the process which is used to amplify the DNA. (1 mark)

Below is a diagram showing part of this process.

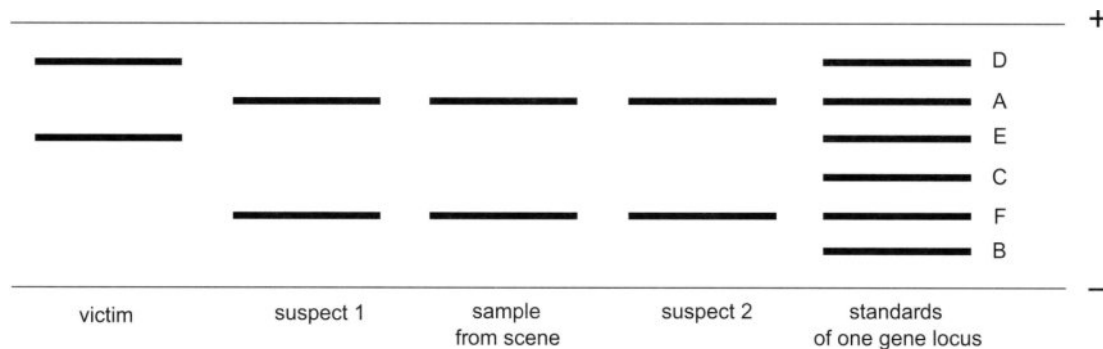


b What must be done between stages 1 and 2 to separate the strands of the DNA molecule? (1 mark)

c Complete and label the diagram at stage 2. (2 marks)

d Small pieces of DNA of differing length can be compared to determine whether a sample could have come from a particular person. In a case, samples of DNA from the victim and the crime scene were compared with samples from two suspects.

The DNA samples were treated with restriction enzymes, amplified and run through gel electrophoresis. The results for one gene locus are shown below.



e Draw an arrow on the right-hand side of the diagram to indicate the direction of movement of the DNA fragments. (1 mark)

f What do the standards consist of, and what is their purpose? (2 marks)

g From these results, give a conclusion which could be drawn about the sample taken from the crime scene. (1 mark)

h What further action would you recommend to the forensic scientists investigating this case? (1 mark)

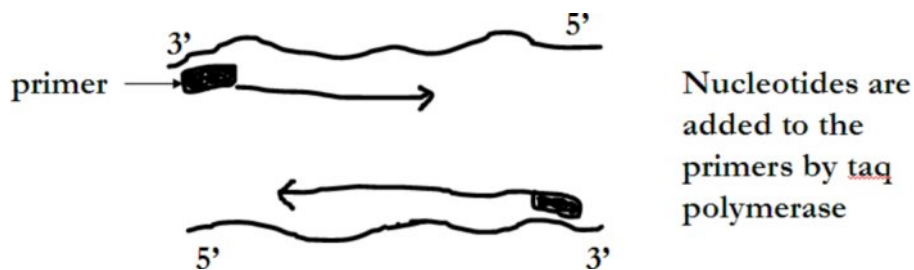
(Total 9 marks)

Solution

2-163 [VCAA 2007 E2 SB Q2]

a Polymerase chain reaction.

b The DNA is heated to 90°C between stage 1 and stage 2. This breaks the hydrogen bonds between the bases and separates the strands.



c

d ↑ (Arrow pointing up the page.)

e The standards consist of DNA of known lengths. The size of the DNA in the other samples can be determined when they are compared with the known standard samples.

f The sample taken from the crime scene is not from the victim but could be from either suspect.

g Any **one** of the following:

- Use different restriction enzymes to cut DNA from the victim, suspects and crime scene sample.
- Repeat the procedure for different gene loci.
- Compare suspects' fingerprints with those found at the scene of the crime.
- DNA profiling of the sample and suspects.

reaction is used by a scientist to amplify a particular sequence of DNA.

a Briefly describe the steps of this technique. (4 marks)

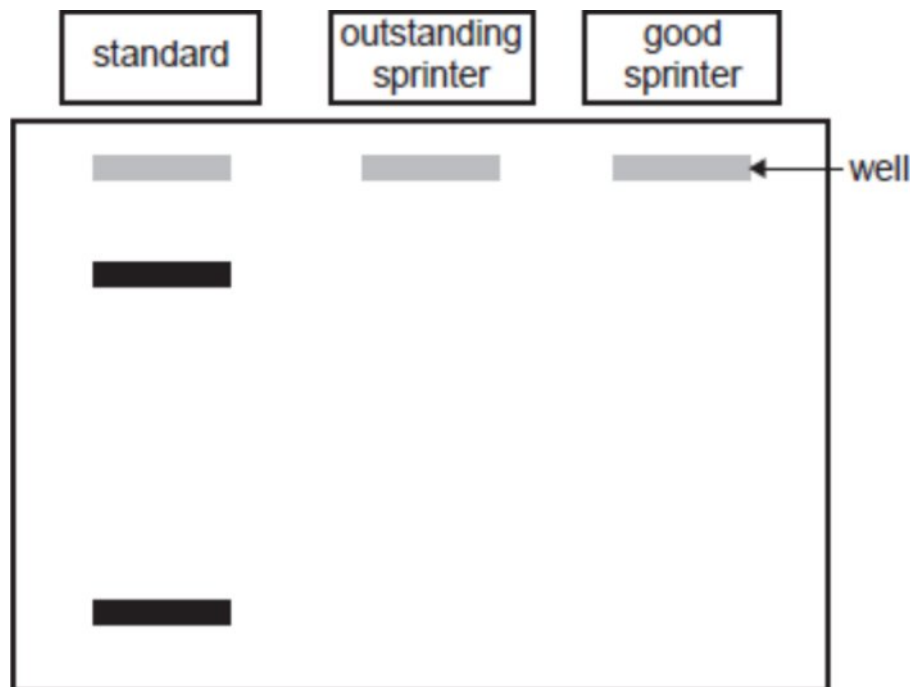
Scientists investigating the performance of athletes found that one gene contributing to the performance of sprinters is the ACTN3 gene. There are two alleles of the gene, the 577R allele and the 577X allele. The 577X allele codes for a very short protein fragment in muscle fibres due to a stop codon mutation.

The table below summarises the athletic potential for the three possible genotypes for the ACTN3 gene.

ACTN3 genotype	Athletic potential
577R/577R	outstanding sprinter
577R/577X	good sprinter or long- distance runner
577X/577X	very good long-distance runner

A scientist tested sprinters to see if they possessed the 577R allele. Samples were obtained from athletes' muscle fibres. A standard containing proteins of the same lengths as the proteins coded for by both alleles 577X and 577R was used as a comparison. The standard and the samples were exposed to gel electrophoresis. In gel electrophoresis, protein molecules separate according to size and charge in the same way as DNA molecules.

The result for the standard is shown below.



b On the diagram of the gel, draw the bands expected for an outstanding sprinter and for a good sprinter. Explain why you have placed the bands in these positions. (3 marks)

(Total 7 marks)

Solution

2-164 [VCAA 2012 E2 SB Q3]

- a**
- DNA is denatured by heating to around 95°C.
 - The sample is cooled tot approximately 50°C. Primers – synthetic single strand pieces of DNA (usually) that are complementary to the DNA sequence either side of the target sequence are added and anneal to the exposed DNA strands.
 - DNA nucleotides are added.
 - The sample is heated to approximately 72°C. Taq polymerase is added (heat tolerant enzyme from *Taq* bacteria). This joins nucleotides together starting at the primer and continuing until the end of the template DNA.
 - The cycle is repeated many times resulting in a mixture of DNA strands including many copies of the desired sequence of DNA.
 - Gel electrophoresis is used to separate out the copies of the desired sequence of DNA.
- b**
- The outstanding sprinter will have one bar corresponding to the standard band at the shortest distance from the well. This band should be slightly thicker. The good sprinter should have two bands corresponding to the standard bands.



Reason: The 577R and the 577X alleles code for proteins that are different length. The 577X allele codes for a short protein and the 577R allele codes for a longer protein. The outstanding sprinter is homozygous for the 577R allele therefore only produces the longer protein therefore there will be only one band, and, as this is

the longer protein, it must correspond to the standard band at the greatest distance from the well. The good sprinter is heterozygous therefore has both alleles and would be expected to produce both proteins and therefore show the same pattern as the standard.

Question 29/ 172

[VCAA 2010 E2 SB Q8]

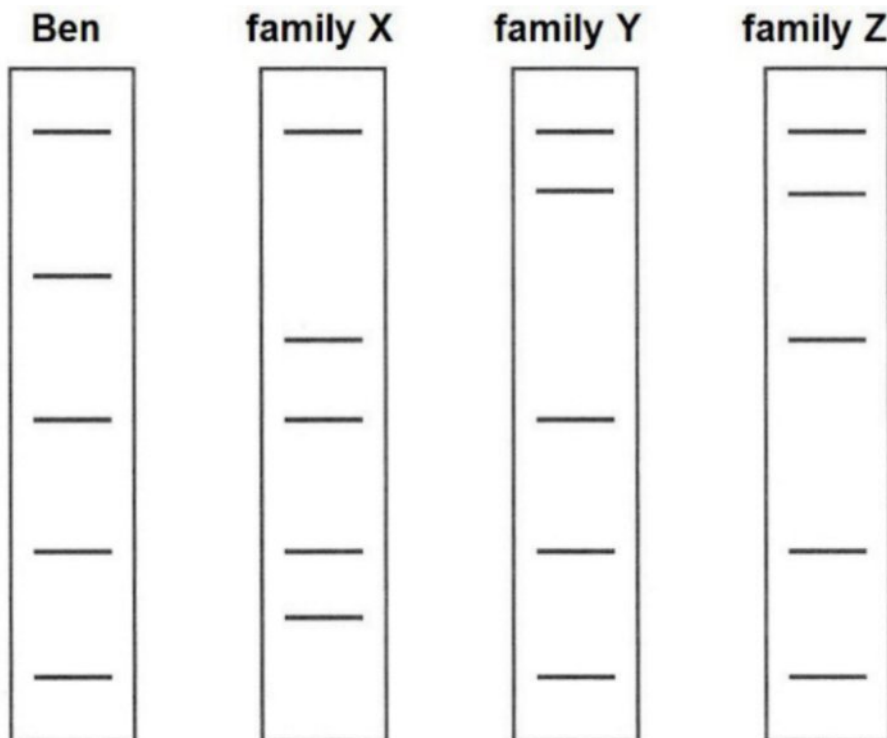
DNA includes sections that are called short tandem repeats (STR). Mutations in STRs occur, on average, every 500 generations. Different numbers of these repeats have no obvious effect on the individual.

a What is the likely reason for this? (1 mark)

A young man, Ben, wants to find out more about his genetic ancestry. He sends a sample of cells, obtained from a swab of his mouth, to a laboratory. On receipt of the sample, the laboratory treats the cells to release the DNA to enable identification of STR markers.

b Name the process used to produce many copies of the STR markers. (1 mark)

Each of the STR markers produced is labelled with a dye and subjected to gel electrophoresis. Five of Ben's STR markers were compared with three family groups who have the same surname as him. The following gels resulted.



c Explain which family is Ben's most recent common ancestor. (2 marks)

(Total 4 marks)

Solution

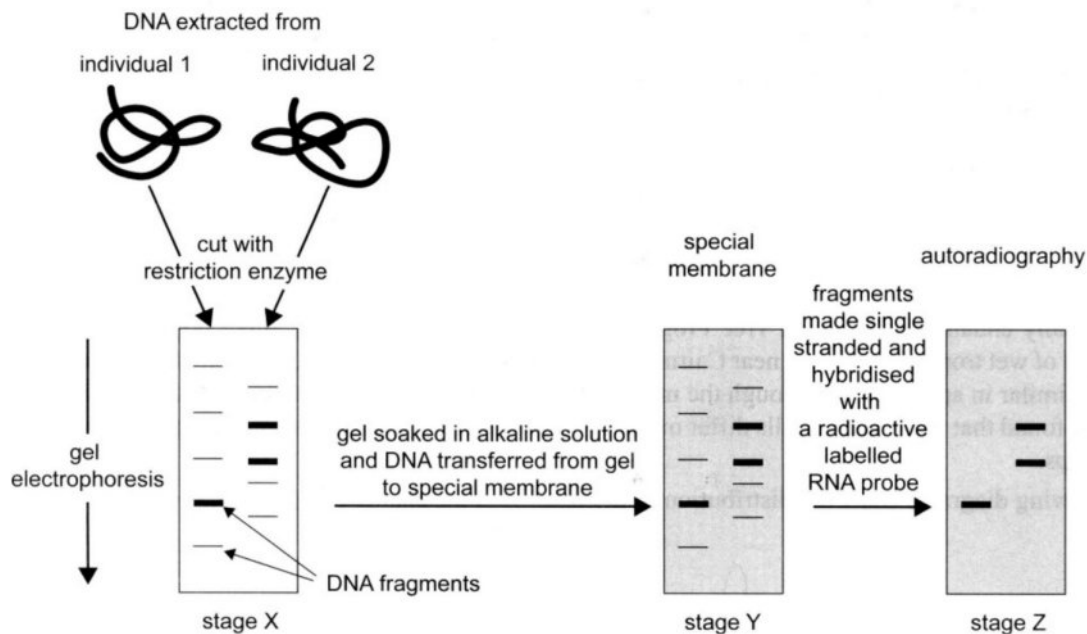
2-165 [VCAA 2010 E2 SB Q8]

- a** STRs are found in introns which are non-coding sections of DNA.
 - b** Polymerase chain reaction.
 - c** Family Y is Ben's most recent common ancestor as there are more (four out of five) STR markers in common between Ben and Family Y than either other family.
-

Question 30/ 172

[VCAA 2008 E2 SB Q6]

RFLP (Restriction Fragment Length Polymorphism) analysis is commonly used to determine genetic variation between individuals. This procedure is summarised in the diagram on the next page.



In this procedure, scientists select a particular restriction enzyme from an available range.

a Explain the reason for their choice. (1 mark)

Electrophoresis uses electrical current to sort DNA fragments.

b i Describe one characteristic of this sorting process. (1 mark)

ii Explain why the DNA of each individual produces a different pattern of fragments after gel electrophoresis, even when the same restriction enzyme is used. (1 mark)

Examine stages Y and Z.

c Describe, at the molecular level, what is meant by the term 'hybridised'. Why is it necessary to carry out hybridisation? (2 marks)

(Total 5 marks)

Solution

2-166 [VCAA 2008 E2 SB Q6]

a Each restriction enzyme cuts DNA at a specific and unique DNA sequence or recognition site. (*Note:* Referring to a recognition place or position is incorrect.) Using the same restriction enzyme on Individual 1 and Individual 2 will allow scientists to compare the genetic variation in the number and position of recognition sites.

b i The different lengths of DNA are sorted as the smaller the fragment the further and faster it will move through the gel.

Or

The DNA fragments have a negative charge and are attracted to the positive end of the gel.

ii Each individual will contain different alleles and thus different DNA sequences. This means the individuals will vary in the number and position of the restriction enzyme's recognition site and this will result in different fragment lengths for each individual.

c In this example, hybridisation refers to the bonding by complementary base pairing, of a single strand of DNA with a single strand of RNA. This is necessary, as the radioactive RNA will allow the bands to be seen by autoradiography enabling the patterns of the two individuals to be compared. (*Note:* Hybridisation should refer to this experiment.)

[VCAA 2021 SB Q9]

The following table provides information on three commonly grown genetically modified (GM) crops in Australia.

Crop	Genetic modification	Characteristic given by modification
GM cotton	several bacterial genes inserted	insect resistance and herbicide tolerance
GM canola	two genes from two different bacterial species inserted	tolerance to several herbicides
GM safflower	a selection of genes silenced within the safflower genome	elevated levels of oleic acid in its seeds

a Select **one** of the GM crops in the table above and justify whether or not this crop could be described as transgenic. (1 mark)

b One issue with GM canola is the accidental release, during transport, of seeds along roadsides. Usually, unwanted plants that grow on the side of the road are killed using the herbicide glyphosate. However, GM canola is resistant to glyphosate.

Suggest **one** practical solution for treating GM canola that is found growing along roadsides. (1 mark)

c A new GM canola crop has been approved for use in Australia. It contains increased levels of omega-3 fatty acids, which are important, in humans, for building healthy cell membranes and for general growth and development, and also protect against a wide variety of diseases.

Omega-3 has traditionally been sourced from fish. Due to the growing demand for sources of omega-3, bioengineers have been encouraged to continue developing GM canola crops as a sustainable alternative.

Discuss **one social implication** and **one biological implication** of using GM canola with increased levels of omega-3. Use a different implication in each response. (4 marks)

(Total 6 marks)

Solution

2-167 [VCAA 2021 SB Q9]

a Either GM cotton or GM Canola. These are transgenic because they contain genes from a different

species.

OR

GM safflower is not transgenic because even though some of its genes have been silenced it does not contain genes from a different species.

b Any **one** of the following.

- Controlled fire burning would reduce the GM canola along roadsides.
- Use a different herbicide that is known to kill GM canola.

c **One** social implication and **one** biological implication:

Social implication

- The population will be healthier so less money will need to be spent on health care/the work force will be more productive.
- Farmers will grow more GM canola, will make more money, and have an improved quality of life.
- Fish farmers will sell less fish, will make less money, and have a poorer quality of life.

Biological implication

- The population will be healthier and average life expectancy will increase.
- Less fish will be eaten so there will be an increase in fish numbers.
- The GM canola may crossbreed with the non-GM canola resulting in an increased the canola genome.
- If more GM canola is grown instead of non-GM canola there will be decreased variation in crops, making them susceptible to unfavourable selection pressures.

(Note: The same implication cannot be used for both social and biological implication.)

Question 32/ 172

[VCAA 2021 SB Q10]

The path to insulin

In the 1970s, recombinant deoxyribonucleic acid methods for cloning and expressing genes in the bacteria *Escherichia coli* were under intense development. An important question that arose at the time

was: Can humans design and chemically synthesise genes that function in bacteria? This question was answered in the late 1970s with the successful expression of human insulin using *E. coli*. For the first time, this provided a practical source of recombinant human insulin for the treatment of diabetes. Prior to this, insulin was isolated from either cows or pigs.

When recombinant human insulin was first developed, researchers had knowledge of the amino acid sequence and the structure of insulin. Researchers investigated cloning the human insulin gene using plasmids found in *E. coli*. They knew of the presence of an EcoRI recognition site (GAATTC) within these plasmids.

When research began, the safety of recombinant plasmids was being actively discussed. Safety regulations were put in place to identify, evaluate, minimise and manage the risks involved. Researchers tested the first recombinant human insulin in cell cultures in the laboratory and in live animals. This was followed by clinical trials where information was gained about the effectiveness and side effects of using this insulin to treat diabetes.

The first recombinant human insulin that was produced and tested established that the use of recombinant plasmids was successful. Facilities were built for recombinant plasmid research and the commercial production of recombinant human insulin. One of insulin's first researchers, Arthur Riggs, stated, 'It is interesting to think about how much progress has been made since [the 1970s]. For example, in 2020, the genes for insulin can be made in a few hours by automated instruments, then cloned and expressed by a single person in about a week'.

Reference: AD Riggs, 'Making, cloning, and the expression of human insulin genes in bacteria: The path to humulin', *Endocrine Reviews*, vol. 42, issue 3, June 2021, pp. 374–380, <https://doi.org/10.1210/edrv/bnaa029>

a What is meant by recombinant deoxyribonucleic acid in the context of this article? (1 mark)

b The article states that the researchers knew the structure of insulin and the amino acid sequence before they created the recombinant human insulin in the laboratory.

How would the researchers have used this information to genetically engineer a human insulin gene and how might this engineered insulin gene have differed from a natural insulin gene isolated from human DNA? (2 marks)

c Outline the steps that are required for the human insulin gene to be cloned and expressed in bacteria in 2020. (3 marks)

d What ethical response would have been expected from the researchers in the 1970s if, during their clinical trials, they discovered that the recombinant human insulin was significantly more effective than using insulin from either cows or pigs? (1 mark)

(Total 7 marks)

Solution

2-168 [VCAA 2021 SB Q10]

a In this article the gene for the production of human insulin has been inserted into a bacterial plasmid. This plasmid has DNA from another species therefore it is considered to be recombinant.

b The genetic code is a triplet code where 3 nucleotides code for one amino acid. Corresponding DNA nucleotides can be assembled in the same order as the amino acid sequence. Some amino acids are coded for by several different DNA codons therefore there is more than one DNA sequence that would code for the same amino acid sequence.

c Steps involved:

1. The human insulin gene is artificially synthesised from the known amino acid sequence.
2. The synthesised insulin gene is amplified using PCR.
3. Plasmids containing an antibiotic resistant gene are extracted from the bacteria.
4. The plasmid and the amplified insulin genes are treated with the same restriction enzyme and mixed.
5. Ligase is added to join the insulin gene to the plasmid.
6. Plasmids are transformed back into the bacteria.
7. Bacteria are grown on an antibiotic to select bacteria that have taken up the plasmids.
8. The insulin gene is turned on and insulin extracted.

d Any **one** of the following expected ethical responses:

- Insulin production from animals should be stopped to protect the animal's welfare.
 - Who should be offered the more effective insulin?
 - How will the public be informed about the genetically modified bacteria?
-

Question 33/ 172

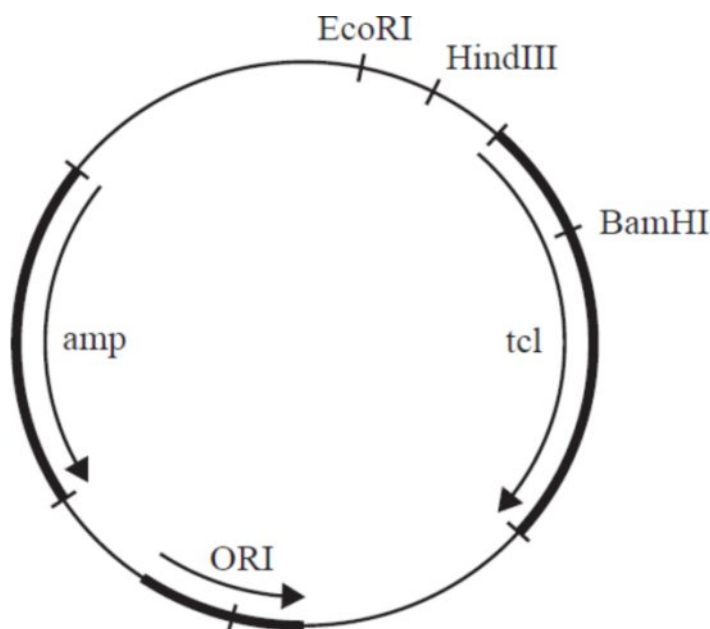
[VCAA 2017 SB Q9]

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

a What is meant by the term ‘vector’ in the context given? (1 mark)

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

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



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

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

i Describe how restriction enzymes such as BamHI are used to help insert a gene coding for a human protein into this plasmid. (2 marks)

ii Draw and label a diagram to show the position of the human gene in this plasmid when BamHI is used. Include the position of the recognition sites for the restriction enzymes EcoRI, HindIII and BamHI on the plasmid. (1 mark)

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

Explain how scientists use antibiotics to identify which of the bacterial cells have been successfully transformed with plasmids carrying the human gene. (3 marks)

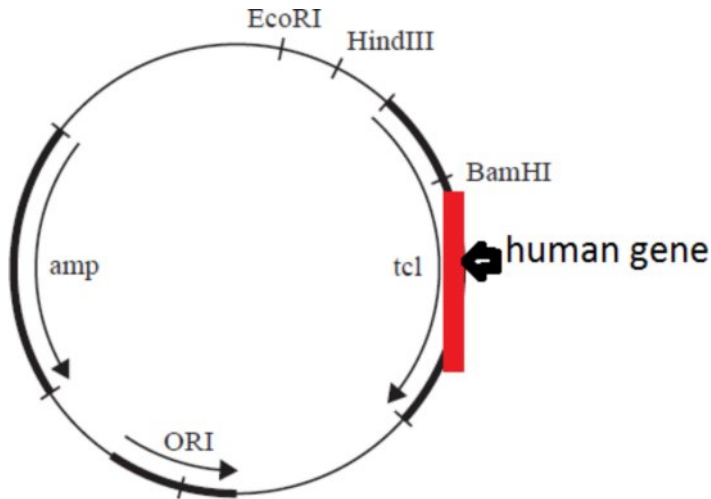
(Total 7 marks)

Solution

2-169 [VCAA 2017 SB Q9]

a Vector refers to the use of a plasmid to introduce recombinant DNA into another cell or organism.

b i BamHI is a restriction enzyme that cuts DNA at a specific recognition site. The resulting cut is uneven leaving sticky ends. If the same restriction enzyme is used to cut a plasmid and the gene to be inserted, the plasmid and the gene will have complementary sticky ends that can then be joined using ligase.



ii

c Plasmids that have taken up the human gene contain the gene for ampicillin resistance but not for tetracycline resistance as the gene for tetracycline resistance has been disrupted by the insertion of the human gene. The disruption has occurred because the recognition site for BamHI is found within the gene for tetracycline resistance. This means that bacteria that are able to grow on ampicillin but not on tetracycline must contain the recombinant DNA.

Question 34/ 172

[VCAA 2006 E2 SB Q4]

a Describe the appearance of a bacterial plasmid. (1 mark)

A bacterial plasmid was modified in the laboratory so that it contained a gene for an enzyme which provided resistance to the antibiotic tetracycline.

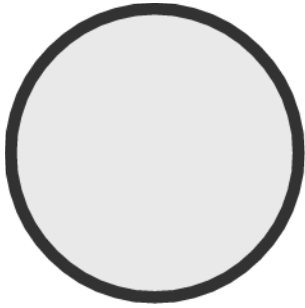
Bacterial cells, which in their natural environment were sensitive to the antibiotic tetracycline, were mixed with the modified plasmid. The bacterial cells were treated so that they could take up the plasmids.

b What is the name of the process in which a bacterial cell takes up a plasmid and expresses the genes of the plasmid? (1 mark)

The outcome of an experiment is shown below.

A

Bacterial cells only, spread on agar



B

Bacterial cells only, spread on agar with tetracycline



C

Bacterial cells exposed to the plasmid, spread on agar with tetracycline



With respect to the growth of bacteria, the results of plates A and C are shown. On plate A there is a continuous growth of bacteria over the surface of the agar. On plate C the colonies are distinguishable from each other.

c i What result would you expect on plate B with respect to the growth of the bacteria? (1 mark)

ii Explain your answer to **c.i.** (1 mark)

d Explain why there is a difference in the way the bacteria have grown on plates A and C. (2 marks)

(Total 6 marks)

Should we grow GM crops?

by Mary Nguyen

More than 25 years after genetically modified (GM) food first appeared, growing GM crops remains a hotly debated topic. Some people argue that GM crops are the only way to feed the growing world population and to minimise environmental harm. Other people express different views.

Bt cotton is a type of cotton that contains two genes from a soil bacterium, *Bacillus thuringiensis*, enabling it to produce insect-resistant proteins. Australian farmers of Bt cotton use only 15% of the quantity of the insecticide that was once needed to protect their cotton crops. However, Bt cotton is not as resistant to the main insect pest of cotton crops, *Helicoverpa*, as it has been in the past.

In Australia, Bt cotton is picked by machine, but in India, it is picked by hand. Workers in India have developed skin allergies, which have been attributed to Bt cotton proteins.

Traditionally, farmers have saved money by keeping seed from one year's crop to plant the following year. However, it is illegal for farmers to keep Bt cotton seeds because these seeds have been declared the legal property of the company Monsanto. Every year, cotton farmers must buy more seeds from Monsanto.

Unlike Monsanto, the company that produces the GM food crop Golden Rice allows farmers to replant

the rice they harvested the previous year. By inserting a gene from the bacteria *Erwinia uredovora* and another from a daffodil, *Narcissus pseudonarcissus*, into white rice, scientists produced Golden Rice – a rice variety containing higher levels of vitamin A. People who eat Golden Rice avoid vitamin A deficiency. Trials conducted in several countries have shown that Golden Rice is safe to eat.

Solution

2-170 [VCAA 2006 E2 SB Q4]

- a** Circular. (*Note:* A circular fragment of DNA is not acceptable.)
 - b** Transformation
 - c**
 - i** No growth of bacteria.
 - ii** Bacterial cells on plate B have not been exposed to the plasmid; therefore, they do not contain the gene for the enzyme, which provides resistance to tetracycline; therefore, they will die when exposed to tetracycline.
 - d** On plate A, there is no tetracycline therefore all bacteria can grow and continuous growth occurs. On plate C where tetracycline is present, only bacteria that have taken up the modified plasmid will survive. Not all bacteria will have taken up the plasmid so the colonies are the descendants of those bacteria that did take up the plasmid.
-

Question 35/ 172

[VCAA 2018 SB Q10]

- a** Bt cotton and Golden Rice are genetically modified organisms but are they also transgenic organisms? Support your response with evidence from the article above. (3 marks)
- b** How can planting a Bt cotton crop lead to an increase in crop yield? (1 mark)
- c** Using information from the article, complete the table below by describing one social and one biological implication relevant to the use of Bt cotton and Golden Rice. The same implication should not be used twice. (4 marks)

	Social implications	Biological implications
Bt cotton		

Social implications

Biological implications

Golden Rice

(Total 8 marks)

Solution

2-171 [VCAA 2018 SB Q10]

a Transgenic organisms have genes from a different species in their cells. Bt cotton cells have genes from a bacterium (*Bacillus thuringiensis*) and Golden Rice has genes from a bacteria (*Erwinia uredovora*) and a daffodil (*Narcissus pseudonarcissus*), therefore they are both transgenic.

b Bt cotton produces a protein that stops insects eating the cotton plants therefore more plants will survive and the yield will be greater.

c

	Social implication	Biological implication
Bt cotton	Any one of: • expensive as new seed must be bought each year • increased yield therefore more money is available for an increased standard of living	Any one of: • increased skin disease in farmers • less pesticides are used • insects may develop resistance therefore more genetic modification maybe required • crops are less resistant to <i>Helicoverpa</i>
Golden Rice	Any one of: • profits are increased as rice can be kept from one year's crop until the next • population is healthier therefore increased standard of living • proven safe	Any one of: • less vitamin A deficiency • improved nutrition • risk of cross pollination with wild rice

Question 36/ 172

Use an example of a named transgenic species to discuss the social and environmental impact of this technology. (Total 5 marks)

Solution

2-172

Transgenic species contain a gene from another species. An example of a transgenic species is bacteria that been genetically engineered to produce human insulin.

In this transgenic bacterium, the human insulin gene was inserted in a plasmid and then the plasmid has been transformed into the bacteria. This has enabled the production of contamination-free insulin for diabetics and has resulted in improved health and life expectancy for diabetics.

Many people think that bacteria should not be used to produce insulin. The use of antibiotic resistant genes in plasmids to select transformed bacteria could be dangerous. If these plasmids were transferred to disease-causing bacteria, it could lead to a strain of bacteria that could not be treated with antibiotics.

Others say that this is very unlikely and that the supply of contamination-free insulin will improve the quality of life for so many diabetics that it is worth the risk.

Chapter 3 How are biochemical pathways regulated?

Question 1/ 46

Is energy used by living organisms?

Solution

3-1 Energy is never used. In doing work, energy is converted from one form to another and at the end of the process may be unusable. Most organisms store energy in chemicals such as fat or starch. The energy is made available to do cellular work during cellular respiration.

Question 2/ 46

Why do cells need energy?

Solution

3-2 Cells need energy to do cellular work. Processes that require energy are cell division, synthesis of new parts and materials, muscular contraction, active transport and nervous conduction.

Question 3/ 46

What is the difference between anabolic and catabolic reactions?

Solution

3-3 Anabolic reactions are those involving the building or synthesis of molecules whereas catabolic reactions are breakdown reactions.

Question 4/ 46

What is the difference between exergonic and endergonic reactions? Give an example of each type.

Solution

3-4 Exergonic reactions (breaking things) release energy, e.g. respiration. **Endergonic reactions** (making or doing things) require an input of energy for them to proceed, e.g. any synthesis reaction such as protein synthesis.

Question 5/ 46

Define the term 'enzyme'.

Solution

3-5 An enzyme is an organic catalyst. They are proteins that alter the rate of reactions – usually to speed them up to a biologically useful rate. Many reactions occur naturally but at extremely slow rates. Enzymes only alter the rate (amount produced in a given time) of reaction. They do not alter the final amount of product produced.

Question 6/ 46

What is the 'lock-and-key' model and how does it differ from the induced fit?

Solution

3-6 Specific enzymes catalyse (alter the rate) of specific reactions. Enzymes bind with the substrates (reactants or ingredients) to form a temporary enzyme substrate complex. The enzymes have areas called active sites. The shape of a specific substrate molecule will match the active sites on a specific enzyme. Only the correct enzyme with the correct molecular shape will bind to the substrate molecule, in the same way that a particular key will open a particular lock. The induced fit model states that there can be some change in the active site. The flexibility allows for closer fit between the substrate and the enzyme.

Question 7/ 46

Use the terms 'substrate', 'enzyme' and 'product' to explain the role of enzymes in living organisms.

Solution

3-7 Substrates are the materials that are to be processed. The processing could be a breakdown reaction (e.g.: digestion) or a synthesis reaction (e.g.: making proteins). The materials present at the end of the reaction are the products. Enzymes allow the formation of product from substrate in a time that allows the efficient operation of an organism. Many of the reactions catalysed by the enzyme would otherwise occur too slowly.

Question 8/ 46

Do enzymes increase the amount of product produced in a reaction?

Solution

3-8 Enzymes do not increase the amount of product produced. They reduce the time it takes to produce the product.

Question 9/ 46

With respect to reactions involving enzymes, what is meant by the rate of reaction?

Solution

3-9 The rate of reaction refers to the amount of product produced in a given time. For example, the rate of reaction could be measured in micrograms of product produced per minute.

Question 10/ 46

What is an enzyme's active site and how is it formed?

Solution

3-10 Enzymes are proteins. The folding of the protein into its tertiary structure provides a site that matches with specific substrates. This site is called the active site.

Question 11/ 46

Enzymes can be denatured. How is this done and what are the consequences?

Solution

3-11 Enzymes are proteins so they can be denatured by:

- high temperatures (break H bonds and van der Waals forces, destroying the quaternary and tertiary structure)
 - extremes of pH (break ionic bonds, destroying the quaternary and tertiary structure).
-

Question 12/ 46

Explain the difference between competitive and non-competitive enzyme inhibitors.

Solution

3-12 Competitive inhibitors have a similar shape to the specific substrate on which an enzyme acts. They compete with the enzyme for the active site, reducing the amount of enzyme available to catalyse the reaction.

Non-competitive inhibitors do not bind to the active site. Instead, they bind to another area of the enzyme (allosteric site). This results in a change in the shape of the active site which decreases the amount of enzyme available to catalyse the reaction.

Question 13/ 46

What are coenzymes and what do they do?

Solution

3-13 Coenzymes are small, non-protein molecules that temporarily bind to enzymes increasing the enzyme's ability to bind to the substrate. Coenzymes are also carrier molecules – they may carry electrons, protons, specific atoms or groups of atoms such as phosphate and energy.

Question 14/ 46

Complete the following table.

Loaded coenzyme	Unloaded form	Function	Involved in photosynthesis/cellular respiration
ATP			
NADH			
NADPH			

Solution

3-14

Loaded coenzyme	Unloaded form	Function	Involved in photosynthesis/cellular respiration
ATP	ADP	transfer of energy and phosphate	both
NADH	NAD ⁺	transfer of protons and electrons	cellular respiration

Loaded coenzyme	Unloaded form	Function	Involved in photosynthesis/cellular respiration
NADPH	NADP	transfer of protons and electrons	photosynthesis

Question 15/ 46

What is ATP (adenosine triphosphate)? Explain its role in cells.

Solution

3-15 ATP is a molecule containing adenosine attached to ribose, which is bound to a chain of three phosphate groups. Energy is released for cellular reactions when the terminal phosphate group is removed to form ADP. ATP is the immediate source of energy for cells. When energy is released by cellular reactions, it is stored in ATP.

Question 16/ 46

Enzyme function is affected by

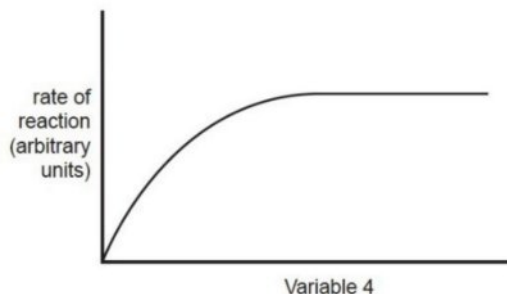
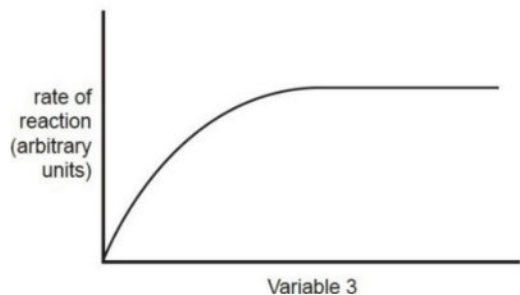
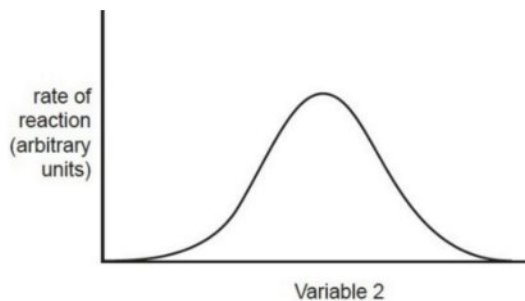
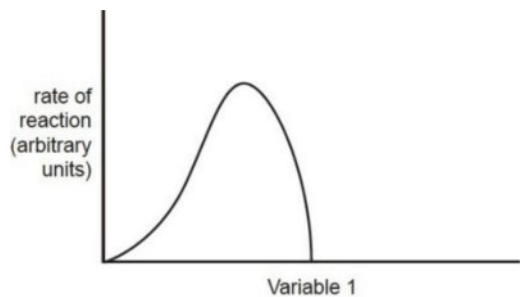
A: temperature

B: pH

C: substrate concentration

D: enzyme concentration

Match the above factors to the graphs below and explain the shape of the curve.



Variable	Factor	Explanation
1		
2		
3		
4		

Solution

3-16

Variable	Factor	Explanation
1	Temperature	At low temperatures the reaction rate is low as the substrates and the enzymes have low kinetic energy. As the temperature increases collisions between molecules increase, resulting in an increase in reaction rate. Above the optimal temperature for an enzyme the enzyme denatures and reaction rate decreases.
2	pH	Enzymes have an optimal pH. Extremes of pH result in denaturing of enzymes and decreased reaction rate.
3	Enzyme concentration	As the concentration of an enzyme increases more active sites are available until substrate concentration becomes a limiting factor.

Variable	Factor	Explanation
4	Substrate concentration	As concentration of substrate increases more substrate that can bind to the enzyme active sites and the reaction rate increases until the number of active sites becomes a limiting factor.

Question 17/ 46

Do all enzymes work efficiently under the same conditions?

Solution

3-17 Different enzymes work best in particular environments. Digestive enzymes produced in the stomach work most efficiently in a low pH environment (acidic). Enzymes present in the ice fish of Antarctic waters work best at about 4°C.

Question 18/ 46

What is the major difference between heterotrophic and autotrophic organisms?

Solution

3-18 Autotrophic organisms make their own organic materials through processes such as photosynthesis or chemosynthesis. Heterotrophs rely on an external source of ready-made organic material. For example, you are a heterotroph and use organic materials found in animal or plant material that you eat.

Question 19/ 46

List the different sorts of organic compounds that heterotrophs require. What form is each type of compound in when moved into or out of cells? (No longer specifically on the course but useful background information.)

Solution

3-19

Compound	Form absorbed
Protein	amino acids
Carbohydrates	glucose
Fats	fatty acid and glycerol
Nucleic acids	nucleotides

Question 20/ 46

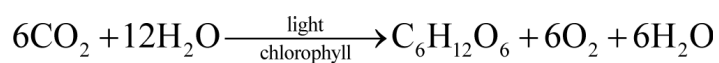
Write down the word and chemical equations for photosynthesis.

Solution

3-20 Photosynthesis:

carbon dioxide + water + light energy → glucose + oxygen + water

(This process occurs in plant cells that contain chlorophyll.)



(Note that you can cancel 6 molecules of water from both sides of the equation and be mathematically correct. From a biochemical point of view, water is both a product and a reactant in the photosynthesis equation.)

Question 21/ 46

Where does photosynthesis occur?

Solution

3-21 Photosynthesis occurs in chloroplast-containing cells if they are exposed to light and are supplied with carbon dioxide and water.

Question 22/ 46

Draw a diagram of a leaf section. Use labels to show how various materials involved in photosynthesis move to and from the site of production.

Solution

3-22 Your diagram should show the following:

cuticle, epidermis, palisade mesophyll cells, spongy cells, air spaces, stomata and vascular tissue. Draw arrows to indicate which way various gases move into and out of the leaf.

Question 23/ 46

What is the role of pigments in photosynthetic organisms and why is there a range of different pigments?

Solution

3-23 Pigments trap the light energy required for the photosynthetic process. Different pigments trap different wavelengths (colours) of light. Green pigments are effective at absorbing red and blue light. A range of pigments means that a plant can trap a wider range of light. Seaweeds that live in deeper water tend to have more red pigments. These are best for absorbing blue light, which penetrates water to a greater depth. The pigments a photosynthetic organism has will enable it to photosynthesise efficiently in a particular environment.

Question 24/ 46

In eukaryotes, photosynthesis occurs in the chloroplast. Describe the structure of the chloroplast. Include in your description where light is absorbed and what wavelengths are involved.

Solution

3-24 Chloroplasts are large membrane-bound organelles that can be seen with a light microscope. Within the outer membrane are a series of folded membranes that form stacks called grana. The grana are green as they contain chlorophyll, the pigment that absorbs red and blue light. The spaces between grana are known as stroma.

Use a table to explain what happens in the light-dependent and light-independent stages of photosynthesis.

Solution

3-25

Light-dependent stage

- Light is absorbed by chlorophyll
- Causes electrons to be emitted making energy available
- Energy is used to make ATP
- Water is split, and oxygen is given off leaving hydrogen

Light-independent stage

- Hydrogen from light stage is added to carbon dioxide
 - ATP produced in the light stage is the energy source
-

What is the role of NADP in photosynthesis?

Solution

3-26 NADP is used to carry H ions from the grana to the stroma where the Calvin cycle takes place.

Complete the following table.

Stage	Location	Inputs	Outputs
light dependent reaction			
light independent reaction (Calvin)			

Solution

3-27

Stage	Location	Inputs	Outputs
light dependent reaction	Grana (thylakoid)	12 NADP ⁺	12 NADPH
		12 H ₂ O	12 ATP
		12 ADP	6 O ₂
		12 Pi	
light independent reaction (Calvin)	stroma	12 NADPH	12 NADP ⁺
		12 ATP	12 ADP
		6 CO ₂	12 Pi
			6 H ₂ O C ₆ H ₁₂ O ₆

Question 28/ 46

What is Rubisco and what is its role in the Calvin cycle?

Solution

3-28 Rubisco is an enzyme that catalyses the first step of the Calvin cycle where CO_2 is added to RuBP. An unstable 6-C compound is then formed that then splits to form two 3-C molecules. Plants where this happens are called C_3 plants.

Question 29/ 46

Why is the rate of photosynthesis in C_3 plants decreased on hot dry days?

Solution

3-29 On hot dry days when stomata are closed, within the plant the level of CO_2 is low and the level of O_2 is high. As a result, O_2 binds more readily with the active site of Rubisco thus reducing the rate of photosynthesis.

Question 30/ 46

Explain how C_4 and CAM plants are able to maintain a high rate of photosynthesis on hot dry days.

Solution

3-30 *C_4 plants:* A step before the Calvin cycle in mesophyll cells results in the formation of one 4-C compound. This 4-C compound is then exported to cells around the vascular bundles. Here the 4-C compound is broken down to CO_2 which then enters the Calvin cycle. This means that C_4 plants are more efficient than C_3 plants in dry habitats because they can capture more CO_2 in less time and the stomata do not need to stay open as long – reducing water loss.

CAM plants: These plants open their stomata at night rather than during the day. CO₂ is taken up by the cells and incorporated into organic acids. During the day when the stomata are closed, CO₂ is released from the organic acids. The CO₂ then enters the Calvin cycle and photosynthesis can continue even though the stomata are closed. Again, this adaptation reduces water loss.

Question 31/ 46

Complete the following table.

	C3	C4	CAM
CO ₂ converted before the Calvin cycle			
Site of the Calvin cycle			
Stomata open (day/night)			
Examples			

Solution

3-31

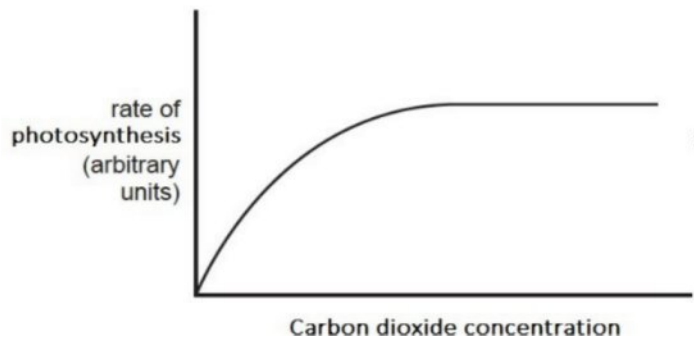
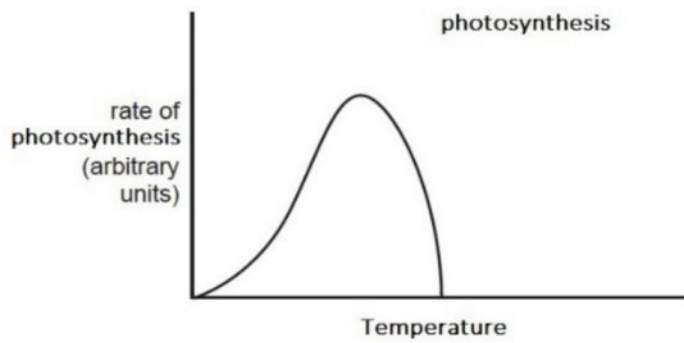
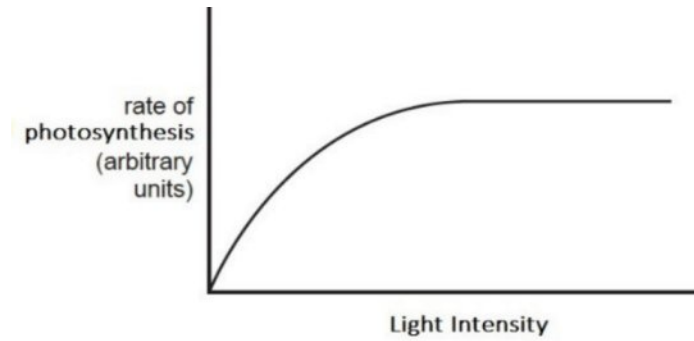
	C3	C4	CAM
CO ₂ converted before the Calvin cycle	No	Yes	Yes
Site of the Calvin cycle	All photosynthetic cells	Bundle sheath cells	All photosynthetic cells
Stomata open (day/night)	Day	Day	Night
Examples	eucalypts, sunflowers, potatoes	corn, sugarcane, tropical grasses	succulents, pineapple

Question 32/ 46

Explain the following graphs by completing the table.

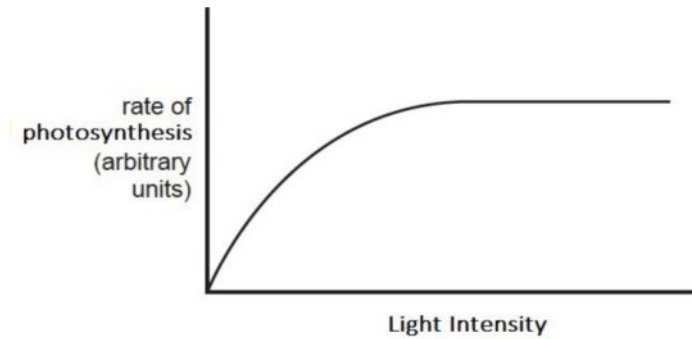
Factor affecting photosynthesis

Explanation



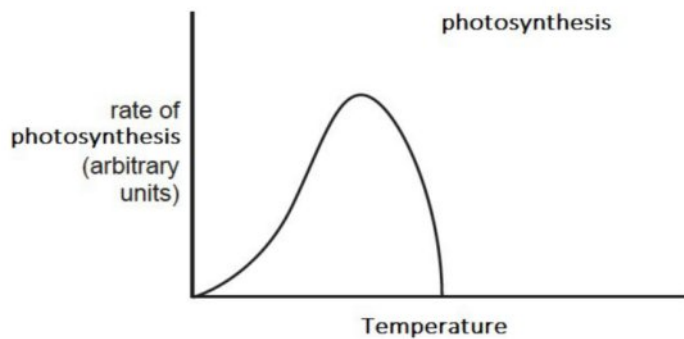
Solution

Factor affecting photosynthesis

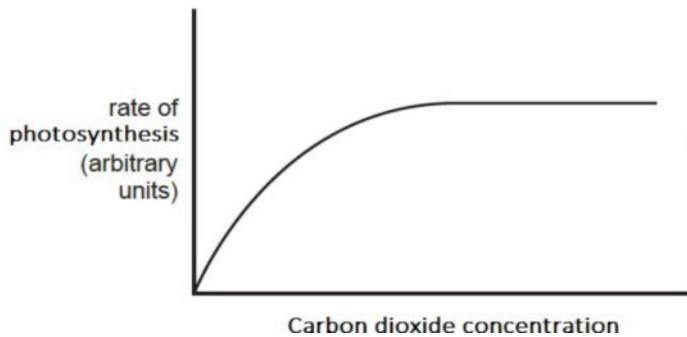


Explanation

As light intensity increases photosynthetic rate increases until the enzymes in chloroplasts are operating at full capacity and the curve levels off. The reaction is limited by the number of chloroplasts or CO_2 availability.



As temperature increases the kinetic energy of the reactants in photosynthesis and enzymes increase resulting in an increased rate of photosynthesis. After optimal temperature is reached the enzymes involved in photosynthesis denature, resulting in a decrease in rate.



As CO_2 concentration increases the rate of photosynthesis until either the enzymes involved are operating at full capacity or light becomes a limiting factor.

Question 33/ 46

What other property of light, apart from intensity, affects the rate of photosynthesis?

Solution

3-33 The quality or wavelength of light – that is colour. For most land plants, that is green plants, it is energy in blue and red light that is absorbed by pigments such as chlorophyll and converted to chemical energy during photosynthesis.

Question 34/ 46

How might the availability of water affect the rate of photosynthesis in C3 plants?

Cellular respiration as an example of a biochemical pathway

Solution

3-34 The stomata of C3 plants are open during the day and closed at night. This allows CO₂ for photosynthesis to diffuse into the leaf. On hot, dry days when the guard cells lose water, the stomata shut. Less CO₂ enters the plant and therefore rate of photosynthesis decreases.

Question 35/ 46

Write down the word equation for aerobic cellular respiration.

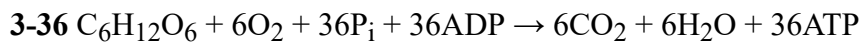
Solution

3-35 glucose + oxygen → carbon dioxide + water + energy released

Question 36/ 46

Convert the above equation to a balanced chemical equation.

Solution



Question 37/ 46

In eukaryotes, aerobic respiration occurs in the mitochondrion. Describe the structure of a mitochondrion.

Solution

3-37 Mitochondria are large membrane-bound organelles found in the cytoplasm. They can be seen with a light microscope if stained but structural detail can only be seen with an electron microscope. Within the outer membrane is a highly folded internal membrane. The projections formed from these folds are called cristae.

Question 38/ 46

Explain what happens in the three main stages of aerobic respiration.

Solution

3-38 Stage 1 Glycolysis. This occurs in the cytoplasm. Glucose is converted to pyruvate and 2 ATP are produced.

Stage 2 Krebs cycle. This occurs on the matrix of the mitochondria. Hydrogen ions are removed, carbon dioxide is formed and 2 ATP are produced. The hydrogen ions and electrons are picked up by the coenzymes NAD and FAD.

Stage 3 Electron transport chain. This occurs in the inner membranes of the mitochondria and requires oxygen. Reduced NAD and FAD provide electrons, which are passed down the electron transport chain producing 32 ATP. The oxygen is used to make water.

Question 39/ 46

Write down the word equation for anaerobic respiration in:

a animals

b yeast.

Solution

3-39 a Anaerobic respiration in animals

glucose $\rightarrow$ lactic acid + 2ATP

b Anaerobic respiration in yeast

glucose $\rightarrow$ carbon dioxide + alcohol + 2ATP

Question 40/ 46

Aerobic respiration is said to be more efficient than anaerobic respiration. Explain this statement.

Solution

3-40 Aerobic respiration is more efficient as the glucose molecule is broken down to simple inorganic materials, carbon dioxide and water, and the maximum amount of energy is extracted – enough to make 36 molecules of ATP. Anaerobic respiration represents the partial breakdown of a glucose molecule to alcohol and lactic acid (still large molecules) and releases only enough energy to make 2 molecules of ATP.

Question 41/ 46

Photosynthesis is similar to respiration. Do you agree?

Solution

3-41 Respiration can be thought of as photosynthesis in reverse. The reactants of one reaction are the products of the other! They are different in terms of energy. Respiration is an exergonic reaction. Photosynthesis is an endergonic reaction.

Question 42/ 46

Mitochondria and chloroplasts contain many membranes embedded with enzymes. How would this increase efficiency?

Solution

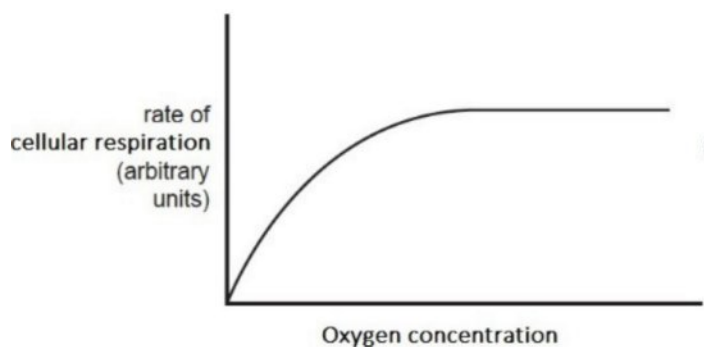
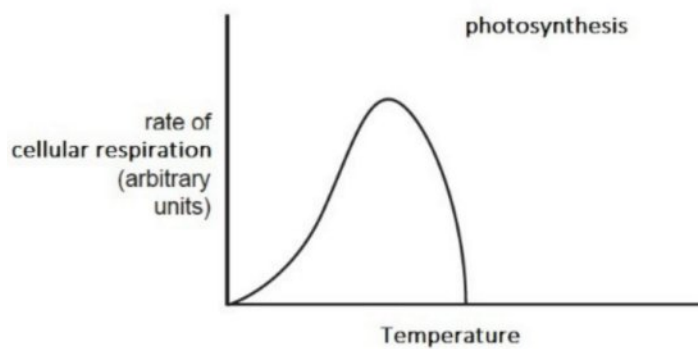
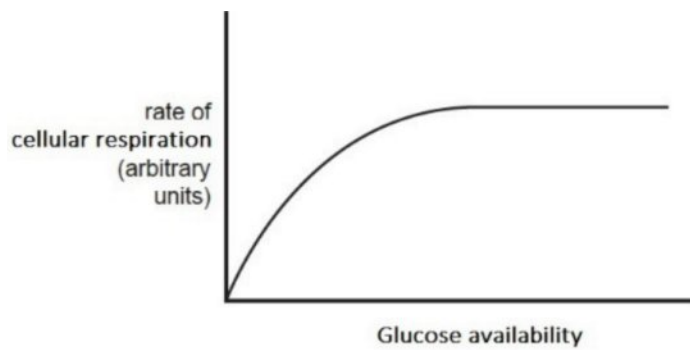
3-42 A double membrane surrounds both mitochondria and chloroplasts, and both contain DNA and RNA similar to that found in bacteria.

Question 43/ 46

Explain the following graphs by completing the table.

Factor affecting photosynthesis

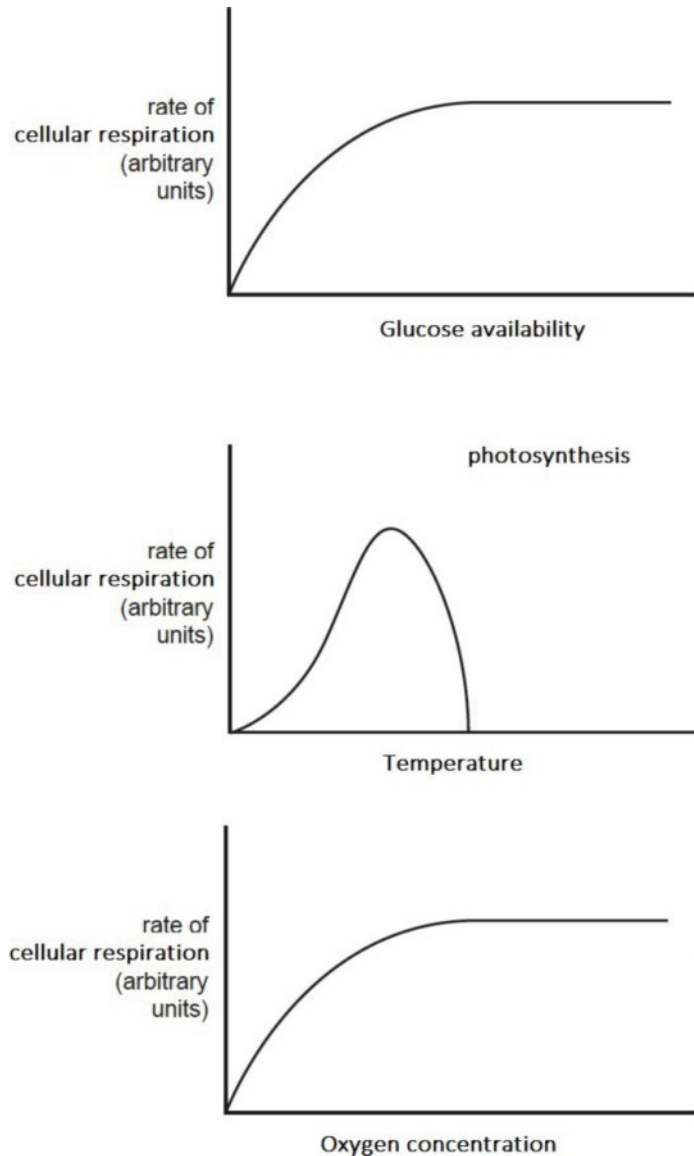
Explanation



Solution

3-43

Factor affecting photosynthesis



Explanation

As glucose is a reactant in cellular respiration, increasing its concentration will increase the rate of reaction until the enzymes are operating at full capacity or oxygen concentration has become a limiting factor.

As temperature increase the kinetic energy of the reactants in cellular respiration and enzymes increase resulting in increased rate of cellular respiration. After optimal temperature is reached, the enzymes involved in cellular respiration denature, resulting in a decrease in rate.

As oxygen is a reactant in aerobic respiration, increasing its concentration will increase the rate of overall cellular respiration until the enzymes are operating at full capacity or availability of glucose has become a limiting factor. Note that oxygen is not a reactant in anaerobic respiration.

Question 44/ 46

Describe how the CRISPR-Cas9 technologies may be used to improve photosynthesis efficiency and crop yields.

Solution

3-44 CRISPR-Cas9 technology allows scientists to make precise changes to a plant's genome. This means genes that improve photosynthetic efficiency and crop yields can be inserted into the genome of plant crops and those genes that reduce photosynthetic efficiency and crop yields can be deactivated or deleted. For example, Yield 10 is developing crops of canola and soybean with improved oil content and that are drought tolerant.

Question 45/ 46

What are meant by the terms 'biomass' and 'biofuel'?

Solution

3-45 Biomass is renewable organic material that comes from plants and animals. Biofuel refers to a fuel that is produced by the anaerobic fermentation of biomass.

Question 46/ 46

Explain how biomass can be used to make biofuel.

Solution

3-46 When yeast respire anaerobically, glucose is broken down to ethanol, carbon dioxide and two molecules of ATP. Biomass can be used as a source of glucose for anaerobic respiration. The ethanol produced can be used as a fuel.

Question 1/ 115

[VCAA 2015 SA Q6]

An experiment was conducted to investigate enzyme activity. A small quantity of amylase solution was added to a solution of starch dissolved in water at 35°C. It was observed that maltose was produced.

Which one of the following is the substrate in this reaction?

A water

B starch

C maltose

D amylase

Solution

3-47 [VCAA 2015 SA Q6]

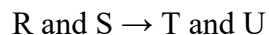
Which one of the following is the substrate in this reaction?

B starch. (Starch is broken down by amylase in the solution and is therefore the substrate. Maltose is the product.)

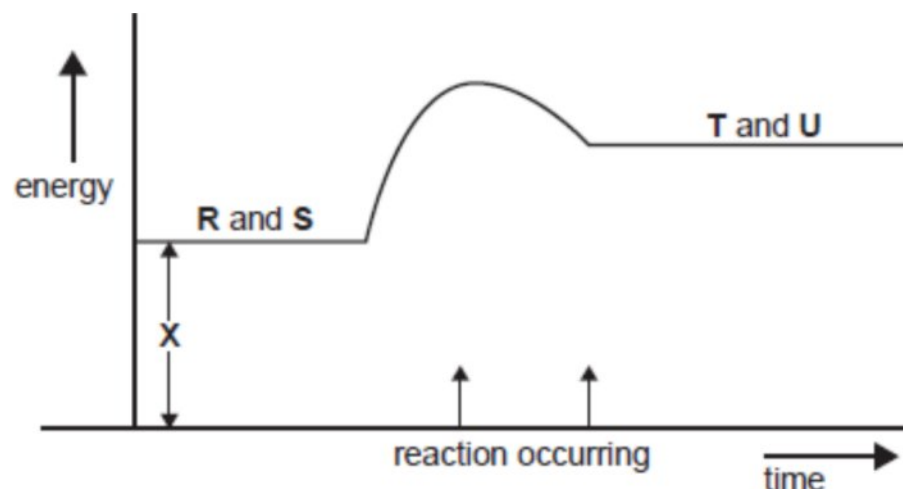
Question 2/ 115

[VCAA 2013 E1 SA Q8]

Consider the following reaction in which substrate molecule R and substrate molecule S are converted into product molecule T and product molecule U.



The graph below shows the energy available in the molecules against time.



Based on the information in the graph, a correct conclusion would be that

A this is an anabolic reaction.

B the reaction would release energy.

C value of the activation energy for the reaction is shown by X.

D product molecules T and U have less energy than substrate molecules R and S.

Solution

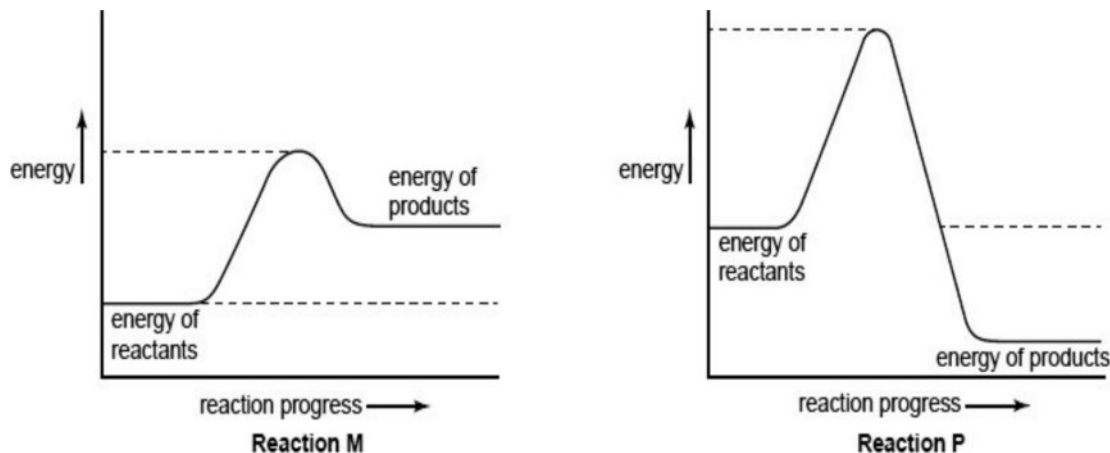
3-48 [VCAA 2013 SA Q8]

Based on the information in the graph, a correct conclusion would be that

A this is an anabolic reaction. (The products of anabolic/build-up reactions store more energy than the reactants as shown by the higher energy level of T and U. The reaction requires energy and the activation energy is the energy required to start the reaction.)

[VCAA 2011 E1 SA Q23]

The following graphs depict two different reactions.



From the two graphs, it is reasonable to conclude that

A in reaction **P**, the energy level of the products is greater than that of the reactants.

B activation energy of reaction **M** is greater than that of reaction **P**.

C both graphs **M** and **P** represent endothermic reactions.

D energy is released in reaction **P** only.

Solution

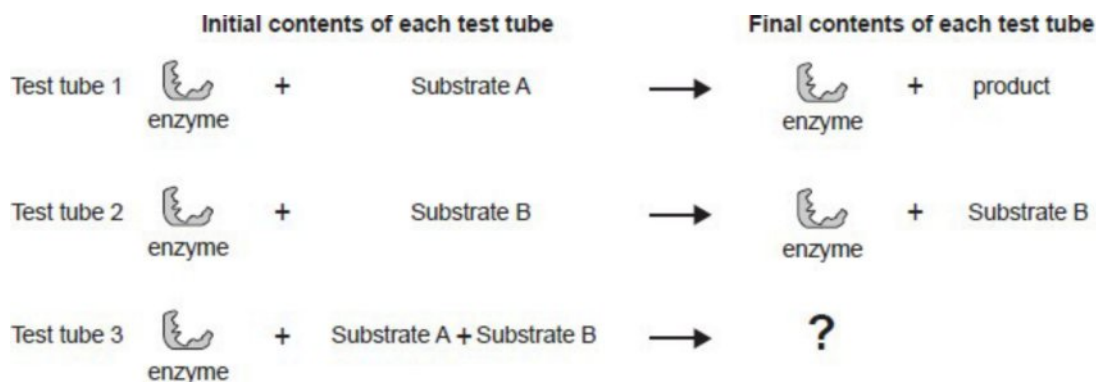
3-49 [VCAA 2011 E1 SA Q23]

From the two graphs, it is reasonable to conclude that

D energy is released in reaction P only. (In Reaction P the energy of products is lower than the energy of the reactants; therefore, energy has been released. The activation energy of reaction M is actually less than that of P. M is an endothermic reaction whereas reaction P is an exothermic reaction.)

[VCAA 2020 SA Q4]

A group of Biology students set up an experiment with three test tubes. Each test tube contained the same enzyme and was kept under the same experimental conditions. All concentrations and volumes of substrate and enzyme placed in the test tubes were kept the same. The diagram below shows the initial contents of each test tube and the final contents of test tubes 1 and 2.



Source: adapted from Chemistry LibreTexts,
<<https://chem.libretexts.org>>

An enzyme-substrate complex was formed in each of the three test tubes.

When compared to the final contents of Test tube 1, the concentration of product contained in the final contents of Test tube 3 will

A be the same because both Substrate A and Substrate B are able to bind to the enzyme at the same time.

B increase because Substrate A is a substrate that can bind to the enzyme's active site.

C decrease due to competitive reversible inhibition by Substrate B.

D be zero due to the presence of an irreversible inhibitor.

Solution

3-50 [VCAA 2020 SA Q4]

Test tube 3 will

C decrease due to competitive reversible inhibition by Substrate B. (Substrate B competes with Substrate A for the enzyme's active site; therefore, less active sites are available to Substrate A so less product will be produced. The results for test tube 2 indicate that Substrate B is a reversible inhibitor.)

Question 6/ 115

[VCAA 2020 SA Q13]

It is reasonable to conclude that

A Celluclast[®] is inactive at 61°C.

B Celluclast[®] is denatured at 35°C.

C the optimum pH for Celluclast[®] is pH 5.

D the optimum temperature for Celluclast[®] is around 57°C.

Solution

3-51 [VCAA 2020 SA Q13]

It is reasonable to conclude that

D the optimum temperature for Celluclast[®] is around 57°C. (At 61°C Celluclast is still active but less active than at 57°C. At 35°C the lack of activity is due to low temperature rather than denaturing. There is no information on pH.)

Question 7/ 115

[VCAA 2020 SA Q14]

The error bars on the graph indicate that the measurements taken at

A 38°C were more valid than at 35°C.

B 52°C were more precise than at 46°C.

C 46°C were more accurate than at 55°C.

D 58°C had more random errors than at 42°C.

Solution

3-52 [VCAA 2020 SA Q14]

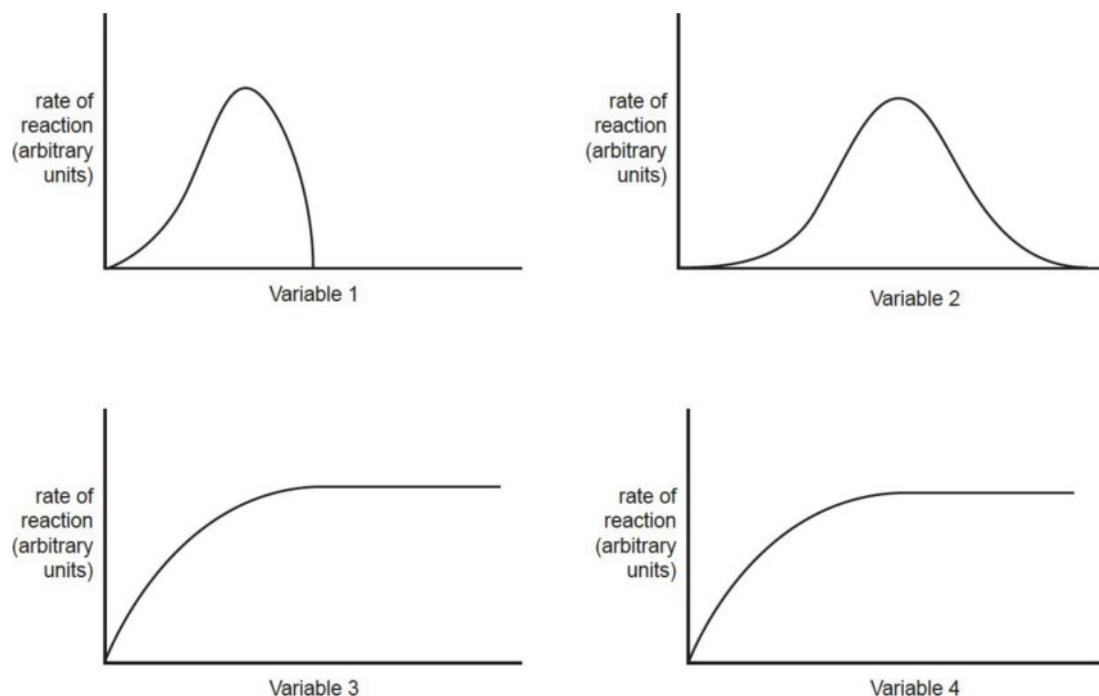
The error bars on the graph indicate that the measurements taken at

B 52°C were more precise than at 46°C. (The smaller the length of the error bars the greater the accuracy. Note that 52°C the error bar is narrower than at 46°C.)

Question 8/ 115

[VCAA 2018 SA Q7]

Four students performed a series of experiments to investigate the effect of four different variables on the rate of an enzyme-catalysed reaction. In each experiment the students changed one of the following variables: substrate concentration, pH, temperature and enzyme concentration. After recording their data, the students displayed their results in a series of graphs, as shown below. Each graph is a line of best fit for their data.



The students did not label the horizontal axis on any of their graphs. The next day, the students could not agree on which variable should be labelled on the horizontal axis of each graph. The students made the

suggestions on the following page as to what each variable could be.

Student	Variable 1	Variable 2	Variable 3	Variable 4
Marcus	substrate concentration	temperature	pH	enzyme concentration
Billy	temperature	substrate concentration	enzyme concentration	pH
Voula	enzyme concentration	temperature	substrate concentration	pH
Sheena	temperature	pH	enzyme concentration	substrate concentration

Which student correctly identified all four variables on the horizontal axes?

A Marcus

B Billy

C Voula

D Sheena

Solution

3-53 [VCAA 2018 SA Q7]

Which student correctly identified all four variables on the horizontal axes?

D Sheena (Variable 1 has to be temperature – activity rises to maximum before the enzyme is denatured. Enzymes usually have a pH optimum, as pH rises activity increases to the optimum then drops off. For variables 3 and 4 – rate of reaction rises to a maximum – additional enzyme or substrate do not cause a further increase.)

[VCAA 2017 SA Q6]

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

A increased the concentration of catalase by adding less water to the ground potato.

B increased the temperature by placing the test tube in a water bath set at 30°C.

C used a hydrogen peroxide solution with a higher concentration.

D added a catalase suspension made from a cooked potato chip.

Solution

3-54 [VCAA2017 SA Q6]

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

C used a hydrogen peroxide solution with a higher concentration. (The graph shows an increase in the volume of oxygen produced, i.e. an increase in the amount of final product. Increasing temperature and amount of enzyme will not increase the amount of final product but increasing the initial amount of substrate will.)

Question 11/ 115

[VCAA 2017 SA Q7]

The student then performed more tests by varying the pH of the buffer solution. It is expected that

A at pH 6 the reaction will cease.

B at pH 9 the reaction will be faster.

C at pH 2 and pH 10 very little oxygen will be produced.

D a greater volume of oxygen will be produced each time the pH is increased.

Solution

3-55 [VCAA 2017 SA Q7]

It is expected that

C at pH 2 and pH 10 very little oxygen will be produced. (Extremes of pH denature enzymes therefore the reaction will only occur slowly. pH 6 is close to the optimum pH of 7 therefore the reaction will occur to some extent.)

Question 12/ 115

[VCAA 2017 SA Q8]

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

The reason the student calibrated the pH meter was to

A ensure a random error would not influence the results.

B eliminate the effect of all uncontrolled variables.

C enable the use of the instrument with precision.

D allow the pH to be measured accurately.

Solution

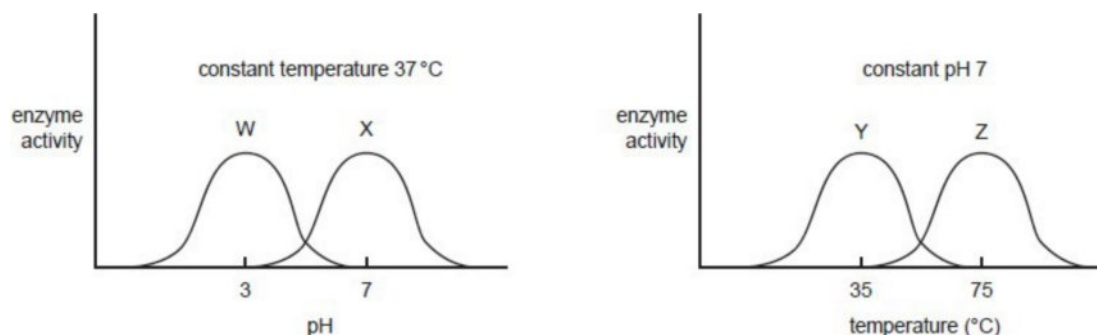
3-56 [VCAA 2017 SA Q8]

The reason the student calibrated the pH meter was to

D allow the pH to be measured accurately. (Accuracy refers to how close a measurement is to the true value or standard, whereas precision refers to how closely two or more measurements agree. Measurements may be precise but inaccurate.)

[VCAA 2014 SA Q13]

The following graphs show the way four enzymes, W, X, Y and Z, change their activity in different pH and temperature situations.



Which one of the following statements about the activity of the four enzymes is true?

A At pH 7, enzyme Y is denatured at temperatures below 20°C.

B Enzyme Z could be an intracellular human enzyme.

C At pH 3 and a temperature of 37°C, the active site of enzyme W binds well with its substrate.

D At pH 3 and a temperature of 37°C, enzyme X functions at its optimum.

Solution

3-57 [VCAA 2014 SA Q13]

Which one of the following statements about the activity of the four enzymes is true?

C At pH 3 and a temperature of 37°C, the active site of enzyme W binds well with its substrate.
(Enzymes are not denatured by low temperatures. The optimal temperature for Z is 75°C therefore, it is unlikely to be from the human body where the temperature is 37°C. Enzyme X optimum is at pH 7.)

[VCAA 2012 E1 SA Q2]

The activity of an enzyme is

A decreased by the presence of an inhibitor.

B unaffected by the pH of the cytosol of a cell.

C reduced at very low temperatures due to denaturation.

D increased as the temperature rises above the enzyme's optimum temperature.

Solution

3-58 [VCAA 2012 E1 SA Q2]

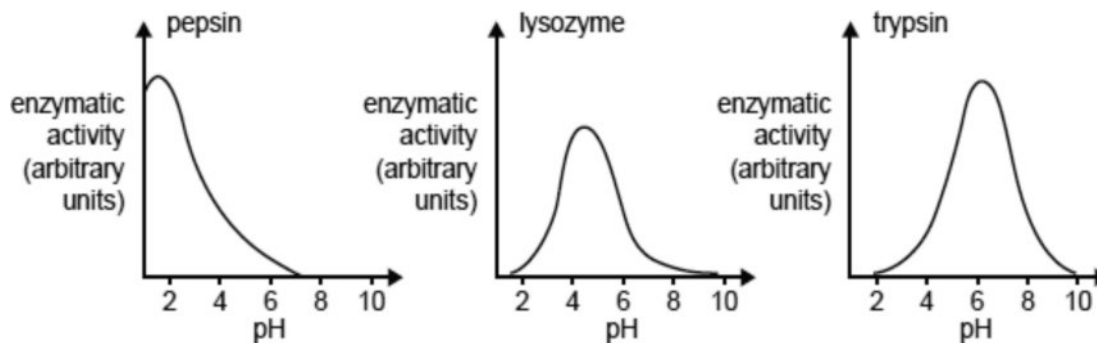
The activity of an enzyme is

A decreased by the presence of an inhibitor. (Enzymes are denatured by high temperatures and have an optimum pH for activity.)

Question 15/ 115

[VCAA 2011 E1 SA Q16]

Examine the following graphs.



From these graphs it is reasonable to infer that at a pH of 4

A trypsin would be inactive.

B all the pepsin would be denatured.

C all three enzymes would lack a functional active site.

D lysozyme has the highest activity of the three enzymes.

Solution

3-59 [VCAA 2011 E1 SA Q16]

From these graphs it is reasonable to infer that at a pH of 4

D lysozyme has the highest activity of the three enzymes. (Looking at the graphs at pH 4 lysozyme is just about at the optimum pH activity. In all other cases the statement is incorrect or there is insufficient information to make a conclusion.)

Question 16/ 115

[VCAA 2011 E1 SA Q22]

The following image is of a Siamese cat.



The colour produced in the fur of a Siamese cat is under the control of a tyrosinase enzyme that is sensitive to particular temperatures. A summary of the enzyme action is

pigment precursor $\xrightarrow{\text{body temperature at or above } 37^{\circ}\text{C}}$ no pigment produced

pigment precursor $\xrightarrow{\text{body temperature below } 37^{\circ}\text{C}}$ pigment produced

The core body temperature of a cat ranges from about 38°C to 39.2°C . It is likely that in Melbourne

A Siamese kittens have dark fur over their bodies when they are born.

B Siamese cats that live outside a house show an increase in pigment during summer.

C Siamese cats that live inside a house in winter have darker fur than those that live outside.

D Siamese cats that live outside in winter have darker fur than Siamese cats in tropical regions.

Solution

3-60 [VCAA 2011 E1 SA Q22]

It is likely that in Melbourne

D Siamese cats that live outside in winter have darker fur than Siamese cats in tropical regions. (You need to have realised that while the core temperature might be constant and above 37°C . No matter what the external temperature is, the temperature of extremities, such as the tail and ears, may be cooler than 37°C and therefore pigment may be produced.)

Question 17/ 115

[VCAA 2018 SA Q10]

Which pair of molecules contains the greatest amount of stored energy?

A NADH and ATP

B NAD^{+} and ATP

C NAD^{+} and ADP

D NADH and ADP

Solution

3-61 [VCAA 2018 SA Q10]

Which pair of molecules contains the greatest amount of stored energy?

A NADH and ATP (These are the largest molecules and contain the biggest stores of chemical energy. Consider alternative D – ADP is converted to ATP with the addition of a free phosphate molecule and energy.)

Question 18/ 115

[VCAA 2017 SA Q16]

A molecule that takes part in many biochemical reactions is NADP^+ . It is correct to state that

A NADP^+ becomes NADH when it is loaded.

B NADP^+ has a higher energy level when it is unloaded.

C energy is released when NADP^+ is converted to NADPH.

D NADP^+ carries additional energy when protons and electrons are added to it.

Solution

3-62 [VCAA 2017 SA Q16]

It is correct to state that

D NADP^+ carries additional energy when protons and electrons are added to it. (NADP^+ becomes NADPH not NADH. Loaded NADPH has a higher energy level and energy is released when NADPH is converted to NADP^+ .)

Question 19/ 115

[VCAA 2016 SA Q9]

ATP is important in living cells as it

A is required for osmosis.

B provides a supply of usable energy for the cell.

C provides one of the building blocks for lipid synthesis.

D is an important structural component of the plasma membrane.

Solution

3-63 [VCAA 2016 SA Q9]

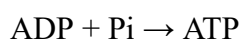
ATP is important in living cells as it

B. provides a supply of usable energy for the cell. (ATP is the immediate source of energy for cellular activity. Osmosis is a passive process not requiring energy, ATP is not a component of lipids or plasma membranes.)

Question 20/ 115

[VCAA 2015 SA Q7]

The production of adenosine triphosphate (ATP) is represented by the following equation.



The production of ATP

A is a catabolic reaction.

B requires an overall input of energy.

C only occurs in the absence of oxygen.

D occurs only in the mitochondria of a cell.

Solution

3-64 [VCAA 2015 SA Q7]

The production of ATP

B requires an overall input of energy. (The reaction is a synthesis reaction – building bigger molecules – therefore requires an energy input. ATP is also produced in anaerobic respiration, which occurs in the cytoplasm.)

Question 21/ 115

[VCAA 2016 SA Q16]

Which one of the following is a catabolic process?

A the conversion of glycogen to glucose.

B the production of carbohydrates during photosynthesis.

C the synthesis of a polypeptide hormone from amino acids.

D the formation of a triglyceride from glycerol and fatty acids.

Solution

3-65 [VCAA 2016 SA Q16]

Which one of the following is a catabolic process?

A the conversion of glycogen to glucose (Catabolic processes involve a release of energy. The other three processes are synthesis reactions and require an energy input.)

Question 22/ 115

[VCAA 2020 SA Q9]

The dependent variable in this experiment is the

A amount of sodium hydrogen carbonate added to the beaker.

B number of bubbles produced in one minute.

C time taken to count the bubbles produced.

D distance of the lamp from the beaker.

Solution

3-66 [VCAA 2020 SA Q9]

The dependent variable in this experiment is the

B number of bubbles produced in one minute. (The dependent variable is what the scientist measures. In this example, the number of bubbles produced in one minute is measured by the scientist.)

Question 23/ 115

[VCAA 2020 SA Q10]

The bubbles produced in this experiment are likely to contain

A oxygen.

B glucose.

C water vapour.

D carbon dioxide.

Solution

3-67 [VCAA 2020 SA Q10]

The bubbles produced in this experiment are likely to contain

A oxygen. (The process that is occurring is photosynthesis. The bubbles of gas will be oxygen a product of photosynthesis.)

Question 24/ 115

[VCAA 2020 SA Q11]

Repeating the experiment three times and finding an average result at each distance increases the

A reliability of the data.

B accuracy of the data.

C precision of the data.

D validity of the data.

Solution

3-68 [VCAA 2020 SA Q11]

Repeating the experiment three times and finding an average result at each distance increases the

A reliability of the data. (By repeating the experiment, the scientist is looking for consistency in results. If

repeating the experiment under the same conditions yields similar or consistent results, the results can be seen as reliable.)

Question 26/ 115

[VCAA 2022 SA Q9]

Where in a plant cell would the stage of the photosynthetic process shown above be located?

A mitochondria.

B thylakoid membrane.

C chloroplast inner membrane.

D chloroplast outer membrane.

Solution

3-69 [VCAA 2022 SA Q9]

Where in a plant cell would the stage of the photosynthetic process shown above be located?

B thylakoid membrane. (The diagram is of the light-dependent stage of photosynthesis which occurs on the thylakoid membranes of the grana.)

Question 27/ 115

[VCAA 2022 SA Q10]

In the diagram shown above, what do V, W and Z represent respectively?

A water, ATP and NADP^+ .

B oxygen, ATP and NADPH.

C oxygen, ADP and NADPH.

D carbon dioxide, ADP and NADP⁺.

Solution

3-70 [VCAA 2022 SA Q10]

In the diagram shown above, what do V, W and Z represent respectively?

C oxygen, ADP and NADPH (The inputs into the light-dependent stage of photosynthesis include NADP⁺, H₂O, ADP, and Pi. These are represented by U, W and Y. The outputs are NADPH, ATP and O₂. These are represented by V, X and Z.)

Question 28/ 115

[VCAA 2021 SA Q5]

Consider the process of photosynthesis.

Which of the following shows correct information about each of the two stages of photosynthesis?

	Light-dependent stage	Light-independent stage
A	produces oxygen	produces carbon dioxide
B	requires water	requires NADH
C	occurs in the stroma	occurs in the grana
D	energy is provided by light	energy is provided by ATP molecules

Solution

3-71 [VCAA 2021 SA Q5]

Which of the following shows correct information about each of the two stages of photosynthesis?

Light-dependent stage	Light – independent stage
energy is provided by light	energy is provided by ATP molecules

D. (Understanding of photosynthesis – during the light-dependent stage, light is absorbed by the leaf to produce ATP that is later used in the light-independent stage as a source of energy to synthesise glucose.)

Question 29/ 115

[VCAA 2020 SA Q12]

During photosynthesis

A ATP and NADH created in the light-independent stage are transported to the chloroplasts' thylakoid membranes.

B ADP and NADH are used in the electron transport chain after being created in the light-dependent stage.

C ATP and NADPH are created in the grana of the chloroplasts and are used in the light-independent stage.

D ADP and NADPH are created during the Krebs cycle and carried to the stroma of the chloroplasts.

Solution

3-72 [VCAA 2020 SA Q12]

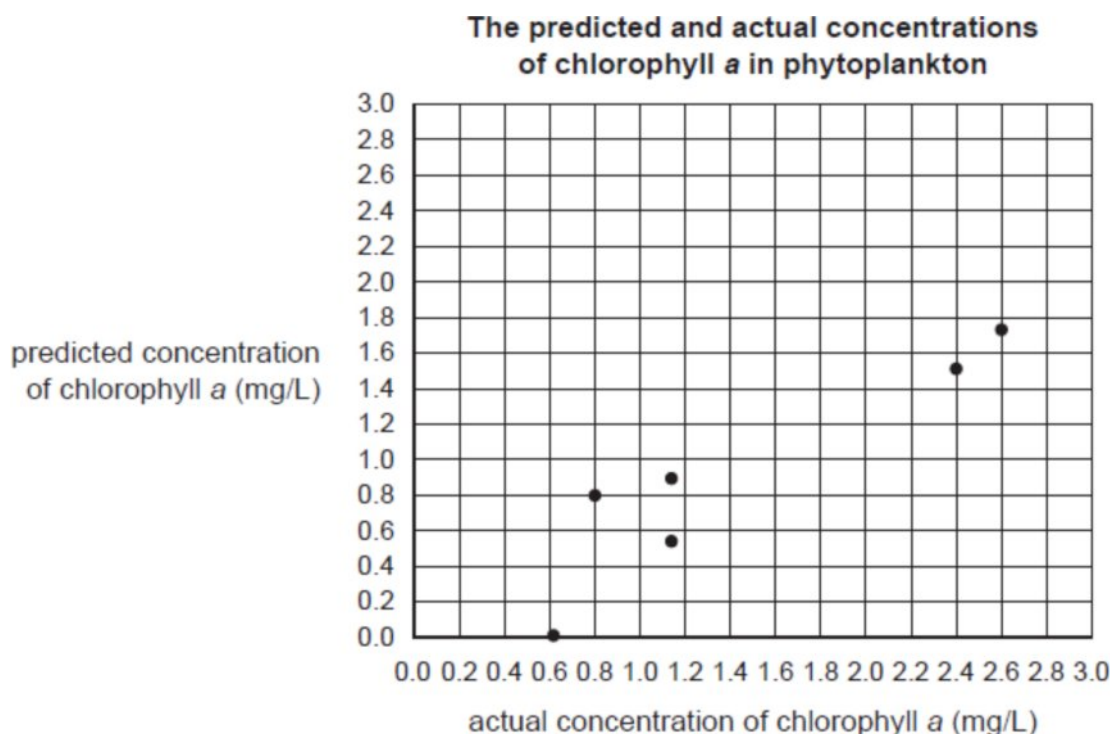
During photosynthesis

C ATP and NADPH are created in the grana of the chloroplasts and are used in the light-independent stage. (Facts. D is incorrect as the Krebs cycle is part of respiration – not photosynthesis. ATP and NADPH are produced in the light- dependent reactions that occur in the grana that are necessary for the light-independent reactions.)

Question 30/ 115

[VCAA 2021 SA Q8]

The graph below shows the relationship between the predicted and actual concentrations of chlorophyll a in phytoplankton.



Source: Fairouz Binti Johan et al, 'Chlorophyll a concentration of fresh water phytoplankton analysed by algorithmic based spectroscopy', *Journal of Physics: Conference Series*, 1083 (2018) 012015, <https://iopscience.iop.org/article/10.1088/1742-6596/1083/1/012015/pdf>

From the graph, it can be inferred that

A the actual concentration of chlorophyll a was lower than the predicted concentration in all recorded measurements.

B at 2.4 mg/L actual concentration of chlorophyll a, the predicted concentration of chlorophyll a was 2 mg/L.

C at 0.8 mg/L, the predicted concentration and the actual concentration of chlorophyll a were the same.

D at zero predicted concentration of chlorophyll a, photosynthesis did not occur.

Solution

3-73 [VCAA 2021 SA Q8]

From the graph, it can be inferred that

C at 0.8 mg/L, the predicted concentration, and the actual concentration of chlorophyll a were the same. (Use a ruler and carefully read the graph – 0.8 on the vertical scale (predicted) corresponds to 0.8 on the horizontal scale.)

Alternatives A and B are incorrect. D may be correct, but you are not provided with information about the rate of photosynthesis.)

Question 31/ 115

[VCAA 2020 SA Q33]

A student completed an experiment to investigate how light is reflected from different leaves. The results were recorded qualitatively.

Which one of the following could be a correct statement about the qualitative data obtained by the student?

A An average result for the data could be obtained.

B The same number would be recorded for each result.

C The data was obtained by measuring the wavelength of light.

D The data could be the names of the different colours of the reflected light.

Solution

3-74 [VCAA 2020 SA Q33]

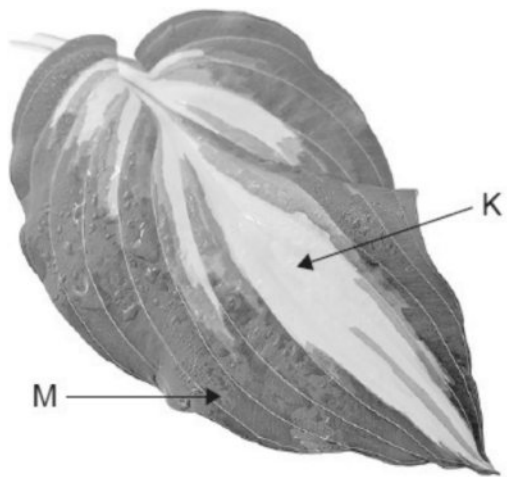
Which one of the following could be a correct statement about the qualitative data obtained by the student?

D The data could be the names of the different colours of the reflected light. (The keyword is qualitative data – that is descriptive data – not numerical or quantitative data. The only alternative that involves qualitative data is D.)

Question 32/ 115

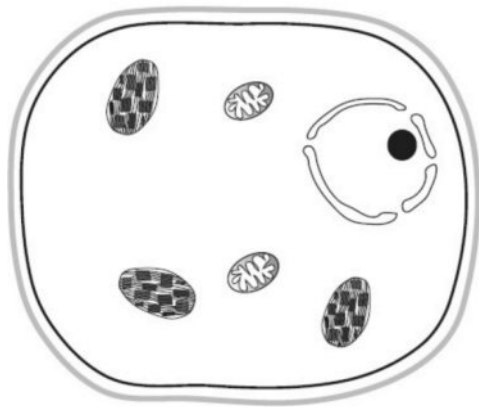
[VCAA 2017 SA Q15]

A variegated leaf from a plant is shown below.

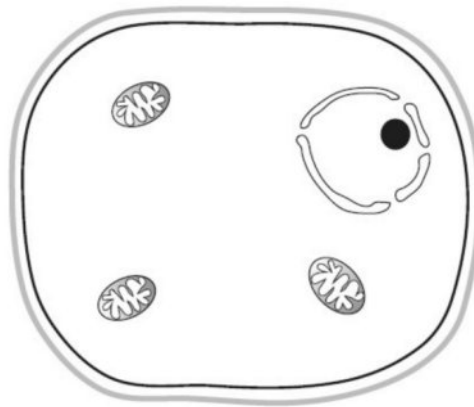


Cells from sections M and K were examined and simple sketches were produced.

A typical cell from section M



A typical cell from section K



From this information, it can be concluded that

A cells in section K would be unable to carry out aerobic respiration.

B light-independent reactions of photosynthesis can occur in cells from section K.

C there is chlorophyll present in cells from section K but not in cells from section M.

D glucose would be manufactured from carbon dioxide and water in cells from section M but not in cells from section K.

Solution

3-75 [VCAA 2017 SA Q15]

From this information, it can be concluded that

D glucose would be manufactured from carbon dioxide and water in cells from section M but not in cells from section K. (Cell K lacks chloroplasts therefore chlorophyll is not present and the light-dependent reactions and following light independent reactions cannot occur. Cell K has mitochondria therefore the cell is able to aerobically respire. Cell M has chloroplasts therefore it can photosynthesise.)

Question 33/ 115

[VCAA 2014 SA Q7]

During photosynthesis in chloroplasts, energy is used to split water, forming oxygen and hydrogen ions. The splitting of water occurs

A in the stroma during the light-independent reaction.

B in the grana during the light-dependent reaction.

C on the membrane of the thylakoids during the light-independent reaction.

D on the surface of the outer chloroplast membrane during the light-dependent reaction.

Solution

3-76 [VCAA 2014 SA Q7]

During photosynthesis in chloroplasts, energy is used to split water, forming oxygen and hydrogen ions. The splitting of water occurs

B in the grana during the light-dependent reaction. (The stroma is the site of the light-independent reactions, but this is not where water is split. The light-dependent reactions occur on the thylakoid membranes of the grana.)

Question 34/ 115

[VCAA 2016 SA Q10]

Plants grown in light were supplied with water containing radioactive oxygen atoms. After four hours, an analysis of the chemicals in and around the plants was undertaken.

Which one of the following would contain the radioactive oxygen atoms after four hours?

A protein

B glucose

C oxygen gas

D carbon dioxide gas

Solution

3-77 [VCAA 2016 SA Q10]

Which one of the following would contain the radioactive oxygen atoms after four hours?

C oxygen gas (As a plant photosynthesises, it uses water.)

Question 35/ 115

[VCAA 2021 SA Q7]

Ribulose biphosphate carboxylase/oxygenase (Rubisco) is an enzyme found in green plants. Rubisco is important in two reactions. These reactions are shown below.

Reaction 1

ribulose1,5-bisphosphate + oxygen



2 phosphoglycolate + 3 phosphoglycerate

Reaction 2

ribulose1,5-bisphosphate + carbon dioxide



3 phosphoglycerate

A Biology student hypothesised that the same active site on Rubisco is used in Reaction 1 and Reaction 2.

Which one of the following observations would support this hypothesis?

A The rate of Reaction 2 increases when the temperature is increased.

B The rate of Reaction 2 decreases when the concentration of oxygen is increased.

C The rate of both reactions decreases when the concentration of Rubisco is increased.

D The rate of Reaction 1 increases when the concentration of carbon dioxide is increased.

Solution**3-78 [VCAA 2021 SA Q7]**

Which one of the following observations would support this hypothesis?

B The rate of Reaction 2 decreases when the concentration of oxygen is increased. (If the same active site on Rubisco is used for both reactions, when oxygen concentration increases, oxygen will compete with carbon dioxide for the active site and the rate of Reaction 2 will decrease.)

Question 36/ 115

[VCAA 2016 SA Q11]

Which one of the following statements about photosynthesis in chloroplasts is correct?

A The grana are the site of the light-independent stage.

B Chlorophyll found in the stroma traps light for use during the light-dependent stage.

C The light-dependent stage produces ATP for use during the light-independent stage.

D The light-independent stage captures carbon dioxide for use during the light- dependent stage to produce glucose.

Solution

3-79 [VCAA 2016 SA Q11]

Which one of the following statements about photosynthesis in chloroplasts is correct?

C The light-dependent stage produces ATP for use during the light- independent stage. (A detailed understanding of the inputs and outputs of all stages of photosynthesis is required. Light energy is the input required to make ATP a source of energy available at all times. Chlorophyll is found in the grana rather than the stoma.)

Question 37/ 115

[VCAA 2014 SA Q8]

An increase in the atmospheric CO₂ level increases the rate of photosynthesis. The rate of photosynthesis increases because

A the rate of the light-independent reactions on the thylakoid membranes of the chloroplasts increases.

B water loss from the leaf decreases, resulting in the availability of water for photosynthesis increasing.

C the increased CO₂ level lowers the pH inside the chloroplasts and increases the rate of enzyme-catalysed reactions.

D the rate of the light-independent reactions in the stroma increases with the increase in CO₂ level.

Solution

3-80 [VCAA 2014 SA Q8]

The rate of photosynthesis increases because

D the rate of the light-independent reactions in the stroma increases with the increase in CO₂ level.

(CO₂ is an input to the Calvin cycle, which is part of the light-independent reactions, which occur in the stroma.)

Question 38/ 115

[Adapted VCAA 2012 E1 SA Q22]

Carbon dioxide is an input in

- A synthesis of polypeptide molecules.
- B breakdown of glucose during glycolysis.
- C the light-independent reactions of photosynthesis.
- D the electron transport chain in cellular respiration.

Solution

3-81 [VCAA 2012 E1 SA Q22]

The process that produces the largest number of ATP molecules is

D the electron transport chain in cellular respiration. (Fact. Synthesis requires the conversion of ATP to ADP; glycolysis and the light-independent reactions produce only a small amount of ATP.)

Question 40/ 115

[VCAA 2018 SA Q14]

The light-independent reaction of photosynthesis occurs at

A T.

B U.

C V.

D W.

Solution

3-82 [VCAA 2018 SA Q14]

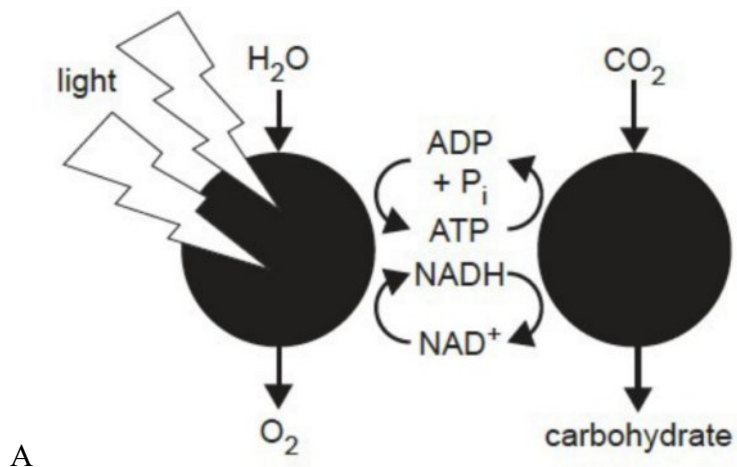
The light-independent reaction of photosynthesis occurs at

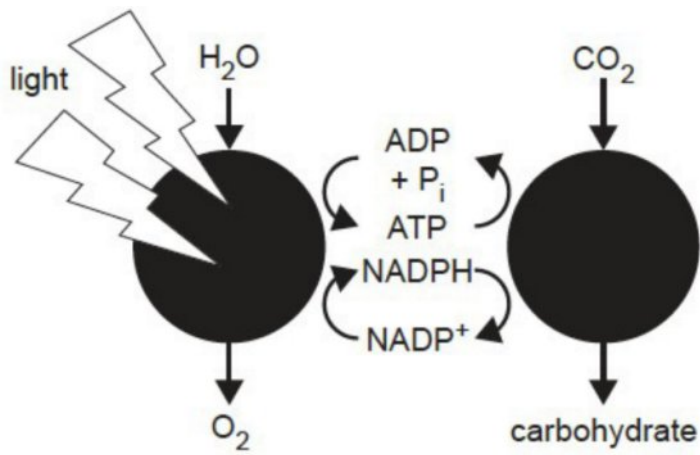
B U. (U is the matrix of the chloroplast and is the site of the light-independent reactions. The light-dependent reactions occur at R – the grana.)

Question 41/ 115

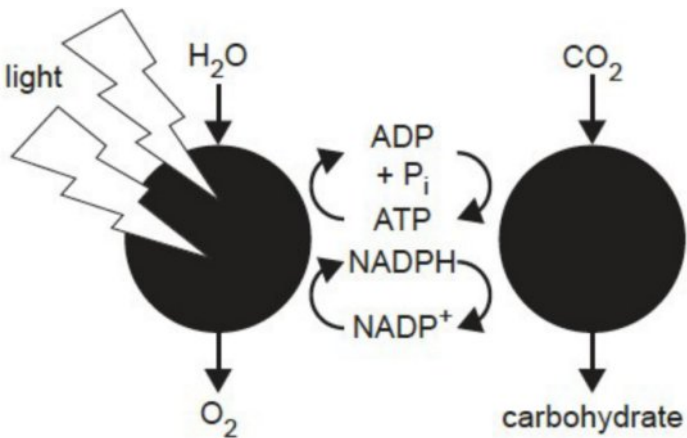
[VCAA 2018 SA Q15]

Which one of the following diagrams correctly represents the inputs and outputs of photosynthesis?

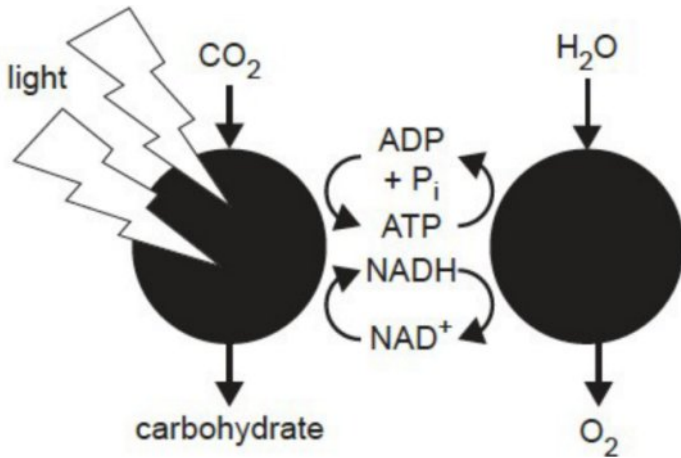




B



C



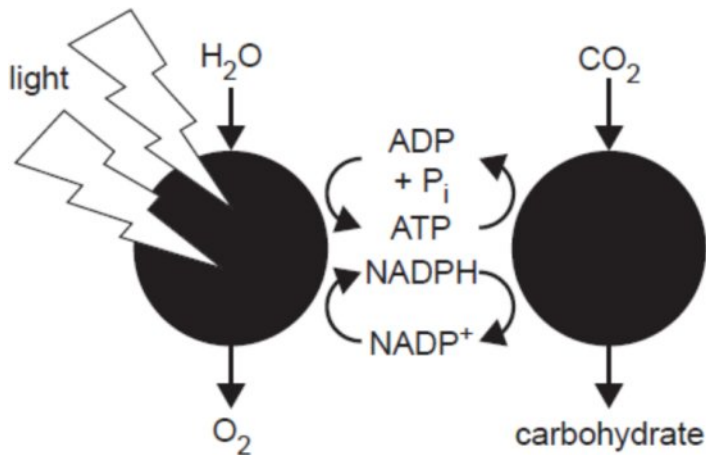
D

Solution

3-83 [VCAA 2018 SA Q15]

Which one of the following diagrams correctly represents the inputs and outputs of photosynthesis?

B.

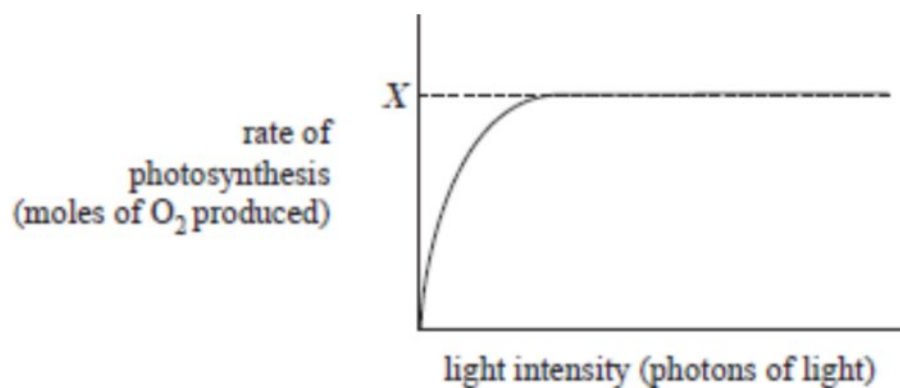


(**D** is incorrect because CO₂ is not split in the light-dependent reaction. **A** is incorrect – it should be NADPH and NADP⁺ rather than NADH and NAD⁺. **C** and **B** are nearly identical but note the direction of arrows in ATP production – as carbohydrate is produced ATP is broken down – hence **B** is correct.)

Question 42/ 115

[VCAA 2022 SA Q11]

A student shone a light on a green leaf and measured the rate of photosynthesis. The student varied the intensity of the light and graphed the findings as shown below. X was the maximum rate of photosynthesis detected by the student.



Which one of the following conditions will increase the value of X?

A adding a filter to the light used

B using a leaf that contains more chloroplasts

C moving the light further away from the leaf

D decreasing the temperature of the leaf's environment

Solution

3-84 [VCAA 2022 SA Q11]

Which one of the following conditions will increase the value of X?

B using a leaf that contains more chloroplasts. (At point X, light intensity is no longer the limiting factor; therefore, adding a filter or moving the light away from the leaf will not increase the rate of photosynthesis. Decreasing temperature will decrease the rate of photosynthesis. Increasing the number of chloroplasts will allow more light to be absorbed by the leaf and thus, the rate of photosynthesis will increase.)

Question 43/ 115

[VCAA 2022 SA Q12]

A plant specialist was investigating the viability of producing a new plant variety. The plant specialist investigated the optimum time to grow the new plant variety in Brisbane, Queensland. This plant flourishes when the temperature is above 20°C, the precipitation is less than 50 mm per month and the number of daylight hours exceeds eight hours per day.

An example of qualitative data that the plant specialist may collect to assist their investigation of the viability of producing the new plant variety would be

A recording the number of days per year that the temperature falls below 20°C in Queensland.

B determining the average number of hours of sunlight per day in Queensland.

C obtaining a list of the plant preferences from people living in Brisbane.

D calculating the mean monthly precipitation in Brisbane.

Solution

3-85 [VCAA 2022 SA Q12]

An example of qualitative data that the plant specialist may collect to assist their investigation of the viability of producing the new plant variety would be

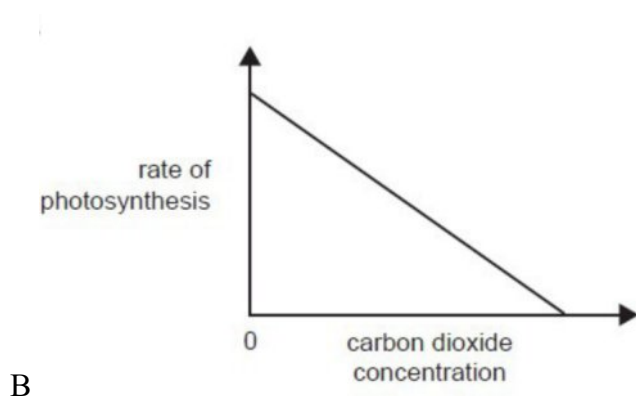
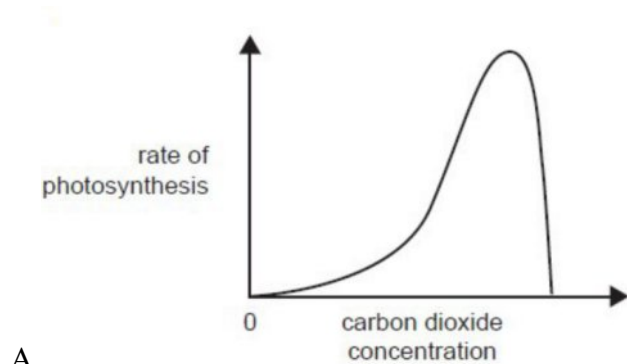
C obtaining a list of the plant preferences from people living in Brisbane. (Qualitative data is descriptive data.)

Question 44/ 115

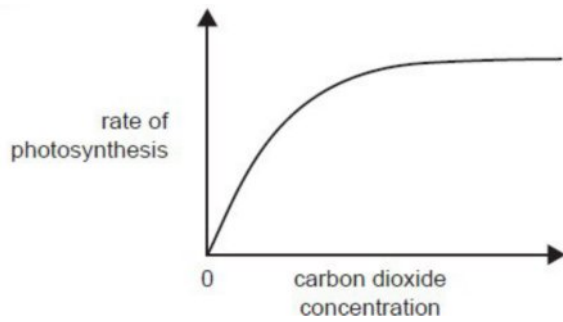
[VCAA 2021 SA Q6]

In a series of experiments, the rate of photosynthesis in plant cells was measured in environments with different concentrations of carbon dioxide. All other variables were kept constant.

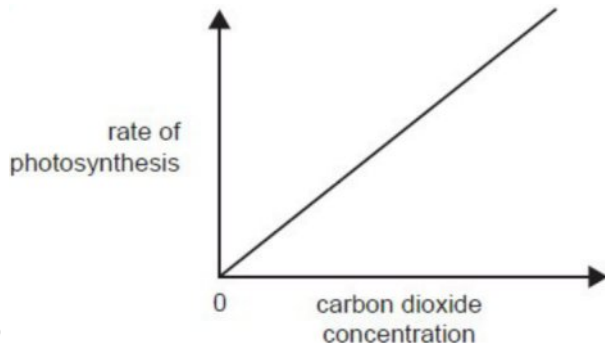
Which one of the following graphs reflects the trend that would be shown by the results of these experiments?



C



D

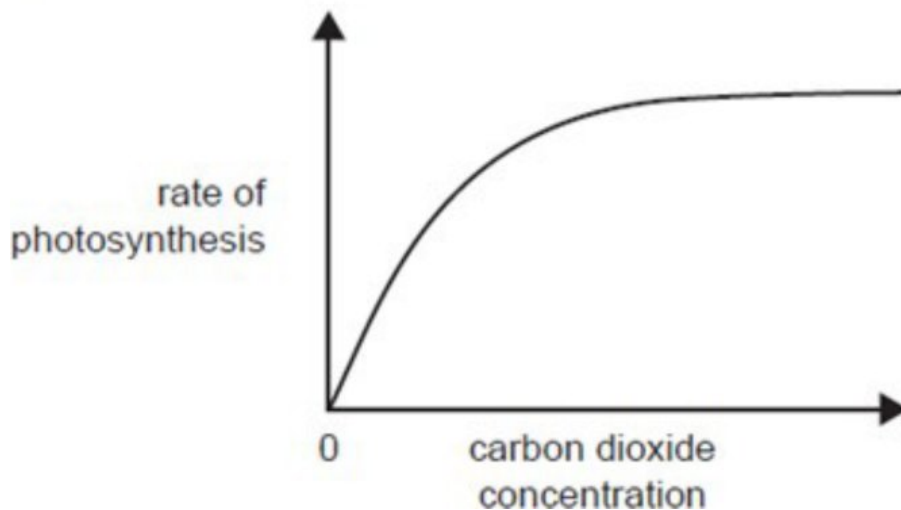


Solution

3-86 [VCAA 2021 SA Q6]

Which one of the following graphs reflects the trend that would be shown by the results of these experiments?

C.

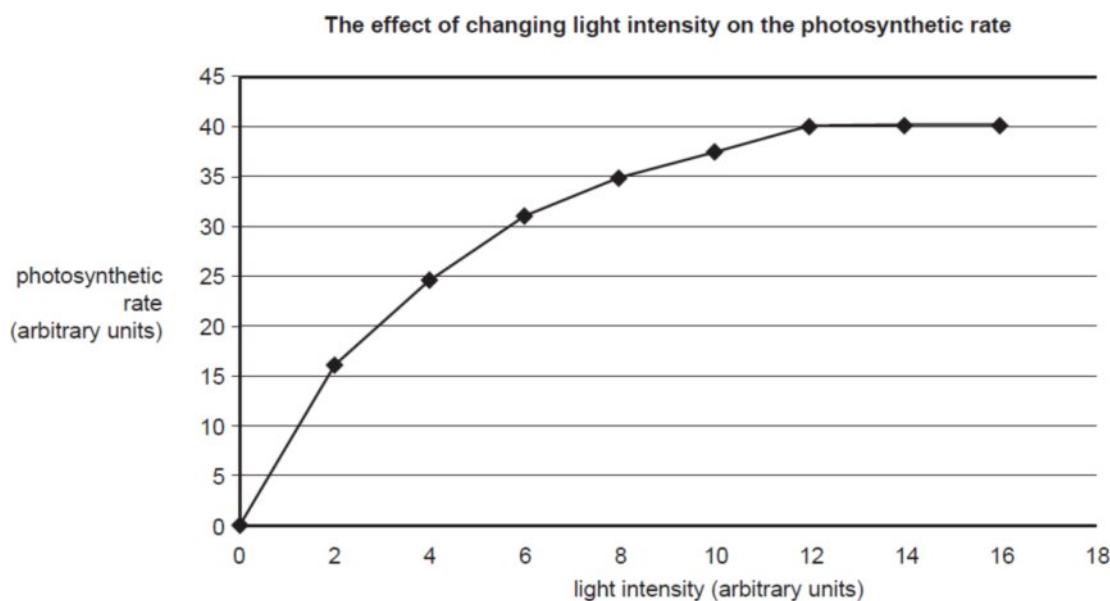


(Rate of photosynthesis will increase up to a point where further increase in carbon dioxide concentration does not increase the rate of photosynthesis. Another factor, such as light, is a limiting factor.)

Question 45/ 115

[VCAA 2019 SA Q15]

An experiment was carried out at a constant temperature and with a constant carbon dioxide concentration in order to determine the effect of changing light intensity on the photosynthetic rate. The following is a graph of the results.



Based on your knowledge and the information in the graph on the previous page, which one of the following conclusions can be reached?

A Photosynthesis ceases to occur at a light intensity of 14 arbitrary units.

B Plants do not undergo photosynthesis at a light intensity of 1 arbitrary unit.

C Light intensity is a limiting factor when the photosynthetic rate is less than 40 arbitrary units.

D Increasing the amount of carbon dioxide at a light intensity of 16 arbitrary units would lead to a decrease in the photosynthetic rate.

Solution

3-87 [VCAA 2019 SA Q15]

Based on your knowledge and the information in the graph, which one of the following conclusions can be reached?

C Light intensity is a limiting factor when the photosynthetic rate is less than 40 arbitrary units.
(Based on the information given provided, light is a limiting factor up to 12 arbitrary units for light – graph levels off – photosynthetic rate then is constant at 40 arbitrary units. B is incorrect because some photosynthesis is occurring at 1 arbitrary unit. No information is given for changes in carbon dioxide level.)

Question 47/ 115

[VCAA 2017 SA Q13]

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

A At point T photosynthesis is no longer occurring.

B The optimal level of light intensity for photosynthesis is 40 AU.

C At point S the amount of oxygen output is a third of that at point P.

D Below 10 AU of light intensity the aerobic respiration rate is greater than the photosynthesis rate.

Solution

3-88 [VCAA 2017 SA Q13]

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

D Below 10 AU of light intensity the aerobic respiration rate is greater than the photosynthesis rate.
(Photosynthesis occurs as soon as the light is turned on. At point T, oxygen output from photosynthesis equals the oxygen input for aerobic respiration. The graph levels off at 50AU rather than 40AU.)

Question 48/ 115

[VCAA 2017 SA Q14]

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

A heat has denatured the enzymes involved in the photosynthesis reactions.

B the concentration of available carbon dioxide limits the rate of photosynthesis.

C the light intensity has damaged the chlorophyll molecules present in the spinach chloroplasts.

D high levels of oxygen produced at point P have accumulated around the spinach leaves, resulting in no more oxygen being produced.

Solution

3-89 [VCAA 2017 SA Q14]

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

B the concentration of available carbon dioxide limits the rate of photosynthesis. (If the enzymes are denatured or chlorophyll damaged the graph would not level off, rather the net output of oxygen would dramatically decrease.)

Question 50/ 115

[VCAA 2022 SA Q13]

Which metabolic pathway is found in Region 3 of the cell?

A electron transport chain

B Calvin cycle

C Krebs cycle

D glycolysis

Solution

3-90 [VCAA 2022 SA Q13]

Which metabolic pathway is found in Region 3 of the cell?

D glycolysis. (Region 3 is the cytosol of the cell. Glycolysis occurs in the cytosol.)

Question 51/ 115

[VCAA 2022 SA Q14]

Which of the following gives the names of compounds R, T and V, shown in the diagram above?

	R	T
A	lactic acid	carbon dioxide
B	lactic acid	carbon dioxide
C	pyruvate	carbon dioxide
D	pyruvate	NADH

Solution

3-91 [VCAA 2022 SA Q14]

Which of the following gives the names of compounds R, T and V, shown in the diagram above?

R	T	V
pyruvate	carbon dioxide	water

C. (Glycolysis occurs in region 3. In glycolysis, glucose is broken down into pyruvate, NADH and ATP; therefore, R must be pyruvate. The Krebs cycle occurs in region 2. Outputs of the Krebs cycle are CO₂, NADH, FADH₂ and ATP; therefore, T could be either CO₂ or NADH. Region 1 is the site of the electron transport chain where O₂ is an input and water is an output; therefore, V is water.)

Question 52/ 115

[VCAA 2022 SA Q15]

The carrier molecules represented in the previous diagram are

A NAD^+ and water.

B FAD^+ and oxygen.

C NADH and FADH_2 .

D NAD^+ , carbon dioxide and FADH_2 .

Solution

3-92 [VCAA 2022 SA Q15]

The carrier molecules represented in the previous diagram are

C NADH and FADH_2 . (Carrier molecules transport electrons. NADH and FADH_2 carry electrons in cellular respiration.)

Question 53/ 115

[VCAA 2022 SA Q16]

The last electron acceptor in cellular respiration is

A water.

B oxygen.

C NADH.

D carbon dioxide.

Solution

3-93 [VCAA 2022 SA Q16]

The last electron acceptor in cellular respiration is

B oxygen. (Electrons are accepted by oxygen at the end of the electron transport chain to form water.)

Question 55/ 115

[VCAA 2020 SA Q5]

Which one of the following is a correct statement?

A Pathway 2 releases oxygen as a by-product.

B Pathway 1 requires carbon dioxide as an input.

C ATP is produced in Pathway 1 and is used by the cell as an energy source.

D NADH created in Pathway 2 carries electrons into the electron transport chain.

Solution

3-94 [VCAA 2020 SA Q5]

Which one of the following is a correct statement?

D NADH created in Pathway 2 carries electrons into the electron transport chain. (The biochemical process shown in the diagram is respiration. Pathway 1 is anaerobic respiration and Pathway 2 is aerobic respiration. Carbon dioxide is an output of respiration, not an input and oxygen is an input to aerobic respiration.)

The electron transport chain is the final step in aerobic respiration.)

Question 56/ 115

[VCAA 2020 SA Q6]

The final products of Pathway 1 are produced in the

A cristae.

B cytosol.

C mitochondrial matrix.

D chloroplast membranes.

Solution

3-95 [VCAA 2020 SA Q6]

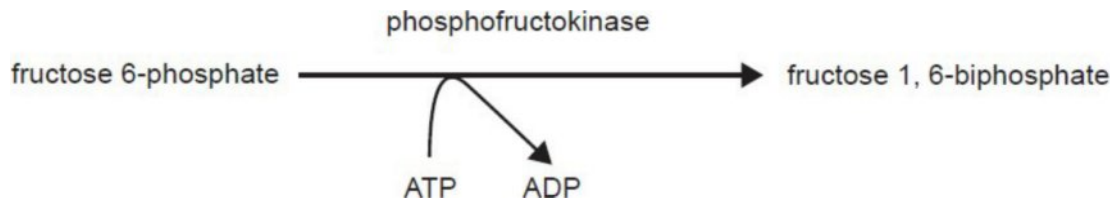
The final products of Pathway 1 are produced in the

B cytosol. (The pathway represents anaerobic respiration which occurs in the cytoplasm rather than the mitochondria.)

Question 57/ 115

[VCAA 2017 SA Q5]

The biochemical pathway of glycolysis involves nine intermediate reaction steps. One of these steps is represented in the diagram below.



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

A acts as a coenzyme.

B increases the rate of reaction.

C is the substrate for the reaction.

D releases energy in the form of ADP.

Solution

3-96 [VCAA 2017 SA Q5]

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

B increases the rate of reaction. (Phosphofructokinase is an enzyme; therefore, it increases the rate of the reaction. Fructose 6-phosphate is the substrate.)

Question 58/ 115

[VCAA 2019 SA Q14]

In glycolysis, the ATP yield per molecule of glucose is

A 4 ATP produced and 2 ATP used for a net gain of 2 ATP.

B 2 ATP produced and 4 ATP used for a net loss of 2 ATP.

C 36 to 38 ATP produced for a net gain of 2 ATP.

D 36 to 38 ATP used for a net loss of 2 ATP.

Solution

3-97 [VCAA 2019 SA Q14]

In glycolysis, the ATP yield per molecule of glucose is

A 4 ATP produced, and 2 ATP used for a net gain of 2 ATP. (Glycolysis is the first step in cellular respiration and results in a net gain of ATP, therefore A is correct and B incorrect. In the complete breakdown of a glucose molecule, there is a net gain of 36 to 38 ATP.)

Question 60/ 115

[VCAA 2019 SA Q7]

Which one of the following hypotheses is supported by the results?

A If the bacteria grow for four days, then the nutrient agar will be completely covered in bacteria.

B If the bacteria are kept in the dark, then the bacteria will grow more slowly.

C If the bacteria grow faster, then the temperature of the location will increase.

D If the temperature increases, then the bacteria will grow more quickly.

Solution

3-98 [VCAA 2019 SA Q7]

Which one of the following hypotheses is supported by the results?

D If the temperature increases, then the bacteria will grow more quickly. (Using the information given D is supported by the results. Going from -10°C to 25°C there is an increase in the percentage cover of agar from 0% to 60% over 4 days.)

Question 61/ 115

[VCAA 2019 SA Q8]

In this experiment, the dependent variable is.

A time.

B temperature.

C the number of bacterial cells.

D the percentage of nutrient agar covered by bacteria.

Solution

3-99 [VCAA 2019 SA Q8]

In this experiment, the dependent variable is

D the percentage of nutrient agar covered by bacteria. (The dependent variable in an experiment is the factor being measured – in this case % agar covered by algae. Temperature is an independent variable and time is the same for all setups.)

Question 62/ 115

[VCAA 2019 SA Q9]

The students wanted to check the reliability of their data. The students should

A repeat the experiment several times to find out if they would obtain the same data.

B organise their data into a different format to help identify a trend.

C change the independent variable in the experiment.

D rewrite the method for completing the experiment.

Solution

3-100 [VCAA 2019 SA Q9]

The students wanted to check the reliability of their data. The students should

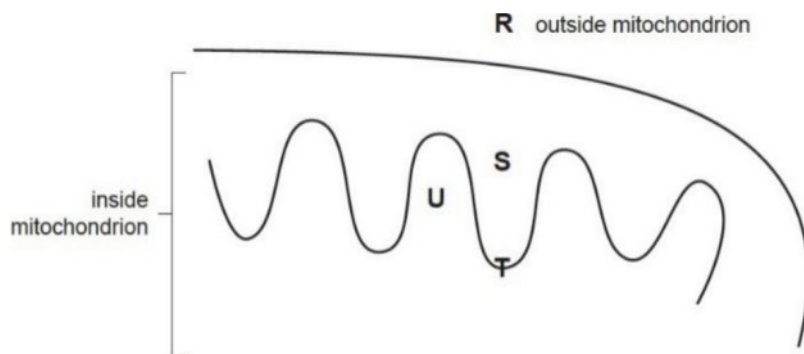
A repeat the experiment several times to find out if they would obtain the same data. (If the data is reliable, repeating the experiment should yield similar results. Rewriting the method or changing format will not affect reliability.

Changing the independent variable results in a different experiment.)

Question 63/ 115

[VCAA 2018 SA Q8]

The diagram that follows shows a section through a part of a mitochondrion.



The sites of the pathways in aerobic respiration are

A R – glycolysis, S – Krebs cycle, T – electron transport chain.

B U – glycolysis, T – Krebs cycle, R – electron transport chain.

C R – glycolysis, U – Krebs cycle, T – electron transport chain.

D D T – glycolysis, R – Krebs cycle, S – electron transport chain.

Solution

3-101 [VCAA 2018 SA Q8]

The sites of the pathways in aerobic respiration are

C R – glycolysis, U – Krebs cycle, T – electron transport chain. (Glycolysis occurs in the cytoplasm, so the answer is one of A or C. Krebs cycle occurs in the mitochondrial matrix (U) and the electron transport membrane occurs in the membrane of mitochondria (T).)

Question 64/ 115

[VCAA 2018 SA Q9]

Which one of the following statements best explains the effect of rotenone in causing death in insects and fish?

A The rate of glycolysis would increase.

B ATP would accumulate in the mitochondria.

C Aerobic respiration in the mitochondria would be disrupted.

D The cell membrane would no longer be permeable to oxygen.

Solution

3-102 [VCAA 2018 SA Q9]

Which of the following gives the inputs and outputs of the electron transport chain in an animal cell?

Inputs

NADH, ADP, oxygen, P_i

Outputs

ATP, NAD⁺, water

A. (Fact)

Question 65/ 115

[VCAA 2017 SA Q11]

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

A adenosine triphosphate

B carbon dioxide

C glucose

D water

Solution

3-103 [VCAA 2017 SA Q11]

After this time, the radioactively labelled oxygen atoms would be present in which cellular chemical?

D water (During aerobic respiration, oxygen combines with H^+ to form water.)

Question 67/ 115

[VCAA 2015 SA Q9]

Which one of the following statements best explains the effect of rotenone in causing death in insects and fish?

A The rate of glycolysis would increase.

B ATP would accumulate in the mitochondria.

C Aerobic respiration in the mitochondria would be disrupted.

D The cell membrane would no longer be permeable to oxygen.

Solution

3-104 [VCAA 2015 SA Q9]

Which one of the following statements best explains the effect of rotenone in causing death in insects and fish?

C Aerobic respiration in the mitochondria would be disrupted. (The electron transport chain occurs on the inner membranes of mitochondria and requires oxygen and produces ATP. Glycolysis occurs in cytoplasm.)

Question 68/ 115

[VCAA 2015 SA Q10]

In the past, people sometimes put extracts containing rotenone into a river to poison the fish, allowing the fish to be more easily caught. When rotenone- poisoned fish are eaten by people, no poisonous effect is observed.

Which one of the following statements best explains this observation?

A Rotenone is not absorbed through the cell membranes of people who have eaten poisoned fish.

B Rotenone is not absorbed by fish tissue and remains dissolved in water.

C Human cell metabolism does not involve the electron transport chain.

D Rotenone only affects organisms that respire anaerobically.

Solution

3-105 [VCAA 2015 SA Q10]

Which one of the following statements best explains this observation?

A Rotenone is not absorbed through the cell membranes of people who have eaten poisoned fish. (Rotenone interferes with the electron transport chain involved in aerobic respiration. It is absorbed by fish tissue as the fish die.)

Question 69/ 115

[VCAA 2015 SA Q12]

A student was investigating four cell types from different organisms. She recorded the results of her microscopic examination of the cells in the table below.

	Cell W	Cell X	Cell Y	Cell Z
Mitochondria	few	many	absent	few
Chloroplasts	present	absent	absent	present
Nucleus	present	present	absent	present

Which one of the following is the correct conclusion that can be drawn from this data?

A Cell W could be a muscle cell from an insect.

B Cell Y could be a living leaf cell from a corn plant.

C Cell X could be a heart-muscle cell from a mammal.

D Cell Z could be an underground root cell from a pea plant.

Solution

3-106 [VCAA 2015 SA Q12]

Which one of the following is the correct conclusion that can be drawn from this data?

C Cell X could be a heart-muscle cell from a mammal. (Cell W contains chloroplasts so cannot be from an insect. Cell Y lacks chloroplasts so is not from a green leaf. Cell Z, if it was from root tissue would not

possess chloroplasts. Cell X, if from muscle tissue would be expected to have many mitochondria.)

Question 71/ 115

[VCAA 2012 E1 SA Q21]

The original source of energy for this reaction is

A ADP.

B glucose.

C sunlight.

D phosphate.

Solution

3-107 [VCAA 2012 E1 SA Q21]

C sunlight. (Fact. Light energy is converted during photosynthesis into chemical energy stored in glucose. This energy is converted into the energy stored in ATP in cellular respiration.)

Question 72/ 115

[VCAA 2012 E1 SA Q22]

The process that produces the largest number of ATP molecules is

A synthesis of polypeptide molecules.

B breakdown of glucose during glycolysis.

C the light-independent reactions of photosynthesis.

D the electron transport chain in cellular respiration.

Solution

3-108 [VCAA 2012 E1 SA Q22]

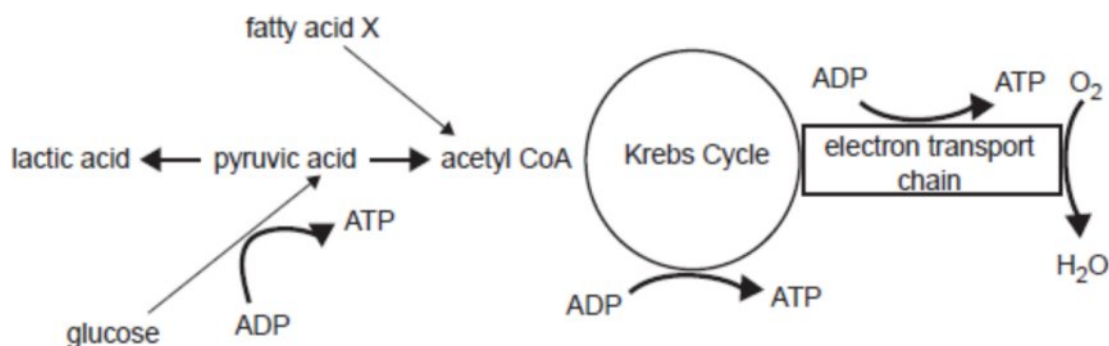
The process that produces the largest number of ATP molecules is

D the electron transport chain in cellular respiration. (Fact. Synthesis requires the conversion of ATP to ADP, glycolysis and the light-independent reactions produce only a small amount of ATP.)

Question 73/ 115

[VCAA 2014 SA Q12]

If there is insufficient glucose for cellular respiration, fatty acids can be changed to acetyl CoA. Each fatty acid X molecule produces eight molecules of acetyl CoA. The diagram below summarises the pathways for the breakdown of fatty acid X and glucose. The number of molecules produced in each step is not shown.



Referring to the information above and your knowledge of cellular respiration, which one of the following conclusions can be made?

A Most of the ATP is made in the Krebs Cycle.

B Pyruvic acid is converted to acetyl CoA under anaerobic conditions.

C No ATP can be formed from the breakdown of glucose under anaerobic conditions.

D One fatty acid X molecule produces more ATP in aerobic conditions than one glucose molecule does.

Solution

3-109 [VCAA 2014 SA Q12]

Referring to the information above and your knowledge of cellular respiration, which one of the following conclusions can be made?

D One fatty acid X molecule produces more ATP in aerobic conditions than one glucose molecule does. (6 ATP molecules and therefore 6 molecules of acetyl CoA are produced for each glucose molecule in aerobic respiration. The stem of the question tells you that 8 molecules of acetyl CoA are produced for each fatty acid.)

Question 74/ 115

[VCAA 2019 SA Q12]

During which process would the production of lactic acid be observed?

A aerobic cellular respiration.

B fermentation in animals.

C fermentation in yeasts.

D photosynthesis

Solution

3-110 [VCAA 2019 SA Q12]

During which process would the production of lactic acid be observed?

B fermentation in animals. (Fact: Lactic acid is produced during anaerobic respiration in animals, i.e. fermentation. In plants, the by-products are ethanol and carbon dioxide rather than lactic acid.)

Question 75/ 115

[VCAA 2022 SA Q18]

A student investigated the effect of temperature and oxygen on the production of lactic acid by cultured human skin cells. At the start of this experiment, each test tube contained the same number of skin cells and the same concentration of glucose. The temperature of each test tube and the amount of oxygen supplied to each test tube are given in the table below. After 24 hours, the student measured the amount of lactic acid in the test tubes.

Temperature and oxygen content of each test tube in the experiment

Test Tube	Temperature (°C)	Oxygen content (%)
1	20	20
2	37	20
3	37	5
4	75	5

Which test tube would be expected to contain the highest concentration of lactic acid?

A Test tube 1

B Test tube 2

C Test tube 3

D Test tube 4

Solution

3-111 [VCAA 2022 SA Q18]

Which test tube would be expected to contain the highest concentration of lactic acid?

C Test tube 3. (Lactic acid is produced in anaerobic respiration; therefore, most lactic acid will be produced where there is low oxygen concentration, i.e. in test tubes 3 and 4. At high temperatures, enzymes are denatured, resulting in a lower reaction rate; therefore, the most lactic acid will be produced in test tube

3.)

Question 76/ 115

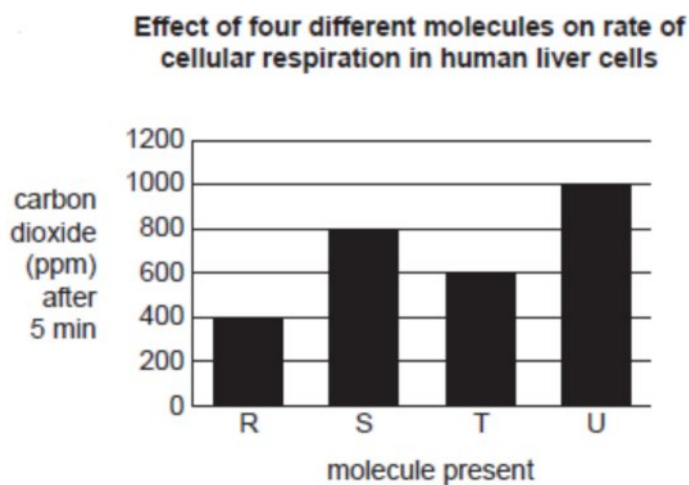
[VCAA 2020 SA Q40]

A student investigated the effect of the presence of four different molecules, R, S, T and U, on the rate of cellular respiration in human liver cells. The production of carbon dioxide by the cells was recorded over a five-minute interval. The final concentration of carbon dioxide was recorded. The data collected is shown below.

Molecule present	Concentration of carbon dioxide (ppm) after five minutes
R	400
S	800
T	600
U	1000

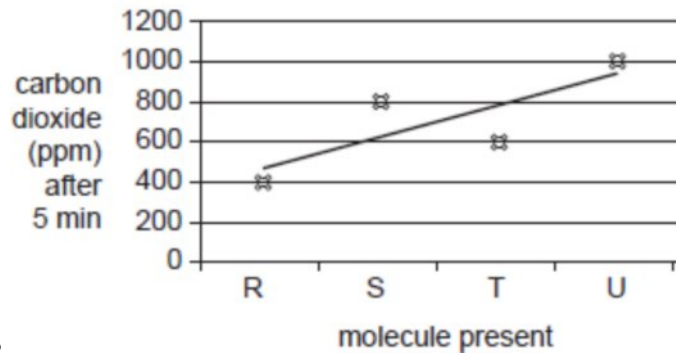
The student presented the results as a graph.

Which one of the following graphs is the best representation of the results?



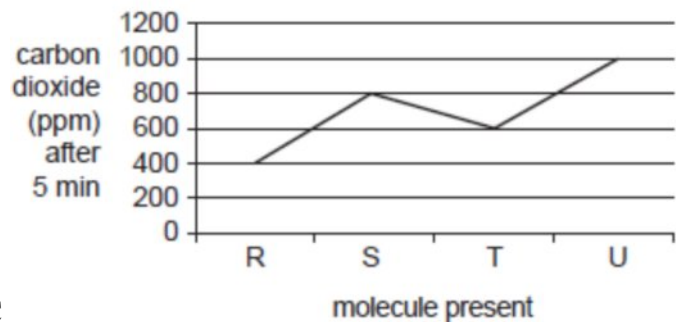
A

Effect of four different molecules on rate of cellular respiration in human liver cells



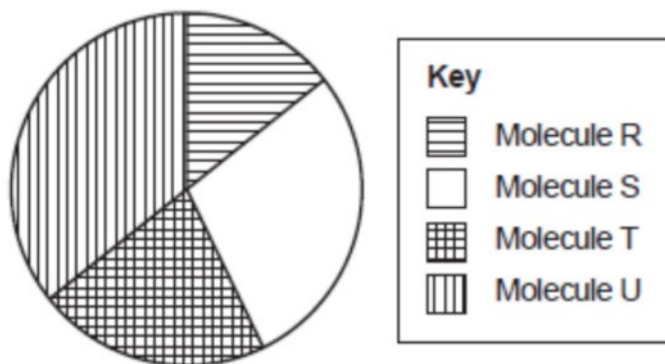
B

Effect of four different molecules on rate of cellular respiration in human liver cells



C

Effect of four different molecules on rate of cellular respiration in human liver cells



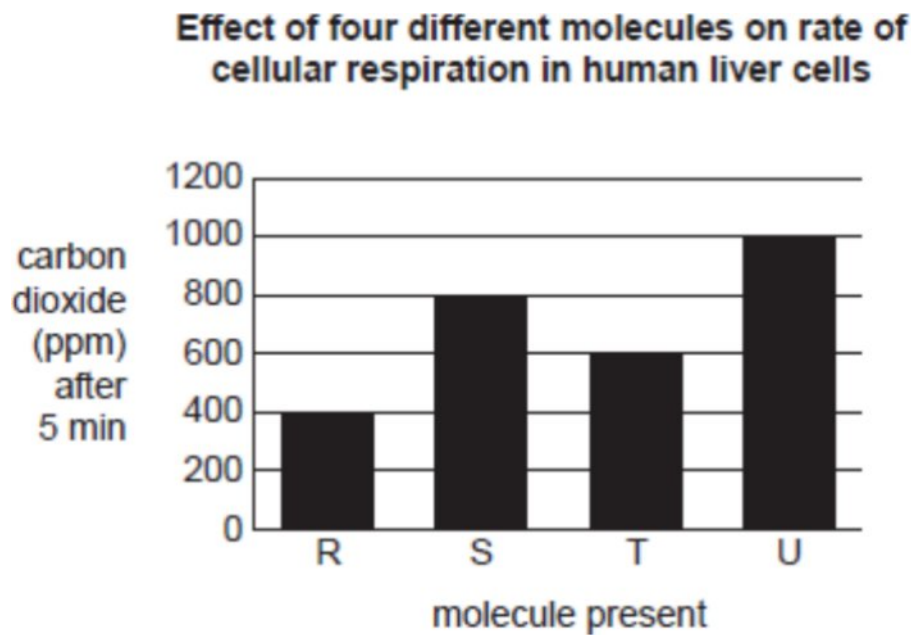
D

Solution

3-112 [VCAA 2020 SA Q40]

Which one of the following graphs is the best representation of the results?

A.



(The data is not continuous – it is discrete in that measurements were taken in four different separate situations. Therefore, a histogram is most appropriate.)

Question 77/ 115

[VCAA 2019 SA Q13]

The rate of aerobic cellular respiration in a human cell may increase if the

A temperature of the cell is lowered from 37°C to 35°C.

B oxygen concentration available to the mitochondria increases.

C carbon dioxide concentration in the cytosol of the cell increases.

D rate of facilitated diffusion of glucose into the cytosol of the cell decreases.

Solution

3-113 [VCAA 2019 SA Q13]

The rate of aerobic cellular respiration in a human cell may increase if the

B oxygen concentration available to the mitochondria increases. (An increase in oxygen concentration, a reactant, for aerobic respiration will increase the rate of aerobic respiration. Decrease in temperature will slow respiration as will increase in carbon dioxide concentration or a reduced level of glucose.)

Question 79/ 115

[VCAA 2018 SA Q11]

Which one of the following statements is correct?

A Group 1's measurements are the most accurate but the least precise.

B Group 2's measurements are accurate but not precise.

C Group 3's measurements are precise but not accurate.

D Group 4's measurements are both accurate and precise.

Solution

3-114 [VCAA 2018 SA Q11]

Which one of the following statements is correct?

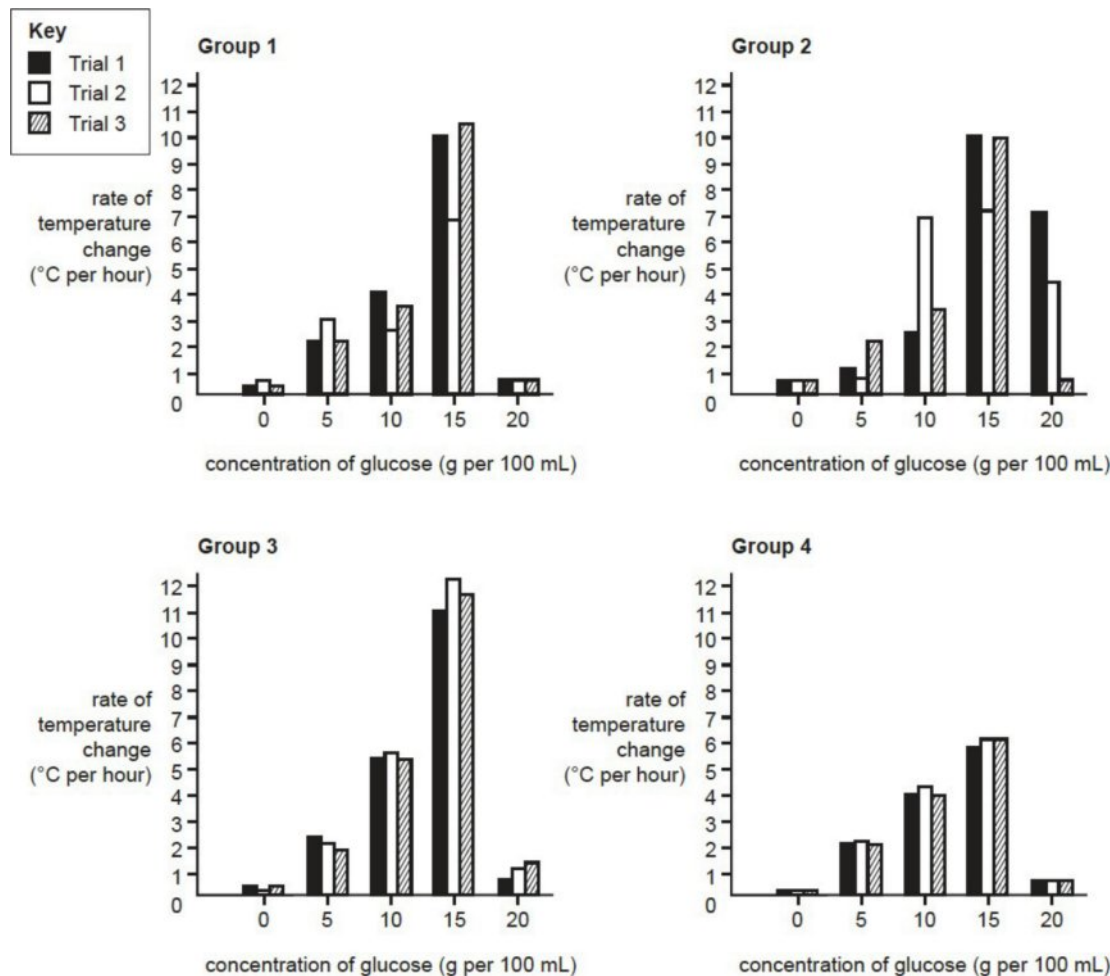
C Group 3's measurements are precise but not accurate. (Group 3's readings were within a tight range – hence they were precise. They were, however, a degree off the actual figure – hence not accurate.)

Question 80/ 115

[VCAA 2018 SA Q12]

Each group conducted the experiment three times (Trial 1, Trial 2, Trial 3). Five different concentrations of

glucose were used in each trial. Each group plotted its results on a graph, as shown below. The black bar represents Trial 1, the white bar represents Trial 2 and the striped bar represents Trial 3.



Which one of the following statements about the experiment's results can be concluded from the graphs?

A Group 1's results are more valid than the other groups', but less reliable.

B Group 2's results are less reliable, but more precise and accurate.

C Group 3's results are the most accurate and reliable.

D Group 4's results are more reliable than the other groups'.

Solution

3-115 [VCAA 2018 SA Q12]

Which one of the following statements about the experiment's results can be concluded from the graphs?

D Group 4's results are more reliable than the other groups'. (Other results may be more valid and

more accurate but from the results, group 4's result for a particular concentration is the most consistent (measurements closer together) – therefore the most reliable.)

Question 1/ 133

[VCAA 2019 SB Q11]

Three students wanted to investigate the activity of the enzyme lipase for a practical investigation. Student 1 made the following notes before designing her experiment.

Lipase catalyses the breakdown of fats into glycerol and fatty acids.

Fatty acids can neutralise an alkaline solution.

Sodium carbonate is an alkaline solution.

Student 1 set up four test tubes each containing 5 mL of a fatty solution and 10 mL of sodium carbonate solution. Each test tube was suspended in a water bath. Each water bath was set at a different temperature. pH probes were placed into each test tube. Each solution had a pH of 8.

After setting up the four test tubes in the water baths, Student 1 waited until the solution in the test tube was the same temperature as the water in the water bath. Student 1 then added 5 mL of lipase solution to each test tube. Student 1 timed how long it took for the pH of the solution to become neutral (pH of 7).

Student 1 repeated the experiment so that she had three measurements for each temperature. She obtained the data shown in Table 1.

Table 1. Results from Student 1

Temperature (°C)	Time taken for solution to become neutral (seconds)		
	Measurement 1	Measurement 2	Measurement 3
5	240	238	241
15	229	230	226
25	200	201	202
35	180	181	180

a Student 1 was concerned about the precision of her measurements. Analyse the data above and state the temperature at which the measurements are the most precise.

Justify your response. (2 marks)

b State whether Student 1 obtained qualitative or quantitative data. Outline a difference between the two types of data. (2 marks)

c Student 2 repeated the experiment designed by Student 1 the next day and obtained the data shown in Table 2.

Table 2. Results from Student 2

Temperature (°C)	Time taken for solution to become neutral (seconds)		
	Measurement 1	Measurement 2	Measurement 3
5	241	239	242
15	230	155	230
25	201	202	170
35	181	181	181

Student 2 indicated that he had errors in his measurements.

Identify which of his measurements have errors. Give two examples of sources of error for these measurements. (3 marks)

d Later that day, the third student performed the experiment. Student 3's data is shown in Table 3.

Table 3. Results from Student 3

Temperature (°C)	Time taken for solution to become neutral (seconds)		
	Measurement 1	Measurement 2	Measurement 3
5	141	139	142
15	130	130	130
25	101	102	102
35	81	81	81

After comparing his results with the other students' results, Student 3 realised he had made an error.

Name the type of error that was made by Student 3 and identify one source of error that may account for the

results obtained by this student. (2 marks)

e Identify a limitation of the experiment that was carried out by all three students. What could the students do to address this limitation? (2 marks)

(Total 11 marks)

Solution

3-117 [VCAA 2019 SB Q11]

a Measurements of a variable that are close in value are precise therefore the measurements taken at 35°C are the most precise as they vary by 1 s, whereas 25°C by 2 s, 15°C by 4 s and 5°C by 3 s.

b The data is quantitative as it expressed numerically, whereas qualitative data is descriptive.

c Measurements for 15°C and 25°C have errors.

Possible sources of energy include: (any two)

- adding less sodium bicarbonate solution to the test tube
- adding a larger volume of lipase solutions to the test tube
- incorrect measurement of volume of fatty solution
- incorrect measurement of the time
- incorrect measurement of pH.

d Type of error: systematic

Source of error (any **one**):

- incorrect calibration of the pH meter
- consistent incorrect measurement of the volume of lipase solution.

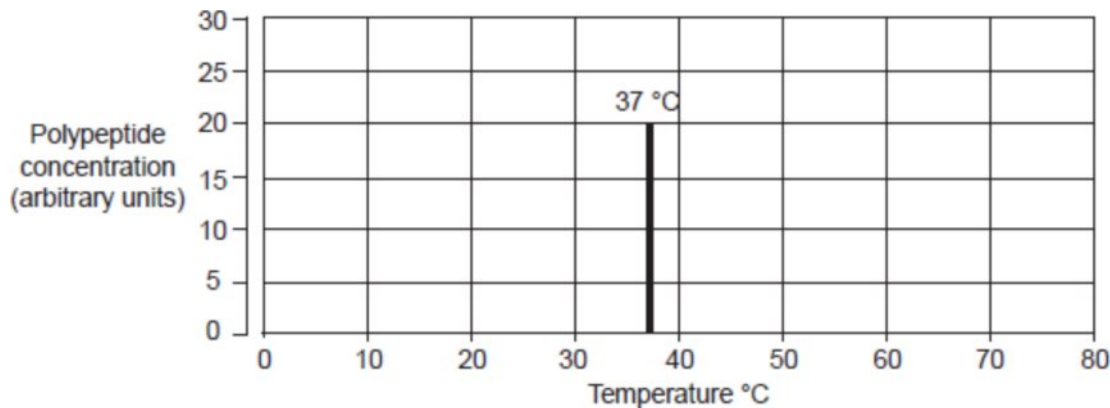
e Any **one** of the following:

Limitation	Address of limitation
Limited temperature range (measured only up to 35°C)	Use a wider range of temperatures
No control	Include a sample without lipase

Question 2/ 133

[VCAA 2012 E1 SB Q5]

Half an hour after an adult person completed eating a protein-rich meal, a sample was taken of the contents of their stomach. This sample was divided into three equal parts in separate tubes. Each tube was incubated at a different temperature for 10 hours. After that time, each tube's contents was tested to determine its polypeptide concentration. The result for the sample incubated at 37°C is shown on the graph below.



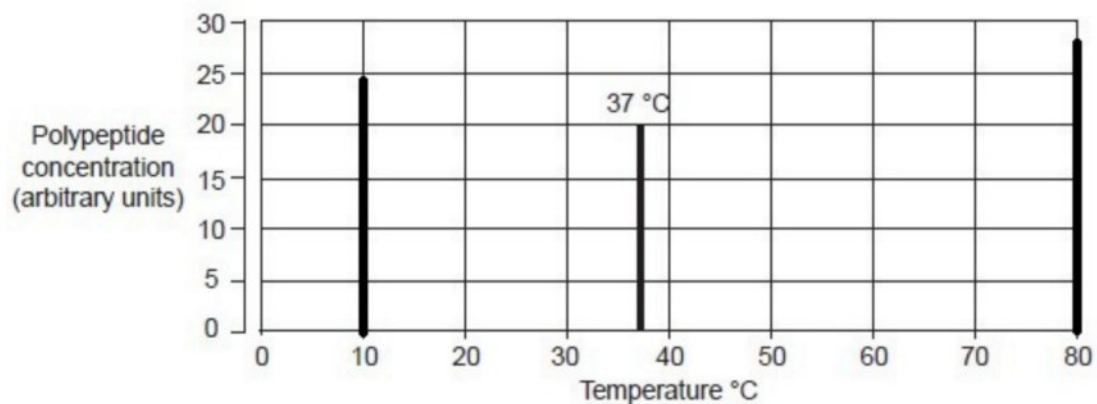
a On the graph above, draw the results you would expect for the samples incubated at 10°C and 80°C. (2 marks)

b Explain your predicted results for the polypeptide concentrations at temperatures of 10°C and 80°C. (2 marks)

(Total 4 marks)

Solution

3-118 [VCAA 2012 E1 SB Q5]



a

b 10°C: At low temperatures there are fewer collisions between the polypeptides and digestion enzymes therefore the breakdown reaction is slow and there would be more polypeptides present than at 37°C.

80°C: At high temperatures enzymes are denatured therefore, the reaction rate will be very slow, and the polypeptide concentration will be the highest.

Question 3/ 133

Six students performed a trial experiment on enzyme activity. The enzyme they were studying acts on a cloudy suspension, breaking it down into a soluble form. The lesson ended, and students were asked to stop their experiment. They then recorded the time the experiment had run and their observations.

These data are collated in the following table.

Student	Volume of enzyme solution (mL)	Temperature (°C)	pH	Volume of cloudy suspension (mL)	Time (minutes)	Observation at end of lesson
1	5	37	2	10	9	Cloudy
2	5	37	2	10	20	Clear
3	5	37	4	10	35	Clear
4	5	37	4	10	20	Cloudy
5	5	37	6	10	8	Cloudy
6	5	37	6	10	40	Cloudy

a What is the purpose of this experiment? (1 mark)

b Describe two changes that would improve the validity of the data collected in the experiment. (2 marks)

c The experiment was repeated with all trials running for 40 minutes. Complete the table to predict the results. (1 mark)

Student	Volume of enzyme solution (mL)	Temperature (°C)	pH	Volume of cloudy suspension (mL)	Time (minutes)	Observation at end of lesson
1	5	37	2	10	40	
2	5	37	2	10	40	
3	5	37	4	10	40	
4	5	37	4	10	40	
5	5	37	6	10	40	
6	5	37	6	10	40	

(Total 4 marks)

Solution

3-119

a To investigate the effect of different pHs on enzyme activity.

b Validity would be improved by including a control group. This group would be exactly the same except it would lack the enzyme. This would show that change in pH alone, does not result in breakdown of substrate.

Also, take observations for a longer time and for the same time interval for each pH. This would allow direct comparisons to be made. (Note: Validity refers to using a control and reliability refers to repetition.)

c

Student	Observation at end of trial
1	clear
2	clear

Student	Observation at end of trial

3	clear
4	clear
5	cloudy
6	cloudy

Question 4/ 133

[VCAA 2020 SB Q3]

Greenhouses have been used to generate higher crop yields than open-field agriculture. To encourage plant growth in greenhouses, the conditions required for photosynthesis are controlled. Commercial greenhouses, like the ones shown following, often use a lot of energy for heating, ventilation, lighting and water.



a Consider the reactions of photosynthesis. Why would it be important to maintain the temperature within narrow limits in a commercial greenhouse? Justify your answer. (2 marks)

b Scientists are developing a new material to cover greenhouses, which can split incoming light and convert the rays from green wavelengths into red wavelengths.

Explain how this new material increases crop yields. (2 marks)

c In plants and algae, photosynthesis is carried out in chloroplasts. It is thought that chloroplasts originated from bacteria.

Describe **two** features of chloroplasts that support the theory that chloroplasts originated from bacteria. (2 marks)

(Total 6 marks)

Solution

3-120 [VCAA 2020 SB Q3]

a Chemical reactions in photosynthesis are controlled by enzymes. Enzymes have an optimum temperature where the reaction rate is fastest. At low temperatures, the reaction rate is slow as the substrate and enzymes have low kinetic energy and collisions are low. At high temperatures, the active site is denatured. Therefore, if the greenhouses are maintained at the enzyme's optimal temperature, the rate of photosynthesis will be highest.

b Red and blue wavelengths of light are absorbed during the light-dependent stage of photosynthesis. Green light is not. Converting green light to red light increases the amount of light available to plants and therefore increases the rate of photosynthesis.

c Any **two** of the following features of chloroplasts:

- They are surrounded by a double membrane suggesting that the internal membrane was the outer membrane of the bacteria and the outer membrane, the cell membrane of the cell that engulfed the bacteria by phagocytosis.
 - They contain a circular DNA chromosome similar to that found in bacteria.
 - They contain small ribosomes similar to those found in bacteria.
 - They can reproduce independently within the cell by binary fission like bacteria.
 - They are similar to bacteria in size and shape.
-

Question 5/ 133

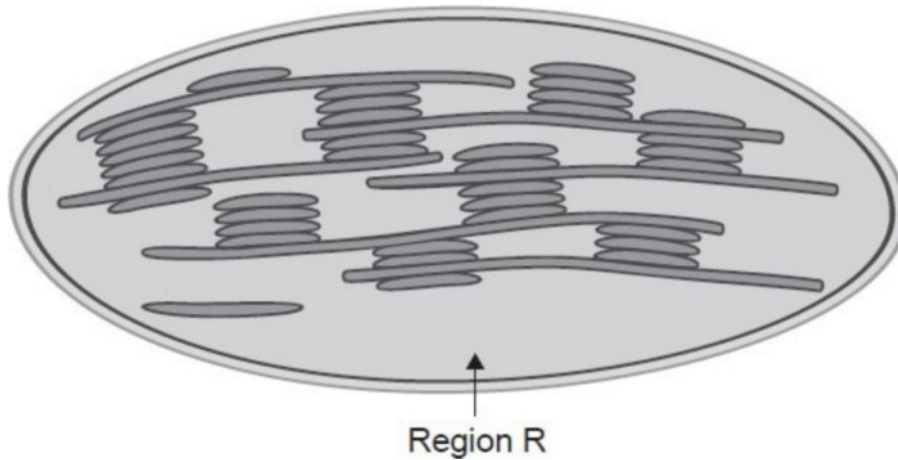
[VCAA 2019 SB Q2]

a A chloroplast is surrounded by a double membrane.

i Name **two** molecules, as inputs for photosynthesis, that would need to diffuse from the cytosol of the plant cell across the chloroplast membranes and into the chloroplast. (1 mark)

ii Under high magnification, the internal structure of a chloroplast is visible.

The diagram below shows part of this structure.



A higher concentration of oxygen is found in Region R when a plant is photosynthesising compared to when it is not photosynthesising.

Account for the differences in oxygen concentrations found in this region.

(2 marks)

b Describe the role played by each of the coenzymes NADPH and ATP in photosynthesis. (2 marks)

(Total 5 marks)

Solution

3-121 [VCAA 2019 SB Q2]

a i Carbon dioxide and water

ii Region R is the stroma. The grana are the site of the light dependent stage of photosynthesis where light is absorbed, and water is split to form H^+ and oxygen. The oxygen then diffuses into the stroma and into R, across the chloroplast membrane into the cytoplasm and then out of the cell. When the plant is photosynthesising, oxygen will be produced therefore there will be a higher concentration in region R than when the plant is not photosynthesising.

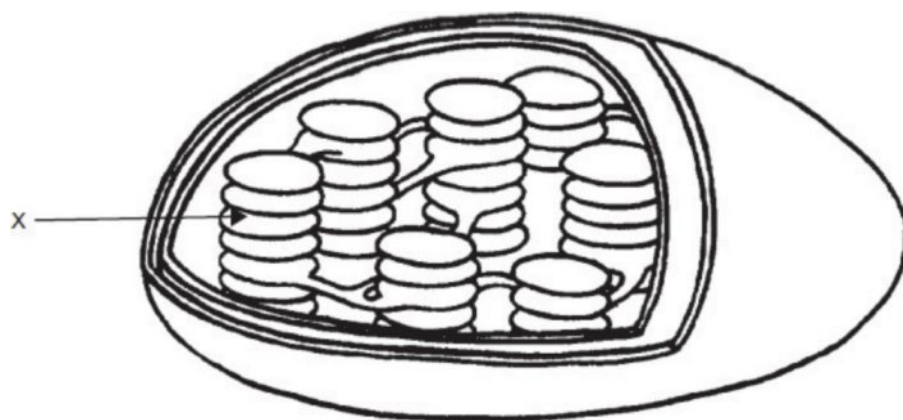
b NADPH: The hydrogen produced in the light dependent stage binds with $NADP^+$ to form NADPH. The NADPH moves into the stroma and delivers hydrogen for the light independent reaction/Calvin cycle.

ATP: is produced as a result of light absorption and the splitting of water in the light dependent stage of photosynthesis. It then diffuses into the stroma where it breaks down to ADP and P_i . The energy released is used in the light independent stage/Calvin cycle to join hydrogen to carbon dioxide to make triose/glucose.

Question 6/ 133

[VCAA 2015 SB Q3]

Below is a diagram of a chloroplast.



a Name the structure labelled X. (1 mark)

b Complete the table below by referring to the diagram above and your knowledge of photosynthesis. (3 marks)

Name of the stage of photosynthesis that occurs at X

Two input molecules that are required for reactions at X

1

2

Two output molecules that result from reactions at X

1

2

(Total 4 marks)

Solution

a X Granum or thylakoid sac

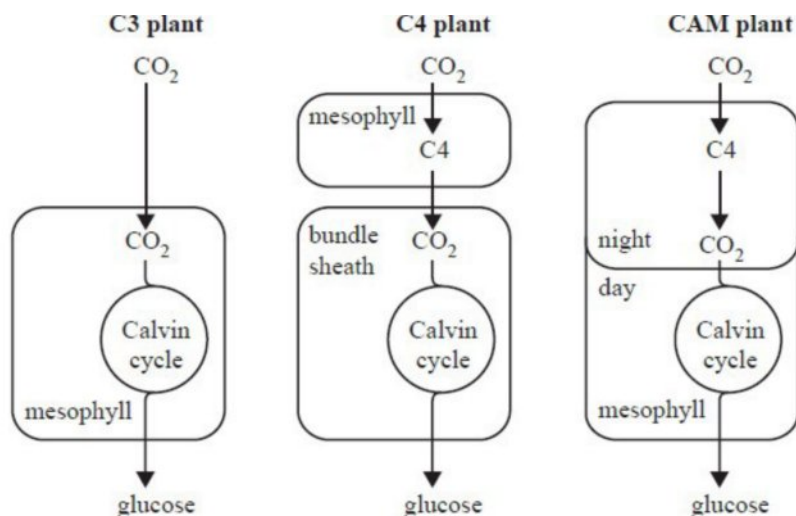
b

Name of the stage of photosynthesis that occurs at X	Light-dependent stage
Two input molecules that are required for reactions at X	Any two : water or ADP or NADP or P _i
Two output molecules that result from reactions at X	Any two : Oxygen or ATP or NADPH/H ⁺

Question 7/ 133

[VCAA 2022 SB Q3]

Plants have the unique ability to photosynthesise and utilise sunlight. They are able to produce high-energy-containing molecules that fix carbon dioxide (CO₂) into forms of carbohydrates that can be stored or used by plant cells. Most plants use the C₃ pathway to fix CO₂ and some use the C₄ pathway. A small group of plants use a combination of both pathways. This smaller number of plants are called the CAM plants.



Source: adapted from H Kheyrodin and S Kheyrodin, 'CO₂ gas exchange in Crassulacean acid metabolism and C₃ and C₄ plants', *International Journal of Advanced Research in Biological Sciences*, vol. 4, issue 10, 2017, <<http://dx.doi.org/10.22192/ijarbs.2017.04.10.007>>

As part of their VCE Biology practical investigation, a group of students collected plant samples from their school grounds. While the students were able to identify most of the plants they collected, there was one they had not seen before. They performed a series of experiments with this plant in the laboratory. The observations they made, as well as documented information for C₃, C₄ and CAM plants, are shown in the table below.

Plant characteristic	Unknown plant	C3 plant	C4 plant	CAM plant
Ideal temperature for photosynthesis	25–35°C	15–25°C	30–40°C	> 40°C
Pathway to fix CO ₂	C4 pathway and Calvin cycle	only Calvin cycle	C4 pathway and Calvin cycle	C4 pathway and Calvin cycle
Stomata open during the day	yes	yes	yes	no
Photorespiration occurring	moderate to low	high	low	Only observed in the middle of the day
Water loss during the day	moderate	high	moderate	low
Plant growth rate	moderate	moderate	fast	very slow

a Based on the information provided, state whether the unknown plant is a C3, C4 or CAM plant. Justify your response. (5 marks)

b Outline three additional steps that could be carried out to extend the investigation and assist with identifying the unknown plant. (3 marks)

(Total 8 marks)

Solution

3-123 [VCAA 2022 SB Q3]

a Unknown plant is a C4 plant. The unknown plant shares more characteristics with C4 plants than with C3 and CAM plants.

Any **four** of the following justifications:

- The unknown plant has an ideal temperature of 25–35°C, which overlaps the range for C4 plants but is the upper optimal temperature for C3 plants and is a long way below the optimal temperature for CAM plants.
- The unknown plant has a different pathway to fix CO₂ than C3 plants; therefore, it is not a C3 plant.
- The unknown plant's stomata are open during the day, unlike CAM plants.
- The unknown plant's rate of photorespiration is moderate to low, similar to C4 plants but not to C3 or

CAM plants.

- The unknown plant's water loss during the day is moderate, similar to C4 plants but not to C3 or CAM plants.

(*Note:* This is a comparison question.)

b Any **three** of the following:

- Test for the presence or absence of malate. If present, the plant is not a C3 plant.
 - Section leaves to look for the presence of bundle-sheath cells. If present, the plant is a C4 plant.
 - Test for the presence or absence of PEP carboxylase. If absent, the plant is not a C3 plant.
 - Compare the plant's structure with other known C3, C4 and CAM plants.
 - Compare the plant's genome with other known C3, C4 and CAM plants.
-

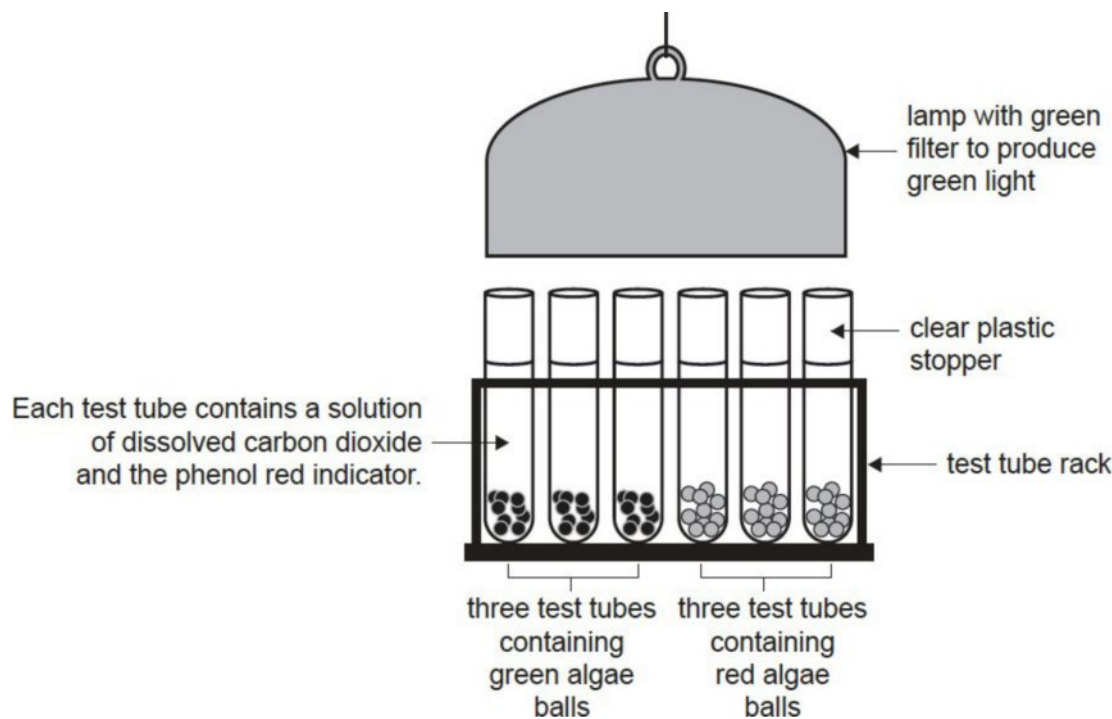
Question 8/ 133

[VCAA 2018 SB Q11]

Elsa read that red algae survive at greater water depths than green algae because of a pigment in the red algae called phycoerythrin. This pigment enables the algae to absorb more of the green light available at greater water depths. Elsa decided to investigate this by carrying out an experiment.

Using a standard technique, the single-celled algae were trapped in jelly balls. One set of balls contained green algae and another set contained red algae.

To measure the rate of photosynthesis, Elsa used a stopwatch and the pH indicator phenol red. Phenol red changes colour in solutions with different concentrations of carbon dioxide. In low carbon dioxide concentrations, phenol red is pink and in higher carbon dioxide concentrations it is yellow. Elsa placed the jelly balls into test tubes and covered them with a solution containing dissolved carbon dioxide. Phenol red indicator was added to each solution. The diagram on the following page shows the set-up of Elsa's experiment.



a State the hypothesis that Elsa was testing. (1 mark)

b List **three** variables that would need to be controlled to ensure the experiment produced valid results. (3 marks)

c State the independent variable and the dependent variable in this experiment. (2 marks)

d What results would disprove the hypothesis of Elsa's experiment? (2 marks)

e Elsa's laboratory partner suggested that they should also set up an identical experiment but keep the test tubes and their contents in the dark.

Explain why this is a good suggestion. (1 mark)

f Elsa's teacher said that even if the students completed the additional experiment in the dark and even if all of those results supported the hypothesis, there may still be other plausible explanations for their results.

Suggest **two** other explanations to which the teacher could be referring. (2 marks)

(Total 11 marks)

Solution

3-124 [VCAA 2018 SB Q11]

a Red algae photosynthesise more than green algae in green light.

b Any **three** of:

- amount of algae present/number of algal balls in each tube
- initial CO₂ concentration
- initial pH
- amount of phenol red added
- temperature.

c Independent variable: type of algae

Dependent variable: CO₂ concentration or colour of solution or pH

d The hypothesis would be disproved if all test tubes were the same colour or if the test tubes containing green algae became pinker than the test tubes containing red algae. (Both required)

e An identical experiment in the dark would show that any change in colour was due to the presence of light and not some other factor.

f Any **two** of:

- The number of algal cells may be different in each type of algal ball.
 - The jelly in the balls may have changed the colour.
 - The phenol red may affect the rate of photosynthesis differently in each type of algae.
 - The phenol red may naturally change colour.
-

Question 9/ 133

[VCAA 2022 SB Q11]

A researcher was testing compounds for their effects on the activity of malate dehydrogenase (MDH), an enzyme in the Krebs cycle. One of the compounds the researcher tested, Compound A, yielded interesting results when the experiment was performed using malate as the substrate.

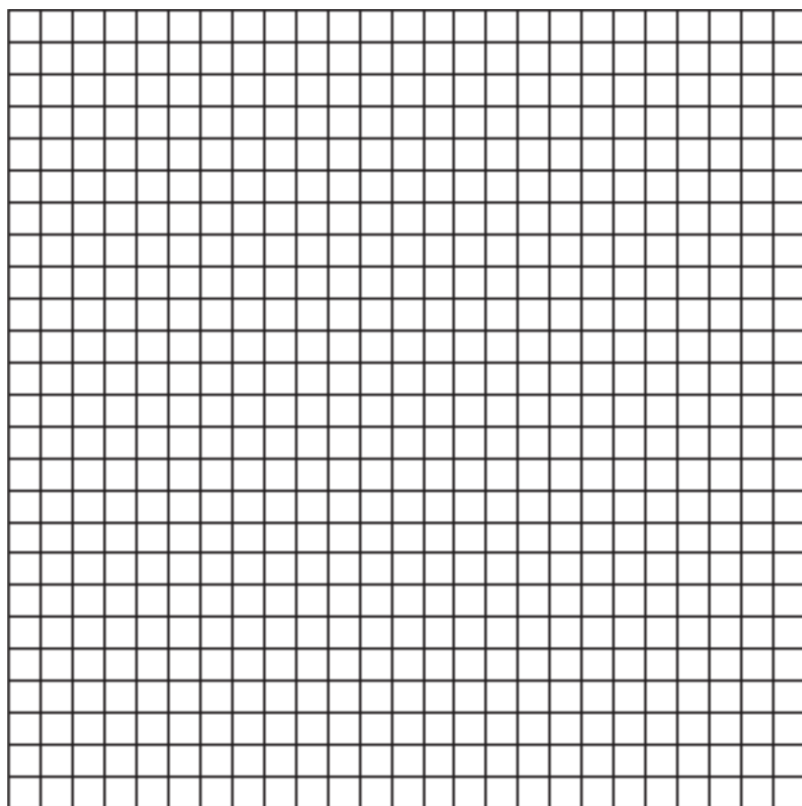
In the experiment, two sets of five test tubes were set up containing different amounts of malate, as shown in the table below. The same amount of enzyme was added to all the test tubes, but Compound A was added to only the experimental set of test tubes. The experiment was performed for one minute at 37°C.

The researcher found the rate at which the product formed, in millimoles per minute, and the results are shown in the table on the next page.

Rate of product formation (millimoles per minute)

Amount of malate added (mmoles)	Without Compound A	Without Compound B
0	0.00	0.00
5	3.30	1.00
10	3.80	2.00
15	3.90	3.00
25	4.00	3.80

a On the grid below, plot a graph representing the results and provide appropriate labels for the axes. (3 marks)



b Compound A was found to be a competitive inhibitor.

Briefly explain how competitive inhibitors affect the activity of an enzyme. (2 marks)

c The researcher repeated this experiment. However, when the researcher plotted the data, they noticed that while the shapes of the curves were similar, the results were different. On re-examination of the experimental set-up, the researcher noticed that the repeat experiment had been carried out at 20°C.

State the effect that this temperature change would have had on these results and explain the cause of this difference. (2 marks)

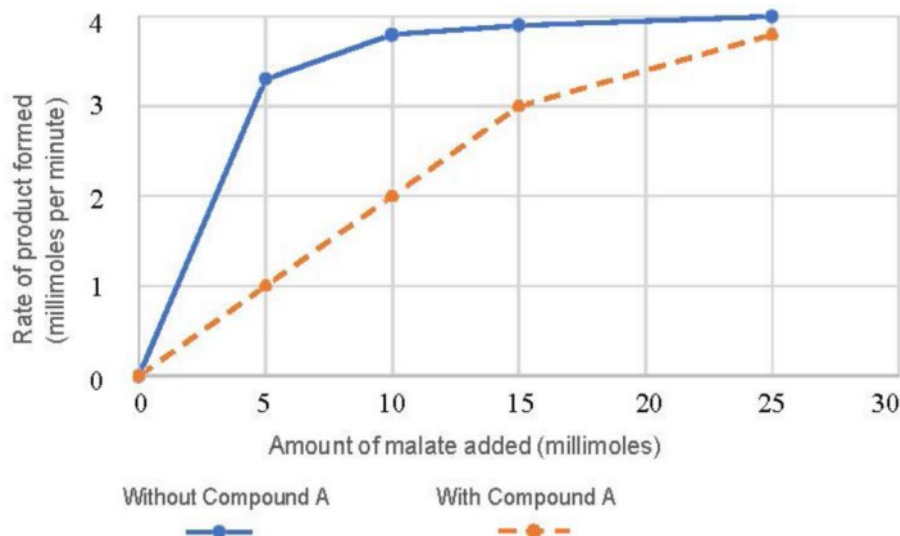
(Total 7 marks)

Solution

3-125 [VCAA 2022 SB Q11]

a Both axes must be correctly labelled with units and a linear scale.

Points need to be correctly plotted with a legend.



b Competitive inhibitors have the same shape as the substrate in reactions involving enzymes. This shape is complementary to the enzyme's active site. The competitive inhibitor competes with the substrate for the active site, preventing the substrate from binding and reducing the reaction.

c Enzyme activity is reduced when temperatures fall below the optimal temperature of the enzyme. This is because the substrate's and enzyme's kinetic energy decreases as temperature decreases. This reduces the number of collisions between them, resulting in a decreased reaction rate; therefore, the amount of product formed would be less.

Question 10/ 133

[VCAA 2021 SB Q3]

Scientists measured the metabolic activity of mammalian cells by measuring the uptake of glucose into the cells. The cells were maintained at 37°C with a pH of 7.4 and suspended in a nutrient solution containing glucose. The uptake of glucose into the cells was recorded for the next 30 minutes.

a Explain why the uptake of glucose into the cells could be used to measure the metabolic activity of the cells. (2 marks)

b The scientists repeated the experiment. They kept all conditions the same as for the first experiment, except that the cells were kept in low-oxygen conditions.

Would the uptake of glucose into the cells be expected to be higher, lower or the same as for the first experiment? Justify your response. (4 marks)

(Total 6 marks)

Solution

3-126 [VCAA 2021 SB Q3]

a Metabolic activity requires ATP. ATP is produced by anaerobic and aerobic respiration. Glucose is a reactant in anaerobic and aerobic respiration; therefore, the greater the metabolic activity, the greater the glucose uptake into the cell.

b The uptake of glucose will be higher in low-oxygen conditions as less ATP is produced in aerobic respiration per glucose molecule; therefore, to produce the same amount of ATP, more glucose will be required.

Or

Glucose uptake will be lower in low-oxygen conditions as the cell will respire anaerobically, resulting in less ATP produced per glucose molecule and less energy available for cellular activities. Cellular activities would reduce, and less glucose would be required.

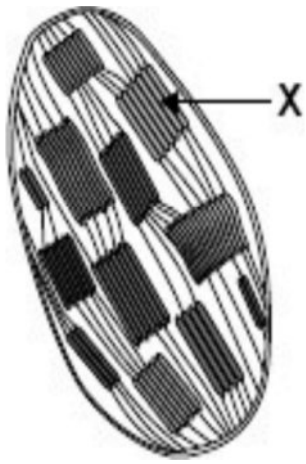
Question 11/ 133

[VCAA 2011 E1 SB Q7]

a Write the word or chemical equation for aerobic cellular respiration. (1 mark)

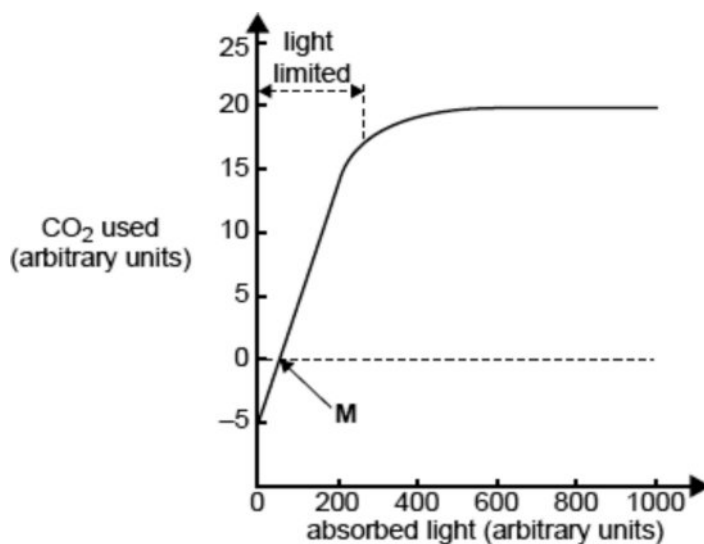
b Cyanide inactivates metabolic reactions at the cristae of mitochondria. Cyanide poisoning often results in death. Explain why. (2 marks)

The diagram that follows shows a chloroplast.



c Describe the chemical changes that occur at location X when light is present. (2 marks)

The graph below shows the rate of carbon dioxide exchange between a leaf and its external environment as light intensity is altered. All other variables are kept constant throughout the experiment.



d i Outline what is occurring at point M in terms of chemical reactions. (1 mark)

ii Explain why the graph line becomes nearly horizontal from about 600 units of absorbed light. (1 mark)

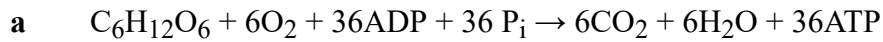
RuBisCo is an enzyme found in chloroplasts. Its normal function is to catalyse the reaction in which carbon dioxide is a substrate. In certain plants, when the level of carbon dioxide is low in the leaf, RuBisCo uses oxygen as the substrate and releases hydrogen peroxide and ammonia.

f Explain why it is beneficial for a plant to have a high level of carbon dioxide in its leaves. (2 marks)

(Total 9 marks)

Solution

3-127 [VCAA 2011 E1 SB Q7]



Or

glucose + oxygen $\rightarrow$ carbon dioxide + water + energy

b The cristae of mitochondria are the sites where the electron transport chain reactions of aerobic respiration occur. Most of the ATP (32 molecules per molecule of oxygen) produced during aerobic respiration occurs here. If they cannot occur not enough ATP (4 molecules per molecule of oxygen) is produced to sustain life.

c Light is absorbed by chlorophyll at X. As a result, water is split. The oxygen is given off and the hydrogen ions combine with NADP to form NADPH. Some ATP (18 molecules) is formed.

d i At M, the rate of carbon dioxide taken up for photosynthesis is equal to the rate of carbon dioxide produced in cellular respiration.

ii At 600 units of absorbed light the graph flattens:

Because the chlorophyll is saturated with light and therefore cannot absorb more light.

Or

Carbon dioxide is a limiting factor. Carbon dioxide is required by photosynthesis. If there is not enough carbon dioxide the reaction will not increase in rate.

Or

The concentration of enzymes controlling photosynthesis is a limiting factor. **e** When levels of carbon dioxide are low, oxygen will compete to bind with Rubisco. As a result, less carbon dioxide will react and photosynthesis will be reduced.

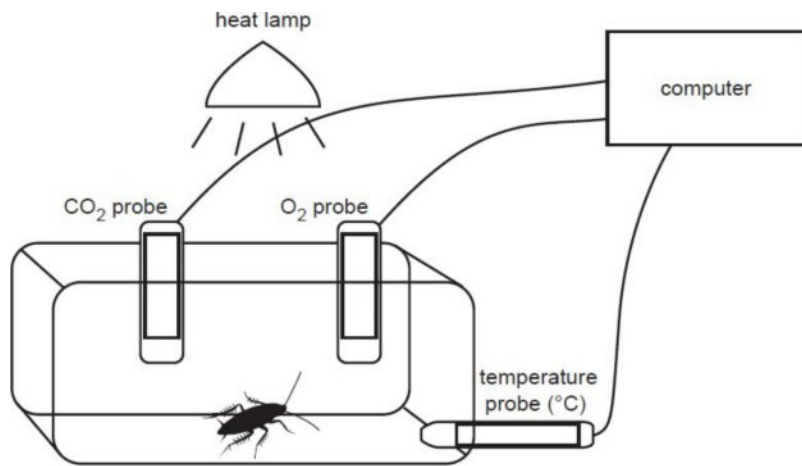
Or

When levels of carbon dioxide are low, oxygen will bind with Rubisco and this will result in higher levels of hydrogen peroxide and ammonia. These are harmful to the cell.

Or

When carbon dioxide levels are high there will be an increased rate of photosynthesis and therefore more glucose produced for the plant.

Matthew investigated how changes in environmental temperature affected oxygen (O₂) and carbon dioxide (CO₂) levels in the air around a cockroach. He used three digital probes linked to a computer, a closed animal chamber and a heat lamp in the experimental set-up shown in the diagram below.



a Name the cellular process being investigated in Matthew's experiment. (1 mark)

b Identify the:

- dependent variables
- independent variable. (2 marks)

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

Time (minutes)	CO ₂ (%)	O ₂ (%)	Temperature (°C)
0	0.04	22.3	29.5
1	0.04	22.1	29.8
2	0.04	22.0	30.0
3	0.04	22.0	30.0
4	0.04	22.0	30.0

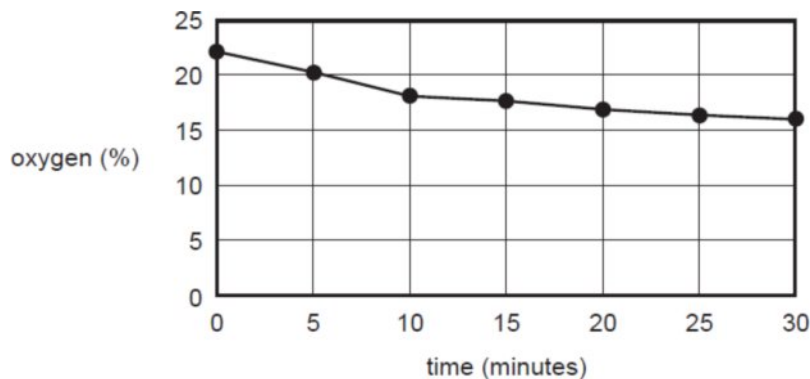
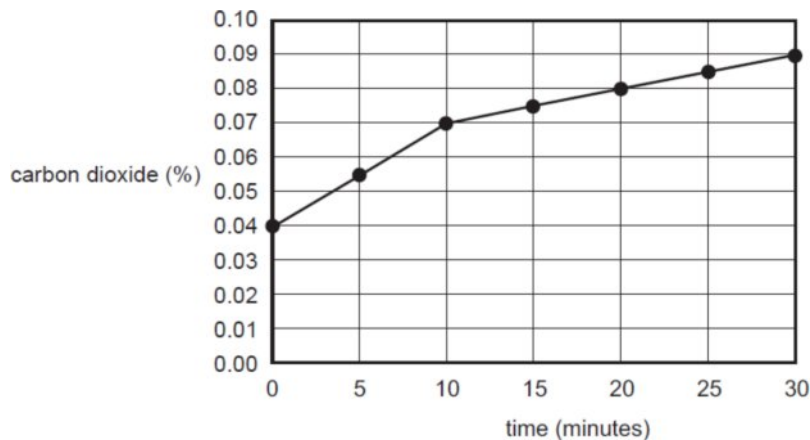
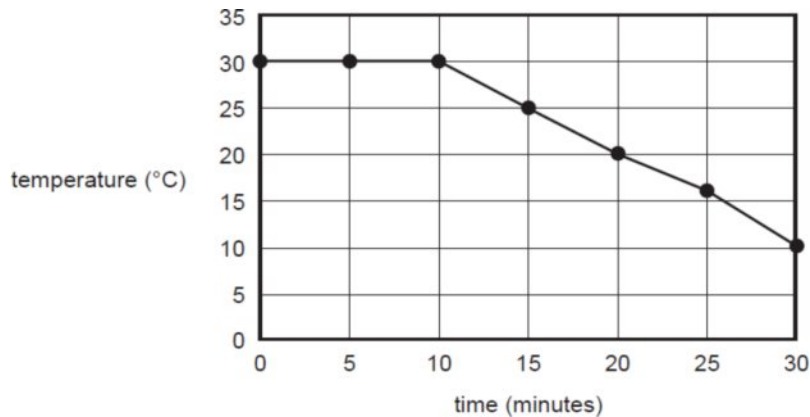
c Explain why Matthew recorded the data for four minutes and not just one minute. (1 mark)

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

d Other than repeating the entire experiment, identify two control measures Matthew should have included in

his experimental design. Explain how each of these control measures could affect the results if not kept constant. (4 marks)

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



e i Using the graphical data, describe the changes in the levels of carbon dioxide and oxygen when the temperature in the chamber was kept constant compared to when the temperature was decreasing. (2 marks)

ii What conclusion do you think Matthew can draw from his investigation?

You should refer to each of the following in your response:

- the cellular process named in **part a**.
- the variables identified in **part b**.

- the evidence collected during Matthew's experiments. (4 marks)

(Total 14 marks)

Solution

3-128 [VCAA 2017 SB Q11]

a Aerobic respiration

b Dependent variables: CO₂ concentration and O₂ concentration

Independent variable: temperature in the chamber (not just temperature)

c The temperature in the chamber was measured for 4 minutes to check that the temperature of the chamber was stable/constant therefore any change in the measurements will be due to temperature change and not some other factor.

d Any **two** of:

- Use more than one cockroach and average the results. If only one cockroach is used and this individual is atypical of all cockroaches, then the results could not be used as a basis for generalisation. Using more than one cockroach and averaging the results reduces the effect on the results of atypical results.
- Ensure the humidity within the chamber is constant and the same for each repeat. If the cockroach became dehydrated, this could affect its respiration rate.
- Ensure the experiment is conducted at the same time each day as cockroaches may be active at different times of the day and this could affect the respiration rate.
- Feed the cockroaches at the same time each day and with the same food. Glucose is a reactant in aerobic respiration and therefore its availability could affect the respiration rate.

e i When the temperature was kept constant at 30°C, the levels of carbon dioxide increased at a steady rate from 0.04% to 0.07%. When the temperature dropped from 30°C to 10°C carbon dioxide levels continued to increase from 0.07% to 0.09% but at a slower rate.

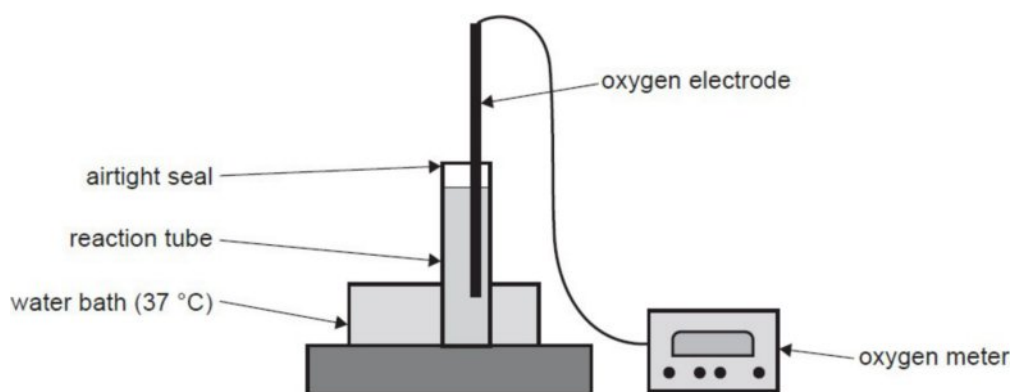
When the temperature was kept constant at 30°C, the levels of oxygen showed a steady decrease from 22% to 18%. When the temperature dropped from 30°C to 10°C, oxygen levels continued to decrease from 18% to 16% but at a slower rate.

ii Conclusion: For cockroaches, the rate of aerobic respiration is dependent on the temperature of the chamber. Low temperatures lower the rate of aerobic respiration. In this experiment, the independent variable was temperature. All other factors were kept constant therefore any change in carbon dioxide levels or oxygen levels must be due to temperature alone. Carbon dioxide can be used as a dependent variable as it is a product of aerobic respiration and therefore when its levels increase aerobic respiration is occurring. Oxygen can also be used as a dependent variable as it is a reactant in aerobic respiration therefore when its levels decrease aerobic respiration is occurring.

Question 13/ 133

[Adapted VCAA 2016 SB Q4]

The apparatus shown in the diagram that follows was used in a series of experiments to study aerobic respiration.



In three different experiments, the reaction tube initially contained the following:

- 1 suspension of mitochondria
- 2 cytosol of cells from which the mitochondria had been removed
- 3 suspension of mitochondria and cytosol of cells.

The temperatures and pH of the mixtures within the reaction tubes were carefully controlled so as not to damage the mitochondrial structure or any of the enzymes.

In each experiment, a solution containing glucose was first added to the mixture in the reaction tube and the oxygen concentration was measured for three minutes. Then, a pyruvate solution was added and the oxygen concentration was measured again for three minutes.

Using your knowledge and understanding of aerobic respiration and mitochondria, give your **prediction** of the change in oxygen concentration of the mixture in the reaction tube after the addition of each substance in the three different experiments and give a **reason** for your prediction.

Experiment 1 – Suspension of mitochondria

Experiment 2 – Cytosol of cells from which the mitochondria had been removed

Experiment 3 – Suspension of mitochondria and cytosol of cells

(Total 6 marks)

Solution

3-129 [Adapted VCAA 2016 SB Q4]

Experiment 1 – Suspension of mitochondria

Substance added	Change in oxygen concentration (increase/decrease/no change)	Reason
glucose	no change	Oxygen is required when water is formed by the electron transport chain, which occurs on the inner membranes of the mitochondria and requires H^+ formed in the Krebs cycle. Pyruvate not glucose enters the mitochondria therefore H^+ would not be available to the electron transport chain.
pyruvate	decrease	Pyruvate enters the mitochondria and as a result of the Krebs cycle H^+ are formed. The H^+ combine with oxygen at the end of the electron transport chain forming water.

Experiment 2 – Cytosol of cells from which the mitochondria had been removed

Substance added	Change in oxygen concentration (increase/decrease/no change)	Reason
glucose	no change	Glycolysis occurs in the cytosol and is anaerobic. Oxygen is not a reactant or product of glycolysis.
pyruvate	no change	Pyruvate is a product of glycolysis. Oxygen is not a reactant or product of glycolysis, which occurs in the cytosol.

Experiment 3 – Suspension of mitochondria and cytosol of cells

Substance added	Change in oxygen concentration	Reason

(increase/decrease/no change)

glucose decrease

In the cytosol, glucose is broken down to pyruvate. The pyruvate enters the mitochondria where through the Krebs cycle H^+ are produced. The H^+ then enter the electron transport chain where finally they combine with oxygen to form water.

pyruvate decrease

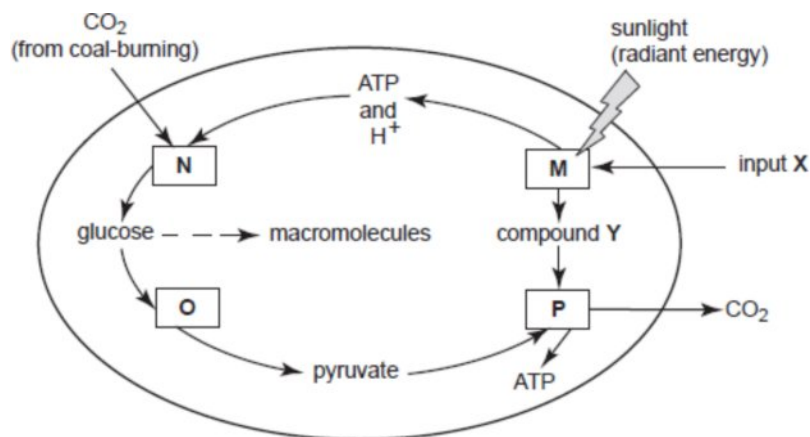
Pyruvate enters the mitochondria where through the Krebs cycle H^+ are produced. The H^+ then enter the electron transport chain where finally they combine with oxygen to form water.

Question 14/ 133

[VCAA 2012 E1 SB Q8]

Climate change has been linked to an excess of carbon dioxide in the atmosphere. The burning of coal is a major contributor to this excess of carbon dioxide. Microalgae such as *Chlorella* can use greater amounts of carbon dioxide than land plants and they do not require prime soil, reliable rainfall and a particular climate. *Chlorella* can be grown cheaply in existing or engineered ponds which are supplied with carbon dioxide from a coal-burning power station nearby.

The diagram below represents a summary of the processes (labelled M, N, O, P) occurring in a *Chlorella* cell.



a Name:

i input X (1 mark)

ii compound Y. (1 mark)

b With reference to the diagram of processes in a *Chlorella* cell, complete the following table.

Process	Name of process	Site of process
M		Grana of chloroplast
O	Glycolysis	
P	Stages of cellular respiration	

(3 marks)

Chlorella pond farms could reduce 50% of the carbon dioxide that is produced by coal-burning power stations. Consider the summary of processes occurring in a *Chlorella* cell.

c Given that carbon dioxide is an output of process P, explain how *Chlorella* farming could prevent 50% of the carbon dioxide emitted by coal-burning power stations from entering the atmosphere. (2 marks)

d What are **two** conditions, other than carbon dioxide supply, that an engineer or biologist maintaining a *Chlorella* pond farm would need to control to keep the growing conditions at an optimum level? (1 mark)

(Total 8 marks)

Solution

3-130 [VCAA 2012 E1 SB Q8]

a i input X: water

ii compound Y: oxygen

b

	Process Name of process	Site of process
M	light-dependent stage of photosynthesis	grana of chloroplast
O	glycolysis	cytosol
P	stages of respiration	mitochondria

c Carbon dioxide is used in photosynthesis. If the rate of carbon dioxide uptake during photosynthesis in *Chlorella* is greater than the rate of carbon dioxide production during cellular respiration, then less carbon dioxide will be produced than used.

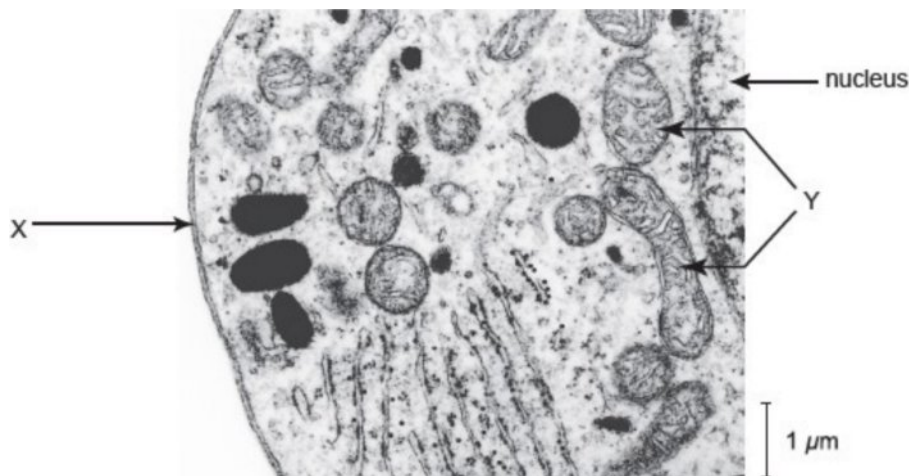
d Any **two** of the following:

- suitable light intensity
 - suitable light quality
 - suitable temperature
 - suitable pH
 - prevention of disease
 - sufficient supply of mineral ions
 - sufficient space.
-

Question 15/ 133

[VCAA 2012 E1 SB Q1]

The electron-micrograph below shows a portion of a cell.



a Name and describe structure **X**. (2 marks)

b It has been suggested that as humans age the structures labelled **Y** become less efficient. Explain the consequence of this for an elderly person. (2 marks)

(Total 4 marks)

Solution

3-131 [VCAA 2012 E1 SB Q1]

a Name: plasma/cell membrane (Not just membrane)

Description: the plasma membrane consists of a phospholipid bilayer with the fatty acid chains on the inside and phosphate heads on the outside. Proteins and glycoproteins are studded in the bilayer. Some of the proteins form channels that cross the membrane.

b The structures labelled Y are mitochondria. They are the site of aerobic respiration. If they become less efficient, less ATP will be available for the cell to do work and the cell will have impaired functioning. The person will tire more easily than when they were younger.

Question 16/ 133

[VCAA 2013 SB Q1]

Yeast is a single-celled, microscopic fungus that uses sucrose as a food source. An experiment was carried out to investigate cellular respiration by a particular species of yeast. Yeast cells were placed in a container and a sucrose solution was added. An airtight lid was placed on the container. The percentages of oxygen and ethanol in the container were recorded over a one-hour period.

The experiment was carried out at room temperature. The results are shown in the following table.

	Percentage of oxygen	Percentage of ethanol
at the start of the experiment	21	0
at the end of the experiment	18	4

a Explain any changes that have been observed in oxygen and ethanol levels within the airtight container. (2 marks)

Levels of carbon dioxide were also monitored during the experiment.

b Predict whether the carbon dioxide concentration inside the airtight container would increase, stay the same or decrease within the time the experiment was carried out. Explain the reasoning behind your prediction. (2 marks)

Scientists are looking at ways to increase the efficiency of photosynthesis in plants, including the way in

which carbon dioxide is captured.

c i Name the stage of photosynthesis in which carbon dioxide is captured. (1 mark)

ii The stage of photosynthesis in which carbon dioxide is captured requires other inputs. Name two other inputs, and describe the role played by each in this stage of photosynthesis. (2 marks)

(Total 7 marks)

Solution

3-132 [VCAA 2013 SB Q1]

a Yeast cells have respired both aerobically and anaerobically. Oxygen is a reactant in aerobic respiration therefore if aerobic respiration occurs; the percentage of oxygen will decrease. Ethanol is a product of anaerobic respiration therefore, if anaerobic respiration occurs, the percentage of ethanol will increase.

b Prediction: carbon dioxide concentration would increase.

Explanation: The container that the yeast is in, is airtight. Carbon dioxide is a product of both aerobic and anaerobic respiration therefore its concentration will increase with time. *Note:* not just a reference to respiration.

c i The light independent stage or the Calvin cycle

ii

Name of input (any two)	Role
ATP	Energy source for the addition of hydrogen to carbon dioxide to form a carbohydrate/glucose.
NADPH	NADP transports H^+ ions to the stroma where the Calvin Cycle occurs. The H ions are combined with carbon dioxide to form a carbohydrate/glucose.
Hydrogen ions	The H^+ ions are combined with carbon dioxide to form a carbohydrate/glucose

Plant materials containing cellulose and other polysaccharides are reacted with acids to break them down to produce glucose. This glucose is then used by yeast cells for fermentation.

a Why is fermentation important for yeast cells? (1 mark)

b What are the products of fermentation in yeast cells? (1 mark)

A by-product of the acid treatment of plant materials is a group of chemical compounds called furans. It has been observed that as the concentration of furans increases, the rate of fermentation decreases. The enzyme alcohol dehydrogenase is required for the process of fermentation.

c Design an experiment to test the hypothesis that one of the furans, called furfural, is an inhibitor of the enzyme alcohol dehydrogenase. Assume that the experiment will be repeated many times and that environmental factors are kept constant. (4 marks)

d Scientists have proposed that furfural is a competitive inhibitor of the enzyme alcohol dehydrogenase.

Explain how furfural could act as a competitive inhibitor of the enzyme alcohol dehydrogenase. (2 marks)

(Total 8 marks)

Solution

3-133 [VCAA 2016 SB Q2]

a Fermentation provides ATP/energy to the yeast cell enabling it to maintain cell structure and function.

b Ethanol, carbon dioxide and ATP. (Not energy)

c Add the same amount of glucose and same amount of alcohol dehydrogenase to two identical beakers. Place the beakers together so that they are exposed to the same environmental conditions. To the first beaker, add 10 grams of furfural. The presence of furfural is the independent variable. Measure the amount of carbon dioxide/alcohol (the dependent variable) produced every 5 minutes. Repeat the experiment many times. If furfural is an inhibitor of alcohol dehydrogenase, then more carbon dioxide/alcohol will be produced in the first container.

d Furfural could act as a competitive inhibitor if parts of its structure have the same shape as the substrate that binds to the active site of alcohol dehydrogenase. Furfural could then bind to alcohol dehydrogenase blocking the active site, reducing the amount of substrate that could bind to alcohol dehydrogenase.

Chapter 4 How do organisms respond to pathogens?

Question 1/ 55

How do organisms determine which cells are theirs and which cells are foreign?

Solution

4-1 Cells in an organism have their own particular molecules on their surfaces (antigens). These molecules are usually made of proteins, carbohydrates, glycoproteins or glycolipids. Cells with different molecules on their surfaces are recognised as foreign or non-self and are attacked by the immune system.

Question 2/ 55

Distinguish between the following terms: pathogen, antigen, antibody and allergen.

Solution

4-2 A pathogen is a disease-causing organism or infectious particle whereas an antigen is a specific molecule recognised by the immune system. Molecules on the pathogens surface may be antigens. An allergen is a molecule that provokes an over-reaction of the immune system. An antibody is a molecule produced as a result of the presence of an antigen.

Question 3/ 55

What is disease? Are all diseases infectious?

Solution

4-3 A disease is any condition that alters the normal functioning of an organism. Infectious diseases are caused by an organism or agent (e.g.: virus) that has ‘infected’ the diseased individual. Not all diseases are infectious. Scurvy and rickets are examples of nutritional diseases. Cancers may be caused by carcinogens in the environment.

Question 4/ 55

Explain the relationship between infectious diseases and pathogens.

Solution

4-4 A pathogen is the organism or agent that causes an infectious disease. The adjective pathogenic describes organisms/agents that cause infectious disease.

Question 5/ 55

In terms of pathogens, what is meant by the term ‘host’?

Solution

4-5 The host is the individual that has been invaded by the pathogen. Most pathogens are internal parasites; that is, they obtain food and shelter from their host.

Question 6/ 55

Pathogens can be non-cellular or cellular. Give three examples of each.

Solution

4-6 Non-cellular pathogens include viruses, viroids, and prions. Cellular pathogens include bacteria, fungi and eukaryotic parasites.

Question 7/ 55

What physical and chemical barriers do plants have against infection?

Solution

4-7 Physical barriers of plants against disease include thick cuticles, hairs, thorns or spikes, thick cell walls and thick bark. Chemical barriers include secretion of resin and antibiotic-like substances called phytoalexins. Caffeine is an example.

Question 8/ 55

The human body has a number of levels of defence against disease. What is the first line of defence?

Solution

4-8 The external barriers of the body are the first line of defence. The skin is relatively tough and impermeable unless broken. The skin produces its own antiseptic – sebum. An antiseptic in tears protects the eyes. Hairs and mucus protect the entrance to the respiratory system. Stomach acid has a role in killing pathogens that enter in food. The vagina's secretions are acidic, which helps reduce chances of bacterial or fungal infection. Urine, itself acidic, helps to flush out any pathogens that enter the urethra. Natural flora of microorganisms out-compete harmful microorganisms.

Question 9/ 55

Complete the following table.

Component of the innate immune response	Role in the innate immune response
Macrophage	
Neutrophil	
Dendritic cells	
Eosinophil	
Natural killer cell	
Mast cell	
Complement protein	
Interferon	

Solution

Component of the innate immune response	Role in the innate immune response
Macrophages	Recognise, engulf and destroy foreign or damaged tissue
Neutrophils	Fast acting and are involved in inflammation. They contain granules which kill engulfed pathogens.
Dendritic cells	Find foreign material in body tissue, engulf and then display foreign antigens. They provide a link to the adaptive immune response.
Eosinophils	Leucocytes that release cytokines that kill parasites
Natural killer cell	Leucocytes that destroy abnormal or infected cells by triggering apoptosis
Mast cell	Leucocytes that release histamines increasing inflammation
Complement proteins	About 20 different proteins that: • stick to invading pathogens, increasing identification by phagocytes. • attract phagocytes to the site of infection and stimulate their activity. • destroy pathogen membranes
Interferon	A type of cytokine produced by infected cells that inhibits the synthesis of new viral proteins within the cell. They also attract natural killer cells to destroy infected cells.

Question 10/ 55

What are the functions of inflammation?

Solution

4-10 The functions of inflammation include:

- destruction of the cause and products of an infection
 - confining the infection to a small area
 - increased rate at which damaged cells are repaired or replaced.
-

Question 11/ 55

Describe the stages of inflammation.

Solution

4-11 The stages of inflammation:

1. Damaged cells and mast cells in blood vessels, gut and lungs release histamines.
 2. Histamines increase the diameter and permeability of blood vessels.
 3. This results in increased blood flow to the infected area, heat and swelling.
 4. Reduced movement.
 5. Plasma fluid, some plasma proteins and phagocytes leave the blood and enter the infected tissue.
 6. Phagocytes are attracted by histamines and destroy the pathogens.
 7. Macrophages secrete interleukins, which then leads to fever.
-

Question 12/ 55

Explain whether the features described above provide specific defence.

Solution

4-12 The second line of defence is non-specific in that any pathogen or foreign material can be removed and continues till the pathogen is removed. The scavenger cells involved will attempt to attack any potential threat.

Question 13/ 55

Give two roles of fever in the immune response.

Solution

4-13

- Fever increases the activity of leucocytes.
 - Fever can slow the growth of bacteria or the spread of viruses.
-

Question 14/ 55

Complete the following table.

Examples

Primary lymphoid organs

Secondary lymphoid organs

Solution

4-14

Examples

Primary lymphoid organs Bone marrow, thymus

Secondary lymphoid organs Lymph nodes, spleen, tonsils

Question 15/ 55

What are the two main functions of lymph vessels?

Solution

4-15 The two main functions of lymph vessels are:

- to drain the interstitial fluid
 - to transport cells (especially dendritic, B and T cells) around the body and to the lymph nodes.
-

Question 16/ 55

What is the function of lymph nodes?

Solution

4-16 Extracellular fluid is filtered in the lymph nodes. The lymph nodes contain many dendritic, B and T

lymphocytes and are the major site of antigen recognition by lymphocytes. Much of the adaptive immune response is initiated in the lymph nodes.

Question 17/ 55

What is the role of the adaptive immune response?

Solution

4-17 The role of the adaptive immune response is to combat any threats that have overcome the first two lines of defence. The host recognises and specifically responds to specific antigens possessed by the pathogen. The adaptive immune response results in immunological memory.

Question 18/ 55

Distinguish between T lymphocytes and B lymphocytes. Where is each sort of cell formed and matured?

Solution

4-18 T lymphocytes and B lymphocytes are both formed from stem cells in the bone marrow of long bones. The B lymphocytes mature in the bone marrow to be released into the blood where they become antibody producers. B cells are involved in humoral immunity. The T lymphocytes travel to the thymus gland to complete their development. (T stands for 'thymus dependent cell'.) The T lymphocytes are involved in cell-mediated immunity. Some become cytotoxic T cells. T helper cells activate B lymphocyte as cytotoxic T cell.

Question 19/ 55

What is the difference between antibodies and antigens? How do they relate to each other?

Solution

4-19 In terms of the immune system, an antigen is a molecule that provokes the production of antibodies. Antibodies are the bullets produced by B cells designed to damage pathogens. The molecules on the surface of pathogens, or for that matter, on the body's own cells, can act as antigens. A specific antigen will provoke the production of one type of antibody.

Question 20/ 55

What are antibodies made of and by what cells are they made?

Solution

4-20 Antibodies are protein molecules made to precise shapes. A form of the B cell called a plasma B cell makes them. The plasma B cells are antibody factories. One type of plasma B cell can only produce one **specific** type of antibody.

Question 21/ 55

Why is the shape/structure of antibodies so important?

Solution

4-21 Antibody shape is important because it determines the antigen to which it can stick. The antibody has a specific complementary shape to the antigen. One antibody type combines with one antigen type. Thus, the defence is **specific**.

Question 22/ 55

List the major steps involved in humoral immunity.

Solution

4-22 Humoral immunity:

- Macrophages engulf pathogens and then display some of the pathogen's antigens on their surface (antigen-MHC complex)
 - T-helper cells are attracted to the macrophages and are activated by the antigen-MHC complex
 - T-helper cells stimulate the activity of B lymphocytes that have also come in contact with the antigen
 - The B lymphocyte divides to form a **clone** of plasma cells that produce a specific antibody
 - Also produced are 'memory cells' that are identical to the original B lymphocyte.
-

Question 23/ 55

List the major steps involved in cell-mediated immunity.

Solution

4-23 Cell-mediated immune response:

- Infected cells display antigen-MHC complex
 - T-helper cells are activated by the antigen-MHC complex
 - T-helper cells stimulate cytotoxic T cells to destroy infected cells.
-

Question 24/ 55

Describe the different ways that T cells are involved in specific defence.

Solution

4-24 Like B lymphocytes there are many kinds of T lymphocytes. Helper T cells recognise foreign antigens and assist B lymphocytes. Some T lymphocytes become the killer T cells involved in graft rejection after transplant operations. Each person's antigens are different and transplant tissue is seen as foreign. The immune system tries to destroy it! Cytotoxic T cells are involved in destroying cells infected with virus and cancer cells.

Question 25/ 55

How does natural immunity differ from artificial immunity?

Solution

4-25 Natural immunity involves either pathogens or antibodies entering the body naturally. Antibodies may cross the placenta from mother to foetus. Artificial immunity involves the transfer of antibodies into an organism or antigens via a vaccine.

Question 26/ 55

What is the principle behind active immunity?

Solution

4-26 With active immunity, the body is producing its own antibodies and memory B cells. Immunisation with a vaccine that contains a harmless form of a microbe can produce immunity without suffering the disease.

Question 27/ 55

How does active immunity differ from passive immunity? Which is best?

Solution

4-27 With passive immunity, the body does not produce the needed antibody and there is no immune memory. In the case of a snakebite where the toxin is fast acting, a dose of the appropriate antivenom (which contains antibodies specific to the snake toxin) is necessary for the patient's survival. The body does not have the time to produce the specific antibody required. In cases of active immunity, the body's own immune system produces the antibody and memory cells, which in the long run is more effective than passive

immunity. In crises, such as snakebite, passive immunity is more effective!

Question 28/ 55

Explain why most people get mumps or measles once only. (Assume they were not vaccinated!)

Solution

4-28 After combating a disease successfully there will be a large number of memory B and T cells. After having mumps once, the memory cells that 'remember' how to make mumps antibody are common. If the mumps virus invades again, the defence system springs into action more quickly because of the large population of the specific B memory cell that are quickly divide and differentiate to produce many antibodies. The body can overcome the second attack without symptoms.

Question 29/ 55

What are the differences between infectious and non-infectious diseases?

Solution

4-29 Infectious diseases can be transmitted from one organism to another whereas non-infectious diseases cannot. Infectious diseases are caused by a pathogen, non-infectious diseases are not.

Question 30/ 55

Explain the relationship between infectious diseases and pathogens.

Solution

4-30 A pathogen is the organism or agent that causes an infectious disease. The adjective pathogenic describes organisms/agents that cause infectious disease.

Question 31/ 55

Give two explanations as to why new diseases emerge.

Solution

4-31 New diseases can arise due to mutations in the pathogen. For example, the influenza virus undergoes small changes to which people are no longer immune. A second possibility is that the pathogen moves to a new species of host. A probable example of this is the AIDS virus which is thought to have been present in chimpanzees and made the transition to humans at some stage.

Question 32/ 55

Why is scarlet fever considered to be a re-emerging disease?

Solution

4-32 A re-emerging disease is a disease that existed in the past, the incidence followed later by a huge increase in the number of infections. Scarlet fever has existed in the human population in the past. It was eradicated in the 1940s but there has been a global increase in the number of cases since 2010.

Question 33/ 55

Give two reasons why diseases re-emerge.

Solution

4-33 Diseases may re-emerge as a result of bacterial antibiotic resistance or a drop in vaccination numbers.

Question 34/ 55

Distinguish between an epidemic and a pandemic by completing the table below.

	Epidemic	Pandemic
Definition		
Cause		
Death rates		
Example		

Solution

4-34

	Epidemic	Pandemic
Definition	An infectious disease outbreak that occurs in one city, region or country	An infectious disease outbreak that occurs over a wider geographic area/global scale
Cause	Sub-types of infectious agents/virus that are already in circulation	New infectious agents usually a virus.
Death rates	High (especially amongst the old and those who are immune compromised)	Higher (often in healthy young people)
Example	Seasonal outbreaks of influenza Ebola SARS	The Black Death HIV/AIDS

Question 35/ 55

What diseases did the first European settlers bring to the Aboriginal and Torres Strait Islanders?

Solution

4-35 The first European settlers brought with them smallpox, typhoid, measles, influenza, pneumonia, whooping cough and venereal diseases.

Question 36/ 55

Why did the diseases brought to Australia with the European settlers have such a devastating effect on the Aboriginal and Torres Strait Islander peoples?

Solution

4-36 The European settlers were descended from people who had survived epidemics in Europe. The settlers have inherited resistance to these diseases. Furthermore, the settlers had been exposed to the pathogens causing these diseases and therefore had immunity. The Aboriginal and Torres Strait Islander people populations had no previous exposure and therefore no immunological memory of the diseases.

Question 37/ 55

Apart from the introduction of pathogens, how has the health of Aboriginal and Torres Strait Islander peoples been affected by European settlement?

Solution

4-37 European settlement resulted in a change of diet of the Aboriginal and Torres Strait Islander populations. Fencing of land, land clearing, and farming reduced the availability of traditional foods. This led to an increase in European style food high in sugar and flour in their diet. Consequently, this has increased the rate of diabetes in Aboriginal and Torres Strait Islander populations.

Question 38/ 55

Complete the following table.

Method	Explanation	Type of pathogen
Morphology		
Genetic		

Method	Explanation	Type of pathogen

Immunology

Solution

4-38

Method	Explanation	Type of pathogen
Morphology	Pathogens differ in • shape • reaction to stains • the presence of special structures, e.g. capsules • requirements for growth. These characteristics can then be used to identify the pathogen.	Bacteria Fungi
Genetic	DNA profiling. Different pathogens have different DNA/RNA sequences and these can be used to identify the pathogen. This method is used to identify pathogens that are difficult to culture.	Viruses Bacteria Fungi
Immunology	• Agglutination. Specific antibodies to the pathogen/antigen are mixed with the patient's serum. If the pathogens/antigens are present, then the antibodies bind with them, resulting in agglutination. • ELISA test. The pathogen is identified using markers attached to antibodies.	Viruses Bacteria Fungi

Question 39/ 55

In terms of disease, what is meant by the term ‘vector’?

Solution

4-39 A vector is an organism that is not affected by a disease but spreads it between hosts.

Question 40/ 55

Explain why cleanliness in food, water and personal hygiene practices assist in control of disease.

Solution

4-40 Infectious diseases are caused by pathogens. Stopping the spread of pathogens will stop the spread of the disease. If food and water are clean (do not contain pathogens) then disease will not spread. Personal hygiene is important as pathogens may pass from one person to another. If hands are clean, then pathogens will not be transmitted.

Question 41/ 55

What are the major ways in which pathogens are transmitted from host to host?

Solution

4-41 Major means of transmission:

- airborne infection (often in water droplets)
- animal transfer – vector is present, e.g. malaria spread by mosquitoes

- foodborne transfer
 - sexual intercourse
 - unsterile needles
 - breaks in the skin.
-

Question 42/ 55

Complete the following table summarising procedures that reduce the spread of disease.

Procedure	How it stops spread	Examples of diseases that are stopped
Personal hygiene		
Community hygiene		
Quarantine		
Vaccination		
Public health programs		
Pesticides		
Genetic engineering		

Solution

4-42

Procedure	How it stops spread	Examples of diseases that are stopped
Personal hygiene	Washing hands stops the accumulation of microorganisms, and stops transmission via mouth	Norovirus Hepatitis A
Community hygiene	Sewage and water treatment destroys pathogens	Giardia

Procedure	How it stops spread	Examples of diseases that are stopped
Quarantine	Minimises exposure to infected organisms	Cholera Citrus greening SARS COVID 19
Vaccination	Produces active acquired immunity by introducing an antigen to produce antibodies to develop immunity in the individual and potentially herd immunity	Measles Mumps Diphtheria
Public health programs	Immunisation programs Education about notifiable diseases	Cervical cancer Breast screening Mass vaccination
Pesticides	Chemicals used to kill plant and animal pests. Can be used to kill vectors such as the malarial mosquito	Malaria Dengue
Genetic engineering	Altering the genetic makeup of an organism to introduce disease resistance	Bt cotton

Question 43/ 55

Complete the following table.

Type of vaccine	Description
Live attenuated vaccine	
Inactivated or killed vaccines	
Inactivated bacterial toxin	
Pathogen sub-unit	

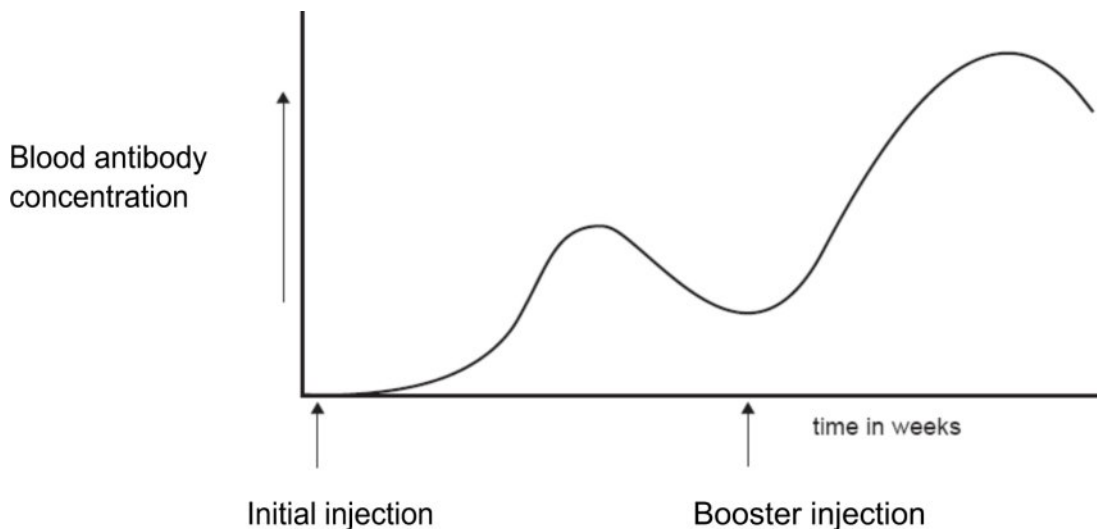
Solution

4-43

Type of vaccine	Description
Live attenuated vaccine	Vaccine contains live weakened bacteria. The bacteria can reproduce but cannot cause disease
Inactivated or killed vaccines	Vaccine contains inactivated viruses or killed bacteria
Inactivated bacterial toxin	Vaccine contains a toxin that is modified to be harmless
Pathogen sub-unit	Vaccine contains antigens made from one or more sub-units of the pathogen

Question 44/ 55

The graph below shows antibody levels after initial immunisation followed by a booster injection. Explain the shape of the graph.



Solution

4-44 The first injection results in the recognition of the antigen and the production of B plasma cells, which produce antibodies and B memory cells. Gradually the antibodies are destroyed but the memory cells remain. After the booster injection, these memory cells quickly divide and produce many antibodies and more memory cells.

Question 45/ 55

The hepatitis B vaccine is given at birth 2 months, 4 months and 6 months. Why?

Solution

4-45 The reason is as described in the previous question but to develop a sufficient number of memory B cells four doses of the vaccine are required. For future protection, further booster shots are needed to prevent infection.

Question 46/ 55

Explain why both quarantine and vaccination are used to stop the spread of disease.

Solution

4-46 Quarantine is used to stop the spread of disease in the first instance. Isolating possibly infected and infected individuals means that the pathogen cannot come in contact with healthy individuals. Quarantine does not protect a population from future infections. Vaccines do but vaccination takes time to develop, administer and then for immunity to develop. Vaccines induce an immune response, and this provides long-term immunity against the pathogen. The greater the number of individuals vaccinated, the lower the chance of the pathogen finding a host and therefore the spread of the disease is contained.

Question 47/ 55

Why does herd immunity rely on the immunisation of most of the population?

Solution

4-47 Herd immunity is the immunity provided when most of the population has been immunised. This reduces the number of individuals the pathogen can infect therefore reducing the chance that the pathogen can find a host, survive and spread to individuals not vaccinated.

Question 48/ 55

What is multiple sclerosis?

Solution

4-48 Multiple sclerosis is an autoimmune disease where the body produces antibodies that attach the myelin sheath surrounding its own nerve fibres. The destruction of myelin results in slowed or blocked nerve impulses.

Question 49/ 55

How is cancer related to cell division?

Solution

4-49 Cancer results from uncontrolled growth of a single cell. The uncontrolled growth occurs due to damage to genes that control the cell leading to a resistance to apoptosis.

Question 50/ 55

How do tumour cells evade the immune response?

Solution

4-50 Tumour cells evade the immune response by:

- proteins as their MHC class 1 bind to natural killer cells and cytotoxic cells preventing the cytotoxic T cells and killer cells from destroying the tumour cells.
 - producing cytokines that suppress cytotoxic T cells and natural killer cells.
 - releasing enzymes that suppress cytotoxic T cells and natural killer cells.
-

Question 51/ 55

What is immunotherapy?

Solution

4-51 Immunotherapy is a disease treatment that works by either activating or suppressing the immune system.

Question 52/ 55

What are monoclonal antibodies and how can they be used to treat cancer?

Solution

4-52 Monoclonal antibodies are artificially mass-produced identical antibodies. They are produced by injecting an antigen into an organism such as a mouse. The mouse's immune system responds by activating B plasma cells to produce specific antibodies against the antigen. These specific antibodies are then isolated and injected into the patient. Monoclonal antibodies can be produced that target antigens present on cancer cells. The antibodies bind with the cancer cells marking them for destruction.

Question 53/ 55

How can monoclonal antibodies be used to treat autoimmune diseases?

Solution

4-53 Ocrelizumab is a monoclonal antibody that is used to treat multiple sclerosis. This monoclonal antibody targets receptors on B-cells reducing their ability to attack the central nervous system. Other drugs include anti-inflammatory monoclonal antibodies that inhibit cytokines that are involved in abnormal inflammatory

response like rheumatoid arthritis.

Question 54/ 55

Explain how conjugated monoclonal antibodies can directly deliver drugs and or radiation to tumour cells.

Solution

4-54 Monoclonal antibodies are produced that have a complementary shape to match the surface of tumour cells. Drugs or radioactive substances are incorporated into the antibody structure. The antibodies are given to the patient and deliver the drug or radioactive substance only to those cells carrying molecules with a shape complementary to the antibody.

Question 55/ 55

Complete the following table:

Type of cancer vaccine	Antigens contained in the vaccine	How the vaccine works
Preventive		
Therapeutic		
Personalised		

Solution

4-55

Type of cancer vaccine	Antigens contained in the vaccine	How the vaccine works
Preventive	Viral antigens	Provides immunity against viruses that cause cancer, e.g. HPV vaccine
Therapeutic	Antigens found on specific cancer cells	Given to people who already have cancer to boost their immune response.
Personalised	Antigens from the patient's own tumour cells	Cells are removed from the tumour, antigens are removed to make them more obvious and then injected back into the patient.

Question 1/ 145

[VCAA 2022 SA Q20]

During their lifetime, plants are exposed to both pathogenic and beneficial microorganisms. Some plants provide shelter within their bodies for beneficial microorganisms. These beneficial microorganisms help plants that have not been genetically modified to resist pathogenic microorganisms.

The beneficial microorganisms may be providing protection by

- A synthesising toxins that kill pathogenic microorganisms.
- B providing a permeable physical barrier to pathogenic microorganisms.
- C stimulating the production of antibodies against pathogenic microorganisms.
- D mobilising the cells of the third line of defence against pathogenic microorganisms.

Solution

4-56 [VCAA 2022 SA Q20]

The beneficial microorganisms may be providing protection by

A synthesising toxins that kill pathogenic microorganisms. (Plants do not produce antibodies or have a third line of defence against pathogens. A permeable physical barrier would increase the ease at which pathogens enter the plant.)

Question 2/ 145

[VCAA 2015 SA Q17]

Which one of the following is an example of a plant defence against a pathogen?

A production of antibodies

B an active immune system

C extensive cell death throughout the plant

D waxy leaf surfaces acting as physical barriers

Solution

4-57 [VCAA 2015 SA Q17]

Which one of the following is an example of a plant defence against a pathogen?

D waxy leaf surfaces acting as physical barriers. (Plants do not have the sophisticated immune systems of animals. Most defence relies on physical barriers such as a layer of wax.)

Question 3/ 145

[VCAA 2014 SA Q15]

The first line of defence against pathogens includes the

A activation of helper T cells.

B presence of acid in the stomach.

C release of histamine from mast cells.

D production of interferon from virus-infected cells.

Solution

4-58 [VCAA 2013 SA Q14]

The first line of defence against pathogens includes the

B presence of acid in the stomach. (The first line of defence refers to barriers stopping pathogens entering body tissue. The stomach is an extension of the external environment. A low pH will destroy pathogens before they are able to cross the gut wall. The release of histamine and interferon are part of the second line of defence and helper T cells the third line.)

Question 4/ 145

[VCAA 2013 SA Q14]

As part of the first line of defence in the human immune system, naturally occurring barriers to invading pathogens include

A lysozymes in tears.

B the production of antibodies.

C the engulfing of pathogens by phagocytes.

D inflammation at the site of infection.

Solution

4-58 [VCAA 2013 SA Q14]

As part of the first line of defence in the human immune system, naturally occurring barriers to invading pathogens include

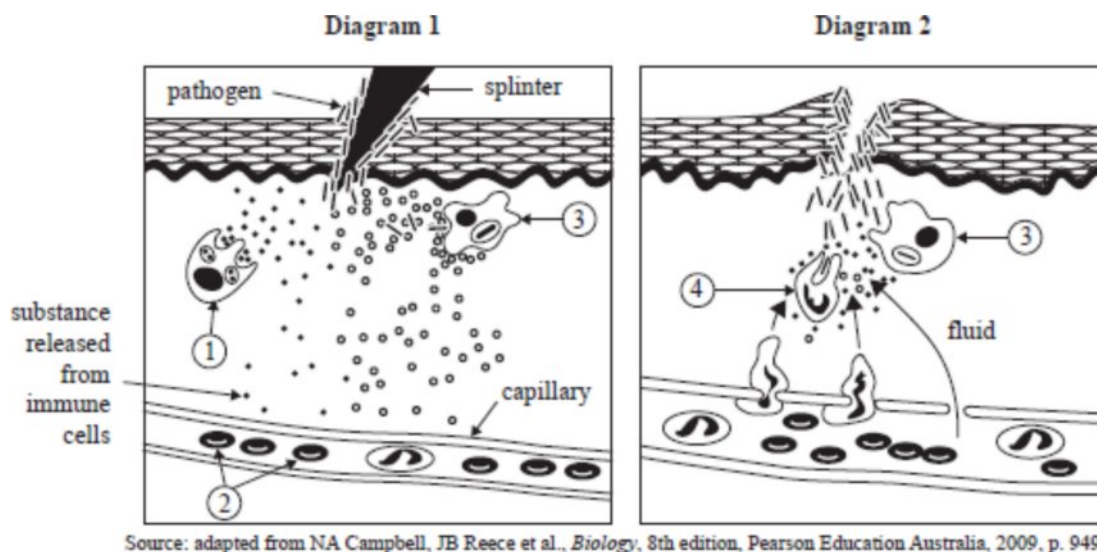
A lysozymes in tears. (The first line of defence refers to the external barriers to infection. Inflammation

and phagocytes are involved in the second line of defence and antibodies in the third line of defence.)

Question 5/ 145

[VCAA 2022 SA Q21]

The diagrams below illustrate the inflammatory response that may occur when a pathogen enters the human body.



Which of the following correctly identifies one of the cells labelled 1 to 4 in the diagrams above and their role in the inflammatory response?

	Cell Number	Name of cell	Role
A	1	T cell	releases cytokines
B	2	dendritic cell	presents antigens to helper T cells
C	3	mast cell	releases histamines
D	4	neutrophil	acts as a phagocyte

A 1: T cell

B 2: dendritic cell

C 3: mast cell

D 4: neutrophil

Solution

4-60 [VCAA 2022 SA Q21]

Which of the following correctly identifies one of the cells labelled 1 to 4 in the diagrams above and their role in the inflammatory response?

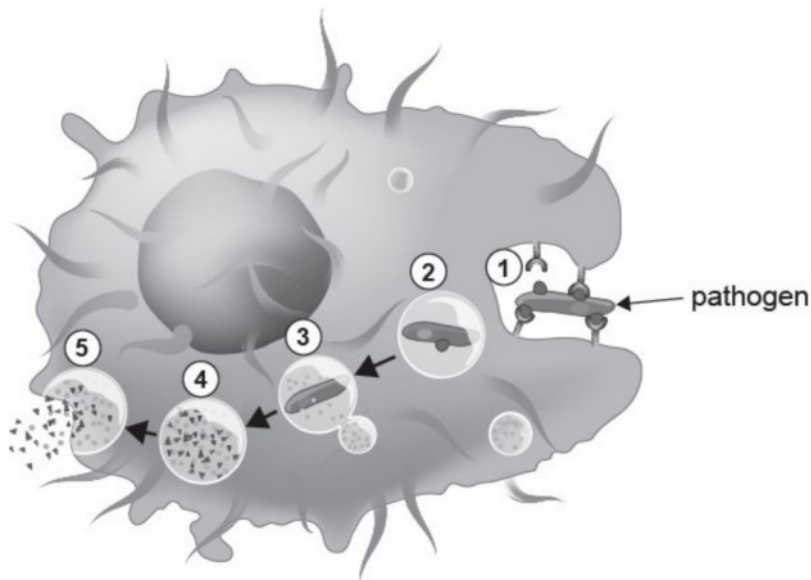
Cell number	Name of cell	Role
4	neutrophil	acts as a phagocyte

D (Cell 1 and not cell 3 is a mast cell. It releases histamines. Cell 2 is a red blood cell, as no nucleus is present. Cell 4 is a neutrophil, as it is involved in phagocytosis.)

Question 6/ 145

[VCAA 2019 SA Q20]

The diagram that follows shows the process of phagocytosis. This process is vital for immunity against extracellular infections.



What is happening at position 3?

A Enzymes that break down the microorganism are released into the vesicle.

B Antibodies are added to the vesicle to kill the microorganism.

C The cell is sampling the vesicle for antigen presentation.

D Intracellular microbes are attacking the microorganism.

Solution

4-61 [VCAA 2019 SA Q20]

What is happening at position 3?

A Enzymes that break down the microorganism are released into the vesicle. (At position 3 a vesicle containing enzyme comes-into-contact with the vesicle containing the pathogen. This is a diagram of phagocytosis. There is no evidence of antigen presentation.

Question 7/ 145

[VCAA 2021 SA Q15]

Neutrophils

A secrete complement proteins.

B migrate to the site of infection and engulf invading pathogens.

C increase the diameter of blood vessels to make them more permeable.

D release histamine following the binding of the antigen to receptors on the neutrophil's surface.

Solution

4-62 [VCAA 2021 SA Q16]

Neutrophils

B migrate to the site of infection and engulf invading pathogens. (Neutrophils are phagocytes and their role is to engulf and destroy pathogens such as bacteria.)

Question 8/ 145

[VCAA 2021 SA Q16]

In humans, an example of a chemical barrier that prevents the entry of pathogens into the internal environment would be

A histamine.

B interferons.

C lysozymes.

D complement proteins.

Solution

4-63 [VCAA 2014 SA Q15]

In humans, an example of a chemical barrier that prevents the entry of pathogens into the internal environment would be

C lysozymes. (Lysozymes are found in tears, saliva and milk. They are secreted onto the surface and therefore destroy pathogens before they enter the internal environment. The other molecules are all found in the internal environment.)

Question 9/ 145

[VCAA 2016 SA Q20]

The inflammatory response is a defence mechanism that evolved in higher organisms to protect them from infection and injury.

This response

A includes phagocyte migration to the site of the injury.

B is part of the adaptive immune system.

C is specific to the type of foreign body.

D involves the production of lymphocytes.

Solution

4-64 [VCAA 2016 SA Q20]

The inflammatory response is a defence mechanism that evolved in higher organisms to protect them from infection and injury.

This response

A includes phagocyte migration to the site of the injury. (Phagocyte migration is part of the inflammatory response, which is the initial general non-specific response to potential infection.)

Question 10/ 145

[VCAA 2015 SA Q18]

A girl is carrying a piece of wood. A small piece breaks off and becomes embedded in her finger. The next day, she notices an inflammatory response occurring in her finger.

In the region around the small piece of wood embedded in her finger

A mast cells would release antibodies.

B the skin tissue would become pale and cold.

C the capillaries would become more permeable.

D red blood cells would leave the blood vessels and engulf foreign material.

Solution

4-65 [VCAA 2015 SA Q18]

In the region around the small piece of wood embedded in her finger

C the capillaries would become more permeable. (The increased permeability is part of the immune response allowing macrophages easier access to the tissue. Note that red blood cells do not normally leave blood vessels and mast cells release histamines.)

Question 11/ 145

[VCAA 2014 SA Q16]

An example of a non-specific response by the immune system is

A phagocytes engulfing non-self-material.

B cytotoxic T cells releasing chemicals into infected cells.

C production of memory T cells.

D cloning of B cells to produce plasma cells.

Solution

4-66 [VCAA 2014 SA Q16]

An example of a non-specific response by the immune system is

A phagocytes engulfing non-self-material. (T and B cells are involved in the specific immune response.)

Question 12/ 145

[VCAA 2013 SA Q15]

Defence mechanisms against bacterial pathogens include:

A the production of interferon.

B neutralisation by histamines.

C destruction by complement proteins.

D agglutination by cytotoxic T cells.

Solution

4-67 [VCAA 2013 SA Q15]

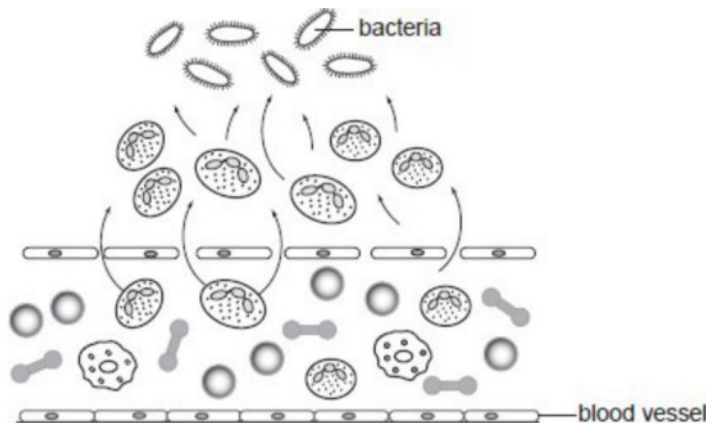
Defence mechanisms against bacterial pathogens include

C destruction by complement proteins. (Interferon and cytotoxic T cells defend the body against viral infection and histamines are involved in allergic reactions.)

Question 13/ 145

[VCAA 2012 E1 SA Q10]

Consider the following diagram showing a bacterial infection within a human.



Cells moving from the blood vessel towards the bacteria

A are natural killer cells.

B would act as phagocytes.

C cause vasodilation of the blood vessel.

D release histamine in response to tissue damage.

Solution

4-68 [VCAA 2012 E1 SA Q10]

Cells moving from the blood vessel towards the bacteria

B would act as phagocytes. (Histamines cause vasodilation and are released by mast cells.)

Question 14/ 145

[VCAA 2012 E1 SA Q23]

Interferon is a chemical that

A kills bacteria by producing holes in the bacterial wall.

B protects uninfected cells from viral attack.

C suppresses the immune response.

D is produced by T cells.

Solution

4-69 [VCAA 2012 E1 SA Q23]

Interferon is a chemical that

B protects uninfected cells from viral attack. (Fact)

Question 15/ 145

[VCAA 2011 E1 SA Q6]

It is reasonable to infer that an infection has occurred if

A histamine is released by cells.

B a scab has formed on a cut in the skin.

C bacteria are found in the large intestine.

D pathogens are found in leg muscle tissue.

Solution

4-70 [VCAA 2011 E1 SA Q6]

It is reasonable to infer that an infection has occurred if

D pathogens are found in leg muscle tissue. (The term pathogen describes a disease-causing organism. Histamines are released for a variety of reasons including responses allergenic materials. Scabs may occur in association with an infected cut but not necessarily. There are always bacteria in the gut and most are beneficial.)

Question 16/ 145

[VCAA 2011 E1 SA Q8]

Nonspecific defences of the immune system that act against bacteria include

A antibodies.

B phagocytes.

C interferons.

D plasma cells.

Solution

4-71 [VCAA 2011 E1 SA Q8]

Nonspecific defences of the immune system that act against bacteria include

B phagocytes. (The other alternatives all refer to items that are part of the specific responses. Phagocytes are large white blood cells that have a general role in removing potential threats such as bacteria.)

Question 17/ 145

[VCAA 2015 SA Q15]

Which one of the following is true of prions?

A They have an outer wall made of cellulose.

B They cause some brain diseases.

C They contain nucleic acids.

D They are unicellular.

Solution

4-72 [VCAA 2015 SA Q15]

Which one of the following is true of prions?

B They cause some brain diseases. (Prions are smaller and simpler than viruses, are made of proteins and do cause some brain diseases. Therefore, they are not cellular, lack cell walls and lack nucleic acids.)

Question 18/ 145

[VCAA 2022 SA Q22]

The human body does not normally produce an immune response against self-cells. Cells in the human immune system can distinguish self-cells from non-self-cells

A because non-self-cells have a faster reproduction rate.

B due to the presence of different antigens on non-self-cells.

C only when antibodies are attached to the surface of non-self-cells.

D because non-self-cells are always smaller in size than self-cells.

Solution

4-73 [VCAA 2022 SA Q22]

Cells in the human immune system can distinguish self-cells from non-self-cells

B due to the presence of different antigens on non-self-cells. (Fact.)

Question 19/ 145

[VCAA 2014 SA Q14]

An example of ‘self’ material in an adult human female is

A pollen inhaled from flowers in her garden.

B sperm cells present in her reproductive tract.

C cells lining her nose and trachea.

D malarial parasites inside her red blood cells.

Solution

4-74 [VCAA 2014 SA Q14]

An example of ‘self’ material in an adult human female is

C cells lining her nose and trachea. (All other alternatives do not include cells that are found in an adult human female.)

Question 20/ 145

[VCAA 2012 E1 SA Q9]

Major Histocompatibility Complex (MHC) class 1 molecules

A release complement proteins.

B are found only on B and T cells.

C present foreign antigens to B and T cells.

D produce antibodies that are specific to each antigen.

Solution

4-75 [VCAA 2012 E1 SA Q9]

Major Histocompatibility Complex (MHC) class 1 molecules

C present foreign antigens to B and T cells. (MHC 1 markers are found on all cells except red blood cells. Plasma B cells produce antibodies.)

Question 21/ 145

[VCAA 2021 SA Q17]

The role of the lymphatic system in an immune response includes

A carrying mast cells to the site of infection.

B activation of platelets to help heal wounds.

C transport of antigen-presenting cells, including dendritic cells.

D delivery of injected monoclonal antibodies to specific target cells.

Solution

4-76 [VCAA 2021 SA Q17]

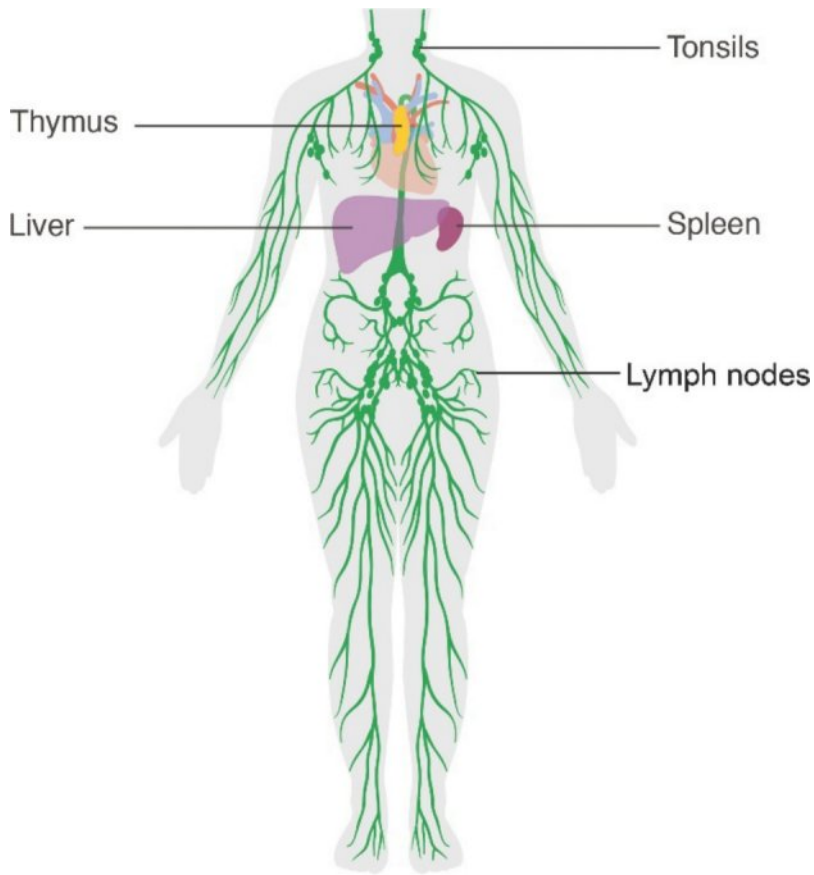
The role of the lymphatic system in an immune response includes

C transport of antigen-presenting cells, including dendritic cells. (Mast cells are found in connective tissue, platelets are found in the blood and the blood delivers monoclonal antibodies to target cells. The antigen-presenting cells travel to the lymph nodes via lymph vessels.)

Question 22/ 145

[VCAA 2017 SA Q23]

The human lymphatic system



The lymphatic system includes the lymph nodes, spleen and tonsils. In these particular organs

A clotting factors are inactivated to help seal a wound.

B clonal selection and proliferation of B cells occurs.

C non-self-antigens are identified by red blood cells.

D the initial response to an allergen is triggered.

Solution

4-77 [VCAA 2017 SA Q23]

The lymphatic system includes the lymph nodes, spleen and tonsils. In these particular organs

B clonal selection and proliferation of B cells occurs. (Clotting factors are activated to help seal a wound. Non-self-antigens are not identified by red blood cells and the initial response to an allergen is triggered by mast cells lining blood vessels.)

Question 23/ 145

[VCAA 2013 SA Q18]

Di George syndrome is a rare, congenital disease that can disrupt the normal development of the thymus gland. This disease would result in the

A swelling of lymph nodes.

B overproduction of B cells.

C reduced production of T cells.

D release of histamines from mast cells.

Solution

4-78 [VCAA 2013 SA Q18]

This disease would result in the

C reduced production of T cells. (T cells mature in the thymus gland therefore disrupting the normal development of the thymus gland will reduce the production of mature T cells. Lymph nodes, B cells and mast cells are not directly associated with the thymus gland.)

Question 24/ 145

[VCAA 2013 SA Q20]

In the lymphatic system

A clonal selection occurs.

B mast cells are produced.

C vessels have thick, muscular walls.

D lymph is pumped by the heart.

Solution

4-79 [VCAA 2013 SA Q20]

In the lymphatic system

A clonal selection occurs. (Lymph is not pumped by the heart, arteries not lymph vessels have thick muscular walls and mast cells are not involved in clonal selection.)

Question 25/ 145

[VCAA 2011 E1 SA Q7]

The lymphatic system contains

A B cells only.

B T cells only.

C B cells and T cells.

D neither B cells nor T cells.

Solution

4-80 [VCAA 2011 E1 SA Q7]

The lymphatic system contains **C B cells and T cells**. (Fact!)

Question 26/ 145

[VCAA 2018 SA Q17]

Antigen-presenting cells deliver antigens to lymphocytes found within lymphoid tissue. These lymphocytes recognise these antigens as being non-self, causing the lymphocytes to become activated and increase in number.

Which of the following lymphocytes are activated by antigen-presenting cells?

A T helper cells

B dendritic cells

C plasma cells

D neutrophils

Solution

4-81 [VCAA 2018 SA Q17]

Which of the following lymphocytes are activated by antigen-presenting cells?

A T helper cells (Definition: This is a definition of the job of a T helper cell.)

Question 27/ 145

[VCAA 2019 SA Q19]

In adaptive immunity, which cells, directly destroy virally infected cells?

A B cells

B plasma cells

C T helper cells

D T cytotoxic cells

Solution

4-82 [VCAA 2019 SA Q19]

In adaptive immunity, which cells, directly destroy virally infected cells?

D T cytotoxic cells. (Fact. T helper cells activate the immune system and B cells divide into plasma cells that produce antibodies.)

Question 28/ 145

[VCAA 2013 SA Q19]

Cytotoxic T cells are

A antibodies.

B able to kill virus-infected cells.

C part of the humoral response.

D part of the second line of the immune defence.

Solution

4-83 [VCAA 2013 SA Q19]

Cytotoxic T cells are

B able to kill virus-infected cells. (Cytotoxic T cells are involved in the cell-mediated immune response and antibodies are involved in the humoral response.)

Question 29/ 145

[VCAA 2017 SA Q22]

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

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

Solution

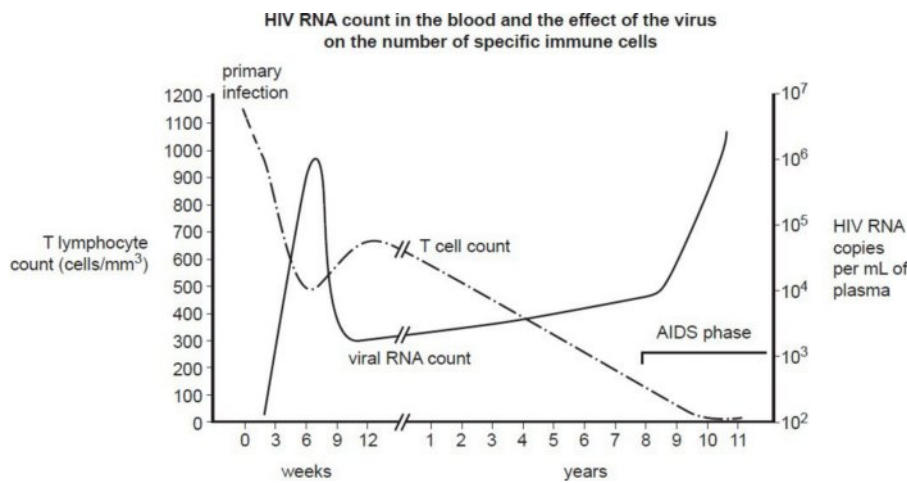
4-84 [VCAA 2017 SA Q22]

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

Cell	Role
dendritic cell	presents fragments of antigens to T helper cel

B (Macrophages and neutrophils engulf bacterial and mast cells are involved in inflammation.)

[VCAA 2019 SA Q23]



The graph above shows the HIV RNA count in the blood and the effect of the virus on the number of specific immune cells in an untreated patient.

Based on your knowledge and the information in the graph above, what is the effect of the change in the number of T cells over time?

A a decrease in the viral RNA count during the AIDS phase.

B loss of effective function of the adaptive immune system.

C failure of macrophages to engulf HIV.

D failure of complement proteins.

Solution

4-85 [VCAA 2019 SA Q23]

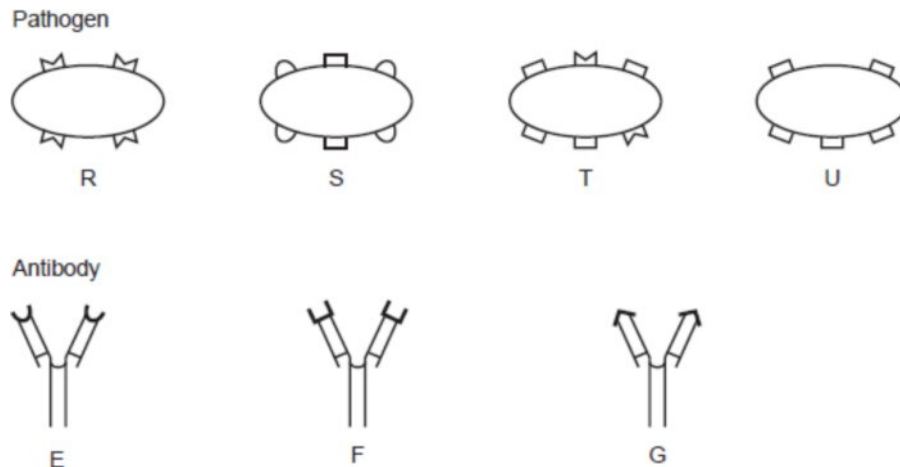
Based on your knowledge and the information in the graph above, what is the effect of the change in the number of T cells over time?

B loss of effective function of the adaptive immune system. (The role of T cells is to activate the immune system. As the T cell count drops in the body, the immune system becomes less effective in combatting the virus.)

Question 31/ 145

[VCAA 2015 SA Q16]

Consider the following diagram of four pathogens and three antibodies.



Which one of the following statements is correct?

A Antibody E would be effective against both pathogen S and pathogen R.

B Antibody F is effective against three of the pathogens.

C There are no antibodies effective against pathogen U.

D Antibody G is only effective against pathogen R.

Solution

4-86 [VCAA 2015 SA Q16]

Consider the following diagram of four pathogens and three antibodies. Which one of the following statements is correct?

B Antibody F is effective against three of the pathogens. (You need to identify matching binding sites. The binding site an F corresponds to at least some sites on Pathogen S, T and F.)

[VCAA 2012 E1 SA Q16]

The ABO blood group system has four main groups. Consider the following table.

Blood group samples				
	O	A	B	AB
Antigens on red blood cells	Neither	A	B	Both
	A nor B		A and B	

Agglutination of blood cells would occur if

A antibodies of type A were added to a sample of group O blood.

B antibodies of type A were added to a sample of group B blood.

C antibodies of type B were added to a sample of group A blood.

D antibodies of type B were added to a sample of group AB blood.

Solution

4-87 [VCAA 2012 E1 SA Q16]

Agglutination of blood cells would occur if

D antibodies of type B were added to a sample of group AB blood. (Blood group AB has both A and B antigens therefore if type B antibodies were added they would combine with the B antigens forming agglutination or clotting. Blood group O has neither antigen therefore adding either A or B antibodies will not result in agglutination. Blood group A does not have B antigens therefore no agglutination will occur.)

[VCAA 2011 E1 SA Q13]

This diagram shows a group of antigens.



An appropriate antibody to use against these antigens would be type



A



B



C



D

Solution

4-88 [VCAA 2011 E1 SA Q13]

An appropriate antibody to use against these antigens would be type

B.



(The antigen binding sites of alternatives B & C match the antibody shape. Alternative **B**, however, is correct because it shows appropriately the heavy chain on the inside of the molecule.)

Question 34/ 145

[VCAA 2020 SA Q19]

The role of T helper cells is to

A destroy cells that are infected with bacteria.

B control the adaptive immune response.

C generate antibodies.

D engulf parasites.

Solution

4-89 [VCAA 2020 SA Q19]

The role of T helper cells is to

B control the adaptive immune response. (The clue is in the name – helper cells. T helper cells signal other cells to gather and respond to an infection. This may result in the production of antibodies by B cells and the attraction of phagocytes.)

Question 35/ 145

[VCAA 2020 SA Q20]

Which one of the following describes a feature common to both T cells and B cells?

A having immunological memory

B rapidly responding to pathogens on first exposure

C providing a physical barrier to the entry of pathogens

D being able to attach to both microorganisms and viruses

Solution

4-90 [VCAA 2020 SA Q20]

Which one of the following describes a feature common to both T cells and B cells?

A having immunological memory (The body has populations of B cells and T cells that react to specific threats. After an initial infection or vaccination, greater numbers of memory T and memory B cells specific to a particular antigen will circulate in the body, providing a more rapid response to subsequent exposure.)

Question 36/ 145

[VCAA 2020 SA Q21]

The property of the immune system that enables it to fight infections and destroy cancer cells is the

A ability to kill all invading organisms.

B ability to adapt to donor tissue, facilitating transplants.

C ability to distinguish self from non-self-biological molecules.

D generation of complement proteins and other chemical barriers.

Solution

4-91 [VCAA 2020 SA Q21]

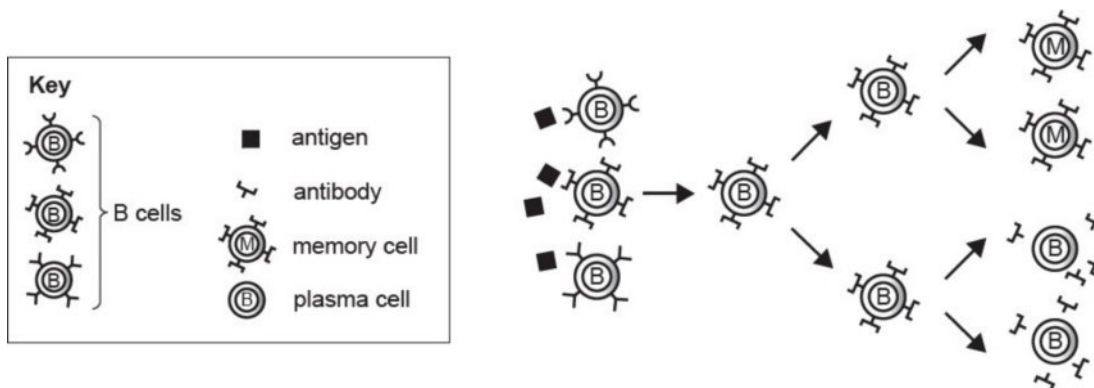
The property of the immune system that enables it to fight infections and destroy cancer cells is the

C ability to distinguish self from non-self-biological molecules. (This is a critical feature of the immune system – recognising the body's own useful cells and not attacking them. The breakdown in the immune system in the case of autoimmune diseases results in the immune system attacking useful, healthy cells.)

Question 37/ 145

[VCAA 2019 SA Q21]

Consider the diagram below of clonal selection in B cells.



In adaptive immunity, which part of this process allows long-term (sometimes lifetime) protection against pathogens?

A recognition of one antigen by one B cell clone.

B production of specific antibodies.

C generation of memory cells.

D production of plasma cells.

Solution

4-92 [VCAA 2019 SA Q21]

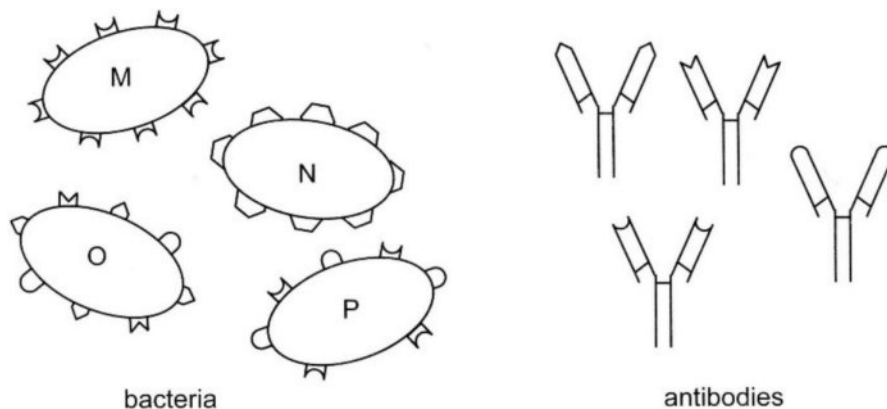
In adaptive immunity, which part of this process allows long-term (sometimes lifetime) protection against pathogens?

C generation of memory cells. (Long-term memory is produced when the body's defence system comes-into-contact with a particular pathogen. B cells will respond by producing antibodies and more clones of themselves that act as memory cells to protect against future attack by the same pathogen.)

Question 38/ 145

[VCAA 2009 E1 SA Q20]

A young woman stood on a dirty, rusty nail. The following diagrams show bacteria isolated from the wound and a range of antibodies that were already present in her body.



The microorganism most likely to cause a severe infection is

A M.

B N.

C O.

D P.

Solution

4-93 [VCAA 2009 E1 SA Q20]

The microorganism most likely to cause a severe infection is

B N. (There are no antibodies present that fit the antigens on the N bacteria.)

Question 39/ 145

[VCAA 2018 SA Q23]

Rabies is a viral disease spread to people by infected animals. A person bitten by an infected animal should be given an injection of specific antibodies.

Following the injection, this person should have

A natural active immunity.

B artificial active immunity.

C natural passive immunity.

D artificial passive immunity.

Solution

4-94 [VCAA 2018 SA Q23]

Following the injection, this person should have

D artificial passive immunity. (The person has immunity because they have received antibodies. The

immunity is passive rather than active because the person has received antibody rather than making their own.)

Question 40/ 145

[VCAA 2016 SA Q23]

A park ranger was injected with an antivenom serum to treat a snakebite. The treating doctor explained that the injection would not protect him against future snakebites.

This is because antivenom serum is used to achieve

A active and natural immunity.

B passive and natural immunity.

C active and induced (artificial) immunity.

D passive and induced (artificial) immunity.

Solution

4-95 [VCAA 2016 SA Q23]

This is because antivenom serum is used to achieve

D passive and induced (artificial) immunity. (The immunity will not last as the body's immune was not stimulated. The introduced antibodies will gradually disappear.)

Question 41/ 145

[VCAA 2011 E1 SA Q9]

Antibodies passed from a mother to her baby during breast-feeding would be best described as

A naturally acquired, passive immunity.

B naturally acquired, active immunity.

C artificially acquired, passive immunity.

D artificially acquired, active immunity.

Solution

4-96 [VCAA 2011 E1 SA Q9]

Antibodies passed from a mother to her baby during breast-feeding would be best described as

A naturally acquired, passive immunity. (The baby acquires antibodies naturally from the mother and because the baby is not producing the antibodies the immunity is passive.)

Question 43/ 145

[VCAA 2011 E1 SA Q24]

From the information in the table, it is reasonable to infer that

A Stella has been infected with RSV.

B Mary has been infected with three kinds of virus.

C Emily has been infected with the greatest number of different viruses.

D Becky and Stella have each been infected with the same set of viruses.

D Once the antibody distribution was known, doctors vaccinated the four patients against viruses for which each patient had no immunity.

Solution

4-97 [VCAA 2011 E1 SA Q24]

From the information in the table it is reasonable to infer that

C Emily has been infected with the greatest number of different viruses. (Emily has produced three of the antibodies under study and therefore has been exposed to three of the viruses studied. A particular antibody will be produced when an individual is exposed to the specific virus that causes that antibody production.)

Question 44/ 145

[VCAA 2011 E1 SA Q25]

From the information given in the table it is reasonable to infer that Becky would be given

A vaccines for Rhinovirus and influenza A.

B vaccines for influenza B and RSV.

C the same vaccines as Emily.

D vaccines for influenza A.

Solution

4-98 [VCAA 2011 E1 SA Q25]

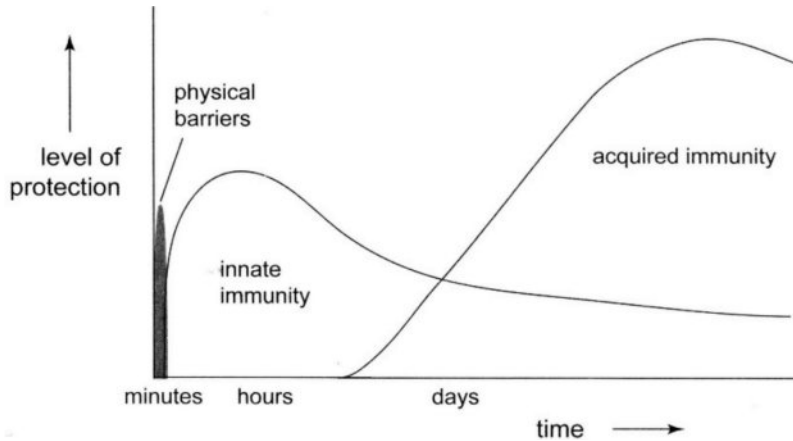
From the information given in the table it is reasonable to infer that Becky would be given

B vaccines for influenza B and RSV. (Becky has not produced antibodies to influenza B or RSV so would do well to receive vaccines for these two viruses.)

Question 45/ 145

[VCAA 2009 E1 SA Q21]

After an individual is exposed to a microbial infection, the immune system increases its activities. The graph below summarises the timeline of the level of those activities.



It is reasonable to conclude that

A physical barriers involve macrophages.

B innate immunity lacks involvement of living cells.

C lymph nodes are involved in the acquired immunity phase.

D the protection developed against the disease ceases at the end of the infection.

Solution

4-99 [VCAA 2009 E1 SA Q21]

It is reasonable to conclude that

C lymph nodes are involved in the acquired immunity phase. (Macrophages are involved after the pathogen passes the organism's physical barriers, innate immunity involves living cells and protection developed against the disease continues after the initial infection.)

[VCAA 2012 E1 SA Q24]

This test for HIV is reliable because the

A dye reacts with the patient's blood serum.

B enzyme has an active site for the HIV antigen.

C man-made antibody has the same shape as the HIV antigen.

D HIV antigen has a complementary shape specific to the HIV antibody.

Solution

4-100 [VCAA 2012 E1 SA Q24]

This test for HIV is reliable because the

D HIV antigen has a complementary shape specific to the HIV antibody. (This allows the HIV antigen to attach to the HIV antibody. If the antibody and the antigen had the same shape, they would not bind together.)

Question 48/ 145

[VCAA 2012 E1 SA Q25]

The results of the tests of three patients are given in the following table.

Positive control	Negative control	Patient R	Patient S	Patient T
1.689	0.153	0.155	0.675	1.999

Numbers are expressed as optical density at 450 nm. The more intense the dye is, the higher the optical density. The cut-off value indicating a positive result is 0.500.

Values below 0.300 are considered to be negative.

The results of these tests suggest that

A patient T has not been exposed to HIV.

B patient R has been exposed to the HIV antigen.

C patient S has responded to exposure to HIV by developing antibodies.

D the positive control contained fewer HIV antibodies than the negative control.

Solution

4-101 [VCAA 2012 E1 SA Q25]

Values below 0.300 are considered to be negative. The results of these tests suggest that

C patient S has responded to exposure to HIV by developing antibodies. (Antibodies are produced after exposure to the virus therefore patient T has been exposed. The positive control contains more antibodies than the negative control. Patient R has a reading of less than 3000 therefore has not been exposed to the HIV antigen.)

Question 50/ 145

[VCAA 2022 SA Q23]

There are many countries where measles is endemic and the vaccination rate for measles is low. Assuming that an unvaccinated person from the state of Montana, USA, travelled home by plane from one of these countries, what is the minimum number of days that this person should be kept in quarantine so that they are not at risk of spreading the disease if they were infected?

A 30

B 21

C 14

D 7

Solution

4-102 [VCAA 2022 SA Q23]

Assuming that an unvaccinated person from the state of Montana, USA travelled home by plane from one of these countries, what is the minimum number of days that this person should be kept in quarantine so that they are not at risk of spreading the disease if they were infected?

B 21. (Range of incubation is 7–21 days; therefore, a possibly infected person would need to be in quarantine for the maximum possible incubation time.)

Question 51/ 145

[VCAA 2022 SA Q24]

Testing a traveller for IgM antibodies would let a health official know if the traveller

A is no longer infectious.

B has had red, watery eyes.

C has recovered from measles.

D has been infected with the measles virus.

Solution

4-103 [VCAA 2022 SA Q24]

Testing a traveller for IgM antibodies would let a health official know if the traveller

D has been infected with the measles virus. (IgM antibodies are the first to be secreted in an infection. They provide defence until enough IgG antibodies are formed.)

Question 52/ 145

[VCAA 2022 SA Q25]

The R_0 is defined as the average number of secondary cases of an infectious disease arising from one case.

According to the infographic provided on the previous page, what is the R_0 for measles?

A 0–7

B 3–97.

C 7–21

D 12–18

Solution

4-104 [VCAA 2022 SA Q25]

According to the infographic provided, what is the R_0 for measles?

D 12-18 (The poster states, “One person can infect 12–18 susceptible people.”)

Question 53/ 145

[VCAA 2022 SA Q26]

There are 200 people aged more than 12 months old in a population. This population is exposed to the measles virus. If the population was fully vaccinated, how many of these 200 people could be expected to be infected with the measles virus?

A 0

B 3

C 6

D 9

Solution

4-105 [VCAA 2022 SA Q26]

There are 200 people aged more than 12 months old in a population. This population was fully vaccinated, how many of these 200 people could be expected to be infected with the measles virus?

C 6 (The poster states, “Two doses of MMR are 97% effective.” This means 3 people out of every 100 or 6 people out of 200 could be expected to be infected.)

Question 54/ 145

[VCAA 2022 SA Q27]

Which of the following cells responds first when a person receives the MMR vaccination?

A helper T cells

B memory T cells

C cytotoxic T cells.

D antigen-presenting cells.

Solution

4-106 [VCAA 2022 SA Q27]

Which of the following cells responds first when a person receives the MMR vaccination?

D antigen-presenting cells. (Antigen-presenting cells detect the antigens in the vaccine and display them to helper T cells that activate memory T cells and cytotoxic T cells.)

Question 55/ 145

[VCAA 2022 SA Q28]

Hendra virus is a disease that can affect horses and human beings. Available evidence implicates fruit bats as the natural reservoir of the Hendra virus, which is transmitted in bodily fluids.

One practical way of controlling the spread of the Hendra virus to horses is to

A stop horses from eating fruit.

B cover the feed and water containers for horses.

C inject all fruit bats with a vaccine against the virus.

D minimise the number of fruit trees that bats rely on for food.

Solution

4-107 [VCAA 2022 SA Q28]

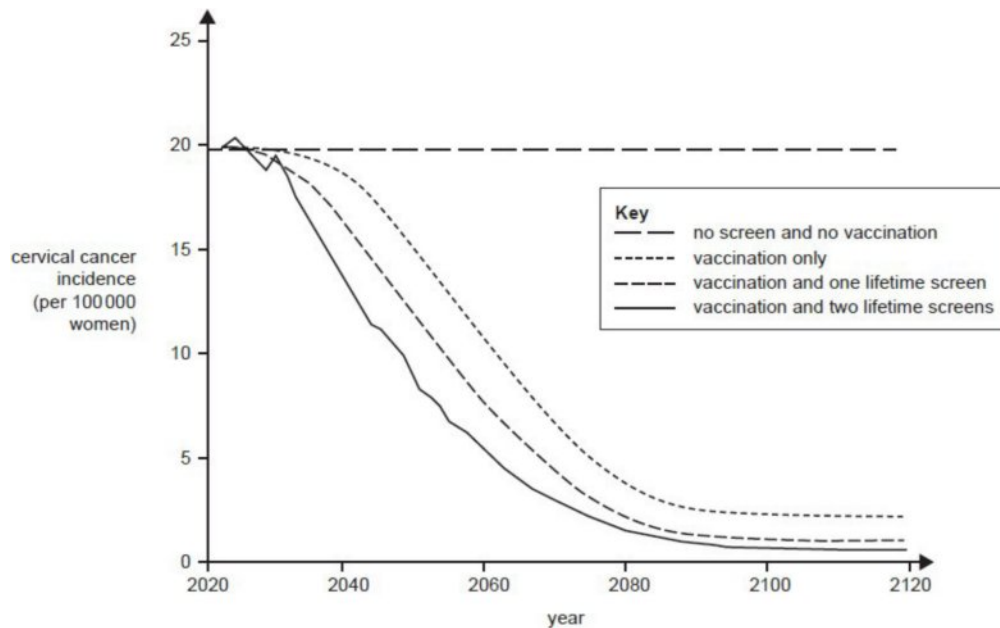
One practical way of controlling the spread of the Hendra virus to horses is to

B cover the feed and water containers for horses. (Horses do not eat fruit and minimising fruit trees would reduce the fruit crop for farmers. It is not practical to immunise all fruit bats, but it is easy to minimise access to feed and water for them as this will reduce contact between horses and bats.)

Question 56/ 145

[VCAA 2021 SA Q34]

The World Health Organization (WHO) runs a campaign to eliminate cervical cancer globally. In response to this campaign, a study was conducted to model the impact of cervical cancer screening along with a human papillomavirus (HPV) vaccination program in low-income and lower-middle-income countries. HPV is the cause of most cervical cancers. The results of the modelling are shown below.



Source: adapted from M Brisson et al, 'Impact of HPV vaccination and cervical screening on cervical cancer elimination: A comparative modelling analysis in 78 low-income and lower-middle-income countries', *The Lancet*, vol. 395 22 February 2020, [https://doi.org/10.1016/S0140-6736\(20\)30068-4](https://doi.org/10.1016/S0140-6736(20)30068-4)

Which one of the following conclusions is supported by the data in the graph?

A The incidence of cervical cancer would be unaffected by a cervical cancer screening program.

B The largest factor in reducing the incidence of cervical cancer in the long term is vaccination.

C With vaccination only, it is possible to achieve fewer than 10 cervical cancer cases per 100 000 women by 2050.

D Vaccination and one lifetime screen would be more effective than vaccination and two lifetime screens by 2070.

Solution

4-108 [VCAA 2021 SA Q34]

Which one of the following conclusions is supported by the data in the graph?

B The largest factor in reducing the incidence of cervical cancer in the long term is vaccination. (A is just wrong – all 3 other alternatives decrease the incidence of cervical cancer. Note the downward curves and decrease on the vertical axes. C has already been achieved by 2020. D is wrong – 2 screenings would help a little more. By itself, vaccination is the biggest cause of reducing cervical cancer incidence.)

Question 58/ 145

[VCAA 2013 SA Q16]

Using the information given, it can be concluded that

A the viral vector is a mosquito.

B the virus is a cellular pathogen.

C Ross River water transmits the virus.

D many kangaroos and wallabies would be killed.

Solution

4-109 [VCAA 2013 SA Q16]

Using the information given, it can be concluded that

A the viral vector is a mosquito. (The virus is a non-cellular pathogen. The mosquito transfers the viral particles from kangaroos and wallabies to humans therefore, the mosquito is a vector.)

Question 59/ 145

[VCAA 2013 SA Q17]

The most effective way to reduce the incidence of Ross River fever in Australia would be to

A prevent humans from living near the Ross River.

B use an attenuated form of the virus to create a human vaccine.

C increase spending on anti-inflammatory drugs to treat the symptoms.

D isolate kangaroos and wallabies in nature reserves near the Ross River.

Solution

4-110 [VCAA 2013 SA Q17]

The most effective way to reduce the incidence of Ross River fever in Australia would be to

B use an attenuated form of the virus to create a human vaccine. (It would be very difficult to stop humans living near the Ross River or to isolate the kangaroos and wallabies. Treating the symptoms will not reduce the chance of infection. Immunising will stop viral particle production and therefore decrease the chance of infection.)

Question 61/ 145

[VCAA 2016 SA Q21]

It is reasonable to say that *S. anatum* is

A a virus.

B a prion.

C an insect.

D a bacterium.

Solution

4-111 [VCAA 2016 SA Q21]

It is reasonable to say that *S. anatum*

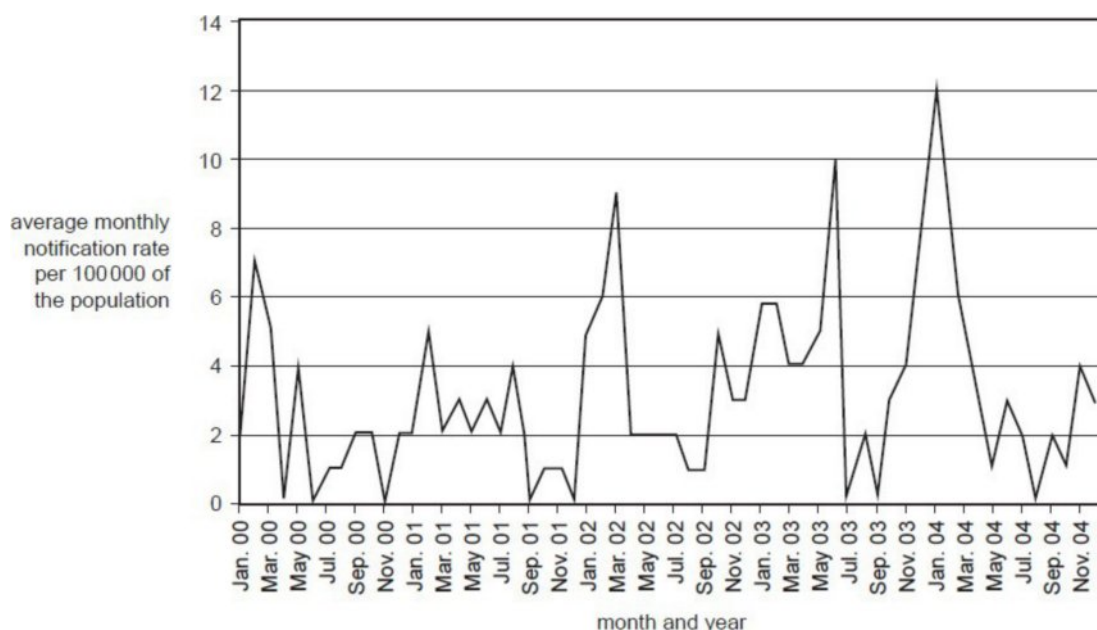
D a bacterium. (*S. anatum* is a bacterium and bacteria are killed by antibiotics. Bacteria can reproduce on the surface of the body and in tissue fluid.)

Question 62/ 145

[VCAA 2016 SA Q22]

S. anatum is not a common cause of food poisoning. Data has been collected and analysed for the occurrence of illness caused by this organism in Queensland over a five-year period.

The graph that follows displays the average monthly notification rate per 100 000 of the population for the illness caused by *S. anatum*.



It can be concluded from the data that

A there are four periods in which the notification rate is greater than six per 100 000.

B the notification rate is always lowest during September of each year.

C the notification rate is fairly steady over the five-year period.

D the notification rate in 2001 was highest in May.

Solution

4-112 [VCAA 2016 SA Q22]

It can be concluded from the data that

A there are four periods in which the notification rate is greater than six per 100 000. (There are three peaks above six per 100 000 Jan 00, Mar 02, June 03 and Feb 04. Careful reading of the graph shows the alternatives to be incorrect.)

Question 63/ 145

[VCAA 2021 SA Q29]

A four-month investigation was undertaken in the classrooms of a large number of Year 2 and Year 3 students from four primary schools. For the first two months, half of the classes from each school used an antimicrobial gel hand sanitiser, while the other half used soap and water for regular hand hygiene. The students then switched hand-cleaning methods for the final two months. No significant differences in illness were observed between the groups.

The purpose of this investigation was most likely to

A reduce water use in schools.

B encourage students to wash their hands more often.

C reduce the number of students who are away from school due to illness.

D decide if purchasing antimicrobial gel hand sanitiser for students was worthwhile.

Solution

4-113 [VCAA 2021 SA Q29]

The purpose of this investigation was most likely to

D decide if purchasing antimicrobial gel hand sanitiser for students was worthwhile. (From the results, there was no significant difference between the use of soap and water or antibacterial gel in reducing illness. Soap would be cheaper and more cost-effective than purchasing antibacterial gel.)

Question 65/ 145

[VCAA 2021 SA Q30]

Which one of the following would be a requirement of either Step 1 or Step 2?

A Step 2 would require the use of a thermocycling machine to maintain the temperature at 37°C.

B Step 1 would require the quill samples to have been stored at a very high temperature.

C Step 1 would require the extraction of DNA from the nuclei of quill epithelial cells.

D Step 2 would usually require a reaction mixture containing two primers.

Solution

4-114 [VCAA 2021 SA Q30]

Which one of the following would be a requirement of either Step 1 or Step 2?

D Step 2 would usually require a reaction mixture containing two primers. (Step 1 is the extraction of DNA from mitochondria, not the nucleus and storing the quills at high temperature would destroy the DNA present.

Thermocycling machines allow temperatures to be changed at regular time intervals. Step 2 is PCR and primers are used in PCR.)

Question 67/ 145

[VCAA 2021 SA Q31]

In order for the student's experiment to be valid, the student would need to

A ensure the amplified DNA region is from the correct locus of the echidna's mitochondrial genome.

B be able to have the same set of results replicated by a different observer at a different time.

C demonstrate that the results from the amplified samples were precise.

D repeat the experiment a minimum of three times.

Solution

4-115 [VCAA 2021 SA Q31]

In order for the student's experiment to be valid, the student would need to

A ensure the amplified DNA region is from the correct locus of the echidna's mitochondrial genome. (Valid experiments are those that test what they claim to test, in this experiment, the echidna's mitochondrial genome.)

Repeating an experiment checks that some other factor has not affected the results and reproducing the experiment by someone else eliminates bias.)

Question 68/ 145

[VCAA 2021 SA Q32]

Attempts to reach a conclusion based on these electrophoresis results may be affected by

A an unidentified systematic error.

B the presence of several outliers in the results.

C a degree of uncertainty in the results for Echidna sample D.

D a random error causing the position of the DNA sample in lane 7.

Solution

4-116 [VCAA 2021 SA Q32]

Attempts to reach a conclusion based on these electrophoresis results may be affected by

C a degree of uncertainty in the results for Echidna sample D. (Systematic errors affect all results. There is only one different result therefore, only one possible outlier. Sample D produces two different results, hence uncertainty.)

Question 69/ 145

[VCAA 2021 SA Q33]

The results from Step 4 are shown in the table below. They compare a sequence of 20 bases between the echidna samples. Of the four samples, three were determined to be from Australia and one was determined to be from New Guinea.

Echidna sample	Mitochondrial DNA sequence
A	... ATAGGCATTGCTCTGGGAAT ...
B	... ATTGGCATGGCTCTCGGATT
C	... ATAGGCATTGCTCTGGCAAT ...
D	... ATAGGCATTGCTCTGAGAAT ...

Considering the information provided, which echidna sample is most likely to be from New Guinea?

A Echidna sample A

B Echidna sample B

C Echidna sample C

D Echidna sample D

Solution

4-117 [VCAA 2021 SA Q33]

Considering the information provided, which echidna sample is most likely to be from New Guinea?

B Echidna sample B (The DNA sequence for B is different to the other 3 sequences – so most likely to have been from a specimen from New Guinea, which has been geographically isolated for a considerable time.)

Question 70/ 145

Why are quarantine measures needed when there is an outbreak of an infectious disease in Australian farm animals?

- A To prevent the spread of the disease to food imported into Australia
- B To prevent Australian animals from becoming immune to the disease
- C To prevent introduced plants threatening the survival of Australian farm animals
- D To prevent the disease from spreading to farm animals in different regions of Australia**

Solution

4-118

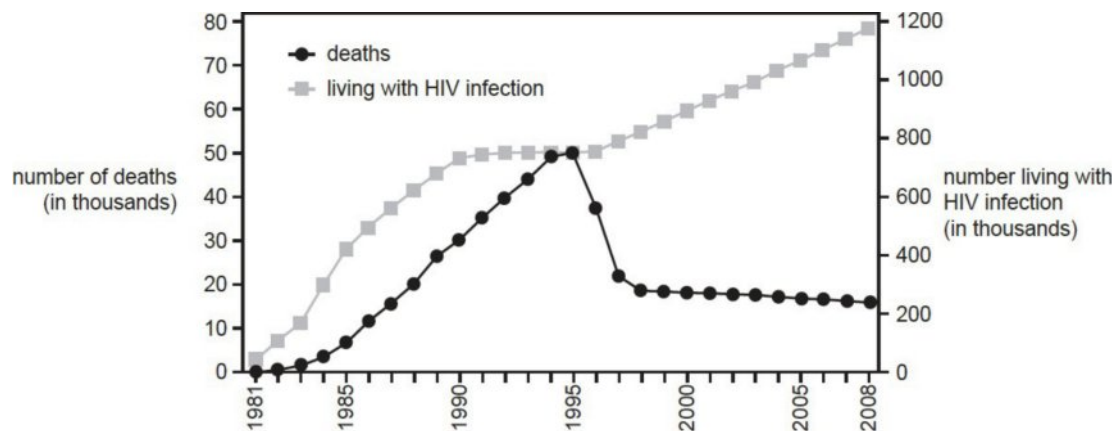
Why are quarantine measures needed when there is an outbreak of an infectious disease in Australian farm animals?

D To prevent the disease from spreading to farm animals in different regions of Australia. (Quarantine refers to the process where animals from another area (often another country) are kept separate until authorities are sure that they are free of contagious infectious diseases.)

Question 71/ 145

[VCAA 2018 SA Q29]

The graph below shows the death rates from acquired immune deficiency syndrome (AIDS) and also the number of people infected with the human immunodeficiency virus (HIV). Before 1995 many people infected with the virus went on to develop AIDS, which led to their deaths.



Based on the information in the graph on the previous page, what is the most likely reason for the change in death rates, even though infection rates continued to climb after 1995?

- A People had access to new antiviral drugs.
- B People were educated about what caused HIV infection.
- C People infected with HIV were isolated from the rest of the public.
- D A widespread vaccination program for HIV was introduced within a targeted population.

Solution

4-119 [VCAA 2018 SA Q29]

Based on the information in the graph, what is the most likely reason for the change in death rates, even though infection rates continued to climb after 1995?

A People had access to new antiviral drugs. (Education has occurred but is not the major cause of reduced death rates and vaccination is still a research area. The major cause is the use of antiviral drugs that reduce the levels of HIV in a person to negligible levels allowing them to survive.)

Question 72/ 145

[VCAA 2021 SA Q36]

A study assessed the effectiveness and safety of a drug called doxycycline. One hundred and fifty adults hospitalised with malaria were involved. These adults were randomly placed into two groups of equal size.

One group received doxycycline in addition to standard care. The other group received standard care only.

The group receiving standard care only was the

A control group.

B variable group.

C unsupported group.

D experimental group.

Solution

4-120 [VCAA 2021 SA Q36]

The group receiving standard care only was the

A control group. (Definition – the group receiving unaltered or standard conditions is the control or reference group.)

Question 73/ 145

[VCAA 2021 SA Q37]

Viruses can be detected in sewage. Human faecal matter is the main source of pathogenic viruses in sewage. Infected individuals shed viral particles in their faeces.

Which one of the following is an advantage of testing sewage for viral particles in order to control possible virus outbreaks?

A Infected individuals can be prevented from shedding the virus.

B Infection in a community can be rapidly identified.

C Infected individuals can be located quickly.

D Sewage can be treated for the virus.

Solution

4-121 [VCAA 2021 SA Q37]

Viruses can be detected in sewage. Human faecal matter is the main source of pathogenic viruses in sewage. Infected individuals shed viral particles in their faeces. Which one of the following is an advantage of testing sewage for viral particles in order to control possible virus outbreaks?

B Infection in a community can be rapidly identified. (A & D are incorrect. C is an aspiration! It is possible to identify that a virus is present in a particular community, but this will only narrow the search and not identify infected individuals.)

Question 75/ 145

[VCAA 2018 SA Q32]

What would be the most effective method of preventing the spread of measles during an outbreak?

A Wash hands thoroughly after going to the toilet.

B Establish a 'clean needle' exchange program.

C Vaccinate all infected people.

D Isolate all infected people.

Solution

4-122 [VCAA 2018 SA Q32]

What would be the most effective method of preventing the spread of measles during an outbreak?

D Isolate all infected people. (As measles is spread by airborne droplets the only effective way of preventing spread is by isolating infected people. Vaccination is useful in preventing outbreaks but does not assist people who are already infected.)

Question 76/ 145

[VCAA 2018 SA Q33]

Based on the information in the table, which one of the following statements is correct?

A Ebola is the most contagious disease.

B Polio and smallpox have a similar infection rate.

C More people would die from measles than any other disease shown.

D The fecal–oral route is the most effective means of spreading pathogens.

Solution

4-123 [VCAA 2018 SA Q33]

Based on the information in the table, which one of the following statements is correct?

B Polio and smallpox have a similar infection rate. (From the information given polio and smallpox have a similar infection rate. Other alternatives may be correct, but information is not available.)

Question 77/ 145

[VCAA 2017 SA Q37]

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

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

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

A This outbreak of yellow fever is considered to be a pandemic.

B Infected individuals who travel to other areas of Brazil will not increase the spread of the disease.

C This outbreak of yellow fever is occurring in populations with high vaccination rates for yellow fever.

D Elimination of mosquito breeding sites in areas with yellow fever will reduce the number of individuals affected.

Solution

4-124 [VCAA 2017 SA Q37]

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

D Elimination of mosquito breeding sites in areas with yellow fever will reduce the number of individuals affected. (The outbreak is confined to Brazil so it is not global and therefore not a pandemic. No information is given about vaccination rates and travel will increase not decrease the spread of disease.)

Question 78/ 145

[VCAA 2020 SA Q34]

Bovine spongiform encephalopathy (BSE) is a prion disease of cattle. It is sometimes called mad cow disease. It is caused by feeding cattle food that contains prions from other infected animals. The time between infection and symptoms appearing can be up to five years. There are concerns that variant Creutzfeldt–Jakob disease (vCJD) in humans could be caused by eating infected cattle meat.

Yellow fever is a viral disease that affects humans. The yellow fever virus can cause symptoms three to six days after infection. The virus is carried by a mosquito vector.

Which combination of approaches would be most effective at controlling the risk of outbreaks of both vCJD and yellow fever?

vCJD	Yellow Fever
A Prevent all cattle that show symptoms of mad cow disease from reproducing.	Remove breeding grounds for mosquitoes.
B Test all cattle for the presence of the prions.	Ensure that all healthcare professionals wear gloves when working with infected patients.
C Destroy all cattle that have been fed infected food containing the prions.	Ensure that people take measures to reduce their chances of being bitten by mosquitoes.

D Stop selling cattle meat.

Instruct people who are infected with yellow fever to wear masks in public places.

Solution

4-125 [VCAA 2020 SA Q34]

Which combination of approaches would be most effective at controlling the risk of outbreaks of both vCJD and yellow fever?

vCJD

Destroy all cattle that have been fed infected food containing the prions.

Yellow Fever

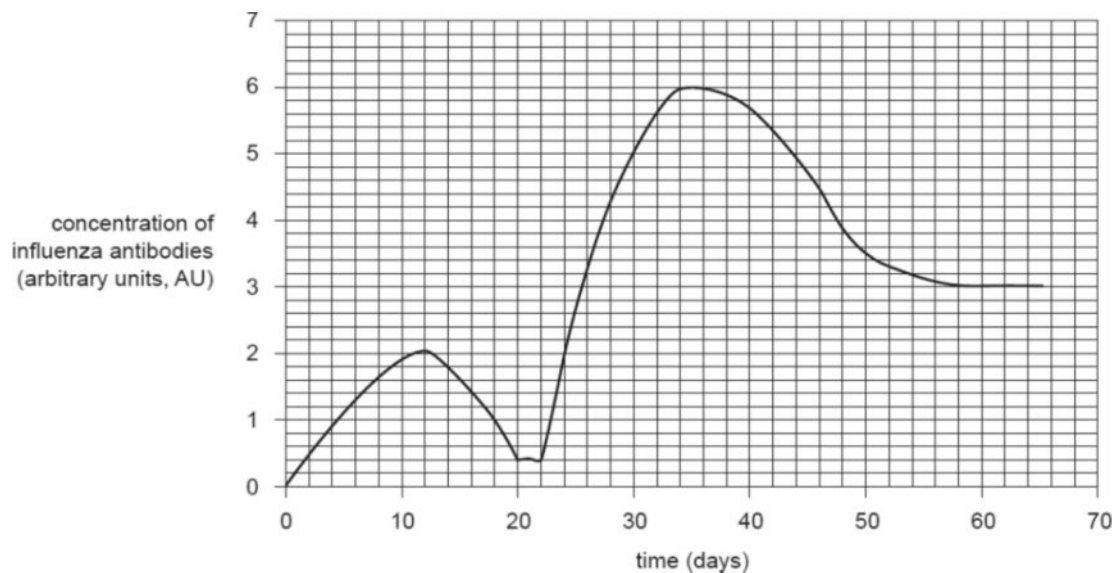
Ensure that people take measures to reduce their chances of being bitten by mosquitoes.

C (As vCJD is caused by ingesting meat-containing prions, alternatives B, C and D would control outbreaks. Yellow fever develops as a result of a mosquito bite, only A and C reduce the chance of being bitten.)

Question 79/ 145

[VCAA 2017 SA Q26]

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



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

A Memory B cells were activated by exposure to the same strain of the influenza virus on day 22.

B B plasma cells specific to this strain of influenza were most numerous on day 12.

C Herd immunity to this particular strain of influenza was achieved by day 55.

D The vaccination containing weakened influenza antigens occurred on day 10.

Solution

4-126 [VCAA 2017 SA Q26]

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

A Memory B cells were activated by exposure to the same strain of the influenza virus on day 22. (B plasma cells were most numerous day 34–36, vaccination occurred at Day 0 and no information is provided about the rest of the population so no conclusion about herd immunity can be reached.)

In the search for a malaria vaccine, scientists have focused on a protein called circumsporozoite protein (CSP).

CSP is secreted by the malaria parasite and is present on its surface. For the vaccination to work, the scientists want CSP to act as

A an antigen.

B an allergen.

C an antibody.

D a complement protein.

Solution

4-127 [VCAA 2016 SA Q24]

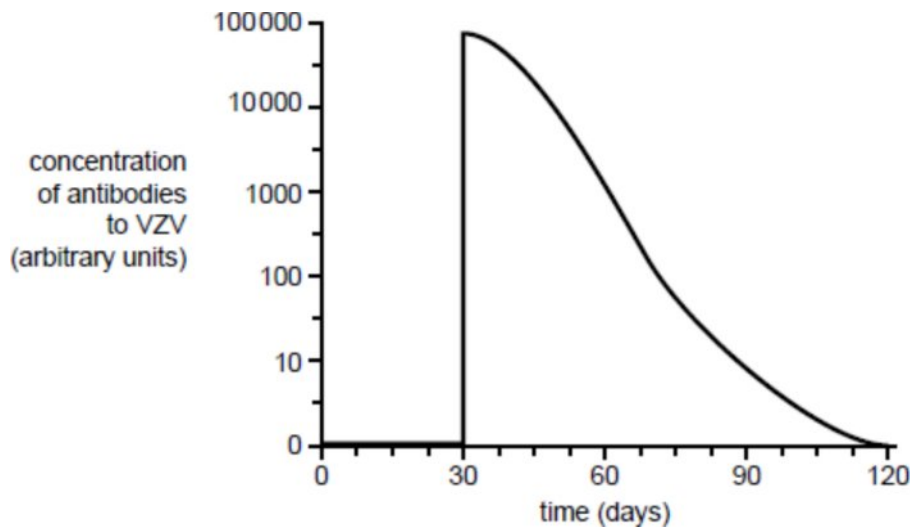
CSP is secreted by the malaria parasite and is present on its surface. For the vaccination to work, the scientists want CSP to act as

A an antigen. (Antigens provoke the immune system to produce its own specific antibody-producing cells – in this case specific to producing protection from malaria.)

Question 81/ 145

[VCAA 2015 SA Q14]

Chickenpox (varicella) is a highly contagious viral disease caused by the varicella-zoster virus (VZV). A technician measured the concentration of antibodies to VZV in a person's blood over a 120-day period. An event occurred on day 30 that significantly altered the concentration of antibodies. The concentration of antibodies over the 120 days is displayed in the graph below.



Which one of the following events could have occurred on day 30?

- A an exposure of the person to VZV
- B a booster vaccination against VZV for the person
- C an injection of antibodies to VZV into the person
- D an oral dose of antibiotics was given to the person

Solution

4-128 [VCAA 2015 SA Q14]

Which one of the following events could have occurred on day 30?

C an injection of antibodies to VZV into the person. (At 30 days, there is an immediate increase of antibodies. The immune response would take time so A and B are incorrect. A dose of antibiotics will not affect antibody concentration.)

Question 82/ 145

[VCAA 2012 E1 SA Q18]

Rubella is a virus that causes a highly contagious infection. When infected with rubella, humans initially produce IgM antibodies and then IgG antibodies. IgM antibodies do not cross the placenta.

Tests for the presence of IgM and IgG antibodies are carried out on a newborn baby if its mother has been diagnosed with a rubella infection during pregnancy. The results from tests carried out on four newborn babies before they had been fed are shown in the following table.

Antibodies for the rubella virus found in the baby's blood

Baby 1 none

Baby 2 IgG

Baby 3 IgM

Baby 4 IgM

Using your knowledge and the information given, it would be correct to conclude that

A the mother of baby 1 has immunity to the rubella virus.

B baby 2 will have about two years of passive immunity to the rubella virus.

C baby 3 received IgM antibodies to the rubella virus from its mother.

D baby 4 was exposed to the rubella virus during fetal development.

Solution

4-129 [VCAA 2012 E1 SA Q18]

Using your knowledge and the information given, it would be correct to conclude that

D baby 4 was exposed to the rubella virus during foetal development. (IgM antibodies do not cross the placenta therefore if they are present in the baby, the baby must have produced them. This means that the baby must have been exposed to the virus in the uterus.)

Question 83/ 145

[VCAA 2012 E1 SA Q19]

At about 12 months of age a baby is immunised against measles, mumps and rubella.

The immunity the baby acquires as a result of this vaccination is called

A active and natural.

B active and induced (artificial).

C passive and natural.

D passive and induced (artificial).

Solution

4-130 [VCAA 2012 E1 SA Q19]

The immunity the baby acquires as a result of this vaccination is called

B active and induced (artificial). (Active because the baby produces the antibodies and induced because the vaccine not the virus stimulates the immune system to produce the antibodies.)

Question 84/ 145

[VCAA 2021 SA Q19]

A new treatment for some cancers includes the use of conjugated monoclonal antibodies, which have an anti-cancer drug attached.

The main advantage of using conjugated monoclonal antibodies in this new cancer treatment is that they

A decrease the amount of the anti-cancer drug delivered to cancerous cells.

B reduce the effects of the anti-cancer drug on non-cancerous cells.

C cause an increase in the number of memory T cells.

D stimulate B cells to produce antibodies.

Solution

4-131 [VCAA 2021 SA Q19]

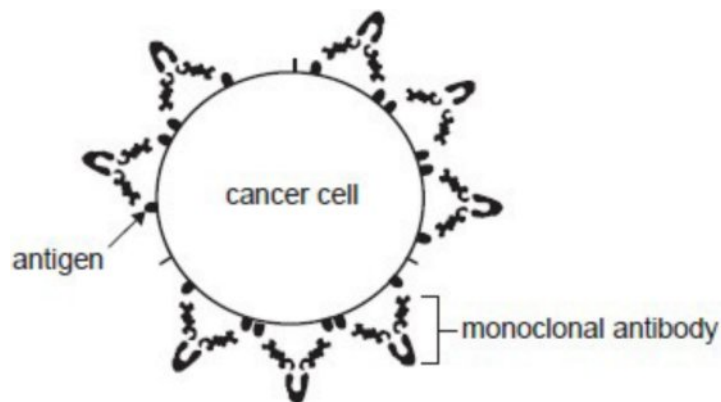
The main advantage of using conjugated monoclonal antibodies in this new cancer treatment is that they

B reduce the effects of the anti-cancer drug on non-cancerous cells. (The problem with many cancer treatments is damage to non-cancerous cells. The advantage of monoclonal antibodies is that they are designed to attack only the cancerous cells.)

Question 85/ 145

[VCAA 2020 SA Q35]

Monoclonal antibodies attaching to antigens on a cancer cell are shown in the diagram below.



Source: adapted from N Halim, 'Monoclonal antibodies:
A 25-year roller coaster ride', *The Scientist*, 20 February 2000,
<www.the-scientist.com>

Monoclonal antibodies

A are used to suppress B cells acting on cancer cells.

B make it easier for cells of the immune system to detect cancer cells.

C can bind to dendritic cells to stimulate them to destroy cancer cells.

D can attach to many structurally different proteins found on the surface of cancer cells.

Solution

4-132 [VCAA 2020 SA Q35]

Monoclonal antibodies

B make it easier for cells of the immune system to detect cancer cells. cells. (Monoclonal antibodies bind to markers of the surface of cancer cells tagging these cells for identification by phagocytes and cytotoxic T cells.)

Question 86/ 145

[VCAA 2020 SA Q25]

DOCK8 syndrome is a disorder in which both B cells and T cells are defective. Patients with DOCK8 syndrome face a range of health issues, including repeated bacterial and viral infections, as well as an increased risk of cancer.

DOCK8 syndrome could be classified as

A acquired immunity.

B an allergic reaction.

C an autoimmune disease.

D an immune deficiency disease.

Solution

4-133 [VCAA 2020 SA Q25]

DOCK8 syndrome could be classified as

D an immune deficiency disease. (If the B and T cells are defective, the body will not be able to defend itself against invading bacteria or viruses. Also, these cells are important in stimulating the removal of damaged cells that might lead to cancer.)

Question 87/ 145

[VCAA 2021 SA Q18]

One method of assessing the progress of multiple sclerosis (MS) in patients detects fragments of the protein NfL. These protein fragments are released into spinal fluid and blood when nerves are damaged.

It can be expected that patients with progressive MS will have

A an increased number of T helper lymphocytes.

B lower levels of the NfL protein in the blood.

C thicker myelin sheaths around nerves.

D levels of antibodies.

Solution

4-134 [VCAA 2021 SA Q18]

One method of assessing the progress of multiple sclerosis (MS) in patients detects fragments of the protein NfL. These protein fragments are released into spinal fluid and blood when nerves are damaged.

It can be expected that patients with progressive MS will have

A an increased number of T helper lymphocytes. (MS is the result of production by the body of antibodies that attach to the myelin sheath resulting in nerve damage. T helper cells activate B cells to produce antibodies; therefore, their numbers would be expected to increase.)

Question 88/ 145

[VCAA 2019 SA Q22]

In multiple sclerosis, which specific part of the nervous system do immune cells attack?

A the receptors of post-synaptic nerve cells.

B the myelin sheath around nerve cells.

C the nuclei of nerve cells.

D the neurotransmitters.

Solution

4-135 [VCAA 2019 SA Q22]

In multiple sclerosis, which specific part of the nervous system do immune cells attack?

B the myelin sheath around nerve cells. (Fact: In MS, nerve transmission is slowed due to the damage to the myelin sheath.)

Question 89/ 145

[VCAA 2018 SA Q16]

Lupus is a condition that results in the increased secretion of antibodies that attach themselves to healthy cells in a patient's body. The accumulation of these antibodies causes inflammation, joint pain, rash, fatigue and fever.

Lupus is an example of

A an allergic reaction.

B an autoimmune disease.

C an immune deficiency disease.

D a complement protein response.

Solution

4-136 [VCAA 2018 SA Q16]

Lupus is an example of

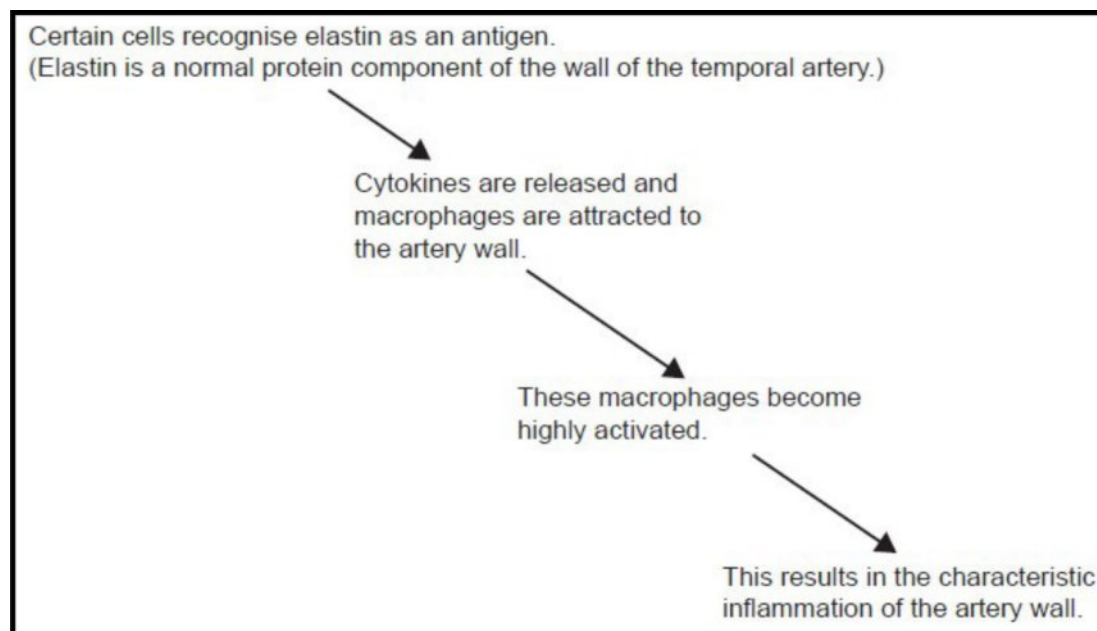
B an autoimmune disease. (The body is producing antibodies that are attacking its own healthy cells – therefore an immune response.)

Question 90/ 145

[VCAA 2016 SA Q25]

Temporal arteritis is a human disease in which the temporal arteries become inflamed. This causes headaches and may result in blindness or stroke.

The sequence of responses in this disease is as shown in the diagram below.



Considering the information on the previous page, temporal arteritis is

A an immunodeficiency disease.

B a pathogenic disease.

C an allergic response.

D an autoimmune disease.

Solution

4-137 [VCAA 2016 SA Q25]

Considering the information above, temporal arteritis is

D an autoimmune disease. (Elastin is a normal protein to which the body's immune system should not respond. Such responses are called autoimmune responses.)

Question 91/ 145

[VCAA 2015 SA Q19]

Autoimmune diseases are different from diseases caused by pathogens because in all autoimmune diseases

A certain self-tissues are not recognised as ‘self’ and this causes an immune response to the tissues.

B histamine is released from mast cells to cause an inflammatory response.

C complement protein causes the breakdown of healthy cells.

D interferon is released to kill infected tissue.

Solution

4-138 [VCAA 2015 SA Q19]

Autoimmune diseases are different from diseases caused by pathogens because in all autoimmune diseases

A certain self-tissues are not recognised as ‘self’ and this causes an immune response to the tissues.
(In autoimmune diseases, the body's immune system is producing antibodies that damage the body's own tissues.)

[VCAA 2017 SA Q24]

Researchers investigating MS have analysed various tissue samples from patients. In these samples they would expect to find

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

Solution

4-139 [VCAA 2017 SA Q24]

Researchers investigating MS have analysed various tissue samples from patients. In these samples they would expect to find

C increased numbers of T helper cells in spinal fluid. (This question is about autoimmune disease not allergies or cancer. Autoimmune diseases involve increased numbers of T helper cells.)

[VCAA 2017 SA Q25]

Scientists are investigating factors that increase the likelihood of developing MS. Recently, the ‘hygiene theory’ has been considered a possible factor. This theory proposes that, if a child's environment is overly hygienic and does not allow sufficient exposure to a wide range of non-self-antigens, an overactive immune system will result later in life.

A recent study tested for the presence of antibodies to the bacteria that cause stomach ulcers, *Helicobacter pylori*, in the blood of 550 MS patients and 299 healthy people. Both groups of people had the same proportion of each gender and were of similar age. Exposure to *H. pylori* usually occurs by the age of two years. The results of the antibody testing showed that the rate of *H. pylori* infection was 30% lower in the women with MS than in the healthy women or healthy men.

A monoclonal antibodies could be used to treat MS.

B males are affected by MS 30% more often than females.

C suffering from a stomach ulcer is a common symptom of MS.

D in females childhood exposure to *H. pylori* helps to protect against MS.

Solution

4-140 [VCAA 2017 SA Q25]

The findings of this study are consistent with the suggestion that

D in females childhood exposure to *H. pylori* helps to protect against MS. (Males are less affected by MS and the presence of antibodies against *H. pylori* does not mean the individual has a stomach ulcer, rather that the individual has been exposed to the bacterium.)

Question 94/ 145

[VCAA 2014 SA Q10]

In the disease multiple sclerosis, the myelin sheath surrounding the axons of neurons is broken down. One of the symptoms of multiple sclerosis is weakening of the muscles.

A possible cause for this weakening could be

A the transmission of electrical impulses along the axons of neurons is slowed.

B the size of the electrical impulses travelling along the axons is smaller.

C neurotransmitter receptors on the muscle cells have become less sensitive.

D neurotransmitters are inhibited from travelling along the neurons.

Solution

4-141 [VCAA 2014 SA Q10]

A possible cause for this weakening could be

A the transmission of electrical impulses along the axons of neurons is slowed. (Myelin acts as an insulator allowing rapid transmission of nerve impulses. Electrical impulses are all or nothing responses.)

Question 95/ 145

[VCAA 2018 SA Q24]

Monoclonal antibodies can be produced and used to treat different types of cancers. Which one of the following is a correct statement about monoclonal antibodies?

A Monoclonal antibodies are carbohydrate molecules.

B Monoclonal antibodies produced from the same clone of a cell are specific to the same antigen.

C Monoclonal antibodies pass through the plasma membrane of a cancer cell and attach to an antigen within the cell.

D Monoclonal antibodies produced to treat stomach cancer will be identical to monoclonal antibodies produced to treat breast cancer.

Solution

4-142 [VCAA 2018 SA Q24]

Monoclonal antibodies can be produced and used to treat different types of cancers. Which one of the following is a correct statement about monoclonal antibodies?

B Monoclonal antibodies produced from the same clone of a cell are specific to the same antigen.

(Monoclonal literally means from one clone – identical antibodies (made of protein) that are specific to the same antigen. They will attach to specific antigens on the outside of the target cancer cells.)

Question 96/ 145

[VCAA 2018 SA Q35]

The emergence of antibiotic-resistant diseases in humans means that

A antibiotics are causing resistance mutations in bacteria.

B some bacteria are less sensitive to antibiotics.

C viruses are becoming resistant to antibiotics.

D humans are less sensitive to antibiotics.

Solution

4-143 [VCAA 2018 SA Q35]

The emergence of antibiotic-resistant diseases in humans means that

B some bacteria are less sensitive to antibiotics. (C is definitely wrong as viruses are not treated with antibiotics. Bacteria that had a natural immunity to antibiotics survived and have become more common – they are the ones that are less sensitive to antibiotics.)

Question 98/ 145

[VCAA 2012 E1 SA Q24]

This test for HIV is reliable because the

A dye reacts with the patient's blood serum.

B enzyme has an active site for the HIV antigen.

C man-made antibody has the same shape as the HIV antigen.

D HIV antigen has a complementary shape specific to the HIV antibody.

Solution

4-144 [VCAA 2012 E1 SA Q24]

This test for HIV is reliable because the

D HIV antigen has a complementary shape specific to the HIV antibody. (This allows the HIV antigen to attach to the HIV antibody. If the antibody and the antigen had the same shape, they would not bind together.)

Question 99/ 145

[VCAA 2012 E1 SA Q25]

The results of the tests of three patients are given in the following table.

Positive control	Negative control	Patient R	Patient S	Patient T
1.689	0.153	0.155	0.675	1.999

Numbers are expressed as optical density at 450 nm. The more intense the dye is, the higher the optical density. The cut-off value indicating a positive result is 0.500. Values below 0.300 are considered to be negative. The results of these tests suggest that

A patient T has not been exposed to HIV.

B patient R has been exposed to the HIV antigen.

C patient S has responded to exposure to HIV by developing antibodies.

D the positive control contained fewer HIV antibodies than the negative control.

Solution

4-145 [VCAA 2012 E1 SA Q25]

Values below 0.300 are considered to be negative. The results of these tests suggest that

C patient S has responded to exposure to HIV by developing antibodies. (Antibodies are produced after exposure to the virus therefore patient T has been exposed. The positive control contains more antibodies than the negative control. Patient R has a reading of less than 0.300, therefore has not been exposed to the HIV antigen.)

Question 1/ 166

[VCAA 2019 SB Q3]

The human immune system consists of a series of defensive barriers that protect the body from infection. When bacteria come into contact with the body, they immediately encounter these defences and must bypass each barrier if they are to survive and infect the body.

a When bacteria come into contact with the body, they must gain access to living tissues to become pathogens.

List **two** possible routes the bacteria could use to access the living tissues of the body. (2 marks)

b Once bacteria are within or have access to the living tissues of the body, before cells are aware of their presence, the bacteria will encounter chemical barriers.

List **one** of these chemical barriers and explain its function. (2 marks)

c When an inflammatory response starts, the first cellular responders will be cells from the innate immune system. One of these cells releases histamine.

How does histamine contribute to the inflammatory response? (1 mark)

d If bacteria are not destroyed by innate immune responses, adaptive immune responses become involved.

Describe how an adaptive immune response is initiated during a bacterial infection. (2 marks)

(Total 7 marks)

Solution

4-146 [VCAA 2019 SB Q3]

a Any **two** of the following:

- cuts or sores

- contact with the mucous membranes of the respiratory/digestive/reproductive systems
- sexual intercourse
- insect/animal bites.

b Any **one** of the following:

- complement proteins: complement proteins stick to invading pathogens, increasing identification by phagocytes. They attract phagocytes to the site of infection and stimulate their activity and some complement proteins destroy pathogen membranes.
- stomach acid: destroys swallowed bacteria
- protease: digest bacterial cell walls.

c Histamines are released by mast cells. They increase the diameter and permeability of blood vessels, increasing blood flow to the site of infection (vasodilation). This results in heat, swelling and reduced movement thereby confining the pathogen to the area. Histamines also attract phagocytes. Phagocytes destroy the pathogen.

d Antigens on the bacteria are recognised by macrophages/dendritic cells. The macrophages/dendritic cells then engulf the bacteria, process the antigens and then display the antigens on MHCII markers. The displayed antigens are recognised by specific T helper cells.

Question 2/ 166

[VCAA 2018 SB Q3]

Plants are a rich source of nutrients for many organisms, including bacteria, fungi and viruses. Although plants lack an immune system that is comparable to animals, plants have evolved chemical barriers to stop invading pathogens from causing significant damage.

a Describe **two** chemical barriers that could be present in a plant that is protecting itself from an invading pathogen. (2 marks)

b Humans have a sophisticated immune response to invading pathogens. State **two** ways that pathogens are prevented from entering the internal environment of the human body. (2 marks)

c Outline how complement proteins and natural killer cells protect the human body once a pathogen has gained entry to the internal environment. (2 marks)

(Total 6 marks)

Solution

4-147 [VCAA 2018 SB Q3]

a Any **two** of the following chemical barriers found in plants:

- secretion of resin at the site of infection. The resin traps and immobilises the pathogen before it can enter plant cells.
- secretion of antibiotic-like substances (phytoalexins)/fungicides/toxins/extracellular enzymes/phenolic substances. These kill the pathogens before they can enter plant cells.
- secretion of enzymes that digest pathogens.
- chemicals released by roots to attract beneficial bacteria.

b Any **two** of the following barrier to pathogens entering the internal environment of humans:

- the presence of an **intact** rough and impermeable skin
- the production of sebum, an antiseptic that kills pathogens
- the presence of hairs/cilia and mucus lining in the respiratory and digestive systems. The hairs trap and immobilise pathogens.
- the production of stomach acid/urine/vaginal secretions. The acid kills pathogens.
- the production of lysozymes in saliva and tears. These destroy/breakdown pathogens.

c Complement proteins stick to the invading pathogens, increasing identification by phagocytes. They attract phagocytes to the site of infection and stimulate their activity and some complement proteins destroy pathogen membranes. Natural killer cells kill virus infected cells. (*Note: Natural killer cells are not in the Study Design.*).

Question 3/ 166

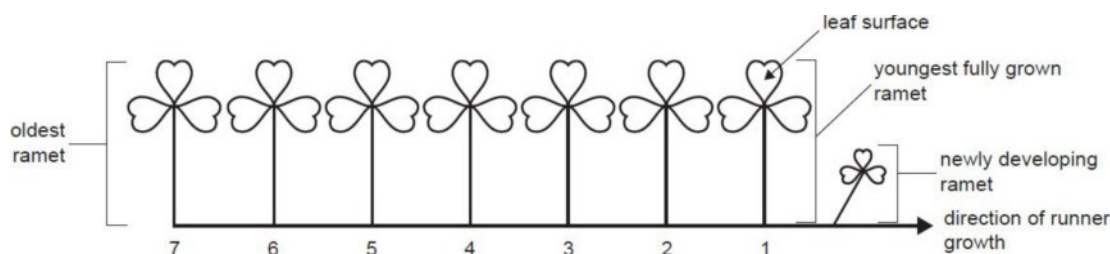
[Adapted VCAA 2017 SB Q2]

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

a Describe **one** example of a physical method of defence in a plant. (2 marks)

White clover (*Trifolium repens*) reproduces asexually from a runner that grows along the soil surface. The

connected new plants are called ramets. The white clover plant in the diagram below is producing ramets in the direction left to right. The fully grown ramets are numbered 1 to 7, from the youngest ramet to the oldest ramet.



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

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

Stage 1 – Leaf damage preparation

Runner A

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

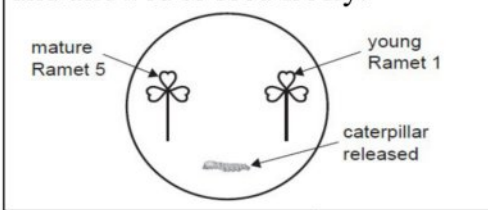
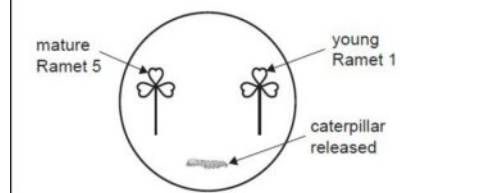
Runner B

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

Stage 2 – Food choice test

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

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

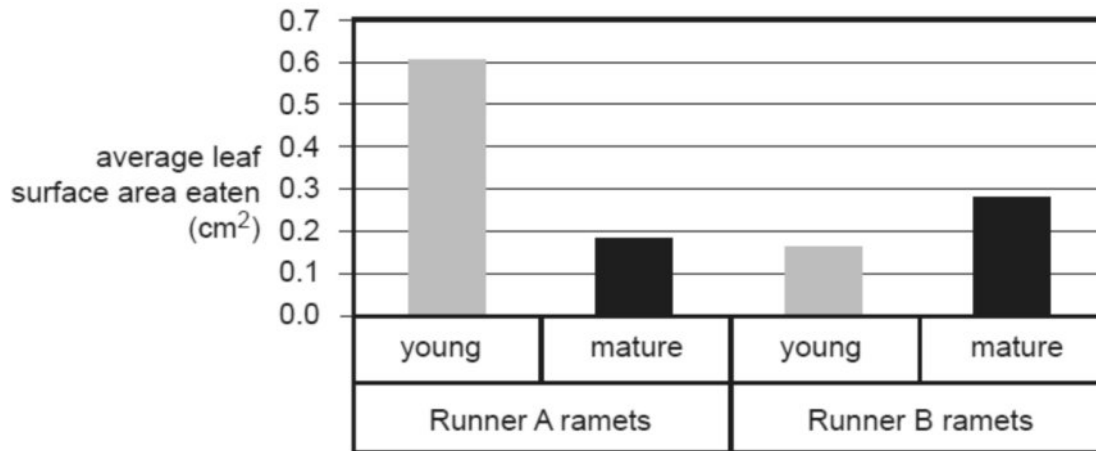


After two days, the leaf surface area eaten on each ramet was measured.

b What was the role of Runner A ramets? (1 mark)

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

White clover (*T. repens*) leaf surface area eaten by caterpillars (*S. exigua*) in food choice test ($n = 40$)



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

c Referring to the data, compare the average leaf surface area of young ramets eaten by the caterpillars in Runner A and Runner B. (1 mark)

(Total 4 marks)

Solution

4-148 [Adapted VCAA 2017 SB Q2]

a Any **one** of the following:

- thick cell wall/cuticle/thick bark. These provide a barrier stopping pathogens and insects from entering plant tissue.
- hairs/spines/prickles. These trap the pathogens and insects on the surface of the plant preventing their entry into plant tissue.
- the formation of galls. Galls are swellings that limit the movement of pathogens and insects to other parts of the plant.

b Runner A ramets are controls. They show the damage that occurs when plants are not stimulated to defend themselves against caterpillars. Any difference in in surface area eaten in runner B ramets, must be due to the prior exposure to caterpillars.

c An average surface area of 0.6 cm² was eaten of young ramets of Runner A compared with 0.15 cm² of young ramets of Runner B therefore a greater surface area was eaten of young ramets of Runner A than Runner B. (*Note: Numbers must be referred to.*)

Question 4/ 166

[Adapted VCAA 2011 E1 SB Q5]

Neisseria meningitidis is a bacterium that causes meningitis. This disease causes inflammation of tissue surrounding the brain and spinal cord in humans. Bacteria enter through plasma membranes as shown in the figure below.



a Name the process shown in the figure. (1 mark)

In an attempt to prevent the spread of the bacteria, the immune system releases antibodies and macrophages to an area of infection.

b Describe how antibodies and macrophages inhibit the spread of *N. meningitidis*. (2 marks)

N. meningitidis can protect itself from the immune system by releasing a protease that breaks the subunits of the antibody.

c Why is this enzyme named a protease? (1 mark)

(Total 4 marks)

Solution

4-149

a Endocytosis or phagocytosis

b Antibodies attach to the bacteria, causing them to clump together and macrophages then engulf and destroy the clumped bacteria.

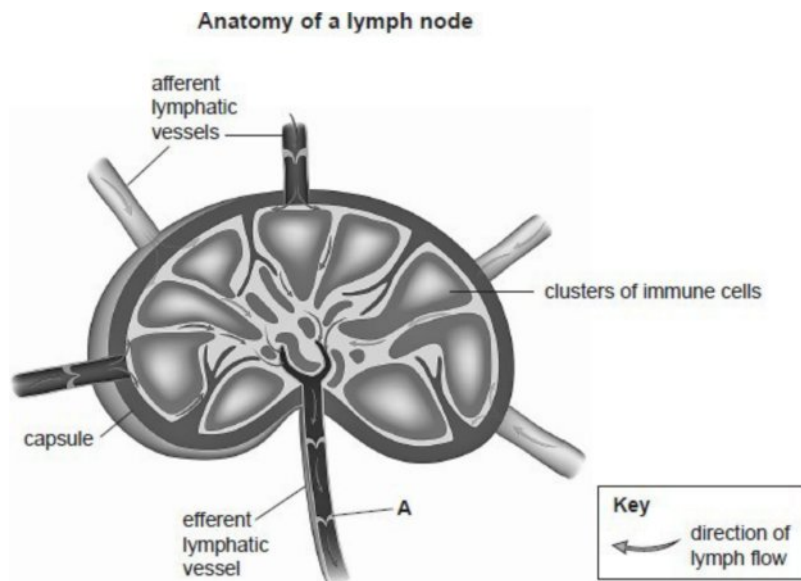
c Antibodies are proteins. Enzymes that break down proteins are called proteases; therefore, if the

enzyme produced by the bacteria breaks down antibodies it is a protease.

Question 5/ 166

[VCAA 2015 SB Q5]

Consider the following diagram of a lymph node.



a Describe the role of the structure labelled A, found within the efferent lymphatic vessel. (1 mark)

Immune cells are clustered within the lymph node (see diagram). There is more than one type of immune cell within each of these clusters.

b Name and describe the role of one type of immune cell found within these clusters that plays a role in the innate immune response. (2 marks)

c Another of the immune cell types found within these clusters has a large nucleus and extensive rough endoplasmic reticulum, and plays an important role in an adaptive immune response.

Name this cell type and explain how the extensive rough endoplasmic reticulum assists this cell to perform its function. (2 marks)

(Total 5 marks)

Solution

4-150 [VCAA 2015 SB Q5]

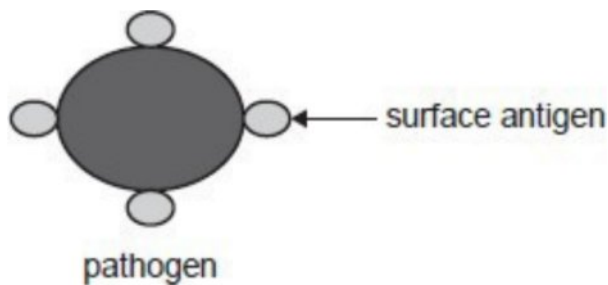
- a** Structure A is a valve. It stops lymph flowing backwards into the lymph node.
- b** Any **one** of the following:
- Phagocytes: engulf and destroy pathogens/antigens.
 - Mast cells: at the site of infection release histamines, resulting in increased blood pressure, blood flow to the infected area, increase permeability of capillary walls and delivery of more macrophages to the site.
- c** B plasma cell: these produce many antibodies which tag pathogens for destruction. Antibodies are proteins and are produced by ribosomes on the rough endoplasmic reticulum.
-

Question 6/ 166

[VCAA 2014 SB Q4]

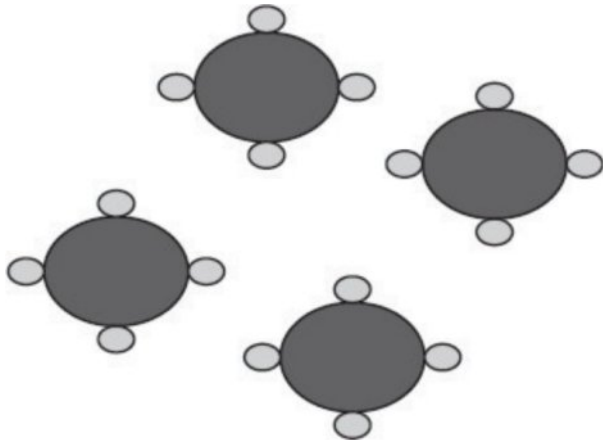
- a** Define the term ‘pathogen’. (1 mark)

The diagram below shows a generalised pathogen with antigens on its surface. The immune system responds to antigens by making antibodies.



- b** Draw an antibody that would be effective against this pathogen. Label the different parts of the antibody. (2 marks)

One way that antibodies work is by forming antigen–antibody complexes. The diagram below shows four pathogens.



c i Illustrate on the diagram above how the antigen–antibody complex forms, using at least four antibodies in your drawing. (2 marks)

ii Explain how an antigen–antibody complex provides protection against these pathogens. (2 marks)

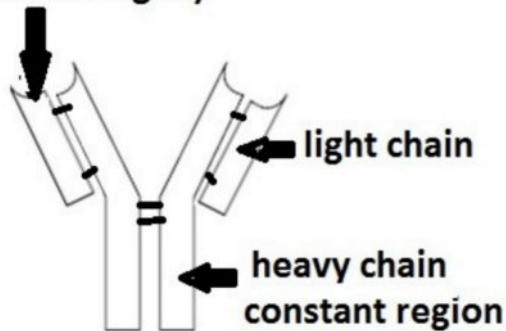
(Total 7 marks)

Solution

4-151 [VCAA 2014 SB Q4]

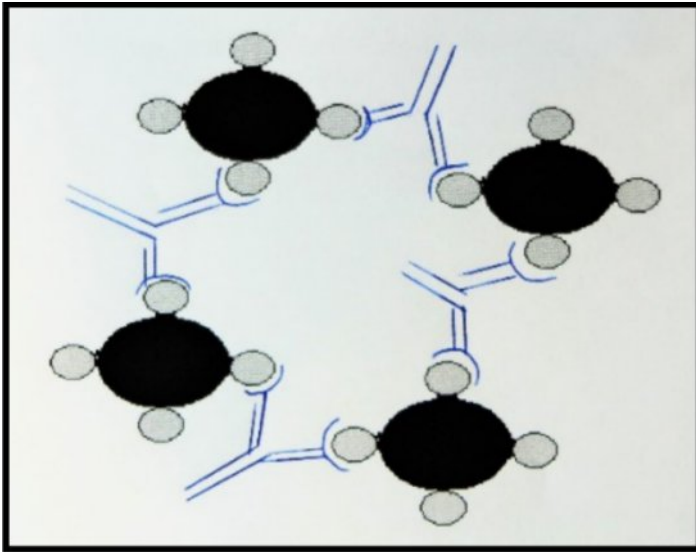
a A pathogen is a disease-causing organism or infectious particle.

antigen binding site/variable region
(must have complementary shape to the surface antigen)



b

c i (Diagram needs to show 4 antibodies attached to at least 4 antigens.)



ii Any **two** of the following:

- Pathogens agglutinate allowing for easier identification by phagocytes.
 - The phagocytes then engulf and destroy the pathogen.
 - Prevent the spread of the pathogen.
 - Prevent the reproduction of the pathogen.
 - Prevent the pathogen entering cells.
 - Attract complement proteins.
-

Question 7/ 166

[VCAA 2016 SB Q5]

Yellow fever is a potentially fatal, mosquito-borne, viral disease that occurs in many countries in Africa, the Caribbean, and Central and South America. An effective and safe vaccine has been available since 1938.

a What is a vaccine? (1 mark)

b For the vaccine to be effective, it is recommended that travellers to these regions have the vaccination approximately two to four weeks before travelling.

Why is this time frame recommended? (2 marks)

c Recent research shows that the vaccine gives lifelong immunity.

Name **two** different cell types that would be important in providing lifelong immunity and explain the **role** of each in providing lifelong immunity. (4 marks)

(Total 7 marks)

Solution

4-152 [VCAA 2016 SB Q5]

a A vaccine is a suspension of attenuated, dead or inactivated pathogens that when injected activates the immune system to form antibodies against the pathogen.

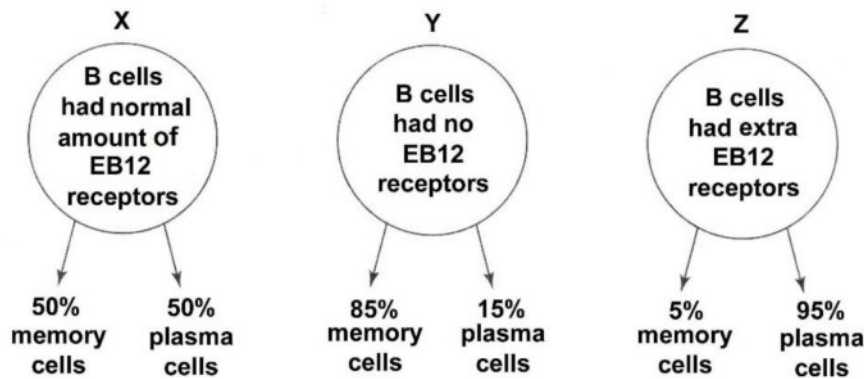
b After vaccination it takes time to produce specific antibodies. The antigens in the vaccine must be engulfed and displayed by macrophages. The displayed antigens then are recognised by T helper cells that then stimulate B cells that have come into contact with the antigens to divide and produce memory cells and antibody producing plasma cells.

c Name of cell type 1: Memory B cells

Role: When memory B cells come into contact with specific antigens, they are able to divide quickly into more memory cells and plasma cells that produce antibodies against the pathogen. The antibodies are then able to destroy the pathogen before the disease develops.

Name of cell type 2: Memory T cells

Role: Memory T cells survive for many years. When they come into contact with specific antigens, they stimulate specific B cells to divide rapidly into memory B cells and plasma cells that produce antibodies against the pathogen. The antibodies are then able to destroy the pathogen before the disease develops.



EB12 is a receptor on the B cells of mice that helps determine if a cell becomes a plasma or a memory cell. Scientists used three different strains of mice to investigate B cell immunity. None of the strains had been exposed to the influenza virus. The strains were as follows.

The three mice strains were infected with the influenza virus.

- Explain which strain, X, Y or Z, would be best at destroying the fast-acting influenza virus. (2 marks)
- Explain how blocking the action of EB12 receptors could result in the production of a more efficient vaccine. (2 marks)

(Total 4 marks)

Solution

4-153 [VCAA 2010 E1 SB Q4]

- Strain Z. Strain Z produces the most plasma cells. Plasma cells produce antibodies which destroy the influenza virus. The greater the number of plasma cells, the greater the number of antibodies produced and thus the faster the virus is destroyed.
- Efficient vaccines are those that result in the production of the most memory cells. Blocking EB12 receptors would result in cells that act like Strain Y. Strain Y produces the most memory cells.

- The human immune system uses several different types of cells to eliminate virally infected cells.

Name **one** of these cells and outline how it eliminates virally infected cells. (2 marks)

b i State the role played by the lymphatic system in an immune response. (1 mark)

ii Describe the sequence of events that occurs in the secondary lymphoid tissue that results in the production of antibodies. (4 marks)

(Total 7 marks)

Solution

4-154 [VCAA 2020 SB Q5]

a Any **one** of the following:

- Cytotoxic T cells: release perforins/chemicals that destroy virally infected cells.
- Macrophages: release tumour necrosis factors that initiate apoptosis of virally infected cells.
- Macrophages or dendritic cells or phagocytes: recognise and engulf virally infected cells.

b i The role played by the lymphatic system in an immune response is to provide transport and deliver antigens to T and B cells that are concentrated in the lymph nodes. The T and B cells then undergo clonal expansion.

ii Dendritic cells displaying specific antigens on MHCII markers move to lymph nodes. Specific helper T cells recognise the displayed antigens and undergo clonal expansion to produce more specific helper T cells and memory T cells. The specific helper T cells then activate specific B cells that display the antigen. The activated B cells then undergo clonal expansion producing more specific plasma B cells and memory B cells. The plasma cells release specific antibodies.

Question 10/ 166

[VCAA 2017 SB Q4]

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

a i What is meant by the term 'sterile' in the context given? (1 mark)

ii Consider a hospital environment. Give two examples of how sterile conditions can be achieved in a hospital. (2 marks)

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

b Describe at a molecular level how antibodies perform their function. (2 marks)

c Name the type of immunity that the joey obtains from the antibodies in the milk and explain how this form of immunity is beneficial to the joey. (3 marks)

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

d i Name the part of the immune system to which these peptides and the other listed chemicals belong. (1 mark)

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

lysozyme complement proteins cytokines venom inhibitors

(1 mark)

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

Suggest what the scientists would hope to achieve as a result of further testing of these peptides with antibiotic properties. (1 mark)

(Total 11 marks)

Solution

4-155 [VCAA 2017 SB Q4]

a i Sterile means absence of pathogens.

ii Any **two** of the following:

- visitors washing their hands with antiseptic before entering a patient's room

- sterilise by heating to very high temperatures all equipment, e.g. bed pans, glass rods, forceps and containers
- using disposable swabs, bed pans
- wearing masks/gloves.

b Antibodies are Y-shaped protein molecules made to a precise shape. Each type of antibody has a specific binding site at the end of each arm of the Y. The shape of this binding site is complementary to that of a specific antigen. The antigen is deactivated/immobilised/tagged for destruction by macrophages when the antigen binds to its specific antibody.

c Passive immunity. This form of immunity is beneficial to the joey as antibodies against the antigen are immediately present in the joey therefore the antigen can be destroyed quickly before the disease has time to develop. This is especially important as the joey's immune system is immature/has had no prior exposure to the antigen and has no specific B memory cells to the antigen therefore cannot produce antibodies quickly enough.

d i The innate immune response.

ii Any **one** of the following:

- lysozyme: catalyse the breakdown of bacterial cell walls.
- complement proteins: stick to the surface of pathogens allowing them to be identified for destruction by macrophages
- cytokines: signalling molecules that active the immune response, e.g. Helper T cells produce cytokines that activate B plasma cells that have come in contact with a specific antigen, to divide into plasma cells and memory cells.
- venom inhibitors: molecules that bind to venom molecules thereby deactivating them.

e They would hope to find that the peptides are effective at destroying bacterial pathogens, that they can be cheaply massed produced and have no side effects on humans and therefore they can be used as a drug to fight antibiotic-resistant bacterial diseases in humans.

Question 11/ 166

[VCAA 2021 SB Q4]

Varicella (chickenpox) is a highly contagious disease caused by the varicella zoster virus. A live, attenuated varicella zoster virus vaccine is recommended for children at age 18 months. In Australia, this vaccine is provided free of charge under the National Immunisation Program.

a Once the varicella zoster virus vaccine is injected into the arm of a child, an immune response occurs.

Summarise the immune response that occurs within the child to result in long-term protection from chickenpox. (5 marks)

b If a person has not been vaccinated and is older than 14 years, it is recommended that this person has two doses of the varicella zoster virus vaccine. The second dose should be given at least four weeks after the first dose. What is the benefit of having two doses instead of one dose? Justify your response. (2 marks)

c Outline similarities and/or differences in active and passive ways of acquiring immunity. (3 marks)

(Total 10 marks)

Solution

4-156 [VCAA 2021 SB Q4]

a An effective chickenpox vaccine contains chickenpox antigens and brings about an immune response. The chickenpox vaccine is engulfed by dendritic cells that then display antigens on their cell membrane. The dendritic cells move to the lymph nodes where they are identified by T helper cells. The T helper cells then stimulate specific B cells that have come into contact with the vaccine to divide many times producing B memory cells and B plasma cells. The B plasma cells produce specific chickenpox antibodies. In the future, when the child becomes infected with the chickenpox virus, the antibodies already present, along with antibodies that are produced by activated B memory cells, quickly destroy the chickenpox virus before the person develops the disease.

b The person will produce varicella zoster virus antibodies and memory B cells after the first vaccination as a primary response. After the vaccination, the number of antibodies will at first increase and then gradually decrease. A second dose will activate the memory B cells resulting in a rapid and higher increase in antibodies and more memory B cells. This secondary response is faster, stronger, and long lasting, resulting in reduced transmission to others.

c Active immunity occurs when the infected person produces antibodies and memory B cells against the pathogen, whereas passive immunity is when antibodies from another source are given to the infected person. Both are similar in that antibodies specific to the disease and used to destroy the pathogen. They differ in that the infected person produces the antibodies in active immunity, whereas in passive immunity, they do not. Active immunity produces specific memory B cells, whereas passive immunity does not. Therefore, active immunity is longer lasting than passive immunity. Passive immunity is faster than active immunity as the body does take time to produce the specific antibodies.

A vaccine for cancer

Scientists are investigating whether it is possible to produce a vaccine that will work against cancer cells. Currently there are vaccines available against certain viruses that are known to cause cancer. For example, the human papillomavirus vaccine is highly effective in preventing cervical cancer. The vaccine contains virus-like particles that have antigens that are found on the surface of the human papillomavirus. These antigens stimulate an immune response when injected into the individual but do not cause disease. The vaccine is very effective as the immune response produces high levels of antibodies.

This example is considered a conventional vaccine. Conventional vaccines contain either a dead or inactivated version of a pathogen, or a protein from that pathogen. Conventional vaccines can take many months to produce.

As most cancers are not caused by viruses, scientists investigated whether a non-conventional vaccine could be developed. A vaccine containing mRNA was produced. mRNA codes for the production of a protein that must be produced by the cells of the individual injected with the vaccine. This protein manufactured by the cells acts as an antigen and, when released from the cells, results in an immune response within the individual.

The scientists determined the genetic code of an antigen found on the surface of a particular cancer cell. They assembled a molecule of mRNA that would code for this antigen. Many copies of this mRNA molecule were then incorporated into a vaccine. In December 2019, a clinical trial to test for a new type of vaccine took place. Individuals injected with the mRNA vaccine produced an immune response that resulted in antibodies that acted against the antigen found on the surface of the cancer cells.

Scientists realised that they could potentially quickly produce vaccines for many different cancers by changing the nucleotide sequence of the mRNA molecule. However, designing vaccines for cancers is not that simple. Cancer cells can easily evade immune cells and continue to reproduce. Mutations can cause changes to the target antigens on the surface of cancer cells. A vaccine designed for one person may not work for another person as their cancers have different mutations.

Reference: N Pardi, MJ Hogan, FW Porter and D Weissman, ‘mRNA vaccines – A new era in vaccinology’, *Nature Reviews Drug Discovery*, vol. 17, April 2018, <https://doi.org/10.1038/nrd.2017.243>

a i According to the article, what are the contents of conventional vaccines and how do they lead to an improved immune response when a person encounters a pathogen? (2 marks)

ii Explain how mRNA vaccines are different from conventional vaccines. (2 marks)

b Using the information in the article above, identify the advantages of developing mRNA vaccines for the treatment of cancer. Outline an ethical concept that should be taken into account when developing mRNA vaccines. (4 marks)

(Total 8 marks)

Solution

4-157 [VCAA 2022 SB Q10]

a i Conventional vaccines contain either a dead or inactivated version of the pathogen or a protein from that pathogen. The antigens in the vaccine are recognised by antigen-presenting cells as foreign and are engulfed and displayed on MHC markers. The displayed antigens activate T helper cells that activate B cells that have also come in contact with the antigens. The B cells undergo clonal expansion producing many plasma cells, which produce antibodies and many memory B cells. When a person encounters a pathogen in the future, the pathogen's antigens are quickly recognised and many more antibodies are rapidly produced, resulting in viral neutralisation.

ii Any **two** of the following differences:

- mRNA vaccines contain mRNA, whereas conventional vaccines do not.
- Conventional vaccines contain antigens, whereas mRNA vaccines do not.
- mRNA vaccines stimulate the cell to make viral antigens, whereas conventional vaccines do not.

b Any **two** of the following advantages:

- The mRNA vaccine can be quickly produced.
- The mRNA vaccine can easily be modified/personalised to the specific cancer.
- The mRNA vaccine is specifically targeted to the type of cancer.
- The immune system responds to the cancer and not the virus.

Any **one** of the following associated ethical concepts:

- **Beneficence:** benefits should be maximised, and risks minimised. mRNA vaccines are very effective and can target cells that could evade the immune system.
 - **Non-maleficence:** Harm should be avoided or not be disproportionate to the benefits. mRNA vaccines do not cause harm.
 - **Respect:** consideration of the rights of the individual, welfare, liberty, beliefs, and culture. Enough easily understood information is available to patients allowing them to make an informed decision.
 - **Justice:** a moral obligation to provide fair treatment. Vaccines can be readily available to all.
 - **Integrity:** All information and communication of experimental trials and ongoing results should be honestly reported whether favourable or unfavourable.
-

Question 13/ 166

Captain Arthur Phillip accompanied by about 1500 convicts, soldiers and civilians arrived in Sydney Cove in 1788. Within 10 years the indigenous population was reduced by 90%. Name and explain **two** reasons for this decrease.

Reason

Explanation

(Total 4 marks)

Solution

4-158

Reason

Explanation

Introduction of new diseases

The indigenous population had had no previous contact with many of the diseases introduced by the settlers. They therefore had no immunological memory and no immunity to the diseases.

Acquisition of land

Reduced availability of food leading to poor health leading to poor health and increased susceptibility to disease.

Question 14/ 166

[VCAA 2020 SB Q10]

Measles in Samoa

Measles is one of the most contagious viruses affecting humans. Measles spreads when an infected person coughs or sneezes and the virus is breathed in by another person, or by direct contact with bodily fluids. In a susceptible population – people who have neither been vaccinated nor had measles previously – one person with measles could infect 12 to 18 other people.

The Pacific Island nation of Samoa had a significant measles outbreak in 2019. This started when a person who had measles arrived in Samoa by plane in August 2019. In the following months over 5000 measles cases were recorded and more than 70 people died.

A measles outbreak was declared by the Samoan Government in October 2019. On 15 November the Samoan Government declared a 30-day state of emergency as the number of measles cases continued to rise and more people died. Ninety per cent of the deaths were among children less than five years old.

More than one in five Samoan babies aged six to 11 months contracted measles during this outbreak and more than one in 150 babies in this age group died. Fewer deaths occurred in babies who were less than six months old.

Prior to the measles outbreak in Samoa, the vaccination rate for measles for five-year- old children in the country had fallen to 31% in 2018. One of the responses of the government to the outbreak was a mandatory vaccination program for all people. By early December 2019 over 90% of the population had been vaccinated.

In Australia a measles-containing vaccine (MMR vaccine) is recommended for children aged 12 months of age or older. A single dose of the measles vaccine provides protection for between 95% and 98% of recipients, while two doses protect 99% of vaccinated people. In 2018 in Australia, 95% of five-year-old Australian children were fully vaccinated.

Reference: K Gibney, 'Measles in Samoa: How a small island nation found itself in the grips of an outbreak disaster', *The Conversation*, 12 December 2019, <<https://theconversation.com/au>>

a Is the measles outbreak discussed in the article above best described as an epidemic or a pandemic? Give your reasoning. (2 marks)

b Consider the Samoan children who were less than five years old during the measles outbreak. Of this group, what age were the children who were least likely to die from measles? Explain why children of this age would be less likely to die. (2 marks)

People who are vaccinated are unlikely to be affected by the measles virus.

c i What is the percentage difference between vaccinated five-year-old children in Samoa and Australia in 2018? (1 mark)

ii The MMR vaccine contains antigens for measles, mumps and rubella. What form of immunity is given when a person is vaccinated with the MMR vaccine? (1 mark)

iii Some children, for example those undergoing chemotherapy, cannot be vaccinated. Explain how high vaccination rates can also protect unvaccinated individuals. (2 marks)

d Describe two strategies, other than vaccination, that could reduce the transmission of measles. (2 marks)

(Total 10 marks)

Solution

4-159 [VCAA 2019 SB Q10]

- a** The measles outbreak in Samoa is an epidemic as it is confined to one local region. A pandemic is a global outbreak.
- b** Children of less than 6 months of age were less likely to die from measles as they received antibodies against measles from their mother via breast milk or placenta. Their mothers produced the antibodies as a result of surviving early contact with the measles virus or as the result of earlier vaccination.
- c**
- i** 64% more five-year-old children in 2018 were vaccinated in Australia than Samoa.
 - ii** Artificial, active immunity
 - iii** High vaccination rates result in herd immunity. Herd immunity is the immunity provided when most (90–95%) of the population has been immunised. This reduces the number of individuals the pathogen can infect, therefore reducing the chance that the pathogen can find a host, survive and spread to individuals not vaccinated.
- d** Any **two** of the following:
- wearing masks/gloves/glasses
 - using alcohol-based sanitisers
 - wipe surfaces with disinfectants
 - wearing gloves
 - quarantining those who have been exposed to the virus
 - enforcing a lockdown.
-

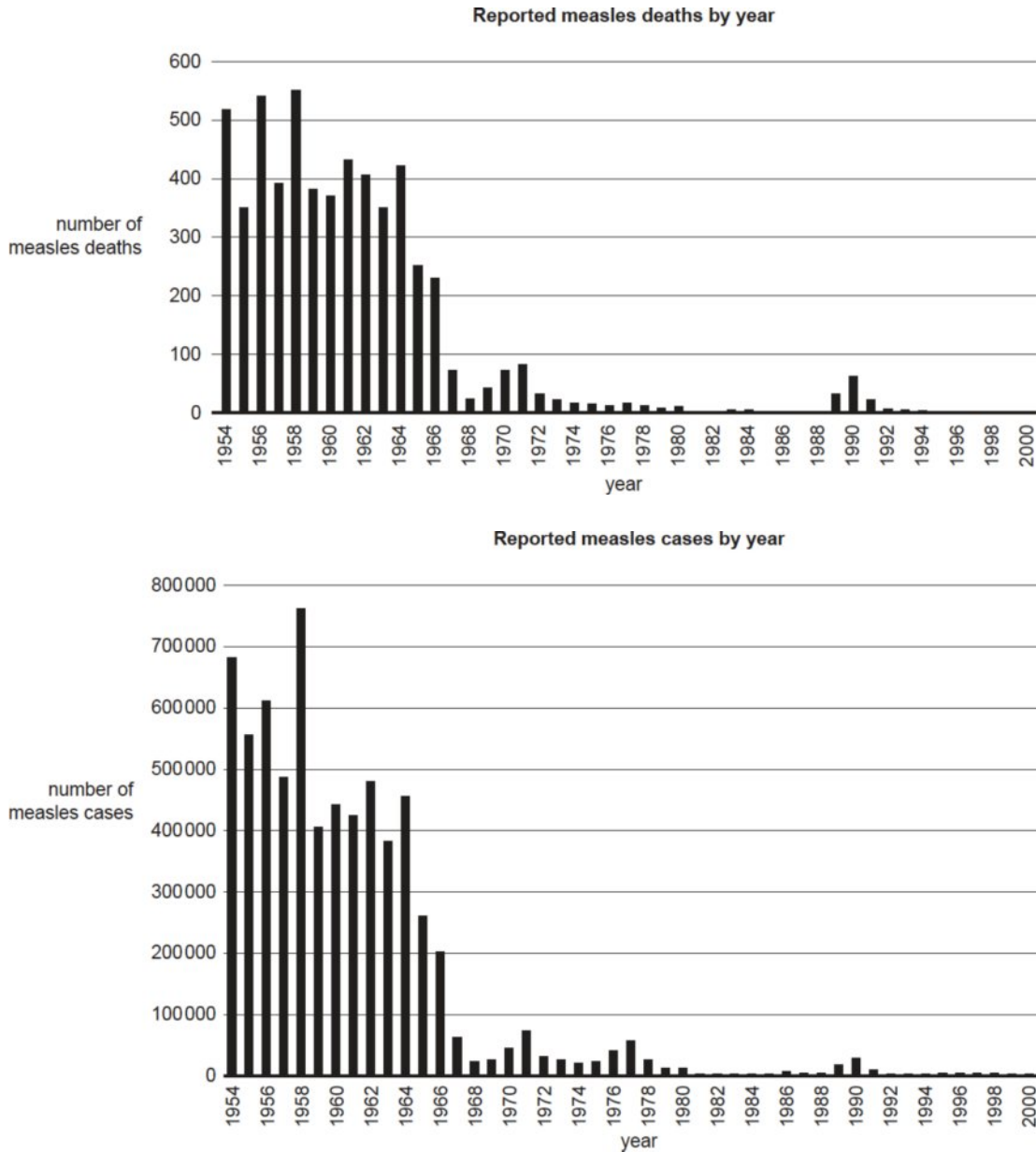
Question 15/ 166

[VCAA 2018 SB Q5]

Measles is a highly infectious and dangerous disease. Young children and individuals with impaired

immunity are especially susceptible to measles.

Analyse the graphs below and on the next page that show the number of people in the United States of America (USA) who were infected with measles during the period 1954–2000 and the number of people who died as a result of having measles during the same period.



Data: ProCon.org

a i Which year had the greatest number of reported measles cases? (1 mark)

ii What trends can be observed when the two graphs are compared? (2 marks)

b Controlling the number of measles cases in a population relies on herd immunity.

What is herd immunity and how does it help control the number of cases of this disease? (2 marks)

(Total 5 marks)

Solution

4-160 [VCAA 2018 SB Q5]

a i 1958

ii Trends observed

- roughly the same shape, i.e. when the number of cases increases, the number of deaths increases
- since 1968 only a few cases and deaths.

b Herd immunity is the immunity provided when most of the population has been immunised. This reduces the number of individuals the pathogen can infect, therefore reducing the chance that the pathogen can find a host, survive and spread to individuals not vaccinated.

Question 16/ 166

[VCAA 2022 SB Q7]

Before the chickenpox vaccine was developed, many people used ‘chickenpox parties’ as a way to infect their children with the virus. The idea was to enable the children to become immune to the virus before reaching adulthood, when the symptoms of the infection can be more severe. Some people continue to hold ‘chickenpox parties’ as an alternative to receiving the vaccine. However, the Center for Disease Control and Prevention (CDC) in the United States of America (USA) warns against this practice, saying that chickenpox can have severe and sometimes unpredictable or life-threatening consequences. The CDC recommends vaccination as a safe way to develop immunity to chickenpox.

a What is the name given to the type of immunity that would develop in children who became infected at the ‘chickenpox parties’? (1 mark)

b A summary of case-control studies conducted from 1997 to 2003 and analysed by the Australian National University showed that a single dose of varicella (chickenpox) vaccine was 97% effective in the first year after vaccination and 86% effective in the second year. From the second to eighth year after vaccination, the vaccine's effectiveness remained stable at 81% to 86%. Most vaccinated children who developed chickenpox during the eight years after vaccination had a mild case of the disease.

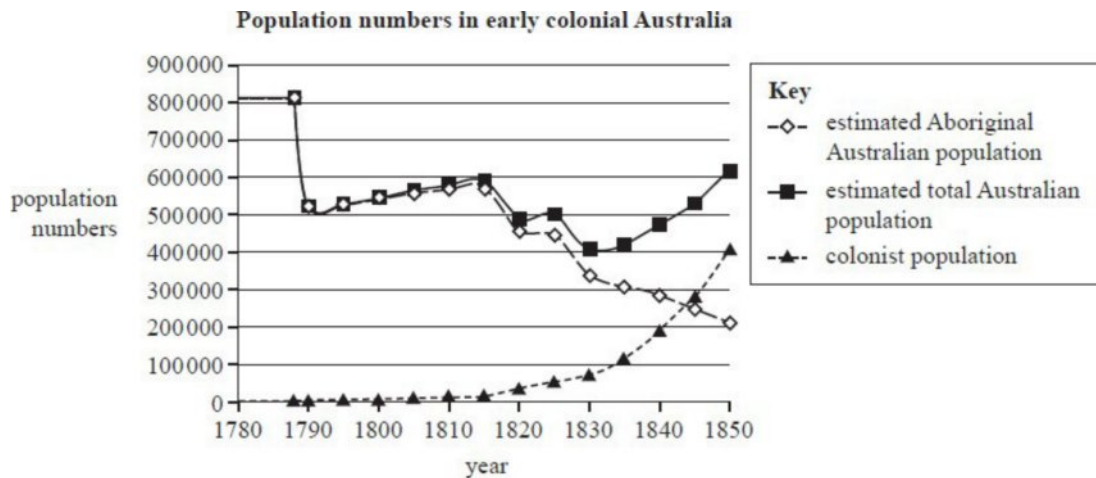
Why do most vaccinated individuals, if they are infected, show only a mild case of the disease? (2 marks)

c Smallpox is widely believed to be the cause of the significant population decline in Indigenous populations during early European arrival in Australia. Recent research suggests that it may have been chickenpox that

caused the change in population numbers rather than smallpox. It is thought that chickenpox did not exist in Aboriginal and Torres Strait Islander communities before European arrival. Chickenpox is fairly mild in young children and is easily transmitted. It can be a fatal disease in adults who were not infected as children.

The graph below shows population numbers during the period 1780–1850:

- the estimated Aboriginal Australian population
- the colonist population
- the estimated total Australian population.



With reference to chickenpox, explain how infection may have caused such a large impact on the Aboriginal Australian population and yet did not affect the population numbers of the colonists significantly, and why the Aboriginal population increased from 1790 to 1810. (3 marks)

(Total 6 marks)

Solution

4-161 [VCAA 2022 SB Q7]

a Natural, active immunity.

b Vaccinations result in the production of antibodies, memory B and memory T cells that recognise specific displayed antigens on antigen-presenting cells and infected cells. When a vaccinated individual is infected, some antibodies are already present, and the memory B cells clonally expand to produce many plasma B cells and many more memory B cells. The many plasma B cells quickly produce many antibodies that then neutralise the virus before severe symptoms can develop.

c Before the colonists arrived in Australia, Aboriginal Australians had no previous contact with the chickenpox virus; therefore, they had no immunity. Further, chickenpox can be fatal to adults who have not

had the disease as a child. As a result, many Aboriginal adults exposed to the disease died. As children in Europe, many colonists were exposed to chickenpox; therefore, fewer died in Australia. By 1790, many Aboriginal Australians had survived chickenpox as children and had developed immunity, so the population began to increase.

Question 17/ 166

[VCAA 2015 SB Q4]

In 2014, an outbreak of Ebola virus disease (EVD) occurred in West Africa. Humans may contract the virus from infected animals or from an infected person.

In 2014, there was no safe and effective vaccine available to prevent EVD.

a Explain how an effective vaccine could provide long-term immunity to EVD. (4 marks)

b Scientists developing new vaccines for EVD are conducting trials in animal subjects. To evaluate the effectiveness of a new vaccine, both humoral and cell-mediated responses are measured in the animal subjects.

Explain how these two immune responses are different. Give differences in your answer. (2 marks)

(Total 6 marks)

Solution

4-162 [VCAA 2015 SB Q4]

a An effective EVD vaccine contains EVD antigens and brings about an immune response. The EVD vaccine is engulfed by macrophages that then display EVD antigens on their cell membrane. These are identified by T helper cells that then stimulate B cells that have come in contact with the vaccine to divide many times producing B memory cells and B plasma cells. The B plasma cells produce specific EVD antibodies. In the future when the person becomes infected with EVD virus, the antibodies already present along with antibodies that are produced by activated memory cells quickly destroy the EVD virus before the person develops the disease.

b The humoral response targets pathogens in tissue fluid whereas the cell-mediated response targets cells that are infected by the pathogen.

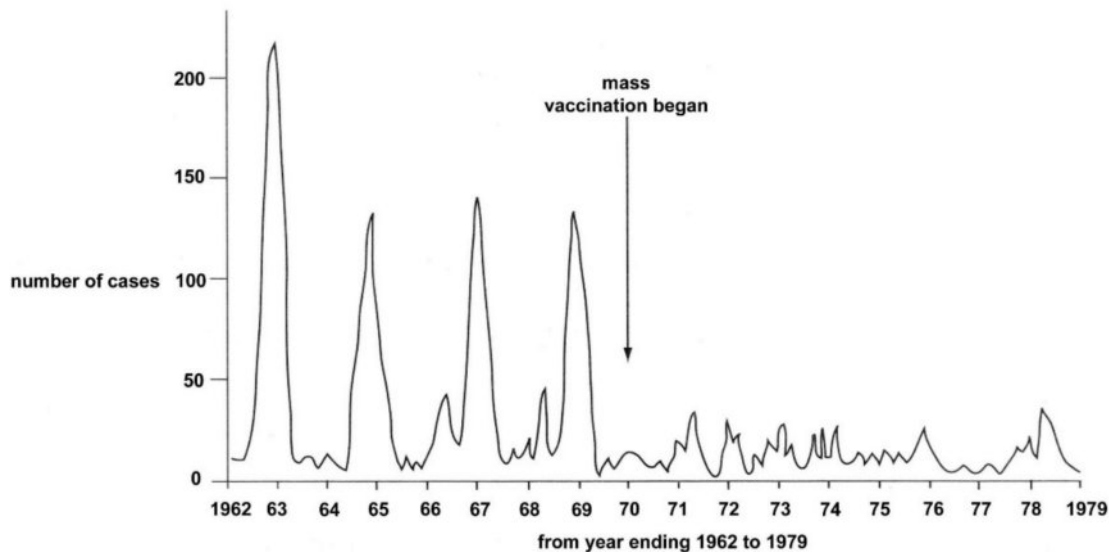
The humoral response results in B plasma cells producing antibodies which tag pathogens for destruction whereas the cell-mediated response results in the production of cytotoxic T cells which recognise and destroy

infected cells.

Question 18/ 166

[VCAA 2010 E1 SB Q8]

Measles is a highly contagious, serious disease caused by an RNA virus. There were regular epidemics of the disease until the introduction of mass vaccination. The following graph indicates the incidence of measles in Victoria from 1962 to 1979.



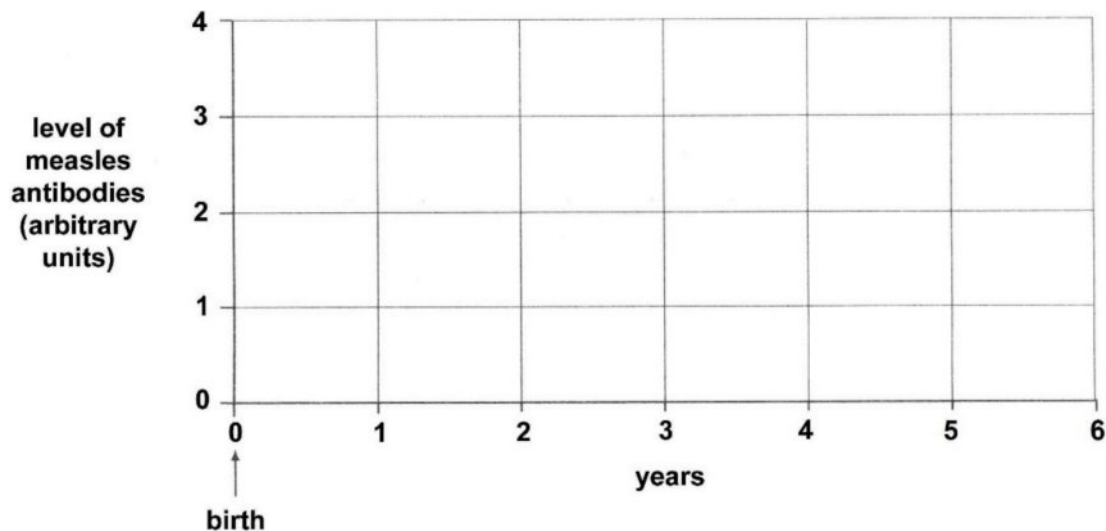
a What was the time period between successive epidemics? (1 mark)

An unaffected person without immunity has a 90 per cent chance of catching the disease if they live in the same house as a person with the disease. If a child is suspected of having measles, a serum sample is taken and tested for measles-specific IgM and IgG antibodies.

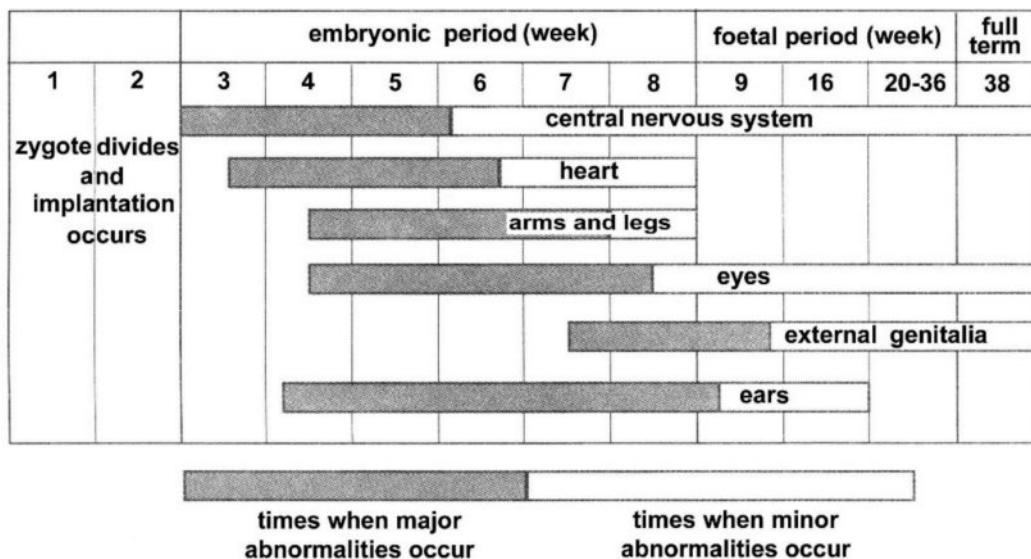
b What conclusion could be made if high levels of these antibodies were found and what action would be taken? (2 marks)

In Australia, vaccination against measles is a two-dose schedule. The first dose is generally given at age 12 months and the second dose at 4 years.

c On the grid below, graph the level of measles antibodies you would expect in a vaccinated child. The child's mother is known to have had measles as a child. (2 marks)



Rubella is a contagious viral disease. An individual may have the disease for two or more weeks before it is diagnosed. If a pregnant woman is infected with Rubella, the developing baby may develop serious defects. The diagram below outlines the development of various organs of a baby in utero.



Each bar shows the time over which a particular organ develops. Two pregnant women are diagnosed with Rubella. Mrs Smith is 6 weeks pregnant, and Mrs Jones is 28 weeks pregnant.

d Which embryo or foetus is at greater risk of developing a major defect? Refer to at least two areas of development to support your answer. (2 marks)

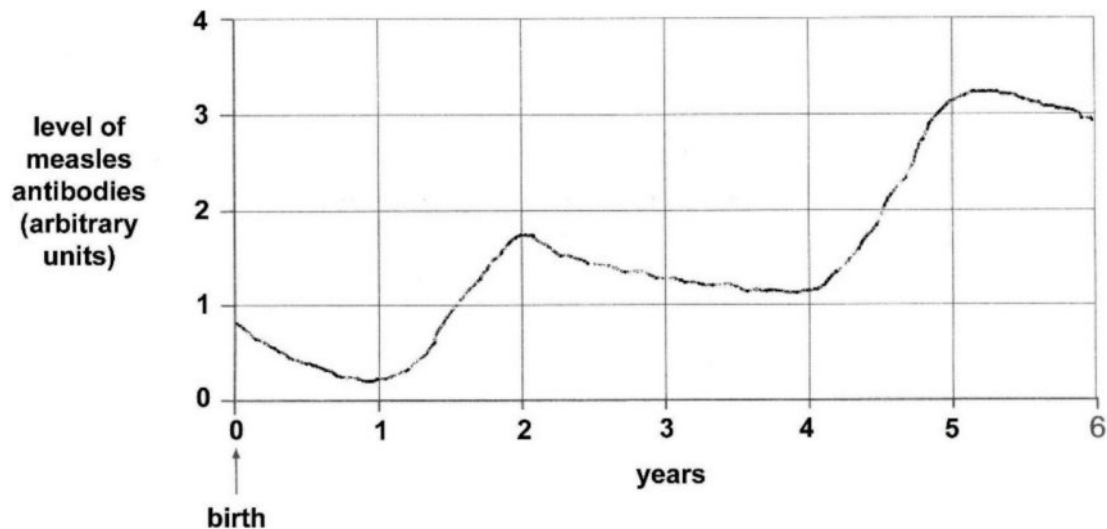
(Total 7 marks)

Solution

- a** Two years.
- b** If high levels of antibodies are found the child has the measles infection.

And **one** of the following:

- the child would then be isolated
- the child would be treated with gamma globin or antivirals
- the family would be vaccinated.



- c**
- d** Mrs Smith's embryo is at greater risk. Most organs of Mrs Jones' embryo are well developed therefore there is less risk of a major defect. Less organs are well developed in Mrs Smith's embryo. Mrs Smith's embryo has a poorly developed heart, arms and legs, eyes, external genitalia and ears. (Only two areas need to be referred to.) Therefore, there is greater risk of abnormalities in these areas.

Question 19/ 166

[VCAA 2013 SB Q4]

In 1995, the Australian Bureau of Statistics released a report showing that only 53 per cent of children aged between three months and six years had completed the immunisation schedule.

- a** Is childhood immunisation an active or passive form of protection against a disease? Justify your answer. (2 marks)

After a major advertising campaign by the government, the immunisation rate increased to 92 per cent.

- b** Complete the following flow chart to show the immune response in a person receiving their first vaccination. The following words must appear in your flow chart.

plasma cells memory cells B cells antibodies cytokines

The first step has been completed. (3 marks)

Step 1

antigens detected by T-helper cells



Step 2



Step 3



Step 4

Many immunisation schedules include regular booster injections.

c Explain how these work, and why they are necessary. (2 marks)

(Total 7 marks)

Solution

4-164 [VCAA 2013 SB Q4]

a Active. Immunisation results in the child's body actively producing B plasma cells and B memory cells.

b Step 1: vaccine antigens detected by T-helper cells.

Step 2: T-helper cells produce cytokines which stimulate specific vaccine antigen displaying B cells.

Step 3: The activated B cells undergo clonal expansion to produce many plasma B cells and memory cells. The plasma B cells produce and release many antibodies against the vaccine antigens.

Step 4: The presence of memory cells allows the body to respond quickly when exposed to the antigen in the future.

c Booster injections contain antigens that are detected by the B memory cells and T-helper cells. The T-helper cells stimulate the B memory cells to divide and produce more memory cells and plasma cells. The plasma cells then produce more antibodies. Booster injections are needed because memory cells die/short-lived cells or the number of memory cells present is not enough to result in a rapid, mass production of antibodies on future contact with the antigen.

Question 20/ 166

[VCAA 2012 E1 SB Q4]

Australia is currently experiencing an epidemic of pertussis. Pertussis is a highly contagious respiratory infection caused by the bacteria *Bordetella pertussis* (whooping cough). Pertussis vaccine is offered as part of an immunisation program for children at two months, four months, six months, four years and in Year 10 of secondary school.

a i Name the cells that are responsible for the production of antibodies. (1 mark)

Two children have been immunised according to the schedule. One is two months old and the other is four months old.

ii What difference would there be in the children's levels of antibodies against *Bordetella pertussis*? (1 mark)

Consider a Year 10 student. Memory cells will have been produced during the periods of immunisation when the student was younger.

b What are **two** advantages of having these memory cells when the student receives their immunisation in Year 10? (2 marks)

In Victoria in the past two years the number of cases of pertussis has increased dramatically. In 2010 there were over 6500 reported cases of pertussis; 66 per cent of these cases were adults and most of these adults had been immunised in childhood.

c i Outline a likely reason for the high percentage of adults with pertussis in 2010. (1 mark)

ii Describe one process that could be introduced by the Department of Health, Victoria, to reduce the number of adults being infected with pertussis. (1 mark)

The human immune response to antigens of *Bordetella pertussis* can be measured by the level of antibodies in the blood.

d Is this test a measure of cell-mediated immunity? Explain your answer. (1 mark)

(Total 7 marks)

Solution

a i B plasma cells

ii The 4-month-old child would have a higher level of antibodies against *Bordetella pertussis* than the 2-month-old child.

b The presence of memory cells will result in:

- a faster rate of production of antibodies against *Bordetella pertussis*
- a higher level of antibodies against *Bordetella pertussis*.

c i Any **one** of the following reasons:

- The level of antibodies present in the adults is too low to provide immunity against the disease/
- The adults did not receive all of the injections required for immunity.
- The present infection is caused by a different strain of *Bordetella pertussis*.

ii Any **one** of:

- Advise adults to have a booster vaccination.
- Provide free vaccinations.

d No, it is not a measure of cell-mediated immunity. Cell-mediated immunity involves cytotoxic T cells. Cytotoxic T cells do not produce antibodies. Antibodies are produced by plasma B cells that are part of the humoral or antibody-mediated immune response.

Question 21/ 166

[VCAA 2013 SB Q5]

Sufferers of autoimmune diseases produce autoantibodies.

a What role do these autoantibodies play in causing the symptoms of an autoimmune disease? (1 mark)

A teenager with a family history of an autoimmune disease underwent a genetic screen for the disease. After receiving a positive result for the genetic screen, she had an additional autoantibody test. The result of this autoantibody test was negative.

b Explain why the autoantibody test could be negative even though the genetic screen was positive. (2 marks)

(Total 3 marks)

Solution

4-166 [VCAA 2013 SB Q5]

- a** The autoantibodies attack antigens found on the person's own cells. These cells die or do not function efficiently resulting in the symptoms of the disease.
- b** The genetic screen indicates that the teenager has the allele that when expressed produces autoantibodies. The presence of the allele means the teenager has the potential to produce autoantibodies, but this will only occur if T-helper cells and B cells are stimulated/activated to produce the antibodies. If they have not been turned on, then no autoantibodies will have been produced, so the test would be negative.
-

Chapter 5 How are species related over time?

Question 1/ 83

Why is meiosis significant to sexually reproducing organisms? You should be able to make several points.

Solution

5-1 The significance of meiosis:

Meiosis results in a reduction in number of chromosomes in the gametes (ova and sperm). Sexual reproduction involves the fusion of gametes. If gametes were diploid, each time fertilisation occurred the chromosome number would double. Meiosis results in gametes containing one of each pair of chromosomes. Fertilisation restores the diploid number in the new individual. Meiosis results in variation in the offspring. Variation in populations allows species to survive changing environments. Meiosis results in new combinations of alleles, which may be expressed as new phenotypes. During meiosis the following lead to variation in gametes:

- random assortment and separation of homologous chromosomes during the first stage of meiosis
- crossing over during prophase I of meiosis.

Gametes that contain unique combinations of alleles that are different from those found in either parents'

cells are the result of meiosis.

Note: Meiosis is a shuffling process and does not add new alleles to gametes. This is the role of mutation.

Question 2/ 83

What is the difference between allele and a gene? Are they the same thing?

Solution

5-2 A gene is a specific sequence of nucleotides that codes for a specific protein. Different forms of a gene are called alleles and have differences in their genetic code that results differences in the proteins that are produced.

Question 3/ 83

Distinguish between the terms 'homologous', 'homozygous' and 'heterozygous'.

Solution

5-3 The term **homologous** refers to the size and shape of chromosomes. If two chromosomes are the same length and contain genes for the same characteristics, they are homologous. (*Note:* The alleles of particular genes do not have to be identical.) The terms **homozygous** and **heterozygous** refer to the alleles for a particular gene carried on homologous chromosomes. If the alleles are identical, an organism is said to be **homozygous** for the alleles of that gene. If the alleles are different, the organism is described as **heterozygous**. (Remember: in this sense, 'homo' means the same and 'hetero' means different.)

Question 4/ 83

What is the difference between the terms 'genotype' and 'phenotype'? What factors determine each?

Solution

5-4 The **genotype** refers to the alleles an individual possesses – literally the type of genes present. Often genotypes are written as pairs of letters. Each letter represents a member of an allele pair. For example, a genotype for eye colour is BB where 'B' represents the allele responsible for production of brown pigment. An individual with this genotype has a particular appearance or phenotype – in this case brown pigments in the eye. **Phenotype** refers to the characteristic that shows or is expressed. A particular feature might not be visibly expressed, such as the production of a particular enzyme but its presence is part of an organism's phenotype. The phenotype is influenced by the alleles inherited (genotype) and the environment. Many individuals with brown hair do not always have brown hair. An environment of excessive sun or bleaching agents may cause an alteration in phenotype even though the genetic potential is for dark-coloured hair!

Question 5/ 83

What is meant by variation when looking at members of a population?

Solution

5-5 Variations are the differences between organisms. In this context, it is phenotypic variation that is of interest in a population. Variations exist in visible features such as external colouring or internal functioning (for example, the ability to produce a particular enzyme).

Question 6/ 83

List the major types of variation that exist between organisms.

Solution

5-6 Variations can be classified into four main groups:

- **Structural variations** are easy to observe. Differences in cats' tail shapes and sizes are due to structural differences. There are huge differences in feather patterns in pigeons. In humans, differences in ear lobes or facial features are structural variations.
 - **Physiological variations** are differences in how an individual's body functions. Some individuals cope better with heat stress or have greater stamina. The ability to taste particular chemicals or see certain colours can show variation. In humans some individuals are red-green colour blind.
 - **Biochemical variations.** The ability to produce pigments of a particular colour leads to different coat colour in animals. Consider the range of hair colour in cats and dogs. These differences are due to biochemical variations. Some people lack the enzymes necessary to break down the sugars in dairy products. Differing abilities to produce enzymes are biochemical variations.
 - **Behavioural variation** in pets is easily observed. Some dog breeds respond well to training, while for others training is a waste of time. In the human population, many of us are right-handed, but many also are left-handed.
-

Question 7/ 83

List the various sources and processes that provide genetic variation in a population. Start with variation that arises during gamete production.

Solution

5-7 Sources of variation include:

- Gene mutation during gamete production (introduces new alleles).
 - Chromosomal mutations (changes in chromosome number or size).
 - Crossing over during prophase I of meiosis (shuffle the alleles within a homologous pair of chromosomes).
 - Random assortment of chromosomes during meiosis (one member of each homologous pair goes to opposite poles during meiosis I).
 - Mate selection (different mates would provide different alleles).
 - Gamete selection (many gametes are produced but few are involved in fertilisation).
-

Question 8/ 83

Point mutations are minor alterations to base sequences in genes. Describe the three major types of point mutation.

Solution

5-8 Three types of point mutation are:

1 Substitution - replacement of one nucleotide by another.

E.g. before: TTT AAG CCG TTG

after: TTA AAG CCG TTG (3rd T substituted for by A)

Result: only 1 amino acid in the chain affected.

2 Addition - addition of one or more nucleotides to a DNA strand.

E.g. before: TTT AAG CCG TTG

after: TTT AAA GCC GTT G (base added to second triplet results in changes to following triplets)

Result: all amino acids coded by bases at or after the addition will be affected.

3 Deletion - removal of one or more nucleotides from a DNA strand.

E.g. before: TTT AAG CCG TTG

after: TTT AAC CGT TG (removal of the 6th base alters all later triplets)

Result: all amino acids coded by bases at or after the addition will be affected.

Question 9/ 83

Explain why mutations are usually harmful. Which of the three types of point mutation are the least harmful? Why? Refer to frameshift in your answer.

Solution

5-9 Mutations are generally harmful as they occur at random. It is unlikely to improve the plan for a protein through random change. A mutation that causes alteration in a few triplets is likely to be less harmful because the sequence of amino acids will be little altered. A single substitution will alter only one amino acid, so it has a relatively small effect. Additions and deletions cause more problems because they result in a frameshift.

As the code is read in threes, removing or adding a base alters all triplets that follow. *Note:* Addition or deletion of three bases would be less harmful as fewer triplets are affected.

Question 10/ 83

What are block mutations?

Solution

5-10 Block mutations involve deletions, duplications, inversions and translocations of large sections of chromosomes. They result in the movement of gene loci to different positions on a chromosome or to non-homologous chromosomes.

Question 11/ 83

Give an example of a condition that arises as a result of non-disjunction. Explain what must have happened during meiosis.

Solution

5-11 Down syndrome is a condition that results from non-disjunction. During meiosis in the mother's ovary, the 21st pair of homologous chromosomes fail to separate. At the end of stage 1 of meiosis, one cell has 24 chromosomes and the other 22. This mistake will be continued through stage 2 of meiosis and results in ova with two chromosome 21s or ova with no chromosome 21. If an ovum with two chromosome 21s fuses with a sperm, a zygote with 47 chromosomes will result.

Question 12/ 83

How do aneuploidy and polyploidy differ?

Solution

5-12 Cells that vary slightly in chromosome number are aneuploid whereas polyploid cells contain more than two sets of homologous chromosomes. Aneuploid cells are formed as a result of non-disjunction in meiosis or mitosis, whereas polyploid cells result when a gamete fuses with a diploid cell or 2 diploid cells fuse.

Question 13/ 83

List some causes of mutation.

Solution

5-13 Mutations are caused by environmental agents such as ultraviolet radiation, X rays, nuclear radiation and certain chemical agents. The effects of chemical mutagenic agents may depend on their concentration and length of exposure.

Question 14/ 83

Distinguish between germline and somatic mutations.

Solution

5-14 Somatic mutations occur in somatic cells. As they do not occur in reproductive tissue, they are not passed on to the next generation. Somatic mutation can result in cancer. Germ-line mutations occur during gamete formation and can be inherited. Note: Mutagenic agents may cause mutation but do not direct it. Mutation is a random process. That is, they can occur anywhere and do not cause changes in a specific piece of DNA.

Question 15/ 83

Which sorts of mutation can be beneficial to a species' long-term survival? Explain.

Solution

5-15 Germ-line mutations are the source of new genetic variation in a species. They are the way in which new alleles for a gene are formed. The results of mutation are generally harmful but very occasionally a new allele that is expressed as a better-adapted phenotype does occur. Individuals who are better adapted are the key to a species' long-term survival. Germ-line mutations can be passed on to offspring and if a mutation is beneficial, it will result in better-adapted future generations.

Question 16/ 83

Which is the more important source of variation – recombination during meiosis or mutation? Justify your opinion explaining the significance of each.

Solution

5-16 Mutation is the more important source of new genetic variation as it introduces new possibilities as new alleles. Recombination of alleles is important in shuffling alleles into different combinations. There is no additional variation but new combinations of alleles could lead to a better set of characteristics in offspring.

Question 17/ 83

What is meant by the terms 'gene pool' and 'allele frequency'?

Solution

5-17 The gene pool is literally the pool of genes for a population. A population is a group of individuals of one species living in one area. Within a population, there is genetic variation. That is, there are alternative forms of genes present – alleles. Calculation of frequency of particular alleles in the population's gene pool can occur. Over a number of generations, alleles that give individuals an advantage will increase in frequency in the gene pool.

Question 18/ 83

How is allele frequency calculated?

Solution

5-18 Allele frequency can be calculated by calculating the percentage of a particular allele in a population. A formula is shown below. It is important to remember that homozygotes contain 2 copies of an allele, whereas a heterozygote contains one copy.

$$\text{allele frequency} = \frac{2(\text{number of homozygotes}) + (\text{number of heterozygotes})}{2(\text{total number of individuals})} \times 100$$

Question 19/ 83

In terms of the gene pool and allele frequency, what is the difference between gene flow and genetic drift? When will the two processes have the greatest effect on allele frequency?

Solution

5-19 Gene flow refers to movement of genes in and out of the gene pool. This occurs through immigration (movement in) and emigration (movement out). Alleles can be added or removed from a population's gene pool.

Genetic drift is a random change that can lead to changes in allele frequency. In a population, there may be a number of phenotypes with equal fitness. Over a number of generations one phenotype (and the alleles that determine it) could become more frequent just by chance. Genetic drift is of importance in smaller populations where random selection could significantly alter an allele's frequency.

Question 20/ 83

Complete the following table.

	Bottleneck	Founder effect
Definition		
Genetic diversity		

Solution

5-20

	Bottleneck	Founder effect
Definition	Chance effects on allele frequencies in a population as a result of a major reduction in population for example disease or loss of habitat. The descendants from the small, reduced population will be genetically similar as they are descended from the same ancestors.	Occurs when a small unrepresentative group migrates to an isolated area. Future generations are descended from this group and so allele frequencies will be different from the original population.
Genetic diversity	Reduced	Reduced

Question 21/ 83

What is biological evolution? Is evolution a process or a result? Explain.

Solution

5-21 Biological evolution is the cumulative change in characteristics of populations over successive generations. To evolve means to change. Biological evolution has occurred if there is change in the characteristics of a population over a number of generations. Biological evolution is the result of change. The process that brings the change about is 'Natural Selection'.

Question 22/ 83

Is biological evolution a theory or fact?

Solution

5-22 Biological evolution is a scientific theory. There is no such thing as a scientific fact! Some theories are better than others. Many biologists believe there is much evidence to support the evolution theory.

Question 23/ 83

How are 'Natural Selection' and 'Biological Evolution' related?

Solution

5-23 'Biological Evolution' occurs as the result of 'Natural Selection'. 'Evolution' refers to the changes in species over time. 'Natural Selection' is the process that results in the change.

Question 24/ 83

If natural selection is to occur, what must exist in a population?

Solution

5-24 For natural selection to occur there must be phenotypic variation (based on genetic variation) in a population. If all individuals were phenotypically identical, selection for better-suited phenotypes could not occur.

Question 25/ 83

Is selection at the phenotypic or genotypic level? Explain what sorts of individuals are most likely to survive in a particular environment.

Solution

5-25 Natural selection occurs at the phenotypic level. The individuals with phenotypes that suit them best to the environment will tend to be selected. Less well-suited individuals tend not to survive and reproduce. As phenotype is largely determined by genotype, alleles that lead to better-suited phenotypes will become more common. The selection, however, is at the phenotypic level.

Question 26/ 83

Does the 'fitness' of an individual vary and if so, what determines an individual's fitness?

Solution

5-26 The genetic fitness of an individual depends on the environment (selecting agents) in which it lives. Polar bears are well adapted to life in the Arctic Circle. A polar bear placed in the Simpson Desert would not survive long!

Question 27/ 83

Which individuals in a population are most likely to survive in a particular environment?

Solution

5-27 The individuals most likely to survive in a particular environment are those with the best set of adaptations for that environment.

Question 28/ 83

Which individuals in a population are most likely to reproduce in a particular environment?

Solution

5-28 Individuals that are well suited to their environment are more likely to reproduce. Poorly suited individuals are less likely to survive to reproduce. If they do reproduce, on average they would produce fewer offspring.

Question 29/ 83

If an individual is to pass on its alleles (genetic information) to the next generation, how long must it live?

Solution

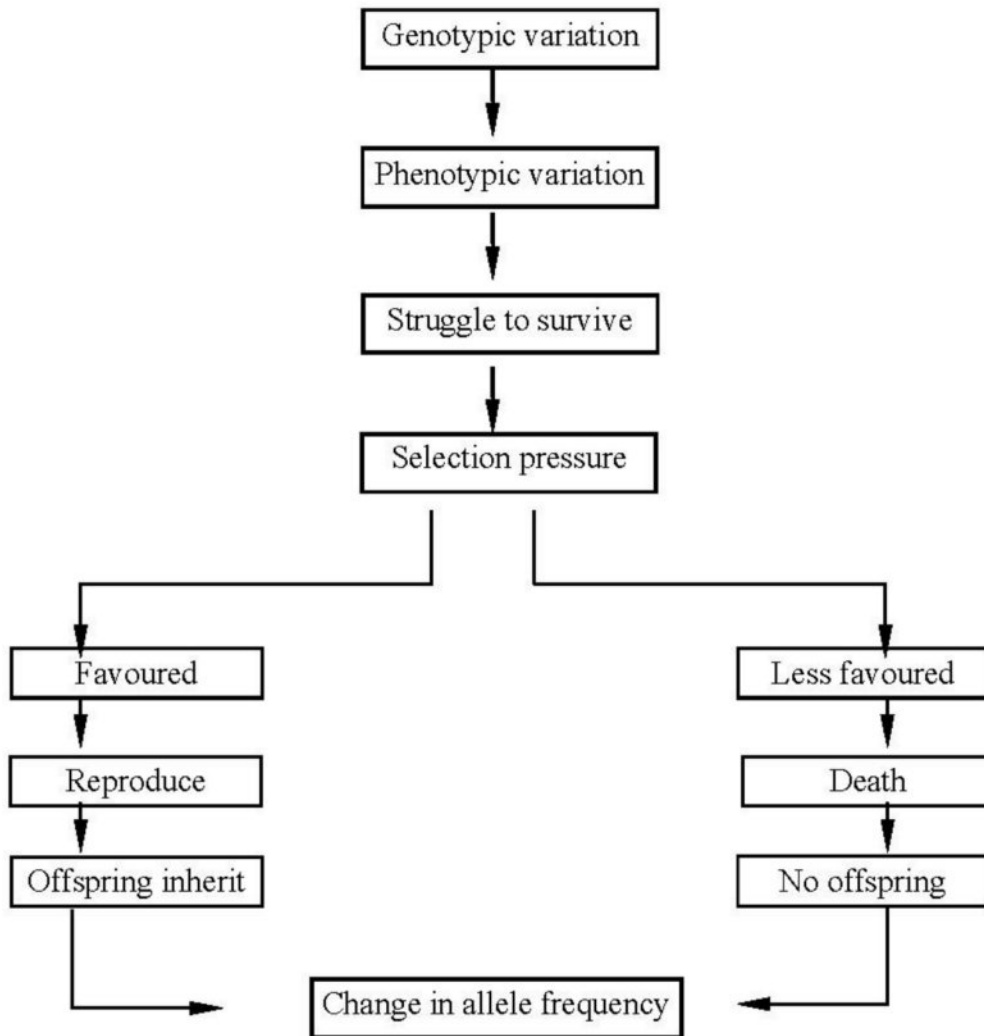
5-29 To pass alleles on to the next generation an individual has to survive long enough to reproduce. One thing of which you can be certain is that your ancestors reproduced. You can thank them for your genetic inheritance!

Question 30/ 83

Darwin proposed the theory of 'Evolution by Natural Selection'. Since then, developments in genetics have led to its modification. Summarise the modern view of evolution by natural selection.

Solution

5-30 Summary of evolution by natural selection



Within a species there is considerable **variation** in physical characteristics that are genetically determined. Some individuals are more likely to survive than others.

In nature, **large numbers** of offspring are produced but not all survive. There is a struggle for survival due to competition for limited resources. Only some individuals survive to reproduce.

Individuals with **certain characteristics** are more likely to survive to reproduce in a particular environment (selection pressure) than other individuals.

The individuals that **survive** pass on their characteristics to the next generation. Those individuals with different characteristics are less likely to survive to reproduce. They are less likely to pass on their characteristics to the next generation.

Over time, there is an increase in the gene pool in the number of the alleles that determine the favoured

characteristics.

Question 31/ 83

Using the Darwin/Wallace theory of natural selection, explain how peppered moths in polluted forests are mainly black whereas populations of these moths in unpolluted forests are mainly pale. This is an example of how physical conditions can affect populations.

Solution

5-31 There was original variation in colour in peppered moth populations. Some were dark and others were pale. In polluted areas, tree trunks are dark. Dark moths are camouflaged and less are eaten by birds. These dark moths survive, reproduce and their offspring inherit the dark colouration. Pale moths are more obvious to birds, more are eaten and less survive to reproduce. Over time, the population has become predominantly dark. In unpolluted areas, tree trunks are pale. Dark moths are less camouflaged, are easily identified by birds and are eaten. Less survive to reproduce. Pale moths are more camouflaged. They are eaten less by birds therefore they survive, reproduce and their offspring inherit their pale colouration. Over time, the population has become paler.

Question 32/ 83

Using the Darwin/Wallace theory of natural selection, explain how mosquitoes have become resistant to DDT. This is an example of how chemical conditions can affect populations.

Solution

5-32 There was original variation in DDT resistance in mosquitoes. Some were resistant, and others were not. In areas where DDT was sprayed, those mosquitoes that were not resistant died. They produced less

offspring. Those mosquitoes that were resistant to DDT survived, reproduced and their offspring inherited DDT resistance. Over time, more individuals in the population have become resistant to DDT.

Question 33/ 83

Explain whether or not individuals with a dominant phenotype will become more frequent in a population than individuals with the recessive phenotype for the same characteristic. In other words, does 'dominance' in numbers have much to do with 'dominance' in phenotype? (HINT – in genetics only use the word 'dominant' when referring to phenotype.)

Solution

5-33 Individuals of a dominant phenotype will only become more common in a population if they are also fitter than individuals with the recessive phenotype. In theory, if there is no difference in fitness there should be no change in frequency.

Question 34/ 83

Complete the following table.

Environment

Genetic diversity advantage

Explanation

Solution

Environment	Genetic diversity advantage	Explanation
Stable	Little diversity	Individuals that are present are well adapted to the environment – therefore their offspring will also be well adapted.
Changing	Very diverse	If the environment changes to the disadvantage of one individual, there is a chance that other individuals will be adapted and survive.

Question 35/ 83

Is there any real difference in the process of ‘Natural Selection’ when compared with ‘Selective Breeding’?

Solution

5-35 There is no major difference between ‘Natural’ and ‘Selective Breeding’. They both produce evolutionary change. The difference is the selecting agent. In ‘Natural Selection’, it is the environment at large. In the case of ‘Artificial Selection’, it could be a dairy farmer keeping certain cows and removing others from her (or his) herd.

Question 36/ 83

How does selective breeding affect genetic diversity and what are the advantages and disadvantages of this?

Solution

5-36 Selective breeding reduces genetic diversity. The advantage of this is that the farmer produces more individuals with the desired trait. It is more efficient. The disadvantage is that if the environment changes to

the detriment of one individual, then as all individuals are genetically similar, it will be to the detriment of all, and the crop will fail.

Question 37/ 83

Explain how bacteria can become resistant to antibiotics.

Solution

5-37 In a population of bacteria there is variation in the ability to survive exposure to a particular antibiotic. When an antibiotic is present, those individuals that are resistant will survive, reproduce, and pass on the genetic information (alleles) to the next generation. Over many generations the percentage of resistant bacteria will increase.

Question 38/ 83

Where are the genes for antibiotic resistance located within a bacterium?

Solution

5-38 The genes for antibiotic resistance are found on plasmids within the bacterial cell.

Question 39/ 83

Describe two ways that plasmids are passed on to daughter cells.

Solution

5-39 Plasmids are passed on in two ways:

- There are many copies of plasmids in the bacterial cytosol. When the cell divides by binary fission, the contents of the cell are transferred to daughter cells.
 - Plasmids can be transferred to cells by conjugation. A tube forms between two bacterial cells. A copy of the plasmid passes through the tube to the new cell. Once in the daughter cell the plasmid may be copied many times.
-

Question 40/ 83

Explain why it is dangerous to overuse antibiotics.

Solution

5-40 Each time an antibiotic is used there is a chance that some resistant bacteria will survive. If this occurs, then in the future there will be more resistant bacteria in the population and the antibiotic will be less effective at reducing the numbers of bacteria and so become a less effective treatment.

Question 41/ 83

Compare antigenic drift and antigenic shift by completing the following table.

Similarities**antigenic drift****antigenic shift****Differences****Solution****5-41****Similarities****Antigenic drift****Antigenic shift**

Both processes result in altered viral antigens

Differences

Changes accumulate as a result of mutations occurring during replication – a gradual process within one viral strain

Changes occur when an individual is infected by two different viruses. The viruses can swap genetic material, resulting in a new antigen. This is a rapid process resulting in two viral strains.

Question 42/ 83

What is palaeontology?

Solution

5-42 Palaeontology is the study of ancient life as preserved in rocks and sediments as fossils.

Question 43/ 83

What is faunal succession and how does it provide evidence to support evolution?

Solution

5-43 Faunal succession predictably reliable order of fossils found in sedimentary rocks where the oldest fossils are found in the deeper rock layers. The fossils indicate that the organisms found on Earth have varied with time therefore evolution has occurred.

Question 44/ 83

Is it always true to say that fossils are the remains of dead organisms?

Solution

5-44 Fossils provide evidence of once-living organisms. Fossils are not always the dead organism's remains. Fossil footprints or body impressions can also provide evidence that an organism existed. Sometimes the actual remains may no longer exist. A cast showing size, shape and texture of the outer surface may remain. Fossils are not always the dead remains but can be evidence that an organism was in the area.

Question 45/ 83

Under what environmental conditions are fossils formed? What conditions reduce the chances of good fossils forming?

Solution

5-45 Any condition that reduces scavenging and decay by other organisms will assist fossilisation.

- **Quick burial:** Fossils are most likely to occur in an environment where there is rapid burial of the dead organism. This reduces the exposure to scavengers and decomposers. Burial of marine organisms in sediments after death is more likely than burial in a terrestrial environment. Quick burial of an organism by volcanic ash provides excellent conditions for fossilisation. A visit to Pompeii in Italy is well worthwhile. The entire town was buried in about 79 AD when Vesuvius erupted. Casts of the residents have been obtained by pouring plaster of Paris into spaces in the compressed ash.
- **Cold temperatures:** Frozen organisms are fossils. Low temperatures protect the remains from decomposers. Consider woolly mammoth remains!
- **Sap:** Sap also protects organisms from decay. Insects in amber were a source of DNA in the movie *Jurassic Park* and its sequels.
- **Anoxic environments:** The remains are protected, as aerobic decomposers cannot survive in anoxic environments.

Disturbance of organisms after death reduces chances of fossilisation. Exposure to wind, rain, scavengers and bacteria also impede fossilisation. Earth movements and erosion after burial tend to damage fossils. Erosion of sedimentary rocks, however, is the major way fossils are revealed, allowing people to find them.

Question 46/ 83

What information can fossils provide about the lifestyle of once living organisms?

Solution

5-46 Evidence of the once-living organism's environment can be deduced by looking at the sediments in which it is buried and other fossils present. An organism whose fossil is found in sandstone probably lived in a marine environment, whereas the fossil of an organism living by a lake would probably be found in mudstone. Fossilised pollen and seeds can indicate the types of plants growing in an area in the past. The condition of a fossilised skeleton can tell a story. Carnivores are likely to have torn apart the skeleton of smaller animals. Fossilised teeth can indicate the diet and age of the organism before it died. The teeth of carnivores and herbivores are very different. Tooth wear indicates the age of an organism at death. For a toothed animal, the greater the teeth wear, the older the animal was at death.

Question 47/ 83

Why is it difficult to identify different species using only fossil evidence?

Solution

5-47 Fossils are difficult to identify to the species level for two major reasons:

- The remains are incomplete and so it is difficult to compare relationships with living organisms.
 - A major aspect of species identification relies on determining whether two individuals can interbreed to produce fertile vigorous offspring. So far, there have been no reports of fossils mating to produce offspring! That fossils are dead may present some insurmountable problems to conducting an active sex life!
-

Question 48/ 83

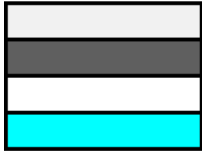
Describe the difference between absolute dating (radioactive isotope dating) and relative dating (stratigraphy).

Solution

5-48 Absolute dating gives an estimate of age in years. For example, one million $\pm$ ten thousand years. Absolute dates are calculated using the known rates of decay of radioactive isotopes.

Relative dating relies on sedimentary layers (strata) being laid down in order. In an environment undisturbed by earth movement, the oldest fossils will be buried more deeply than younger fossils. An actual date cannot be determined with relative dating.

Younger fossil near the surface



Deeply buried sediments with oldest fossil

Question 49/ 83

What role do index fossils have in dating rocks?

Solution

5-49 Index fossils are fossils of organisms that were widely spread but existed for a short period of known time. If these fossils were found in a sedimentary rock layer, then that layer was formed during that known time.

Question 50/ 83

Different radioactive isotopes have different half-lives. What does this mean?

Solution

5-50 Radioisotope dating relies on palaeontologists knowing the half-life of the isotope with which they are dealing. Radioactive isotopes break down at known rates. Carbon-14's half-life is 5568 years. If you had 1 gram of carbon-14 today, in 5568 years you would have 0.5 grams. After another 5560 years (a total of 11 136 years) then you would have 0.25 grams of carbon-14. Radioactive rubidium isotopes have a half-life of 47 000 million years.

Question 51/ 83

Different radioisotopic methods are used to date fossils of different ages. List some commonly used isotopes and state their use. Is it always the fossil that is dated?

Solution

5-51 Carbon-14: This method is used for dating organic matter up to 50 000 years in age. *Note:* Carbon occurs in all organic molecules, therefore the ^{14}C isotope is useful for dating organic matter.

Potassium/Argon: Used to date volcanic rock from 10 000 to 100 million years in age.

Fission Track: This method can be used to date volcanic rock over 10 000 years old.

Uranium/Thorium: A method used to date bone and teeth of less than 350 000 years old.

Direct dating of fossils is not always possible. If sediment formation was at the same time as the fossilisation, dating the sediment dates the fossil.

Question 52/ 83

What is the significance of fossils like *Archaeopteryx*?

Solution

5-52 Palaeontologists believe *Archaeopteryx* represents an intermediate stage in the evolution of birds from reptile-like ancestors. A problem for evolutionists is the lack of a complete fossil record. The fossil record has many gaps. Excitement is generated by fossils, like *Archaeopteryx*, because they fill gaps in the fossil

record.

Question 53/ 83

What is meant by the term 'species'?

Solution

5-53 The term 'species' is a human concept used to classify organisms. Classification is often subjective as organisms are hard to pigeonhole. Therefore, no definition is perfect!

A species is a group of organisms that are structurally and biochemically similar. Members share more characteristics in common than with any other individuals. Members of a species interbreed to produce vigorous fertile offspring. Members of a species share the same gene pool or are connected by gene flow to other populations' gene pools.

The species definition is a matter of debate and there is no absolute definition.

Question 54/ 83

What is the most important test used to distinguish members of a species?

Solution

5-54 The test used most is to determine whether individual organisms mate to produce fertile offspring. This test is not always possible!

Question 55/ 83

What is the significance of geographical barriers in the evolution of new species? Describe features that act as geographical barriers.

Solution

5-55 Geographical barriers can separate populations of one species to prevent interbreeding. As explained in the next answer, this is important in speciation. Some features that act as geographical barriers are oceans, rivers, mountain ranges, deserts and deep canyons.

Question 56/ 83

Summarise the important steps that lead to allopatric speciation.

Solution

5-56 A single population of one species contains **genetically determined variation**. A **geographical barrier** splits the original population into two. The isolated populations are subjected to **different environmental conditions**. **Different phenotypes** are selected in the two isolated populations. Over a number of **generations**, the populations become different. **Mutations** occur that affect reproductive structures and behaviours. If after removal of the geographical barrier **interbreeding is no longer possible**, then **two species** have formed.

Question 57/ 83

How can you determine if you have one species or two distinct species in an area?

Solution

5-57 To determine whether one or two species are present, you need to look for interbreeding. If individuals from the two groups can mate to produce vigorous fertile offspring under natural conditions, they are members of one species. If interbreeding or gene flow is not possible, two species are present. Remember that domestic dogs belong to the one species even though the largest and the smallest do not mate. They do mate with dogs closer to their size and so gene flow is possible.

Question 58/ 83

If two closely related species live in the same area, what are the possible isolating mechanisms that might prevent interbreeding?

Solution

5-58 Two types of isolating mechanisms exist. Pre-mating isolating mechanisms prevent successful mating. Post-mating mechanisms prevent successful production of vigorous and fertile offspring.

Pre-mating isolating mechanisms include habitat isolation, seasonal isolation, differences in courtship, and mechanical isolation (reproductive organs are not compatible).

Post-mating isolating mechanisms include gamete mortality (gametes do not survive until fertilisation), zygote mortality (formed but not viable), and hybrid sterility (for example, mules).

Question 59/ 83

Use the finches of the Galapagos Islands to explain what is meant by adaptive radiation. What type of evolution is this?

Solution

5-59 Adaptive radiation occurs when one ancestral species gives rise to a number of new species occupying different niches. Finches on the Galapagos Islands are descended from a mainland South American seed-eating finch species. The finches live on different islands and have been subjected to different selection pressures such as type of food available. The finches now vary in what they eat and the size and shape of their beaks.

Question 60/ 83

Name two features that characterise adaptive radiation.

Solution

5-60 Adaptive radiation involves a **rapid increase** in species diversity within a short time.

Question 61/ 83

How do allopatric speciation of sympatric speciation differ?

Solution

5-61 Allopatric speciation occurs in isolated populations whereas sympatric speciation occurs in within the same location. Allopatric speciation involves a geographical or physical barrier whereas sympatric speciation does not.

Question 62/ 83

How did sympatric speciation of *Howea* plants on Lord Howe Island occur?

Solution

5-62 Lord Howe Island was colonised by an ancestor of both *Howea* species. Some seeds germinated on calcareous soils with high pH and low nutrients. The stressed plants flowered at a different time to the nearby plants on volcanic soil, leading to reproductive isolation. Over time the soil provided different selection pressures and significant genetic differences accumulated in the two different populations of *Howea*, resulting in two species.

Question 63/ 83

Complete the following table.

Evidence for evolution	Example

Palaeontology	

-transitional forms	

Comparative anatomy	

-homologous structures	

Evidence for evolution Example

-vestigial organs

Molecular homology

-Universal genetic code

-similar DNA sequences

-similar amino acid sequences

Solution

5-63

	Evidence for evolution	Example
Palaeontology	Fossil record shows that living organisms have changed over time.	Ferns appear in the fossil record before gymnosperms and angiosperms appear most recently.
- transitional forms	If new species have evolved from a common ancestor, then the fossil record should include fossils that have characteristics that are intermediate between the ancestral form and the new form.	• <i>Archaeopteryx</i> fossils: intermediate between birds and reptiles • Lung fish: intermediate between fish and amphibians
Comparative anatomy – homologous structures	If new species have evolved from a common ancestor, it would be expected that the new and ancestral species would have the same basic structure. The basic structure may be modified according to the organism's way of life.	The pentadactyl limb: All mammals have similar structures. The skeleton is similar. The same bone pattern is present although the size and shape of bones may vary.
- vestigial organs	If new species have evolved from a common ancestor, structures may be present that no longer have a function. These structures would have had a function in ancestral organisms.	• Presence of an appendix in humans. • Vestigial hind limbs in whales.

	Evidence for evolution	Example
Molecular homology	This suggests all living things are related.	TTT codes for phenylalanine in all living organisms.
- Universal genetic code		
- similar DNA sequences	Differences in nucleotide sequences arise by mutation. The greater the number of mutations present the longer time since divergence from a common ancestor.	The genetic similarity between humans and chimpanzees is 98.9%.
- similar amino acids	As DNA codes for the sequences of amino acids in a protein, the order of amino acids is also an indicator of the time passed since divergence.	There is one amino acid difference in cytochrome c between humans and the rhesus monkeys.

Question 64/ 83

What is molecular homology and how can it be used to determine the relatedness between species?

Solution

5-64 Molecular homology involves looking at the similarity between molecules found in different organisms. DNA and amino acid sequences are often used in molecular homology. The genetic code is universal. This suggests that all living things are related. Differences in nucleotide sequence arise by mutation. The greater the number of mutations present the longer the time since divergence from a common ancestor. As DNA codes for the sequence of amino acid in a protein, the order of amino acids is also an indication of the time that has passed since divergence.

Question 65/ 83

Draw a phylogenetic tree based on the following hybridisation results.

Human and chimpanzee: 97.7%

Human and gibbon: 94.7%

Solution

5-65

Human Chimpanzee Gibbon

Common ancestor

Question 66/ 83

List the major characteristics that distinguish mammals from other animals.

Solution

5-66 Major distinguishing features of mammals are their ability to maintain a constant body temperature, body covering of hair, relatively large brain and mammary glands. Compared with other groups, mammals invest heavily in parental care.

Question 67/ 83

Humans are primates. Describe the major features that distinguish primates from other mammals.

Solution

5-67 Features that distinguish primates from other mammals are:

- brain larger when compared with other mammals
 - hands and feet with curling fingers
 - nails on digits instead of claws (support tips of fingers when gripping)
 - an opposable digit which makes possible the power and precision grips
 - large forward-facing eyes that provide stereoscopic vision
 - reproductive patterns with emphasis on caring for fewer offspring well.
-

Question 68/ 83

Why are opposable digits important to primates? In particular, how is an opposable digit important to humans?

Solution

5-68 Opposable digits are important to all primates. They allow a primate to grip in two ways. The power grip with all digits curled is especially useful to apes climbing trees. The precision grip where the thumb tip meets fingertips is useful for manipulating small objects. The precision grip is particularly important for humans in making and using tools.

Why do netballers and footballers require good stereoscopic vision?

Solution

5-69 Stereoscopic vision provides 3D vision or depth perception. This allows better judgement of distances. Good netballers and footballers need to be able to judge distances to catch or mark a ball.

What features distinguish hominins from other primates?

Solution

5-70 Major features of the hominins are:

- **Development of bipedalism** – that is, walking upright on two legs. To allow an upright stance, changes to the backbone, hips, knees and feet occurred during evolution of the hominids.
- **Enlarged brain** – the skull had to undergo several changes. Jaw and tooth size decreased, along with muscles to support and move big jaws.
- **Increased intelligence** – allow more complex behaviour and development of language.
- **Lack of oestrus** – most female primates have a time when they are ‘on heat’ (obviously sexually receptive). Human females do not show greater interest in mating when fertile. Ovulation is concealed and the male is continuously interested in sexual activity. Suggestions have been made that continuous interest promotes more stable relationships and keeps the father around to help look after his offspring. In primates and other mammals, the male competes with other males for females who are ‘on heat’.
- **Longer developmental periods** – all primates take a relatively long time to mature, but this is particularly long in humans. This allows a greater time for skill development and learning to problem-solve.

Question 71/ 83

Distinguish between the terms 'hominoid' and 'hominin'.

Solution

5-71 Hominoid refers to both the apes and humans, whereas Hominin refers only to humans and their extinct erect-walking ancestors.

Question 72/ 83

Describe the location changes of the foramen magnum.

Solution

5-72 The foramen magnum is the hole in the bottom of the skull through which the spinal cord connects to the brain. In four-legged mammals, the foramen magnum is at the back of the skull. In humans, it is in the centre of the base. This allows upright stance as the head is balanced on top of the backbone. During the evolution of the primates and with the change to bipedalism, the foramen magnum has had to 'move' forward.

Question 73/ 83

What changes in jaw and tooth structure have occurred during human evolution? How might behaviour have

changed during this evolution?

Solution

5-73 Reduction in jaw and tooth size has occurred, while the brain takes up proportionately more room in the skull. The larger and stronger teeth of the apes allow thorough ripping and crushing of food. Human ancestors used their brains to develop tools to do these jobs. Increased brain size must have been more advantageous than decreased jaw and tooth size.

Question 74/ 83

Skull shape and size have changed during human evolution. Describe their changes and their significance.

Solution

5-74 The change in skull shape and size is associated with the huge expansion in brain size. The area of the brain most increased in size is the cerebrum, which is associated with reasoning and problem solving. Increased brain size has allowed the development of complex spoken and written language. Increased brain size also allows complex social behaviour. Humans can work and plan together. All organisms affect their environment, but humans are able to alter any environment to suit their needs. The changes described are not unique to humans. Unique, however, is the extent of the changes.

Question 75/ 83

What has been the limiting factor to a further increase in skull size?

Solution

5-75 A significant limiting factor to further increases in skull size is the size of the human female's pelvis. Most mothers would attest to the fact that it is already a tight squeeze to get junior out.

Question 76/ 83

What selective pressures might have led to increased brain size?

Solution

5-76 The major selective pressures acting on human ancestors were probably competition and predation. It is thought that early hominins hunted on the African plains. Other larger animals could catch and kill one lone hominin. A group of well-organised stick-waving hominins would have been more formidable. Good organisation required more brainpower. To hunt animals for food requires planning and cooperation. Again, greater brainpower would have been an advantage. Hominins with larger brains and problem-solving abilities would have had a selective advantage.

Question 77/ 83

Is it true to say that man has evolved from chimps and gorillas? If not, rephrase the statement.

Solution

5-77 It is not true to say that humans have evolved from gorillas and chimps. Chimps, gorillas and humans have a common ancestor. That common ancestral species would have lived several million years ago.

Question 78/ 83

Complete the following table.

Homo neanderthalensis

When did they live?

Where did they live?

Features of their skull

Brain size

Culture

Disappeared from the fossil record

Solution

5-78

Homo neanderthalensis

When did they live?

200 000 to 30 000 years ago

Where did they live?

Western Europe

Central and Northern Asia

Features of their skull

- Low slopping foreheads
- Heavy brow
- Ridges rounded chins
- Large eye sockets
- Projecting faces
- Larger jaw with a gap between the last molar and back of the

Homo neanderthalensis

jaw

Brain size	1400 mL (large)
Culture	• Stone tools • Ornaments • Buried their dead • Clothing
Disappeared from the fossil record	30 000 years ago

Question 79/ 83

How is mitochondrial DNA different from nuclear DNA?

Solution

5-79 Comparison of mitochondrial DNA and nuclear DNA.

	Mitochondrial DNA	Nuclear DNA
Shape	Circular	Linear
Location	Within the mitochondria	Within the nucleus
Inherited from	Mother	Mother and Father
Number of alleles per gene per cell	Many	Two alleles per gene. The alleles maybe the same or different.

Question 80/ 83

Why is mitochondrial DNA useful for tracking human evolution?

Solution

5-80 When a sperm fertilises an ovum, the sperm's nucleus passes into the ovum. This forms the first cell of the new individual and therefore the mitochondrial DNA present, comes from the mother not the father. This makes mitochondrial DNA very useful in the study of evolution as changes in mitochondrial DNA are due to mutation and not recombination during meiosis. Evolutionary change can be measured by comparing the mitochondrial DNA from two different species. The longer the time passed since their divergence, the longer the time for the accumulation of different mutations.

Question 81/ 83

What does the comparison of mitochondrial DNA indicate about *Homo sapiens*, *Homo neanderthalensis* and *Homo denisovan*?

Solution

5-81 The mitochondrial DNA of *Homo sapiens*, *Homo neanderthalensis* and *Homo denisovan* are different enough to classify them as separate species but there are similarities and these indicate that at times they have interbred. *Homo neanderthalensis* and *Homo denisovan* are more closely related to each other.

Question 82/ 83

Complete the following table summarising two theories of human migration.

Hypothesis	Description	Evidence
Out of Africa		
Multi-Regional		

Solution

5-82

Hypothesis	Description	Evidence
Out of Africa	Early <i>Homo sapiens</i> lived in Africa and spread out from Africa to the rest of the world. There has been more than one migration out of Africa. The most recent resulted in the modern <i>H. sapiens</i> ancestral population.	• most older hominin fossils are found in Africa. • <i>Homo neanderthal</i> in Eurasia interbred with European and Asian <i>H. sapiens</i> but not African <i>H. sapiens</i>. • African populations have the greatest genetic diversity.
Multi-regional	<i>Homo erectus</i> migrated from Africa into a variety of different regions. As the spread was gradual and did not result in isolated populations, interbreeding occurred, increasing the gene pool but maintaining one species. Change to <i>Homo sapiens</i> were worldwide.	• Low genetic diversity in modern human populations • Physical differences between human populations indicate a long time has passed since a common ancestor.

Question 83/ 83

There is debate about when humans first arrived in Australia. What is the evidence that arrival was at least 65 000 years ago?

Solution

5-83 Fossil evidence, for example, the skeletons at Lake Mungo are dated at over 40 000 years old. DNA evidence suggests that indigenous Australians have been present in Australia for at least 65 000 years.

Question 2/ 170

[VCAA 2022 SA Q29]

The low genetic diversity within the French Island koala population can be explained by

A the bottleneck event.

B the founder effect.

C gene flow.

D mutations.

Solution

5-84 [VCAA 2022 SA Q29]

The low genetic diversity within the French Island koala population can be explained by

B the founder effect. (A small, unrepresentative group has founded the population.)

Question 3/ 170

[VCAA 2022 SA Q30]

The population of koalas on French Island

A will show more variation in traits than the populations in New South Wales.

B will have the same number of alleles per trait as the populations in Queensland.

C may be vulnerable to future changes in selective pressures acting on the population.

D will have more harmful mutations than the populations in New South Wales and Queensland.

Solution

5-85 [VCAA 2022 SA Q30]

The population of koalas on French Island

C may be vulnerable to future changes in selective pressures acting on the population. (The French Island population of koalas has low genetic diversity. This means they will have less variation in traits than the populations in New South Wales. The number of alleles per trait will depend on the different alleles present in the original population and island selection pressures. The rate of harmful mutations will be the same as for New South Wales. The low genetic diversity means that individuals are genetically similar. If one individual is adversely affected by an environmental change, all will be affected, thus increasing the chance of extinction.)

Question 4/ 170

[VCAA 2022 SA Q31]

When completing the research on the French Island koalas, the scientists would have needed to take into account bioethical issues. The scientists were aware that they would need to communicate all results, whether favourable or unfavourable.

Which one of the following principles of bioethics would the scientists be addressing?

A non-maleficence

B beneficence

C integrity

D respect

Solution

5-86 [VCAA 2022 SA Q31]

Which one of the following principles of bioethics would the scientists be addressing?

C integrity. (Definition.)

Question 6/ 170

[VCAA 2018 SA Q20]

This change in the sequence of amino acids was caused by

A a deletion of a nucleotide.

B an insertion of a nucleotide.

C a substitution of a nucleotide.

D an inversion of adjacent nucleotides.

Solution

5-87 [VCAA 2018 SA Q20]

This change in the sequence of amino acids was caused by

C a substitution of a nucleotide. (The third amino acid, pro is coded for a codon that starts with C – a change to G would result in a codon coding for ala.)

Question 7/ 170

[VCAA 2018 SA Q21]

Another mutation within the original gene resulted in a shortened protein. The protein was truncated (cut short) after the amino acid valine, as shown below.



This truncated protein resulted from the codon

A UAU changing to UAA.

B UAC changing to UGC.

C GUA changing to UGA.

D GUG changing to UGG.

Solution

5-88 [VCAA 2018 SA Q21]

This truncated protein resulted from the codon

A UAU changing to UAA. (This change causes a codon that codon for tyr to result in a STOP codon.)

Question 8/ 170

[VCAA 2018 SA Q22]

In humans, Duchenne muscular dystrophy (DMD) is caused by mutations in the dystrophin encoding DMD gene. The DMD gene contains 79 exons. In some patients, duplication of one exon occurs.

If the number of nucleotides in the duplicated exon is divisible by three, the

A transcribed mRNA will contain many stop codons.

B length of each of the 79 exons will increase by three nucleotides.

C translated protein will be longer than the dystrophin protein found in a person without DMD.

D dystrophin of these patients will show one amino acid change in the sequence compared to normal dystrophin.

Solution

5-89 [VCAA 2018 SA Q22]

If the number of nucleotides in the duplicated exon is divisible by three, the

C translated protein will be longer than the dystrophin protein found in a person without DMD.

(From the information given the only thing that can be said is that the transcribed protein will be longer. If an exon is duplicated many STOP codons will not be created. The exon will code for an amino acid, so the protein will be longer.)

Question 9/ 170

[VCAA 2014 SA Q23]

In populations of fruit flies, there are individuals that are resistant to the effects of insecticides. Insecticide-resistant fruit flies arose as a result of a mutation. In normal insecticide-susceptible fruit flies, a specific section of mRNA has the sequence GCU, whereas in the insecticide-resistant fruit flies, the sequence is UCU.

This mutation is an example of a

A chromosomal deletion during the formation of a gamete.

B nucleotide substitution during the formation of a gamete.

C chromosomal deletion during the formation of a somatic cell.

D nucleotide substitution during the formation of a somatic cell.

Solution

5-90 [VCAA 2014 SA Q23]

This mutation is an example of a

B nucleotide substitution during the formation of a gamete. (All cells of the fruit fly carry the mutation therefore the mutation must occur during the formation of a gamete and not during the formation of a somatic cell. The sequence found in normal insecticide-susceptible fruit flies differs by one base from the sequence found in insecticide resistant fruit flies and both sequences are the same length, therefore the mutation is a substitution.)

Question 11/ 170

[VCAA 2017 SA Q27]

In a mutation, the eighth nucleotide in this sequence was changed from C to T. What would be the result of this mutation?

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

Solution

5-91 [VCAA 2017 SA Q27]

What would be the result of this mutation?

- A The peptide chain would be shortened.** (The mutation in the DNA sequence results in triplet ATC. This

is transcribed into mRNA codon UAG. UAG is a stop codon therefore the rest of the DNA sequence will not be transcribed, the mRNA sequence will be shorter and when this is translated, a shorter polypeptide chain will be produced.)

Question 12/ 170

[VCAA 2017 SA Q28]

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

The result of this mutation would be that

A all amino acids in this entire sequence would change.

B only the first amino acid in the sequence would change.

C only the second amino acid in the sequence would change.

D all amino acids after the first in the sequence would change.

Solution

5-92 [VCAA 2017 SA Q28]

The result of this mutation would be that

D all amino acids after the first in the sequence would change. (This mutation results in a frameshift where all amino acids after the first would change.)

Question 13/ 170

[VCAA 2012 E2 SA Q25]

Biological evolution

A includes changes in the learnt behaviour of individuals in a population.

B involves inherited change in a population over many generations.

C occurs faster than technological evolution.

D is defined as simply change over time.

Solution

5-93 [VCAA 2012 E2 SA Q25]

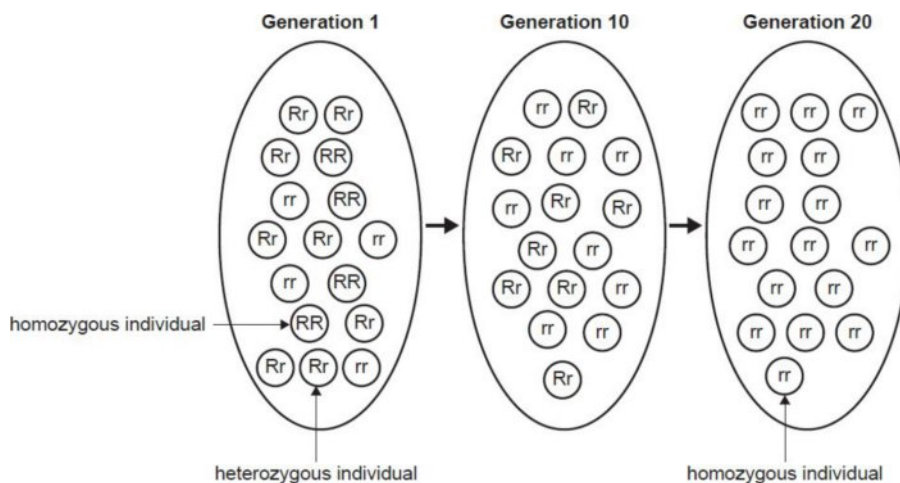
Biological evolution

B involves inherited change in a population over many generations. (Changes in learnt behaviour are classed as cultural evolution. Technological evolution occurs faster than biological evolution.)

Question 14/ 170

[VCAA 2019 SA Q26]

Consider the diagram below showing the gene pool of a population over 20 generations.



It would be correct to conclude that, over the 20 generations

A genetic diversity is increasing in this population.

B individuals with the genotype RR had a selective advantage in this population.

C the frequency of each allele is equal in Generation 1 but not in other generations.

D new advantageous alleles for this gene were introduced as individuals joined this population.

Solution

5-94 [VCAA 2019 SA Q26]

It would be correct to conclude that, over the 20 generations

C the frequency of each allele is equal in Generation 1 but not in other generations. (From the information provided alternative C is correct. Diversity is decreasing in the population – not increasing. The frequency of R is decreasing therefore it must be of selective disadvantage and there is no evidence that individuals joined the population.)

Question 15/ 170

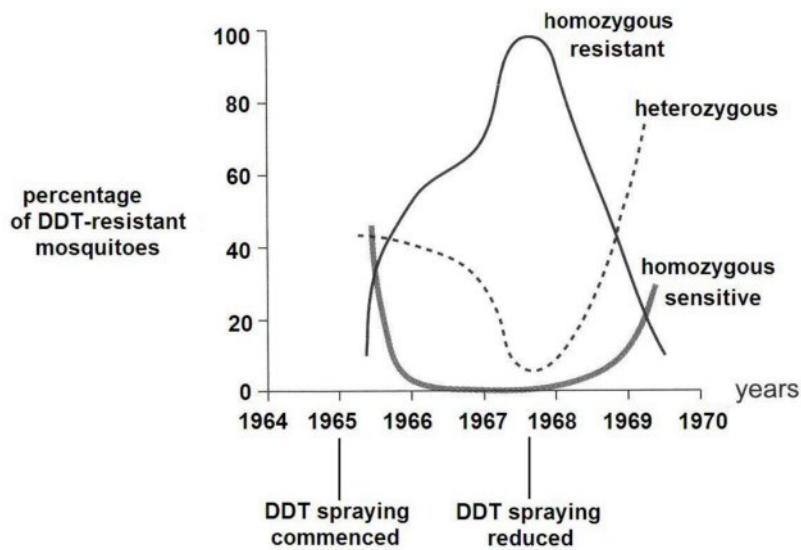
[VCAA 2010 E2 SA Q23]

In the mid-1960s, DDT was widely used as an insecticide against mosquitoes. The sensitivity to insecticide in mosquitoes is determined by a single gene that has two alleles.

allele 1 : resistant to DDT

allele 2 : sensitive to DDT

Over several years genotypic frequencies were measured in a population of mosquito larvae. The graph on the next page shows the results.



Analysis of the graph reveals that in the population

A when spraying levels declined, heterozygous advantage occurred.

B there were no alleles for sensitivity present in the population in 1967.

C the number of alleles for resistance was equal to the number for sensitivity in 1966.

D the homozygous resistant genotype was unable to produce offspring at low spraying levels.

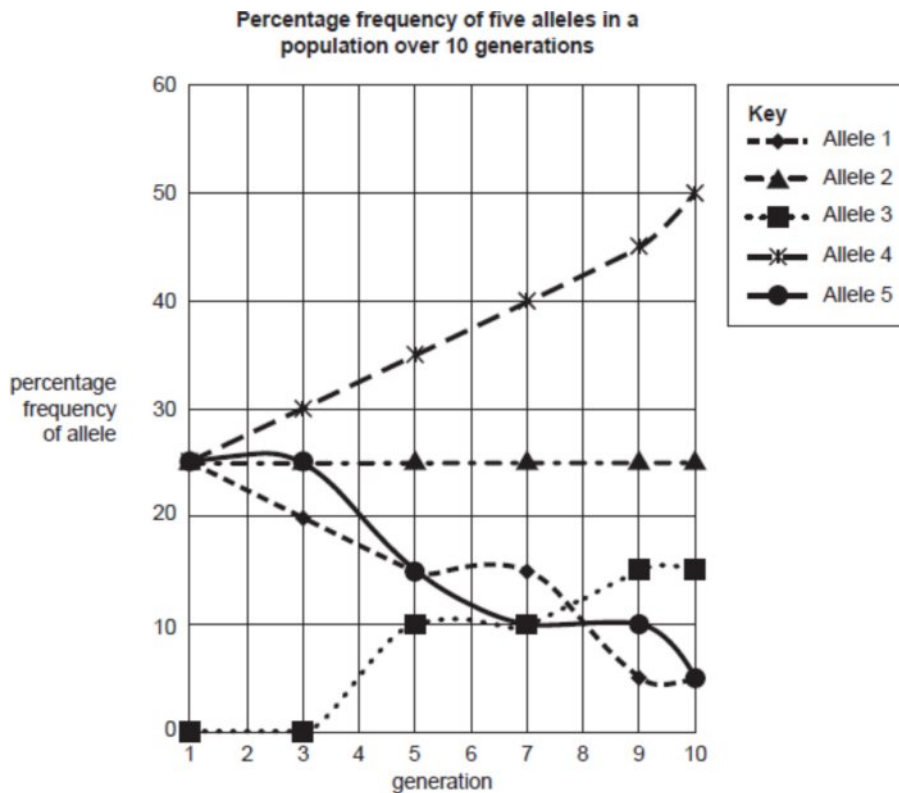
Solution

5-95 [VCAA 2010 E2 SA Q23]

Analysis of the graph reveals that in the population

A when spraying levels declined, heterozygous advantage occurred. (B is an incorrect statement. Alleles for sensitivity were present in heterozygous individuals. With respect to alternative C, it is more likely that there will be a greater number of alleles for resistance in 1966 as the frequency of homozygous resistant individuals is increasing and each resistant individual is homozygous. The presence or absence of DDT is a selective pressure and heterozygous individuals were at an advantage when DDT levels were reduced.)

The graph below shows the frequency of five alleles in a population over 10 generations. The change in allele frequency is represented as a percentage of the frequency of the five alleles.



Based on the information in the graph, which one of the following is most likely?

A The founder effect can explain the change in allele frequency in the first three generations.

B Genetic diversity within the population remains unchanged over the 10 generations.

C The appearance of Allele 3 after Generation 3 may be explained by gene flow.

D A bottleneck event occurred between Generation 7 and Generation 9.

Solution

5-96 [VCAA 2020 SA Q28]

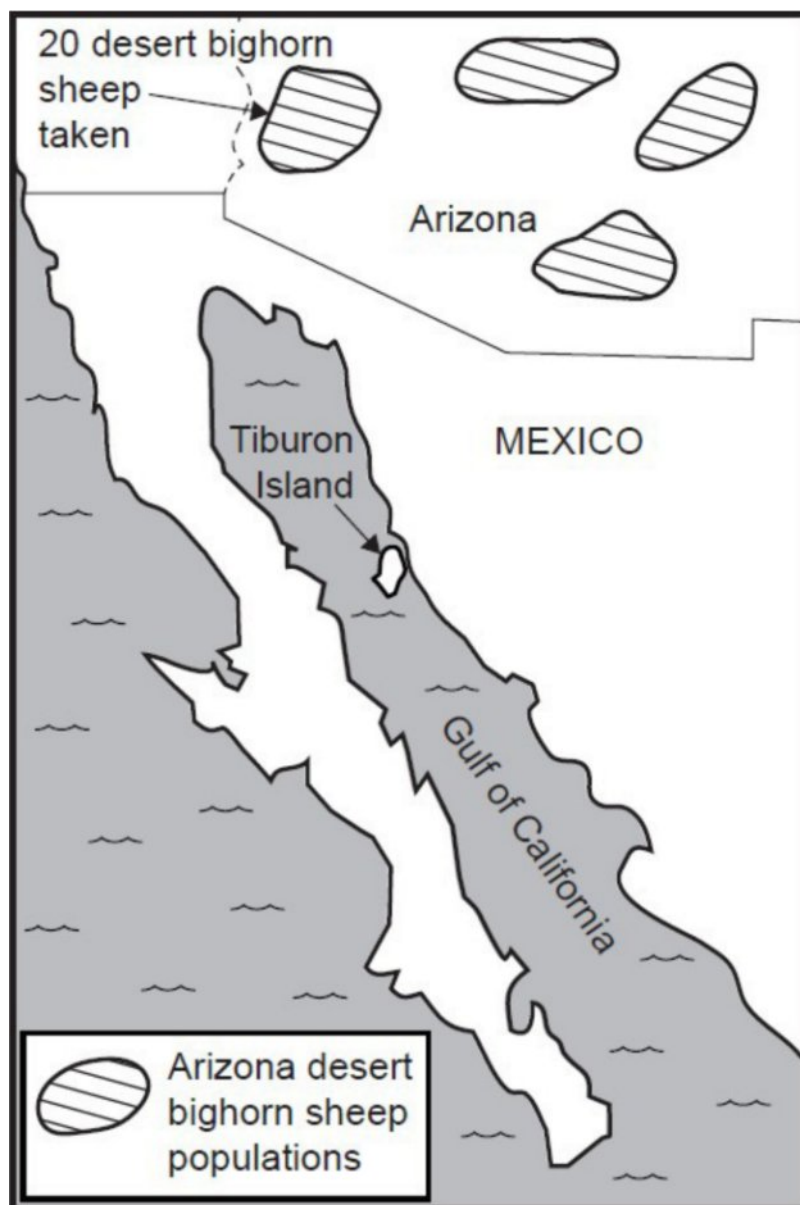
Based on the information in the graph, which one of the following is most likely?

C The appearance of Allele 3 after Generation 3 may be explained by gene flow. (Allele 3 appears after generation 3 – supported by the graph. A is incorrect as a new allele has been introduced – not in the founding population. Genetic diversity has changed with a new allele appearing. There is no evidence to support alternative D.)

Question 17/ 170

[VCAA 2016 SA Q37]

Tiburon is an isolated island off the coast of Mexico. Desert bighorn sheep became extinct on this island hundreds of years ago. In 1975, 20 desert bighorn sheep were taken from a population in the American state of Arizona (shown on the map below) and were re-introduced to Tiburon Island. By 1999, the population of desert bighorn sheep on Tiburon Island had risen to 650.



Which one of the following statements about this 1999 population of desert bighorn sheep on Tiburon Island is correct?

A The gene pool of this population will be identical to the gene pool of the Arizona populations.

B This population has less genetic variation than the Arizona populations and is an example of the founder effect.

C This population will have become a new species because the mutation rate on Tiburon Island will be much higher than in Arizona.

D Having been through a population bottleneck, the current population will now show increased genetic variation compared to the Arizona populations.

Solution

5-97 [VCAA 2016 SA Q37]

Which one of the following statements about this 1999 population of desert bighorn sheep on Tiburon Island is correct?

B This population has less genetic variation than the Arizona populations and is an example of the founder effect. (The 20 introduced sheep represent a relatively small gene pool that will contain less variation than the original mainland populations – so in 1999 the variation on the island would be less than that in Arizona. Speciation may occur eventually, but the time involved is short.)

Question 18/ 170

[VCAA 2015 SA Q40]

Northern elephant seals, *Mirounga angustirostris*, were nearly hunted to extinction in the 1890s, with only about 20 individuals left at the end of the century. The population has now grown to more than 120 000. In the 1890s, southern elephant seals, *Mirounga leonina*, were not as severely hunted and currently there are estimated to be 600 000 southern elephant seals.

Based on this information, it is true to say that

A northern elephant seals have evolved as a result of the ‘founder effect’.

B northern elephant seals would show less genetic variation than southern elephant seals.

C southern elephant seals would have experienced greater genetic drift than northern elephant seals.

D the mutation rate in northern elephant seals would have been greater than in southern elephant seals.

Solution

5-98 [VCAA 2015 SA Q40]

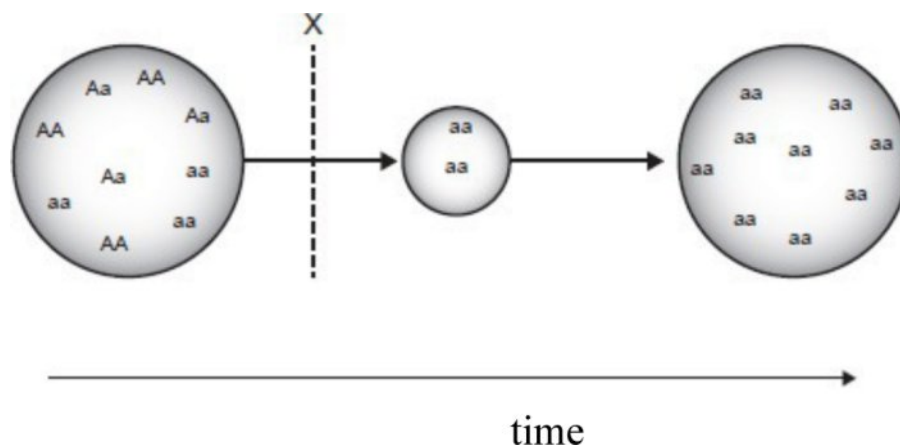
Based on this information, it is true to say that

B northern elephant seals would show less genetic variation than southern elephant seals. (Very few northern elephant seals were left and hence there was a limited gene pool from which the recovered population have come from. The southern elephant seals are descended from a more diverse gene pool and would show greater genetic variation.)

Question 19/ 170

[VCAA 2014 SA Q33]

Consider the diagram below that models the changes in allele frequencies for one trait in a population over two generations. The original population is shown on the left.



If the diagram above models the founder effect, then event X is

A migration.

B a natural disaster.

C random mating.

D a random assortment of alleles.

Solution

5-99 [VCAA 2014 SA Q33]

If the diagram above models the founder effect, then event X is

A migration. (The diagram is of the founder effect. This is when a population that is unrepresentative of the original population settles in a new area.)

Question 20/ 170

[VCAA 2012 E2 SA Q21]

Retinitis pigmentosa (RP) is an autosomal recessive trait that results in progressive blindness in humans. On the island of Tristan da Cunha in the Atlantic Ocean, the frequency of the allele causing RP is four times greater in its population of a few hundred individuals than in the original British population from which it was colonised in the early 1800s. No natural disasters have occurred on the island since it was colonised.

The process that is most likely responsible for this observation related to allele frequency is

A genetic drift.

B founder effect.

C bottleneck effect.

D natural selection.

Solution

5-100 [VCAA 2012 E2 SA Q21]

The process that is most likely responsible for this observation related to allele frequency is

B founder effect. (Founder effect occurs when a small unrepresentative group migrates to an isolated area. Future generations are descended from this group and so allele frequencies will be different from the original

population.)

Question 21/ 170

[VCAA 2010 E2 SA Q13]

In populations

A genetic drift will have less effect in a large population compared to a small population.

B bottlenecks enable a population to become better equipped for future changes in the environment.

C some organisms develop mutations in order to better suit them to their environment compared to other members of the population.

D allele frequencies remain constant if the number of individuals leaving the population equals the number of individuals entering it.

Solution

5-101 [VCAA 2010 E2 SA Q13]

In populations

A genetic drift will have less effect in a large population compared to a small population. (Genetic drift – random changes in allele frequency in a population – is only significant in small populations.)

Question 22/ 170

[VCAA 2012 E2 SA Q23]

Early in 2012, biologists announced the discovery of a new lizard species.

To claim that the lizards belong to a new species, the biologists must show that the lizards

A look different from one another.

B look different from known species.

C have similar genetic sequences to known species.

D do not produce fertile offspring with members of known species.

Solution

5-102 [VCAA 2012 E2 SA Q23]

To claim that the lizards belong to a new species, the biologists must show that the lizards

D do not produce fertile offspring with members of known species. (Definition.)

Question 24/ 170

[VCAA 2011 E2 SA Q19]

From this information it would be reasonable to conclude that

A the golden rain tree was introduced around 1970.

B no long-beaked bugs existed prior to the introduction of the golden rain tree.

C the diameter of the golden rain tree fruit acted as a selection pressure on beak length.

D the response of an individual golden rain tree to predation by soapberry bugs would be to grow larger fruit.

Solution

5-103 [VCAA 2011 E2 SA Q19]

From this information, it would be reasonable to conclude that

C the diameter of the golden rain tree fruit acted as a selection pressure on beak length. (There is not enough evidence to conclude when the golden rain tree was introduced but it was probably earlier than 1970. There would have always been some long-beaked bugs in the population, but they would have become more common with a new selective pressure – the fleshy golden rain tree fruit.)

Question 25/ 170

[VCAA 2011 E2 SA Q20]

In neighbouring regions, the fruits of other introduced plants have also been used by the soapberry bug. Male and female soapberry bugs from different regions can interbreed. Evidence indicates that genetic isolation of some of these populations is gradually occurring.

The situation that would lead to an increase in genetic isolation would be if

A different types of host plants have fruiting seasons which do not overlap.

B pheromones of female soapberry bugs attract soapberry males from neighbouring populations.

C the soapberry tree is common throughout the distribution and each tree produces large amounts of fruit.

D male soapberry bugs new to a region are reproductively active, whereas female bugs need to feed before becoming reproductively active.

Solution

5-104 [VCAA 2011 E2 SA Q20]

The situation that would lead to an increase in genetic isolation would be if

A different types of host plants have fruiting seasons which do not overlap. (If the bugs tend to stay with particular trees, then if fruiting seasons do not overlap populations in the different trees may become genetically isolated.)

[VCAA 2020 SA Q27]

Tasmanian devils (*Sarcophilus harrisii*) were originally broadly distributed across Australia. When sea levels rose 12 000 years ago, an island, now referred to as Tasmania, was formed. The small number of Tasmanian devils on Tasmania was cut off from the Australian mainland populations. The population in Tasmania showed less genetic variation than the mainland populations. Mainland populations became extinct approximately 3000 years ago.

Over the last 20 years, the total Tasmanian devil population on Tasmania has halved. Many of the deaths have been the result of Tasmanian devil facial tumour disease (DFTD). Scientists have taken some Tasmanian devils that do not have DFTD to mainland Australia to set up a conservation program. The scientists have shown that greater genetic diversity among offspring in this program is observed when the Tasmanian devils are kept in isolated male–female pairs rather than in larger groups.

The conservation program for Tasmanian devils is an example of

A a population bottleneck.

B allopatric speciation.

C selective breeding.

D natural selection.

Solution

5-105 [VCAA 2020 SA Q27]

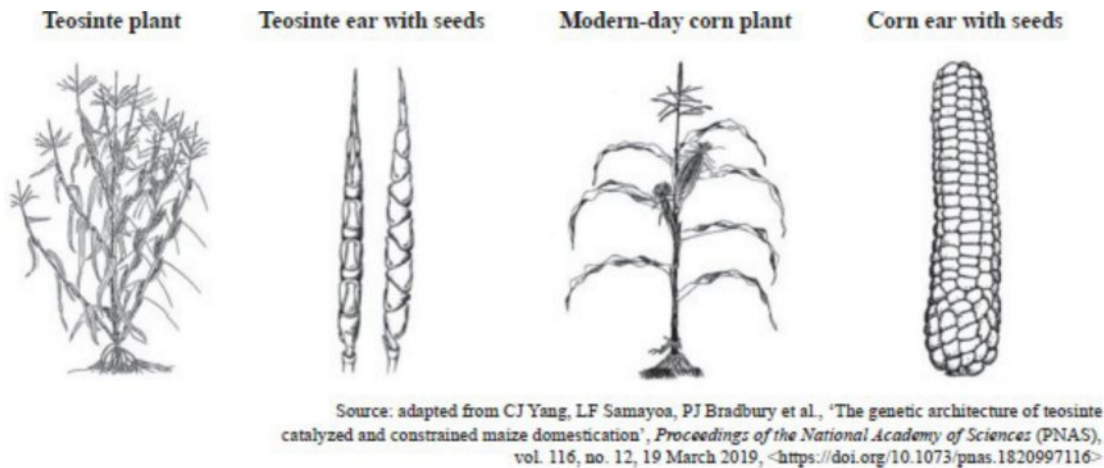
The conservation program for Tasmanian devils is an example of

C selective breeding. (The scientists have chosen Tasmanian devils with particular **characteristics** and allowed them to breed – the basis of selective breeding.)

[VCAA 2022 SA Q35]

Corn (*Zea mays* subsp. *mays*) is a crop grown in Australia. The direct ancestor of corn is widely believed to be a wild grass known as teosinte (*Zea mays* subsp. *parviglumis*). Approximately 9000 years ago, farmers in

Mexico began selecting for more favourable traits in teosinte. Further selective breeding has resulted in the current form of the corn plant. Some of the traits of both the ancestral teosinte plant and the modern-day corn plant are shown in the diagram that follows.



In the selective breeding to produce modern-day corn, a trait that has been selected for is an increase in the number of

A branches per plant.

B leaves on the plant.

C seeds in the ear.

D ears per plant.

Solution

5-106 [VCAA 2022 SA Q35]

In the selective breeding to produce modern-day corn, a trait that has been selected for is an increase in the number of

C seeds in the ear. (The modern-day corn plant produces more seeds on the corn ear than the Teosinte plant.)

[VCAA 2019 SA Q27]

Farmers and supermarkets agree that green beans are bought more frequently than yellow beans. A supermarket has asked a farmer to produce only green beans.

One way this could be achieved is by

E condensation polymerisation.

F DNA hybridisation.

G selective breeding.

H adaptive radiation.

Solution

5-107 [VCAA 2019 SA Q27]

One way this could be achieved is by

C selective breeding. (The farmer would only use seeds from plants that produced green beans – that is selective breeding. Over time, it would be expected that the vast majority of beans produced would be green.)

Question 29/ 170

[VCAA 2017 SA Q30]

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

A genetic fitness.

B natural selection.

C selective breeding.

D allopatric speciation.

Solution

5-108 [VCAA 2017 SA Q30]

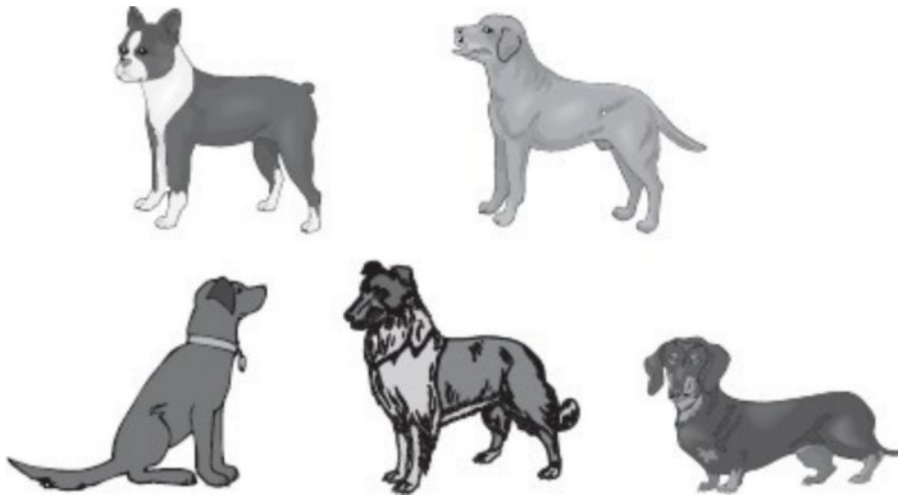
This is an example of

C selective breeding. (Definition.)

Question 30/ 170

[VCAA 2014 SA Q38]

The diagram that follows shows five different breeds of dog that now exist within the *Canis lupus familiaris* species.



The development of variant breeds within *Canis lupus familiaris* is an example of

A natural selection occurring in geographically isolated populations.

B gene-transfer technology transforming the genotype of a species.

C convergent evolution occurring in a range of similar habitats.

D human intervention through artificial selection.

Solution

5-109 [VCAA 2014 SA Q38]

The development of variant breeds within *Canis lupus familiaris* is an example of

D human intervention through artificial selection. (Humans have decided which dogs to breed.)

Question 31/ 170

[VCAA 2011 E2 SA Q22]

Selective breeding over many generations has produced gradual changes in farm animals.

It is reasonable to state that such gradual changes in a herd of cattle

A result from random mating in the herd in each generation.

B are due to the occurrence of gene mutations in each generation.

C will improve traits that enhance survival of the animals in the wild.

D result from the restriction of breeding to chosen animals in the herd.

Solution

5-110 [VCAA 2011 E2 SA Q22]

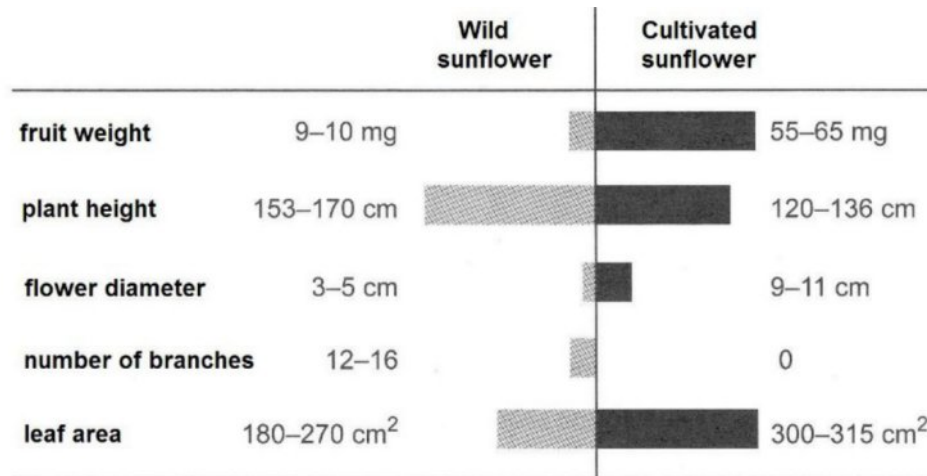
It is reasonable to state that such gradual changes in a herd of cattle

D result from the restriction of breeding to chosen animals in the herd. (Farmers will only allow those animals with the desired characteristics to breed. Over time, the number of offspring with the characteristics required will increase. In dairy cattle, farmers might look to breed from cows that produce more milk than the average.)

[VCAA 2010 E2 SA Q20]

The wild sunflower plant has been cultivated by humans over several generations. During that time, selection for or against particular sunflower traits has been carried out.

A comparison of some of the traits in wild and cultivated sunflowers is given the diagram that follows.



From the information on the previous page, we can assume that humans have selected against large

A leaf area.

B plant height.

C fruit weight.

D flower diameter.

Solution

5-111 [VCAA 2010 E2 SA Q20]

From the information above, we can assume that humans have selected against large **B plant height**. (Plant height is lower in the cultivated sunflowers, supporting the idea that humans have selected against taller plants. All the other characteristics are greater in the cultivated sunflowers.)

Question 34/ 170

[VCAA 2013 SA Q39]

Any rise in incidence of antibiotic-resistant bacteria is due to

- A these bacteria having acquired immunity to antibiotics.
- B the overuse of antibiotics causing mutations in bacteria.
- C the introduction of selectively bred, antibiotic-resistant bacteria.
- D antibiotic-resistant phenotypes being favoured through natural selection.

D Up to 80 per cent of bacterial diseases are caused by bacteria living in biofilms. Biofilms are large communities of bacteria encased in extra-cellular coverings that attach to slippery surfaces, such as teeth and contact lenses. Special features of biofilms include the following.

- Some regions of cells form spores for reproduction and dispersal.
- Other regions of cells grow flagella for movement.
- Cells can detect others of their own species through cell-to-cell signalling (so they can sense when sufficient numbers are present to invade new areas successfully).

Solution

5-112 [VCAA 2013 SA Q39]

Any rise in incidence of antibiotic-resistant bacteria is due to

D antibiotic-resistant phenotypes being favoured through natural selection. (Antibiotics do not induce mutations. There would have originally been genetic and phenotypic variation in the bacteria in terms of resistance to antibiotics. When the antibiotic was used, those bacteria that were resistant survived, reproduced and their offspring inherited resistance. Over time, more resistant bacteria would be present.)

Question 35/ 170

[VCAA 2013 SA Q40]

Researchers are trying to develop therapies that avoid the use of antibiotics. These therapies could include

- A using drugs that stop spindle fibres forming during mitosis.
- B providing amino acid supplements to promote flagella development.
- C preventing biofilm bacteria from detecting others of their own species.
- D targeting the biofilm's covering to make it more permeable to antibiotics.

Solution

5-113 [VCAA 2013 SA Q40]

These therapies could include

C preventing biofilm bacteria from detecting others of their own species. (Bacteria divide by binary fission not mitosis, promoting flagella development would encourage spreading and alternative D would encourage the use of antibiotics. Preventing bacteria from detecting others of their own species would mean that the bacteria could not sense that their numbers were large enough to invade a new area successfully and therefore the area would not be invaded.)

Question 37/ 170

[VCAA 2022 SA Q32]

Which combination of findings from the list above is most likely to be associated with an increased chance of formation of *K. cleelandi* fossils?

- A findings 1 and 6.
- B findings 2 and 4.
- C findings 3 and 5.
- D findings 2 and 7.

Solution

114 [VCAA 2022 SA Q32]

Which combination of findings from the list above is most likely to be associated with an increased chance of formation of *K. cleelandi* fossils?

B findings 2 and 4. (Quick burial is a condition for fossilisation. Hard bones fossilise best.)

Question 38/ 170

[VCAA 2022 SA Q33]

It is most likely that scientists determined the absolute age of *K. cleelandi* fossils

A through mtDNA analysis of *K. cleelandi* scales and fangs.

B through carbon-14 dating of jaw bones, skull, vertebrae and ribs.

C by finding index fossils nearby, such as those of small dinosaurs and turtles.

D through radioisotope dating of rock surrounding the fossils.

Solution

115 [VCAA 2022 SA Q33]

It is most likely that scientists determined the absolute age of *K. cleelandi* fossils

D through radioisotope dating of rock surrounding the fossils. (*K. cleelandi* fossils were formed 125 million years ago; therefore, carbon-14 dating and mtDNA could not be used to date the fossils.)

Question 39/ 170

[VCAA 2021 SA Q21]

Which of the following shows some of the organisms on the fossil record in the correct order in which they first appear?

A fish, green algae, mammals, flowering land plants

B green algae, fish, flowering land plants, mammals

C fish, mammals, green algae, flowering land plants

D green algae, fish, mammals, flowering land plants

Solution

5-116 [VCAA 2021 SA Q21]

Which of the following shows some of the organisms on the fossil record in the correct order in which they first appear?

D green algae, fish, mammals, flowering land plants (Facts – Green algae and fish are ancient. The first mammals (monotremes) appeared about 210 mya and flowering plants 160 mya.)

Question 40/ 170

[VCAA 2021 SA Q24]

Sea stars are soft-bodied marine animals that have survived periods of mass extinction. The oldest sea star fossils have been dated to 480 million years ago. The number of sea star fossils found is relatively low.

One reason why the number of sea star fossils found is relatively low is that sea stars

A are easily eroded from rock layers after exposure to wind.

B live in seawater that fluctuates widely in temperature.

C are unlikely to be covered in sediment after death.

D have bodies that decompose quickly.

Solution

5-117 [VCAA 2021 SA Q24]

Sea stars are soft-bodied marine animals that have survived periods of mass extinction. The oldest sea star fossils have been dated to 480 million years ago. The number of sea star fossils found is relatively low. One reason why the number of sea star fossils found is relatively low is that sea stars

D have bodies that decompose quickly. (Fossilisation is most likely if a dead organism is covered quickly, but fossilisation is not likely unless there is something hard to preserve, such as a bony skeleton or woody material.)

Question 41/ 170

[VCAA 2021 SA Q25]

The two photographs that follow (Image A and Image B) are of arthropod fossils found in tree resin (amber) and a drawing of an arthropod (Image C). Each image has a scale in micrometres (μm).

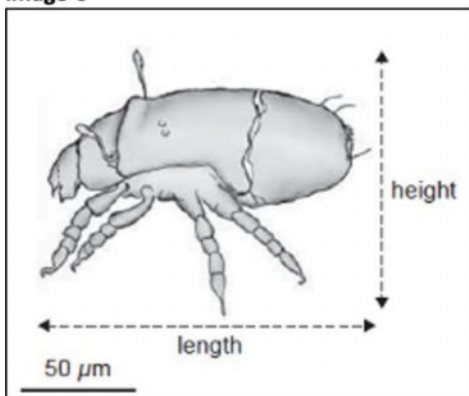
Image A



Image B



Image C



Sources: Ernest Cooper/[Dreamstime.com](#) (Image A); Ernest Cooper/[Dreamstime.com](#) (Image B); JD Stilwell, A Langendam, C Mays et al, ‘Amber from the Triassic to Paleogene of Australia and New Zealand as exceptional preservation of poorly known terrestrial ecosystems’, *Scientific Reports*, 10, 5703 (2020), <<https://doi.org/10.1038/s41598-020-62252-z>> (Image C)

From the images shown, it can be concluded that the arthropod

A fossils are examples of trace fossils.

B in Image C is less than 90 μm in height.

C fossil in Image A is greater than 100 μm in length.

D that was fossilised in Image B was buried in sediment before it was surrounded by amber.

Solution

5-118 [VCAA 2021 SA Q25]

Below are two photographs (Image A and Image B) of arthropod fossils found in tree resin (amber) and a drawing of an arthropod (Image C). Each image has a scale in micrometres (μm).

Image A



From the images shown, it can be concluded that the arthropod.

C fossil in Image A is greater than 100 μm in length. (Use a ruler and check length against the scale -the arthropod is about 200 μm in length. Trace fossils are something like a footprint rather than actual remains. If you look at image C it is about 150 μm in length, more than 90 μm in length. Fossils found in amber will

have been covered in resin (that becomes amber) at the time of death.)

Question 42/ 170

[VCAA 2019 SA Q28]

Consider the close-up image that follows of a dinosaur footprint discovered by scientists.



This type of fossil is best described as

A preserved remains.

B a petrified fossil.

C a trace fossil.

D a cast.

Solution

5-119 [VCAA 2019 SA Q28]

This type of fossil is best described as

C a trace fossil. (A footprint is not preserved remains or a petrified fossil. A cast is produced when remains are surrounded by something like mud or ash. Over time, the remains disappear. Footprints are trace fossils rather than casts because there were never organic remains involved.)

Question 43/ 170

[VCAA 2018 SA Q25]

It is most probable that the two stratigraphically younger fossils would have been found in a layer of rock that
A was closer to the present-day ground surface than the rock surrounding the *D. pickeringi* fossil.

B contained a smaller quantity of carbon-14 than the rock surrounding the *D. pickeringi* fossil.

C was located at a depth of 2.3 m below the ancient riverbed.

D was formed from extremely hot, volcanic lava flow.

Solution

5-120 [VCAA 2018 SA Q25]

It is most probable that the two stratigraphically younger fossils would have been found in a layer of rock that

A was closer to the present-day ground surface than the rock surrounding the *D. pickeringi* fossil.
(Younger fossils will generally be found nearer the surface unless there has been dramatic land movement. They would also contain larger amounts of carbon-14 rather than small amounts.)

Question 44/ 170

[VCAA 2018 SA Q26]

Palaeontologists believe that the Victorian ornithopods shared a close common ancestor with several ornithopod fossils found in Antarctica, South America and Africa.

Which one of the following is the most likely explanation for the distribution of these fossils?

A Antarctica, South America and Africa were joined to Australia in the distant past.

B The strong tails of the ornithopods enabled them to swim for sustained periods of time.

C The small forelimbs of the ornithopods suggest that they were evolving wings for flight.

D Seagoing, scavenger birds carried the fossil bones of the ornithopods to other continents.

Solution

5-121 [VCAA 2018 SA Q26]

Which one of the following is the most likely explanation for the distribution of these fossils?

A Antarctica, South America and Africa were joined to Australia in the distant past. (These continents were once joined in one large landmass – Gondwanaland. The common ancestor was widely distributed before the continents separated.)

Question 45/ 170

[VCAA 2016 SA Q38]

In India, a group of scientists was studying fossils from a coal deposit formed during the Permian period (290–245 million years ago). They found three fossil species from the same genus in different levels (strata) of the coal. When radiocarbon dating on these fossils was performed, it showed exactly the same levels of carbon-14 in all three fossil species.

The data is summarised in the table below.

Fossil species	Depth at which fossil was found in the coal deposit (m)	Proportion of carbon-14 (%)
<i>Gangamopteris major</i>	6.2	0.0001
<i>Gangamopteris obliqua</i>	8.1	0.0001
<i>Gangamopteris clarkeana</i>	4.7	0.0001

Which one of the following is the correct conclusion to draw from these findings?

A There is no evolutionary relationship between these three fossil species.

B *G. clarkeana* is the common evolutionary ancestor of *G. major* and *G. obliqua*.

C As carbon dating is a more reliable dating technique than analysis of strata in coal deposits, the fossils of *G. major*, *G. obliqua* and *G. clarkeana* are all of the same age.

D An analysis of strata in coal deposits is a more reliable dating technique than carbon dating for Permian fossils; the fossil of *G. major* is younger than the fossil of *G. obliqua*.

Solution

5-122 [VCAA 2016 SA Q38]

Which one of the following is the correct conclusion to draw from these findings?

D An analysis of strata in coal deposits is a more reliable dating technique than carbon dating for Permian fossils; the fossil of *G. major* is younger than the fossil of *G. obliqua*. (As *G. major* is less deeply buried than *G. obliqua* this indicates *G. major* is younger. The carbon-14 data do not reflect a difference in age.)

Question 46/ 170

[VCAA 2015 SA Q35]

Potassium-40 has a half-life of 1.25 billion years. In igneous rocks closely associated with a fossil layer, the ratio of potassium-40 to its radioactive breakdown product, argon-40, is approximately 1:1.

The age of the fossils in the fossil layer will be close to

A 125 million years.

B 310 million years.

C 1.25 billion years.

D 2.5 billion years.

Solution

5-123 [VCAA 2015 SA Q35]

The age of the fossils in the fossil layer will be close to

C 1.25 billion years. (After 1.25 billion years you would expect that half the Potassium-40 to have broken down – therefore ratio between Potassium-40 and Argon-40 would be 1:1.)

Question 48/ 170

[VCAA 2014 SA Q34]

Trilobite fossils in a particular layer of rock were used to date a fossil shell in the same layer. A palaeontologist dated the fossil shell to 328–359 million years old. It is most likely that the trilobite fossils present were of the order

A Y.

B U.

C Q.

D T.

Solution

5-124 [VCAA 2014 SA Q34]

It is most likely that the trilobite fossils present were of the order

C Q. (Q is the fossil of the only organism that existed 328–359 million years ago.)

Question 49/ 170

[VCAA 2014 SA Q35]

The absolute age of the trilobite fossils was most likely determined by using

A carbon dating.

B transition fossils.

C index fossils.

D potassium-argon dating.

Solution

5-125 [VCAA 2014 SA Q35]

The absolute age of the trilobite fossils was most likely determined by using

D potassium-argon dating. (Transition fossils and index fossils are forms of relative dating. The fossils are too old to use carbon dating.)

Question 50/ 170

[VCAA 2014 SA Q36]

The geological time periods shown on the chart differ in duration because the time periods reflect

A the diversity of fossils and mass extinction events.

B the absence of trilobite fossils in the Late Cambrian period.

C different rates of radioactive decay.

D different rates of fossilisation.

Solution

5-126 [VCAA 2014 SA Q36]

The geological time periods shown on the chart differ in duration because the time periods reflect

A the diversity of fossils and mass extinction events. (Each time period is characterised by the organisms that existed at the time. Mass extinctions result in major change of organisms present and signify a new time period.)

Question 51/ 170

[VCAA 2014 SA Q37]

The chance of a trilobite becoming fossilised is increased by

A slow burial of its remains in dry sediment.

B large temperature variations in the sediment containing its remains.

C the presence of hard body parts.

D the presence of scavengers at the time of its death.

Solution

5-127 [VCAA 2014 SA Q37]

The chance of a trilobite becoming fossilised is increased by

C the presence of hard body parts. (Hard body parts fossilise best.)

Question 52/ 170

[VCAA 2013 SA Q31]

The thylacine (*Thylacinus cynocephalus*) was a large, dog-like marsupial that was declared extinct in 1986. A mummified carcass of a thylacine was found in a cave on the Nullarbor Plain. The carcass was dated about 5000 years old.

The most likely method used to date the mummified carcass would involve

A dating the layers of rocks within the cave.

B potassium–argon dating of the mummified remains.

C measuring the proportion of carbon-14 atoms in the carcass.

D comparing the teeth in the mummified carcass to the teeth of other dog-like marsupials.

Solution

5-128 [VCAA 2013 SA Q31]

The most likely method used to date the mummified carcass would involve

C measuring the proportion of carbon-14 atoms in the carcass. (Potassium- argon is used for older fossils and comparing teeth will not give an actual age.)

Question 54/ 170

[VCAA 2012 E2 SA Q16]

Factors that would have contributed to the fossilisation of this animal include

A its predatory way of life.

B the action of waves and currents.

C the salt content of the water in which it lived.

D its hard-plated mouth and spiny appendages.

Solution

5-129 [VCAA 2012 E2 SA Q16]

Factors that would have contributed to the fossilisation of this animal include

D its hard-plated mouth and spiny appendages. (Hard parts of organisms are more easily fossilised.)

Question 55/ 170

[VCAA 2012 E2 SA Q17]

In order to estimate the age of *Anomalocaris* fossils, paleontologists would have most likely used

A index fossils.

B carbon-14 dating.

C a molecular clock.

D DNA hybridisation.

Solution

5-130 [VCAA 2012 E2 SA Q17]

In order to estimate the age of *Anomalocaris* fossils, palaeontologists would have most likely used

A index fossils. (The fossil is older than 50 000 years therefore carbon-14 dating, DNA hybridisation and a molecular clock cannot be used.)

Question 56/ 170

[VCAA 2012 E2 SA Q18]

A likely explanation for the extinction of *Anomalocaris* is that

A its populations had high genetic diversity.

B its disc-shaped mouth was unsuitable for ingesting prey.

C it produced offspring that were suited to their environment.

D selection pressures changed dramatically due to rapid climate change.

Solution

5-131 [VCAA 2012 E2 SA Q18]

A likely explanation for the extinction of *Anomalocaris* is that

D selection pressures changed dramatically due to rapid climate change. (High genetic diversity reduces the chance of extinction when the environment changes as there is a greater chance that one variant will be suited to the environment.)

Question 57/ 170

[VCAA 2011 E2 SA Q12]

The technique of carbon dating would be most suitable for dating organic remains that are aged

A 4 000 000 000 years and beyond.

B 4 000 000 years.

C 400 000 years.

D 40 000 years.

Solution

5-132 [VCAA 2011 E2 SA Q12]

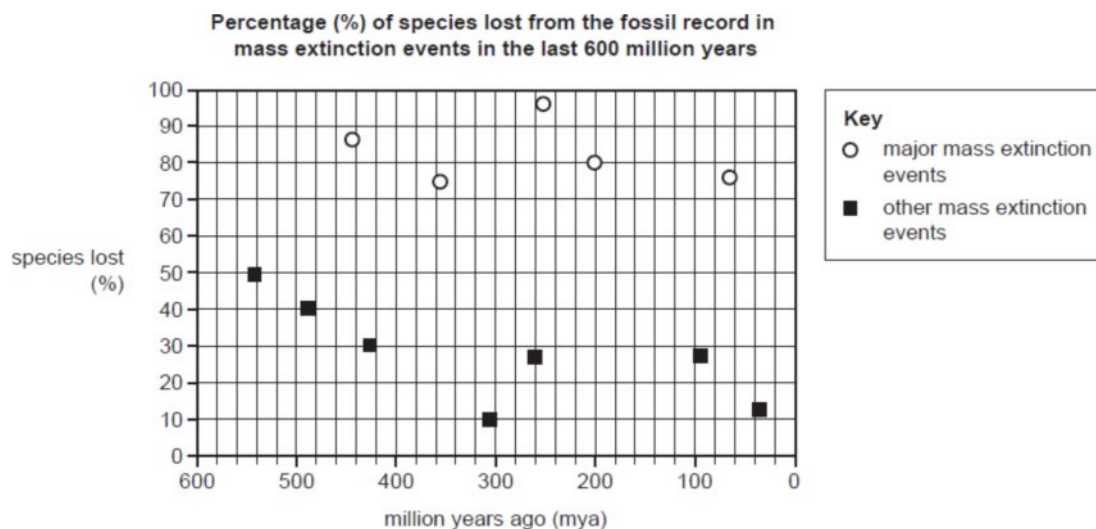
The technique of carbon dating would be most suitable for dating organic remains that are aged

D 40 000 years. (Fact. Carbon dating is only useful for relatively young fossils – less than 50 000 years old.)

Question 58/ 170

[VCAA 2021 SA Q22]

The graph below shows when the five major mass extinction events and several other mass extinction events occurred. It also shows the percentage of species that were lost in each event.



According to the graph above, to be classified as a major mass extinction event, the percentage of species that are lost has to be at least

A 10%

B 50%

C 74%

D 97%

Solution

4-133 [VCAA 2021 SA Q22]

According to the graph, to be classified as a major mass extinction event, the percentage of species that are lost has to be at least

C 74% (From the information given on the graph, the major mass extinction with the smallest percentage lost was 74%, occurring about 350 mya.)

Question 59/ 170

[VCAA 2021 SA Q23]

Mass extinction events

A allow new species to evolve to occupy available niches.

B allow all species that survive to recover and diverge.

C result from a constant global climate.

D affect all species equally.

Solution

4-134 [VCAA 2021 SA Q23]

Mass extinction events

A allow new species to evolve to occupy available niches. (Some species will be more able to survive than others, so those that survive will be able to occupy a greater range of niches.)

Question 60/ 170

[VCAA 2015 SA Q36]

Biologists have found evidence for mass extinction events in Earth's history at approximately 65 million years ago (mya) and at approximately 200 mya. The fossil record indicates a rapid increase in diversity of species after these mass extinction events.

This increased diversity of species can be explained by

A decreased mutation rates associated with the extinction event.

B increased numbers of fossils produced by the extinction event.

C populations of species returning to their pre-extinction event size.

D the extinction of many species providing many unoccupied niches.

Solution

5-135 [VCAA 2015 SA Q36]

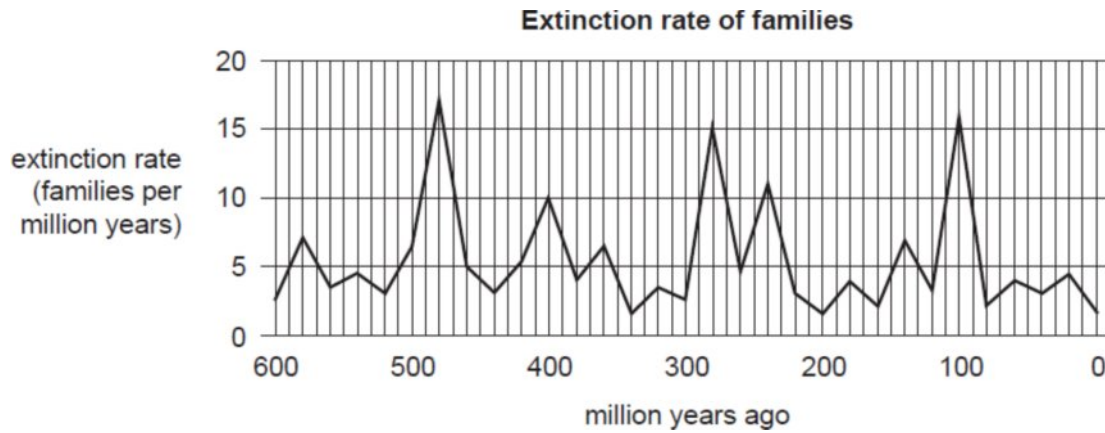
This increased diversity of species can be explained by

D the extinction of many species providing many unoccupied niches. (After the extinction event, there would be opportunities for divergent evolution in the remaining species to fill the unoccupied niches. Consider an example such as the Galapagos' finch – an ancestral population diversified to fill many slightly different niches on neighbouring islands.)

Question 61/ 170

[VCAA 2019 SA Q29]

Refer to the following graph that shows the extinction rate of families.



A scientist stated that a mass extinction occurred when the extinction rate was eight families per million years or greater.

The number of mass extinction events recorded on the graph above is

- A eight.
- B seven.
- C six.
- D five.

Solution

5-136 [VCAA 2019 SA Q29]

The number of mass extinction events recorded on the graph above is.

D five. (Looking along the extinction rate of 10 families per million years on the graph there are 5 peaks near or above the line – therefore 5 extinction events.)

A kill all but the most primitive species.

B are caused by the introduction of competing species.

C are followed by a period of rapid divergent evolution.

D have been caused by continental drift and earthquakes.

Solution

5-137 [VCAA 2017 SA Q33]

Mass extinctions

C are followed by a period of rapid divergent evolution. (Mass extinctions result in an increase in availability of unoccupied niches and therefore more opportunity for divergent evolution.)

Question 63/ 170

[VCAA 2022 SA Q34]

Consider a hypothetical animal species, Species X, that can neither fly nor swim. Separate populations of Species X live in the same geographical area and often interbreed. After a period of time, a new species, Species Z, arises from Species X.

The following list describes some barriers that may have contributed to the formation of Species Z:

1. A newly formed river separated one population of Species X from the other populations.
2. One population of Species X developed a new mating ritual that was not recognised by members of the other populations of Species X.
3. One population of Species X began to breed several weeks later than the other populations of Species X.
4. A volcanic eruption created a mountain that separated one population of Species X from the other populations of Species X.

The barrier(s) that could have led to the formation of Species Z by sympatric speciation is

A either barrier 1 or barrier 4.

B either barrier 2 or barrier 3.

C barrier 1 only.

D barrier 2 only.

Solution

5-138 [VCAA 2022 SA Q34]

The barrier(s) that could have led to the formation of Species Z by sympatric speciation is

B either barrier 2 or barrier 3. (Sympatric is the formation of new species without a geographical barrier.)

Question 65/ 170

[VCAA 2022 SA Q36]

The arrangement of bones in the forelimbs of these vertebrates can be described as

A putative.

B vestigial.

C analogous.

D homologous.

Solution

5-139 [VCAA 2022 SA Q36]

The arrangement of bones in the forelimbs of these vertebrates can be described as

D homologous (They have the same basic structure.)

Question 66/ 170

[VCAA 2022 SA Q37]

Based on your knowledge of evolution and the images above, which one of the following is a reasonable conclusion?

A The earliest ancestors of horses had only one digit on their forelimbs.

B The crocodile is a transitional form between horses and humans.

C Humans are more closely related to crocodiles than to horses.

D Humans, crocodiles and horses share a common ancestor.

Solution

5-140 [VCAA 2022 SA Q37]

Based on your knowledge of evolution and the images above, which one of the following is a reasonable conclusion?

D Humans, crocodiles and horses share a common ancestor. (The same basic structure is found in all three animals. This suggests they share a common ancestor.)

Question 67/ 170

[VCAA 2015 SA Q24]

The genome of the northern white-cheeked gibbon, *Nomascus leucogenys*, has been sequenced and compared to other primate species.

The *N. leucogenys* genome would

A include only the non-coding DNA sequences.

B be an uninterrupted, circular sequence of DNA base pairs.

C be identical to the genome of the black-crested gibbon, *Nomascus concolor*.

D consist of all the genetic sequences within the haploid cells of individuals of the species.

Solution

5-141 [VCAA 2015 SA Q24]

The genome of the northern white-cheeked gibbon, *Nomascus leucogenys*, has been sequenced and compared to other primate species.

The *N. leucogenys* genome would

D consist of all the genetic sequences within the haploid cells of individuals of the species. (Definition.)

Question 69/ 170

[VCAA 2016 SA Q39]

Using only the data for the molecular homology of cytochrome c, which one of the following organisms is most closely related to the dogfish?

A *Drosophila*

B chicken

C human

D yeast

Solution

5-142 [VCAA 2016 SA Q39]

Using only the data for the molecular homology of cytochrome c, which one of the following organisms is most closely related to the dogfish?

A *Drosophila* (The *Drosophila* shares 5 of the 6 amino acids tested. Not that the pig also does but is not an alternative.)

Question 70/ 170

[VCAA 2016 SA Q40]

Using only the data for the molecular homology of cytochrome c, which pair of organisms is most distantly related to wheat?

A dogfish and *Drosophila*

B *Drosophila* and yeast

C *Drosophila* and pig

D human and yeast

Solution

5-143 [VCAA 2016 SA Q40]

Using only the data for the molecular homology of cytochrome c, which pair of organisms is most distantly related to wheat?

D human and yeast (These two organisms have the least amino acids in common with wheat at the sites analysed.)

Question 72/ 170

[VCAA 2013 SA Q37]

The measurement of the rate of accumulation of random genetic changes in the genomes of chimpanzees and humans is called

A stratigraphy.

B a molecular clock.

C radiometric dating.

D relative dating.

Solution

5-144 [VCAA 2013 SA Q37]

The measurement of the rate of accumulation of random genetic changes in the genomes of chimpanzees and humans is called

B a molecular clock. (Definition. Stratigraphy and relative dating refer to the dating of rock according to the position of the layer in which it is found. Radiometric dating refers to dating rock according to the ration of radioactive isotopes present.)

Question 73/ 170

[VCAA 2013 SA Q38]

Research has shown that in a number of genes the sequence of nucleotides is unique to humans and is not found in chimpanzees.

Gene with sequence unique to humans

HAR1

FOXP2

AMY1

Functional role of gene with sequence unique to humans

active in the brain necessary for development of the cerebral cortex

facilitates formation of words by the mouth

facilitates digestion of starch

Gene with sequence unique to humans

Functional role of gene with sequence unique to humans

ASPM

controls brain size

LCT

permits digestion of milk sugar in adulthood

HAR2

drives gene activity in the wrist and thumb during development

Using the information in the table, it is reasonable to conclude that humans

A can digest milk sugar only in infancy.

B have less-opposable thumbs than chimpanzees.

C are able to walk on two feet in an upright position.

D process and remember more complex information than chimpanzees.

Solution

5-145 [VCAA 2013 SA Q38]

Using the information in the table, it is reasonable to conclude that humans

D process and remember more complex information than chimpanzees. (The presence of: the LCT sequence means that humans can digest milk as an adult, The HAR2 sequence that humans have a more opposable thumb than chimpanzees and there is not information about walking on two feet.)

Question 74/ 170

[VCAA 2012 E2 SA Q20]

Another source of DNA that could be used to determine evolutionary relationships among eucalypts would be

A plasmids.

B ribosomes.

C mitochondria.

D reverse copy DNA.

Solution

5-146 [VCAA 2012 E2 SA Q20]

Another source of DNA that could be used to determine evolutionary relationships among eucalypts would be

C mitochondria. (Plasmids are not found in plant cells and ribosomes are made of RNA not DNA.)

Question 75/ 170

[VCAA 2022 SA Q38]

Which one of the following statements is correct?

A Phylogeny I shows the evolutionary relationships between groups of vertebrates more accurately than Phylogeny II.

B Phylogeny I and Phylogeny II use different features of vertebrates as evidence to draw evolutionary relationships.

C Phylogeny II shows the same evolutionary relationships between groups of vertebrates as Phylogeny I.

D The most advanced groups in Phylogeny II are the hagfishes and lampreys.

Solution

5-147 [VCAA 2022 SA Q38]

Which one of the following statements is correct?

C Phylogeny II shows the same evolutionary relationships between groups of vertebrates as

Phylogeny I. (Phylogeny I and Phylogeny II show the same distance between common ancestors for all organisms based on the same features; therefore, one is not more accurate than the other.)

Question 76/ 170

[VCAA 2022 SA Q39]

Which one of the following is a correct conclusion from Phylogeny I?

A Frogs arose more recently than coelacanths.

B The common ancestor of all vertebrates is animal Q.

A The most closely related groups are lampreys and hagfishes.

B Animal R is the most recent common ancestor of ray-finned fishes and sharks.

Solution

5-148 [VCAA 2022 SA Q39]

Which one of the following is a correct conclusion from Phylogeny I?

A Frogs arose more recently than coelacanths. (Frogs diverged from a common ancestor more recently than coelacanths. The common ancestor of all vertebrates is not Q, as hagfish and lampreys are also vertebrates. Q is the most recent ancestor of ray-finned fishes and sharks.)

Question 78/ 170

[VCAA 2019 SA Q24]

O. latipes is most closely related to

A *A. quadracus*.

B *T. lineatus*

C *P. chilotes*.

D *T. flavidus*.

Solution

5-149 [VCAA 2019 SA Q24]

O. latipes is most closely related to

C *P. chilotes*. (*O. latipes* and *P. chilotes* have a most recent common ancestor. The other three alternatives are members of the Tetraodontiformes whose common ancestor is older than that of *O. latipes* and *P. chilotes*.)

Question 79/ 170

[VCAA 2019 SA Q25]

Which one of the following statements is correct?

A Cichlids diverged to form three distinct species 100 million years ago.

B *C. chanos* was the last species to diverge from the most distant common ancestor.

C Gasterosteiformes, Beloniformes and Cichliiformes do not share a common ancestor.

D *T. flavidus* and *T. lineatus* diverged to form two distinct species 25 million years ago.

Solution

5-150 [VCAA 2019 SA Q25]

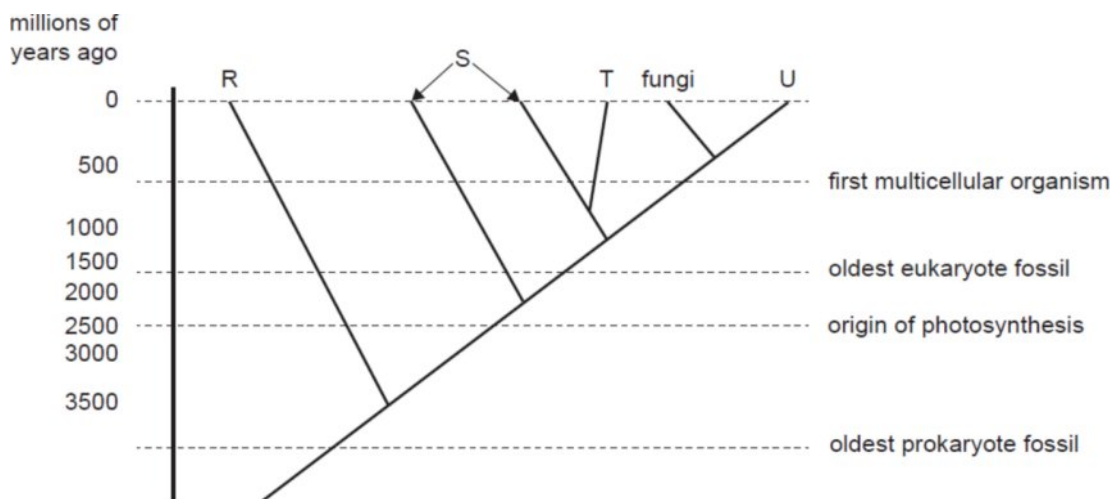
Which one of the following statements is correct?

D *T. flavidus* and *T. lineatus* diverged to form two distinct species 25 million years ago. (Drawing a line from 25 million years ago up intersects with the branch *T. flavidus* and *T. lineatus* - point where the divergence occurred.)

Question 80/ 170

[VCAA 2017 SA Q32]

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



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

A R – animals, S – plants, T – bacteria, U – protists

B R – bacteria, S – protists, T – plants, U – animals

C R – protists, S – animals, T – bacteria, U – plants

D R – plants, S – animals, T – bacteria, U – protists

Solution

5-151 [VCAA 2017 SA Q32]

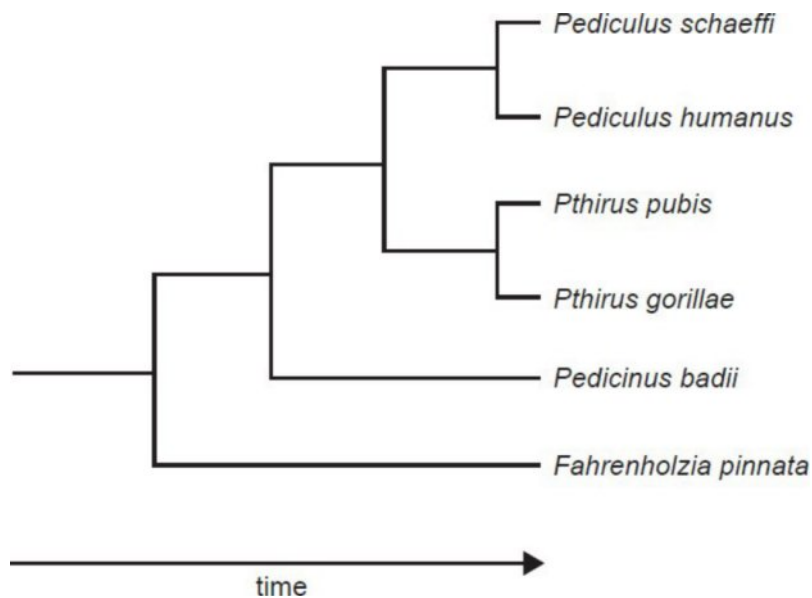
Which of the following shows the correct placement of the organisms on the phylogenetic tree?

B – bacteria, S – protists, T – plants, U – animals (Bacteria diverge first and B is the only alternative stating this.)

Question 81/ 170

[VCAA 2016 SA Q29]

Consider the following phylogenetic tree for different species of lice. The tree has been constructed based on molecular and morphological data.



This information suggests that

A *Pedicinus badii* shares a more recent common ancestor with *Pthirus gorilla* than with *Fahrenholzia pinnata*.

B *Pediculus humanus* is more closely related to *Pedicinus badii* than it is to *Pthirus pubis*.

C the six species of lice would have evolved by convergent evolution.

D *Pediculus schaeffi* is the ancestor of *Pediculus humanus*.

Solution

Consider the following phylogenetic tree for different species of lice. The tree has been constructed based on molecular and morphological data.

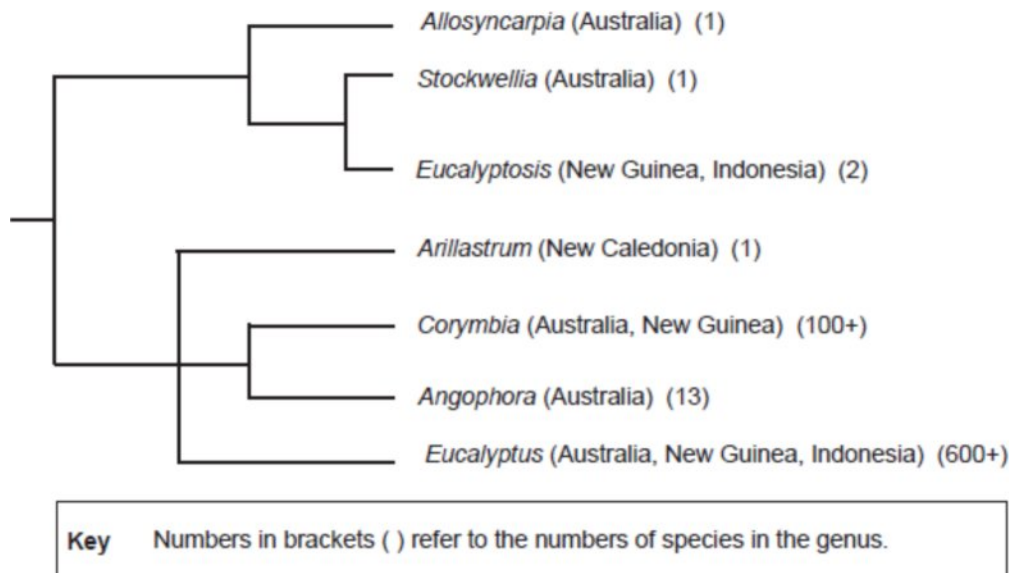
This information suggests that

A *Pedicinus badii* shares a more recent common ancestor with *Pthirus gorillae* than with *Fahrenholzia pinnata*. (Look for the branching patterns. *Pedicinus badii* and *Pthirus gorilla* share a more recent branch than *Fahrenholzia pinnata* so the statement is true.)

Question 82/ 170

[VCAA 2012 E2 SA Q19]

A proposed phylogeny for the seven genera is shown in the diagram below, along with the countries in which they are found.



It would be reasonable to conclude that

A DNA sequences in *Eucalyptosis* would be more similar to those in *Allosyncarpia* than to those in *Stockwellia*.

B speciation in *Eucalyptus* was assisted by different selecting pressures.

C the greater the number of species in a genus, the younger the genus.

D the genus that evolved most recently was *Angophora*.

Solution

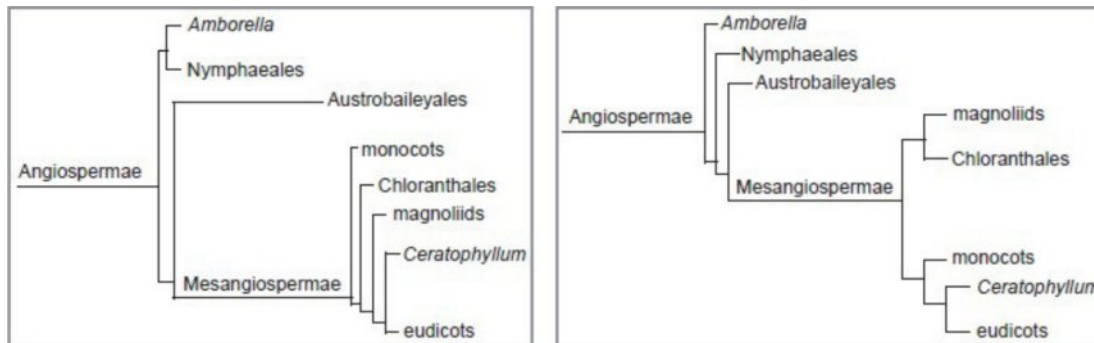
5-153 [VCAA 2012 E2 SA Q19]

It would be reasonable to conclude that

B speciation in *Eucalyptus* was assisted by different selecting pressures. (*Eucalyptosis* and *Stockwellia* are on the same branch and therefore will be the most similar. Their point of divergence is the most recent, so they have been the most recent to evolve.)

Question 83/ 170

[VCAA 2011 E2 SA Q23]



Two possible phylogenetic relationships between eight groups of flowering plants are shown in the following diagrams.

One similarity between the alternatives is

A monocots diverged before Chloranthales.

B *Ceratophyllum* and eudicots diverged from monocots.

C *Amborella* and *Nymphaeales* diverged first from Angiospermae.

D magnoliids were the first group to diverge from Mesangiospermae.

Solution

5-154 [VCAA 2011 E2 SA Q23]

One similarity between the alternatives is

C *Amborella* and Nymphaeales diverged first from Angiospermae. (This can be seen as *Amborella* and Nymphaeales are the first branch – see the top of each diagram. Monocots and Chloranthales diverged at similar times. Looking at the first diagram *Ceratophyllum* and eudicots are on different branch to monocots. Magnoliids in the first diagram diverge after monocots and the Chloranthales.)

Question 84/ 170

[VCAA 2019 SA Q40]

What evidence in the image below enables the primate shown to be classified as a hominoid?



- A the presence of an opposable thumb
- B the absence of claws on the toes
- C the presence of hair
- D the absence of a tail

Solution

5-155 [VCAA 2019 SA Q40]

What evidence in the image above enables the primate shown to be classified as a hominoid?

D the absence of a tail. (An opposable thumb, presence of hair and claws are not unique to hominoids.)

Question 85/ 170

[VCAA 2018 SA Q37]

Members of the order Primates are mammals.

Which combination of features is common to all primates and distinguishes them from other mammals?

	Feature 1	Feature 2	Feature 3
A	forward-facing eyes	sloping forehead	fur or hair
B	binocular vision	opposable thumbs	fully rotating shoulder joints
C	parabolic jaw	tail	nails instead of claws
D	even-sized teeth	arms longer than legs	bipedal stance

Solution

5-156 [VCAA 2018 SA Q37]

Members of the order Primates are mammals. Which combination of features is common to all primates and distinguishes them from other mammals?

Feature 1	Feature 2	Feature 3
Binocular vision	Opposable thumbs	Fully rotating shoulder joints

B (Primates do not have tails, so **C** is incorrect. Arms longer than legs is not a characteristic of all primates, so **D** is incorrect. In **A** the sloping forehead is not a characteristic of all primates – consider humans. Alternative **B** features are present in all primates.)

Question 86/ 170

[VCAA 2021 SA Q26]

Until May 2019, Denisovan fossils had been found in only two locations: Siberia and Tibet. Since then, Denisovan DNA has been discovered in some present-day populations. These populations are found on several continents, including Australia.

This suggests that the ancient Denisovan hominin group was, or its descendants were

A only fossilised in Siberia and Tibet.

B genetically identical to *Homo sapiens*.

C extinct prior to the presence of Neanderthals.

D more widespread than fossil evidence suggests.

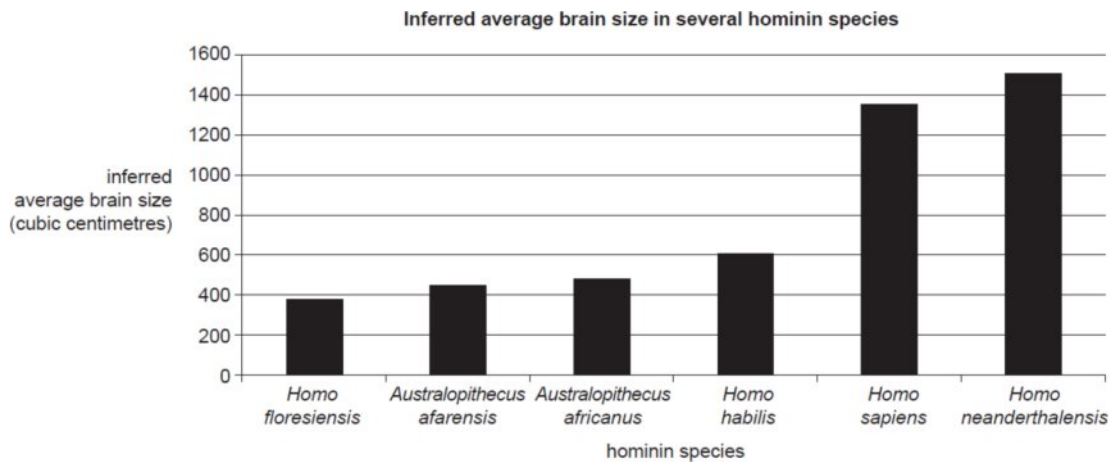
Solution

5-157 [VCAA 2021 SA Q26]

This suggests that the ancient Denisovan hominin group was, or its descendants were

D more widespread than fossil evidence suggests. (**A** is incorrect from the information given. **B** is incorrect because the Denisovans were of a different species, so genetically different. For **C** we have no information and **D** is correct from the information given.)

Question 87/ 170



The graph above shows the inferred average brain size of a number of hominin species.

Based on your knowledge and using the information in the graph, which one of the following species does not follow the general trend in inferred brain size seen in hominin evolution?

A *H. habilis*

B *H. sapiens*

C *A. afarensis*

D *H. floresiensis*

Solution

5-158 [VCAA 2019 SA Q32]

Based on your knowledge and using the information in the graph, which one of the following species does not follow the general trend in inferred brain size seen in hominin evolution?

D *H. floresiensis* (The information in the graph shows that *H. floresiensis* had on average the smallest inferred average brain size. The general trend is one of increased brain size in hominin evolution.)

[VCAA 2019 SA Q33]

Which row shows the group of characteristics that best reflects the trends in hominin evolution from the *Australopithecus* species to the *Homo* species?

Characteristics

- A** decreasing tooth size, increasing size of brow ridges, increasingly bowl-shaped pelvis, increasing size of zygomatic arch
- B** decreasing tooth size, decreasing size of brow ridges, decreasing arch of feet, more-opposable big toe
- C** increasing jaw size, decreasing size of zygomatic arch, increasing arch of feet, decreasing tooth size
- D** decreasing size of canines, decreasing size of zygomatic arch, increasingly bowl-shaped pelvis, increasing arch of feet

Solution

5-159 [VCAA 2019 SA Q33]

Which row shows the group of characteristics that best reflects the trends in hominin evolution from the *Australopithecus* species to the *Homo* species?

Characteristics

decreasing size of canines, decreasing size of zygomatic arch, increasingly bowl-shaped pelvis, increasing arch of feet

D. (C can be eliminated on basis of increasing jaw size. A is eliminated on increasing brow size and B on a more-opposable big toe.)

Question 89/ 170

[VCAA 2018 SA Q38]

Consider the evolution of hominins.

Which one of the following statements about hominin evolution is correct?

A *Homo sapiens* and *Homo neanderthalensis* are the only present-day hominin species.

B Members of the *Australopithecus* genus are not classified as hominins.

C *Homo erectus* was a bipedal primate.

D All hominoids are also hominins.

Solution

5-160 [VCAA 2018 SA Q38]

Consider the evolution of hominins.

Which one of the following statements about hominin evolution is correct?

C *Homo erectus* was a bipedal primate. (*Homo erectus* was named for its upright stance and hence bipedal – walking on two feet.)

Question 90/ 170

[VCAA 2018 SA Q39]

Which general trend is shown by hominin fossils?

A The older the fossil, the more central the position of the foramen magnum in the skull.

B The older the fossil, the smaller the braincase that surrounds the cerebral cortex.

C The more recent the fossil, the less bowl-shaped the pelvis.

D The more recent the fossil, the larger the jaw bones.

Solution

5-161 [VCAA 2018 SA Q39]

Which general trend is shown by hominin fossils?

B The older the fossil, the smaller the braincase that surrounds the cerebral cortex. (Earlier hominins had smaller brains and therefore smaller brain cases. Jaw bones have over time decreased in size and the pelvis has become more bowl- shaped.)

Question 91/ 170

[VCAA 2018 SA Q40]

Biologists have suggested that the development of bipedalism was a factor contributing to cultural evolution in hominins.

The advantage of bipedalism that had the greatest impact on cultural evolution was that it allowed

A improved teamwork and social bonding during ritual dances.

B food sources to be seen from long distances.

C the free use of hands to manipulate objects.

D fast escape from predators.

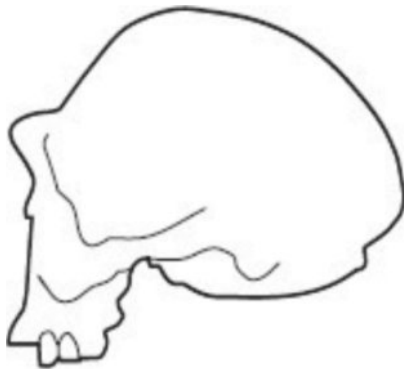
Solution

5-162 [VCAA 2018 SA Q40]

The advantage of bipedalism that had the greatest impact on cultural evolution was that it allowed

C the free use of hands to manipulate objects. (Free use of hands allowed more elaborate tool making which accelerated cultural evolution.)

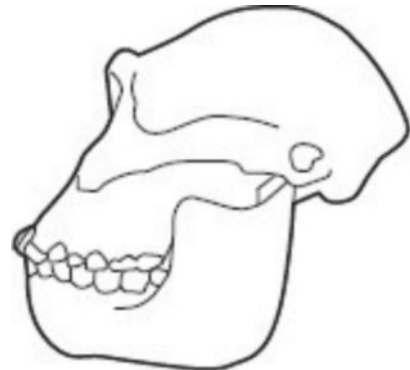
Below are three images of fossil hominin skulls.



Skull 1



Skull 2



Skull 3

Which sequence best shows the order from the most ancient fossil skull to the most modern fossil skull?

A Skull 3, Skull 1, Skull 2

B Skull 1, Skull 2, Skull 3

C Skull 3, Skull 2, Skull 1

D Skull 1, Skull 3, Skull 2

Solution

5-163 [VCAA 2015 SA Q37]

Which sequence best shows the order from the most ancient fossil skull to the most modern fossil skull?

A Skull 3, Skull 1, Skull 2. (Skull 2 has the flattest face therefore is the most recent. Skull 3 has the largest jaw and brow ridge therefore is the oldest.)

Question 93/ 170

[VCAA 2015 SA Q38]

Fossil remains of a number of individuals from the genus *Australopithecus* were found at various sites in the eastern half of Africa and have been dated to between three and four million years old.

These fossil remains

A are descendants of *Homo erectus*.

B represent the oldest evidence found of primates.

C show early evidence that hominins were bipedal.

D represent the earliest examples of the hominoid super-family

Solution

5-164 [VCAA 2015 SA Q38]

These fossil remains

C show early evidence that hominins were bipedal. (*Homo erectus* evolved after *Australopithecus* and older fossils of primates and apes – part of the hominoid super-family have been found.)

Question 94/ 170

[VCAA 2011 E2 SA Q25]

Consider the following hominin (previously called hominid) species.

M *Homo erectus*

N *Homo neanderthalensis*

O *Australopithecus africanus*

P *Australopithecus afarensis*

The order of oldest to youngest hominin species is

A M N O P.

B P O M N.

C N O P M.

D O M P N.

Solution

5-165 [VCAA 2011 E2 SA Q25]

The order of oldest to youngest hominin species is

B P O M N. (The genus *Homo* is more recent than *Australopithecus* therefore alternative having M and N last must be correct.)

Question 95/ 170

[VCAA 2017 SA Q35]

Modern African *Homo sapiens* do not contain Neanderthal DNA. Modern non- African *H. sapiens* contain a small percentage of Neanderthal DNA because of interbreeding between Neanderthals and *H. sapiens*. This interbreeding is thought to have occurred within the time period 65 000 to 47 000 years ago.

A recent study has found *H. sapiens* DNA in the genomes of 100 000-year-old Neanderthal remains.

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

A modern Africans are the descendants of Neanderthals.

B there was an early migration of *H. sapiens* out of Africa before 100 000 years ago.

C the ancestors of modern Africans migrated from Europe to Africa between 65 000 and 47 000 years ago.

D approximately 100 000 years ago, Neanderthals bred with *H. sapiens* in Africa before the Neanderthals spread to the rest of the world.

Solution

5-166 [VCAA 2017 SA Q35]

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

B there was an early migration of *H. sapiens* out of Africa before 100 000 years ago. (Modern Africans did not breed with Neanderthals therefore they are not directly related and Neanderthals were not present in Africa. If Neanderthals were not present in Africa but were able to interbreed with *H. sapiens* 100 000 years ago, *H. sapiens* must have migrated before 100 000 years ago.)

Question 96/ 170

[VCAA 2022 SA Q40]

Scientists are investigating the mitochondrial genomes of different Aboriginal Australian populations. A purpose of these investigations is to reveal the pathways of migration of Aboriginal Australians who arrived from Sahul.

Mitochondrial DNA can be used for this purpose because it

A contains genes that code for enzymes.

B is always the same in specific populations.

C is conserved through the maternal lineage.

D is more structurally stable than nuclear DNA.

Solution

5-167 [VCAA 2022 SA Q40]

Mitochondrial DNA can be used for this purpose because it

C is conserved through the maternal lineage. (Nuclear DNA also contains genes that code for enzymes, mitochondrial DNA is not always the same in specific populations and is not more stable than nuclear DNA.)

Question 97/ 170

[VCAA 2013 SA Q22]

You have the same mitochondrial DNA as your

A paternal grandfather.

B paternal grandmother.

C maternal grandfather.

D maternal grandmother.

Solution

5-168 [VCAA2013 SA Q22]

You have the same mitochondrial DNA as your

D maternal grandmother. (Mitochondrial DNA is inherited through ova, i.e. from the mother, grandmother and so on.)

Question 99/ 170

[VCAA 2014 SA Q39]

This evidence and current theories of hominin evolution indicate that

A the very small stature of *H. floresiensis* is unexpected in a species that is geographically isolated on a small island.

B *H. floresiensis* was a species that showed considerable social cooperation and methods for passing on knowledge.

C the sloping forehead and absence of chin of members of the *H. floresiensis* species suggest they were members of the first migration of hominins into Australia over 50 000 years ago.

D the skull shape and size of *H. floresiensis* suggest a close relationship to the *Homo neanderthalensis* species.

Solution

5-169 [VCAA 2014 SA Q39]

The above evidence and current theories of hominin evolution indicate that

B *H. floresiensis* was a species that showed considerable social cooperation and methods for passing on knowledge. (The presence of tools, evidence of fire and the ability to catch prey much larger than themselves suggests that *H. floresiensis* hunted and this requires considerable social cooperation.)

Question 100/ 170

[VCAA 2014 SA Q40]

The fossils of *H. floresiensis* showed that they had opposable thumbs. The development of an opposable thumb in primate evolution

A is used to distinguish members of the genus *Homo* from the other great apes.

B was a necessary step in the development of bipedalism in hominins.

C was an important anatomical development that assisted tool-making in hominins.

D is a significant factor in determining the arm-to-leg ratio of modern humans.

Solution

5-170 [VCAA 2014 SA Q40]

The fossils of *H. floresiensis* showed that they had opposable thumbs. The development of an opposable

thumb in primate evolution

C was an important anatomical development that assisted tool making in hominins. (Apes have an opposable thumb and arm-to-leg ratio relates to bipedalism not the ability to manipulate tools.)

Question 1/ 205

[VCAA 2020 SB Q7]

Only 35% of the world's adult human population can digest lactose, which is found in milk. These people continue to produce the enzyme lactase throughout their lives. Most people who can digest lactose have European ancestry. There is evidence that people kept animals for milk in Europe 10 500 years ago. About 7500 years ago in central Europe, a gene mutation occurred in the lactase gene, where cytosine was replaced by thymine. The allele produced by this mutation allows individuals to produce lactase and to digest lactose throughout their lives.

Researchers have estimated that populations in Europe with this mutation produced more offspring than populations who did not have this mutation.

a Name the type of mutation that occurred 7500 years ago in central Europe. (1 mark)

b i The increase in frequency of the allele for lactase persistence happened relatively quickly in some populations. Explain why the frequency of this allele increased relatively quickly. (3 marks)

ii In some present-day populations there are no individuals with the mutation. Give **two** reasons for the absence of the mutation in these populations. (2 marks)

c Cows are the main source of milk in Europe. Modern dairy cow breeds can produce 25 L of milk each day – much more than their wild ancestors.

Describe how an increase in production of cow's milk could be achieved by farmers over many generations of cows. (2 marks)

(Total 8 marks)

Solution

5-171 [VCAA 2020 SB Q7]

a Substitution point mutation

b i In Europe where milk was an important component of the diet, those individuals without the mutation that allowed them to digest milk throughout their life obtained less food. They were less healthy, mated less frequently and produced fewer offspring. Fewer alleles for digesting milk were passed on to their offspring. Those with the mutation were able to digest milk obtained more food, were healthier, survived to mate and produced more offspring that inherited the alleles for digesting milk. Over many generations, the allele frequency and phenotype for digesting milk increased.

ii Any **two** of:

- The mutation had not occurred in an isolated population with no gene flow.
 - The population did not rely on milk as a major component of the diet, therefore, there was no selective advantage to be able to digest milk.
 - The population was established by a group of individuals that did not have the mutation.
- c** Through selective breeding where the farmer allows only high milk-producing cows to breed with bulls whose mother was high milk-producing.
-

Question 2/ 205

[VCAA 2019 SB Q6]

From 10 weeks into pregnancy, a woman can decide to have a non-invasive prenatal test that detects fetal aneuploidies. A blood sample is taken from the woman for the test.

a i What does aneuploidy refer to? (1 mark)

ii What would scientists examine in the woman's blood sample? (1 mark)

If there is a requirement to look for other genetic abnormalities, such as block mutations, different procedures can be conducted.

b Describe **two** different types of block mutations. (2 marks)

Some procedures can detect single gene mutations. Sickle-cell anaemia is produced by a single gene mutation that affects the production of the beta chain of the haemoglobin protein (the oxygen-carrying protein that makes blood cells red). Beta haemoglobin is a single chain consisting of 147 amino acids.

5'	AUG	GUG	CAC	CUG	ACU	CCU	GAG	GAG	3'

Shown below is a small section of the mRNA nucleotide sequence found in an individual without the mutation.

The codon table below can be used to determine amino acids coded for by a nucleotide sequence.

1st position (5' end)	2nd position				3rd position (3' end)
	U	C	A	G	
U	phe	ser	tyr	cys	U
	phe	ser	tyr	cys	C
	leu	ser	STOP	STOP	A
	leu	ser	STOP	trp	G
C	leu	pro	his	arg	U
	leu	pro	his	arg	C
	leu	pro	gln	arg	A
	leu	pro	gln	arg	G
A	ile	thr	asn	ser	U
	ile	thr	asn	ser	C
	ile	thr	lys	arg	A
	met	thr	lys	arg	G
G	val	ala	asp	gly	U
	val	ala	asp	gly	C
	val	ala	glu	gly	A
	val	ala	glu	gly	G

c Use the section of mRNA provided above and the codon table above to complete the table below. (2 marks)

Translated sequence

d i The gene for sickle-cell anaemia produces misshapen red blood cells that do not carry oxygen efficiently. In an individual with sickle-cell anaemia, the twentieth nucleotide has changed to uracil in the transcribed mRNA provided after part **b**.

How would this alter the amino acids coded for in this sequence? (1 mark)

ii If this twentieth nucleotide was deleted, how could this mutation alter the structure and function of the haemoglobin protein produced? (2 marks)

(Total 9 marks)

Solution

5-172 [VCAA 2019 SB Q6]

a i Aneuploidy refers to cells with too many or too few chromosomes (abnormal number) due to non-disjunction during cell division.

ii The number of chromosomes in foetal cells.

b Any **two** of the following:

- Deletion where a large section of a chromosome is missing
- Inversion where a large section of a chromosome is cut and re-joined upside down
- Duplication where a large section of chromosome is copied and added to the chromosome
- Translocation where a section of one chromosome becomes attached to another.

c

5'	AUG	CUC	CAC	CUG	ACU	CCU	GAG	GAG	3'
	met	leu	his	leu	thr	pro	glu	glu	

d i

5'	AUG	CUC	CAC	CUG	ACU	CCU	GUG	GAG	3'
	met	leu	his	leu	thr	pro	val	glu	

The 7th amino acid will change from glu in the person without the mutation to val in the person with the mutation.

ii

5'	AUG	CUC	CAC	CUG	ACU	CCU	GGG	AG	3'
	met	leu	his	leu	thr	pro	gly		

This would result in a frameshift where all amino acids after the 6th amino acid would be different. This would affect the primary, secondary and tertiary structure of the resulting protein therefore the proteins would have a different shape and would not function effectively.

Question 3/ 205

[VCAA 2021 SB Q11]

Two students designed an experiment to investigate antibiotic resistance in *Escherichia coli* bacteria. They began with an *E. coli* culture. The following procedure was conducted in a filtered air chamber using aseptic techniques:

- On Day 0, spread 1 mL of *E. coli* culture onto a nutrient agar plate containing 0 µg/mL (micrograms per millilitre) of the antibiotic ampicillin. Spread 1 mL of the *E. coli* culture onto a separate nutrient agar plate containing 1 µg/mL of ampicillin. Cover each plate with an airtight lid.
- On Day 1, transfer a sample of bacteria from one of the Day 0 plates to one of the Day 1 plates containing 2 µg/mL of ampicillin. Transfer a sample of bacteria from the other Day 0 plate to the other Day 1 plate, which also contains 2 µg/mL of ampicillin. Cover as before.
- On Day 2, transfer a sample of bacteria from one of the Day 1 plates to one of the Day 2 plates containing 4 µg/mL of ampicillin. Transfer a sample of bacteria from the other Day 1 plate to the other Day 2 plate, which also contains 4 µg/mL of ampicillin. Cover as before.
- On Day 3, transfer a sample of bacteria from one of the Day 2 plates to one of the Day 3 plates containing 6 µg/mL of ampicillin. Transfer a sample of bacteria from the other Day 2 plate to the other Day 3 plate, which also contains 6 µg/mL of ampicillin. Cover and seal the plates.

All plates were incubated at 37°C for each 24-hour period. Used plates were refrigerated until the end of the experiment. They were then photographed to compare the amount of bacterial growth and disposed of safely.

The students drew a diagram (Figure 1 on the next page) to help explain the experimental design and to show their predicted results in each condition at the end of each day.

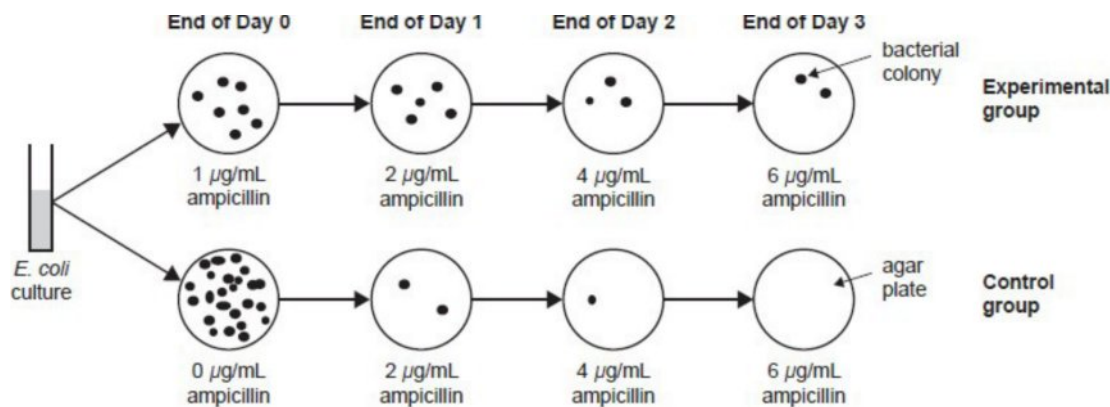


Figure 1

a Identify any **two** controlled variables for this experiment. (2 marks)

b Write a suitable hypothesis for this experiment. (2 marks)

The refrigerated plates kept from Days 0, 1, 2 and 3 of the experiment were photographed. The diagrams in Figure 2 on the following page represent the bacterial growth seen in the photographs.

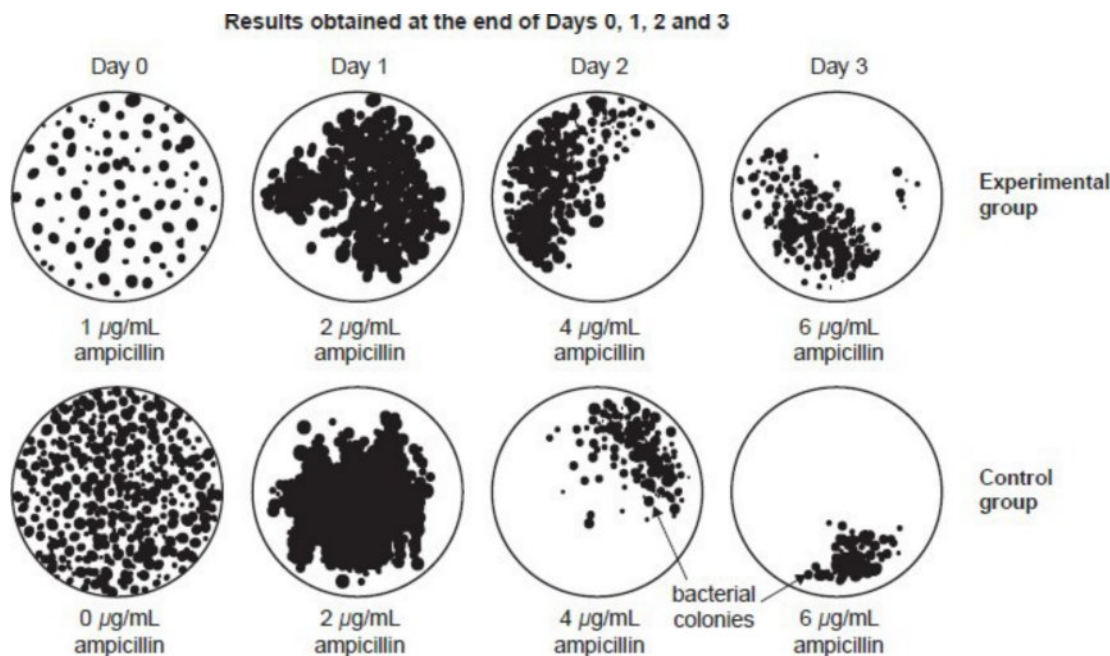


Figure 2

c i Analyse the results of the experiment shown in Figure 2. (3 marks)

ii Explain whether the results of the students' experiment shown in Figure 2 support the predicted results shown in Figure 1. (2 marks)

(Total 9 marks)

Solution

5-173 [VCAA 2020 SB Q11]

a Any **two** of the following controlled variables

- The same bacteria *Escherichia coli* was used.
- The plates were incubated at the same temperature.
- The plates were incubated for the same length of time.
- Initially the same volume of bacteria was added to each plate.
- The same nutrient agar was used on the plates.
- The same sized plates were used.

b If *E. coli* is exposed to low concentrations of ampicillin initially then there will be more growth of *E. coli* when exposed to increasingly higher levels ampicillin.

c i Any **three** of the following points:

- On day zero, less bacteria grew on the plate with ampicillin than on the plate without ampicillin.
- On day 1, both plates had the same amount of ampicillin but less bacteria grew on the plate that initially contained ampicillin than the plate that initially had no ampicillin.
- On day 2, both plates had the same amount of ampicillin, but more bacteria grew on the plate that initially contained ampicillin than the plate that initially had no ampicillin.
- On day 3, both plates had the same amount of ampicillin, but more bacteria grew on the plate that initially contained ampicillin than the plate that initially had no ampicillin.
- By day 3, more resistant bacteria were present on the plate that initially contained ampicillin than the plate that initially had no ampicillin.

ii The results shown in Figure 2 do not support the predicted results shown in Figure 1. The Day 3 predicted results for the plate containing no ampicillin initially was no bacterial growth but Figure 2 shows there was growth.

Or

The results shown in Figure 2 do support the predicted results shown in Figure 1. The predicted results show a decrease in growth in all plates regardless of whether there is initial exposure to ampicillin or not. This is also shown in Figure 2. The predicted results show a greater growth in the plate initially exposed to ampicillin than the plate without exposure and this is also shown in Figure 2.

[VCAA 2018 SB Q7]

Populations of the lizard species *Anolis sagrei* are found on the many islands of the Bahamas. There is natural variation between the phenotypes of individuals within each population.

a Explain how natural variation can exist between individuals within a lizard population. (3 marks)

In 2004 a hurricane killed all populations of *A. sagrei* lizards on seven of the smaller islands. Scientists randomly chose seven males and seven females from a remaining population on a large island. They introduced one male and one female to each of the seven smaller islands. Over the next three years, the scientists noted that the size of the populations increased on each of the seven smaller islands. The scientists measured the genetic diversity within each of the populations and found there was lower genetic diversity in each new population compared with the population on the large island.

b Explain the reasons for the lower genetic diversity of the new populations on the smaller islands compared with the population on the large island. (2 marks)

c The scientists noted that after three years there was a significant decrease in the average length of the hind legs of the lizards living on the smaller islands compared with those on the large island. Explain what may have happened on the smaller islands to produce this decrease in the average length of hind legs. (2 marks)

(Total 7 marks)

Solution

5-174 [VCAA 2018 SB Q7]

a An individual's phenotype is determined by the expression of genes found on chromosomes. Genes are made of DNA and the order of bases determines the proteins produced by the organisms. New forms of genes are introduced into a population by mutation. Mutagens include certain chemicals and radiation. Additionally, errors in cell division may result in changes in chromosome number and size (chromosomal mutations). Lizards reproduce sexually. They inherit half their chromosomes from each parent via sperm and ova. Crossing over during prophase I of meiosis shuffles the alleles within a homologous pair of chromosomes and random assortment of chromosomes during meiosis results in new combinations of alleles again increasing variation in the lizard population.

b Offspring inherit their characteristics from their parents. The new populations are descended from only two individuals therefore the founding gene pool was smaller than the gene pool on the large island. As there is no gene flow between the islands the gene pool will only include the alleles found in the founders of the population.

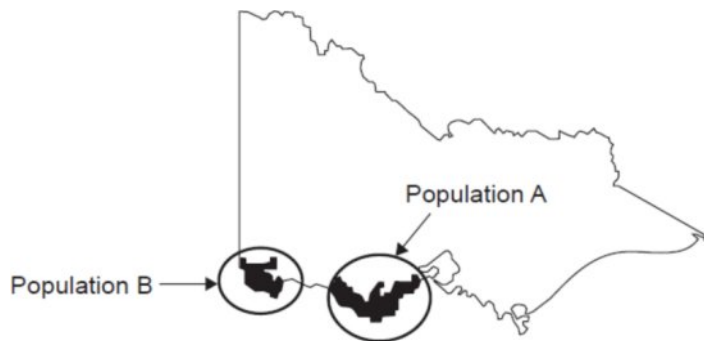
c There was original variation in length of hind legs of lizards living on the smaller islands. There were different selection pressures on the small islands compared with the large island. Shorter hind limbs were an advantage on smaller islands so lizards with short hind limbs were more likely to survive, reproduce and pass on the alleles for short hind limbs to their offspring. Over time the population would have an increased

number of lizards with short hind limbs.

Question 5/ 205

[VCAA 2017 SB Q5]

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



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

a Define the term ‘gene flow’ and explain whether gene flow is likely to occur between these two populations. (3 marks)

b Both of the rufous bristlebird populations in Victoria are small. Referring to the theory of natural selection, explain why the rufous bristlebird is at risk of extinction. (3 marks)

(Total 6 marks)

Solution

5-175 [VCAA 2017 SB Q5]

a Gene flow is the exchange of alleles between different populations or gene pools. Gene flow is unlikely to occur between these populations as the birds are poor flyers and the populations are 200 km apart

therefore, they are unlikely to interbreed.

b Small populations will have low genetic diversity. If the environment changes and one individual is adversely affected, then there is a high probability that all individuals will be adversely affected, and the population will be wiped out.

Question 6/ 205

[VCAA 2017 SB Q10]

Aboriginal Australians co-existed with the megafauna for at least 17 000 years

Australia was once home to giant reptiles, marsupials and birds known as megafauna. Many researchers have suggested a rapid extinction model to account for the extinction of megafauna thought to have occurred soon after the arrival of the First Australians¹.

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

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

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

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

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

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

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

a Using the information in the text, explain how the rapid extinction model may account for the extinction of Australia's megafauna. (3 marks)

b Complete the following table by identifying three pieces of evidence in the text that cast doubt on the rapid extinction model. Justify how each piece of evidence can be used to reject the rapid extinction model. (6 marks)

Evidence	Justification

1	

2	

3	

(Total 9 marks)

Solution

5-176 [VCAA 2017 SB Q10]

a The rapid extinction model suggests that a dramatic change in the environment may lead to widespread death of organisms. When the First Australians arrived in Australia, they dramatically changed the environment through burning and hunting. This drastically reduced the amount of food available to the megafauna and hunting further reduced their numbers, causing their extinction.

b

Evidence	Justification

1. No record of fire-sensitive plants undergoing a bottleneck as a result of significant burning events	

If the rapid extension model occurred, then significant burning events would result in most of the populations of fire-sensitive plants dying. The plants remaining would be similar as they are descended from the small surviving population. There is no evidence of this.

2. For tens of thousands of years, Indigenous populations were not that large.	

If the population was not large, then the people would have little effect on the immediate environment therefore, there would be no significant habitat change and no rapid extinction.

3. Many of the megafauna species became extinct before	

If the extinction of the species occurred before the First Australians arrived, then First Australians could not have caused the extinction.

Evidence**Justification**

the First Australians arrived.

Question 7/ 205

[VCAA 2013 SB Q9]

The southern brush-tailed rock wallaby (*Petrogale penicillata*) is threatened with extinction in Victoria. Since European settlement, it has suffered from hunting for its fur, clearing of habitat and predation by foxes. Early in 2012, the population of brush-tailed rock wallabies in the Grampians National Park numbered only four individuals.



Source: Richard Lydekker, A Hand-book to the Marsupialia and Monotremata, R Bowdler Sharpe (ed.), W.H. Allen & Co. Limited, London, 1894

a What is meant by extinction? (1 mark)

Eighteen brush-tailed rock wallabies were released into the Grampians in late 2012. The wallabies had been bred in captivity in zoos and nature reserves in Victoria, South Australia, New South Wales and the Australian Capital Territory. Care was taken to ensure that the gene pool of the released wallabies was as diverse as possible.

b i What is a gene pool? (1 mark)

ii Using your knowledge of natural selection, explain why it is an advantage to have a diverse gene pool among the released wallabies. (2 marks)

Wildlife officers are hoping that the Grampians population will increase to at least 50 wallabies in five years and that it will be maintained over time. A small population of wallabies could be affected by **genetic drift**

and, possibly, a genetic **bottleneck effect**.

c Explain the meaning of each of these terms with reference to allele frequencies. (2 marks)

The Grampians wallabies will be closely monitored by surveillance cameras and radio collars after their release.

d Suggest one further measure that wildlife officers should carry out to help maintain the population over time. (1 mark)

(Total 7 marks)

Solution

5-177 [VCAA 2013 SB Q9]

a Extinction means that individuals of a particular species no longer exist.

b i Gene pool refers to all the alleles, of all the genes, of all the individuals, in a population. (*Note: all the genes.*)

ii Natural selection relies on genetic diversity in a population. Genetic diversity results in phenotypic variation. If all individuals are similar and the environment changes to the detriment of one individual, all individuals will be selected against, and extinction may result. If the gene pool is diverse, there is a chance that some individuals may have characteristics that are selected for, and the population will survive.

c

Term	Explanation
Genetic drift	Unpredictable changes in allele frequencies from one generation to the next due to the action of chance events. More likely to occur in small populations.
Bottleneck effect	Chance effects on allele frequencies in a population as a result of a major reduction in population; for example, disease or loss of habitat. The descendants from the small, reduced population will be genetically similar as they are descended from the same ancestors.

d Any **one** of the following:

- Wildlife officers could continue to introduce brush-tailed rock wallabies from other areas
- Fencing to remove foxes or other introduced species.
- Restore the habitat through reduced grazing/control of hikers to walking paths

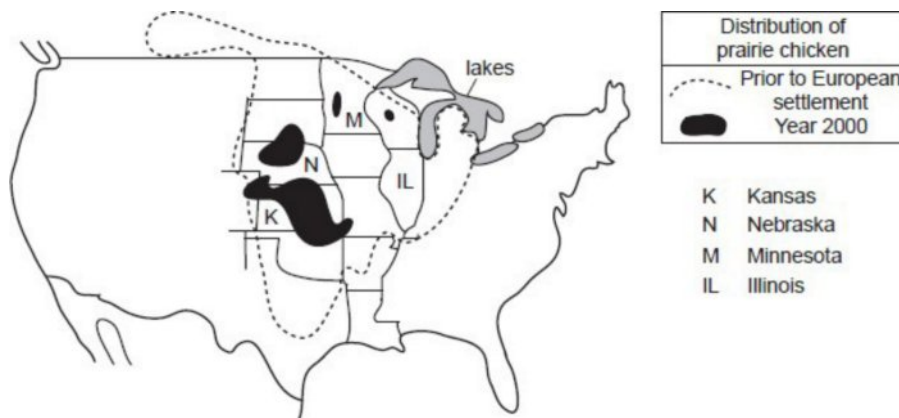
- Reduce the number of predators.

Question 8/ 205

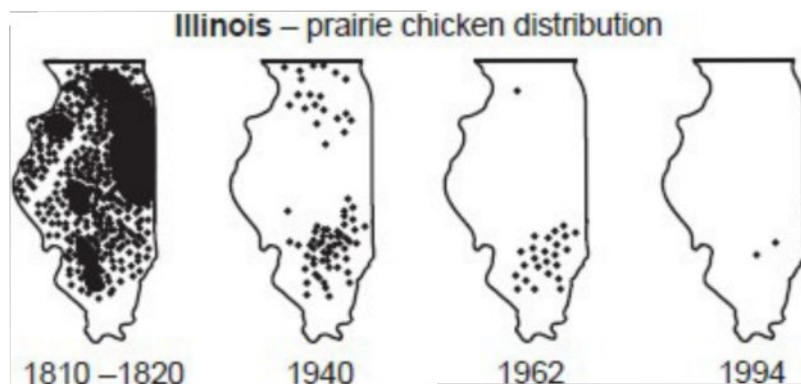
[VCAA 2011 E2 SA Q6]

a Define 'genetic drift'. (1 mark)

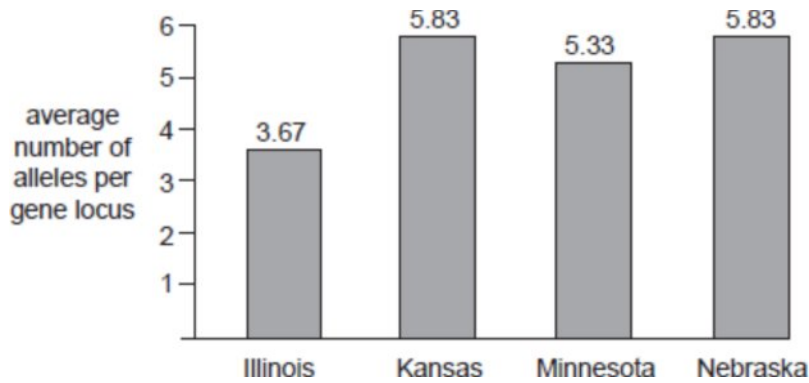
The prairie chicken (*Tympanuchus cupido pinnatus*) is a grassland bird native to North America. A prairie chicken spends its entire life within several kilometres of its birthplace. Prior to European settlement, prairie chickens numbered in the millions across the Midwest of the United States of America. As a result of the grasslands being replaced by plant food crops, the distribution of prairie chickens has diminished, as shown in the diagram on the next page.



By 1994, Kansas, Nebraska and Minnesota still supported large and widespread populations; however, in the state of Illinois, the number of prairie chickens fell to less than fifty individuals isolated in two separate geographical areas.



Representative samples of prairie chickens from the four states were selected for testing. Each prairie chicken had six gene loci tested. The average number of alleles at each gene locus for each prairie chicken group is shown in graph below.



b i Explain the significance of the results for the Illinois birds compared to the results of the birds from the three other states. (2 marks)

ii Explain why the results for the Kansan birds and Nebraskan birds are similar to each other. (1 mark)

Measures were taken in the 1990s to prevent the Illinois prairie chicken from dying out completely.

c i Explain why low genetic diversity in a population threatens the survival of the population. (2 marks)

ii Describe one measure that could be used to prevent the Illinois prairie chicken from dying out. (1 mark)

(Total 7 marks)

Solution

5-178 [VCAA 2011 E2 SB Q6]

a Genetic drift: changes, unpredictable in direction, in allele frequencies from one generation to the next owing to the action of chance events. More likely to occur in small populations.

b i The Illinois birds have a lower average number of alleles per gene locus (3.67) compared to prairie chickens from the other states (5.33–5.83). They show less genetic variation than the birds from the other three states. This is because they are descended from less than 50 individuals. They are closely related. The other groups are descended from larger populations of genetically different birds.

ii Kansas birds and the Nebraskan birds are similar (5.83 average number of alleles per gene locus) to each other as there is probably gene flow or interbreeding occurring between the two adjacent populations.

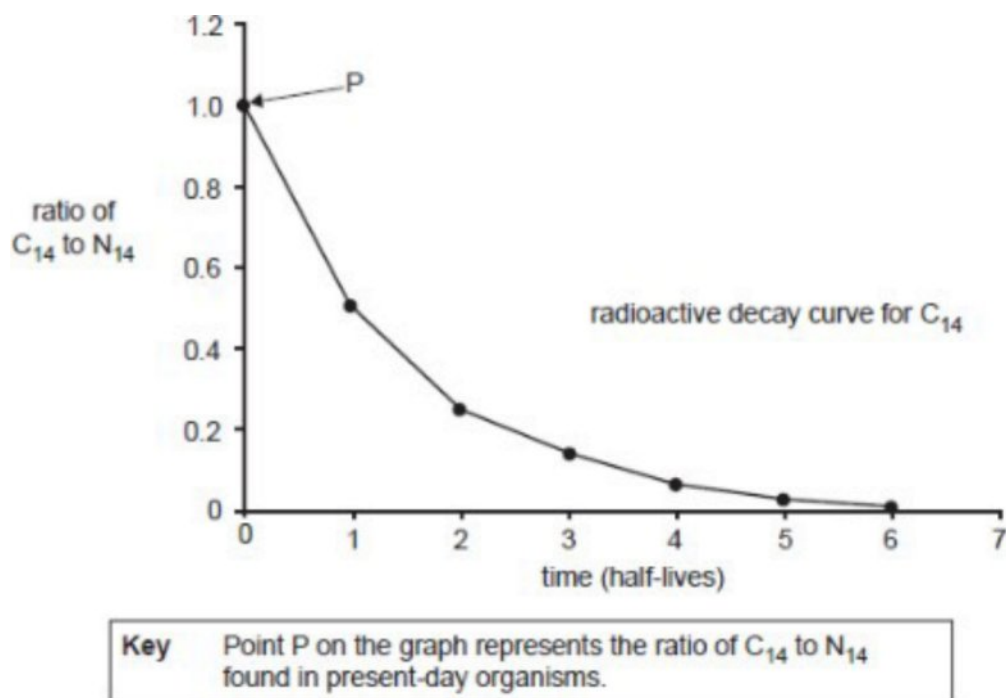
c i If individuals in a population are genetically similar then they will also be phenotypically similar. If the environment changes to the detriment of one individual, then all individuals will be similarly affected and the population could die out. For example, if they were exposed to a new disease, if one individual is susceptible, they will all be susceptible and all may die.

ii The Illinois prairie chickens could be interbred with prairie chickens from the other states. This would increase genetic variation and thus phenotypic variation. If the environment changes to the detriment of some, there may be some variants that will not die out.

Question 9/ 205

[VCAA 2012 E2 SB Q6]

One form of dating the age of a fossil is by radioactive carbon dating. The ratio of carbon-14 to nitrogen-14 ($C_{14} : N_{14}$) in the fossil is analysed and compared with the ratio of these elements in an organism living today. The following graph shows the rate of decay for carbon-14.



A fossil kangaroo skull was found in a limestone cave. The skull's $C_{14} : N_{14}$ ratio was analysed and found to contain one-quarter ($\frac{1}{4}$) of the carbon-14 of a kangaroo that died in 2012.

a i Place an X on the curve to show the fossil's $C_{14} : N_{14}$ ratio. (1 mark)

ii Given the half-life of carbon is approximately 6000 years, what is the approximate age, in years, of the kangaroo skull? (1 mark)

Carbon-dating analysis is not always possible, and the age of the fossil can be estimated by dating the rock in which it is found.

b i Why is carbon-dating analysis not always possible? (1 mark)

ii Name another absolute dating technique that can determine the age of the rock surrounding a fossil. (1 mark)

(Total 4 marks)

Solution

5-179 [VCAA 2012 E2 SB Q6]

- a i** The X should be placed exactly on the curve at the 2 time (half-lives) point.
- ii** 12 000 years (2×6000 years)
- b i** C14 has a short half-life. If the fossil is very old, very little C14 will be present.
- ii** Any **one** of the following:
- potassium–argon dating
 - uranium-238 dating
 - thermoluminescence
 - electron spin resonance.
-

Question 10/ 205

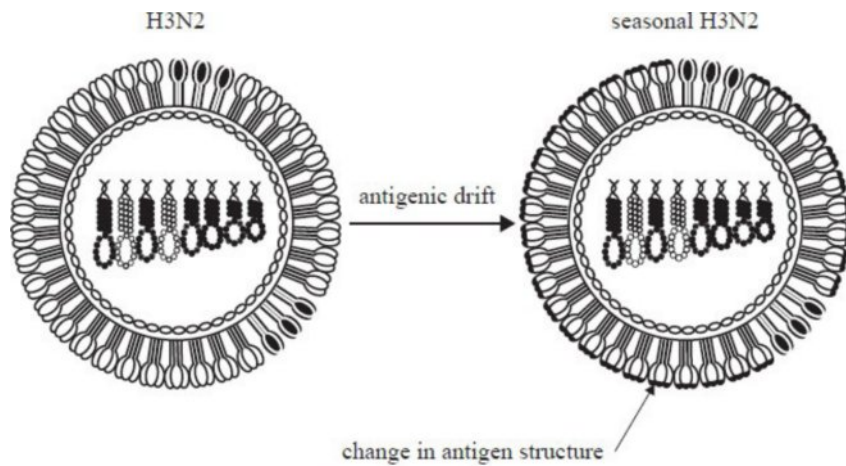
[VCAA 2022 SB Q6]

Influenza is an infectious respiratory disease. In humans, it can be caused by the influenza A or influenza B viruses.

a Natural killer cells and cytotoxic T cells both play an important part in the human immune response to the virus causing influenza.

Compare the roles played by each of these two types of cells in the immune response to the influenza virus. (4 marks)

Antigenic drift can result in small changes to the structure of the antigens on the surface of the influenza virus, as shown in the diagram on the next page.



Source: adapted from F Krammer, GJD Smith, RAM Fouchier et al., 'Influenza', *Nature Reviews Disease Primers*, 4:3 (2018), <<https://doi.org/10.1038/s41572-018-0002-y>>

b i What change would have occurred within the virus to bring about the change in the structure of the antigen? (1 mark)

ii Vaccines against influenza are available and it is recommended that people are vaccinated each year.

Explain, in terms of antigenic drift, why vaccinations are recommended yearly for influenza rather than once every few years. (2 marks)

(Total 7 marks)

Solution

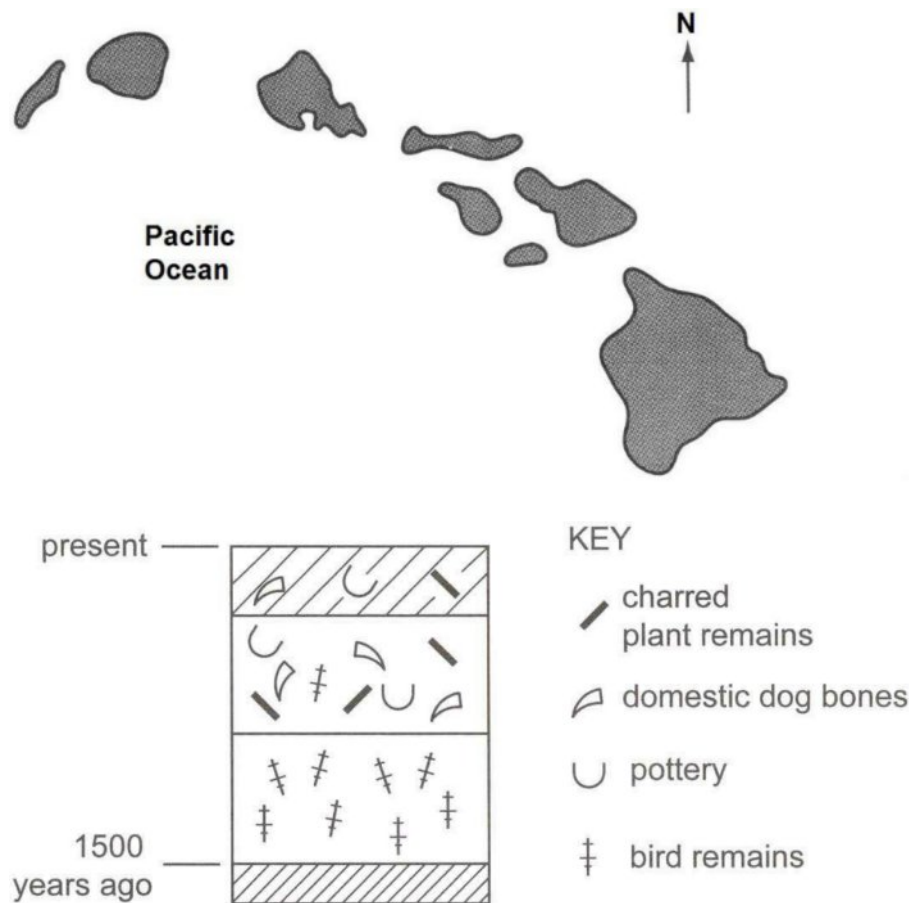
5-180 [VCAA 2022 SB Q6]

a Both natural killer cells and cytotoxic T cells recognise displayed antigens on MHC-1 markers of infected cells. Both release chemicals that result in the death of infected cells. Natural killer cells are involved in the second line of defence. They act early in the infections and target any cell infected with any virus, whereas cytotoxic T cells are involved in the 3rd line of defence. They act later and are specific to cells infected by a particular virus. Further, natural killer cells have no memory of the infection, whereas cytotoxic T cells do.

b i Mutation

ii Vaccinations result in the production of memory B and T cells that recognise specific displayed antigens on antigen-presenting cells and infected cells. These specific antigens are realised when an infection occurs and bring about an immune response. The antigens are coded for in the viral genetic material. If antigenic drift occurs, the new antigens are not recognised by the memory B and T cells and an immune response does not occur. Yearly influenza vaccines are produced that target the current viral antigens. This creates memory B and T cells specific to the new influenza strain.

The islands of Hawaii in the Pacific Ocean were formed as a result of volcanic action in which small land masses were thrown up by submarine volcanoes. The youngest of the islands lies to the east of the oldest.



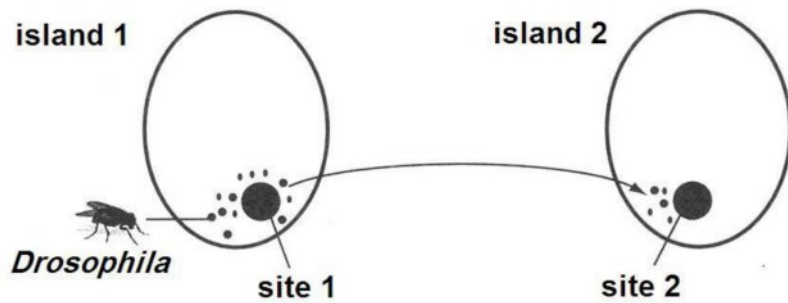
A similar pattern of deposition has been found across all islands, shown by the profile below.

a What assumption is made about the formation of strata when interpreting profiles such as this? (1 mark)

b i State a hypothesis to account for the disappearance of many of the bird species from the groups of islands. (1 mark)

ii Provide evidence to support your hypothesis. (1 mark)

Biologists studied many species of the fruit fly, *Drosophila*, living on the Hawaiian Islands. The species vary widely in appearance, behaviour and habitat. The diversity of *Drosophila* can be explained by the successive colonisation of newly formed islands by a small number of individuals 'island-hopping' from the neighbouring westerly island. This is represented in the diagram below.



c i What name is given to this small group of colonising individuals? (1 mark)

ii Explain how the new and old colonies became separate species. (3 marks)

(Total 7 marks)

Solution

5-181 [VCAA 2010 E2 SB Q7]

a It is assumed that the oldest layer is at the bottom (deepest) and the youngest layer is near the surface.

b i and ii Any **one** of the following and its associated evidence:

i Hypothesis

The disappearance of bird species is due to hunting by humans.

The disappearance of bird species is due to predation by dogs.

The disappearance of bird species is due to habitat destruction by humans.

The disappearance of bird species is due to volcanic eruptions.

ii Evidence

The number of bird fossils decreases at the same time pottery appears in the fossil record. Pottery indicates the presence of humans.

The number of bird fossils decreases at the same time dog bones appear in the fossil record.

The number of bird fossils decreases at the same time pottery and charred plant remains appear in the fossil record. Pottery and charred plants indicate human settlement and associated habitat destruction.

The number of bird fossils decreases at the same time charred plant remains appear in the fossil record. The plants were destroyed by volcanic eruptions.

c i Founders

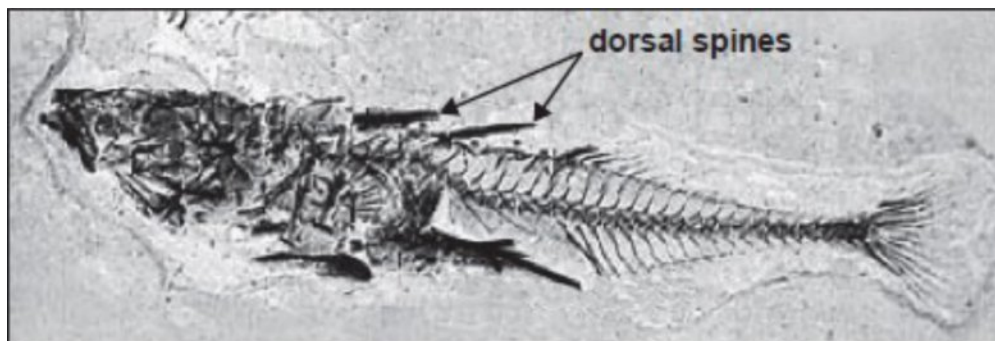
ii The new and old colonies were separated by a geographical barrier (the sea) that resulted in no gene flow. Each population was subject to different selection pressures and, as a result of this and the accumulation

of new mutations, the populations became progressively different. The two populations eventually became so different that when brought back together they could no longer reproduce to produce vigorous, fertile offspring.

Question 12/ 205

[VCAA 2015 SB Q10]

Scientists studying the fossils in an ancient lakebed have an almost perfect fossil record ranging more than 25 000 years. In this fossil record, there are two forms of a fish called a ‘stickleback’. One form has large spines on the back of the fish (dorsal spines) and large pelvic bones. The other form has smaller or no spines and smaller pelvic bones. Modern-day stickleback fish with large dorsal spines are common in the ocean, while the stickleback fish with small spines are more common in fresh water.



The table below contains a summary of some structural features of the fossils found in different sediment layers in the ancient lake bed.

Sediment layer	Pelvis	Dorsal spines
top	small	small or absent
middle	large	large
lower	small	small or absent

a i Suggest a hypothesis that could explain the change in the structural features seen in the different sediment layers. (1 mark)

ii Give evidence from the information provided to support your hypothesis. (2 marks)

b Scientists studying modern-day sticklebacks taken from freshwater lakes have discovered that young fish that grow to have small pelvises and small or no dorsal spines grow more quickly and move faster as young fish than those that grow into fish that have larger pelvises and dorsal spines.

Outline how the sticklebacks with small pelvises have become more common over time in fresh water. (2 marks)

(Total 5 marks)

Solution

5-182 [VCAA 2015 SB Q10]

a i The salinity of the lake has changed over time.

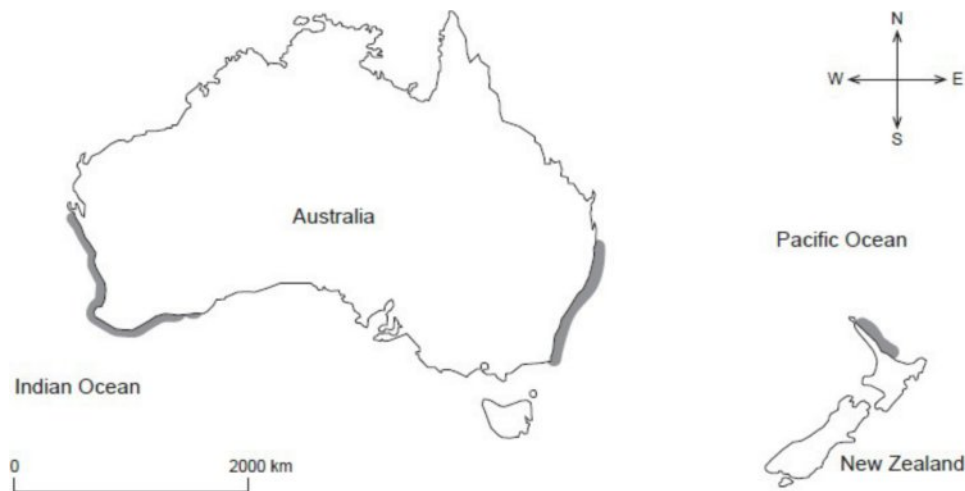
ii The top and lower sediment layers contain fossils that have small pelvis and small or absent spines. These fossilised bones are similar to bones of modern-day fish found in fresh water. This suggests that the lake was fresh when the top and lower sediments were formed. The middle layer contains fossilised bones similar to bones of modern-day fish found in the ocean. This suggests that the lake was salty when the middle sediments were formed.

b Size of pelvis is genetically determined in fish. There was original variation in size of pelvis in the population of fish in the lake. When the water in the lake was fresh, those fish that had small pelvises grew more quickly and were able to escape predators better than those with large pelvises. Those with large pelvises died early and left behind fewer offspring. Those with small pelvises survived and left behind more offspring that inherited the alleles for a small pelvis. Over time, the alleles for small pelvis increased in frequency in the population's gene pool.

Question 13/ 205

[VCAA 2021 SB Q6]

Many species of octopus can be found in the oceans surrounding Australia and New Zealand. Populations of octopus can be found on both the east and west coasts of Australia and on the north coast of New Zealand. The distribution of the populations is shown shaded on the map below.



Source: adapted from MD Amor, MD Norman, HE Cameron and JM Strugnell,
 '... within a cryptic species complex of Australasian octopuses',
PLOS ONE, vol. 9, issue 6, e98982, June 2014,
<https://doi.org/10.1371/journal.pone.0098982>

a Scientists investigated whether the octopus populations on Australia's east coast are a separate species from the populations on the west coast. After analysing both molecular and morphological results, the scientists concluded that all populations share a distant common ancestor. They also concluded that the populations of octopus on the east coast of Australia are a distinct species from the populations of octopus on the west coast of Australia.

Describe the process that may have led to the formation of the two distinct species of octopus from the distant common ancestor. (4 marks)

b The scientists also compared the populations of east Australian octopus with the populations of the New Zealand octopus. No significant genetic differences between these populations of the New Zealand octopus and east Australian octopus were found. It is known that young octopi can be carried long distances by water currents. Occasionally, adult octopi have been seen on pieces of floating wood.

Give **two** reasons that may account for the lack of genetic diversity between the populations. (2 marks)

(Total 6 marks)

Solution

5-183 [VCAA 2021 SB Q6]

a The ancestral octopus population existed when much of Australia was underwater. As the water level dropped, the population was split into two populations separated by land. The two populations were no longer able to interbreed and were subjected to different selection pressures. Different mutations occurred in the separated populations. Over time the populations became so different due to the accumulation of mutations that they were no longer able to interbreed, therefore were two different species.

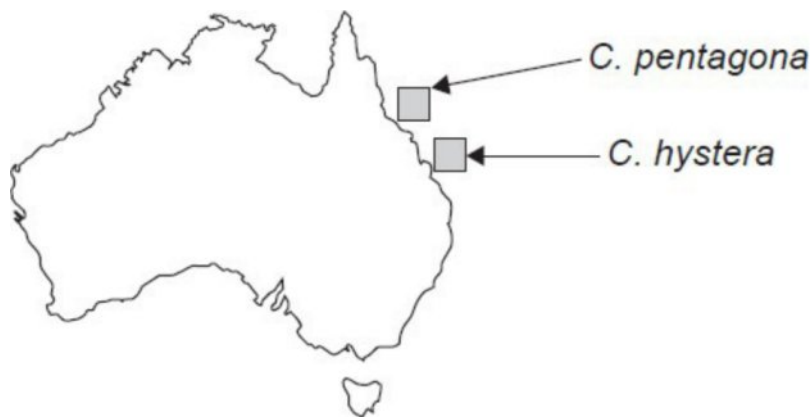
b The lack of genetic diversity between the eastern octopus population and the New Zealand population

may be due to gene flow. The octopi can be carried long distances by water currents and can therefore interbreed. Secondly, if the environments where the octopi are found in Australia and New Zealand are similar, similar traits will be selected for in both populations resulting in a lack of genetic diversity.

Question 14/ 205

[VCAA 2016 SB Q8]

Two species of *Cryptasterina* sea stars are found in coastal Queensland. *Cryptasterina pentagona* is found in warmer water further north, while *Cryptasterina hystera* is found further south in cooler water.



Researchers have concluded that these two species arose from a recent common ancestor via natural selection. They believe that, over thousands of years, the sea environment has changed, with the boundary line between cold water and warm water moving further north. They have found that water temperature and predation of sea star larvae by cold-water predators are important selection pressures for these sea stars.

a Using the information above, explain how natural selection can lead to differences in phenotypes between these two sea star species. (4 marks)

b One of the phenotypic differences between these two species of sea stars is their method of reproduction. *C. pentagona* reproduces sexually and its sperm and eggs are free-floating in the ocean.

C. hystera self-fertilises and its fertilised eggs are kept within the sea star until maturity. The researchers found that one species of *Cryptasterina* has a significantly higher diversity of alleles in its gene pool than the other species.

Using this information about reproduction strategies, which species of *Cryptasterina* would you expect to have the highest diversity of alleles? Explain your answer. (2 marks)

(Total 6 marks)

Solution

5-184 [VCAA 2016 SB Q8]

a Originally there was one population of sea stars that differed genetically and phenotypically. The population became separated with little gene flow between the two new populations. Those sea stars in the south were exposed to lower water temperatures and predation by cold water predators. Those sea stars that had adaptations that allowed them to survive in cold water or cold-water predators, survived, reproduced and their offspring inherited their favourable adaptations. In the north, those sea stars that had adaptations that allowed them to survive in warmer water survived, reproduced and their offspring inherited their favourable adaptations. As a result of these different selection pressures, over time the populations would become progressively phenotypically different.

b *Cryptasterina pentagona* would have the highest diversity of alleles as offspring result from the gametes produced by different individuals, whereas *C. hystera* offspring result from gametes produced by one individual.

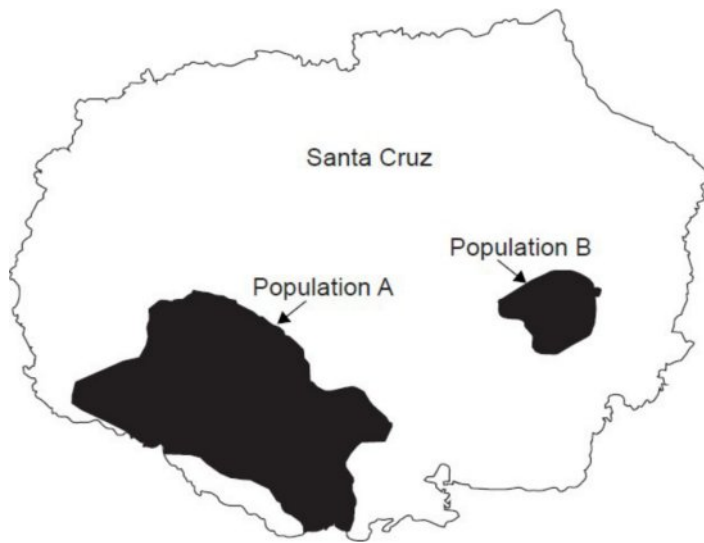
Question 15/ 205

[VCAA 2016 SB Q9]

Galápagos tortoises (*Chelonoidis* spp.) can be found on many of the islands that make up the Galápagos Islands. Originally, 14 different species were identified based on the islands on which they lived and on their morphology.

Santa Cruz, the second largest of the Galápagos Islands, has two isolated tortoise populations. Population A contains more than 2000 individuals covering an area of 156 square kilometres. Population B is a small population of 250 individuals covering an area of 40 square kilometres.

The position of the two populations on the island of Santa Cruz is shown below. The two populations are separated by a distance of 20 kilometres.



In 2015, scientists investigated whether the individuals of the two populations belong to the same species or whether they are two different species.

Average measurements of skull size were calculated for tortoises belonging to both populations A and B. The skulls were measured in six different places. The six measurements were also compared to average measurements taken from skulls of other Galápagos tortoise species. The results are shown in the table below.

Comparisons have been made with three other Galápagos tortoise species.

Measurement position	Average skull measurement (mm)				
	Population B	Population A	<i>Chelonoidis vicina</i>	<i>Chelonoidis chathamensis</i>	<i>Chelonoidis ephippium</i>
1	118	98	86	80	74
2	40	37	28	27	25
3	21	18	16	14	12
4	26	23	21	18	17
5	10	9	8	7	6
6	19	17	16	14	13

a Consider the data given.

Does the data support the hypothesis that individuals in Population A belong to a different species from individuals in Population B? Explain your answer. (2 marks)

b Scientists have carried out genetic studies on the two populations.

Give an example of genetic evidence that may be produced by scientists to support the hypothesis that individuals of the two populations belong to different species. Explain your answer. (2 marks)

c Some scientists thought that allopatric speciation may have occurred on the island of Santa Cruz.

i Name a feature that scientists would look for in the island environment to support the occurrence of allopatric speciation. (1 mark)

ii Explain how the feature named in **part c.i.** could contribute to allopatric speciation. (2 marks)

(Total 7 marks)

Solution

5-185 [VCAA 2016 SB Q9]

a Yes. Populations B and A have different skull sizes. For example, the difference between B and A for measurement position 1 is 20 mm. The difference between the other 3 species ranges from 4 to 8 mm which is smaller than between B and A.

b Comparison of karyotypes. Different number of chromosomes in the karyotypes of the two populations would suggest that the two populations belong to different species. To belong to one species, individuals must be able to produce vigorous fertile offspring. If individuals of each population have a different number of chromosomes in their karyotypes, they will produce gametes with a different number of chromosomes. The cells of individuals formed from the fertilisation of these gametes will contain non-homologous chromosomes and will therefore not be able to undergo meiosis and the individual will be infertile.

Or

Comparison of DNA sequences. Different DNA sequences in the DNA of the two populations. The greater the difference in DNA sequences the longer the time since divergence from a common ancestor and the more likely the two populations are different species.

Or

Comparison of mitochondrial DNA. Different mitochondrial DNA sequences in the DNA of the two populations. The greater the difference in DNA sequences the longer the time since divergence from a common ancestor and the more likely the two populations are different species.

c i Any **one** of: mountain, large river, canyon, lake

ii This feature would stop gene flow between the two populations of tortoise. Different selection pressures on each population would lead to different phenotypes being selected for and the populations would become increasingly different until when the populations were brought back together they could no longer produce vigorous, fertile offspring.

Question 16/ 205

[VCAA 2019 SB Q7]

Consider the information provided on the three species shown in the table that follows.

Species	rock hyrax	elephant	dugong
			
Size	small terrestrial mammal (2–5 kg)	large terrestrial mammal (4500–6000 kg)	mid-sized marine mammal (150–300 kg)

a These three species are closely related, sharing a relatively recent common ancestor, but have different features.

Identify the type of evolution involved. Justify your response. (2 marks)

In 2014 palaeontologists discovered a frozen, well-preserved, complete specimen of an extinct species, the steppe bison, in Siberia. The intact specimen was dated at 9300 years old.

b Scientists are debating the cause of the steppe bison's extinction. Give **one** possible cause of its extinction. (1 mark)

c Though steppe bison are extinct, palaeontologists know a lot about them as they have found several frozen, intact steppe bison bodies.

Describe what would have occurred to lead to the preservation of the animal from when the steppe bison died to when the frozen, well-preserved remains were discovered. (4 marks)

(Total 7 marks)

Solution

a Type of evolution: Divergent

Divergent evolution occurs when populations of organisms that have a recent common ancestor are exposed to different selection pressures and therefore appear different. These animals are all mammals, therefore they are closely related and have a recent common ancestor. They have been exposed to different selection pressures – hyrax living in rocky outcrops, the elephant in the savannah and the dugong in the sea.

b Any **one** of the following:

- The bison were hunted by humans.
- The bison had gone through a bottleneck and were genetically similar. When the environment, e.g. a new disease changed to the detriment of one, it was to the detriment of all, so they died out.
- The bison were descended from a small group that moved to the area. They were genetically similar. When the environment, e.g. a new disease changed to the detriment of one, it was to the detriment of all so they died out.

c The animal died and quickly was covered by snow (snow meant that liquid water/oxygen was not available to decomposers therefore the body did not decompose. The area was permanently cold, so the body did not thaw out.

Question 17/ 205

[VCAA 2021 SB Q7]

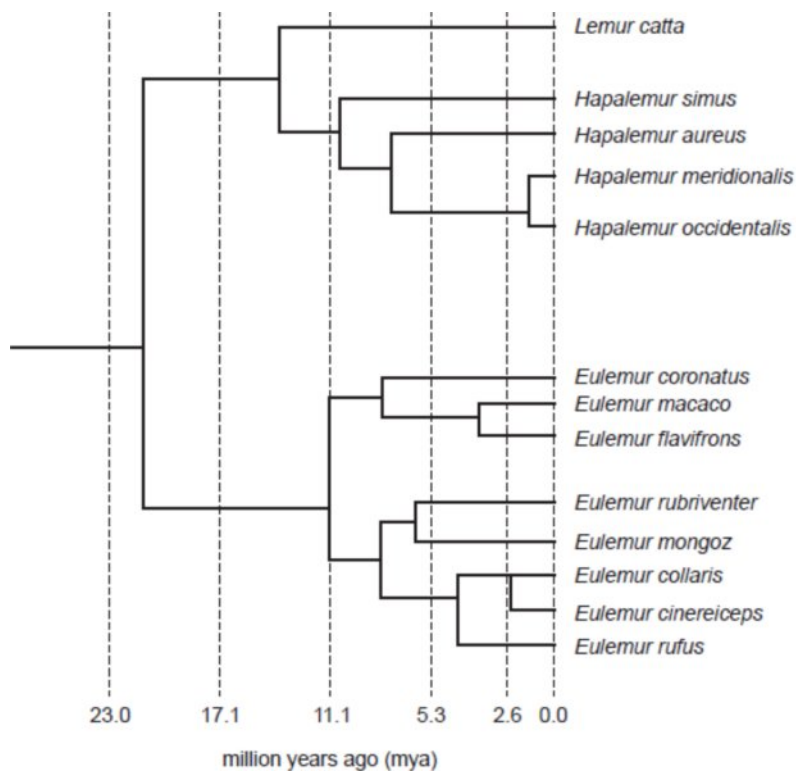
Lemurs belong to the order Primates and are found in the wild only on the African island of Madagascar.

a Identify **two** structural features that are common to most primates and that distinguish them from other mammal groups. (2 marks)

A team of biologists combined morphological data from extinct and living lemur species, along with genetic data, to produce a phylogenetic tree for lemurs. The biologists used published sequences from mitochondrial DNA (mtDNA) as a molecular clock.

b Give **two** advantages of using mtDNA as a molecular clock. (2 marks)

A small part of the phylogenetic tree for lemurs, constructed by the biologists, is shown below.



Source: adapted from JP Herrera and LM Dávalos, 'Phylogeny and divergence times of lemurs inferred with recent and ancient fossils in the tree', *Systematic Biologists*, 65(5), 2016, p. 781

c Describe the phylogenetic relationships between *Lemur catta*, *Eulemur coronatus* and *Eulemur flavifrons*, as shown in the phylogenetic tree shown. (2 marks)

d Biologists isolated DNA from different species of present-day lemurs and performed DNA hybridisation.

Outline the main steps in the process of DNA hybridisation and explain how DNA hybridisation supports the relationships shown in the phylogenetic tree above. (4 marks)

(Total 10 marks)

Solution

5-187 [VCAA 2021 SB Q7]

a Any **two** of the following structural features common to most primates.

- nails on digits
- opposable digits
- large forward-facing eyes.

b Any **two** of the following advantages of mtDNA:

- mtDNA is inherited from the mother only, whereas nuclear DNA is inherited from both the mother and the father. Therefore, any changes in base sequences can be tracked directly and are not due to recombination during meiosis.
- There are many mitochondria in each cell, each with the same mitochondrial DNA; therefore, there are many copies of each mitochondrial gene.
- Mitochondrial DNA is shorter and simpler than nuclear DNA; therefore, it is easier to track changes in sequence.
- The high, known mutation rate can be used to estimate the time of divergence for different species. The high rate means that mitochondrial DNA can be used to separate closely related species.

c *Eulemur coronatus*, *Eulemur flavifrons* and *Lemur catta* shared a common ancestor 20 mya. *Eulemur coronatus* and *Eulemur flavifrons* share a more recent common ancestor and are more closely related to each other than to *Lemur catta*.

d The DNA from the two species is mixed and then heated (94°C) so that the double-stranded DNA becomes single-stranded. The DNA is cooled (55°C), allowing double-stranded DNA to form that is composed of one strand from each species. The DNA is then reheated. The higher the temperature required to denature the hybrid DNA, the greater the number of complementary bonds and, therefore, the greater the similarity.

Closely related species will have similar DNA sequences as there has been little time for mutations to accumulate since divergence from a common ancestor; therefore, the higher the temperature required to separate the hybrid DNA, the more closely related the organisms. *Hapalemur meridionalis* and *Hapalemur occidentalis* would have the most similar DNA as the point of divergence is most recent.

Question 18/ 205

[VCAA 2022 SB Q8]

There are 13 species of small birds commonly known as Darwin's finches, found only on the Galápagos Islands in the Pacific Ocean, 1000 km west of South America. Their closest living relative is the dull-coloured grassquit, *Asemospiza obscura*, which is found on mainland South America. It is believed that Darwin's finches evolved from *A. obscura* or from its ancestor on the mainland. The different finch species are similar in colour but vary in beak size and shape, habitat and diet.

a Discuss how the different species of Darwin's finches arose from an ancestral population on the mainland. In your response, name the type of speciation that occurred, identify the main selection pressure that has acted on finch populations and explain how the Galápagos Islands enabled rapid speciation. (6 marks)

The table that follows shows the distribution of Darwin's finch species on the Galápagos Islands.

The species of Darwin's finches found on each island of the Galápagos

Species	Abbreviated name of island															
	Esp.	Fern.	Flor.	D. Maj.	Gen.	Isa.	Pint.	Mar.	N. Sey.	Pinz.	Rab.	S. Cris.	S. Cruz	S. Fe	Santi.	W. & Dar.
<i>Certhidea olivacea</i>	✓	✓	✓		✓	✓			✓	✓	✓		✓		✓	
<i>Certhidea fusca</i>	✓		✓		✓		✓	✓				✓		✓		
<i>Geospiza scandens</i>			✓	✓	✓	✓	✓		✓	?	✓	✓	✓	✓	✓	
<i>Geospiza conirostris</i>	✓															
<i>Geospiza magnirostris</i>		✓	extinct	✓	✓	✓	✓	✓		✓	✓	extinct	✓	extinct	✓	
<i>Geospiza psittacula</i>		✓	extinct			✓	✓	✓		extinct	✓		✓	✓	✓	
<i>Geospiza heliobates</i>						✓										
<i>Geospiza fortis</i>		✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
<i>Geospiza pauper</i>			✓													
<i>Geospiza difficilis</i>		✓	extinct				✓						extinct			✓
<i>Geospiza fuliginosa</i>	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
<i>Geospiza parvula</i>		✓	✓	✓		✓			✓	✓	✓	✓	✓	✓	✓	
<i>Geospiza pallida</i>		?				✓				?		✓	✓		✓	

Source: Galapagos Conservation Trust, 'Darwin's finches', <<https://galapagosconservation.org.uk/wildlife/darwins-finches/>>

b Using the table above, identify the species of Darwin's finches that is currently the most widely distributed. (1 mark)

c The species *G. magnirostris*, *G. psittacula* and *G. difficilis* are listed as 'extinct' on several islands. Describe two types of evidence that would allow biologists to classify a species as extinct on a particular island. (2 marks)

(Total 9 marks)

Solution

5-188 [VCAA 2022 SB Q8]

a The type of speciation is allopatric speciation.

Asemospiza obscura or its ancestor may have been blown by storms to the different Galapagos Islands. Genetic variation in the founding populations resulted in different beak sizes. The populations on the different islands were isolated from each other by the water that separated the islands. This resulted in no gene flow between the populations. The different vegetation on each of the islands resulted in different selection pressures. Different beaks were selected for on each island depending on the type of food available. The selected birds survived, reproduced and their offspring inherited the same beaks. Over many generations, different mutations accumulated in each population resulting in populations on different islands that could no

longer interbreed to produce vigorous, fertile offspring.

b *Geospiza fuliginosa*

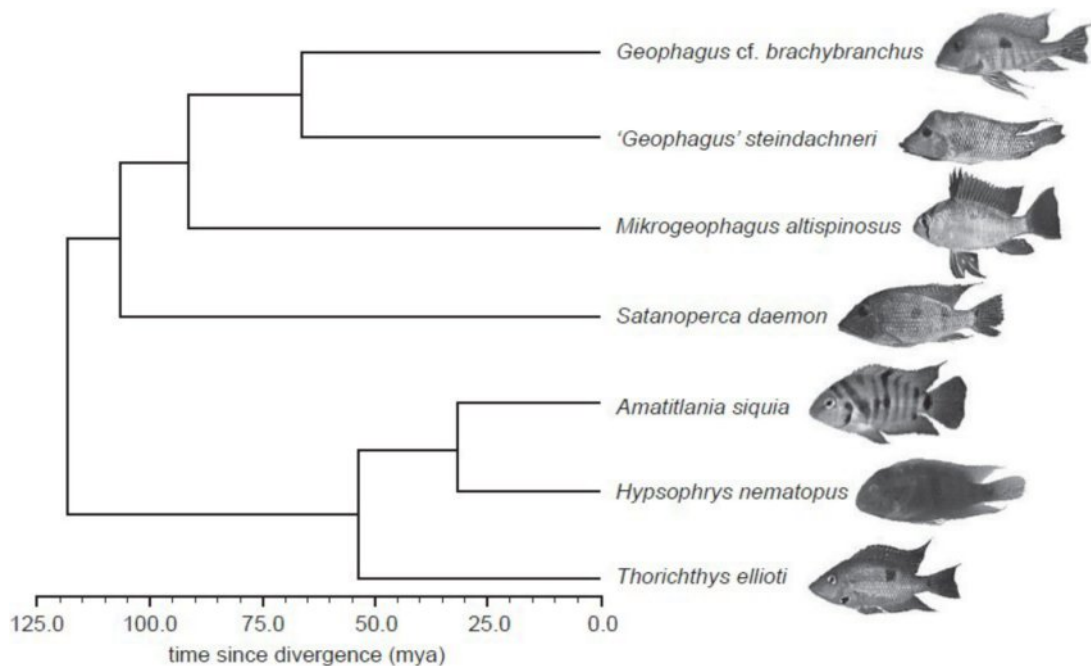
c Any **two** of the following pieces of evidence of extinction:

- No members of the species have been sighted on the islands
 - No evidence of recently used nesting sites
 - Presence of fossils indicating that individuals had existed on the islands in the past.
-

Question 19/ 205

[VCAA 2020 SB Q8]

The phylogenetic tree below shows the evolutionary relationship between seven species of cichlid fish.



Source: H López-Fernández et al.,
'Morphology and efficiency of a specialized foraging behavior, sediment sifting,
in neotropical cichlid fishes', *PLoS ONE*, 9(3): e89832,
6 March 2014, <<https://doi.org/10.1371/journal.pone.0089832>>

a Molecular homology can be used to construct a phylogenetic tree. Based on the information above, state which two species of cichlid fish would be expected to have the most similar amino acid sequences in their proteins. Justify your answer. (3 marks)

b Fossils of species of fish are more likely to be found than fossils of land-dwelling animals. Explain why this is the case with reference to two conditions required for the fossilisation of an organism. (2 marks)

c A group of scientists stated that a particular fossilised fish was 5000 years old. Outline a dating technique that could have been used by the scientists to determine the age of the fossil. (2 marks)

(Total 7 marks)

Solution

5-189 [VCAA 2020 SB Q8]

a *Amatitlania siquia* and *Hypsophrys nematopus*. The shortest time has passed since their divergence; therefore, they have the most recent common ancestor, so there has been less time for mutations that code for different amino acids to accumulate.

b Fossilisation occurs when organisms are protected by decay from decomposers. When an organism dies in water, it is more quickly covered by sediments than on land. This reduces disturbance from scavengers and the low oxygen environment does not allow decomposers to survive.

c Carbon-14 dating

Carbon-14 is radioactive and along with carbon-12 is incorporated into the bodies of organisms at a rate that stays constant while the organism is alive. When an organism dies, it is no longer eating or breathing in carbon and as the carbon-14 decays, the ratio of ^{14}C to ^{12}C changes. By comparing the ratio of ^{14}C to ^{12}C in a fossil with the known half-life, it is possible to calculate how much time has passed.

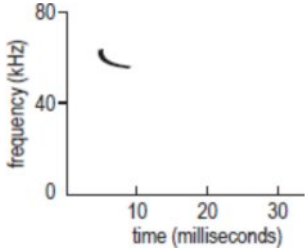
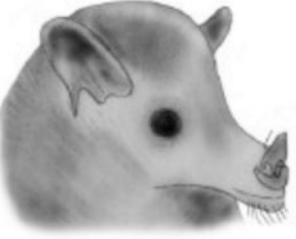
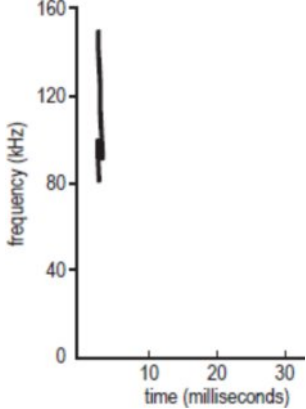
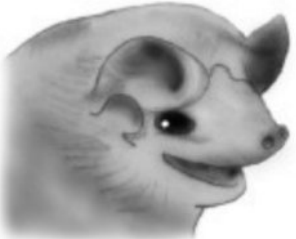
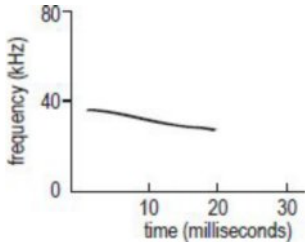
Question 20/ 205

[VCAA 2012 E2 SB Q5]

Barro Colorado Island is a small island covered by tropical forest in Central America. Seventy-four different species of bats live in the forest.

Bats are nocturnal, flying mammals. To find their way around in darkness, many bat species emit high-frequency sound pulses that bounce off obstacles and prey. These pulses enable them to judge the distance to an object. This behaviour is called echolocation.

Three of the Barro Colorado Island species are described in the table on the next page.

Species name	Facial appearance of bat	Diet	Feeding location	Echolocation signal
Black myotis bat (<i>Myotis nigricaris</i>)		insects	around trees at forest's edge and in clearings	
Mexican long-tongued bat (<i>Choeronyct eris mexicana</i>)		Nectar and pollen flowers that open at night, for example cactus, agave	narrow gaps and small spaces	
Velvety free-tailed bat (<i>Molossus molossus</i>)		Insects	above trees, in open spaces	

a From the information provided, state **one** selection pressure operating on the bats of Barro Colorado Island. (1 mark)

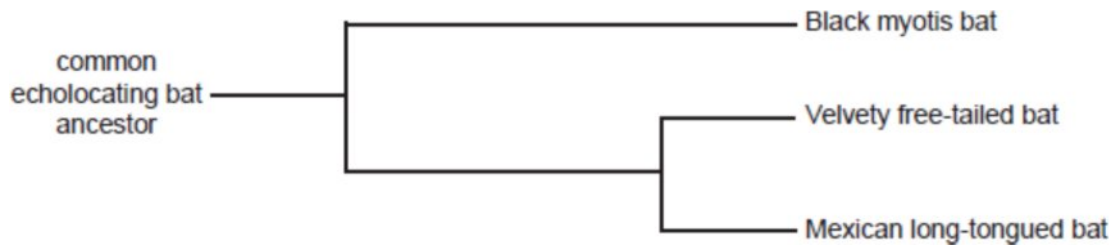
b i In terms of time, which of the three species emits the longest echolocation signal? (1 mark)

ii Explain how this could be a selective advantage for this bat species. (1 mark)

c A biologist suggested that the three species shown evolved from a recent common ancestor. What is this type of evolution called? (1 mark)

The biologist wanted to establish the order in which each species had evolved from the common ancestor. DNA hybridisation between the various species was carried out.

After analysing the results, the scientist drew the following phylogenetic tree.



d What results would have been obtained from the DNA hybridisation that led the biologist to construct this phylogeny? (2 marks)

e A student suggested that the evolution of the three species was an example of allopatric speciation. Explain why you agree or disagree with the student. (2 marks)

(Total 8 marks)

Solution

5-190 [VCAA 2012 E2 SB Q5]

a Availability of prey/food (Not just diet, predators or feeding location)

b i Velvety free-tailed bat (*Molossus molossus*)

ii Velvety free-tailed bats feed above the trees in open spaces. There are few objects to bounce signals off therefore if the closest object is far away there may be long delay before the pulse is bounced back to the bat. If many short signals were sent, it would be difficult to establish which signal is returning. Longer signals travel better over larger distances, increasing the chance of velvety free-tailed bats finding food.

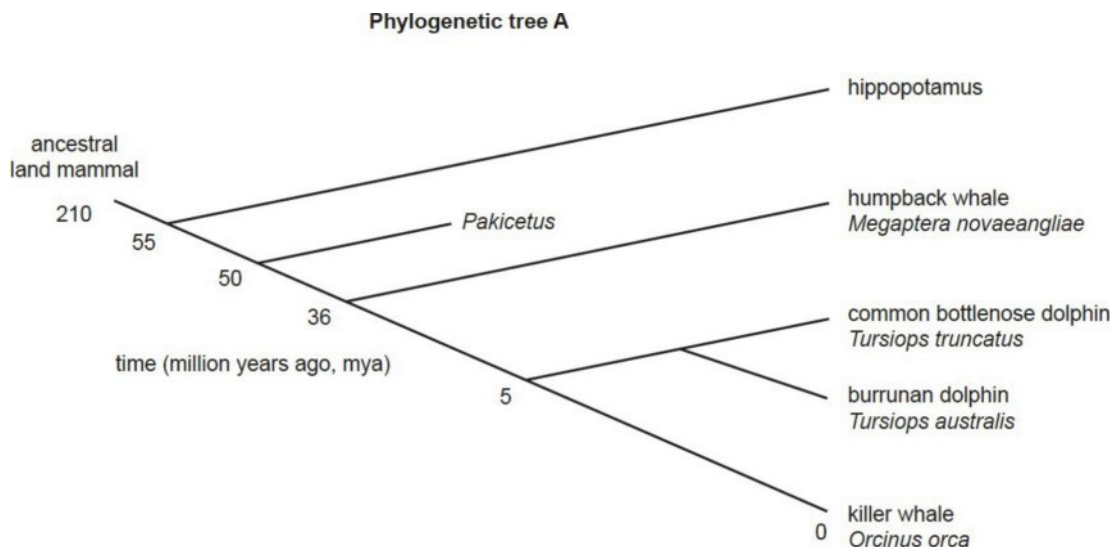
c Divergent evolution (adaptive radiation)

d Velvety free-tailed bats and Mexican long-tongued bats would have fewer differences in their DNA than between themselves and the black myotis bat. The approximate number of differences between the velvety free-tailed bat and the myotis bat would be the same as the number of differences between the Mexican long-tongued bat and the black myotis bat.

e Disagree. Allopatric speciation occurs when one population is split into smaller populations separated by a geographical barrier. These bats are all living in the same forest/island, therefore are not separated by a geographical barrier.

Cetaceans (whales, porpoises and dolphins) are marine mammals belonging to the order Artiodactyla (even-toed hoofed mammals). The closest living relatives of cetaceans are the hippopotamuses.

Phylogenetic tree A summarises the evolutionary relationships of four present-day cetacean species and the hippopotamus.



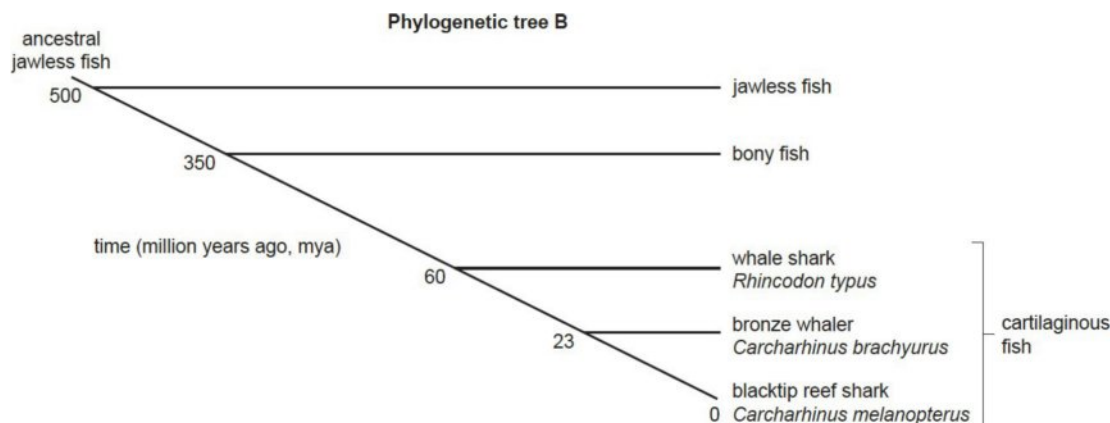
a What does the length of the line that represents the evolution of *Pakicetus* suggest? (1 mark)

b A fossil named *Ambulocetus* was found in 1992 and dated at 49 million years old. Some palaeontologists believe that it is a transitional fossil between the ancestral land mammal shown in Phylogenetic tree A and present-day cetaceans.

Predict **two** structural features of the *Ambulocetus* fossil that would provide evidence to support the hypothesis that it is a transitional fossil and suggest a survival advantage of each feature. (3 marks)

Sharks are marine fish of the order Chondrichthyes (cartilaginous fish).

Phylogenetic tree B summarises the evolutionary relationships of three present-day shark species and main fish classes.



The table below provides information about the present-day species shown in phylogenetic trees A and B.

Marine animal		Average length (m)	Diet
	Humpback whale <i>Megaptera novaeangliae</i>	16	filters plankton and krill by sucking water into mouth through baleen plates
	common bottlenose dolphin <i>Tursiops truncatus</i>	4	hunts fish, squid and crustaceans
	burrunan dolphin <i>Tursiops australis</i>	3	hunts fish and squid
	killer whale <i>Orcinus orca</i>	10	hunts sea birds, squid, seals, baleen whales, dolphins, fish, sharks and sea turtles depending on location
	whale shark <i>Rhincodon typus</i>	12	filters plankton, small squid and fish through filter pads and 300 rows of teeth
	bronze whaler <i>Carcharhinus brachyurus</i>	3	hunts squid, bony fish and other cartilaginous fish
	blacktip reef shark <i>Carcharhinus melanopterus</i>	2	hunts small bony fish, squid and shrimp

c i Give a specific example of **divergent** evolution using two animals from the information provided in Phylogenetic trees A & B and the table above and justify your response. (2 marks)

ii Give a specific example of **convergent** evolution using **two** animals from the information provided in Phylogenetic trees A and B, and the table above and justify your response. (2 marks)

In 2011, Australian scientists identified the burrunan dolphin as a separate species from the common bottlenose dolphin. They gathered evidence from living dolphin populations as well as museum specimens.

d Briefly describe **two** types of evidence that the scientists would have used to establish whether the burrunan dolphin is a separate species from the common bottlenose dolphin. (2 marks)

e Burrunan dolphins are found only in Port Phillip Bay and the Gippsland Lakes in Victoria. There are only 150 burrunan dolphins alive today. The Port Phillip Bay population is very isolated and rarely mixes with dolphins outside the bay. Port Phillip Bay is impacted by the human population and industry of Melbourne and surrounding towns, and is used heavily for recreation, fishing and shipping.

Suggest **two** possible future outcomes for the Port Phillip Bay population of burrunan dolphins. Justify each outcome. (2 marks)

(Total 12 marks)

Solution

5-191 [VCAA 2018 SB Q9]

a The line does not continue to the present time therefore *Pakicetus* became extinct.

b Any **one** of:

- the presence of even-toed hooves allowing *Ambulocetus* to walk on land
- the presence of short legs allowing *Ambulocetus* to walk on mud

And **one** of:

- a streamlined body shape allowing *Ambulocetus* to move easily through water
- the presence of a blow hole on the top of the skull allowing *Ambulocetus* to breathe under water
- the presence of a flat tail/fins to help *Ambulocetus* swim

c i Any **two** mammals, e.g. hippopotamus and killer whale or any two fish, e.g. bronze whaler and blacktip reef shark, and as they have a recent common ancestor but have diverged as a result of different selection pressures.

ii One mammal and one shark, e.g. whale shark and humpback whale and as they do not have a recent common ancestor but have been subject to similar selection pressure resulting in structures enabling them to filter feed.

d Any **two** of the following:

- Interbreed the burrunan dolphin and common bottlenose dolphin. If they cannot produce vigorous, fertile offspring they are different species.
- Use DNA hybridisation to compare the DNA sequences of burrunan dolphins and common bottlenose dolphins. Many differences would suggest they are different species.
- Compare the sequence of amino acids in their proteins. Many differences would suggest they are different species.
- Compare structural features of their skulls/bones. Many differences would suggest they are different species.

e Any **two** of the following:

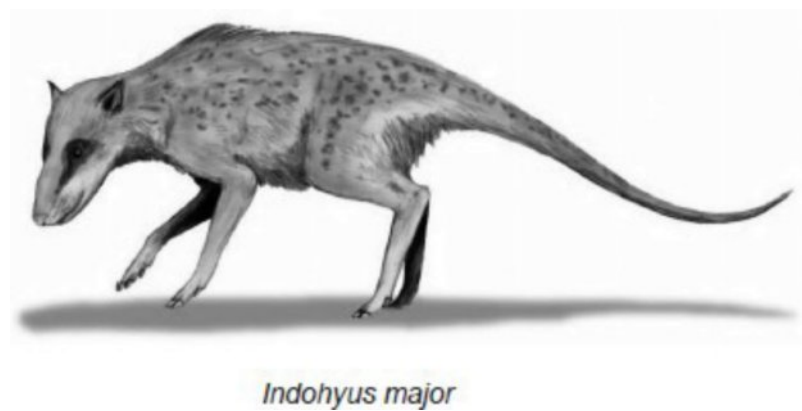
- The burrunan dolphin may become a separate species as there is no gene flow between the populations and there are different selection pressures acting on each population
- The burrunan dolphins may become extinct as a result of overfishing and/or pollution.

- As there is no gene flow between the populations, the burrunan dolphins would have low genetic diversity. If the environment changes to the detriment of one individual, it will be to the detriment of all individuals, increasing the chance of extinction.
-

Question 22/ 205

[VCAA 2015 SB Q9]

A fossil of an extinct species called *Indohyus major*, found in northern India, is thought to share a recent common ancestor with the group of living organisms called cetaceans. Cetaceans include dolphins and whales.



a Name the type of evolution that describes the relationship between *I. major* and cetaceans. (1 mark)

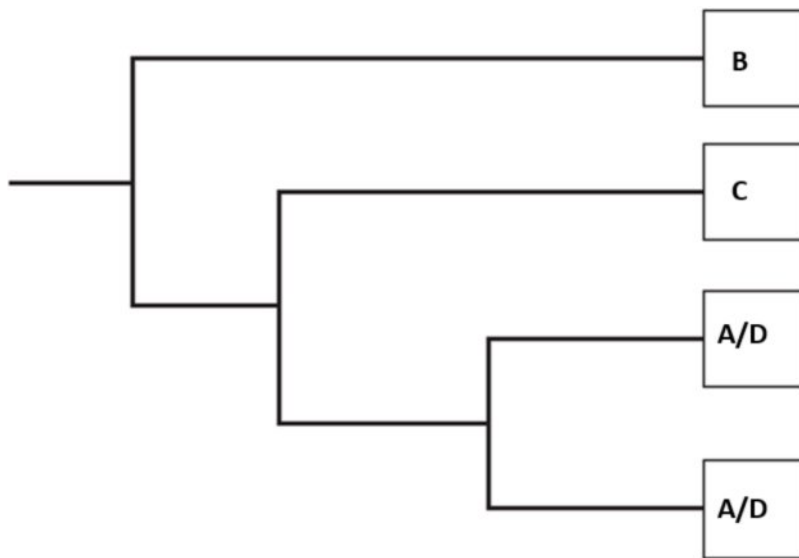
For a long time, scientists have believed that cetaceans are related to the group of terrestrial mammals classified as artiodactyls, which includes pigs and hippopotami. The name ‘artiodactyl’ refers to the shape of the feet or hooves of these animals.

To work out the evolutionary relationships between *I. major* and living animals, scientists closely studied their bones and skeletal structures.

b What name is given to the study of the similarities and differences between the bones and skeletal structures of animals, including fossils of extinct species? (1 mark)

The table below shows a summary of the scientists’ findings.

Animal	Feet	Limb bones	Inner-ear bones
cetaceans (e.g. whales)	artiodactyl	thick	thick
suids (e.g. pigs)	artiodactyl	thin	thin
hippopotamids (e.g. hippopotami)	artiodactyl	thick	thin



ii Organism that share a more recent ancestor will be more similar as there is less time for mutations to accumulate. Whales and *L. major* have the most features (3) in common, therefore they are the closest together on the tree. Whales and *L. major* share two features with the hippopotamids and only one with the suids so are more closely related to the hippopotamids than the suids.

Question 23/ 205

[VCAA 2010 E2 SB Q6]

DNA sequencing is often performed to help produce phylogenetic trees or to classify organisms. Sections of nuclear DNA from similar organisms are sequenced and compared for similarities.

a Name and describe another DNA method that is used to determine how closely related two species are. (2 marks)

Scientists use a specific mitochondrial gene called *cox1* in comparative studies in fish. The *cox1* gene lacks introns and is only 654 bp long, making it economical and easy to sequence. The sequenced gene appears like a 'barcode' found on grocery products, for example:



A worldwide database has over 45 000 *cox1* gene sequences obtained from different kinds of fish. Illegal fishing occurs in Australian waters. Often only a small portion, such as a fin, is kept by the fishermen and the remainder is thrown overboard.

b How would the barcode database be used to identify the fish species that had been caught by the

fishermen? Provide an example of a situation (other than illegal fishing) when humans would want to identify the fish species. (2 marks)

Scientists using the *cox1* gene have seen that even within the same species of fish, differences within the DNA sequence can occur. The scientists believe this is often due to the redundancy in the genetic code.

c Explain what redundancy in the genetic code means. (1 mark)

As the database grows it is hoped that at least five samples for each species will be collected and analysed. The species samples will be taken from as many different locations as possible.

d Why is it important to sequence multiple samples from the same species? (1 mark)

(Total 6 marks)

Solution

5-193 [VCAA 2010 E2 SB Q6]

a Any **one** of the following:

Name	Brief description
DNA hybridisation	Chromosomes from two species are isolated and mixed. They are heated so that they denature and separate. The mixture is allowed to cool and DNA to anneal so that pieces consist of one chain of DNA from the first species and one chain of DNA from the second species. The DNA is then reheated. The higher the temperature required for the DNA to denature, the more complementary the bonding and the more closely related the species.
mDNA sequencing	Mitochondrial DNA from two species is extracted and sequenced. The resulting sequences are compared. The more similar the sequences, the more closely related the species.

b Most cells of the fish contain mitochondria. Therefore, mitochondrial analysis can be performed on any part of the fish including a portion of a fin. This can then be compared to the database and the identity of the fish determined.

Any **one** of the following examples where humans would want to identify fish species:

- to identify endangered species
- to monitor fish population numbers
- to monitor fish movements

- to help identify fish wholesalers who are selling incorrectly labelled fish.

(*Note:* The sequenced gene looks like a barcode. It is not attached to the fish as a barcode.)

- c** Redundancy in the genetic code means more than one triplet/codon codes for the same amino acid.
 - d** Multiple samples from the same species ensures the accuracy of results as it allows the identification of any variations/mutations that may occur in the same species.
-

Question 24/ 205

[VCAA 2013 SB Q10]

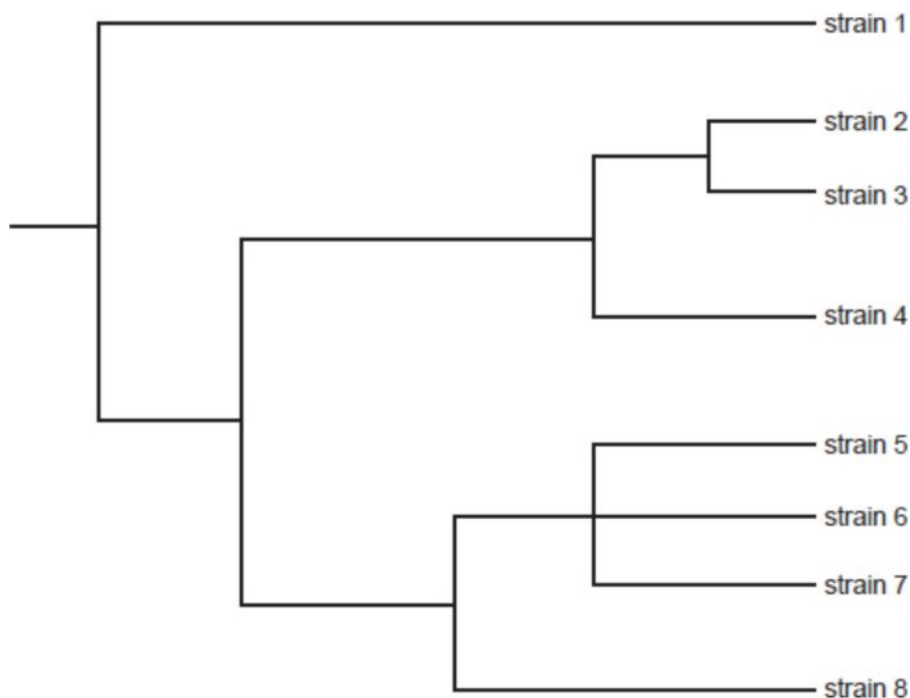
In humans, severe acute respiratory syndrome (SARS) is a serious form of pneumonia. SARS is caused by a coronavirus that was first identified in 2003.

Scientists suspected that the virus had been transmitted to humans from some other animal. Testing was completed on several animal species. Strains of the coronavirus similar to those found in humans were identified in different species of horseshoe bats (genus *Rhinolophus*) and palm civets (*Paguma larvata*).

Samples were taken from the different sources and the virus's RNA from each sample was sequenced.

- a** What molecular information would the scientists obtain from sequencing RNA? (1 mark)

The molecular information enabled the scientists to draw an evolutionary tree for different strains of the coronavirus. The following evolutionary tree was drawn.



b Coronavirus strains 2 and 3 are the most similar of the strains. Using your knowledge and the information given in the evolutionary tree, give **two** possible explanations as to why they are the most similar of the strains. (2 marks)

Strain 7 is found in palm civets, and strains 5 and 6 in humans. All other strains are found in different species of horseshoe bats.

c What conclusion can be drawn about the origin of the strain of virus that causes SARS in humans? (1 mark)

(Total 4 marks)

Solution

5-194 [VCAA 2013 SB Q10]

a Sequencing the RNA would show the order of nucleotides present in the viral RNA or the order of amino acids in proteins coded for by the viral RNA.

b Strains 2 and 3 are the most similar of the strains because they have the **most recent** common ancestor, therefore there has been a shorter time to accumulate mutations/genetic differences.

c The strain of virus that causes SARS in humans originated in bats and viral strains 5, 6 and 7 **share a recent common** ancestor.

Question 25/ 205

[VCAA 2020 SB Q9]

In 1931 a team of Dutch archaeologists unearthed 12 skulls and two leg bones at a site in Ngandong, Indonesia.

a Describe **two** key structural features of these fossils that would suggest that the skulls were from *Homo erectus* rather than from *Homo sapiens*. (2 marks)

Figure 1 and Figure 2 below show *Homo* evolutionary trees that were created in 1997 and 2013 respectively.

1997 *Homo* evolutionary tree

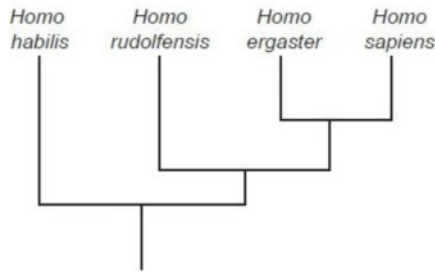


Figure 1

2013 *Homo* evolutionary tree

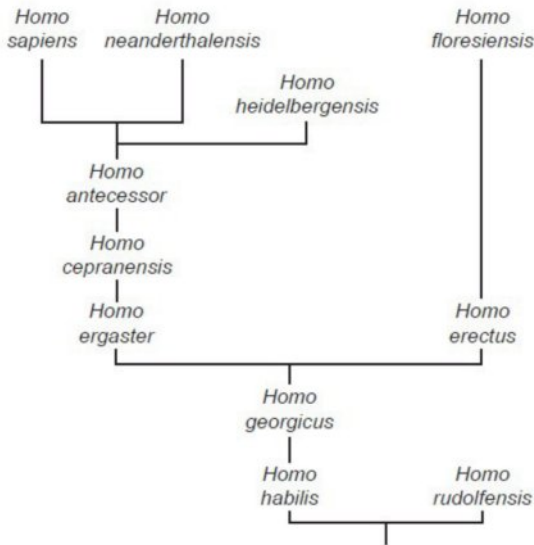


Figure 2

Sources (from left): adapted from DS Strait, FE Grine and MA Moniz, 'A reappraisal of early hominid phylogeny', *Journal of Human Evolution*, volume 32, issue 1, January 1997, pp. 17–82; C Schultz, 'Homo Sapiens' family tree may be less complicated than we thought', *Smithsonian Magazine*, 18 October 2013, <www.smithsonianmag.com>

b State **one** difference between Figure 1 and Figure 2 with respect to the evolutionary relationships between *Homo ergaster* and *Homo sapiens*. (1 mark)

Homo denisovan is one species that is missing from both evolutionary trees shown in the previous figures.

c Draw a branch on Figure 2, the 2013 *Homo* evolutionary tree, that represents where you think *Homo denisovan* should be placed. Justify why you have put the branch in that position. (2 marks)

d Scientists do not always agree on the position of each *Homo* species on evolutionary trees. Explain why this is the case. (2 marks)

(Total 7 marks)

Solution

5-195 [VCAA 2020 SB Q9]

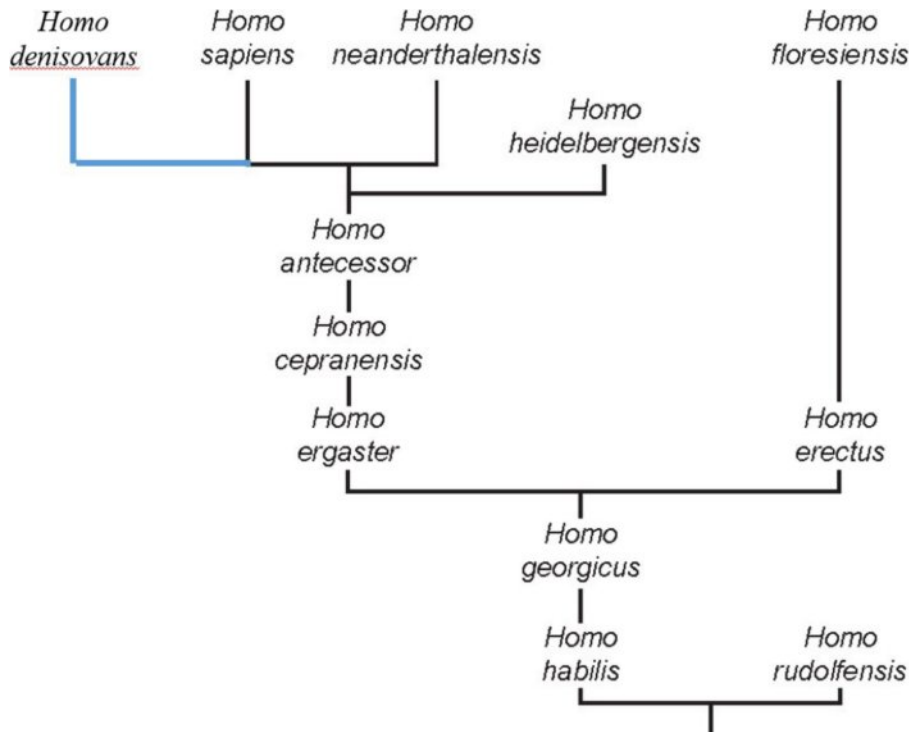
a Any **two** of the following:

- *Homo erectus* would have a larger brow ridge than *Homo sapiens*.
- *Homo erectus* would have a small braincase than *Homo sapiens*.
- *Homo erectus* would have a more sloping forehead than *Homo sapiens*.

- *Homo erectus* would have a small braincase than *Homo sapiens*.
- *Homo erectus* would have a less parabolic jaw than *Homo sapiens*.
- *Homo erectus* would have a thicker jaw than *Homo sapiens*.
- *Homo erectus* would have less slender zygomatic arch than *Homo sapiens*.

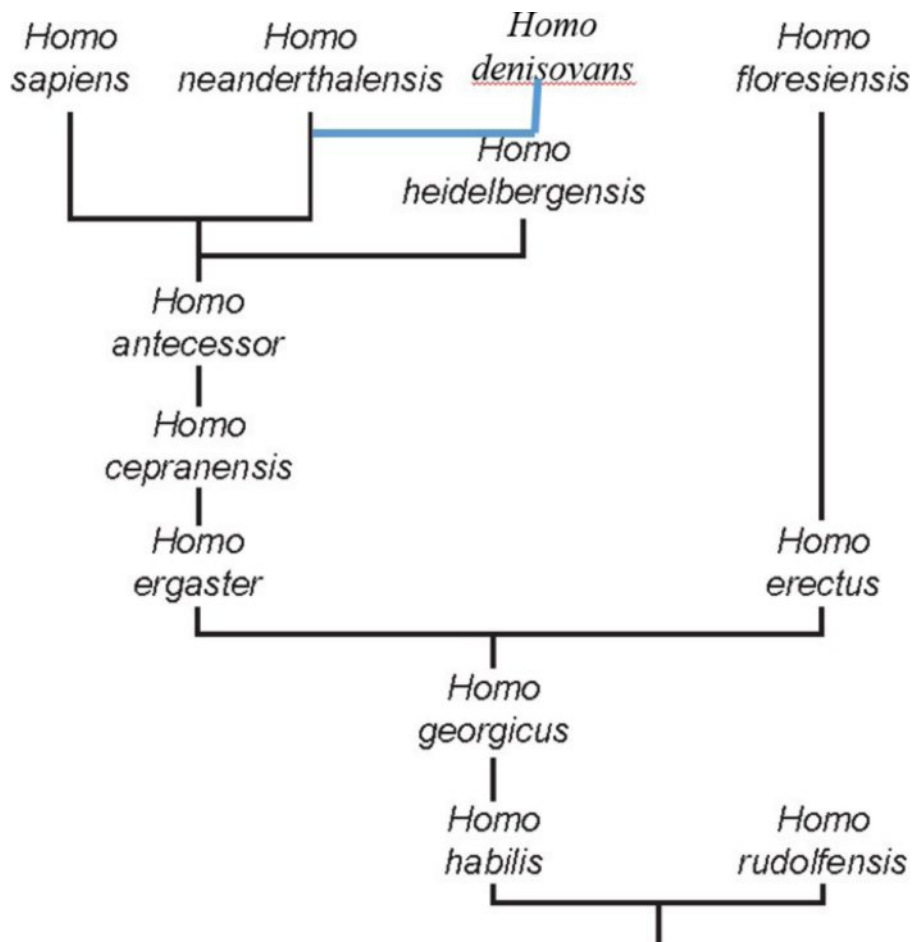
b In Figure 1, *Homo ergaster* is not a direct ancestor of *Homo sapiens*, whereas in Figure 2, *Homo ergaster* is a direct ancestor of *Homo sapiens*.

c

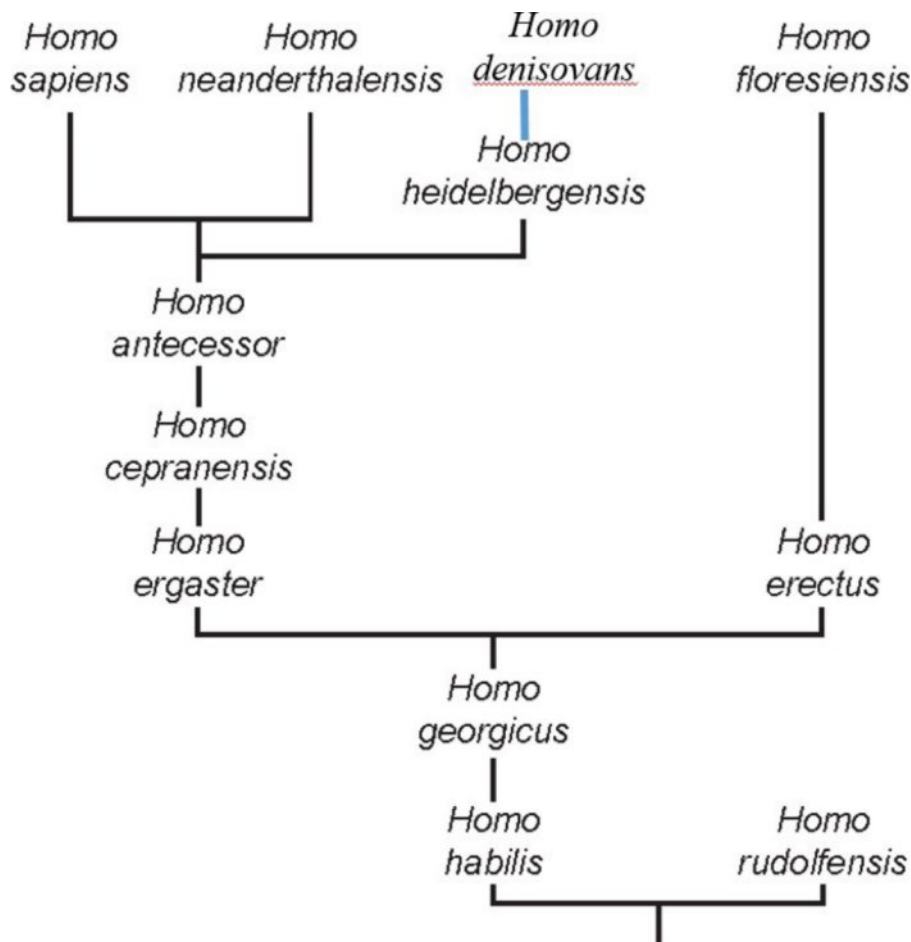


Reason: the DNA of *H. sapiens* and *H. neanderthalensis* is more similar to *H. denisovan*, therefore they are more closely related to *H. denisovans*, or they existed at the same time and are believed to have interbred.

OR



Reason: the DNA of *H. neanderthalensis* is more similar to *H. denisovans* therefore, they are most closely related.



OR

Reason: the DNA of *H. heidelbergensis* is more similar to *H. denisovans*; therefore, they are most closely related to *H. denisovans*, but as *H. heidelbergensis* existed before *H. denisovans*, *H. heidelbergensis* must be an ancestor of *H. denisovans*.

d Any **two** of the following:

- Few *Homo* fossils have been found therefore the fossil record is incomplete.
- *Homo* fossils continue to be found leading to new interpretations of the evidence.
- *Homo* fossil evidence is based on small fragments; therefore, the evidence is open to interpretation.

Question 26/ 205

[VCAA 2022 SB Q9]

Homo sapiens are the only species of hominin alive today. The table below gives estimated ranges of

existence for several hominin species, based on fossil evidence.

Species Name	Earliest date found (number of years ago)	Latest date found (number of years ago)	Location
<i>Australopithecus anamensis</i>	4 200 000	3 800 000	East Africa
<i>Australopithecus afarensis</i>	3 850 000	2 950 000	East Africa
<i>Australopithecus africanus</i>	3 300 000	2 100 000	South Africa
<i>Homo habilis</i>	2 400 000	1 400 000	East and South Africa
<i>Homo rudolfensis</i>	1 900 000	1 800 000	East Africa
<i>Homo floresiensis</i>	700 000	50 000	South-East Asia (Indonesia)
<i>Homo neanderthalensis</i>	400 000	40 000	Europe South-West and Central Asia
<i>Homo sapiens</i>	300 000	present	earliest in North Africa, now worldwide

Data: Smithsonian National Museum of Natural History, 'What does it mean to be human?',
<https://humanorigins.si.edu/evidence/human-evolution-interactive-timeline>

a Describe two trends that would be observed in fossils of these hominin species, with respect to brain size and limb structure, from the most ancient to the most recent species. (2 marks)

b Several times during hominin evolution, different hominin species lived in the same locations, and it is possible that they interbred. There is evidence to support the theory that *H. sapiens* and *H. neanderthalensis* interbred in some parts of Europe.

i Using the table above, apart from interbreeding between *H. sapiens* and *H. neanderthalensis*, identify two other occasions when interbreeding may have occurred between two different species of hominin and name the species involved. (2 marks)

ii Discuss the limitations of the evidence that supports your response to part **b. i.** (2 marks)

(Total 6 marks)

Solution

5-196 [VCAA 2022 SB Q9]

a Any **two** of the following trends:

- Fossil skulls would show increasing cranial capacity and therefore increasing brain size from ancient to most recent hominin species.
- Fossils would indicate an increasing leg–arm length ratio from ancient to most recent hominin species.
- Fossils would indicate an increasing femoral angle from ancient to most recent hominin species.

b i Any **two** of the following:

- *Australopithecus afarensis* and *Australopithecus africanus* (Better answer)
- *Homo habilis* and *Homo rudolfensis* (Better answer)
- *Australopithecus anamensis* and *Australopithecus afarensis*
- *Australopithecus anamensis* and *Australopithecus africanus*
- *Australopithecus afarensis* and *Homo habilis*
- *Australopithecus africanus* and *Homo habilis*
- *Homo rudolfensis* and *Homo erectus*
- *Homo erectus* and *Homo sapiens*
- *Homo erectus* and *Homo habilis*
- *Homo erectus* and *Homo neanderthalensis*
- *Homo erectus* and *Homo floresiensis*
- *Homo neanderthalensis* and *Homo floresiensis*
- *Homo floresiensis* and *Homo sapiens*

ii For interbreeding to occur, the populations of hominin species must exist together in the same place and at the same time. However, existing in the same place at the same time does not mean interbreeding must have occurred.

Any **two** of the following limitations:

- The data is based on a fossil record that is scarce and therefore incomplete and no fossils of intermediate forms are noted in the table.
- Only large areas are stated for locations. Many populations could exist in these large areas without ever coming in contact.
- No molecular/DNA evidence is provided.
- New evidence may suggest different relationships.

Question 27/ 205

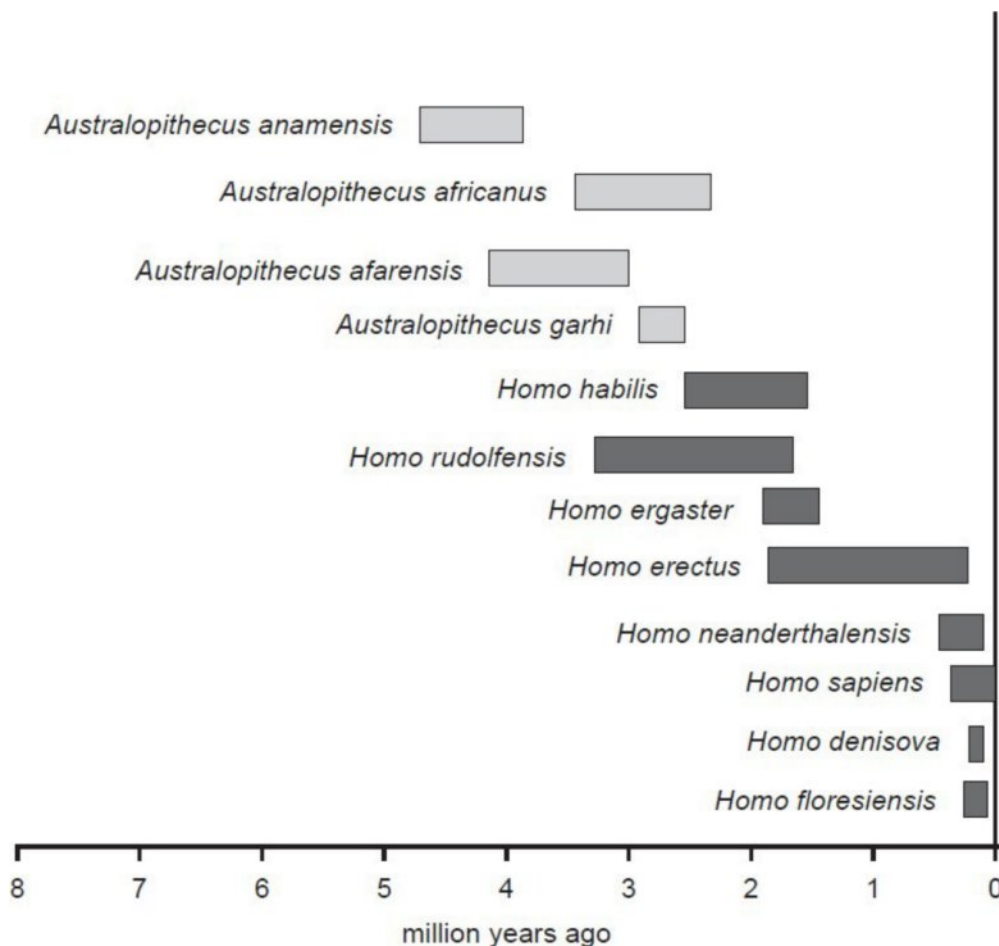
[VCAA 2017 SB Q7]

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

a What are **two** features that the fossil skeleton would need to have in order to be classified in the genus *Homo* and not in the genus *Australopithecus*? (2 marks)

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

The diagram that follows indicates the time periods for different *Australopithecus* and *Homo* species.



b If the second group of scientists has correctly dated the *H. naledi* fossils, what evidence from the diagram above supports this group's claim that *H. naledi* cannot be the 'link' between *Australopithecus* and *Homo*? (1 mark)

(Total 3 marks)

Solution

5-197 [VCAA 2017 SB Q7]

a Any **two** of the following:

- skull: a larger brain case
- skull: a more central foramen magnum
- skull: a flatter face
- jaw: more parabolic shape
- jaw: more uniform shaped teeth
- jaw: smaller canines
- skeleton: an S-shaped spine
- skeleton: a narrower pelvis
- skeleton: longer legs and shorter arms

b *Homo* fossils older than *H. naledi* (older than 900 000 years) are shown in the diagram therefore *H. naledi* cannot be the link.

Question 28/ 205

[Adapted VCAA 2016 SB Q10]

Over the past 20 years, a number of new hominin fossils have been discovered. *Homo erectus georgicus* was found near the banks of the Black Sea in Georgia and *Homo naledi* was found in a cave in South Africa.

a Consider the conditions that may have led to the fossilisation of members of these species.

Complete the table below by identifying one condition in the environment of each species that will have made fossilisation possible. The same answer cannot be used for both species. (2 marks)

Species	Environment	Condition
<i>H. erectus georgicus</i>	Near the banks of the Black Sea	
<i>H. naledi</i>	Cave in South Africa	

Shown below is a photograph of a skull of *H. erectus georgicus*. Scientists compared this skull to that of modern humans (*Homo sapiens sapiens*).



b Describe any two features of the skull shown in the photograph above that allowed scientists to determine that this was a much earlier species of the genus *Homo* than modern humans (*H. sapiens sapiens*). (2 marks)

c Describe one structural feature (other than skull structure) of *H. naledi* that would indicate it is a more modern species than members of the genus *Australopithecus*. (1 mark)

(Total 5 marks)

Solution

5-198 [VCAA 2016 SB Q10]

a

Species	Environment	Condition

Species	Environment	Condition
<i>H. erectus georgicus</i>	Near the banks of the Black Sea	Any one of the following: • quick covering by sediments • low oxygen
<i>H. naledi</i>	Cave South Africa	Any one of the following: • no scavengers • constant humidity • constant temperature • no wind/water/sunlight

b Any **two** of the following:

- sloping forehead whereas modern humans have a large vertical forehead
- large brow ridges whereas modern humans have small brow ridges
- large heavy lower jaw whereas modern humans have a small lower jaw
- large canine teeth whereas modern humans have small canine teeth.

c Any **one** of the following:

- a narrower more bowl-shaped pelvis
- an S-shaped spine
- shorter arm : leg ratio.

d Any **two** of:

- presence of rock paintings
 - presence of musical instruments
 - presence of idols/totems
 - bodies positioned indicating burial
 - presence of bone or shell jewellery.
-

Question 29/ 205

[Adapted VCAA 2012 E2 SB Q8]

In 2008, two incomplete, fossilised skeletons were found in cave deposits in South Africa. The scientists compared the newly discovered bones with those of members of the genus *Australopithecus*, early *Homo*, modern humans and apes. The fossilised skeletons, named *Australopithecus sediba*, displayed an unusual mix of characteristics. They partly resembled primitive, ape-like animals.

Like the apes, *A. sediba* was of small stature. Scientists determined that *A. sediba*, like apes, was suited to climbing in trees.

a What feature of the *A. sediba* skeleton allowed scientists to reach this conclusion? (1 mark)

A. sediba was found to have many characteristics in common both with the members of the genus *Australopithecus* and with the genus *Homo*. Two characteristics shared with the genus *Homo* included a projecting nose and hands with a precision grip.

b Explain how each of these characteristics may have given *A. sediba* an advantage over other *Australopithecus* species. (2 marks)



Below is a drawing of the skull of a modern-day human.

c Using the drawing, suggest one feature of modern-day humans that makes humans more advanced than other *Homo* species. Explain the significance of this feature to the evolution of modern humans. (2 marks)

(Total 7 marks)

Solution

5-199 [VCAA 2012 E2 SB Q8]

a Any **one** of the following:

- presence of a tail
- long arms for climbing and swinging between branches
- presence of a prehensile toe.

b Projecting nose: greater sense of smell. This makes it easier to find food or detect danger.

Precision grip: allows for greater manipulation of tools. This makes it easier to get food, defend against predators and to make shelters from environmental conditions.

c Enlarged braincase/shape of the skull/large forehead: This allows for the development of a large cerebral cortex in the brain. The cerebral cortex is the area of the brain that is used for abstract thought and problem solving. Therefore, an increased ability to problem solve allows modern-day humans to use tools more effectively and adapt to changing new environments.

Question 30/ 205

[VCAA 2019 SB Q10]

Neanderthal or Denisovan?

When *Homo sapiens* left Africa about 60 000 years ago, they were not alone. At least two other hominin groups made the same journey – Neanderthals and Denisovans.

Neanderthals left Africa about 300 000 years ago, settling in Europe and parts of western Asia.

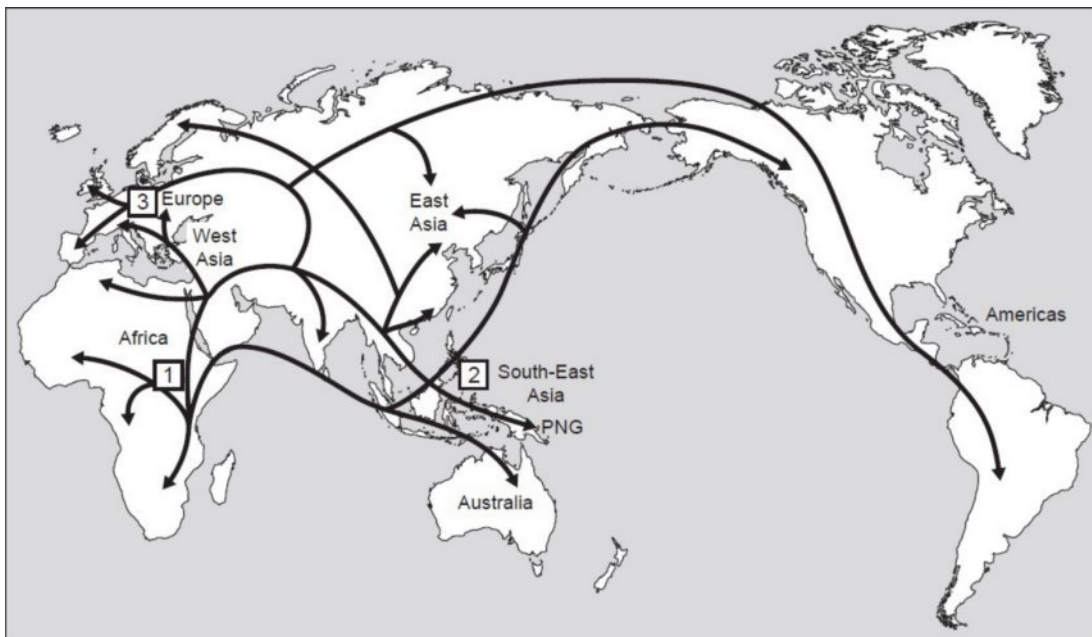
Anthropologists in southern Siberia unearthed a 40 000-year-old adult tooth and a well-preserved fossilised finger bone that had belonged to a young girl. Nuclear DNA analysed from the finger bone showed that the girl was closely related to Neanderthals but could be classified as a new species of ancient humans, which scientists named ‘Denisovan’.

The scientists found similarities between the Denisovan genome and that of some present-day Pacific Islanders living in Papua New Guinea (PNG), known as the Melanesians. It appears the Denisovans contributed between 3–5% of their genetic material to the genomes of the Melanesians. The scientists think the most likely explanation is that Denisovans living in eastern Eurasia interbred with the modern

human ancestors of the Melanesians. When those humans crossed the ocean to reach PNG around 45 000 years ago, they brought their Denisovan DNA with them.

Studies of modern human DNA concluded that most humans with European ancestry have 1–3% Neanderthal DNA. According to one theory, Neanderthals, Denisovans and modern humans are all descended from the ancient human *Homo heidelbergensis*. Between 400 000 and 300 000 years ago, an ancestral group of *H. heidelbergensis* left Africa and then split shortly after. One branch ventured north-west into West Asia and Europe and became the Neanderthals. The other branch moved east, becoming the Denisovans. By 130 000 years ago, *H. heidelbergensis* in Africa gave rise to *H. sapiens*, who did not leave Africa until about 60 000 years ago.

- a** Based on the information given in the article, would it be possible to classify Denisovans as a separate group from Neanderthals without using DNA analysis? Justify your response. (2 marks)
- b** Scientists could have extracted mitochondrial DNA from the young girl's finger bone sample but, instead, extracted and sequenced nuclear DNA. Explain why the scientists chose to sequence the nuclear DNA for this sample. (2 marks)



- c** Using the information in the article and by referring to the map above, name which hominin group would most likely have been found living at each site between 300 000 and 60 000 years ago. Justify your response.

Site	Name of hominin group	Justification
1 – Africa		
2 – South-East Asia and Papua New Guinea		
3 – Europe		

(3 marks)

(Total 7 marks)

Solution

5-200 [VCAA 2019 SB Q10]

a No. With no DNA evidence for the Denisovans and Neanderthals to be a separate group, they must be anatomically very similar. Only a finger bone was found of a Denisovans, and this is insufficient structural evidence. For organisms to belong to the same species they must be able to interbreed and produce fertile offspring. As these groups are extinct, this is difficult to determine.

b The more DNA that is analysed the more complete the DNA evidence. Mitochondrial DNA contains only a few genes, and these genes are inherited only from the mother whereas nuclear DNA contains DNA from both parents and all the genes except mitochondrial genes that code for that individual.

c

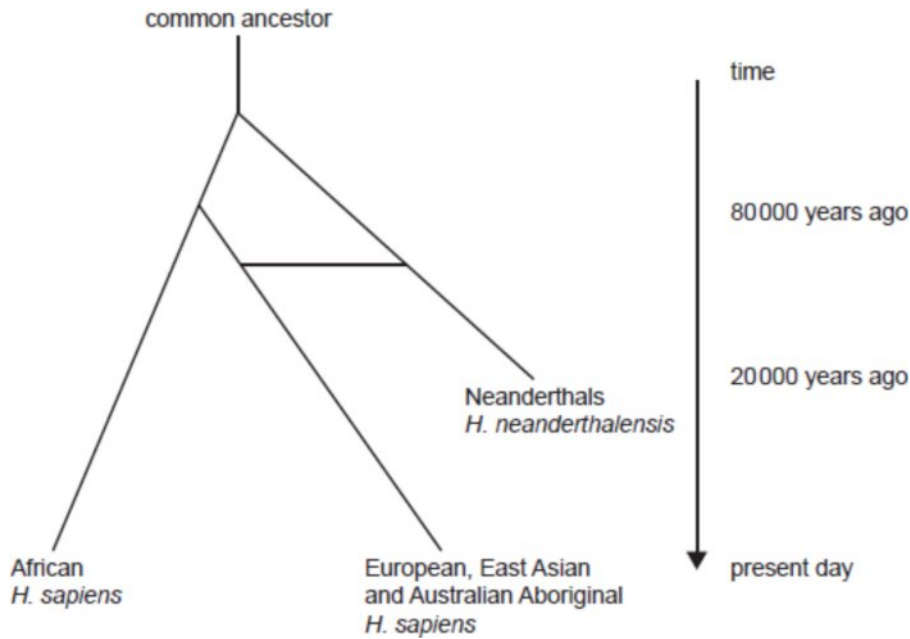
Site	Name of hominin group	Justification
1 Africa	<i>Homo heidelbergensis</i>	There is no fossil evidence of the Neanderthals and Denisovans in Africa and there is no Neanderthal or Denisovan DNA present in modern Africans.
	Neanderthals	
	<i>Homo sapiens</i>	<i>Homo sapiens</i> did not leave Africa until 60 000 years ago.
2 SE Asia and PNG	Denisovan	3–5% Denisovan DNA is present in modern Asian and Pacific islanders.
3 Europe	Neanderthals	1–3% Neanderthal DNA is present in most humans with European ancestry.

Question 31/ 205

[VCAA 2015 SB Q11]

Fossil evidence indicates that between 30 000–80 000 years ago, populations of the two hominin species – modern humans (*Homo sapiens*) and the extinct Neanderthals (*Homo neanderthalensis*) – lived close to one

another in parts of the Middle East, Europe and Asia.



Researchers have constructed a theory about the relationships between ancient populations. This is represented in the diagram below.

Recent DNA evidence has shown that:

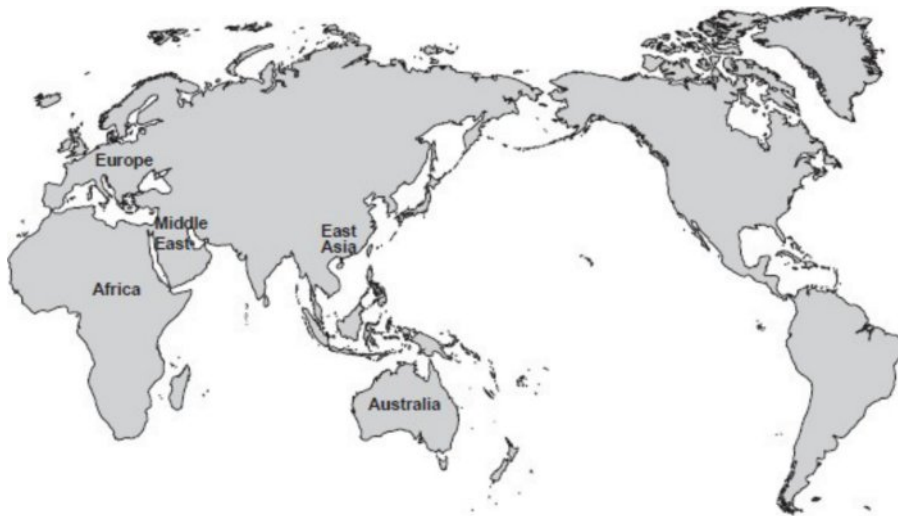
- the genome of living humans of African descent does not contain Neanderthal DNA
- the genomes of living humans of European, East Asian and Australian Aboriginal descent all contain small amounts of Neanderthal DNA (1–4%).

a i Suggest how DNA from *H. neanderthalensis* entered the genome of present-day European, East Asian and Australian Aboriginal *H. sapiens*, and continues to be found in modern populations. (2 marks)

ii What implication does this DNA evidence have for the classification of the two hominin species, *H. sapiens* and *H. neanderthalensis*, according to the common definition of a species? (1 mark)

b There are several theories about the geographical origins of *H. sapiens*. Scientists consider that the absence of Neanderthal DNA in present-day African *H. sapiens* lends support to one theory about the geographical origins of *H. sapiens*. Name this theory and explain how the recent DNA evidence provided supports it. (3 marks)

c Consider the map provided below.



What does the DNA evidence provided on the previous page suggest about the route and timing of the migration of the first Australian Aboriginals to arrive in Australia? (2 marks)

(Total 8 marks)

Solution

5-201 [VCAA 2015 SB Q11]

a i There was interbreeding between *H. neanderthalensis* and *H. sapiens* when they lived close to each other. Their offspring were fertile and would have inherited genetic information from both *H. neanderthalensis* and *H. sapiens* and they have passed this information onto their offspring in future generations.

ii Organisms that belong to the same species are able to interbreed and produce fertile offspring. The presence of Neanderthal DNA in *H. sapiens* suggests that *H. sapiens* and *H. neanderthalensis* should be classified in the same species, as they were able to interbreed and produce fertile offspring.

b Out of Africa theory.

This theory suggests that modern humans are descended from a population that originated in Africa where there were no Neanderthal populations. This is supported by the lack of *H. neanderthalensis* DNA in African *H. sapiens*. The ‘Out of Africa’ theory suggests human populations moved out of North Africa encountering other *Homo* species. This is supported by the presence of Neanderthal DNA in European, East Asian and Australian Aboriginal *H. sapiens* but not in African *H. sapiens*.

c Route: Migration occurred through northern Africa, through the Middle East, through East Asia to Australia.

Timing: After interbreeding with Neanderthals, i.e.: after 80 000 years ago.

[VCAA 2014 SB Q11]

In 1991, the body of a man was found frozen beneath a glacier in Italy. Researchers named him Ötzi. It was determined that Ötzi died 5300 years ago and that his body is the oldest mummified human body ever found. Scientists have successfully extracted DNA from the nucleus of his frozen cells.

a Describe the process scientists would use on a small sample of Ötzi's DNA to obtain larger quantities of identical DNA. (3 marks)

Using gel electrophoresis, scientists discovered that there were four different types of blood on Ötzi's clothes. Their results were as shown on the next page.

Ötzi's blood taken from his blood vessels	Blood sample 1 from Ötzi's clothes	Blood sample 2 from Ötzi's clothes	Blood sample 3 from Ötzi's clothes	Blood sample 4 from Ötzi's clothes

- b i** Which blood sample on Ötzi's clothes belongs to Ötzi? (1 mark)
- ii** Propose one hypothesis that would explain the presence of the other blood samples on Ötzi's clothes. (1 mark)

c Analysis of mammalian proteins provides evidence of evolutionary relationships.

Explain how amino acid differences in a protein can indicate evolutionary relationships. (2 marks)

d The development of bipedalism in hominins is believed to have had a very significant effect on human evolution.

Describe **two** effects of bipedalism on hominin behaviour. (2 marks)

(Total 9 marks)

Solution

5-202 [VCAA 2014 SB Q11]

a Polymerase Chain Reaction

- DNA sample is heated to 95°C causing the strands to separate.
- Primers, short sequences of DNA, that bind to either end of the DNA to be copied, are added to the DNA sample along with extra nucleotides.
- Temperature is lowered to 50°C to allow primers to attach to the single stranded DNA.
- The primers provide a 3' end to which DNA nucleotides can be added and joined together by Taq polymerase at 72°C.
- The above steps are repeated many times.

b i Sample 3

ii The blood on Ötzi's clothes is from the three animals he hunted or from three people he had a fight with and all were injured.

c Organisms that are closely related will have similar DNA sequences. DNA codes for amino acid chains therefore they will also have similar amino acid sequences. Mutations change the DNA sequence and may change the amino acid sequence. The greater the amino acid difference, the greater the time passed since divergence (last common ancestor) as there has been more opportunity for accumulation of mutations.

Note: When referring to common ancestor you must include in your description recent or most distant.

d Any **one** of the following:

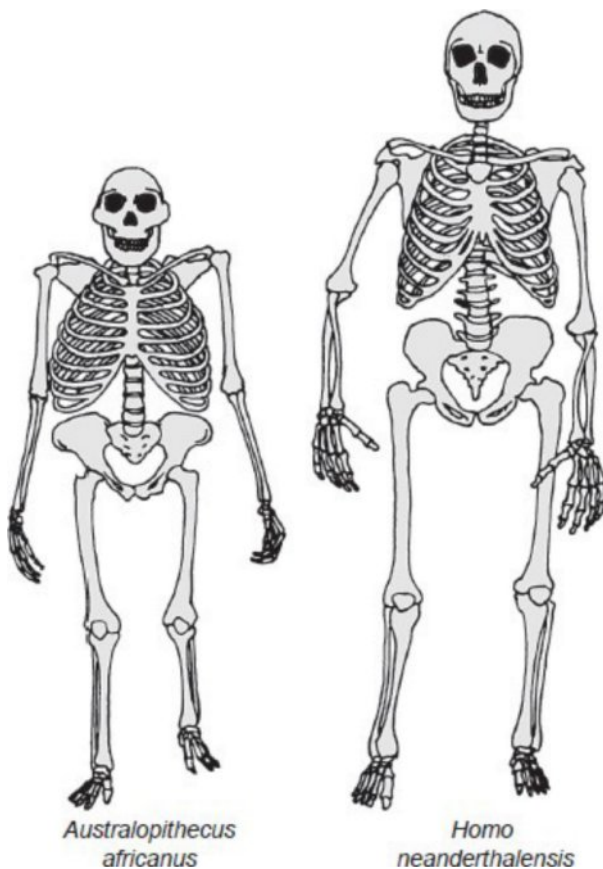
- Bipedalism allowed early humans to live on open plains as they could stand up and see prey/predators more easily.
- Bipedalism allowed humans to carry tools/more efficient hunting behaviours. Bipedalism allowed more efficient long-distance locomotion, and this enabled humans to live a nomadic lifestyle. (*Note:* Must refer to a

behaviour.)

Question 33/ 205

[Adapted VCAA 2013 SB Q11]

The skeletal structures of two extinct members of the hominin family tree, *Australopithecus africanus* and *Homo neanderthalensis*, are shown in the diagram that follows.



a Examine the skeletal structures. For each of the features listed in the table below, describe the difference between the two species and state the significance of the difference. (4 marks)

Feature	Description of difference	Significance of difference
Pelvic structure		
Arm to leg length ratio		

Neanderthals lived in the cold climate of Europe and Asia from 200 000 to 30 000 years ago. Modern humans and Neanderthals coexisted for around 10 000 years. Fossil evidence indicates Neanderthals shared much behaviour with modern humans. Scientists are undertaking research to find reasons why Neanderthals became extinct, but modern humans survived. Fossil evidence of the use of sewing needles and the division of labour between men and women was found only for modern humans, but not for Neanderthals.

People today with non-African heritage carry some Neanderthal DNA.

b State a hypothesis to account for these findings. (1 mark)

(Total 5 marks)

Solution

5-203 [VCAA 2013 SB Q11]

a

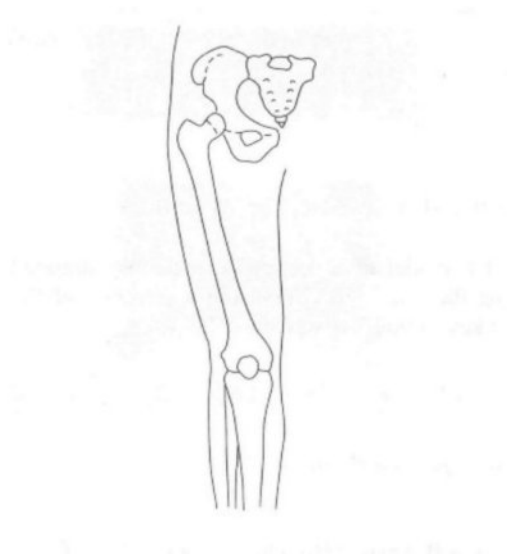
Feature	Description of difference	Significance of difference
Pelvic structure	A narrow more bowl- shaped pelvis in <i>H. neanderthalensis</i> compared to <i>A. africanus</i>	This moves the centre of gravity so that it is easier to be bipedal Or gives greater support to organs when bipedal
Arm to leg length ratio	The arm to leg ratio of <i>A. africanus</i> is 1:1 whereas for <i>H. neanderthalensis</i> the ratio is 1:1.4. <i>H. neanderthalensis</i> had proportionally longer legs	This gives <i>H. neanderthalensis</i> a longer gait and makes it easier to be bipedal Or <i>A. africanus</i> were knuckle walkers Or <i>A. africanus</i> used arms to climb trees

b Any **one** of the following:

- There was gene flow/interbreeding between modern humans and Neanderthals.
 - Modern humans and Neanderthals share a **recent** common ancestor.
 - The DNA that is similar in modern humans and Neanderthals arose independently in each species.
-

Question 34/ 205

a i Using the diagram, name TWO features of the *Homo sapiens* skeleton that make it unique among the primates. (2 marks)



ii Outline how ONE named non-skeletal characteristic has assisted primates in their evolution. (2 marks)

b Examine the data collected on *Homo neanderthalensis* fossils found in recent years.

Date

Data

2008	• Full sequence of mitochondrial DNA of a range of Neanderthal fossils from within and between different fossil sites. • The sequence is nearly identical within one fossil site. • The sequence is very different between fossil sites.
2010	• Full sequence of Neanderthal nuclear DNA. • 1%–4% of genes in European modern humans are specific Neanderthal genes. • No identifiable specific Neanderthal genes in modern sub-Saharan African humans. • No specific modern human genes in nuclear DNA of Neanderthal fossils.

i What inferences can be made about Neanderthal populations, based on the data collected in 2008? (3 marks)

ii What inferences can be made about migration and breeding, based on the data collected in 2010? (3 marks)

(Total 10 marks)

Solution

5-204

a i Two features of the skeleton that make it unique among the primates:

- broad and barrel-shaped pelvis
- thigh bone angles inwards.

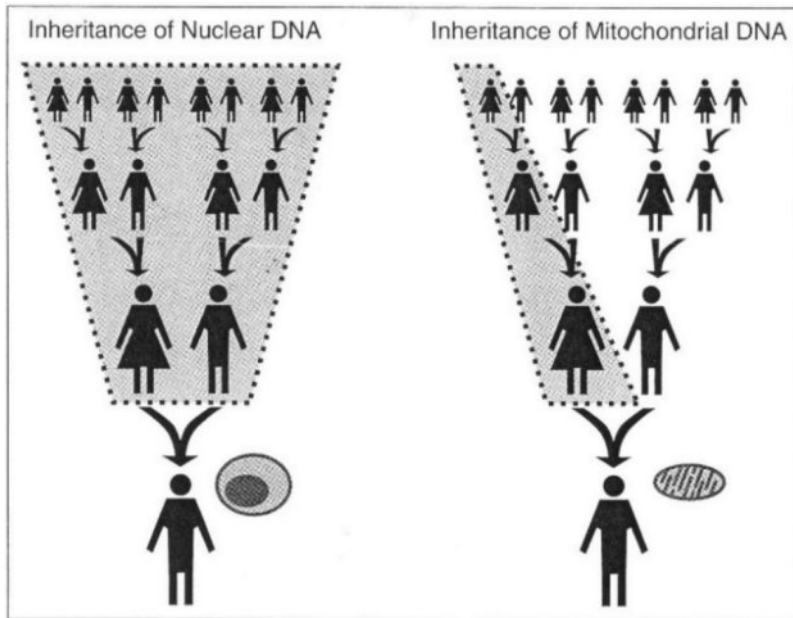
ii Non-skeletal characteristic: lengthy gestation period and parental care. The long gestation period allows for greater brain development before birth leading to increased intelligence. The long period of parental care allows more time for the offspring to learn behaviours that help them live in a group and use tools. Living in a group provides protection from predators and increased chance of finding food.

b i It can be inferred from the 2008 data that individuals within one fossil site are very closely related as the more similar the mDNA, the closer the relationship. mDNA is passed from mother to children. It can also be inferred that there was little gene flow/mating between populations as the sequences between fossil sites were different.

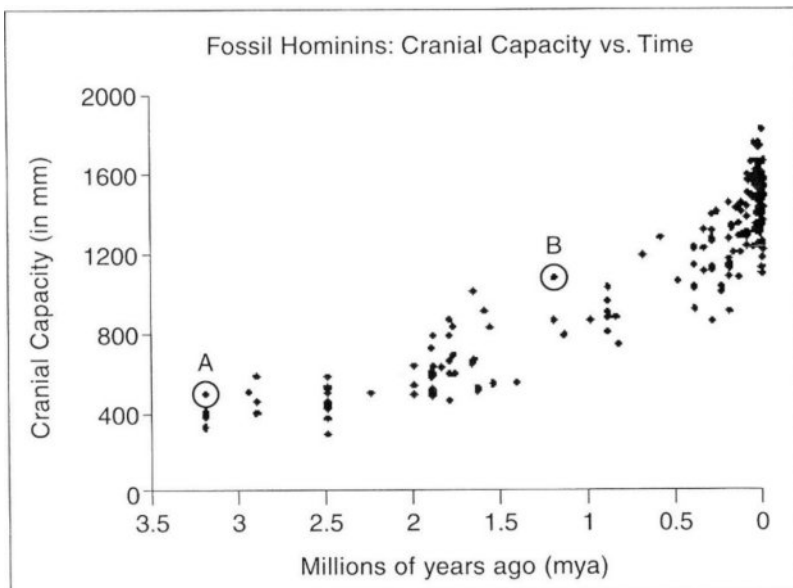
ii It can be inferred from the lack of specific Neanderthal genes in modern sub-Saharan African humans that the Neanderthals evolved after early humans migrated out of Africa. The lack of specific modern human genes in nuclear DNA of Neanderthal fossils suggests that there was no interbreeding between modern humans and Neanderthals. The presence of specific Neanderthal genes in humans suggest that the Neanderthals interbred with at least one other early human group that, in turn, bred with early modern human populations. The Neanderthals were not direct modern human ancestors.

Question 35/ 205

a The diagram below compares the inheritance of nuclear DNA with mitochondrial DNA.



- i** Compare the pattern of inheritance of nuclear DNA with mitochondrial DNA. (1 mark)
- ii** Assess whether the analysis of nuclear DNA or mitochondrial DNA is more useful to evolutionary biology. (4 marks)
- b** The graph below shows the results of an investigation into cranial capacity of fossil hominins.
- Data were obtained from measurements of hominin cranial capacity published in scientific journals.
 - Each data point on the graph represents the average cranial capacity of the adult skull at a single archaeological dig.
 - The results from 215 archaeological digs are represented.



- i** Justify the methods used to collect and present the data. (4 marks)
- ii** For either data point A or B, propose the name of the hominin species and its regional location. (2 marks)

(Total 11 marks)

Solution

5-205

a i Mitochondrial DNA is inherited from the mother only, whereas nuclear DNA is inherited from both the mother and the father.

ii Mitochondrial DNA is more useful to evolutionary biology because:

- it is inherited from the mother only, whereas nuclear DNA is inherited from both the mother and the father. Therefore, any changes in base sequences can be tracked directly and are not due to recombination during meiosis.
- there are many mitochondria in each cell each with the same mitochondrial DNA, therefore there are many copies of each mitochondrial gene. There is only one copy of nuclear DNA in every cell. This means it is easier to extract mitochondrial DNA especially from fossils where there is little DNA remaining.
- mitochondrial DNA is shorter and simpler than nuclear DNA therefore it is easier to track changes in sequence.
- the high, known mutation rate can be used to estimate time of divergence for different species. The high rate means that mitochondrial DNA can be used to separate closely related species.

b i Justification for the methods used to collect and present data:

- Data was used in the investigation that had been published in scientific journals. This data would be reasonably reliable as scientific journals are usually peer reviewed and follow a set format, including citing of sources.
- Each data point represents average cranial capacity of the adult skull. This means like skulls are compared as skulls may vary according to age, sex and health. Average also suggests that a number of measurements were used and averaged. This reduces the effect of individual variation on the results.
- A large number of archaeological digs are represented. This reduces the effect of abnormal results on the overall results.
- The use of a scatter graph to represent the results is a good way to show visually the trend of increasing cranial capacity and the spread of results at each point in time.

ii A = *Australopithecus afarensis* from Ethiopia

B = *Homo erectus* from Asia

Chapter 7 VCE Examination Paper Units 3 & 4 2023

Question 1/ 40

[VCAA SA Q1 2023]

Which one of the following correctly matches the nucleic acid molecule with its role?

Molecule	Role
DNA	carries genetic information to ribosomes
tRNA	carries amino acids to ribosomes
mRNA	structural component of ribosomes
rRNA	contains genetic information that is transcribed

Solution

1 [VCAA SA Q1 2023]

Which one of the following correctly matches the nucleic acid molecule with its role?

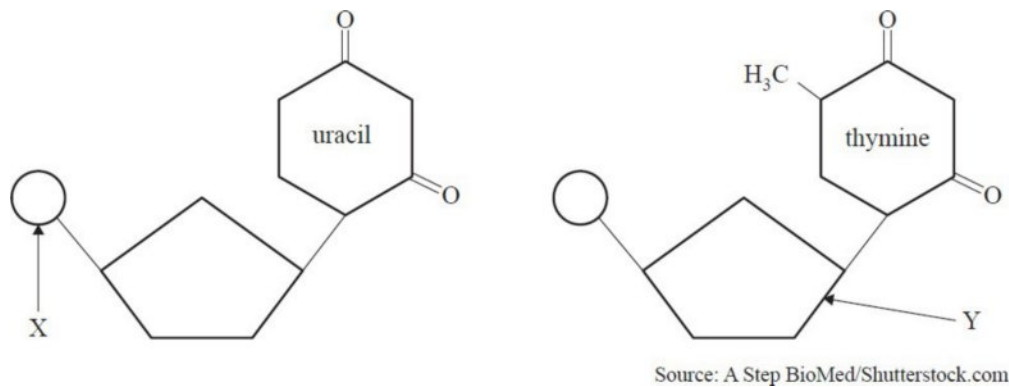
	Molecule	Role
B	tRNA	carries amino acids to ribosomes

(Fact: tRNA – transfer RNA – carries or transfers amino acids to ribosomes to allow the production of polypeptides. mRNA carries the genetic information to ribosomes and rRNA is a structural component of ribosomes.)

Question 2/ 40

[VCAA SA Q2 2023]

The basic structure of two nucleotides is in the diagram that follows. Each nucleotide has three subunits.



It can be concluded that the

A subunit labelled X is a nitrogen base.

B subunit labelled Y is a ribose sugar.

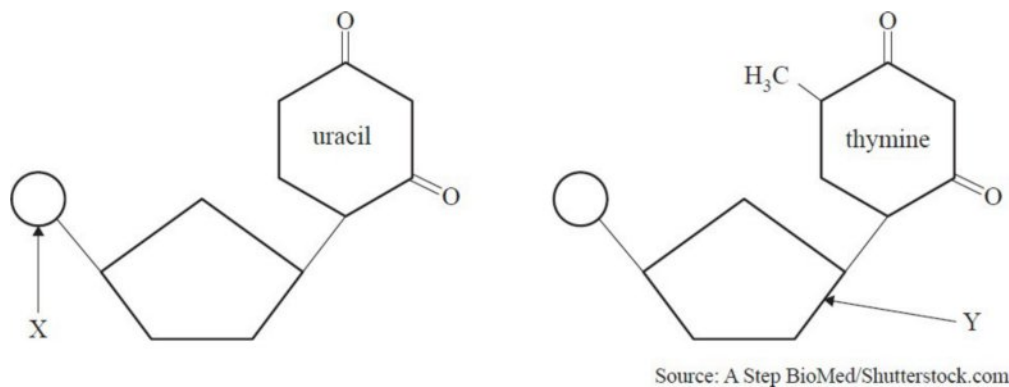
C nucleotide with the subunit labelled uracil can be found in DNA.

D nucleotide with the subunit labelled thymine will have a pentose sugar subunit.

Solution

2 [VCAA SA Q2 2023]

The basic structure of two nucleotides is in the diagram that follows. Each nucleotide has three subunits.



It can be concluded that the

D nucleotide with the subunit labelled thymine will have a pentose sugar subunit.

(In A – X is a phosphate rather than a nitrogen base. C is incorrect because uracil is only found in RNA. The sugar labelled Y is a pentose sugar. It is not ribose as thymine is present and thymine is found in DNA nucleotides. Ribose is found in RNA nucleotides.)

Question 4/ 40

[VCAA SA Q3 2023]

Which one of the following is a correct statement?

A Step 1 represents translation.

B There are six introns in the gene.

C RNA polymerase is required for Step 3.

D The circle on molecule F represents a modified guanine molecule.

Solution

3 [VCAA SA Q3 2023]

Which one of the following is a correct statement?

D The circle on molecule F represents a modified guanine molecule. (Step 1 represents transcription, not translation. The diagram shows a section of a gene shown by the dashed lines at each end. This means there would be more than six introns in the entire gene. RNA polymerase is involved in step 1. A methyl-G cap is added to the 5' end during posttranscriptional modification.)

Question 5/ 40

[VCAA SA Q3 2023]

Molecule G codes for a protein containing 100 amino acids that form a single polypeptide chain.

The number of codons required to code for these 100 amino acids is

A 33.

B 66.

C 100.

D 300.

Solution

4 [VCAA SA Q3 2023]

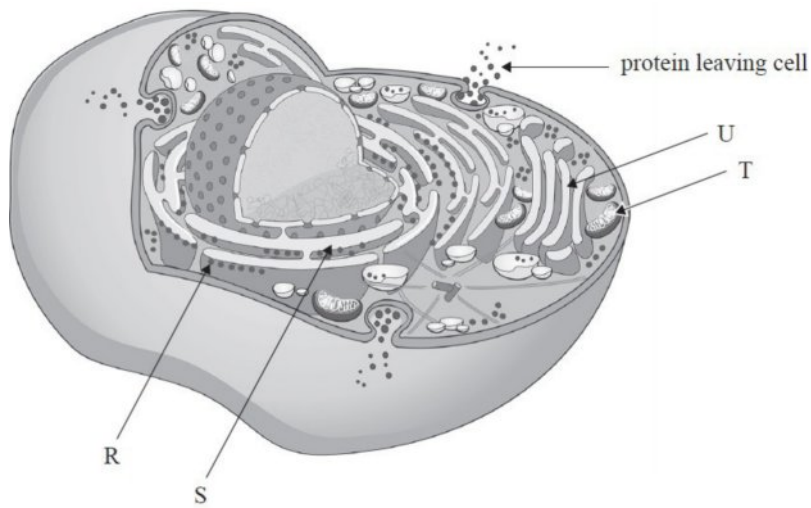
The number of codons required to code for these 100 amino acids is

C 100. (One codon codes for one amino acid; therefore, the number of codons required to code for 100 amino acids is 100.)

Question 6/ 40

[VCAA SA Q5 2023]

The diagram below represents a mammalian cell undergoing the process of exocytosis.



Source: adapted from Soleil Nordic/Shutterstock.com

In the process of exocytosis, the role of

A organelle R is to carry the protein to the plasma membrane.

B organelle S is to enable folding and transport of the protein.

C organelle T is to synthesise the protein.

D organelle U is to produce energy for the synthesis of the protein.

Solution

5 [VCAA SA Q5 2023]

In the process of exocytosis, the role of

B organelle S is to enable folding and transport of the protein. (S is rough endoplasmic reticulum and this is its function. Organelle R is a ribosome – the site of protein synthesis. T is a mitochondrion which is the site of cellular respiration. U is the smooth endoplasmic reticulum and does not have a role in energy production.)

In their investigation, the students would have expected

A all proteins within each cell type to be identical.

B that proteins within the same cell could differ in structure and function.

C all proteins to consist of multiple polypeptide chains.

D gene expression for each protein in each cell to be occurring continuously.

Solution

6 [VCAA SA Q6 2023]

In their investigation, the students would have expected

B that proteins within the same cell could differ in structure and function. (In one cell, a range of proteins will have different structures and functions.

Therefore, A & C are incorrect. D is incorrect as gene expression will depend on the need for a particular protein.)

Question 9/ 40

[VCAA SA Q7 2023]

Students completed their investigation and analysed their results. They suggested their results were affected by systematic errors.

Systematic errors

A result in a spread of readings.

B affect the precision of a measurement.

C are easy to identify and eliminate.

D cause readings to differ from the true value by a consistent amount each time.

Solution

7 [VCAA SA Q7 2023]

Students completed their investigation and analysed their results. They suggested their results were affected by systematic errors.

Systematic errors

D cause readings to differ from the true value by a consistent amount each time. (A systematic error will cause the same error each time an experiment is conducted. A is incorrect as results will tend to be narrowed rather than spread. The experiment's precision will not be affected, and such errors may be difficult to identify and eliminate.)

Question 11/ 40

[VCAA SA Q8 2023]

Plants have a number of barriers and mechanisms to prevent entry of pathogens.

The most likely route of entry of the fungal pathogen to the wheat plants above is via the

A stomata.

B waxy cuticle.

C leaf receptors.

D external layer of small hairs.

Solution

8 [VCAA SA Q8 2023]

The most likely route of entry of the fungal pathogen to the wheat plants above is via the

A stomata. (Stomata are leaf openings that allow gaseous exchange; therefore, fungal spores could enter the leaf via stomata. The other alternatives would not provide access to the leaf.)

Question 12/ 40

[VCAA SA Q9 2023]

Some plants, such as rye and wild grasses, have genes that code for proteins that make them resistant to rust disease.

Recently, scientists have taken genes coding for resistance to rust disease and transferred them into a variety of wheat plants susceptible to rust disease.

Wheat plants with transferred genes for resistance to rust disease are known as

A recombinant.

B transgenic.

C polyploid.

D vectors.

Solution

9 [VCAA SA Q9 2023]

Wheat plants with transferred genes to resist rust disease are known as

B transgenic. (Fact – definition. Organisms with genes that have come from another species are described as being transgenic.)

Question 13/ 40

[VCAA SA Q10 2023]

To determine the uptake of resistance genes by the wheat plants, scientists investigate gene fragments using

electrophoresis to

A cut the DNA.

B amplify the DNA.

C separate the DNA.

D denature the DNA.

Solution

10 [VCAA SA Q10 2023]

To determine the uptake of resistance genes by the wheat plants, scientists investigate gene fragments using electrophoresis to

C separate the DNA. (Having been cut, fragments of DNA are sorted using electrophoresis. Remember what you have learned about gel plates. The other alternatives may be used to prepare DNA for electrophoresis.)

Question 15/ 40

[VCAA SA Q11 2023]

The interaction with the drug will result in the protease being

A denatured.

B activated.

C catalysed.

D inhibited.

Solution

11 [VCAA SA Q11 2023]

The interaction with the drug will result in the protease being

D inhibited. (The drug molecule interacts with the protease to block an active site, thus preventing the protease from interacting with other molecules. The change is not permanent, as the final diagram shows an unaltered protease.)

Question 16/ 40

[VCAA SA Q12 2023]

After the research was concluded, the results of the study, whether favourable or unfavourable, were published.

The publishing of all of the results would most closely align to the ethical concept of

A non-maleficence.

B beneficence.

C integrity.

D justice.

Solution

12 [VCAA SA Q12 2023]

The publishing of all of the results would most closely align to the ethical concept of

C integrity. (Integrity, in this context, means honesty. In reporting results, it is ethical or honest to report all results to allow others to decide whether the new drug is effective and whether any benefits outweigh any negative aspects of the drug – e.g., harmful side effects.)

Question 18/ 40

[VCAA SA Q13 2023]

Where in this chloroplast would you find the Calvin cycle occurring?

A location A

B location B

C location C

D location D

Solution

13 [VCAA SA Q13 2023]

Where in this chloroplast would you find the Calvin cycle occurring?

B location B. (B is the stroma and is where the Calvin cycle occurs – a light-independent process. The Calvin cycle uses the ATP and NADPH from the light-dependent reactions to fix carbon dioxide, producing three-carbon sugars—glyceraldehyde-3-phosphate, or G3P, molecules within the thylakoids – labelled D.)

Question 19/ 40

[VCAA SA Q14 2023]

Which one of the following statements about the Calvin cycle is correct?

A It is light-independent.

B It requires glucose as an input.

C It only occurs in complete darkness.

D It only occurs when the humidity is high.

Solution

14 [VCAA SA Q14 2023]

Which one of the following statements about the Calvin cycle is correct?

A It is light-independent. (The Calvin cycle is light-independent, occurring regardless of the presence of light – fact. ATP and NADPH are the required inputs rather than glucose.)

Question 20/ 40

[VCAA SA Q15 2023]

Which molecules are involved in a light-independent reaction?

A oxygen, ADP and NADH

B oxygen, ADP and NADPH

C carbon dioxide, ATP and NADH

D carbon dioxide, ATP and NADPH

Solution

15 [VCAA SA Q15 2023]

Which molecules are involved in a light-independent reaction?

D carbon dioxide, ATP and NADPH. (ATP and NADPH produced in the lightdependent reactions are the sources of energy and H^+ needed to drive the Calvin cycle – the raw ingredient is carbon dioxide – the carbon source for the sugars produced in photosynthesis.)

Question 21/ 40

[VCAA SA Q16 2023]

Where in a plant leaf cell does a light-dependent reaction occur?

A stroma

B mitochondrion

C thylakoid membrane

D chloroplast inner membrane

Solution

16 [VCAA SA Q16 2023]

Where in a plant leaf cell does a light-dependent reaction occur?

C thylakoid membrane. (The reactions that require light energy occur in the thylakoid membranes and produce ATP and NADPH needed for the light-independent reactions – in the Calvin cycle.)

Question 22/ 40

[VCAA SA Q17 2023]

The enzymes involved in glucose metabolism are what type of biological molecule?

A carbohydrates

B nucleotides

C proteins

D lipids

Solution

17 [VCAA SA Q17 2023]

The enzymes involved in glucose metabolism are what type of biological molecule?

C Proteins. (Fact: Enzymes are proteins that enable a particular reaction to occur.)

Question 24/ 40

[VCAA SA Q18 2023]

Under which of the following conditions is the rate of lactate formation highest?

A 10 °C in the absence of oxygen

B 20 °C in the absence of oxygen

C 35 °C in the presence of oxygen

D 50 °C in the presence of oxygen

Solution

18 [VCAA SA Q18 2023]

Under which of the following conditions is the rate of lactate formation highest?

B 20 °C in the absence of oxygen. (Of the alternatives given, lactate formation is highest at 20 °C without oxygen. Note according to the graph, lactate production is highest at 35 °C in the absence of oxygen, but this is not an alternative.)

Question 25/ 40

[VCAA SA Q19 2023]

Why is the rate of consumption of glucose higher in the absence of oxygen than in its presence at 35 °C?

- A Oxygen stimulates lactate formation.
- B Oxygen inhibits the uptake of glucose by the cell.
- C Glycolysis reactions require the presence of oxygen.
- D Less ATP is formed from glucose in the absence of oxygen.

Solution

19 [VCAA SA Q19 2023]

Why is the rate of consumption of glucose higher in the absence of oxygen than in its presence at 35 °C?

D Less ATP is formed from glucose in the absence of oxygen. (Anaerobic respiration produces less ATP per glucose molecule (2 ATP) than aerobic respiration (36-38 ATP) when oxygen is present. Therefore, more glucose will be used to produce enough ATP for cellular requirements.)

Question 26/ 40

[VCAA SA Q20 2023]

Why are the rates of consumption of glucose and formation of lactate at 50 °C the same irrespective of oxygen levels?

- A Most of the enzymes involved in glycolysis have become denatured.
- B Glucose is converted to ATP by a single chemical reaction.
- C At 50 °C the cell uses heat as a source of energy.
- D At 50 °C metabolic pathways are very efficient.

Solution

20 [VCAA SA Q20 2023]

Why are the rates of consumption of glucose and formation of lactate at 50 °C the same irrespective of oxygen levels?

A Most of the enzymes involved in glycolysis have become denatured. (Fact: Most enzymes are denatured at high temperatures and, therefore, will not catalyse the reactions involved regardless of whether oxygen is present or not.)

Question 27/ 40

[VCAA SA Q21 2023]

Hay fever (allergic rhinitis) is caused by a range of allergens, including pollen, animal fur, dust mites and moulds entering the body via the eyes, nose or mouth.

The cells that release histamine in the allergic response are

A mast cells.

B eosinophils.

C macrophages.

D natural killer cells.

Solution

21 [VCAA SA Q21 2023]

The cells that release histamine in the allergic response are

A mast cells. (Fact: Mast cells are part of the first line of defence. The histamines produced will signal other cells, such as those listed, to become involved in the immune response.)

Question 28/ 40

[VCAA SA Q22 2023]

Allergens are presented by antigen-presenting cells to specific T cells using which of the following?

- A IgE antibodies
- B complement proteins
- C dendritic cell receptors
- D major histocompatibility complex proteins

Solution

22 [VCAA SA Q22 2023]

Allergens are presented by antigen-presenting cells to specific T cells using which of the following?

D major histocompatibility complex proteins. (Fact. IgE antibodies are produced as a result of exposure to allergens. Complement proteins are secreted by cells, not displayed by cells.)

Question 29/ 40

[VCAA SA Q23 2023]

Tea-tree oil is derived from the leaves of *Melaleuca alternifolia*, which is endemic to Australia and native to Bundjalung country located in northern New South Wales.

Bundjalung people have used tea-tree oil as a traditional medicine. It is typically used as a topical medication for the treatment of skin conditions. It has anti-inflammatory properties and reduces skin inflammation caused by insect bites or hives.

It is reasonable to conclude that tea-tree oil inhibits the

A physical barrier of the skin.

B innate immune response.

C proliferation of B cells.

D lymphatic system.

Solution

23 [VCAA SA Q23 2023]

It is reasonable to conclude that tea-tree oil inhibits the

B innate immune response. (Tea-tree oil must inhibit the initial immune response to insect bites, reducing swelling. Note it might be used before bites, which might increase the physical barrier, but the question is about how it is used as a treatment after the bite.)

Question 31/ 40

[VCAA SA Q24 2023]

It is most reasonable to conclude that AIT

A demonstrates long-term and sustained effects.

B was not administered correctly in the first year.

C is most effective between the first and second year.

D is not effective, as both the experimental group and control group reduced the number of prescriptions required.

Solution

24 [VCAA SA Q24 2023]

It is most reasonable to conclude that AIT

A demonstrates long-term and sustained effects. (AIT after the first year reduces the number of prescriptions for hay fever medication and this effect is sustained for the nine years of the study. It is not most effective between the first and second year as there is little difference in results compared with the control.)

Question 32/ 40

[VCAA SA Q25 2023]

It is reasonable to conclude that, compared to the experimental group, the control group

A was randomly selected from the general population.

B participants were unable to leave the study.

C had a similar number of participants.

D had double the number of participants.

Solution

25 [VCAA SA Q25 2023]

It is reasonable to conclude that, compared to the experimental group, the control group

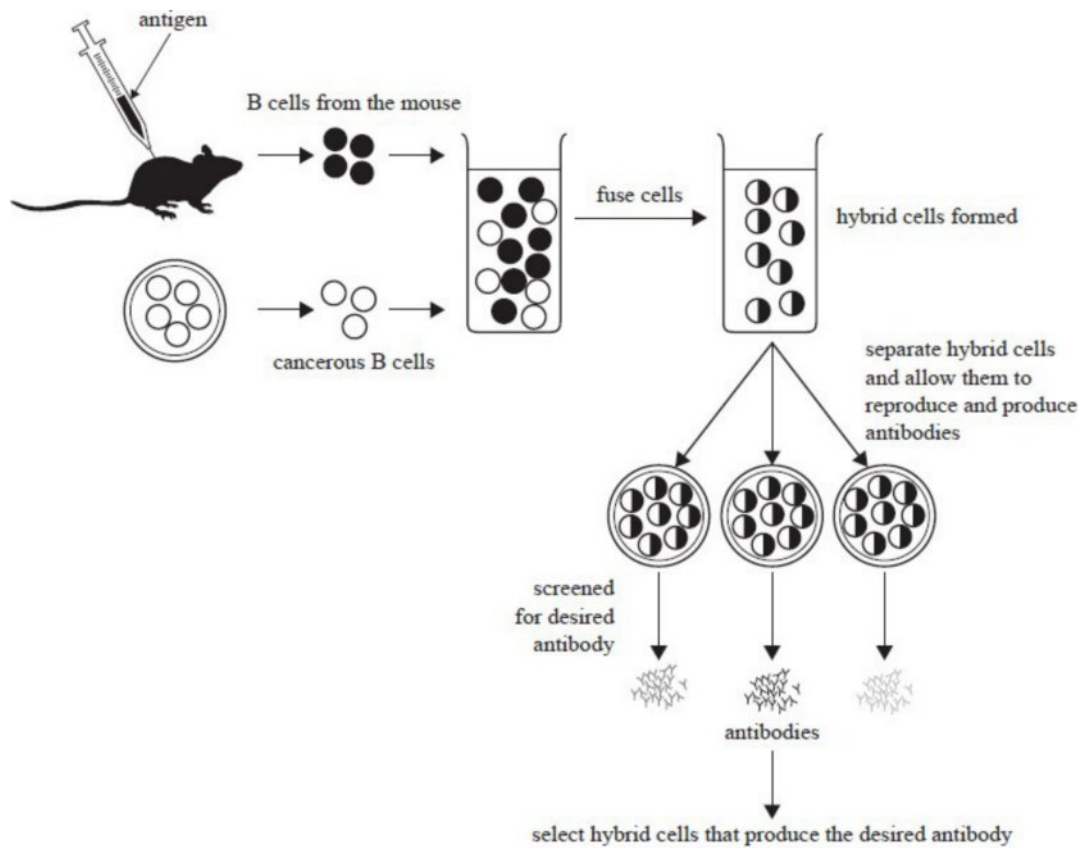
C had a similar number of participants. (In a well-designed experiment, the size and background of the control and treatment groups should be as similar as possible. The aim is to test the effectiveness of AIT – not some other factor.)

Question 33/ 40

[VCAA SA Q26 2023]

Monoclonal antibodies (mAbs) have been the focus of much attention in the fight against cancer. The basic process of monoclonal antibody production is summarised in the diagram that follows, beginning with a

mouse being injected with cancer antigens.



Source: adapted from <<https://openstax.org/books/microbiology/pages/20-1-polyclonal-and-monoclonal-antibody-production>>

Which one of the following statements regarding the production of monoclonal antibodies is correct?

A The monoclonal antibodies produced by one hybrid cell are identical to each other.

B The monoclonal antibodies are specific to the antigens on mouse skin cells.

C The cancerous B cells are extracted from the mouse.

D The antigens are combined with cancerous B cells.

Solution

26 [VCAA SA Q26 2023]

Which one of the following statements regarding the production of monoclonal antibodies is correct?

A The monoclonal antibodies produced by one hybrid cell are identical to each other. (Each hybrid cell can make only one type of antibody. Antigens are injected into the mouse and are not associated with the mouse's skin. B cells are combined with cancerous B cells.)

Question 34/ 40

[VCAA SA Q27 2023]

Bevacizumab is a humanised monoclonal antibody that is used to treat several different cancers. Humanising involves removing part of the constant region of a mouse monoclonal antibody and replacing it with the constant region from a human antibody. Therefore, the humanised antibody has both human-derived and mouse-derived components.

An advantage of humanising monoclonal antibodies such as bevacizumab would be to

A decrease the binding strength between bevacizumab and the cancer cell antigens.

B reduce the chances of an immune response against bevacizumab.

C allow greater destruction of cancerous and non-cancerous cells.

D deliver toxic substances less effectively to the cancer cells.

Solution

27 [VCAA SA Q27 2023]

An advantage of humanising monoclonal antibodies such as bevacizumab would be to

B reduce the chances of an immune response against bevacizumab. (Removing the constant region of the mouse antibody reduces the chance of rejection, which might otherwise be seen as foreign (non-self) by the human immune system.)

Question 35/ 40

[VCAA SA Q28 2023]

Mosunetuzumab is a bispecific monoclonal antibody. Bispecific antibodies are designed to simultaneously bind to two different targets, such as a cancer cell antigen and a cytotoxic T cell. The T cell then destroys the

cancer cell.

Mosunetuzumab bispecificity would arise from the fact that it

A lacks a constant region.

B contains only heavy chains.

C contains both a light and a heavy chain.

D has two different-shaped variable regions.

Solution

28 [VCAA SA Q28 2023]

Mosunetuzumab is a bispecific monoclonal antibody. Bispecific antibodies are designed to simultaneously bind to two different targets, such as a cancer cell antigen and a cytotoxic T cell. The T cell then destroys the cancer cell.

Mosunetuzumab's bispecificity would arise from the fact that it

D has two different-shaped variable regions. (There needs to be regions that can bind with the cancer cell and another that can bind with the cytotoxic T cell.)

Question 36/ 40

[VCAA SA Q29 2023]

Which one of the following correctly describes an event that may occur in the lymphatic system?

A antigen presentation by a dendritic cell to helper T cells

B valves moving lymph fluid in two different directions

C histamine triggering the release of IgE antibodies

D phagocytosis of eosinophils

Solution

29 [VCAA SA Q29 2023]

Which one of the following correctly describes an event that may occur in the lymphatic system?

A antigen presentation by a dendritic cell to helper T cells. (This is a correct description. Looking at other alternatives – valves cause fluid to move in one direction, histamines cause the initial inflammatory response. Eosinophils are cells that are capable of phagocytosis rather than being the target. The action of histamines and eosinophils occurs in the tissues.)

Question 37/ 40

[VCAA SA Q30 2023]

Atlantic salmon (*Salmo salar*) are fish that are farmed in the waters of Tasmania. A selective breeding program was introduced that focused on increasing the growth of the fish, increasing the resistance of the fish to disease and maintaining the colour and oil content of the fish meat.

The selective breeding program resulted in at least a 10% increase in growth of the fish in each generation. Increased resistance to disease has been noted as fewer fish in each generation have required treatment for disease.

In this selective breeding program

A offspring will be produced by random mating of parents.

B genetic variation within the fish population will increase.

C the frequency of alleles for the desired phenotypes will increase over generations.

D maintaining the colour and oil content of the fish meat will be advantageous for the fish.

Solution

30 [VCAA SA Q30 2023]

In this selective breeding program

C the frequency of alleles for the desired phenotypes will increase over generations. (Fish farmers will select fish with the desired characteristics rather than allowing random mating. This will reduce genetic variation in the population rather than increase it. This is an example of artificial selection rather than natural selection.)

Question 39/ 40

[VCAA SA Q31 2023]

The diphtheria vaccine contains an inactivated form of the diphtheria toxin.

Which type of immunity will be acquired by individuals who receive this vaccine?

A artificial active

B natural active

C natural passive

D artificial passive

Solution

31 [VCAA SA Q31 2023]

The diphtheria vaccine contains an inactivated form of the diphtheria toxin.

Which type of immunity will be acquired by individuals who receive this vaccine?

A artificial active. (This is an example of artificial active immunity because the body is stimulated to produce its own antibodies and memory cells by receiving inactivated diphtheria toxins rather than suffering the consequences of diphtheria.)

Question 40/ 40

[VCAA SA Q32 2023]

Outbreaks of diphtheria occasionally occur.

Which statement is the most likely explanation for outbreaks of diphtheria?

A Mutations produce a new strain, which means the bacteria are less able to enter cells in the nose and throat.

B Herd immunity is lost due to parents choosing not to vaccinate their children.

C Free genetic testing to identify individuals who are at risk is not provided.

D There was a failure to use antiviral medication to treat individuals quickly

Solution

32 [VCAA SA Q32 2023]

Outbreaks of diphtheria occasionally occur.

Which statement is the most likely explanation for outbreaks of diphtheria?

B Herd immunity is lost due to parents choosing not to vaccinate their children. (Not all individuals will be vaccinated, so occasional diphtheria outbreaks may occur. If all individuals were vaccinated, the disease could be eradicated. Mutations that result in bacteria being less able to enter the nose and throat would reduce the chances of outbreaks. Genetic testing would be unlikely to be useful and antiviral medication is usually used after infection rather than before.)

Question 42/ 40

[VCAA SA Q33 2023]

The World Health Organization declared that the outbreak of Zika virus in 2015 and 2016 was an epidemic rather than a pandemic because

A the cases were confined to specific geographic regions.

B no vaccination was available for the pathogen.

C cases were confirmed in different countries.

D people of all ages were affected.

Solution

33 [VCAA SA Q33 2023]

The World Health Organization declared that the outbreak of Zika virus in 2015 and 2016 was an epidemic rather than a pandemic because

A the cases were confined to specific geographic regions. (Definition: Epidemics affect a particular geographic region, whereas a pandemic such as COVID has a worldwide impact.)

Question 43/ 40

[VCAA SA Q34 2023]

Which one of the following measures would be least effective in controlling the spread of Zika virus?

A using television and radio advertisements to educate people on how Zika virus spreads

B providing free face masks and encouraging people to wear them in public

C quarantining infected individuals inside their homes

D wearing clothing that covers arms and legs

Solution

34 [VCAA SA Q34 2023]

Which one of the following measures would be least effective in controlling the spread of Zika virus?

B providing free face masks and encouraging people to wear them in public. (This would not provide useful protection as the disease is spread by a vector – the mosquito. The other methods could assist in controlling the spread of the Zika virus.)

Question 44/ 40

[VCAA SA Q35 2023]

Students designed a controlled experiment. After they had performed the experiment, another group of students gave them feedback suggesting that they should modify the experiment to improve the accuracy of their results.

A change that the first group of students could make to improve the accuracy of their results could include

A ignoring outlying results.

B repeating the experiment many times.

C carefully calibrating the equipment used.

D having many people take the measurements.

Solution

35 [VCAA SA Q35 2023]

A change that the first group of students could make to improve the accuracy of their results could include

C carefully calibrating the equipment used. (Poorly calibrated equipment could reduce the accuracy of results. Repeating the experiment if equipment is not correctly calibrated will not improve accuracy and having many people take measurements introduces errors due to individual interpretations of the method.)

Question 45/ 40

[VCAA SA Q36 2023]

An evolutionary biologist used several methods to construct a phylogenetic tree for a group of mammals.

Which one of these methods would have been least useful?

A amino acid sequences

B protein sequences

C bone structure

D presence of hair

Solution

36 [VCAA SA Q36 2023]

An evolutionary biologist used several methods to construct a phylogenetic tree for a group of mammals.

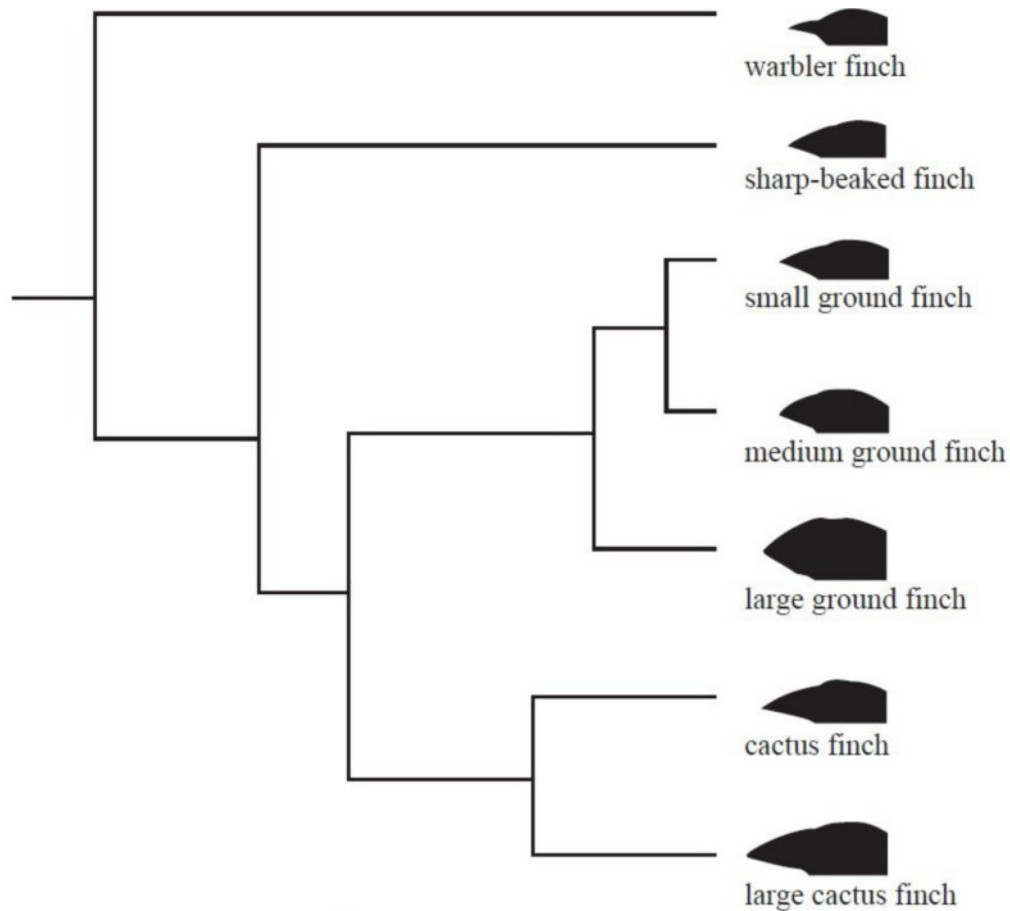
Which one of these methods would have been least useful?

D presence of hair. (The other alternatives could provide useful information to construct a phylogenetic tree. Presence or absence of hair may or may depend on the age or health of individuals.)

Question 46/ 40

[VCAA, SA, Q37, 2023]

The phylogenetic tree below shows the evolutionary relationship between several species of finches.



Source: adapted from WJ Cromie, 'How Darwin's finches got their beaks', *The Harvard Gazette*, 24 July 2006, <<https://news.harvard.edu/gazette/story/2006/07/how-darwins-finches-got-their-beaks>>

Which pair of finches has the most recent common ancestor?

- A large cactus finch and cactus finch
- B sharp-beaked finch and warbler finch
- C large ground finch and medium ground finch
- D small ground finch and medium ground finch

Solution

37 [VCAA SA Q37 2023]

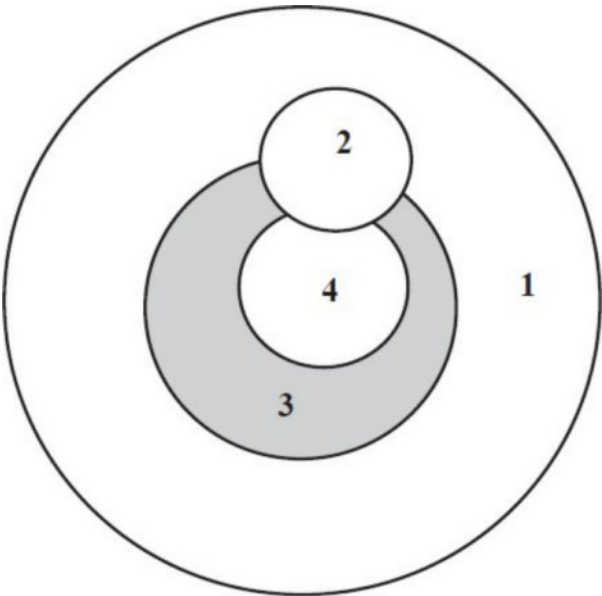
Which pair of finches has the most recent common ancestor?

D small ground finch and medium ground finch. (Looking at the tree, these finches arise from the most recent branching. They are closely related to the large ground finch but have diverged from that species.)

Question 47/ 40

[VCAA SA Q38 2023]

Students constructed a diagram to illustrate the relationships between hominins and other groups. They produced the diagram on the next page.



Which one of the following options correctly represents each group?

Circle 1	Circle 2	Circle 3	Circle 4
mammals	primates	hominoids	hominins
mammals	primates	hominins	hominoids
primates	hominins	hominoids	mammals
hominins	hominoids	primates	mammals

Solution

38 [VCAA SA Q38 2023]

Which one of the following options correctly represents each group?

Circle 1 Circle 2 Circle 3 Circle 4

A mammals primates hominoids hominins

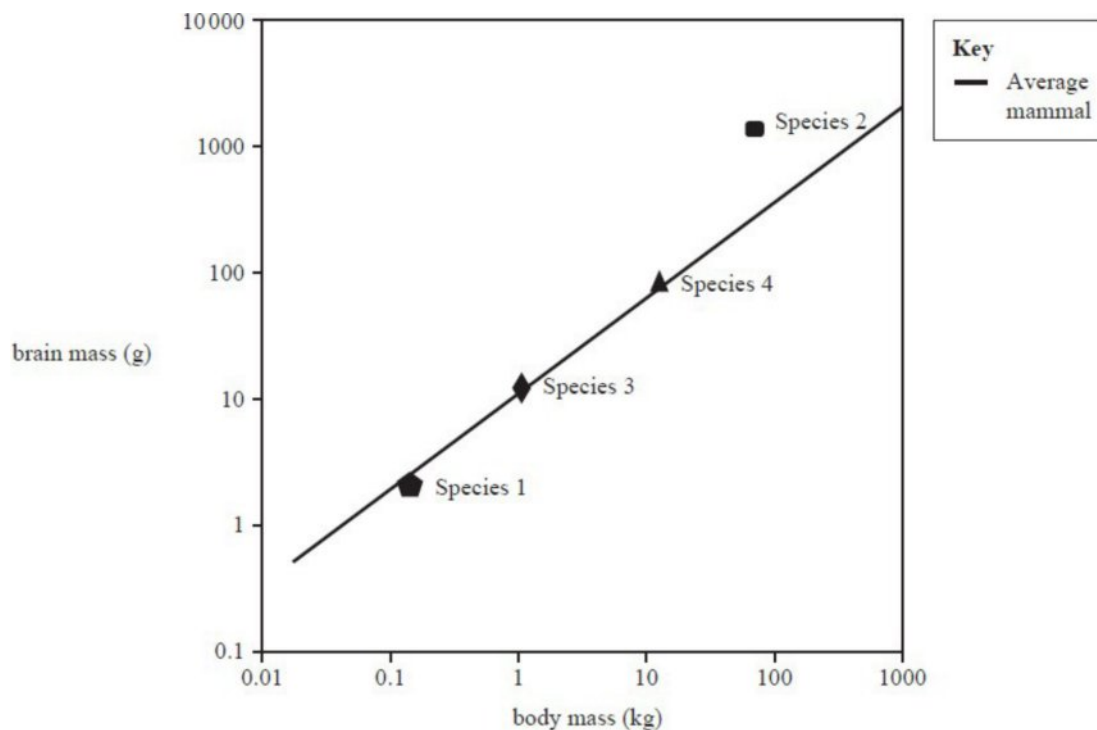
(Hominins include modern humans and their ancestors, hominoids include apes and humans, hominoids are a subset of primates and primates are a subset of mammals.)

Question 48/ 40

[VCAA SA Q39 2023]

Scientists investigated the relationship between body mass and brain mass in primate species. The graph below shows the data for several primate species including Homo sapiens.

Both the body mass (kg) and brain mass (g) of each species have been plotted using a logarithmic scale.



Source: adapted from P Schoenemann (2008), 'Evolution of the Size and Functional Areas of the Human Brain', *Annual Review of Anthropology* 35(1), <<https://www.researchgate.net/publication/228173421>>

Based on the information in the graph on the previous page, which species is most likely to represent Homo sapiens?

A Species 1

B Species 2

C Species 3

D Species 4

Solution

39 [VCAA SA Q39 2023]

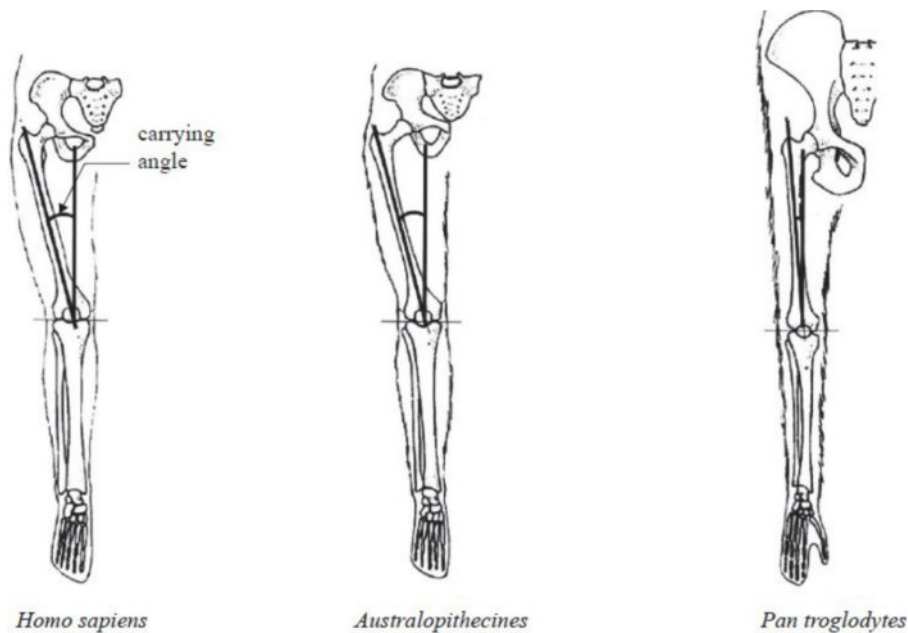
Based on the information in the above graph, which species is most likely to represent *Homo sapiens*?

B Species 2. (Note that species 1 and 3, have a body mass of much less than 10kg. Most adults will have a body mass of 50kg or more. Species 2 has a large brain mass compared to body mass which is typical of *Homo sapiens*. Species 4 has a very small brain, so it is unlikely to be a human brain.)

Question 49/ 40

[VCAA SA Q40 2023]

The diagram below shows the position of the pelvis and leg bones of *Homo sapiens*, *Australopithecines* and chimpanzees (*Pan troglodytes*). The carrying angle for each is shown.



Source: adapted from S Shefelbine, C Tardieu and D Carter, *Bone*, 2002, vol. 30

Which one of the following statements is correct?

- A *Homo sapiens* have the smallest carrying angle of the skeletons shown.
- B The carrying angle in *Australopithecines* allows their centre of gravity to be shifted forward.
- C The carrying angle of the *Pan troglodytes* suggests that, of the three species, it is the best suited to bipedalism.
- D The large carrying angle of *Australopithecines* supports bipedalism.

Solution

40 [VCAA SA Q40 2023]

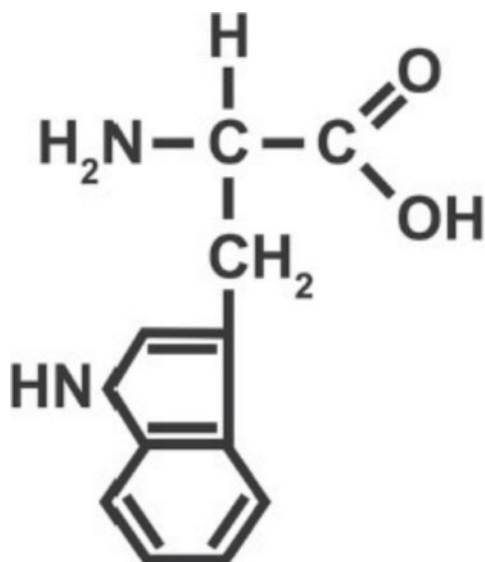
Which one of the following statements is correct?

D The large carrying angle of *Australopithecines* supports bipedalism. (Statement A is incorrect looking at the diagrams – the carrying angle is similar for *Homo sapiens* and the *Australopithecines*. A large carrying angle ensures the knee is brought under the body during walking.)

Question 1/ 11

[VCAA SB Q1 2023]

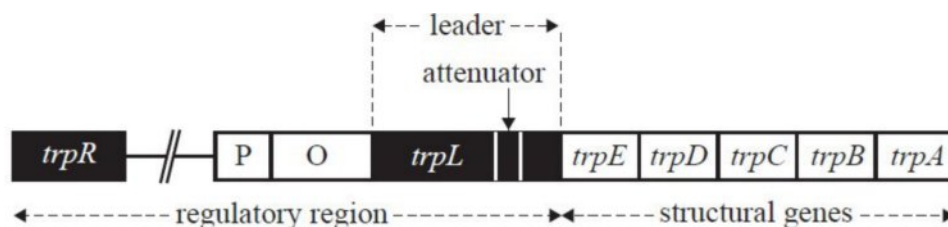
The diagram below shows the structure of tryptophan.



Source: Ali DM/Shutterstock.com

a To what group of biological monomers does tryptophan belong? Use the information in the diagram to justify your response. [2 marks]

b The synthesis of tryptophan in prokaryotic cells such as *Escherichia coli* is regulated. The positions of both the regulatory region and the structural genes are shown in the diagram below.



Source: adapted from Trpoperon, <<https://en.wikipedia.org/wiki/File:Trpoperon.svg> licensed CC-BY SA 3.0>

E. coli has two mechanisms that regulate the expression of the structural genes for the synthesis of tryptophan: repression and attenuation.

Compare the two mechanisms of regulation. Refer to the diagram in your answer.

[6 marks]

[Total 8 marks]

Solution

1 [VCAA SB Q1 2023]

a Tryptophan is an amino acid.

Any one of the following reasons:

- an amino group/ H_2N is present in amino acids, and this is present in the diagram.
- a carboxyl group/ COOH is present in amino acids, and this is present in the diagram.
- an R side chain is present in amino acids, and this is present in the diagram.
- a central carbon atom is present in amino acids, and this is present in the diagram.

b Similarities

Both repression and attenuation

- structural genes are not expressed because of processes occurring in the regulatory region.
- result in no/little production of trp when trp levels are high.
- result in the production of trp when trp levels are low.
- conserve cellular energy.
- occur in the gene's regulatory region.

Differences

- when trp levels are high, transcription of the trp genes does not occur during repression, whereas transcription begins and is not completed in attenuation.
- when trp levels are high, the operator is blocked in repression, whereas in attenuation, the operator is not blocked.
- when levels of trp are high, in attenuation, a hairpin/terminator loop is formed in the leader region stopping transcription, whereas in repression, a hairpin loop is not formed.

Note: This is a comparison question; therefore, both processes must be mentioned, as well as at least one similarity and one difference. When discussing a difference, use the following format. X does.... whereas Y does. The question is worth 6 marks; therefore, there is a maximum of 3 marks for each process. The question asks you to refer to the diagram; consequently, you must mention some of the diagram labels in your answer.

A student found an unusual plant species growing in the local park. Without knowing what type of plants they were, the student undertook experiments to identify the photosynthetic output of the plants as measured by the rate of starch formed per day. Plants of the same size were exposed to different environmental conditions, and the rate of starch formed per day was measured.

The results are shown in the table that follows.

Effect of different environmental conditions on starch production per day

Temperature (°C)	Light Source	Carbon Dioxide (%)	Relative Humidity (%)	Rate of starch formed (mg/day)
20	white	5	70	1.5
20	white	1	70	1.2
20	white	5	30	1.8
20	green	5	30	0.3
20	blue	5	30	1.4
40	white	5	70	2.8
40	white	1	70	2.4
40	white	5	30	3.0
40	green	5	30	0.4
40	blue	5	30	2.7

a To which plant group (C3, C4 or CAM) would this unusual plant species most likely belong? Justify your answer.

Justify your answer. [3 marks]

b Why does exposing the plants to green or blue light as opposed to white light affect the formation of starch? Justify your answer.

[4 marks]

[Total 7 marks]

Solution

2 [VCAA SB Q2 2023]

a The unknown plant is a CAM plant.

The unknown plant shares more characteristics with CAM plants than with C3 or C4 plants.

Reason:

– the unknown plant has a maximum photosynthetic rate at 40°C. This is close to the optimal temperature for CAM plants, whereas the optimum temperature for C3 plants is 15-25°C and 40°C is the upper temperature for C4 plants.

– CAM plants are adapted to dry/low humidity, whereas C3 and C4 are not. The unknown plant had an optimum photosynthetic rate at low relative humidity of 30.

(Note: this is a comparison question.)

b White light is composed of many different wavelengths/colours of light. In the light-dependent stage of photosynthesis, light energy is absorbed and converted to chemical energy. Chlorophyll absorbs red and blue light and reflects green light; therefore, exposing the plant to green light will limit the amount of light energy absorbed and the amount of energy available for photosynthesis.

Question 3/ 11

[VCAA SB Q3 2023]

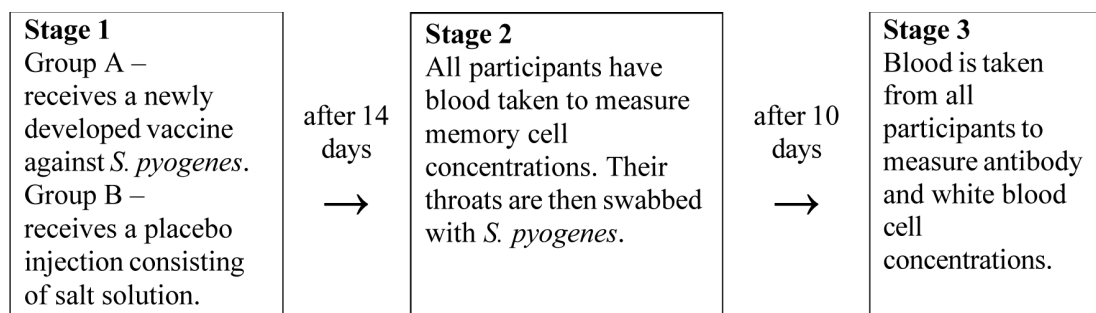
Streptococcus pyogenes is a pathogenic bacterium that can cause a range of diseases including a sore throat. People infected by *S. pyogenes* produce specific antibodies against the bacterium that normally enable them to recover after several days.

a Describe the functions of these specific antibodies during an *S. pyogenes* infection and how this leads to recovery. [3 marks]

In 2021, researchers from Melbourne's Nucleus Network were involved in the early stages of developing a vaccine against *S. pyogenes*. Part of their investigation involved determining the bacterial concentration needed to cause a sore throat in at least 60% of people whose throats were deliberately infected with *S. pyogenes*.

b Some scientists suggest that this study may have violated a principle of bioethics. Suggest which **principle** this may be and **explain** why. [2 marks]

In a follow-up study, the participants were divided into two groups (A and B) of equal size and put through a three-stage trial, as shown below.



Participants also indicated whether they suffered from a sore throat at any point during the study. The data in the table that follows shows the results from four participants at the end of the study.

	Participant			
	1	2	3	4
Sore throat during study?	yes	no	no	yes
Blood memory cell concentration at stage 2	low	high	medium	high
Blood memory cell concentration at stage 3	medium	high	high	high
Blood antibody concentration at stage 3	medium	high	high	high
Blood cytotoxic T cell concentration at stage 3	low	low	low	high

c Explain which participant is the most likely to have received the placebo injection. [3 marks]

d Another example of a pathogenic bacteria is *Mycobacterium tuberculosis*. This bacterium causes the disease tuberculosis (TB). Some strains of this bacterium have become resistant to many of the common drugs used in the treatment of TB.

Outline two ongoing challenges for treatment strategies as a result of this resistance. [2 marks]

[Total 10 marks]

Solution

3 [VCAA SB Q3 2023]

a The specific antibodies bind to specific antigens on or produced by *Streptococcus pyogenes*, thus tagging *S. pyogenes* for easier identification by phagocytes, immobilising *S. pyogenes*, reducing the infection's spread and activating complement proteins to destroy *S. pyogenes*. Phagocytes then destroy *S. pyogenes*, reducing the number of *S. pyogenes* circulating in the body, thus reducing symptoms and increasing recovery time.

b Principle violated: non-maleficence

Explanation: Non-maleficence focuses on not doing or causing harm. In this experiment, at least 60% of people were deliberately harmed.

Note: Other answers are possible, but non-maleficence is the best answer.

c Individual 1 is most likely to have received the placebo injection.

Individuals who received the vaccine would have developed immunity to *S. pyogenes* and would not develop a sore throat; therefore, 2 and 3 would not have received the placebo. Individual 1 has the lowest blood memory cell concentration at stage 2. This suggests they have had no vaccine exposure, whereas the others have been exposed and have produced an adaptive immunity response resulting in memory cells already present. Individuals 2, 3 and 4 have a high blood memory cell and antibody concentration at stage 3. This suggests that they have had prior exposure to the *S. pyogenes* vaccine, whereas Individual 1 has the lowest memory cell concentration at stage 3, indicating no exposure to the vaccine.

d Any two of the following ongoing challenges:

- current available drugs will be ineffective in treating TB.
 - new drugs for fighting TB will need to be developed continually.
 - obtaining funding to develop new drugs/vaccines
 - the incidence of TB will increase and place pressure on healthcare.
-

Question 4/ 11

[VCAA SB Q4 2023]

In most mammalian cells the ATP produced from the complete breakdown of glucose occurs by a series of chemical reactions. Coenzymes also play an important role in glucose metabolism.

a Describe the roles of coenzymes in the formation of ATP. [3 marks]

A student measured the effect of oxygen on the metabolism of glucose in red blood cells at 37 °C and observed the results shown in the table below.

Effect of oxygen availability on the metabolism of glucose by red blood cells

Oxygen	Glucose consumed (nmoles/ 10^7 cells/hour)	Lactate produced (nmoles/ 10^7 cells/hour)
absent	1.6	3.2
present	1.6	3.2

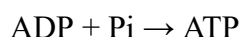
b Why are the results the same irrespective of the presence of oxygen? Explain your answer. [3 marks]

[Total 6 marks]

Solution

4 [VCAA SB Q4 2023]

a ATP is produced in cells by the following chemical reaction.



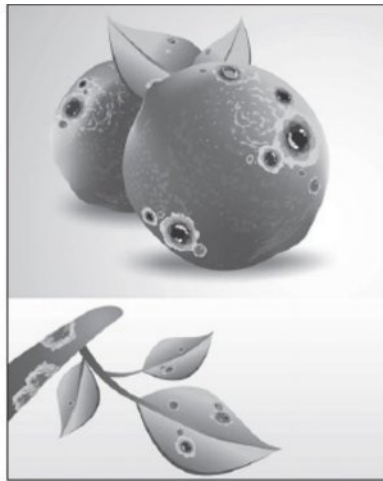
Coenzymes are non-protein molecules that bind with the active site of specific enzymes to catalyse specific reactions. They exist in unloaded and loaded forms, e.g.: ADP/ATP, NAD/NADH and FAD/FADH₂. Cycling of coenzymes between loaded or unloaded forms moves energy, protons and electrons between reactions in the cell. Coenzymes are involved in reactions that convert the chemical energy stored in glucose into the chemical energy stored in ATP.

b Oxygen is required in aerobic respiration, which occurs in mitochondria. Red blood cells lack mitochondria; therefore, they cannot respire aerobically. The first stage of cellular respiration is glycolysis, which occurs in the cytoplasm. In glycolysis, glucose is broken down into pyruvate and 2 ATP. Pyruvate is converted into lactate. Oxygen is not required for glycolysis; therefore, its absence or presence will not affect lactate production.

Question 5/ 11

[VCAA SB Q5 2023]

Citrus canker is a disease that affects citrus plants such as lime and orange trees, reducing fruit yield and quality by causing the development of dark spots on the fruit and leaves. It is caused by several different bacteria species, including *Xanthomonas axonopodis*. There have been several outbreaks in Australia.



Source: adapted from kaew409/Shutterstock.com

Scientists have recently tried to use CRISPR-Cas9 technology to inactivate genes involved in the citrus canker pathway. This pathway for citrus canker disease is summarised below:

Xanthomonas axonopodis bacteria enter a citrus plant.



CsWRKY22 gene in citrus plant cells is activated by the bacteria.



CsWRKY22 gene is transcribed producing *CsWRK22* protein.



CsWRKY22 protein then binds to *CsLOB1* gene.



Transcription of *CsLOB1* gene produces proteins that result in citrus canker development.

a Using the information in the flow chart above, explain how CRISPR-Cas9 technology could be used to produce citrus-canker-resistant plants.

[4 marks]

During outbreaks of citrus canker, the infected trees and fruit are removed and burned. Recently it has been proposed that instead of being burned, the trees could be used to produce biofuel.

The first stage in the production of biofuel from infected trees could involve a technique known as steam explosion. This involves using very hot steam at high pressures inside a pressure chamber to break open the cells from the trees.

An investigation was conducted to determine the relationship between temperature and the percentage of cells broken open during the steam explosion technique. The results are shown below.

Temperature inside pressure chamber (°C)	Percentage of cells broken open

80	47
150	57
200	85
250	94

b Scientists decided to use the steam explosion technique at 250 °C. The temperature was then lowered to 35 °C and yeast was added to the ruptured cell mixture.

Why did the scientists decide to do each of the following?

i Use 250°C [1 mark]

ii Lower to 35°C and add yeast [1 mark]

[Total 6 marks]

Solution

5 [VCAA SB Q5 2023]

a The scientist would first identify the *CsWRKY22* gene. This would be used as a template to form a complementary chain of RNA nucleotides, resulting in sgRNA. Cas9 enzyme would be added to the sgRNA to form a CRISPR-Cas9 complex. The CRISPR-Cas9 complex would be injected into citrus plant cells.

The sgRNA would guide Cas9 to the *CsWRKY22* gene, where it would cut the DNA, producing blunt ends. The cell would then attempt to repair the DNA and may introduce new DNA into the gene that would stop transcription and formation of the *CsWRK22* protein. The *CSWRK22* protein would not bind to the *CSLOBI* gene and the citrus-canker-producing proteins would not be produced. Cells that have been modified would then be cultured.

Or

The scientist would first identify the *CsLOBI* gene. This would be used as a template to form a complementary chain of RNA nucleotides, resulting in sgRNA. Cas9 enzyme would be added to the sgRNA to form a CRISPR-Cas9 complex. The CRISPR-Cas9 complex would be injected into citrus plant cells.

The sgRNA would guide Cas9 to the *CsLOBI* gene, where it would cut the DNA, producing blunt ends. The cell would then attempt to repair the DNA and may introduce new DNA into the gene that would stop transcription and formation of the citrus canker-producing proteins. Cells that have been modified would then be cultured.

b i Use 250°C

This is the temperature where the highest percentage of cells are broken open. The glucose within the cell is an input in the fermentation process.

ii Lower to 35°C and add yeast.

Yeast uses glucose in anaerobic respiration to produce ethanol and CO₂. Ethanol is then used as a biofuel. 35°C is the optimum temperature for yeast activity. If the temperature was not lowered, the yeast would die and not produce ethanol.

Question 6/ 11

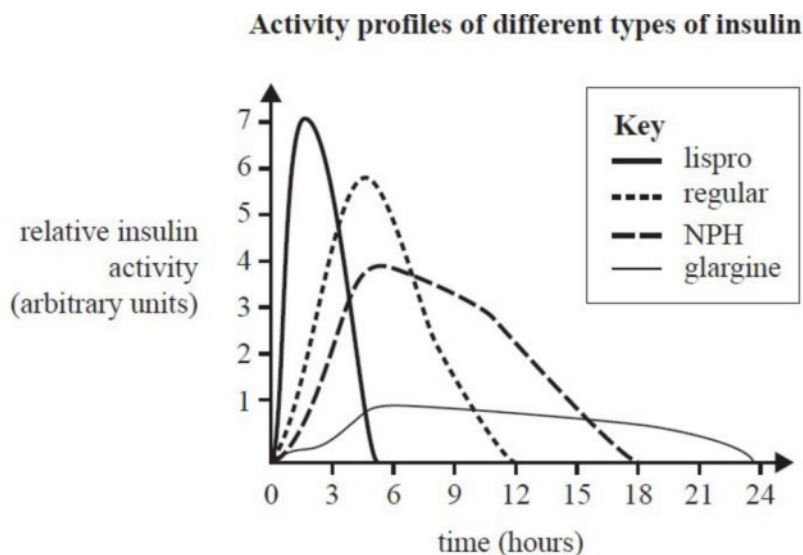
[VCAA SB Q6 2023]

Diabetes can be an autoimmune condition where the body is activated to destroy the beta cells in the pancreas that produce insulin. Human insulin is a polypeptide hormone. Insulin consists of two polypeptide chains, chain A (21 amino acids) and chain B (30 amino acids), connected by two disulfide bridges. Human insulin can be made using recombinant plasmids.

a Outline how human insulin is made using recombinant plasmids.

[5 marks]

There are different types of insulin available for use. The activity profile of each of these insulins is shown in the graph below.



Source: adapted from 'Types of Insulin', Diabetes Education Online, <<https://dtc.ucsf.edu/types-of-diabetes/type2/treatment-of-type-2-diabetes/medications-and-therapies/type-2-insulin-rx/types-of-insulin/>>

b Identify which type of insulin is rapid acting compared to regular insulin. Use data from the graph to justify your response. [3 marks]

Insulin contains 2 polypeptide chains.

c i What hierarchical level of organisation is insulin? [1 mark]

Scientists alter the primary structure of insulin to create different types of insulin.

ii What should scientists consider when altering the primary structure of insulin? Justify your response. [2 marks]

[Total 11 marks]

Solution

6 [VCAA SB Q6 2022]

a Sequence and synthesise the gene coding for Chain A. The exons of the gene coding for Chain A would be artificially produced using DNA sequencing/the genetic code and the known sequence of amino acids in Chain A. PCR would be used to make many copies of the gene coding for Chain A.

Prepare the plasmid. Endonucleases and ligase would be used to insert the Chain A gene, an antibiotic resistance gene, a reporter gene, an origin of replication and a lac operon into a plasmid.

Transformation. The plasmids would then be mixed with a culture of bacteria. Heat shock or electroporation would allow some bacteria to take up the plasmids.

Select transformed bacteria. The bacteria would be grown on the antibiotic associated with the inserted antibiotic resistance gene. Only transformed bacteria would survive.

Turn the Chain A gene on. Lactose would be added to the culture. This would turn the gene for Chain A on and produce the Chain A protein, which would then be purified.

Repeat for Chain B. The whole process would be repeated in a separate flask using the gene for Chain B rather than Chain A.

Combine Chain A and Chain B. The purified Chain A and B proteins would then be mixed to form a functional insulin protein.

b Lispro

Relative insulin activity rises the fastest and reaches a higher peak of 7 arbitrary units at 2 hours than regular insulin, which peaks at 5.5 arbitrary units at 5 hours.

c i Quaternary

ii Scientists would consider whether altering the primary structure of insulin would alter the shape of the insulin molecule's binding site. The insulin may not be functional if the binding site shape is altered.

Question 7/ 11

[VCAA SB Q7 2023]

The helmeted honeyeater (*Lichenostomus melanops cassidix*) can be found in forest to the east of Melbourne. There are only three small wild populations. The bird has been listed as critically endangered.

a Explain how the genetic diversity of helmeted honeyeaters may change over time as a result of genetic drift. [3 marks]

b Since 1989, Zoos Victoria has run a captive-breeding program for the helmeted honeyeater. More than 250 helmeted honeyeaters have been released into the wild and the total number of birds in the wild has tripled since 1989.

Each year, eggs are swapped between the wild populations and the captive-bred population.

How is genetic diversity within the wild populations being maintained?

[2 marks]

c Define a consequence-based approach to bioethics and outline how this relates to the work by Zoos Victoria to prevent extinction of the helmeted honeyeater.

[3 marks]

[Total 8 marks]

Solution

7 [VCAA SB Q7 2022]

a Genetic drift refers to changes, unpredictable in direction, in allele frequencies from one generation to the next owing to the action of chance events. It is more likely to occur in small populations as only a few individuals with a particular phenotype will exist. For example, the helmeted honeyeater lives in a small population outside Melbourne. If this population varies in the shape of its helmet, there will only be a few individuals with each type of helmet. If a fire passes through the area and all individuals with a particular phenotype die by chance, the phenotype will disappear from the population and genetic diversity will decrease.

b The genetic diversity within the wild population is maintained by introducing eggs from the captive breeding population. This results in gene flow between the captive and wild populations, increasing genetic diversity.

c The consequence-based approach to bioethics involves considering all possible outcomes and then making a decision that maximises the positive and minimises the negative outcomes. The positive consequences of Zoos Victoria's captive-breeding and egg swap programs are that the helmeted honey eater will not become extinct, and the genetic diversity of the wild population will be maintained. The negative consequences are that swapping the eggs may lead to the rejection of the eggs and, therefore, less hatching.

Question 8/ 11

[VCAA SB Q8 2023]

Neanderthals and early *Homo sapiens* share a common ancestor that originated in Africa. By the time modern humans left Africa around 300 000 years ago, Neanderthals had been living in Europe and Asia for approximately 100 000 years.

Early genetic studies identified around 0.02% of Neanderthal DNA in genomes of modern Africans. New research has identified that those with African ancestry have closer to 0.5% Neanderthal DNA. The same study found that Neanderthal DNA contributed 1.7% to European genomes and 1.8% in Asian genomes.

a Suggest two possible ways in which people with African ancestry could have some Neanderthal DNA in their genomes. [2 marks]

b Suggest why it is reasonable that modern Europeans and Asians show greater percentages of Neanderthal DNA than people who originated in Africa.

[2 marks]

[Total 4 marks]

Solution

8 [VCAA SB Q8 2022]

a Any two of the following reasons why people with African ancestry could have some Neanderthal DNA in their genomes:

– the Neanderthal DNA was inherited from the common ancestor

– some of the modern African ancestors left Africa and migrated to

Europe/Asia interbred with the Neanderthals and then returned to Africa.

- some Neanderthals returned to Africa and interbred with the African ancestor populations before returning to Europe.
- People with African ancestry interbred with *Homo sapiens* containing Neanderthal DNA.

b Modern Europeans and Asians show higher percentages of Neanderthal DNA than people who originated in Africa; as Modern Europeans, Asians and Neanderthals occupied the same area more recently; therefore, there were more interbreeding opportunities. There has been less time for mutations to accumulate between Modern Europeans, Asians and Neanderthals as they share a more recent common ancestor.

Question 9/ 11

[VCAA SB Q9 2023]

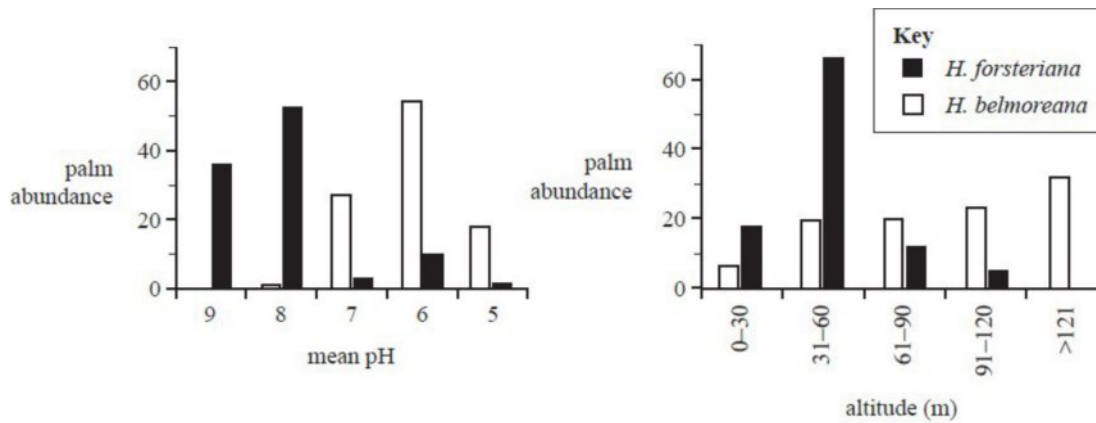
Scientists recorded flowering information for two *Howea* palm species found on Lord Howe Island. The information recorded is presented in the following table.

Palm species	Flowering frequency each week over 13 weeks												
	1	2	3	4	5	6	7	8	9	10	11	12	13
male <i>H. forsteriana</i>	0.16	0.25	0.27	0.16	0.05	0.02	0.01	0.01	0.01	0	0	0	0
female <i>H. forsteriana</i>	0.04	0.06	0.15	0.25	0.26	0.15	0.03	0	0	0	0	0	0
male <i>H. belmoreana</i>	0	0	0	0	0.03	0.04	0.05	0.17	0.25	0.17	0.14	0.1	0.02
female <i>H. belmoreana</i>	0	0	0	0	0.01	0.04	0.15	0.16	0.21	0.14	0.16	0.11	0.05

Source: adapted from V Savolainen, MC Anstett, C Lexer, I Hutton, J Clarkson, M Norup, M Powell, D Springate, N Salamin, & W Baker, *Nature*, 2006, <<https://www.researchgate.net/publication/7306249>>

a Using the information in the table, identify two factors that may have contributed to speciation in these two palms. [2 marks]

Scientists also recorded the pH of the soil in which the palm species were growing and the altitude where the plants could be found.



Source: adapted from V Savolainen, MC Anstett, C Lexer, I Hutton, J Clarkson, M Norup, M Powell, D Springate, N Salamin, & W Baker, *Nature*, 2006, <<https://www.researchgate.net/publication/7306249>>

b i Referring to the graphs above, complete the table below, listing the most ideal environment for *H. forsteriana* and *H. belmoreana*. [1 mark]

	pH	Altitude range (m)
<i>H. forsteriana</i>		
<i>H. belmoreana</i>		

b ii Evidence suggests that a common ancestor of the two palm species colonised acidic (pH below 7) volcanic soils on the island around 6 million years ago. Much more recently (2 million to 500 000 years ago), *H. forsteriana* diverged from the common ancestor.

Explain how these differences between pH and altitude could have led to speciation. [2 marks]

[Total 5 marks]

Solution

9 [VCAA SB Q9 2022]

a Two factors that may have contributed to speciation in the palms:

– different flowering times. *Howea forsteriana* flowers mainly in the first 7 weeks, whereas *Howea belmoreana* flowers mainly in the last 9 weeks. There is only a short time when both species are flowering together.

– different peak flowering frequency. Peak flowering frequency for male *H. forsteriana* is at week 3 and for female *H. forsteriana* at week 5, whereas for male and female *H. belmoreana*, it is at week 9. Peak flowering frequencies are very different; therefore, there is less opportunity for gene flow.

b i

	pH	Altitude range (m)
<i>H. forsteriana</i>	8	31-60
<i>H. belmoreana</i>	6	>121

ii The original population of *Howea* was found in pH soil below 7. Between 2 million and 500 00 years ago, some seeds germinated on nearby soils of higher pH and lower altitude. These conditions were not ideal and resulted in stressed plants. The stressed plants flowered earlier than the plants of the original population, leading to reproductive isolation. Over time, the differences between pH and altitude provided different selection pressures, leading to significant genetic differences accumulating in the two populations and resulting in two species. Alleles coding for phenotypes favoured by high pH and low altitude were selected in populations that became *H. forsteriana*. In contrast, alleles coding for phenotypes favoured by low pH and high altitudes continued to be selected for in populations that became *H. belmoreana*.

Question 10/ 11

[VCAA SB Q10 2023]

The platypus (*Ornithorhynchus anatinus*) is a semi-aquatic animal, historically present in rivers throughout Victoria.



Source: John Carnemolla/Shutterstock.com

Platypuses usually occur in areas that have stable banks for burrowing, invertebrates for food, and reliable

water flows. The platypus is potentially vulnerable to a range of natural and human-induced threats that degrade aquatic ecosystems, including drought, predators, habitat destruction, poor water quality and altered river flows. The Victorian Government listed the platypus as vulnerable in 2021.



Source: metha1819/Shutterstock.com

An innovative detection technique using environmental DNA (eDNA) allowed scientists to develop a detailed map of platypus populations across the state. eDNA is comprised of traces of DNA that wildlife shed into their environment. Volunteers were provided with water-sampling kits and collected water samples from over 1500 selected sampling sites on Victorian rivers.

At each sampling site, six water samples were collected and tested in the laboratory using the Polymerase Chain Reaction (PCR) method. The PCR results were analysed using a platypus-specific DNA probe. At least two positive PCR results (out of six water samples) were required to classify the site as positive for the presence of platypus DNA.

a Give two examples of possible sources of eDNA from the platypus.

[2 marks]

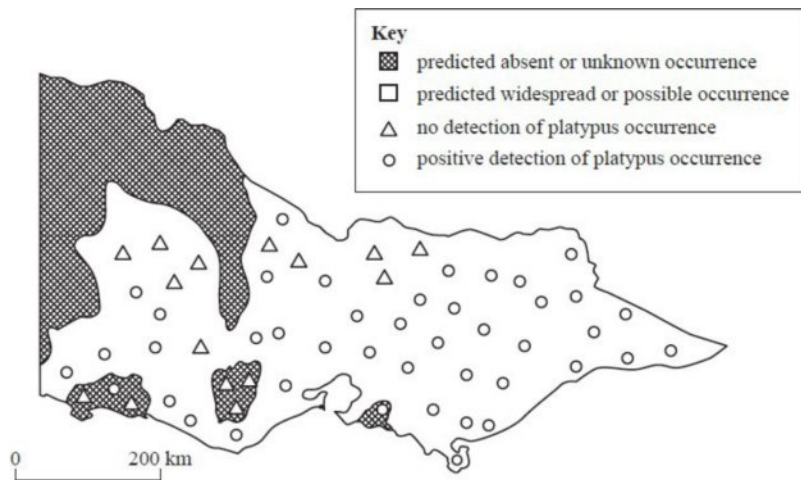
b Explain two factors to consider when sampling the water to reduce sources of error. [4 marks]

c State why PCR was used in the test of the water samples.

[4 marks]

Prior to the project, state-wide data on the occurrence of platypuses across Victorian rivers was collated. Refer to the shading on the map below for predicted platypus occurrences.

The project detected platypuses at 19–25% of sampled Victorian rivers. Refer to the icons on the map below for the results from eDNA surveys for detection of platypus occurrence at a range of sampling sites.



Source: adapted from 'eDNA tells story of platypus distribution throughout Victoria', EnviroDNA,

<https://www.envirodna.com/news/edna-tells-story-of-platypus-distribution-throughout-victoria>

d Referring to the map on the previous page, describe one difference between predicted platypus occurrence and detection of platypus occurrence from the eDNA survey results. Justify your response.

[2 marks]

[Total 8 marks]

Solution

10 [VCAA SB Q10 2023]

a Any two of the following sources of eDNA:

- faeces.
- urine.
- hair.
- skin.
- saliva.
- venom.
- semen.

b Any 2 of the following factors to consider when sampling water:

- a number of samples to be taken at each sampling site.

- the same number of samples taken at each sampling site.
- samples to be taken from the same depth at each sampling site.
- samples to be taken at the same time/season at each sampling site.
- the wearing of gloves by the scientists to reduce contamination of the samples.
- detailed labelling of the samples, including date, time and location.

c The amount of platypus eDNA in the water samples would be tiny. PCR would be used to make many copies of (amplify) the platypus eDNA present so there would be enough for the scientists to work with.

d Any one of the following differences:

- the positive detection of platypus occurs in 2 southern populations where they were predicted to be absent. Circles in hatched areas show this.
 - no detection of platypus in areas of northern Victoria where they were predicted to occur. This is shown by the presence of triangles in white areas.
-

Question 11/ 11

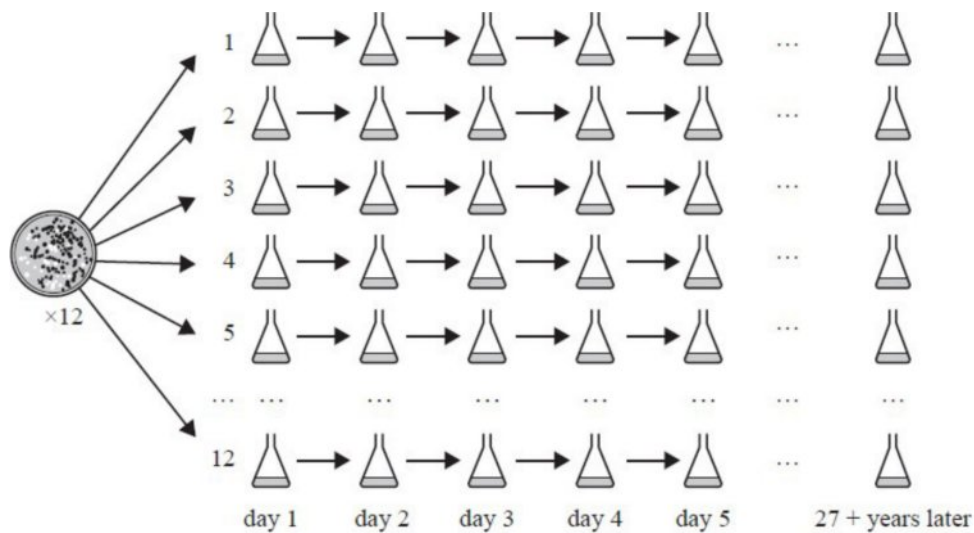
[VCAA SB Q11 2023]

In 1988 a scientist called Richard Lenski and his group used a single ancestral genome of *Escherichia coli* to put 12 genetically identical populations in 12 identical environments. Each environment consisted of a flask filled with 10 mL of bacterial growth medium, a nutrient broth containing glucose and citrate. Citrate is a potential food source that *E. coli* cannot use.

The group was interested in observing the evolution of diversification and adaptation as they happened in the laboratory.

The method of their experiment involves a simple serial transfer protocol: As the populations grow over the course of every 24 hours, they use up the resources in their flasks, so every day a 0.1 mL sample of each population is transferred to a flask of 9.9 mL of fresh growth medium and thus allowed to keep reproducing.

The method is shown in the diagram below.



Source: E Parke, 'Experiments, Simulations, and Lessons from Experimental Evolution',
Publicly Accessible Penn Dissertations, 1114, 2015, <<https://repository.upenn.edu/edissertations/1114>>

The experiment had been running for 27 years at the time the results were shown.

This was equivalent to 65 000 generations of bacteria. A generation is the time between when an organism is formed and when it reproduces.

a State **two** factors that were controlled in this experiment. [2 marks]

b At about 30 000 generations, a mutation was seen that allowed the mutant bacteria to use citrate as an energy source.

What effect would you expect this mutation to have on subsequent generations of this group of bacteria and why? [2 marks]

c Assume that you are a scientist looking to further this research and you have access to the bacteria from a generation after 30 000.

Describe how you would conduct an experiment to investigate the effect of different glucose concentrations on the frequency of the mutant citrate phenotype. [2 marks]

[Total 7 marks]

Solution

11 [VCAA, SB Q11, 2023]

a Any two of the following factors controlled in the experiment:

- the original populations were genetically identical.
- the same growth medium was used in each flask.

- the same amount of growth medium was used in each flask.
- the same size and type of flask was used.
- the same serial transfer protocol was used.

b The frequency of the mutation in subsequent generations of this group of bacteria would increase as bacteria that can use citrate as a food source would be able to obtain more food, be stronger and produce more offspring that would inherit the mutation.

c Take 12 identical flasks. Add 10ml of bacteria derived from the same 30 000 generation flask to each flask. Add the same volume of nutrient broth containing the same citrate volume to each flask. These are the controlled variables. Add different glucose concentrations to 11 of the flasks – the independent variable. Add no glucose to one flask – the control group. Incubate the flasks at the same temperature, pH and for the same time -controlled variables. Every 24 hours, perform the simple serial transfer protocol. Measure the frequency of bacteria with the mutant citrate phenotype in each group - dependent variable. Repeat the whole experiment many times.

The author and publisher wish to thank the following sources for permission to reproduce material:

Cover: © Getty Images / National Institutes of Health/Stocktrek Images

Images/text: © Getty Images / Dr_Microbe, p.18 (neurophil) / © Fotosearch, p.18 (neuron) / ttsz, p.20 and p.33 (molecule 1) / NATALIJA OMELCHENKO, p.33 (molecule 2) / Science Photo Library, p.43 (A–B) / Kuklev, p.66; VW Pics, p.85 / Kristian Bell, p. 112 / Inner_Vision, p.152 / RF Pictures, p.162 / PhotoStock-Israel, p.179 (rock hyrax) / Ayzensteyn, p.179 (elephant) / Torsten Blackwood, p.179 (dugong); © SCistyle, p.40 (2); © [Dreamstime.com](https://www.dreamstime.com/) / Le Thuy Do, p.70 (1) / Luayana, p.86 (1) / Designua, p.99 / Alila07, p.125 (lymph node) / © Cancer Research UK / Wikimedia Commons, p.102; Chapter 5, p.181 appearing at VCAA 2020 SB Q8: López-Fernández H, Arbour J, Willis S, Watkins C, Honeycutt RL, Winemiller KO (2014) Morphology and Efficiency of a Specialized Foraging Behavior, Sediment Sifting, in Neotropical Cichlid Fishes. PLoS ONE 9(3): e89832. <https://doi.org/10.1371/journal.pone.0089832>. Copyright: © 2014 López-Fernández et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License (CC By 4.0 Int'l License); Wikimedia commons/public domain, image p.170-1; Extract adapted from M Westaway (Griffith University), J Olley (Griffith University), R Grun (Griffith University), 'Aboriginal Australians co-existed with the megafauna for at least 17 000 years', The Conversation website, 12 January 2017, appearing at VCAA 2017 SB Q10. Read The Conversation full article here: <https://theconversation.com/aboriginal-australians-co-existed-with-the-megafauna-for-at-least-17-000-years-70589>.