STAV PUBLISHING

**STAV Publishing 2021**

**Student name**

# BIOLOGY
# Units 3 & 4
# Trial Examination

## QUESTION AND ANSWER BOOK

**Total writing time: 2 hours 30 minutes**

### Structure of book

| Section | Number of questions | Number of marks |
|---|---|---|
| A | 40 | 40 |
| B | 12 | 80 |
| | **Total** | **120** |

- Students are permitted to bring into the examination room: pens, pencils, highlighters, erasers, sharpeners and rulers.
- Students are NOT permitted to bring into the examination room: blank sheets of paper and/or white out liquid/tape.
- No calculator is allowed in this examination.

### Materials supplied

- Question and answer book of 33 pages, with a detachable answer sheet for multiple-choice questions inside the front cover.

### Instructions

- Detach the answer sheet for multiple-choice questions during reading time.
- Write your **name** in the space provided above on this page and on the answer sheet for multiple-choice questions.
- Unless otherwise indicated, the diagrams in this book are **not** drawn to scale.
- All written responses should be in English.

### At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.

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Phone: 61 + 3 9385 3999 • Fax: 61 + 3 9386 6722 • Email: stav@stav.vic.edu.au Website: http://www.sciencevictoria.com.au/stavpublishing/

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# *STAV Publishing*

**2021**

# BIOLOGY

## Units 3 & 4 Trial Examination

# MULTIPLE CHOICE ANSWER SHEET

| **STUDENT NAME:** | |
|---|---|

**INSTRUCTIONS:** **USE PENCIL ONLY**

- Write your name in the space provided above.
- Use a **PENCIL** for **ALL** entries.
- If you make a mistake, **ERASE** it – **DO NOT** cross it out.
- Marks will **NOT** be deducted for incorrect answers.
- **NO MARK** will be given if more than **ONE** answer is completed for any question.
- Mark your answer by **SHADING** the letter of your choice.

| | ONE ANSWER PER LINE | | | | | ONE ANSWER PER LINE | | | | | ONE ANSWER PER LINE | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | A | B | C | D | 15 | A | B | C | D | 28 | A | B | C | D |
| 2 | A | B | C | D | 16 | A | B | C | D | 29 | A | B | C | D |
| 3 | A | B | C | D | 17 | A | B | C | D | 30 | A | B | C | D |
| 4 | A | B | C | D | 18 | A | B | C | D | 31 | A | B | C | D |
| 5 | A | B | C | D | 19 | A | B | C | D | 32 | A | B | C | D |
| 6 | A | B | C | D | 20 | A | B | C | D | 33 | A | B | C | D |
| 7 | A | B | C | D | 21 | A | B | C | D | 34 | A | B | C | D |
| 8 | A | B | C | D | 22 | A | B | C | D | 35 | A | B | C | D |
| 9 | A | B | C | D | 23 | A | B | C | D | 36 | A | B | C | D |
| 10 | A | B | C | D | 24 | A | B | C | D | 37 | A | B | C | D |
| 11 | A | B | C | D | 25 | A | B | C | D | 38 | A | B | C | D |
| 12 | A | B | C | D | 26 | A | B | C | D | 39 | A | B | C | D |
| 13 | A | B | C | D | 27 | A | B | C | D | 40 | A | B | C | D |
| 14 | A | B | C | D | | | | | | | | | | |

## SECTION A – Multiple Choice Questions

**Specific instructions for Section A**

This section consists of 40 questions. You should attempt **all** questions.

Each question has four possible correct answers. Only **one** answer for each question is correct. Select the answer that you believe is correct and indicate your choice on the Multiple Choice Answer Sheet by shading the letter that corresponds with your choice of the correct answer.

If you wish to change an answer, erase it and shade your new choice of letter.

Each question is worth **one** mark. **No** mark will be given if more than one answer is completed for any question. Marks will **not** be deducted for incorrect answers.

### Question 1

Concerning the plasma membrane, it can be stated that:

**A.** the phospholipid bilayer has a solid consistency.
**B.** the basic structure of the plasma membrane is determined by the proteins present.
**C.** the inner hydrophilic regions of the phospholipid molecules orientate towards the cytoplasm.
**D.** all cell membranes contain cholesterol to allow water to pass through.

### Question 2

Which one of the following statements about transport across the cell membrane is correct?

**A.** Glucose is always transported across the cell membrane by active transport rather than facilitated diffusion.
**B.** Proteins do not pass through the cell membrane as they would denature.
**C.** A carrier protein moves substances across the cell membrane by chemically reacting with them.
**D.** Ions are transported across the cell membrane by proteins forming protein channels.

### Question 3

A mucus cell secretes large amounts of a glycoprotein called mucin. A tick (✓) in the following table indicates the presence of large numbers of a particular cell organelle. Which one of the following shows the correct combination of organelles that would be present in this mucus cell?

| | rough endoplasmic reticulum | golgi body | mitochondria | smooth endoplasmic reticulum |
|---|---|---|---|---|
| **A.** | ✓ | ✓ | ✓ | |
| **B.** | ✓ | ✓ | | |
| **C.** | | ✓ | ✓ | ✓ |
| **D.** | ✓ | | ✓ | |

### Question 4

Mercaptoethanol has the ability to denature protein. It does this by disrupting disulfide bonds. The level of protein affected by mercaptoethanol would be:

**A.** the primary structure.
**B.** the secondary structure.
**C.** the tertiary structure.
**D.** all four levels of protein structure.

**Question 5**

The nitrogenous bases that make up DNA are the pyrimidines – cytosine and thymine, and the purines – adenine and guanine. In a sample of DNA, 20% of the bases are thymine. It can therefore be concluded that the total percentage of purines would be:

**A.** 20%
**B.** 30%
**C.** 50%
**D.** 70%

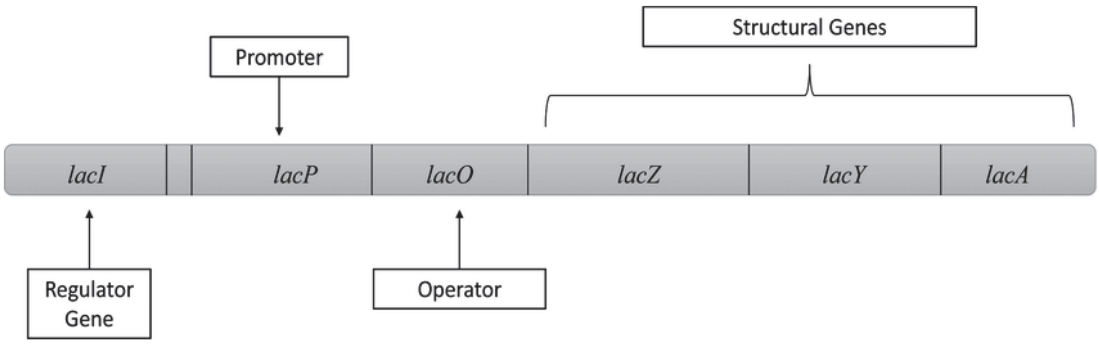
**Question 6**

The expression of the β globin gene occurs only in erythroblasts (immature adult red blood cells) and not in any other cell, even though the gene is present in all cells. This process would be controlled by:

**A.** mutations in the β globin gene in cells other than the erythroblasts.
**B.** translation factors.
**C.** different ribosomal RNA in erythroblasts producing β globin.
**D.** transcription factors.

***Questions 7 and 8 refer to the following information and diagram.***

The *lac* operon in the bacteria *E.coli* controls the expression of genes involved in lactose metabolism.




**Question 7**

When lactose is present in the medium the *lac* repressor protein binds to:

**A.** RNA polymerase
**B.** lactose
**C.** the promoter
**D.** the operator

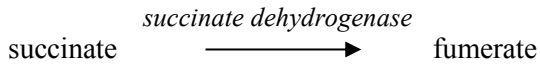
**Question 8**

If in the *lac* operon shown above, there is a mutation in the coding part of the structural gene *lacZ* that results in a stop codon, then, when lactose is present, the result would be that:

**A.** *lacZ* would not be expressed but the genes *lacY*, *lacA* and *lacI* would be expressed.
**B.** none of the genes *lacI*, *lacZ*, *lacY* and *lacA* would be expressed.
**C.** *lacZ, lacY,* and *lacA* would not be expressed but *lacI* would be expressed.
**D.** *lacZ* and *lacI* would not be expressed but *lacY* and *lacA* would be expressed.

***Questions 9 and 10 refer to the following information.***

Succinate dehydrogenase catalyses the reaction of succinate to fumerate in the Krebs cycle.




A student set up an experiment to investigate the effect of malonic acid on this reaction. Into two test tubes, labelled 1 and 2, she added the same amount of enzyme and succinate. She also added malonic acid into test tube 2. This set up is illustrated in the following table where the plus sign (+) indicates the addition of that substance.

| | test tube 1 | test tube 2 |
|---|---|---|
| succinate dehydrogenase | + | + |
| succinate | + | + |
| malonic acid | | + |

The student found that the rate of reaction was slower in test tube 2 when compared to test tube 1. The student then added excess succinate to test tube 2 and found that the rate of fumerate formation increased.

**Question 9**

A reasonable explanation for these observations would be that:

**A.** malonic acid acts to inhibit succinic dehydrogenase by binding to a site that is not the active site.
**B.** an increase in succinate in test tube 2 increases the likelihood of collisions between the enzyme and the succinate.
**C.** malonic acid acts as a non-competitive inhibitor of succinate by distorting the active site of the enzyme.
**D.** fumerate would be produced in test tube 1 but not in test tube 2.

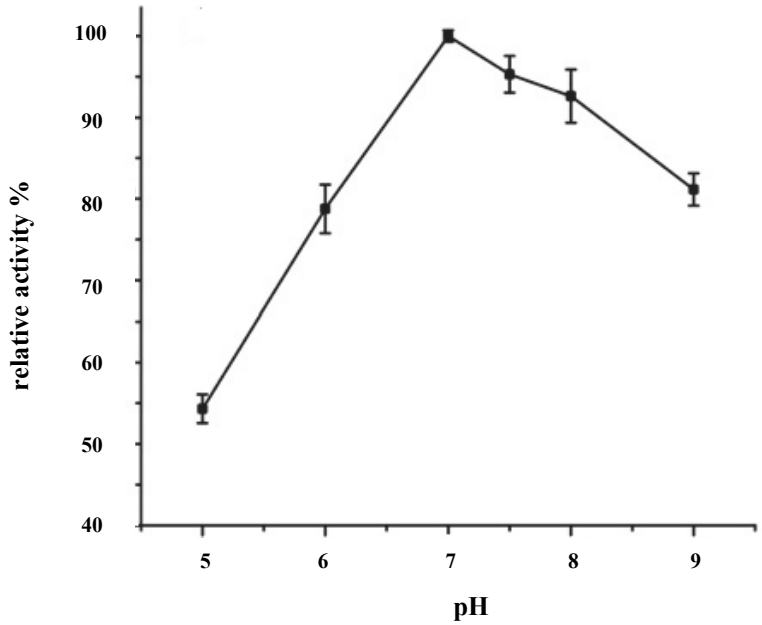
**Question 10**

In the cell, the reaction of succinate to fumerate takes place in the:

**A.** cytosol.
**B.** stroma of the chloroplast.
**C.** matrix of the mitochondria.
**D.** cristae of the mitochondria.

***Questions 11 and 12 refer to the following information and graph.***

A group of scientists conducted an investigation using a protease extracted from the bacteria *Sulfolobus solfataricus*. Part of the investigation involved measuring the relative activity (%) of the protease at 55°C. The experiment was repeated three times and error bars were used to represent the range of activity that was measured. The graph of the results is shown below.




**Question 11**

From the graph it can be stated that:

**A.** this protease is denatured by an acid pH.
**B.** this protease only functions at 55°C.
**C.** the optimum pH for this protease is 7.
**D.** this protease ceases to react at pH 9

**Question 12**

From the graph it can be stated that the:

**A.** readings at pH 5 were more precise than at pH 6.
**B.** closer the readings of pH are to 7 the more accurate they are.
**C.** error bars represent systematic errors at each pH.
**D.** readings at pH 5 are more accurate than at pH 6**.**

**Question 13**

The reaction that takes place in the stroma of the chloroplast is:

**A.** $ADP + P_i \longrightarrow ATP$
**B.** $H_2O \longrightarrow \frac{1}{2} O_2 + 2H^+$
**C.** $6CO_2 + 6H_2O \longrightarrow C_6H_{12}O_6 + 6O_2$
**D.** $NADPH \longrightarrow NADP^+ + H^+$

**Question 14**

While some people who were infected with SARS-CoV-2, the virus that causes COVID, showed very mild symptoms, others were so ill that they were hospitalised and even died. Scientists found a variant in the IFNAR 2 gene that codes for the receptor site for interferon on cell surfaces in these patients. Those with the variant appear to be more susceptible to a more severe infection because:

**A.** they are unable to produce interferon that stimulates B cells to attack virus infected cells.
**B.** they cannot produce antibodies against SARS-CoV-2 that is mediated by interferon.
**C.** they are unable to initiate specific immunity.
**D.** interferon helps uninfected cells to resist virus infections when it binds to its receptor.

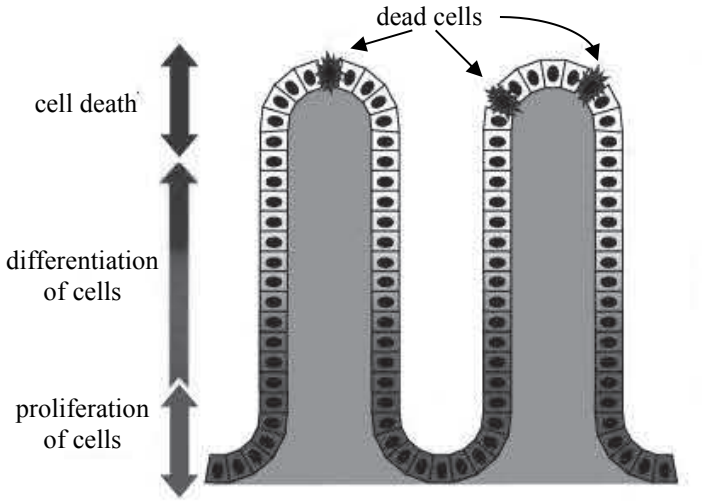
**Question 15**

Signalling molecules that move between cells resulting in inflammation are:

**A.** antibodies
**B.** complement proteins
**C.** cytokines
**D.** microbial antigens

***Questions 16 and 17 refer to the following information and diagram.***

The cells at the tip of the villi of the small intestine are continuously dying and being removed as shown in the diagram below.




**Question 16**

These cells are dying:

**A.** by the extrinsic pathway of apoptosis.
**B.** because their DNA is damaged.
**C.** by the intrinsic pathway of apoptosis.
**D.** because all cells are replaced as they age.

**Question 17**

The death of these cells of the villi:

**A.** starts with the rupture of the cell membrane.
**B.** involves the action of caspases within the cell.
**C.** increases the rate of cell proliferation of the cells at the base of the villi.
**D.** involves the release of histamine from nearby mast cells.

**Question 18**

Chronic granulomatous disease (CGD) is a genetic disorder involving mutations in either the NCF1, NCF2 or NCF4 genes. This results in a defective NADPH oxidase enzyme, specifically in phagocytes. The enzyme is needed for the destruction of intracellular pathogens that have been engulfed. People with this disorder experience many serious bacterial and fungal infections. Using this information it can be stated that CGD would be classified as:

**A.** an autoimmune disease.
**B.** a disease resulting in a failure of the body to recognise non-self molecules.
**C.** a pathogenic disease.
**D.** an immunodeficiency disease.

**Question 19**

Dendritic cells, macrophages and B cells are all:

**A.** able to produce antibodies.
**B.** antigen presenting cells.
**C.** able to move into the lymph nodes.
**D.** a type of lymphocyte.

**Question 20**

The presence of which of the following cells is essential for both the humoral and cell mediated immune response to occur?

**A.** B cells
**B.** antibodies
**C.** T cells
**D.** plasma cells

**Question 21**

Artificially acquired passive immunity occurs when:

**A.** antibodies move across the placenta from mother to foetus.
**B.** an antigen is injected into an individual in a vaccine.
**C.** immunoglobulins from a previously infected person are injected into an individual.
**D.** an individual makes antibodies as a result of infection.

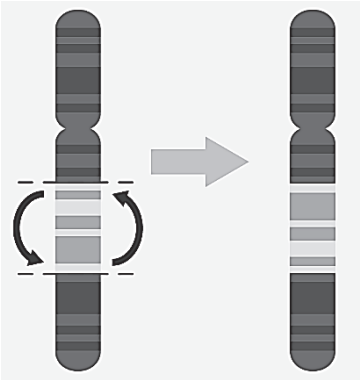
**Question 22**

The term ‘type 1 hypersensitivity’ is an immediate allergic reaction that occurs when an individual is re-exposed to a specific allergen. The main cells and molecules involved are:

**A.** mast cells, IgE antibodies and histamine
**B.** B cells, IgG antibodies and interferon
**C.** mast cells, IgG antibodies and complement
**D.** B cells, IgE antibodies and histamine

**Question 23**

Haemophilia A is a blood condition caused by a mutation on the X chromosome. The type of mutation is shown on the diagram below.



Such a mutation depicted is referred to as a:

**A.** point mutation
**B.** block mutation
**C.** nonsense mutation
**D.** frame shift mutation

**Question 24**

The bearded vulture *(Gypaetus barbatus)* having been blamed for the loss of goats and lambs was hunted to extinction in the European Alps in the early 1900s. Some bearded vultures remained in zoos and these were bred and released into the Alps to try and establish a wild population. This new wild population:

**A.** would show the same genetic diversity as the original population.
**B.** is an example of a founder effect.
**C.** is an example of selective breeding.
**D.** is an example of a genetic bottleneck.

**Question 25**

Two populations of monkey flowers were found to use two different pollinators, bees and hummingbirds. This resulted in the formation of two different species, *Mimulus lewisii* and *Mimulus cardinalis.* This was due to:

**A.** lack of genetic diversity between the populations.
**B.** geographical isolation between the two populations.
**C.** lack of genetic drift between the two populations.
**D.** lack of gene flow between the populations.

**Question 26**

The list that shows the correct order of appearance according to the fossil record would be:

**A.** amphibians, fish, retiles, mammals
**B.** fish, amphibians, reptiles, mammals
**C.** fish, amphibians, birds, reptiles
**D.** amphibians, fish, birds, reptiles

**Question 27**

Fossilised dung from ancient animals such as dinosaurs can reveal information about their diet. Fossilised dung or coprolite is an example of a/an:

**A.** trace fossil
**B.** index fossil
**C.** cast
**D.** physical fossil

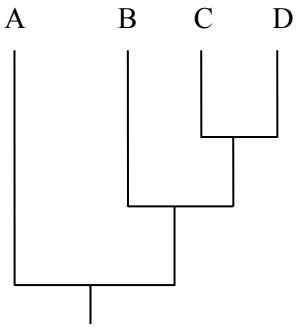
**Question 28**

A mass extinction event:

**A.** occurs when all species in a geographical location become extinct due to a sudden change in climate.
**B.** occurs when a particular species becomes extinct due to pollution of its habitat.
**C.** occurs when multiple species over the earth become extinct over a relatively short period of time.
**D.** leads to less biodiversity over time due to extinction of species.

**Question 29**

The following phylogenetic tree shows four different species of organisms.




It would be fair to state that:

**A.** A is more closely related to B than to C and D.
**B.** C and D are more advanced than A and B.
**C.** B is an ancestor of C and D.
**D.** D is more closely related to B than to A.

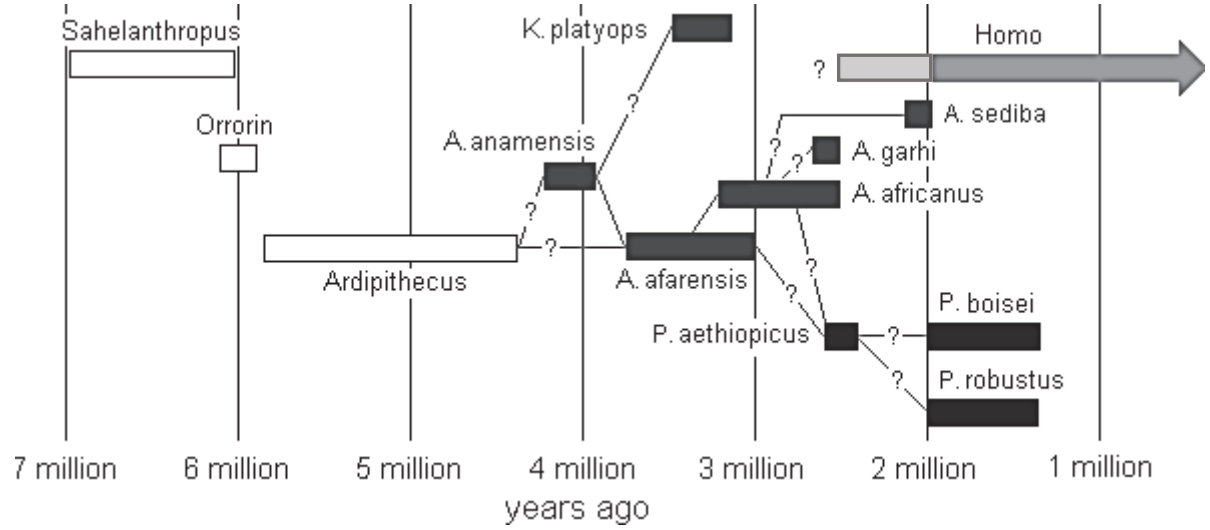
**Question 30**

Concerning molecular clocks, it can be stated that they:

**A.** are calibrated using phylogenetic trees.
**B.** can be unreliable because the rates of change of molecules may differ between species.
**C.** measure the number of changes in the fossil record.
**D.** measure changes in the rates of time.

**Question 31**

In 2016 a fossil skull was discovered in Africa and identified as *Australopithicus anamensis.* It was dated as 3.8 million years old. *Australopithicus afarensis* lived in Africa between 4 and 3 million years ago. **Prior to this discovery**, the relationship between *Australopithicus anamensis* and *Australopithicus afarensis* is shown in the diagram below.




Considering this new discovery it could be stated that:

**A.** *Australopithicus anamensis* is the ancestor of *Australopithicus afarensis.*
**B.** *Australopithicus anamensis* and *Australopithicus afarensis* co-existed together for 100,000 years or more.
**C.** *Australopithicus anamensis* and *Australopithicus afarensis* were able to walk upright.
**D.** *Australopithicus anamensis* and *Australopithicus afarensis* were able to interbreed.

**Question 32**

When comparing *Homo sapiens* with *Homo neanderthalensis* it can be stated that *Homo neanderthalensis*:

**A.** had more bones in their skeletons than *Homo sapiens*.
**B.** were not as accomplished in bipedal locomotion as *Homo sapiens.*
**C.** had wider, stockier torsos than *Homo sapiens.*
**D.** had smaller brains on average than *Homo sapiens.*

**Question 33**

Scientists now believe that the *Homo heidelbergensis* is the common ancestor of both *Homo sapiens* and *Homo neanderthalensis. Homo heidelbergensis* left Africa around 600,000 years ago and migrated to Europe. *Homo neanderthalensis* appeared about 430,000 years ago in Europe. Fossil remains of *Homo neanderthalensis* have only been found in Europe and Asia. Non-African modern humans (i.e. Europeans and Asians) have 1 - 4% Neanderthal DNA. Previously it was believed that modern African *Homo sapiens* did not have any Neanderthal DNA but in 2020 a group of scientists found five northern African populations with 0.3% Neanderthal DNA. The best explanation for this latest discovery would be:

**A.** *Homo neanderthalensis* evolved in Africa and mated with *Homo sapiens* there.
**B.** modern Africans have descended from *Homo neanderthalensis.*
**C.** the DNA found in modern Africans is from *Homo heidelbergensis.*
**D.** *Homo sapiens* that had mated with *Homo neanderthalensis* in Europe came back to Africa and mated with African populations that had never left.

***Questions 34 and 35 refer to the following information:***

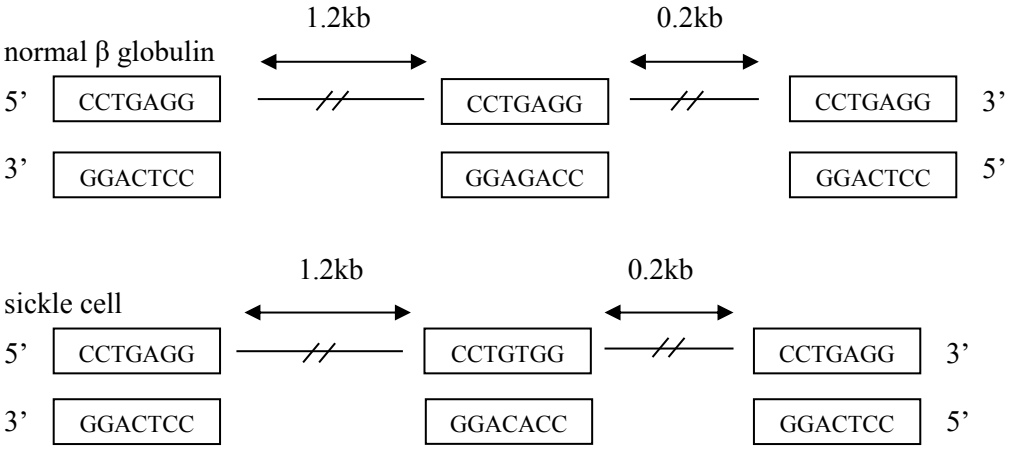
In the disease sickle cell anaemia, a thymine base replaces an adenine base in the β globulin gene on chromosome 11. Those individuals that are heterozygous are carriers, while those that are homozygous for the sickle cell allele have the condition of sickle cell anaemia.

normal β globulin CCTGAGG sickle cell CCTGTGG

The endonuclease enzyme MstII recognises the sequence shown where N is any nucleotide and cuts as shown by the arrow to produce sticky ends.

CCTNAGG

In both normal β globulin and sickle cell there are restriction sites recognised by MstII at 1.2kb upstream in the 5' flanking region and at 0.2kb downstream at the 3' end as shown in the diagrams below.




MstII can be used as a diagnostic tool for sickle cell anaemia.

**Question 34**

The resulting double strand of DNA after using MstII showing the correct pattern of the cut using lines would be:

**A.** 5' CCT|GAGG 3'

**B.** 5' CCT⌊GAGG 3'
3' GGAC⌋TCC 5'

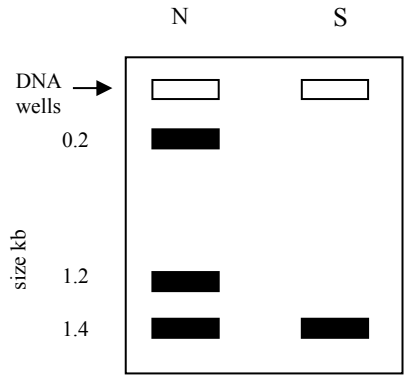
**C.** 5' CCT|GAGG 3'
3' GGA|CTCC 5'

**D.** 5' CCT|GA|GG 3'
3' GGA|CT|CC 5'

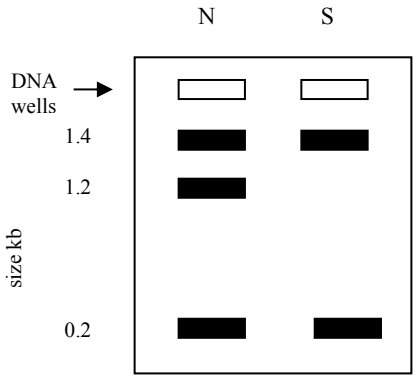
**Question 35**

Gel electrophoresis of DNA from a normal individual (N), and an individual with sickle cell anaemia (S) after treatment with MstII would best be represented by:

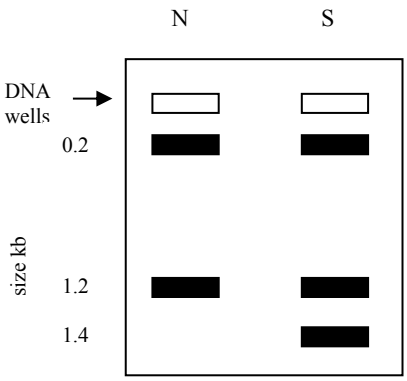
**A.**



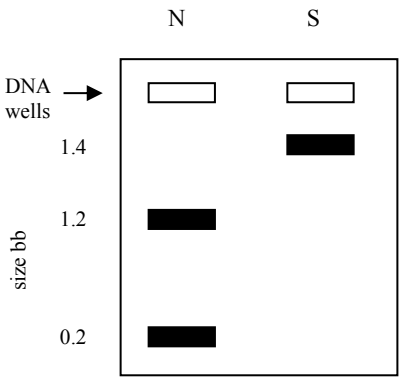

**B.**




**C.**




**D.**



***Questions 36, 37 and 38 refer to the following information.***

Bananas are susceptible to a disease called Panama disease caused by the fungus *Fusarium oxysporum.* The fungus exists in the soil and when it invades the banana plant the result is cell death by apoptosis leading to eventual death of the plant. Australian scientists isolated a gene, ced9, from a nematode worm. This gene prevents apoptosis. The scientists inserted the ced9 gene into banana cell tissue culture using a virus. These cells were able to grow into banana plants. In a field trial in Australia, banana plants carrying the ced9 gene and plants without the ced9 gene were planted in areas where the fungus *Fusarium oxysporum* was present in the soil. Results showed that banana plants with the ced9 gene remained disease free whereas the control group became infected and most of them died.

**Question 36**

The insertion of the ced9 gene into the banana cells is an example of:

**A.** transformation
**B.** transduction
**C.** transgenesis
**D.** transcription

**Question 37**

A possible result of the process described above is:

**A.** the increased use of fungicides.
**B.** the improved taste of the bananas.
**C.** the bananas will become resistant to the ced9 gene.
**D.** public concern with genetically modified food.

**Question 38**

The virus used in this process:

**A.** enables the bananas to produce a fungicide against the fungus *Fusarium oxysporum.*
**B.** acts as a vector to deliver the ced9 gene into the banana cell.
**C.** acts as a pathogen to cause cell death in the cells of the fungus *Fusarium oxysporum.*
**D.** prevents apoptosis of banana cells.

**Question 39**

Bacteriophages are viruses that can kill bacteria. Bacteriophages attach to receptors on specific bacteria based on a lock and key mechanism. Bacteriophages have been used to treat patients with bacterial diseases. The advantage of bacteriophage therapy for bacterial infections is:

**A.** many different bacteria are susceptible to a specific bacteriophage.
**B.** bacteriophages are not affected by antibiotics.
**C.** the use of bacteriophages would be important treatment for infections with antibiotic resistant bacteria.
**D.** bacteria would not be able to develop resistance to bacteriophages by mutations.

**Question 40**

Concerning cultural evolution, it can be stated that:

**A.** as cultural evolution occurs faster than biological evolution it influences the effect of natural selection on humans.
**B.** cultural evolution occurs independently of biological evolution.
**C.** transmission in cultural evolution can only occur from one generation to the next.
**D.** cultural evolution only occurs in *Homo sapiens.*

**END OF SECTION A**

**SECTION B – Short Answer Questions**

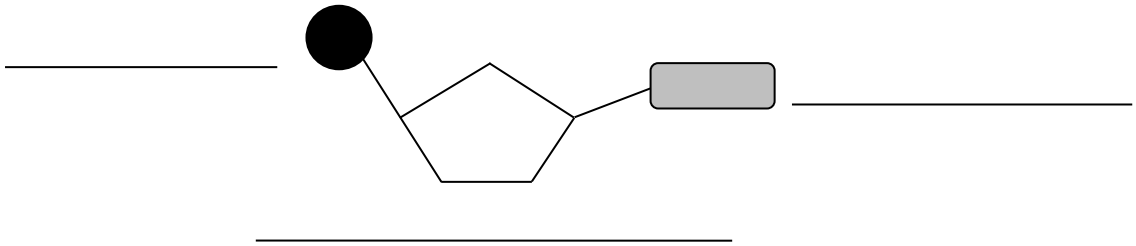
**Specific instructions for Section B**

This section consists of 12 questions. There are 80 marks in total for this section.
Write your responses in the spaces provided. You should attempt **all** questions. Please write your responses in **blue** or **black ink**.

**Question 1**

A nucleotide of a DNA molecule is shown below.

**a** Label the three subunits of the DNA nucleotide.



(1 mark)

**b** Identify **two** differences between a nucleotide of RNA and nucleotide of DNA.

_____

_____

_____

_____

(2 marks)

Primary mRNA was transcribed from a section of DNA. The DNA molecule separated and one strand was used to transcribe primary RNA. A section of the two strands of DNA and the primary mRNA was analysed and the percentages of nitrogenous bases calculated. The results are shown in the table below.

**c** Complete the table by filling in the two empty boxes.

| Nitrogenous base | T | U | A | G | C |
|---|---|---|---|---|---|
| DNA strand 1 | 23.5 | 0 | 18.5 | 32.7 | 25.3 |
| DNA strand 2 | 18.4 | 0 | 23.6 | 25.6 | 32.4 |
| Primary mRNA | | | 18.6 | 32.2 | 25.3 |

(1 mark)

**d** Name the strand of DNA (strand 1 or 2) above that would be the template strand. Use evidence from the data to support your answer.

_____

_____

(2 marks)

**Total 6 marks**

**Question 2**

Students investigated photosynthesis in spinach leaves. They cut discs from the leaves and placed them in different syringes with different concentrations of sodium hydrogen carbonate ($NaHCO_3$) solutions. The air was removed from the syringes by placing a finger over the nozzle and the plunger was gently pulled down. This caused bubbles of air to be removed from the discs and as a result the discs fell to the bottom of the syringes. The syringes were then placed in white light as shown below. As photosynthesis took place the leaves started to float to the top of the syringe.

The time it took for 50% of the leaves to float to the top in each solution is called the effective time or $ET_{50}$ and was measured for each concentration of sodium hydrogen carbonate. As the rate of photosynthesis is inversely proportional to the $ET_{50}$ value, therefore $\frac{1}{ET_{50}}$ is the rate of photosynthesis. The results are shown in the table below.

| concentration of $NaHCO_3$ ($mol/dm^3$) | $ET_{50}$ | $\frac{1}{ET_{50}}$ |
|---|---|---|
| 0.3 | 10 | 0.10 |
| 0.6 | 7 | 0.14 |
| 0.9 | 8 | 0.13 |
| 1.2 | 8 | 0.13 |
| 1.5 | 5 | 0.20 |

**a** Suggest an hypothesis for this experiment.

_____

_____

_____

(1 mark)

**b** What are the independent and dependent variables?

independent variable: _____

dependent variable: _____

(2 marks)

**c** Name the product of photosynthesis accumulated in the spongy mesophyll of the leaf disc causing it to rise.

_____

(1 mark)

**d** Name a variable that needed to be controlled in this experiment **and** state why control of this variable was important.

_____

_____

_____

(2 marks)

**e** Suggest **two** sources of error for this experiment.

_____

_____

(2 marks)

**f** Give one way the experiment could be improved to increase its reliability.

_____

_____

(1 mark)

**g** Write a conclusion using the results of this experiment. Refer to $ET_{50}$ in your answer.

_____

_____

_____

_____

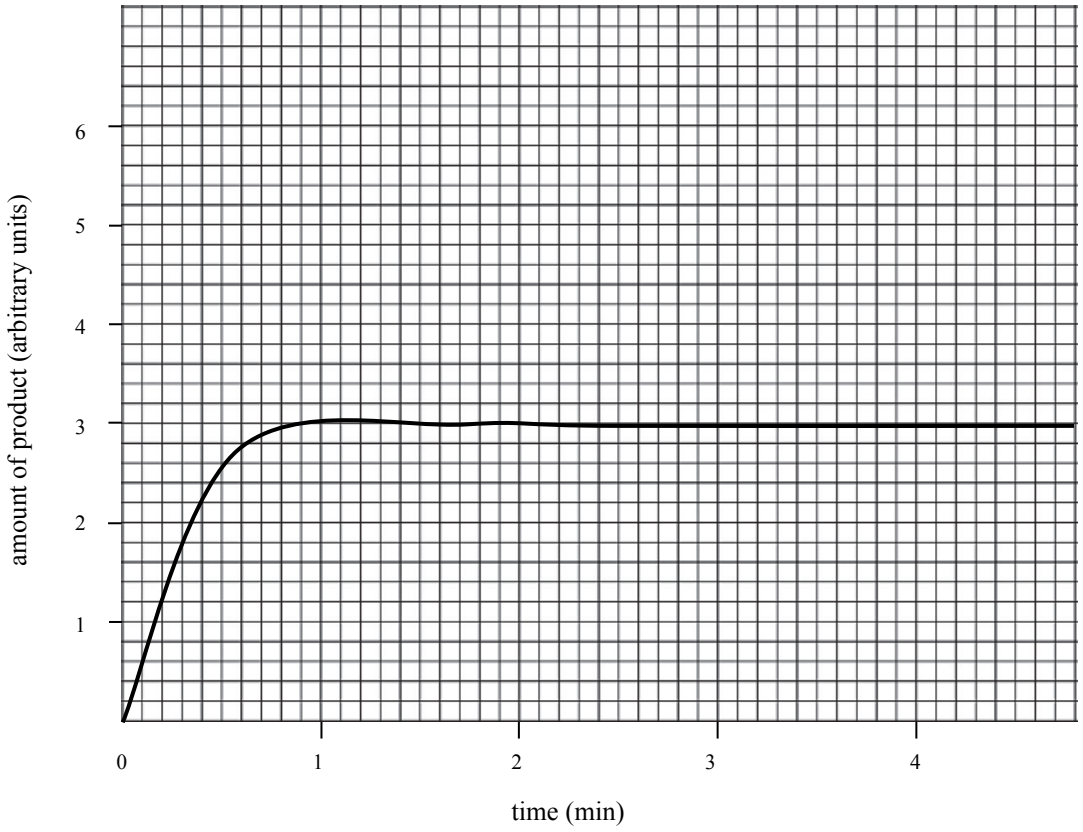
_____

(2 marks)

**Total 11 marks**

**Question 3**

A student investigated the action of an enzyme on its substrate. They mixed 0.5 mL of enzyme with 5 mL of substrate. The reaction occurred at 37°C and at the optimum pH for the enzyme. The rate of the reaction was determined by measuring the amount of product formed. The graph of the results is shown below.




The student then repeated the experiment except this time she mixed 10 mL of substrate with 0.5 mL of enzyme and ran the experiment at 15°C.

**a** Draw a graph on the axes above depicting the likely result for this experiment. (2 marks)

**b** Explain the shape of the graph you have drawn by referring to the rate of reaction in this experiment and the amount of product formed.

_____

_____

_____

_____

_____

_____

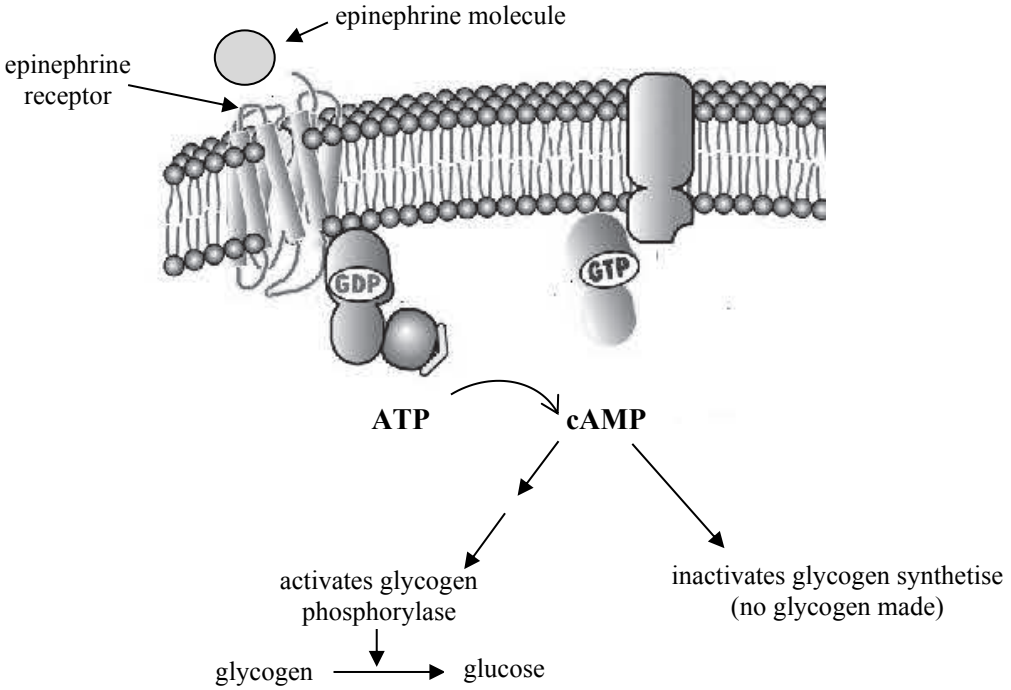
_____

(2 marks)

**Total 4 marks**

**Question 4**

Epinephrine, a signalling molecule, is produced by the adrenal gland situated above the kidneys. It is produced when an individual is stressed or in danger. The resulting response is sometimes called the 'fight or flight' response. Epinephrine is carried in the bloodstream to different cells where it has an effect. The diagram below shows the effect of epinephrine on skeletal muscle cells.




**a** Name the general term given to a signalling molecule that is produced in one part of the body and travels in the bloodstream to target cells?

_____

(1 mark)

**b** Refer to the diagram above to identify epinephrine as either a hydrophobic or hydrophilic molecule. Explain your reasoning.

_____

_____

(1 mark)

**c** Name the term used to describe the molecule **cAMP** in the above diagram.

_____

(1 mark)

**d** Describe the function of a molecule such as **cAMP**.

_____

_____

(1 mark)

**e** Suggest how the final response of the muscle cell to epinephrine would help the individual in the stressful situation that triggered the release of epinephrine?

_____

_____

_____

_____

(2 marks)

Epinephrine acts on other tissues such as the smooth muscle of the lung with the same receptors. In the lung the response is relaxation of the muscle.

**f** Suggest why the response is different in the lung tissue compared with the response in skeletal muscle.

_____

_____

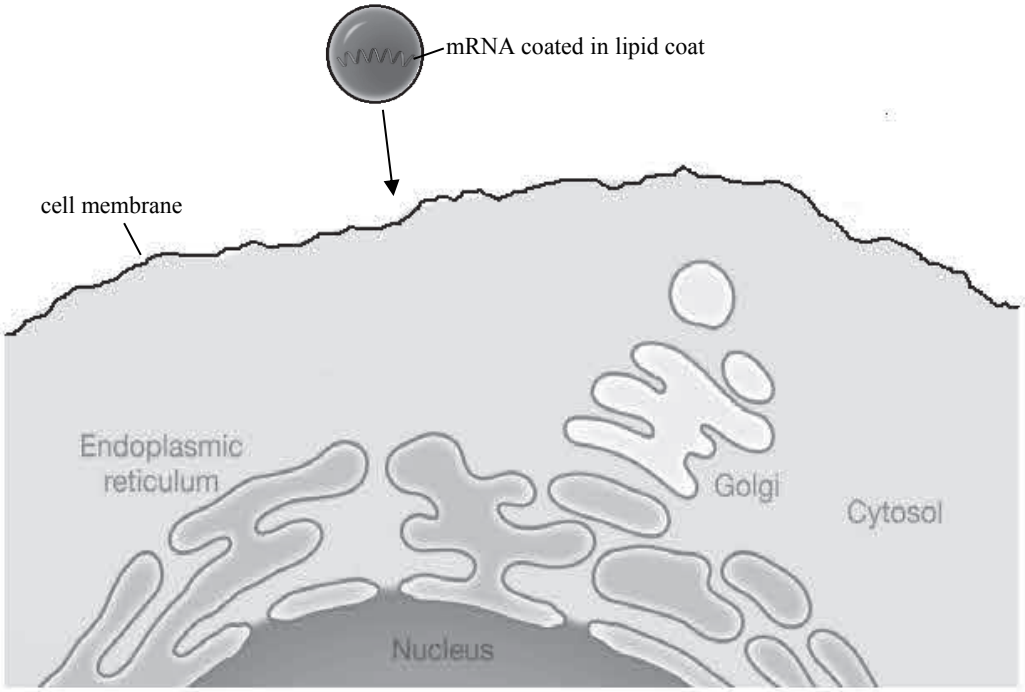
_____

(1 mark)

**Total 7 marks**

**Question 5**

A new approach to the manufacture of vaccines using mRNA was used to make a vaccine against SARS-CoV-2, the virus that causes COVID. Scientists are able to make synthetic RNA in the lab which codes for the virus spike protein. The scientists modified this RNA the same way that primary mRNA is modified to become mature mRNA before it leaves the nucleus. They packaged this mature mRNA into lipid nano- particles. These nanoparticles are made into a vaccine. When vaccine mRNA enters the cells, it produces the spike protein that it codes for using the cell organelles. The spike protein is then displayed on the cell surface triggering an immune response.




**a** What **two** modifications occur to primary mRNA to make it into mRNA?

_____

_____

_____

_____

(2 marks)

**b** Suggest **two** functions of the lipid coating on the nanoparticle carrying the mRNA.

_____

_____

_____

_____

_____

(2 marks)

**c** Outline the steps, after mRNA is introduced into the cell, that result in the formation of the spike protein.

(3 marks)

**d** Draw a line with an arrow on it on the cell diagram on the previous page to show the movement of the spike protein to the cell membrane from where it is produced.

(1 mark)

Many traditional vaccines consist of a weakened or attenuated virus that, when injected, bring about an immune response without causing the disease.

**e** Suggest one advantage of the mRNA vaccine over the traditional vaccine described.

(1 mark)

Scientists are hoping that the mRNA vaccine will provide long term immunity against COVID.

**f** Explain why long term immunity occurs after administering a vaccine.

(2 marks)

**Total 11 marks**

**Question 6**

DNA hybridisation techniques are used to determine the evolutionary relationship between species.

**a** Explain why DNA molecules with many G–C complementary nucleotide bonds need higher temperatures to separate than molecules with many A–T bonds.

_____

_____

_____

_____

(1 mark)

**b** Outline the steps in DNA hybridisation that would enable a scientist to determine the evolutionary relationship between different species.

_____

_____

_____

_____

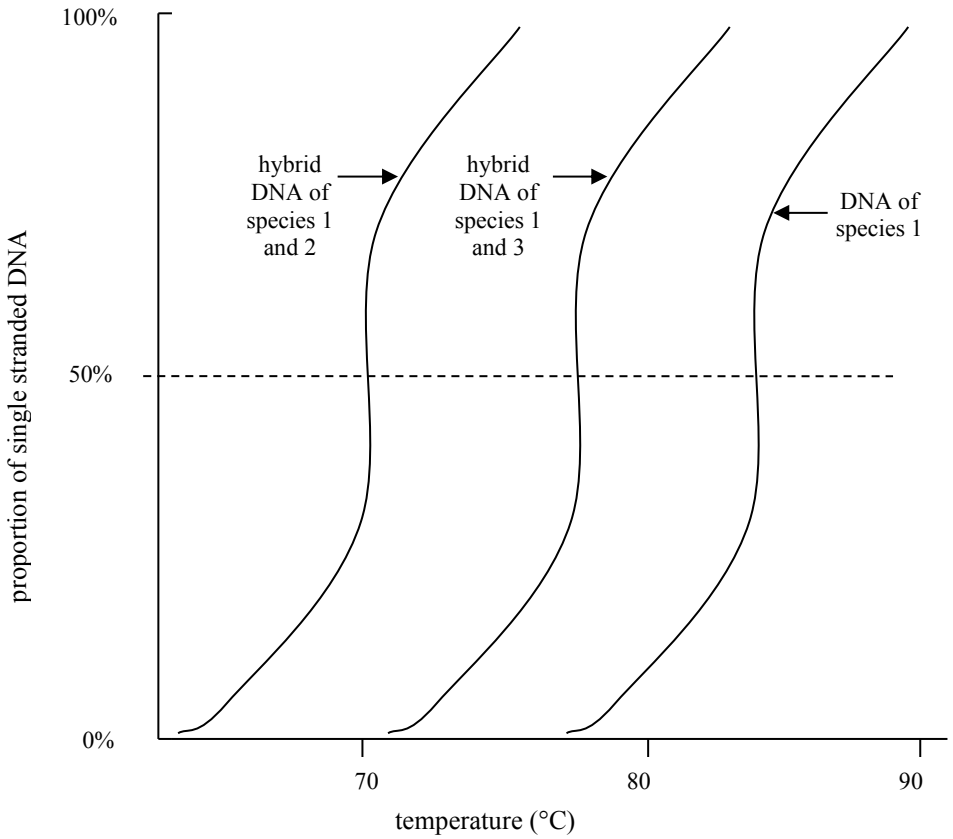
_____

_____

_____

(3 marks)

The relationship between species 1 and two other species, 2 and 3, was investigated using DNA hybridisation. The results are shown in the graph below.




**c** Identify which species, 2 or 3 is the most closely related to species 1? Use the information in the graph to support your answer.

_____

_____

_____

_____

_____

_____

(2 marks)

**Total 6 marks**

**Question 7**

Three vertebrate species are shown below.

shark
class Chondrichthyes

dolphin
class Mammalia

hippopotamus
class Mammalia

**a** Draw an evolutionary tree for these three animals (not to scale).

(2 marks)

**b** Identify the type of evolution resulting in the two species that are the most closely related sharing a recent common ancestor. Justify your answer.

_____

_____

_____

_____

(2 marks)

**c** Refer to the diagrams of the three animals to identify another type of evolution and explain the results of this evolution.

_____

_____

_____

_____

(2 marks)

**Total 6 marks**

**Question 8**

***Read the following extract and answer the questions that follow.***

**Genetic testing IVF embryos doesn't improve the chance of a baby**
November 25, 2019 12.12pm AEDT

Pre-implantation genetic testing for aneuploidy known as PGT-A, is an "add on" (extra cost of A$700 per embryo which adds up to A$2,800 if there are four embryos to test) used to help choose embryos not showing aneuploidy. It's promoted by IVF clinics as a way to increase the chance of success, especially for women over 35. But the evidence shows that in most cases, PGT-A doesn't improve the chance of a live baby. The chance of aneuploidy increases with the age of the woman; by the time a woman reaches age 40, approximately 80% of her embryos are aneuploid.

**What is PGT-A?**
All couples produce some aneuploid embryos, whether they conceive naturally or with IVF. The idea behind PGT-A is that if the aneuploid embryos can be identified they can be discarded, so that only embryos capable of producing a healthy pregnancy are used.

PGT-A involves the woman having fertility drugs to produce several eggs. When they are mature, they are retrieved and mixed with sperm to create embryos.

A proportion of embryos are "mosaic" – they have a mix of normal and abnormal cells. Surprisingly, mosaic chromosome abnormalities are quite common in early human embryos, and do not seem to prevent the embryo developing into a healthy baby. In a recent study of 98 women who had mosaic embryos, 32 (33%) elected to have at least one transferred. Of these, 11 (34%) had a successful pregnancy with apparently healthy babies born.
https://theconversation.com/genetic-testing-ivf-embryos-doesnt-improve-the-chance-of-a-baby-126839

**a** Define 'aneuploidy' **and** describe the usual consequences for the embryo.

_____

_____

_____

_____

_____

(2 marks)

**b** Explain if PGT-A is able to correct aneuploidy.

_____

_____

(1 mark)

**c** Use information in the article to explain if PGT-A is 100% accurate in predicting which embryo will result in the successful birth of a healthy baby.

_____

_____

(1 mark)

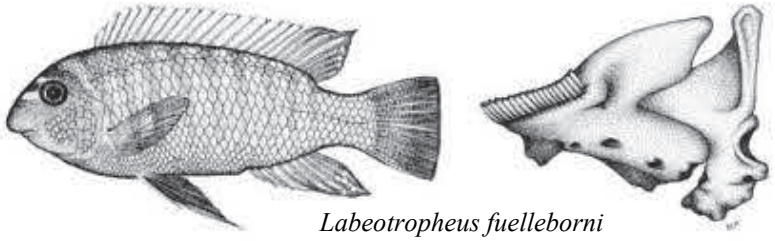
**d** Using the information and your knowledge of Biology, fill in the table below regarding issues to be considered when electing to undergo PGT-A.

| | |
|---|---|
| a social implication | |
| an ethical implication | |

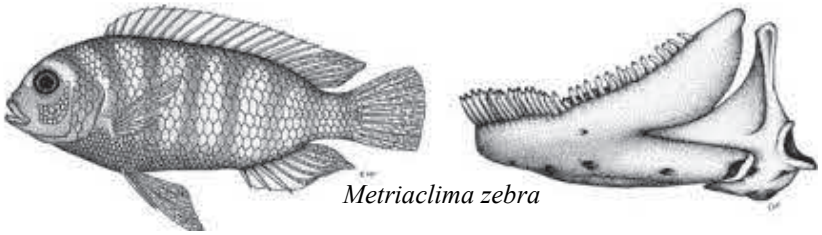
(2 marks)
**Total 6 marks**

**Question 9**

Cichlids are a group of fish found in isolated lakes in Africa. Over a relatively short period of time they have developed into many different species in these lakes showing many different colours, shapes and jaws. This evolution has occurred much faster than if there had to be mutations in all the structural genes involved. Biting cichlids have short robust lower jaws and an outer row of closely spaced tricuspid teeth as shown in species *Labeotropheus fuelleborni* below. Those that feed by suction have more elongated jaws and an outer series of larger bicuspid teeth as in species *Metriaclima zebra* below.



*Labeotropheus fuelleborni*



*Metriaclima zebra*

BMP4 is a master regulatory gene shown to be important in jaw development in the fish embryo. High levels of BMP4 expression results in jaws that are short and robust for biting whereas low levels of BMP4 expression results in jaws that are more elongated that are more suitable for suction.

**a** Describe how a master regulatory gene influences embryonic development?

_____

_____

_____

(1 mark)

**b** Outline the sequence of events involving the master regulatory gene BMP4 along with natural selection that would have resulted in the evolution of the different jaw development in cichlid fish in the different lakes in Africa.

_____

_____

_____

_____

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_____

_____

_____

_____

(3 marks)
**Total 4 marks**

**Question 10**

*Aedes aegypti* mosquitoes spread the virus that causes dengue fever. Only female mosquitoes bite to suck blood to mature their eggs and in so doing spread the disease. Scientists have genetically modified (GM) male mosquitoes by inserting a 'lethality gene' that consists of a combination of DNA sequences from the bacterium E. coli and from the herpes simplex virus. This gene codes for a protein tetracycline-controlled transactivator or tTAV. tTAV binds to its own gene promoter and in so doing promotes the production of even more tTAV protein. tTAV also binds to transcription factors of other genes preventing them from carrying out their function. When the antibiotic, tetracycline is fed to the GM mosquito larva it binds to the tTAV protein and prevents it from binding to its own promoter. Male GM mosquitoes are raised in the laboratory and then released into the environment where dengue fever is endemic. The male GM mosquitoes mate with the wild type females, pass the gene on to their offspring that then die.

**Diagram 1**

**No tTAV gene present**

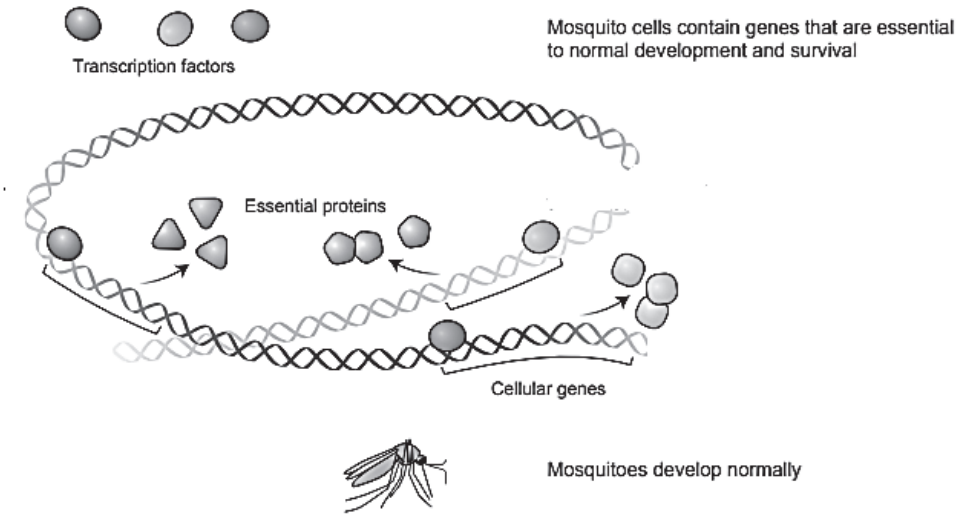



**Diagram 2**

**tTAV gene inserted and no tetracycline present**

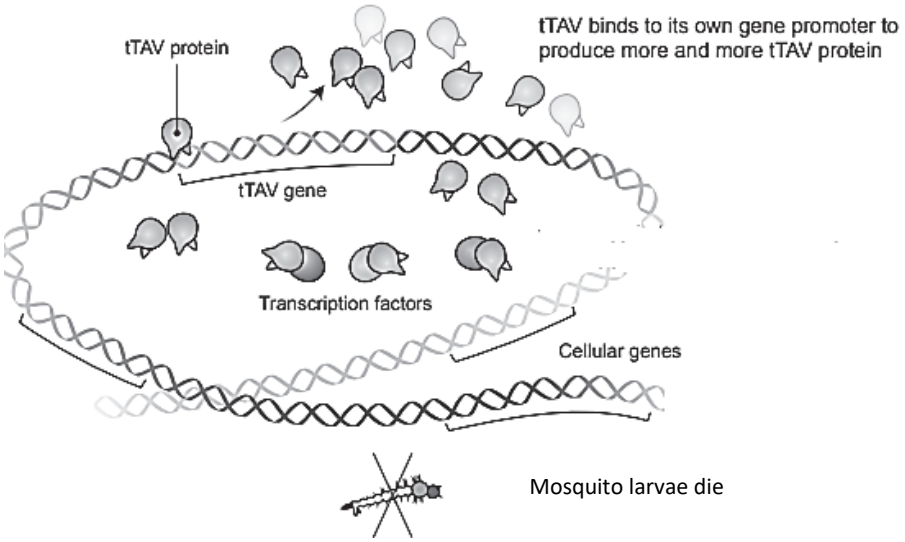
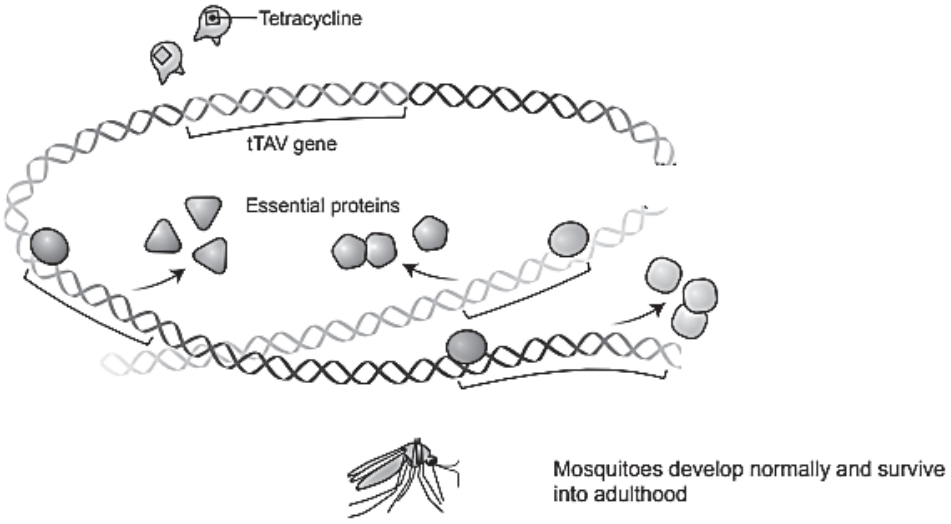


**Diagram 3**

**tTAV gene inserted and tetracycline present**




Diagrams **1 and 2** show transcription factors.

**a** Define 'transcription factor'.

_____

_____

(1 mark)

**b** Explain how the action of the tTAV protein leads to the death of mosquito larvae in diagram 2.

_____

_____

_____

_____

(2 marks)

**c** By referring to diagram 3, describe how tetracycline, when fed to mosquito larvae, enables them to develop into adults.

_____

_____

_____

(1 mark)

**d** Are these GM mosquitoes transgenic? Explain your answer by defining what is meant by the terms 'genetically modified' and 'transgenic'.

(2 marks)

**e** Explain why only GM male mosquitoes were released into the wild?

(1 mark)

**f** Suggest **two** positive outcomes that the scientists hope to achieve using this strategy.

(2 marks)

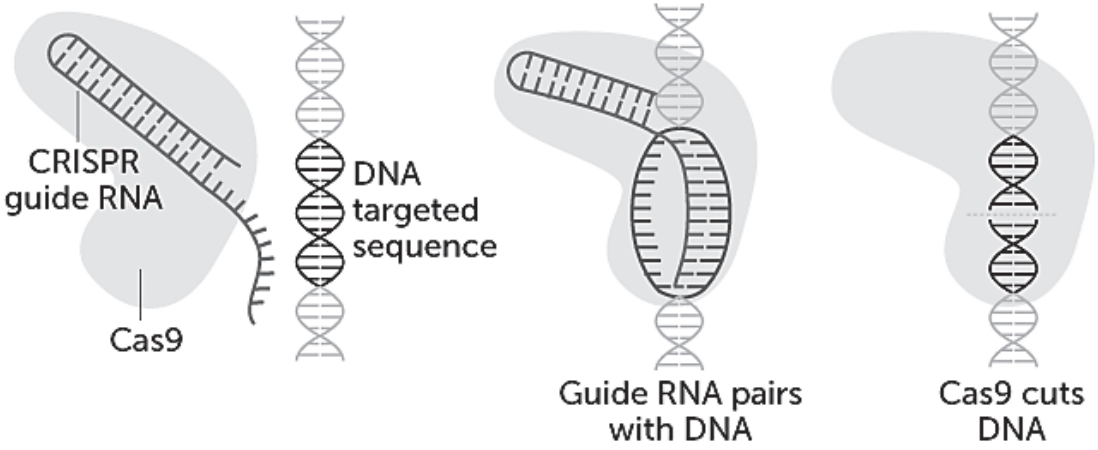
**g** Suggest **two** possible concerns that may be raised regarding the release of these GM male mosquitoes.

(2 marks)

**Total 11 marks**

**Question 11**

CRISPR/Cas9 is a two-part gene editing tool made up of a guide RNA (gRNA) and an enzyme, Cas9, that cuts DNA. A guide RNA brings the Cas9 enzyme to a particular gene in an organism's DNA that researchers wish to cut (such as the targeted sequence shown in the diagram below). Both strands of the DNA are then cut. After the DNA has been cut the two ends of the DNA molecule must be restored and joined together by the cell repair mechanisms.




**a** Describe how the action of gRNA/Cas9 differs from the action of other restriction endonucleases.

_____

_____

_____

_____

(1 mark)

**b** Describe how the gRNA is able to identify a specific location on the host DNA.

_____

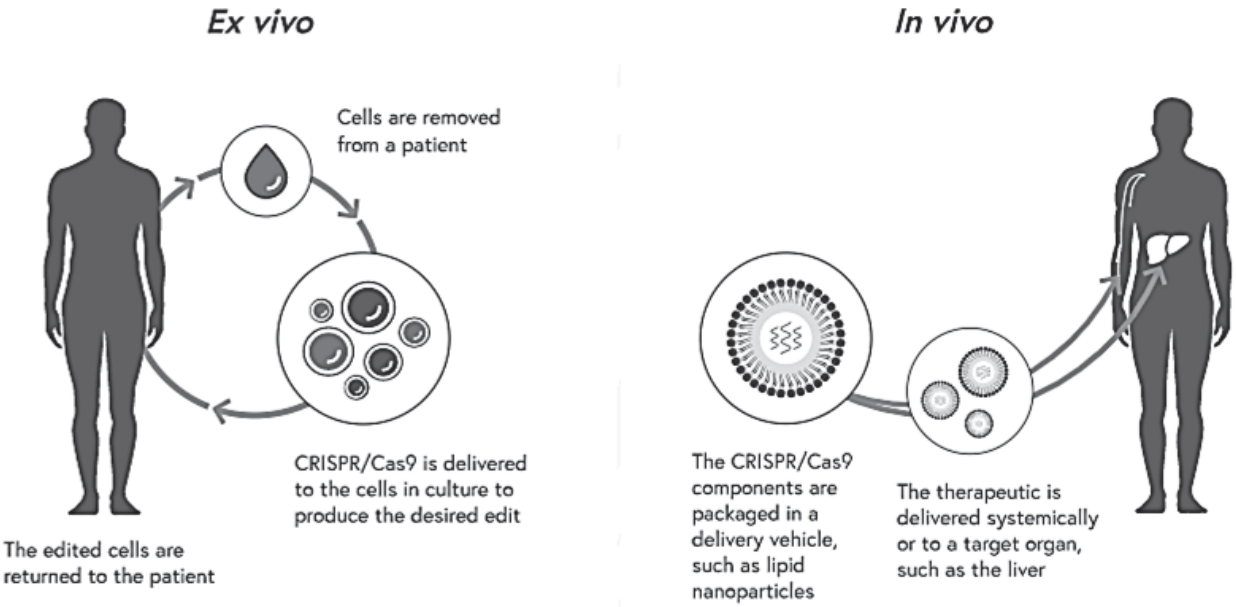
_____

_____

_____

(1 mark)

CRISPR/Cas9 can be used in either ex vivo or in vivo gene editing for human diseases as shown in the diagrams below.




**c** Describe an advantage of ex vivo gene editing compared to in vivo gene editing.

_____

_____

_____

_____

(1 mark)

**d** Describe a possible risk in the use of CRISPR/Cas9 in its application of gene editing.

_____

_____

_____

_____

(1 mark)

**Total 4 marks**

**Question 12**

Relenza is a drug that was developed using rational drug design. It works by inhibiting neuraminidase, an enzyme found on the surface of the influenza virus. This enzyme enables the newly formed virus particle to break away from the surface of the host cell.

**a** Outline the steps showing how the drug Relenza was designed.

_____

_____

_____

(1 mark)

**b** Explain how the administration of this drug acts to reduce the spread and hence the symptoms of influenza in the patient.

_____

_____

_____

_____

_____

(2 marks)

**c** Suggest a problem that could arise concerning the treatment of influenza with an antiviral drug such as Relenza.

_____

_____

_____

(1 mark)

**Total 4 marks**

**END OF TRIAL EXAMINATION**

Acknowledgements
https://www.researchgate.net/figure/The-lac-operon-A-basic-schematic-of-the-operon-and-its-regulatory-elements-A-version-of_fig1_303747389
https://www.researchgate.net/figure/Temperature-and-pH-dependence-of-Sso0660-protease-activity-A-The-pH-range-was-generated_fig6_230803446
https://www.researchgate.net/figure/A-View-of-normal-intestinal-villi-Cells-are-produced-in-the-intestinal-crypts-at-the_fig2_7785802
https://www.pageuk.org/pageuk/gfx/genomes-inversion.png
https://www2.palomar.edu/anthro/hominid/australo_2.htm
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