

BIOLOGY UNITS 3&4



2020 Practice Exam

(including fully-worked answers for every question!)

ABOUT THIS RESOURCE

Our VCE Biology Practice Exam is written by our experienced textbook authors and VCE teachers.

- The exam consists of questions worth 120 marks, in exactly the same format as the VCE exam.
- The questions have been designed and written to simulate the experience of sitting a VCAA-style exam.
- Included is a full answer section with exemplar answers and checklists to guide students on how to produce a high-scoring answer.
- All questions are tailored to the study design updates for 2020.

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DATE: _____

STUDENT NAME: _____

TEACHER NAME: _____

BIOLOGY

Practice written examination

Duration: 15 minutes reading time, 2 hrs 30 minutes writing time

QUESTION BOOK

Structure of book

Section	Number of questions	Number of marks
A	40	40
B	11	80
		Total 120

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

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

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

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

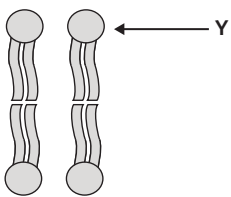
Marks will **not** be deducted for incorrect answers.

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

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

Question 1

The diagram represents the arrangement of a type of molecule found in the plasma membrane.



The structure labelled Y in the molecule is

- A involved in cell signalling.
- B hydrophobic.
- C cholesterol.
- D polar.

Question 2

Which one of the following statements about passive transport is correct?

- A Facilitated diffusion, osmosis, and exocytosis are examples of passive transport.
- B Passive transport can occur down or against the concentration gradient.
- C ATP may facilitate the passive transport of certain molecules.
- D Passive transport can involve the use of protein channels.

Question 3

The diagram below shows four processes that transport substances from the extracellular environment into a cell.

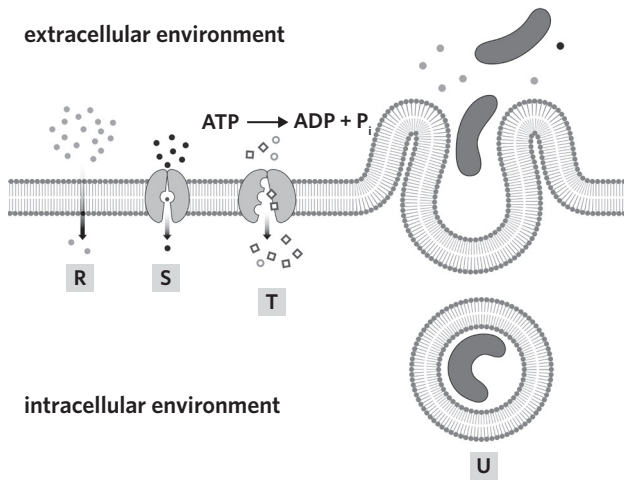


Image: Aldona Griskeviciene/Shutterstock.com

Which one of the following statements about the diagram is correct?

- A Process T is the only process shown that requires energy.
- B Process R shows water molecules actively moving by osmosis.
- C Process S shows molecules moving passively by facilitated diffusion.
- D Process U is exocytosis where large substances are moved into the cell.

Question 4

Proteins

- A can function with only a primary and secondary structure.
- B are affected by changes in pH but are not affected by changes in temperature.
- C are synthesised in the rough endoplasmic reticulum and packaged for export by the Golgi apparatus.
- D are synthesised from their monomers by ribosomes attached to the smooth endoplasmic reticulum.

Question 5

Proteins are transported to the plasma membrane for exocytosis by

- A vesicles.
- B ribosomes.
- C the Golgi apparatus.
- D the rough endoplasmic reticulum.

Question 6

The template strand of a particular gene is 90 nucleotide bases long and contains 40 adenine bases, 10 thymine bases, 20 cytosine bases, and 20 guanine bases. The number of adenine bases in the mRNA strand transcribed from this template would be

- A 0.
- B 10.
- C 20.
- D 40.

Question 7

Following transcription, pre-messenger RNA (pre-mRNA) must undergo post-transcriptional modifications before it is ready for translation.

Which row correctly matches the listed properties to their action during post-transcriptional modification of pre-mRNA?

	Introns	Exons	5' end	3' end
A	removed	remain and are joined	methyl cap added	poly-A tail added
B	removed	removed	poly-A tail added	methyl cap added
C	remain and are joined	removed	no modifications	poly-A tail added
D	removed	remain and are joined	poly-A tail added	methyl cap added

Question 8

Which one of the following statements about structural genes is correct?

- A A promoter region is always found downstream of structural genes that are undergoing transcription.
- B Proteins coded for by structural genes include enzymes, carrier proteins, and repressor proteins.
- C Structural genes do not make proteins that are involved in the regulation of other genes.
- D Structural genes play a large role in controlling gene expression.

Question 9

Ornithine decarboxylase (ODC) is an enzyme that catalyses the breakdown of ornithine into putrescine in the urea cycle. α -difluoromethylornithine (DFMO) is an irreversible competitive inhibitor that inhibits the function of ODC by

- A temporarily blocking the active site of ODC.
- B increasing the rate at which putrescine is formed.
- C forming strong bonds with the active site of ODC that cannot be broken.
- D permanently binding to a site on ODC that is not the active site and causing a conformational change in the active site.

Use the following information to answer Questions 10–12.

Four groups of students carried out an experiment examining the effect of pH on an enzyme's rate of reaction. They used the enzyme catalase which is responsible for converting hydrogen peroxide into water and oxygen gas.

Before beginning the experiment, each group practised measuring the pH of a stock solution with a known pH of 7 to calibrate their digital pH meters.

The following results were obtained during the practice measurements.

	1st measurement	2nd measurement	3rd measurement
Group 1	6.8	7.0	7.2
Group 2	6.8	6.8	6.8
Group 3	6.9	7.0	7.1
Group 4	7.0	7.0	7.6

Question 10

Which one of the following statements is correct?

- A Group 1's measurements are precise but not accurate.
- B Group 2's measurements are accurate but not precise.
- C Group 3's measurements are both accurate and precise.
- D Group 4's measurements are the most accurate but the least precise.

Question 11

The independent variable in the experiment is

- A pH.
- B the amount of oxygen gas produced.
- C the concentration of hydrogen peroxide.
- D the accuracy and precision of the digital pH meter.

Question 12

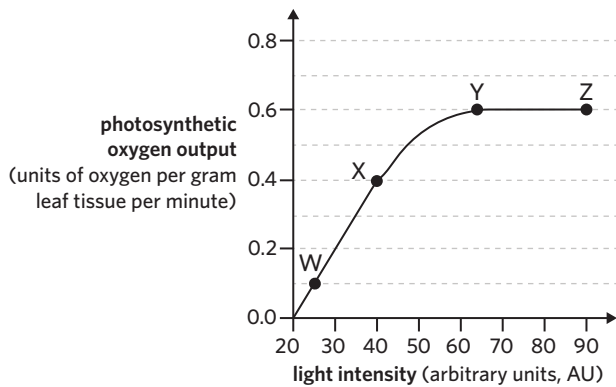
After completing the enzyme experiment, the students wanted to check the reliability of their data.

The students should

- A alter the method to obtain qualitative and quantitative data.
- B repeat the experiment at a higher pH to ensure the trend is correct.
- C graph the results differently to determine if there is another trend in the data.
- D increase the number of replicates in the experiment to see if they obtain the same data.

Use the following information to answer Questions 13-15.

An experiment was carried out to determine the photosynthetic output of oxygen in tomato leaves under changing light intensity. Temperature and carbon dioxide concentration were kept constant during the experiment. The following graph depicts the results of the experiment.



Question 13

At point Z

- A the same rate of oxygen production as point Y was observed.
- B the rate of oxygen production is twice the rate observed at point X.
- C photosynthesis is no longer occurring as the light is too intense for the plant.
- D the rate of photosynthesis is almost ten times the rate observed at 30 AU of light.

Question 14

Light intensity is the limiting factor of photosynthesis at point(s)

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

Question 15

Based on the information in the graph, there is enough evidence to conclude that

- A increasing the temperature at point Y will increase the rate of photosynthesis.
- B at point Z the rate of photosynthesis is equal to the rate of aerobic cellular respiration.
- C increasing the light intensity above 65 AU without changing other factors will not increase the rate of photosynthesis.
- D at points W, X, and Y, light is the limiting factor of photosynthesis, but at point Z, carbon dioxide and temperature are the limiting factors.

Question 16

Which one of the following processes does not involve carbon dioxide as either an input or output?

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

Question 17

The rate of anaerobic cellular respiration in a human cell may decrease if the

- A temperature of the cell is lowered from 37 °C to 34 °C.
- B oxygen concentration available to the mitochondria decreases.
- C carbon dioxide concentration in the cytosol of the cell decreases.
- D rate of facilitated diffusion of glucose into the cytosol of the cell increases.

Question 18

Which one of the following statements about apoptosis is correct?

- A Only the intrinsic pathway involves caspase activation.
- B Cytotoxic T cells can bind to and stimulate apoptosis in infected cells.
- C Sudden changes in ion concentration can initiate apoptosis, resulting in cell lysis.
- D Cytochrome c released by the mitochondria activates an inflammatory response.

Question 19

Rheumatoid arthritis is an autoimmune disease where the immune system attacks the lining of joints leading to inflammation, swelling, and pain.

Rheumatoid arthritis is caused by

- A an adaptive immune response involving cytotoxic T cells and antibodies attacking the joint lining.
- B the release of histamine by mast cells resulting in severe inflammation.
- C the initiation of necrosis in the joint lining by complement proteins.
- D a bacterial infection around the joint lining.

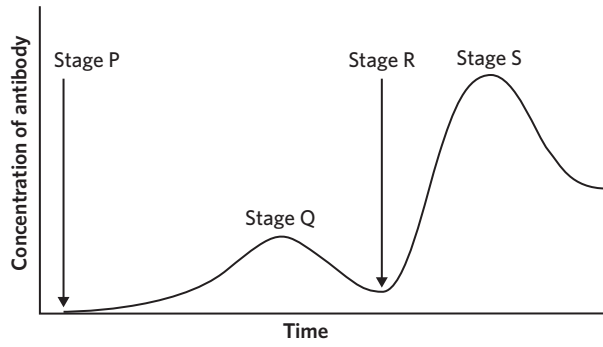
Question 20

Which of the following statements describing the lymphatic system is correct?

- A Clonal selection and expansion primarily occur in lymph nodes.
- B Antigen-presenting cells are only found in the lymphatic system.
- C The thymus is an organ of the lymphatic system where B cells mature.
- D The bone marrow is a tissue of the lymphatic system where T cells mature.

Use the following information to answer Questions 21 and 22.

The following diagram represents the vaccination of an individual for hepatitis B.



Question 21

Which of the following statements correctly describes the stages depicted in the diagram?

- A Antibodies complementary to the hepatitis B virus exist before Stage P.
- B There are no complementary helper T cells to the hepatitis B virus before Stage P.
- C The concentration of antibodies at Stage S is greater than Stage Q due to the presence of more T lymphocytes.
- D After Stage S, while some memory cells remain in the system until reactivation others undergo apoptosis to conserve energy.

Question 22

The hepatitis B vaccine

- A contains a virulent strain of the virus.
- B only stimulates cell-mediated immunity.
- C contains antibodies that are injected into the bloodstream.
- D interacts with both the innate and adaptive immune responses.

Question 23

The prostate is a gland found in the male reproductive system. Prostate cancer represents the second most frequent type of tumour in men worldwide. The *BRCA1* and *BRCA2* genes that have been linked to breast cancer have also been linked to an increased risk of prostate cancer.

A section of the normal *BRCA2* gene and a section of a mutated *BRCA2* gene are shown below.

<i>BRCA2</i> normal	TGACCTTGAGGCCAGAAAGTTTGA
<i>BRCA2</i> mutated	TGACCGAGGCCAGAAAGTTTGA

The mutation that has occurred in the mutated *BRCA2* gene is an example of a

- A missense substitution mutation.
- B silent substitution mutation.
- C frameshift mutation.
- D block mutation.

Question 24

Breast cancer and stomach cancer are often treated with a monoclonal antibody called trastuzumab. In particular, it targets a receptor called HER2 which is found on the surface of cancerous cells.

Trastuzumab would

- A attract immune cells towards the cancer cells with interferons.
- B have two identical complementary sites to the HER2 receptor.
- C be produced by plasma B cells inside the human body.
- D induce necrosis in cancer cells.

Question 25

The immune system of babies is underdeveloped and susceptible to infection. Fortunately, they can acquire antibodies from their mother during embryonic development through the umbilical cord and through breast milk after they are born.

This form of immunity is known as

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

Use the following information to answer Questions 26 and 27.

Zika fever is a viral disease. It is most commonly transferred from one person to another by the *Aedes* species of mosquito. It can also be spread through blood transfusions and through sexual transmission. The Zika virus is injected into a person when an infected mosquito bites them. The virus then enters the bloodstream and may cause fever, rash, joint pain, red eyes, and can lead to developmental defects in foetuses when pregnant women are infected.

Question 26

Using the information given, it can be concluded that

- A all individuals bitten by an infected mosquito will develop symptoms.
- B Zika fever is most dangerous to people who need blood transfusions.
- C the Zika virus is a prokaryote.
- D foetuses act as a host.

Question 27

Based on the information provided, which of the following would not be an effective method of stopping the spread of Zika fever?

- A culling of mosquitoes
- B using nets to cover a person while they sleep
- C compulsory wearing of face masks by infected individuals
- D scanning donated blood to test for the presence of the virus

Use the following information to answer Questions 28 and 29.

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.

Question 28

Within each species of *Drosophila* there is a low level of genetic diversity. This is an example of

- A founder effect.
- B bottleneck effect.
- C artificial selection.
- D allopatric speciation.

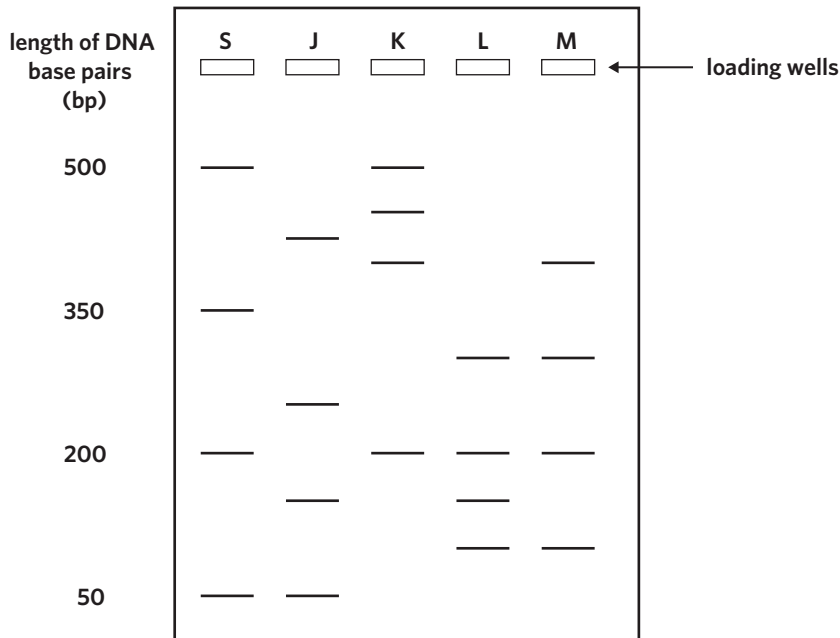
Question 29

The low level of genetic diversity means that individual species of *Drosophila*

- A have a high mutation rate.
- B will be very susceptible to infectious diseases.
- C will show a low frequency of genetic disorders.
- D have a high chance of survival when encountering environmental change.

Use the following information to answer Questions 30–32.

Genetic testing can be used to test for the allele for Huntington’s disease (HD). The onset of HD predominantly occurs in adulthood. Four individual family members were tested for the HD allele. The diagram below shows the electrophoresis gel results of a test for the presence of the allele. Individuals L and M have been diagnosed with the disease. A standard ladder (S) has also been included.



Question 30

Which other individual/s is/are likely to suffer from HD now or in the future?

- A S
- B J
- C K
- D S and K

Question 31

Which lane represents a sample that was loaded with DNA fragments of four different lengths: 100 bp, 200 bp, 300 bp, and 400 bp?

- A J
- B K
- C L
- D M

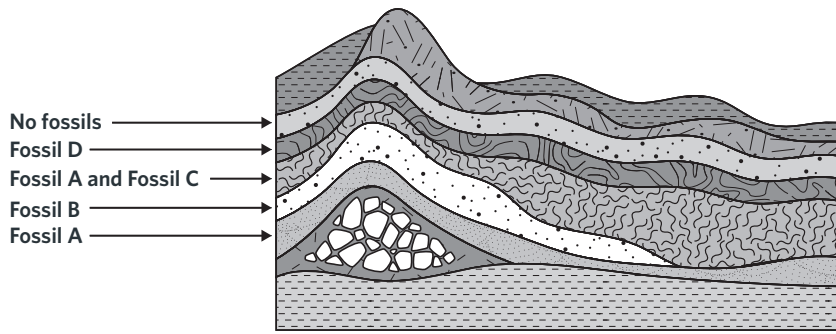
Question 32

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

- A J
- B K
- C L
- D M

Use the following information to answer Questions 33 and 34.

The fossils present in different rock strata in a particular location are shown in the diagram.



Question 33

From the diagram above, it can be concluded that

- A Fossil B is older than Fossil A.
- B the species represented by Fossils A and B existed at the same time.
- C the species represented by Fossil D existed for the longest period of time.
- D because there are no fossils in the topmost layer, all the species are extinct.

Question 34

Fossil C features no organic material and shows the outline of the organism. The actual body of the organism is thought to have decomposed.

This type of fossil is best described as

- A a trace fossil.
- B preserved remains.
- C an impression fossil.
- D a permineralised fossil.

Use the following information to answer Questions 35 and 36.

In 2013, about 1 500 fossil bones of a hominin species were found in a cave in South Africa. From these bones, scientists have managed to construct almost a 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*.

Question 35

In order for the fossil skeleton to be classified in the genus *Homo* and not in the genus *Australopithecus*, which of the following features would have been present?

- A large teeth
- B a c-shaped spine
- C a relatively large cranial capacity
- D the presence of a large sagittal crest

Question 36

As a result of bipedal locomotion, which of the following features would you expect to find in the newly classified *Homo* fossil?

- A a less protruding big toe
- B a bowl-shaped pelvis
- C opposable thumbs
- D a low foot arch

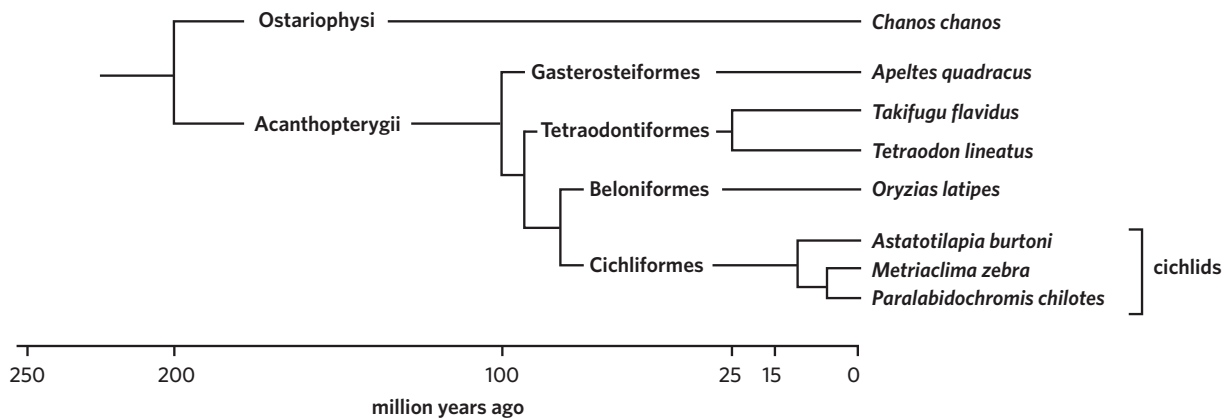
Question 37

Which group of characteristics best reflects the trends in hominin evolution from the *Australopithecus* species to the *Homo* species?

- A increasingly opposable big toe, increasing heel size, increasingly funnel-shaped rib cage, decreasing arm to leg ratio
- B increasingly flat face, more central foramen magnum, increasingly barrel-shaped rib cage, decreasing arm to leg ratio
- C increasingly flat face, less central foramen magnum, increasingly barrel-shaped rib cage, decreasing arm to leg ratio
- D decreasingly flat face, more central foramen magnum, increasingly barrel-shaped rib cage, increasingly bowl-shaped pelvis

Question 38

Consider the following phylogenetic tree, which summarises the evolutionary relationships between certain fish species.



Which of the following statements is correct?

- A *T. flavidus* and *T. lineatus* diverged 100 million years ago.
- B *C. chanos* does not share a common ancestor with cichlids.
- C *O. latipes* is more closely related to *P. chilotes* than it is *T. flavidus*.
- D *M. zebra* and *P. chilotes* diverged from a common ancestor approximately 15 million years ago.

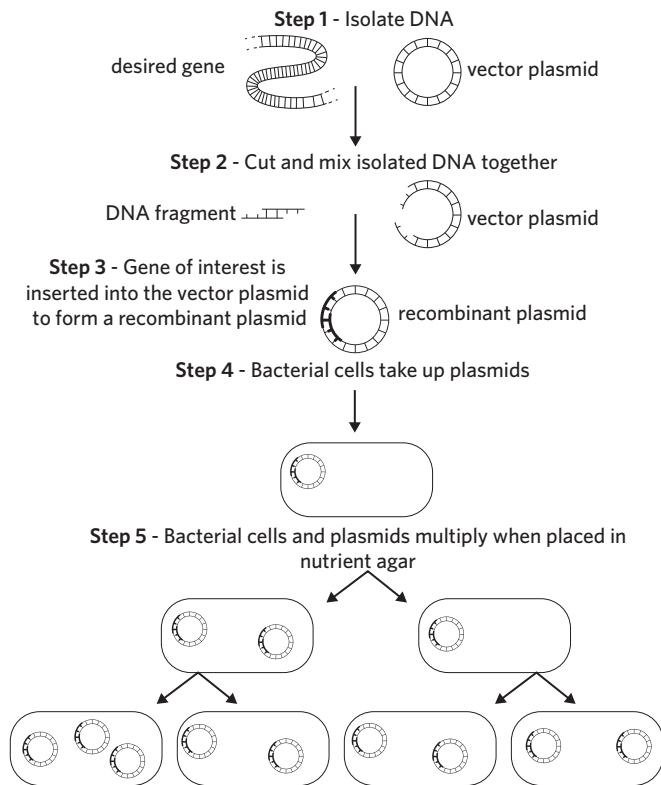
Question 39

Restriction enzymes

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

Question 40

A molecular biologist performed the procedure outlined in the flowchart below.



Step 6 - Colonies of transformed bacteria are identified and grown in large tanks

Step 7 - Proteins produced by bacteria are harvested and purified

Image: adapted from P Ladiges, B Evans, R Saint and B Knox, *Biology: An Australian Focus*, 3rd edition, McGraw Hill Australia, NSW, 2008, p. 273

Which one of the following is a correct statement about the procedure outlined above?

- A In Step 2, the same restriction enzyme is used to cut both the desired gene and vector plasmid.
- B In Step 3, polymerase enzymes are required to establish a recombinant plasmid.
- C In Step 4, all bacteria in the colony will take up the plasmid.
- D In Step 5, bacterial colonies are undergoing PCR.

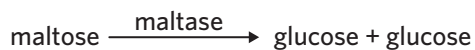
SECTION B

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen.
 Unless otherwise indicated, the diagrams in this question book are **not** drawn to scale.

Question 1 (6 MARKS)

Maltase is an enzyme that catalyses the breakdown of maltose into glucose as shown.



The coding information in the DNA molecule for maltase is initially transferred to mRNA before the strand undergoes translation to produce the protein.

a Describe how mRNA is synthesised from a DNA strand. 3 MARKS

b i Apart from temperature and pH, identify two other variables that can be altered to increase the rate of production of glucose. 2 MARKS

ii Scientists created a new drug that acts as a reversible competitive inhibitor of maltase. What does this suggest about the structure of the drug? 1 MARK

Question 2 (9 MARKS)

The mitochondrion and chloroplast are membrane-bound organelles that are the site of aerobic cellular respiration and photosynthesis respectively.

- a** Photosynthesis can be broken down into two stages, the light-dependent and light-independent stage. Identify two molecules that are outputs of the light-dependent stage and inputs of the light-independent stage. 2 MARKS

- b** The following three-dimensional diagram depicts the internal structure of a mitochondrion.

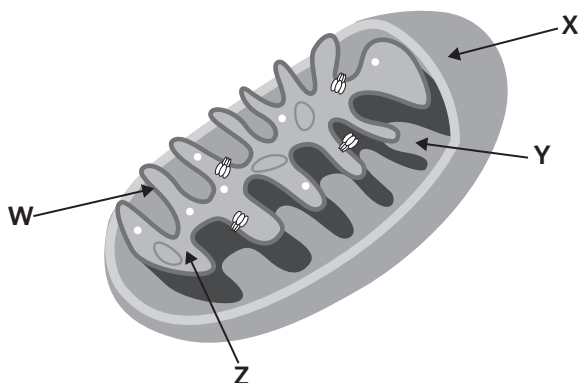


Image: Alila Medical Media/Shutterstock.com

- i** Which letter represents the matrix? 1 MARK

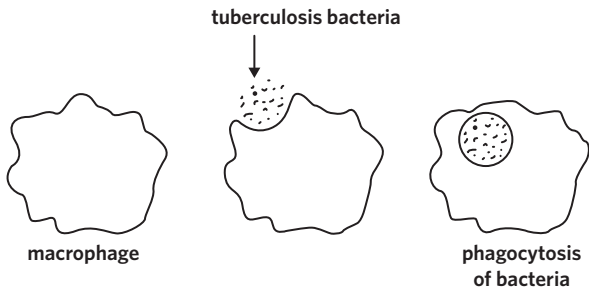
- ii** The electron transport chain takes place at W. Identify the structure represented by W. 1 MARK

- c** A number of factors influence the rate of aerobic cellular respiration. Explain the relationship between temperature and the rate of aerobic cellular respiration in humans. 3 MARKS

- d** It is commonly understood that chloroplasts and mitochondria used to live as single-celled organisms. Provide two pieces of evidence to support this theory. 2 MARKS

Question 3 (10 MARKS)

Tuberculosis is a disease caused by the bacterium *Mycobacterium tuberculosis*. It is usually transmitted between individuals by airborne droplets and mainly affects the lungs. Once inside the lungs, the bacterium is phagocytosed by macrophages, however it is able to evade destruction within the macrophage and can continue to replicate.



a Describe how macrophages typically digest pathogenic material once it has been engulfed. 1 MARK

b Tuberculosis is often contracted by individuals infected with the human immunodeficiency virus (HIV).
Explain whether an individual infected with HIV can effectively defend against tuberculosis. 3 MARKS

c While macrophages are largely incapable of stimulating an immune response, the ability of dendritic cells to migrate towards lymph nodes has been reported to be critical in initiating a targeted immune response against tuberculosis.
Suggest how dendritic cells could initiate an adaptive immune response against tuberculosis. 2 MARKS

- d** Occasionally, tuberculosis can remain dormant for many years inside macrophages before symptoms arise. During this period, the tuberculosis bacterium does not actively replicate. However, once it becomes active, it can cause disease and disrupt the normal functioning of the body. One mechanism of the disease involves the overstimulation of the immune system through a cytokine storm, which leads to the production of an excessive quantity of cytokines.

Describe the effects of a cytokine storm on the immune system.

2 MARKS

- e** Rifampicin is a broad-spectrum antibiotic often used to target many different strains of bacteria, regardless of whether they are pathogenic or not. It does this by targeting bacterial RNA polymerase, and is often used to treat tuberculosis.

Explain why individuals are more susceptible to bacterial infection after consuming antibiotics such as rifampicin.

2 MARKS

Question 4 (4 MARKS)

In Victoria, the ‘no jab, no play’ policy requires children to be fully vaccinated unless they have a medical exemption in order to enrol in childcare or kindergarten. This is so that herd immunity can be maintained.

- a** Describe the purpose of herd immunity. 1 MARK

- b** An example of a reasonable medical exemption includes the presence of an allergic reaction to a particular vaccine.

- i** Outline the process of an individual developing an allergy upon first exposure to an allergen. 2 MARKS

- ii** Explain whether allergies can be categorised as a disease. 1 MARK

Question 5 (4 MARKS)

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** In 2004, a hurricane killed many *A. sagrei* lizards on one of the islands of the Bahamas. Over the next three years, the scientists measured the genetic diversity within the population and found there was lower genetic diversity.

Explain the reasons for the lower genetic diversity of the *A. sagrei* lizards on the island being studied compared with the population on an unaffected island.

2 MARKS

- b** Describe the effect of having reduced genetic diversity for a species.

2 MARKS

Question 6 (9 MARKS)

The *CFTR* gene is responsible for the production of the cystic fibrosis transmembrane conductance regulator protein. This protein is responsible for moving chloride ions down their concentration gradient. This flow of chloride ions in and out of cells is important for the production of normal, thin mucus in the airways.

a Identify which type of transport chloride ions take through the membrane. 1 MARK

b Explain the role of mucosal secretions in the first line of defence that protects the respiratory tract from pathogens. 2 MARKS

Cystic fibrosis is a genetic disease caused by mutations that lead to the malfunctioning of the CFTR protein. Shown below is a small section of the mRNA nucleotide sequence found in an individual without the mutation.

5'	AUC	AUC	UUU	GGC	GUU	3'
----	-----	-----	-----	-----	-----	----

The codon table 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 and the codon table above to complete the table below. 2 MARKS

Translated sequence	
---------------------	--

d A common cause of cystic fibrosis is a deletion of three nucleotides, CUU, from the RNA sequence above.

i How would this alter the amino acids coded for in this sequence? 1 MARK

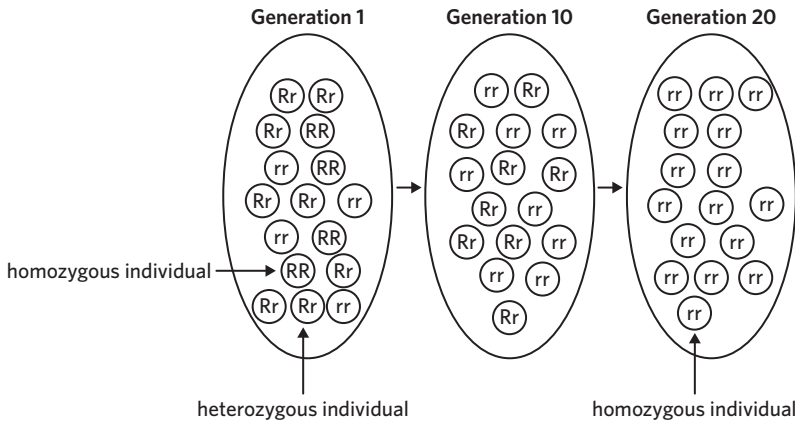
ii Explain if this mutation is a frameshift mutation. 2 MARKS

e In people without cystic fibrosis, the *CFTR* gene shows tight, tissue-specific regulation of expression. For example, in the intestinal epithelium there is a strong gradient of expression from the proximal to distal intestine.

Describe the role of the promoter region in gene expression. 1 MARK

Question 7 (6 MARKS)

Consider the diagram below showing the gene pool of a population over 20 generations.



a Using the information above, explain how natural selection can lead to the differences in genotypes seen in this population over time.

3 MARKS

b Scientists later discovered a different population of organisms on the other side of a mountain range. When they compared the gene pools of the two populations, they found that the newly discovered population had a gene pool similar to Generation 1 of the initial population shown above. They hypothesised that this second population was a separate species that shared a common ancestor with the original population they studied.

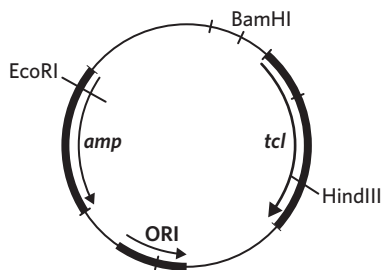
Name and describe the type of speciation that has taken place between the two populations.

3 MARKS

Question 8 (9 MARKS)

The *INS* gene encodes proteins that are essential for proper insulin production. When this gene is silenced, it often leads to type I diabetes. Scientists treat type I diabetes through synthetic insulin produced by bacteria that have the human insulin gene inserted into their genomes via bacterial transformation. To transform bacteria, a recombinant plasmid must be created.

A particular bacterial plasmid contains recognition sites for the sticky-end 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.



a Before the bacterial transformation process can begin, scientists must amplify the *INS* gene. The DNA amplification mixture was made up of the specific gene segment, a supply of four nucleotide bases, *Taq* polymerase, and DNA primers.

i Complete the table below and state the relevant temperatures for each step of PCR. 1 MARK

Step	Temperature (°C)
1	
2	
3	

ii Explain the role temperature has in each step. 3 MARKS

b The scientists decided to use *EcoRI* to cut the bacterial plasmid and the *INS* gene. Explain why *EcoRI* is used for both the plasmid and *INS* gene. 1 MARK

c Explain whether the transformed bacteria could be described as both a genetically modified organism and a transgenic organism.

2 MARKS

d 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.

2 MARKS

Question 9 (4 MARKS)

Between 2014–2016, an outbreak of Ebola virus disease (EVD) occurred in Guinea, Liberia, and Sierra Leone in West Africa. There were 28 616 reported cases of EVD in these countries and 11 310 deaths from EVD. It was found that humans may contract the Ebola virus from infected animals or from an infected person.



Image: Peter Hermes Furian/Shutterstock.com

a Explain whether this is an example of a pandemic or an epidemic. 1 MARK

b Identify one social or economic factor that could increase the transmission rate of the Ebola virus. 1 MARK

c Human to animal transmission can occur from close contacts with infected animals like bats, chimpanzees, and antelopes, including the handling and preparation of meat prior to consumption.

Describe two different approaches, other than vaccination, that government health officials could implement to reduce the spread of Ebola virus. 2 MARKS

Question 10 (6 MARKS)

Denny: Meet Our Hybrid Relative

In 2012, a team of Russian archeologists discovered a hominin bone fragment at the Denisova Cave in the Altai Mountains of Siberia, Russia. The bone was dated to 90 000 years old and was estimated to have belonged to a 13-year-old, who scientists named Denisova 11 ('Denny'). The bone was ground down into a fine powder before the DNA was extracted and the genome sequenced. To determine which hominin group Denny originated from, the scientists compared particular fragments of the genome with matched alleles from both a Neanderthal genome and a Denisovan genome. At these sites, it was found that 38.6% of Denny's alleles matched the Neanderthal genome, while 42.3% matched the Denisovan genome.

The discovery of Denny is often cited as conclusive evidence that disproves the idea that the hominin species evolved linearly from *Homo erectus*. According to this theory, the evolution of modern humans can be traced sequentially species-by-species from our primitive ancestors all the way through to modern humans.

While Denny's discovery has helped scientists confirm one aspect of hominin evolution, they are still piecing together clues to understand how and when *Homo sapiens* became so widespread. Analysis of modern human genomes reveals that present-day Africans have more genetic variation than humans from other continents. This supports the Out of Africa hypothesis, which suggests that early *Homo sapiens* lived solely in Africa and spread out across the world later in time, forming new populations. The genetic diversity of these populations was impacted by the founder effect. The Out of Africa hypothesis is also supported by the fact that the oldest known *Homo sapiens* fossil was found on the African continent.

- a Given that Denny had approximately equal amounts of Neanderthal and Denisovan ancestry, what conclusion were the scientists able to draw about their parentage? 1 MARK

- b Describe why the discovery of Denny contradicts the validity of the linear evolution of modern humans theory. 1 MARK

- c The multiregional hypothesis proposes that an ancestor of modern humans such as *Homo erectus* became widespread across the globe first and evolved into *Homo sapiens* independently in several different human populations.

Complete the following table by identifying two pieces of evidence in the text that dispute the multiregional hypothesis. Justify how each piece of evidence can be used to reject the multiregional hypothesis.

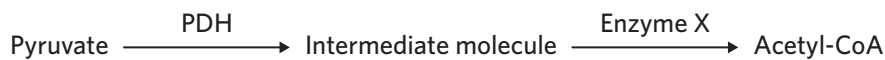
2 MARKS

Evidence	Justification
1. _____ _____ _____	_____ _____ _____
2. _____ _____ _____	_____ _____ _____

Question 11 (13 MARKS)

Nadine wanted to investigate the effect of enzyme inhibition on cellular respiration.

Pyruvate dehydrogenase (PDH) is an enzyme required to convert pyruvate to acetyl-CoA, an input of the Krebs cycle. It catalyses the breakdown of pyruvate into an intermediate molecule that can then go on to become acetyl-CoA.



Nadine knew that NADH was a reversible inhibitor for PDH, but did not know whether it was a competitive or non-competitive inhibitor. She designed an experiment to test which type of inhibitor NADH was using the following method.

1. Collect three beakers.
2. Label each beaker sample A, B, and C.
3. Measure 10 mL of a 0.1 M NADH solution using a measuring cylinder, then add it to sample A. Repeat for sample B and C.
4. Using a clean measuring cylinder, measure 50 mL of a 0.2 M pyruvate solution, then add this to sample A.
5. Repeat step 4 for sample B and C, except for sample B pour 50 mL of a 0.4 M pyruvate solution and for sample C pour 50 mL of a 0.1 M pyruvate solution.
6. Pipette 2 mL of PDH solution and 2 mL of Enzyme X into all three beakers.
7. Test for the initial concentration of acetyl-CoA.
8. Leave all beakers uncovered for 20 minutes at 37 °C.
9. After 20 minutes, test for the concentration of acetyl-CoA.

Nadine’s results are shown in the table below.

	Concentration of acetyl-CoA (M)	
	Initial	20 minutes
Sample A	0.00	0.02
Sample B	0.00	0.02
Sample C	0.00	0.02

- a** State the independent and the dependent variable in this experiment. 2 MARKS

Independent variable _____

Dependent variable _____

- b** List two variables that would need to be controlled to ensure the experiment produced valid results. 2 MARKS

1. _____

2. _____

- c** After completing the experiment, Nadine decided she could improve her experimental design by adding another beaker that contained the following:
- 50 mL of 0.1 M pyruvate solution
 - 2 mL of PDH solution
 - 2 mL of Enzyme X solution

The results from this beaker are shown below.

	Concentration of acetyl-CoA (M)	
	Initial	20 minutes
Sample D	0.00	0.30

Explain how this additional beaker would improve her experimental design.

2 MARKS

- d** With reference to the type of inhibition and its location of binding, what conclusions do you think Nadine can draw from her investigation? You should refer to evidence collected from Nadine’s experiment in your response.

2 MARKS

From her first experiment, she knew NADH inhibits the conversion of pyruvate to acetyl-CoA, leading to an accumulation of pyruvate, which promotes anaerobic cellular respiration. In a second experiment, Nadine wanted to measure how NADH concentration affects the rate of anaerobic respiration in yeast. She set up three test tubes, unsealed, with the contents listed in the table below.

Test tube	Contents of test tube
1	10 mL of 3% glucose solution 5 mL solution containing yeast 10 mL of 5% NADH
2	10 mL of 3% glucose solution 5 mL solution containing yeast 10 mL of 2% NADH
3	10 mL of 3% glucose solution 5 mL solution containing yeast 10 mL of distilled water

Nadine wanted to measure the rate of fermentation. She knows that in yeast, the outputs of anaerobic cellular respiration are carbon dioxide and ethanol. She chooses to measure the concentration of ethanol rather than carbon dioxide.

e State the hypothesis that Nadine was testing. 1 MARK

f Explain why it is more valid to measure the concentration of ethanol rather than carbon dioxide. 2 MARKS

g What results would disprove the hypothesis of Nadine’s experiment? 2 MARKS

END OF QUESTION BOOK