- 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?

Keywords and terms

Key science skills

accuracy	control group	controlled variable
dependent variable	hypothesis	independent variable
outliers	precision	qualitative data
quantitative data	random error	reliability
repeatability	reproducibility	systematic error
treatment group	uncertainty	validity

Nucleic acids

degenerate code	deoxyribonucleic acid	deoxyribose
nucleic acid	intron	monomer
ribosome	nucleotide	ribonucleic acid
transcription	translation	exon

Gene structure and regulation

eukaryote	genome	trp operator
prokaryote	promoter	regulatory gene
repressor protein	structural gene	transcriptional factors

Proteins

amino acids	condensation	denaturisation
hydrolysis	polymerisation	proteome
primary structure	secondary structure	quaternary structure
ribosome	peptide	protein

Protein secretory pathway

exocytosis	vesicle	endoplasmic reticulum
Golgi apparatus	ribosome	

DNA manipulation techniques and applications

blunt end	DNA ligase	DNA polymerase
endonuclease	gel electrophoresis	ligase
PCR	plasmid	primer
recognition site	recombinant	standard lane
sticky end	Taq polymerase	transformation
vector	CRISPR-Cas 9	DNA profiling
GMO	transgenic	

Diagram 1

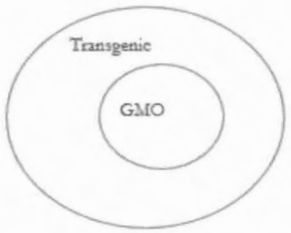


Diagram 2

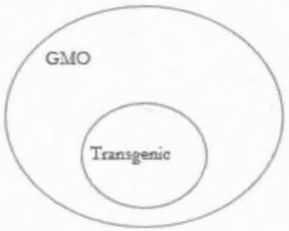
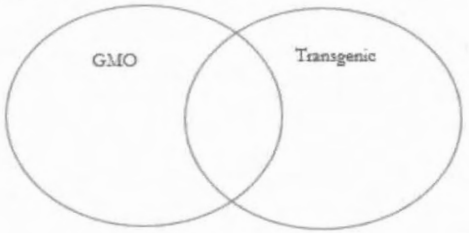


Diagram 3



69 What is the difference between transformation and transfection?

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

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

72 Complete the following table.

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

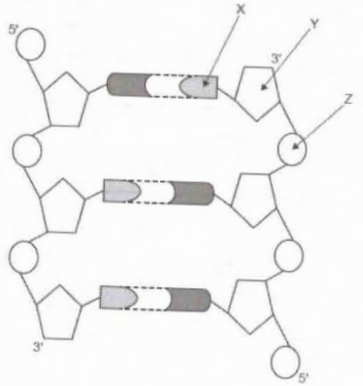
73 Complete the following table by stating three reasons why we should use GMOs and three reasons why we shouldn't.

For	Against

Multiple-choice questions

Use the following information to answer Questions 74 and 75.

The diagram below represents part of a DNA molecule.



74 [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.

75 [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.

76 [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.

77 [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.

78 [VCAA 2015 SA Q23]

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

– Asn – Gly – Pro – Arg – Ser –

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

Using the table provided, 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

79 [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.

80 [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.

81 [VCAA 2011 E1 SA Q44]

A molecule of transfer RNA could include the nucleotide sequence

A CTCGAUTAC

B GGCUUUAAA

C CCUUTUGAG

D AAAATACCG

82 [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.

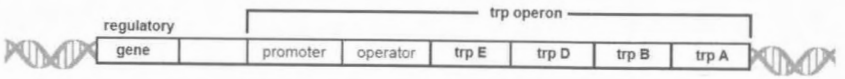
B attaches RNA polymerase.

C codes for the production of an enzyme.

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

*Use the following information to answer Questions **83** and **84**.*

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.



83 [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.

84 [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.

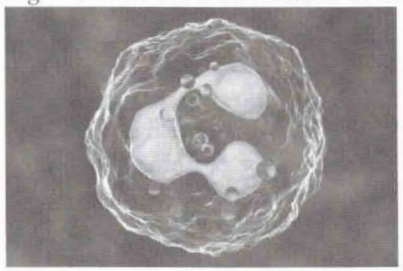
C tryptophan.

D mRNA.

85 [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

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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.

86 [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.

87 [VCAA 2019 SA Q5]

Which one of the following statements about proteins is correct?

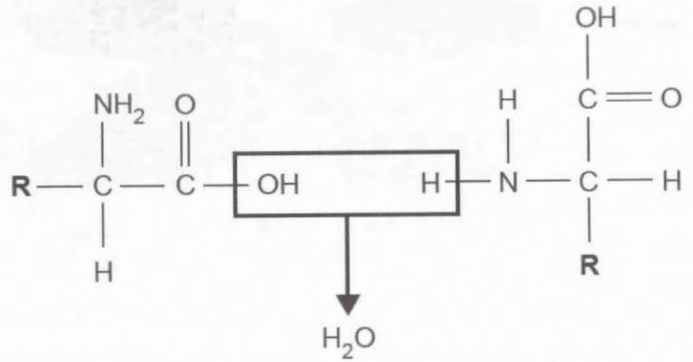
A The activity of a protein may be affected by the temperature and pH of its environment.

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.

88 [VCAA 2018 SA Q3]



The diagram above 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.

89 [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.

90 [VCAA 2018 SA Q2]

The proteome is

A the total DNA content that is present within one cell of an organism.

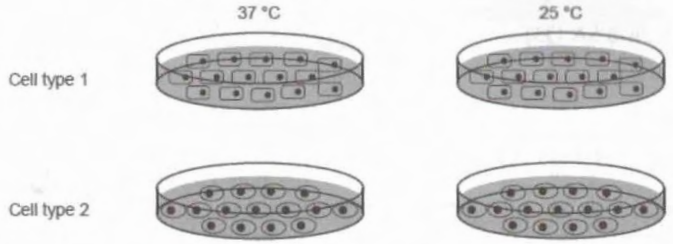
B a complete set of chromosomes found inside a cell of an organism.

C the entire set of proteins expressed by an organism at a given time.

D the four hierarchical levels of protein structure.

91 [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 Percentage of protein taken up by cell		Cell type 2 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.

92 [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.

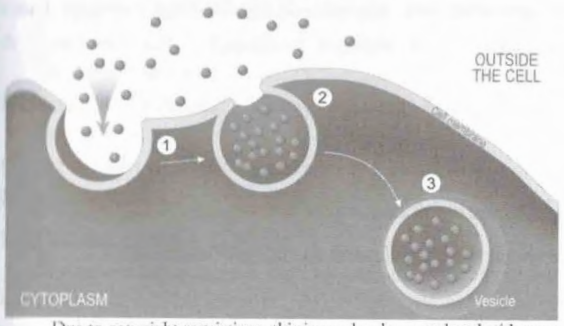
B nucleus – ribosome – endoplasmic reticulum – vesicle – Golgi apparatus.

C nucleus – vesicle – endoplasmic reticulum – Golgi apparatus – ribosome.

D nucleus – vesicle – Golgi apparatus – ribosome – endoplasmic reticulum.

93 [VCAA 2019 SA Q1]

Consider the movement of macromolecules across the plasma membrane, as shown in the diagram on the following page.



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What type of transport is shown?

A facilitated diffusion.

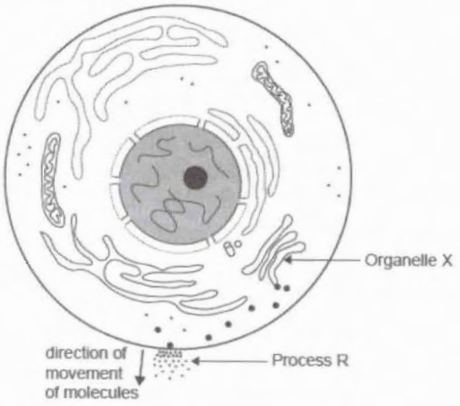
B simple diffusion.

C endocytosis.

D exocytosis.

*Use the following information to answer Questions **94** and **95**.*

Consider the following cell diagram.



94 [VCAA 2014 SA Q3]

Process R is an example of

A exocytosis.

B phagocytosis.

C pinocytosis.

D endocytosis.

95 [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.

96 [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

*Use the following information to answer Questions **97** and **98**.*

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

97 [VCAA 2013 SA Q6]

The site of synthesis of protein M is the

A vesicles.
B ribosomes.
C plasma membrane.
D smooth endoplasmic reticulum.

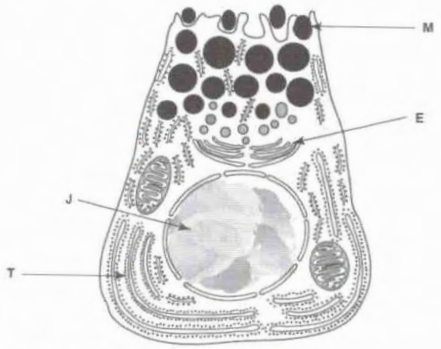
98 [VCAA 2013 SA Q7]

The export of protein M by these cells would involve

A centrioles.
B lysosomes.
C the Golgi apparatus.
D chromosomes.

99 [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.

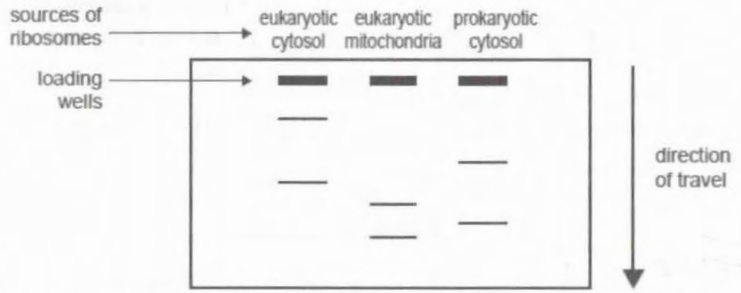
100 [VCAA 2019 SA Q38]

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.

101 [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 below.



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.

*Use the following information to answer Questions **102** and **103**.*

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	G* A A T T C C T T A A *G
HindIII	A* A G C T T T T C G A *A
AluI	A G* C T T C* G A
HaeIII	G G* C C C C* G G

102 [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.

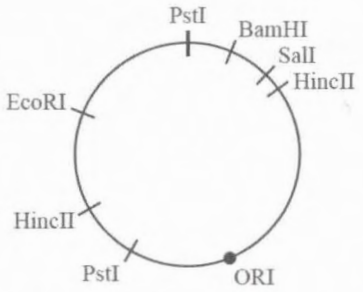
103 [VCAA 2013 SA Q30]
Now consider a different length of double-stranded DNA with the sequence

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.

104 [VCAA 2019 SA Q39]
The diagram below is a map of a bacterial plasmid showing ORI, the origin of DNA replication, and selected restriction endonuclease sites.



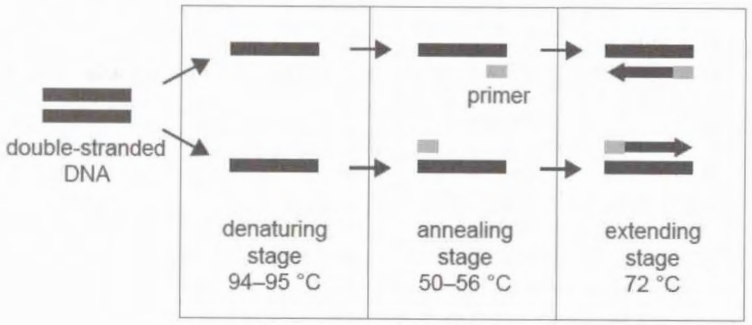
One plasmid was mixed with the restriction enzymes EcoRI, BamHI and HincII.
Which of the following shows the number of restriction sites that have been cut and the resulting number of DNA fragments produced?

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

105 [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 is quadrupled in each cycle.

106 [VCAA 2018 SA Q28]
The diagram below represents a method of DNA manipulation.



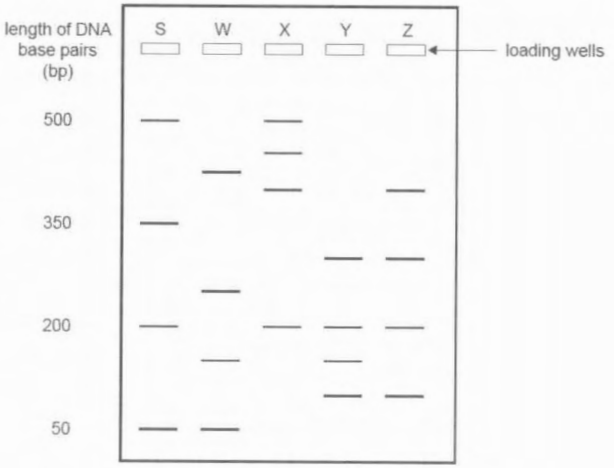
Source: *Genome Research Limited, in Your Genome, www.yourgenome.org*

The method represented is

A gel electrophoresis.
B DNA transformation.
C bacterial transformation.
D polymerase chain reaction.

*Use the following information to answer Questions **107** and **108**.*

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.



107 [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

108 [VCAA 2018 SA Q31]

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

A W **B** X
C Y **D** Z

109 [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.

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

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

Use the following information to answer Questions ***110–112****.*

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.

110 [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.

111 [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.

112 [VCAA 2020 SA Q32]

Target DNA is to be inserted into a plasmid.

For a recombinant plasmid to be produced.

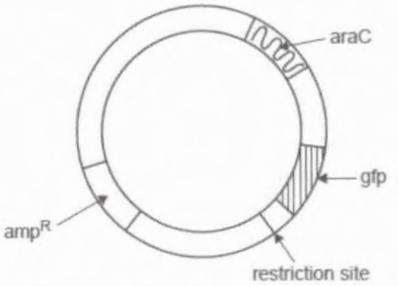
A the plasmid sections and the target DNA must have blunt ends.
B the target DNA must come from the same species as the bacteria.
C the plasmid and the target DNA must be cut by a polymerase.
D DNA ligase is used to re-join the sugar-phosphate sections of the plasmid and the target DNA.

Use the following information to answer Questions ***113–115****.*

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:

- ampR – 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 below.

Plate	W untransformed bacteria only	X untransformed bacteria only	Y transformed bacteria	Z 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

113 [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.

114 [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

115[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.

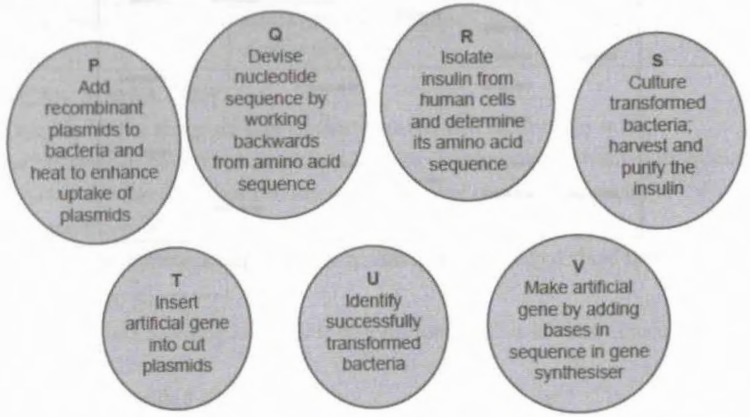
B Plate W shows that the percentage of transformed bacteria was high.

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.

*Use the following information to answer Questions **116–118**.*

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.



116 [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.

117 [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.

118 [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.

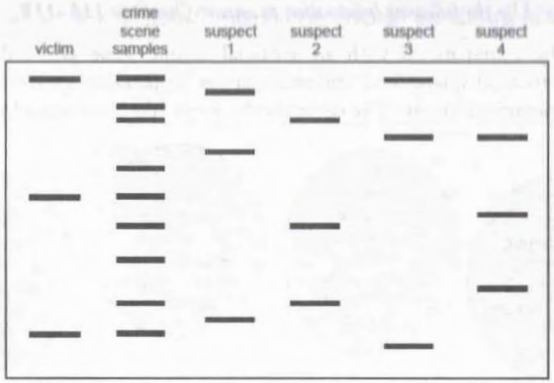
C mutated by heat shock.

D contaminated by bacterial DNA.

119 [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 on the following page.



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

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

120 [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.

121

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.

*Use the following information to answer Questions **122** and **123**.*

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

122 [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.

123 [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

Short-answer questions

124 [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]

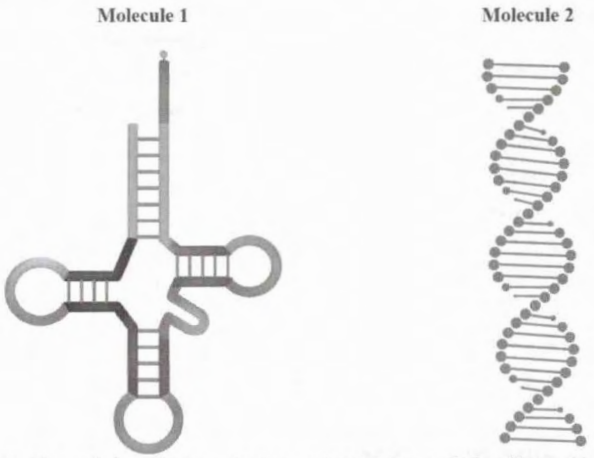
Type of RNA	Role in a cell
tRNA	
mRNA	

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

[Total 7 marks]

125 [VCAA 2019 SB Q1]

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



Due to copyright restrictions, this image has been replaced with an equivalent likeness. To view the original image, please visit the VCAA website.

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]

126 [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

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

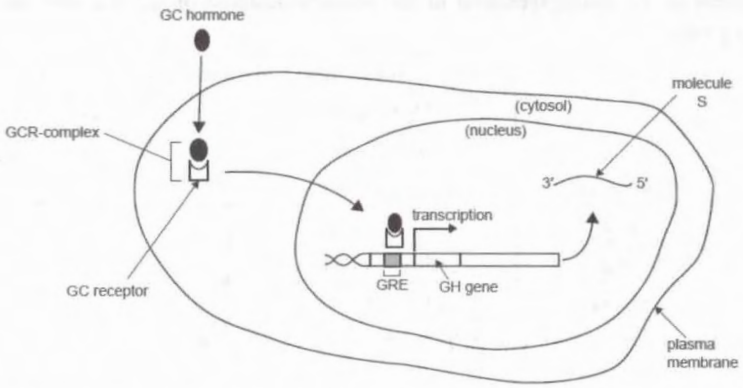
ii whether the sequence of nucleotides in DNA coding for the amino acid at position 30 will be identical in cows, pigs and sheep. [1 mark]

[Total 6 marks]

127 [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]

128 [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

	Second letter				
First letter	**A**	**G**	**T**	**C**	**Third letter**
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).

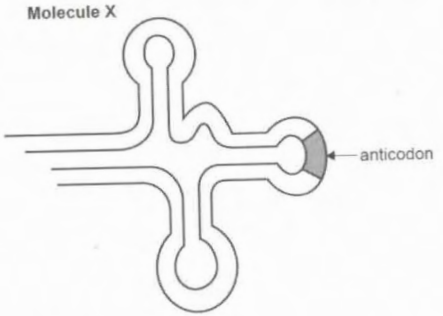
b What is the amino acid sequence for the TSD individual in **Table 2**? Use the information in **Table 1** to explain how changing one amino acid in a polypeptide may adversely affect the function of a protein of which the amino acid is part. [1 + 2 = 3 marks]

[Total 4 marks]

129 [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 that follows.



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]

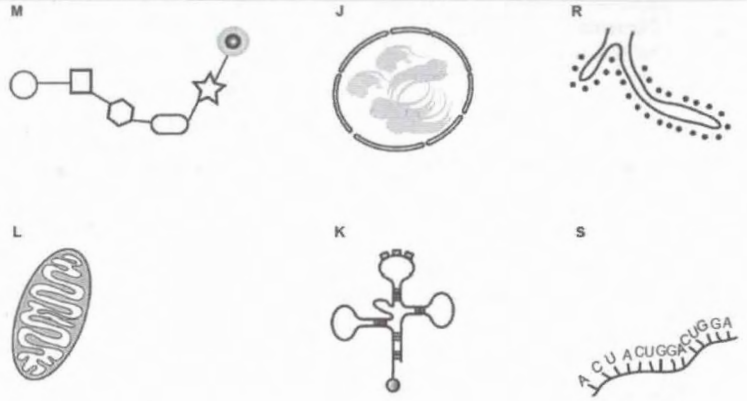
130 [VCAA 2012 E2 SB Q1]

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]

131 [VCAA 2014 SB Q7]

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

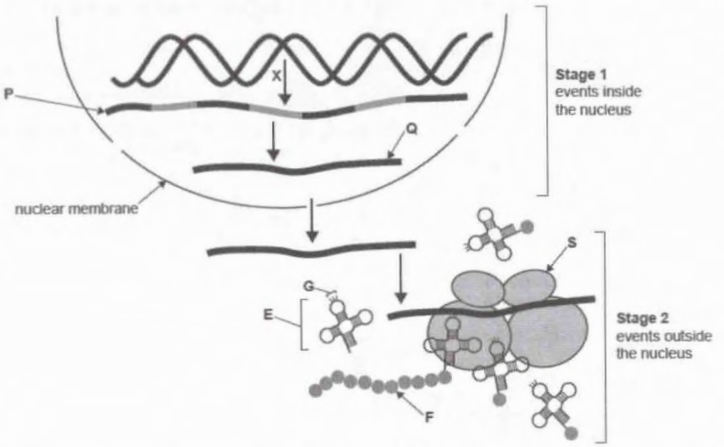
These scientists noticed that one type of nucleic acid chain was able to pass through the nuclear membrane and move to a ribosome. After the nucleic acid chain attaches to the ribosome, a polymer is produced.

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]

132 [VCAA 2013 SB Q6]

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



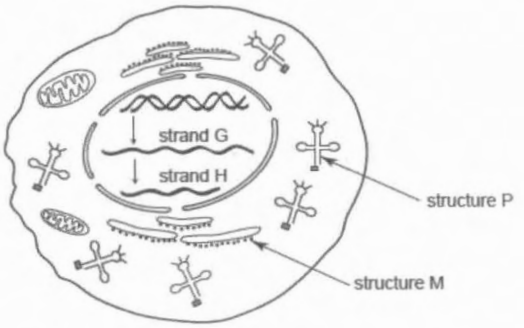
a i Outline events that occur during action X. [2 marks]

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]

133 [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]

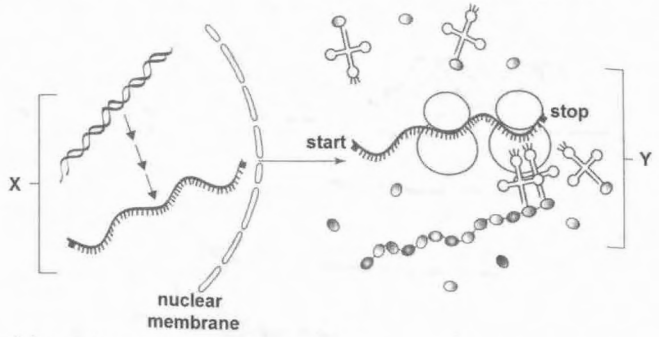
b Describe the function of RNA polymerase. [2 marks]

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]

134 [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]

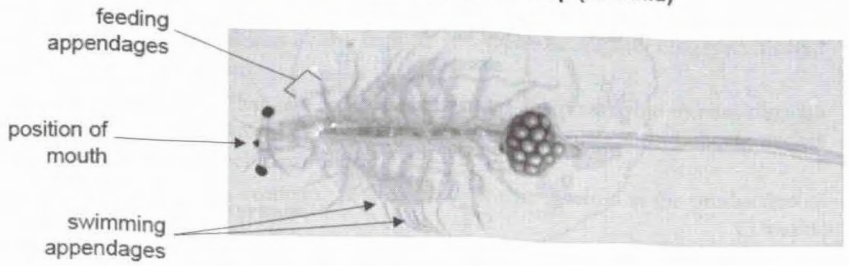
[Total 8 marks]

135 [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.

Adult brine shrimp (*Artemia*)



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]

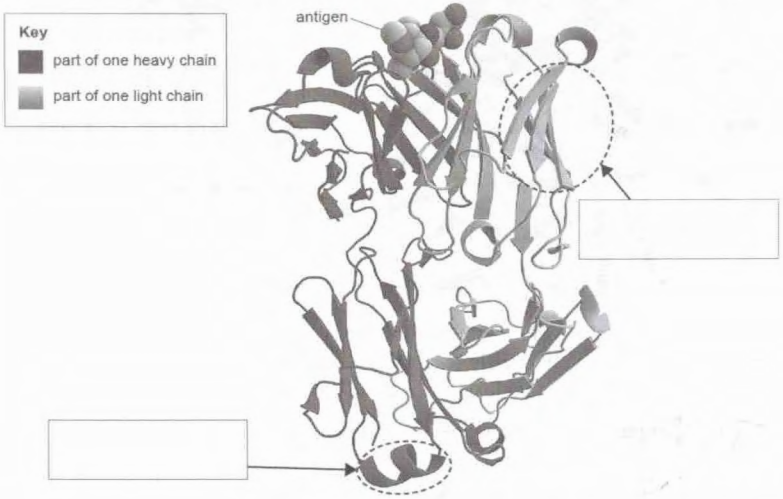
136 [VCAA 2016 SB Q1]

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 that follows. 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]



Source: Thomas Splettstoeesser (www.scistyle.com)

c Immunoglobulin molecules also display a tertiary structure and a quaternary structure. [2 marks]

[Total 5 marks]

137 [VCAA 2018 SB Q1]

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.

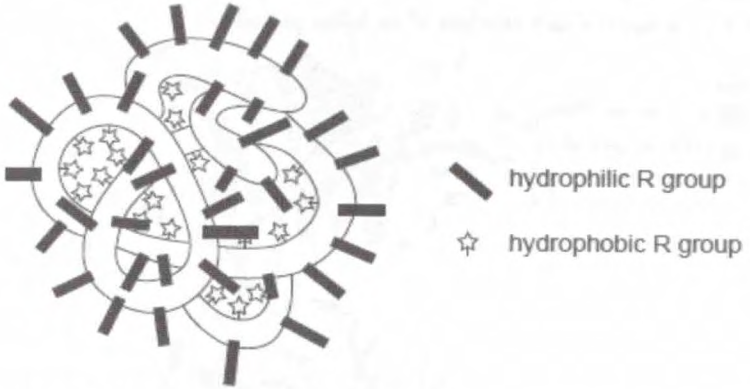
Complete the table below by naming three different organelles directly associated with the transport of the synthesised tryptase within or from mast cells and state the role of each organelle in this process. [3 marks]

Organelle	Role

[Total 6 marks]

138 [Adapted VCAA 2011 E1 SB Q1]

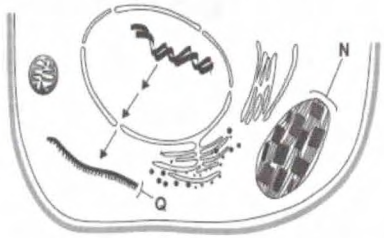
The following figure represents a globular protein.



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		
Structure Q		

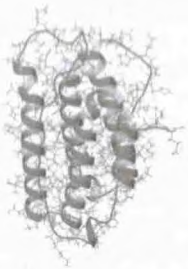
[4 marks]

[Total 6 marks]

139 [VCAA 2015 SB Q1]

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

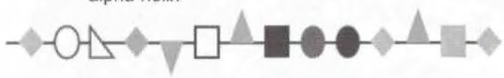
A



B

human interferon

C



alpha-helix

a polypeptide sequence

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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.

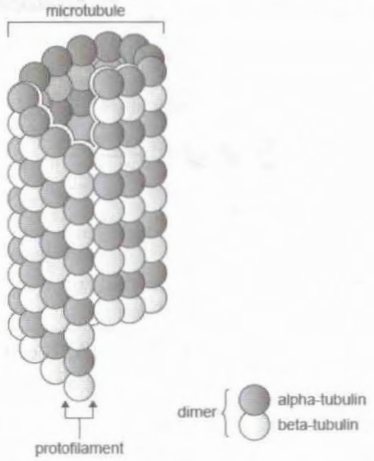
Describe **one** structural characteristic of the molecular chaperone proteins that would need to be considered in order for this approach to provide a successful treatment. [1 mark]

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]

140 [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]

141 [VCAA 2020 SB Q11]

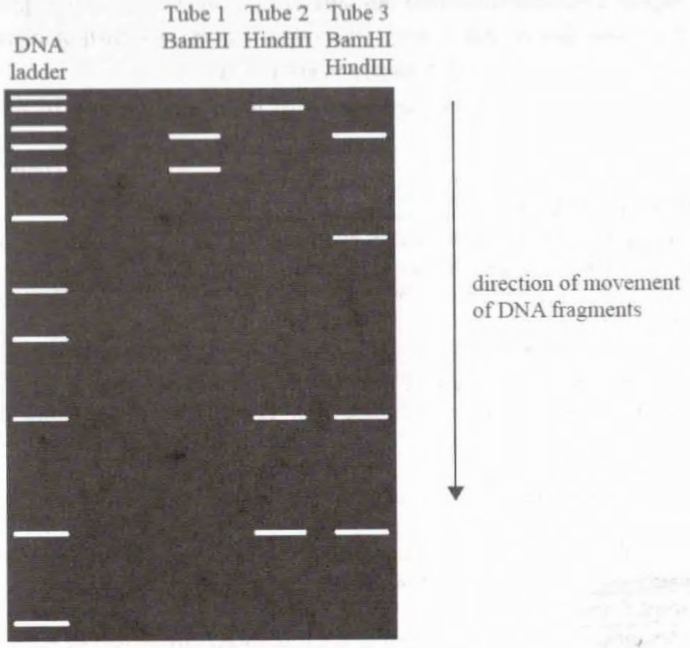
A student wanted to investigate the effect of two different endonucleases (restriction enzymes) on a linear DNA fragment.

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.

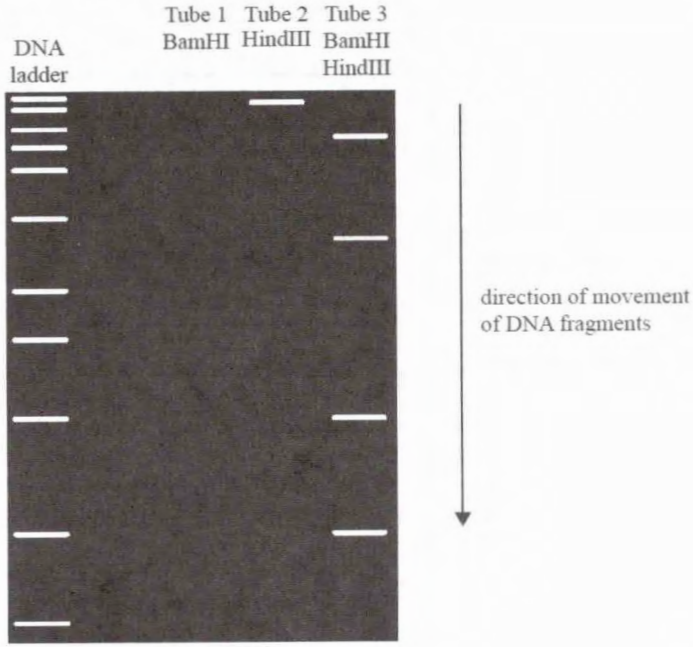
After 45 minutes the student obtained the results shown below.



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]

142 [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]

143 [VCAA 2004 SB Q7]

Sickle cell anaemia is a serious inherited blood condition. It leads to tiredness and kidney or heart failure and without treatment children usually die before the age of 10. Sickle cell anaemia is due to a change in the gene which codes for beta haemoglobin. There are two alleles for the beta haemoglobin gene; **HbA** coding for normal beta haemoglobin and **HbS** coding for the changed haemoglobin. An individual with two copies of the **HbS** allele will develop symptoms of sickle cell anaemia.

It is now possible to genetically test people to see if they carry the HbS allele. This test uses PCR, the restriction enzyme *MstII* and gel electrophoresis.

MstII is a restriction enzyme that recognises the 7-base sequence in DNA,

C C T G A G G
G G A C T C C

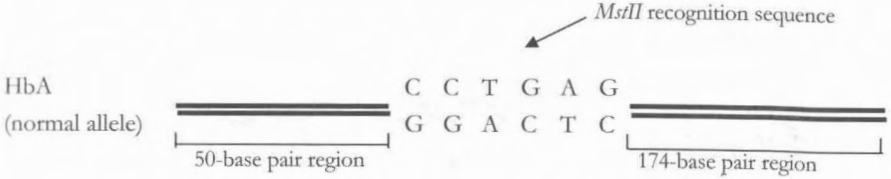
and cuts it between the C and the T to produce

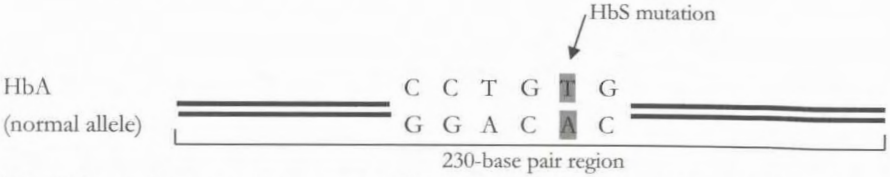
C C
G G A C T

T G A G G
C C

a What term is used to describe the ends of the fragments produced by *MstII*? [1 mark]

Molecular studies have shown that the sickle cell allele differs by only one base pair from the normal allele. This base change occurs in a 7-base sequence that is recognised by the restriction enzyme *MstII*. This is the only *MstII* site found within the region of the gene that is used in the genetic test.





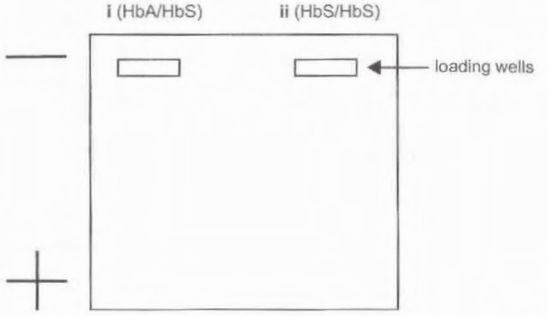
The PCR products are digested using *MstII*. The resulting fragments undergo gel electrophoresis.

b How is the action of the *MstII* enzyme affected by the HbS mutation? [1 mark]

c Mark on the picture of the gel on the following page, the banding patterns you could expect to see for someone who has each of the following genotypes.

i HbA/HbS [1 mark]

ii HbS/HbS [1 mark]



[Total 4 marks]

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In 2020, Emmanuelle Charpentier and Jennifer Doudna were awarded the Nobel Prize in Chemistry for their work on developing the CRISPR-Cas 9 genome editing technique.

a CRISPR-Cas 9 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-Cas 9 RNA guide?
(i) RNA guide
(ii) Cas 9 endonuclease [2 marks]

c Describe two ways CRISPR-Cas 9 can be used to edit genes. [2 marks]

d What are the advantages of CRISPR-Cas 9 over other gene editing techniques. [2 marks]

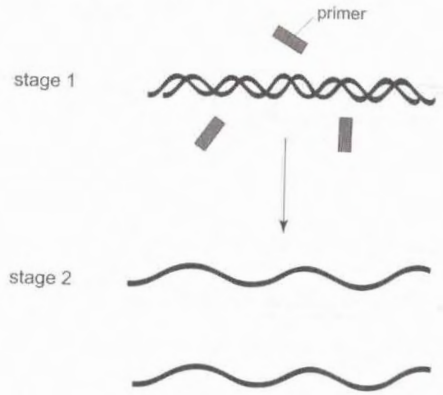
[Total 7 marks]

145 [VCAA 2007 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.

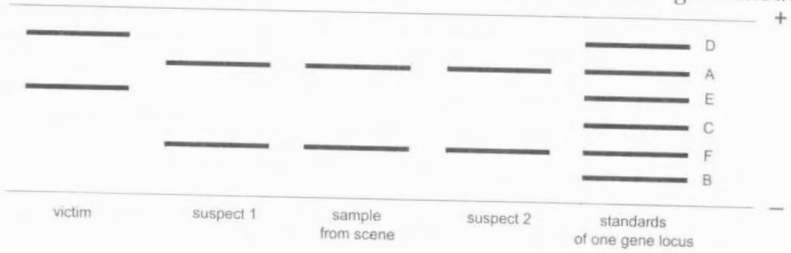


b What must be done between stages 1 and 2 to separate the strands of the DNA molecule? [1 mark]

c Complete and label the diagram at stage 2. [2 marks]

Small pieces of DNA of differing length can be compared to determine whether or not 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 the diagram below.



d Draw an arrow on the right-hand side of the diagram to indicate the direction of movement of the DNA fragments. [1 mark]

e What do the standards consist of, and what is their purpose? [2 marks]

f From these results, give a conclusion which could be drawn about the sample taken from the crime scene. [1 mark]

g What further action would you recommend to the forensic scientists investigating this case? [1 mark]

[Total 9 marks]

146 [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 that follows 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 above, 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]

147 [VCAA 2010 E2 SB Q8]

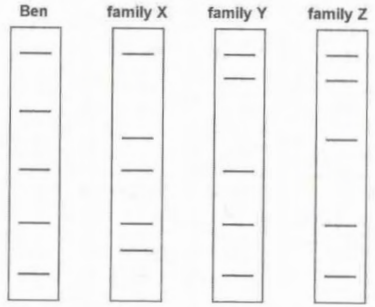
DNA includes sections that are called short tandem repeats (STR). Mutations in STRs occur, on average, every 500 generations. Different numbers of these repeats have no obvious effect on the individual.

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.

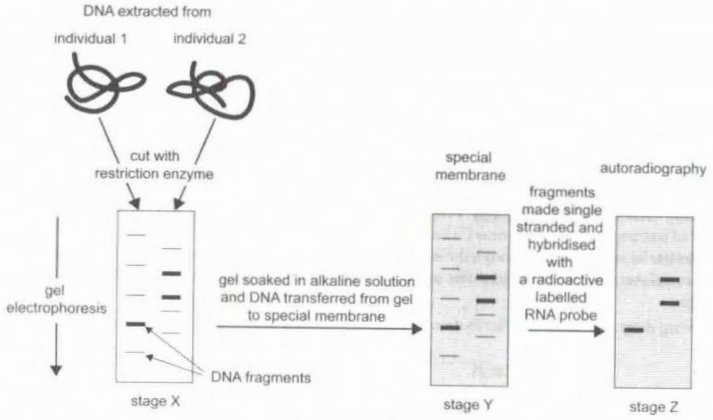


c Explain which family is Ben's most recent common ancestor. [2 marks]

[Total 4 marks]

148 [VCAA 2008 SB Q6]

RFLP (Restriction Fragment Length Polymorphism) analysis is commonly used to determine genetic variation between individuals. This procedure is summarised below.



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]

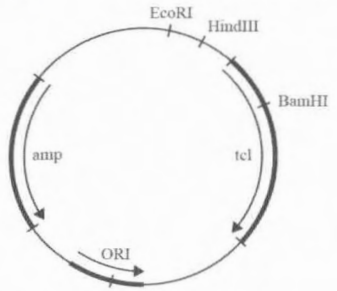
149 [VCAA 2017 SB Q9]

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 in the space below 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]

150 [VCAA 2006 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]

151 [VCAA 2018 SB Q10]

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.

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		
Golden Rice		

[Total 8 marks]

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