THE SCHOOL FOR EXCELLENCE (TSFX)

VCE BIOLOGY UNIT 3 & 4

WRITTEN EXAMINATION 2020

Reading Time: 15 minutes
Writing Time: 2 hours 30 minutes

QUESTION AND ANSWER BOOK

Student Number: | | | | | | | | | | **Letter** |

Structure of Book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	40	40	40
B	10	10	80
			Total 120

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

Materials Supplied

- Question and answer book of 34 pages.
- Answer sheet for multiple choice questions.

Instructions

- Write your **student number** in the space provided above on this page.
- All written responses must be in English.

At the End of the Examination

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

Students are **NOT** permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

VIC: Level 3, 99 William Street, Melbourne VIC 3000
Phone: (03) 9663 3311 Fax: (03) 9663 3939

www.tsfx.com.au
admin@tsfx.com.au

NSW: PO Box r1407, Royal Exchange, Sydney NSW 1225
Phone: 1300 364 173 Fax: 1300 364 065

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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 book are **not** drawn to scale.

QUESTION 1
Proteins are required by all living cells for structure and functioning. Some proteins must enter or leave cells. However, they cannot diffuse through the plasma membrane or move through protein channels because they are

A. hydrophobic.
B. hydrophilic.
C. too large.
D. polar.

QUESTION 2
The protein hormone insulin is synthesised by cells in the pancreas and then must leave those cells to travel in the blood stream to cause a response in the effector cells. Which of the following is the correct sequence from synthesis to secretion?

A. Ribosomes → Rough endoplasmic reticulum → Vesicles → Golgi apparatus → Vesicles → Plasma membrane → Outside cell

B. Ribosomes → Smooth endoplasmic reticulum → Vesicles → Golgi apparatus → Vesicles → Plasma membrane → Outside cell

C. Ribosomes → Rough endoplasmic reticulum → Golgi apparatus → Vesicles → Plasma membrane → Outside cell

D. Rough endoplasmic reticulum → Ribosomes → Vesicles → Golgi apparatus → Vesicles → Plasma membrane → Outside cell

QUESTION 3
The following table shows some of the substances absorbed from the gut, through the plasma membranes and into the cells lining the small intestine.

Substance	Concentration in gut (mg/L)	Concentration in cells (mg/L)
Glucose	62	41
Amino acids	10	23
Fatty acids	5	3
Calcium ions	7	3

Using this information, which of the following sequences is correct?

	Substance	Pathway Through Plasma Membrane	Hydrophobic or Hydrophilic
A.	Glucose	Protein carriers	Hydrophobic
B.	Amino acids	Protein channels	Hydrophilic
C.	Fatty acids	Pores in phospholipid bilayer	Hydrophobic
D.	Calcium ions	Phospholipid bilayer	Hydrophilic

Use the following information to answer Questions 4 and 5.

Titin is the largest protein in the human body and plays an important role in the muscles, together with actin and myosin. It consists of more than 34,000 subunits and is greater than 1 micron in length. Titin is classified in the quaternary level of protein structure, whereas actin and myosin are tertiary level.

QUESTION 4
The specific name for one subunit of titin would be

A. a nucleotide.
B. a monomer.
C. an amino acid.
D. a polypeptide.

QUESTION 5
According to their classification in the hierarchical structural levels of proteins

A. Titin consists of one polypeptide chain.
B. Actin and myosin consist of several polypeptide chains.
C. Actin and myosin are both globular proteins.
D. Titin, actin, and myosin all include primary structure.

Use the following information to answer Questions 6, 7 and 8.

The following graph (Figure 1) shows the effect of substrate concentration on an enzyme found in the human small intestine that functions at an optimal temperature of 37°C and optimal pH of 6.2. This enzyme acts in the way shown in Figure 2.

Figure 1

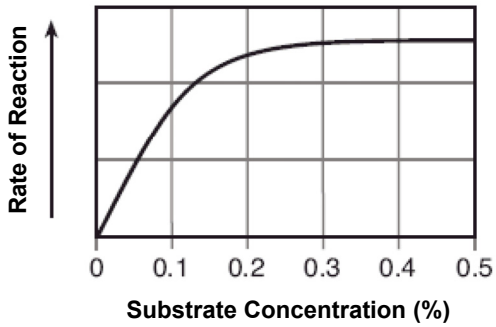
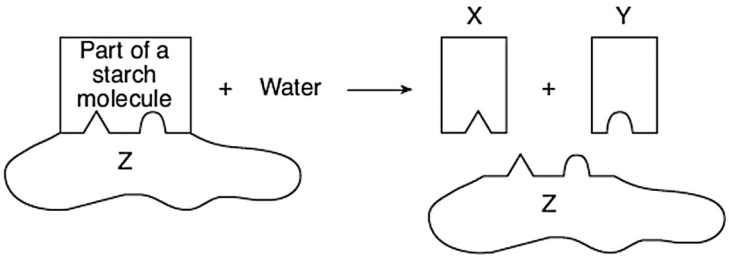


Figure 2



QUESTION 6
The reaction sped up by the enzyme is an example of

A. condensation polymerisation, as water is a reactant.
B. hydrolysis, as it uses water for breakdown of a more complex molecule.
C. an exergonic reaction, as energy is needed for the reaction to occur.
D. an anabolic reaction, as a more complex molecule is broken down.

QUESTION 7
In Figure 2, the molecule labelled

A. Z is made of protein.
B. X and Y are made of amino acids.
C. X could be a polypeptide.
D. Z has a fixed unchangeable shape.

QUESTION 8
In the graph in Figure 1, when the substrate concentration increases from 0.4% to 0.5%, the rate of the reaction

A. remains the same, as all the enzyme is saturated.
B. decreases, as all the substrate has been used up.
C. increases, as substrate production is greater than substate use.
D. remains constant, as all the enzyme has been used up.

QUESTION 9
Which of the following is a true statement about cellular respiration?

A. Anaerobic cellular respiration produces, per glucose molecule, 2 ATP in glycolysis and 2 ATP in the second stage of fermentation.

B. The Kreb's cycle is also known as the Calvin cycle and produces 2 ATP per glucose molecule.

C. The electron transport chain occurs on the cristae and produces 32 or 34 ATP per glucose molecule.

D. Glycolysis occurs in all eukaryotic cells producing net 2 ATP per glucose molecule, but it does not occur in prokaryotic cells.

Use the following information to answer Questions 10 and 11.

The following diagram summarises aerobic cellular respiration.

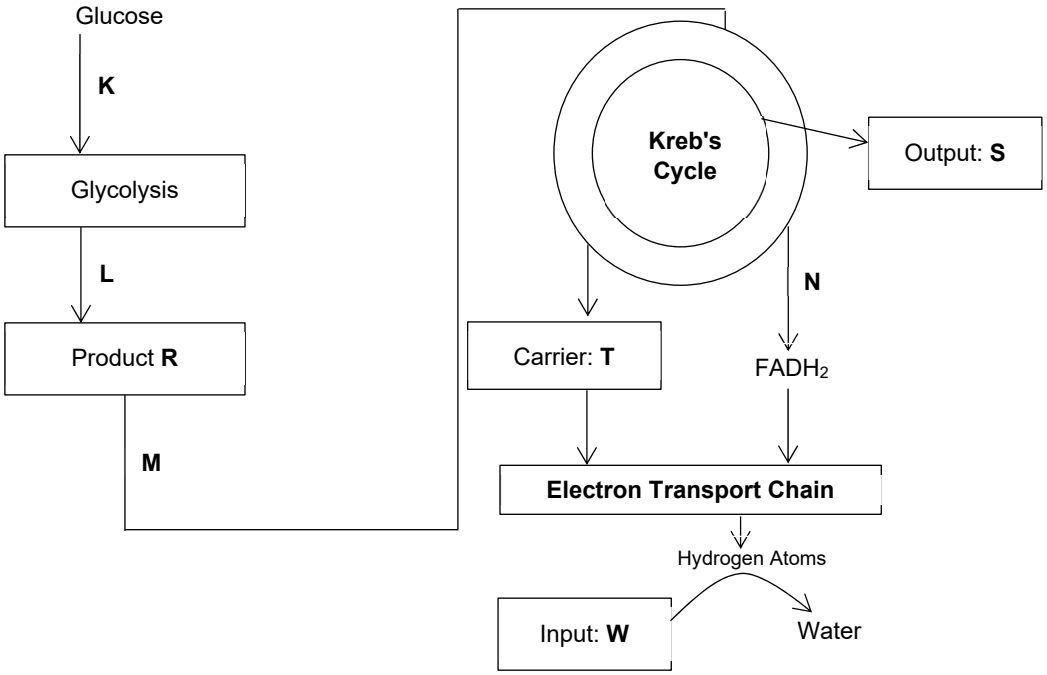


Figure 3

QUESTION 10
In this process of aerobic cellular respiration

A. R would be lactic acid.
B. S would be carbon dioxide.
C. T would be NADPH.
D. W would be ATP.

QUESTION 11
The hydrogen ions used in the electron transport chain were

A. carried by coenzymes from glycolysis and the Kreb's cycle.
B. produced by breakdown of water at each catabolic stage.
C. generated from the conversion of ADP to ATP.
D. carried by NADPH and $FADH_2$ from the citric acid cycle.

Use the following information to answer Questions 12 and 13.

The following diagram is of one of the stages in photosynthesis.

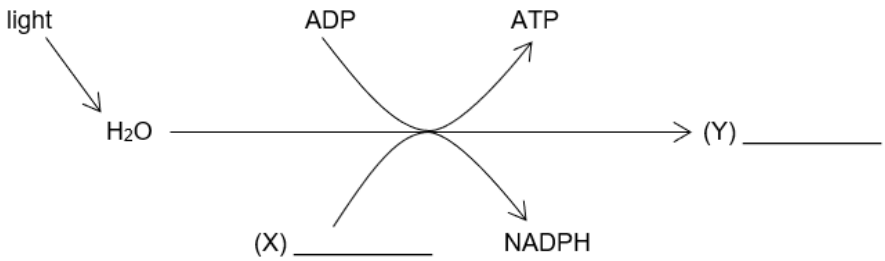


Figure 4

QUESTION 12
This stage is called

A. the light dependent stage and results in the production of carbon dioxide (Y).
B. the Calvin cycle which has a net production of ATP.
C. the light independent stage in which water combines with carbon dioxide.
D. the light dependent stage in which ATP, NADP and NADPH are coenzymes.

QUESTION 13
Which of the following statements is correct?

A. The rate of reaction of this stage would be limited by the wavelength of light available.

B. The ADP and NADP (X) would have been cycled from cellular respiration in plant cells.

C. The amount of ATP produced in this stage will be greater than that used in the second stage.

D. All oxygen produced in this stage will pass out of the plant into the air.

Use the following information to answer Questions 14, 15, 16 and 17.

The following diagram is of a special type of white blood cell that engulfs and destroys microbes. After carrying out this process, some of these special cells will display fragments of the microbe on their surface. These cells then trigger other white blood cells to begin their specific immune function.

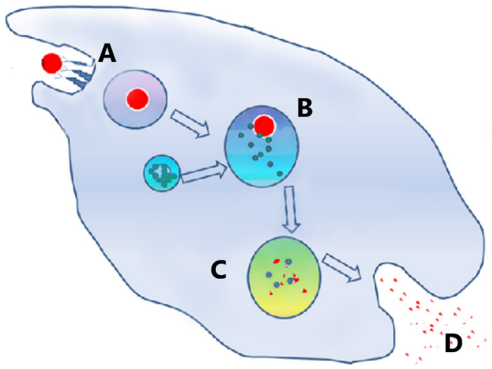


Figure 5

QUESTION 14
Which one of the following types of white blood cells does not engulf and destroy microbes?

A. Phagocyte
B. Mast cell
C. Macrophage
D. Neutrophil

QUESTION 15
Which of the following sequences is correct for the processes occurring in Figure 5?

	Process	Chemicals or Organelles	How Process Occurs
A.	Ingestion	Of microbe	Exocytosis
B.	Fusion	Of vacuole and microsome	Phagocytosis
C.	Digestion	Of microbe by lysozymes	Chemical breakdown
D.	Secretion	Of unwanted substances	Endocytosis

QUESTION 16
The fragment presented on the surface of the cell which will trigger an immune response in another white blood cell is called an

A. Antigen
B. Antibody
C. Immunoglobulin
D. Interferon

QUESTION 17
From the following alternatives, choose the one that gives the correct white bloods cells that respond to the cells presenting the fragment and how they would respond.

	Type of White Blood Cell	Cellular Response Once Activated
A.	B lymphocytes	Produce B-helper and B-memory cells
B.	Th lymphocytes	Stimulate plasma cells to clone
C.	B plasma cells	Produce antibodies against many different antigens
D.	Tc lymphocytes	Produce cytotoxins to destroy certain cells

Use the following information to answer Questions 18, 19, 20 and 21.

The earliest studies of apoptotic pathways were on the cells of a nematode worm, *Caenorhabditis elegans*. Each individual worm develops in the same way, with 131 of its somatic cells dying of apoptosis, and the remaining 959 cells forming the adult worm. Genetic testing of the DNA of *C. elegans* led to the identification of 4 genes that regulate apoptosis: one that codes for a protein that blocks apoptosis, an anti-apoptotic gene; and three that code for pro-apoptotic proteins, called caspases, that cause apoptosis.

QUESTION 18
Apoptosis

A. is a passive process as phagocytes are the main cells involved in degrading apoptotic cell fragments.

B. involves a signal transduction cascade and activation of different proteins.

C. can be controlled by intrinsic pathways activated by irreparable damage to ribosomes.

D. can be controlled by extrinsic pathways mediated by death receptors located in the cell cytosol.

QUESTION 19
Which of the following statements would be true for the 131 somatic cells that die by apoptosis during development in *C. elegans*? They

A. have different DNA compared to the 959 surviving cells.
B. are unhealthy cells and would not function.
C. carry mutations and would develop abnormally.
D. were in excess so not needed for development into an adult.

QUESTION 20
The pro-apoptotic proteins coded for by the three genes are classed in a group called caspases. It would be expected that these caspase proteins would

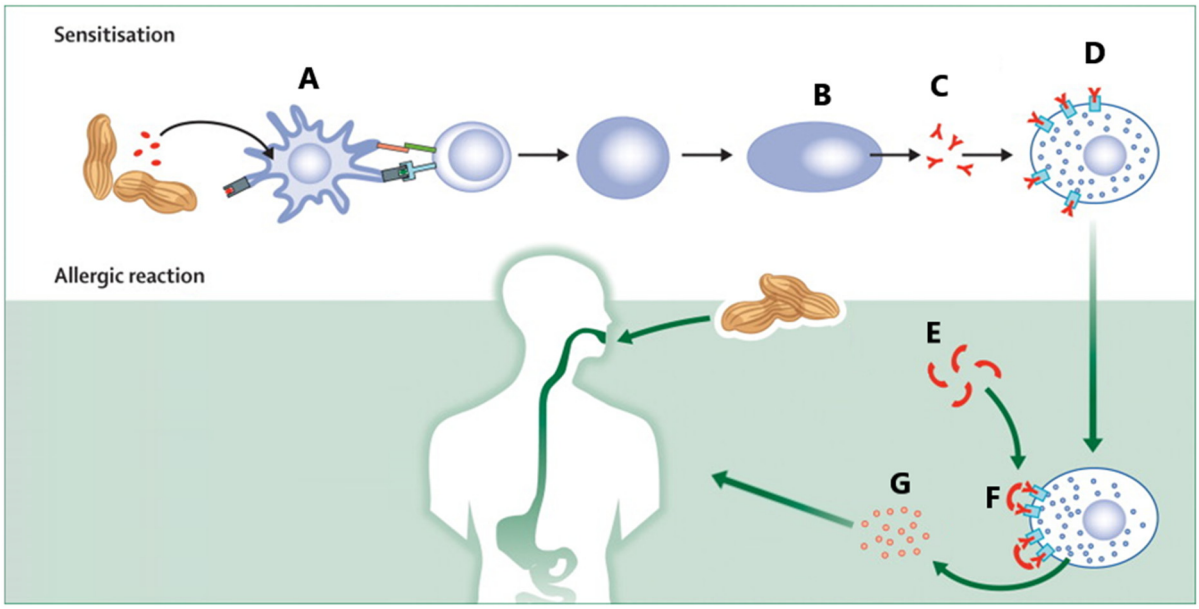
A. have a secondary level of protein hierarchy structure.
B. be highly conserved in multicellular organisms.
C. cleave or cut the nuclear membrane.
D. not be involved in signal transduction pathways in the cell.

QUESTION 21
If a similar control mechanism for apoptosis existed in humans and it was possible to design a drug that blocks the pro-apoptosis genes, it may be possible to reduce the frequency of or prevent

A. cancers.
B. blood leukemia cancer.
C. Alzheimer's disease.
D. brain tumours.

Use the following information to answer Questions 22, 23 and 24.

The following diagram shows what happens in a person allergic to peanuts. Two stages are shown, above and below the dotted line. Use this information and your knowledge of allergic reactions to answer the following questions.



https://www.sciencedirect.com/science/article/abs/pii/S0140673608606595

Figure 6

QUESTION 22
In the sensitisation stage, the person

A. feels ill and has a mild allergic reaction.
B. produces many Ig M antibodies that circulate in the blood.
C. produces some peanut specific IgE immunoglobulins.
D. has an increased production of mast cells in their body.

QUESTION 23
On second exposure to the peanut allergen

A. the allergen binds to the mast cells.
B. no more IgE antibodies will be produced.
C. the mast cells release histamine.
D. histamine causes bronchiole/air tubes to dilate.

QUESTION 24
If the person was treated and recovered from the second exposure, but then was offered a chocolate drink and didn't realise that the flavouring was from Nutella containing hazelnuts, their body may respond with a severe anaphylactic shock attack because they have

A. many mast cells with IgE antibodies attached to them to which the allergen will bind.

B. a lot of histamine left in their body from the first and second exposures which will cause the symptoms.

C. a high concentration of cloned B lymphocytes that have differentiated into plasma cells on the two previous exposures.

D. few B-memory cells that contribute to the severe reaction on the third exposure.

Use the following information to answer Questions 25 and 26.

Many children in the years from 1950 to 1970 had their tonsils removed if they were inflamed or the children regularly had throat infections. Nowadays, removal of the tonsils is avoided unless the infection is serious and occurs frequently.

QUESTION 25
Removal of the tonsils is avoided because the tonsils

A. are important for the maturation of T lymphocytes.
B. provide defence against ingested or inhaled pathogens.
C. produce important antibodies against throat infections.
D. contain lymph nodes where lymphocytes are concentrated.

QUESTION 26
The tonsils are part of the secondary lymphoid tissue, together with the

A. thyroid gland.
B. bone marrow.
C. spleen.
D. thymus.

QUESTION 27
Mutations are rare random changes in the DNA of the cell which

A. only happen if there is a mutagenic agent, such as ultraviolet radiation.
B. always have harmful effects.
C. can be somatic or germline, but only somatic mutations are inherited.
D. vary in type and include additions, deletions, and substitutions.

QUESTION 28
When Darwin described natural selection as the 'survival of the fittest', he did not mean physically fit, rather the organisms in a species that contribute most to the gene pool of the next generation. If magpie birds laid different numbers of eggs, which of the following would be considered the 'fittest?

A. Magpie W laid 4 eggs but only 1 of the offspring survived to reproductive age.
B. Magpie X laid 3 eggs and all the offspring survived to reproductive age.
C. Magpie Y laid 6 eggs and 2 of the offspring survived to reproductive age.
D. Magpie W laid 5 eggs, but none hatched successfully.

QUESTION 29
Agriculturists have increased the rate of evolution in grain-producing plants considerably by carrying out all the following except one. Which one would not have been beneficial?

A. Increasing the gene frequencies of certain desirable traits.
B. Selecting seed from larger plants in a population of mature plants.
C. Discarding plants that are more susceptible to fungal diseases.
D. Allowing cross pollination at random between plants.

QUESTION 30
In the early 1800s, some colonists set up a British settlement on a small island in the Atlantic Ocean. One of them was a carrier of retinitis pigmentosa, a progressive form of blindness that is inherited as a recessive disorder and affects homozygous individuals. In 1960, four of the 240 descendants living on the island had the disease and the frequency of this allele today remains 10 times higher on the island than in other populations. This is an example of

A. gene flow.
B. genetic drift.
C. genetic bottleneck.
D. geographic variation.

QUESTION 31
The frequencies of most alleles in a natural population remain relatively constant from generation to generation. Which of the following would not cause a change in the frequency of an allele in a natural population?

A. Increased selection of one phenotype.
B. More migration of one phenotype.
C. A large increase in the size of the population.
D. One phenotype having more successful matings.

QUESTION 32
By comparing the skeletons of flightless birds of different species and determining the nucleotide sequences in their DNA, the following possible phylogenetic tree has been proposed.

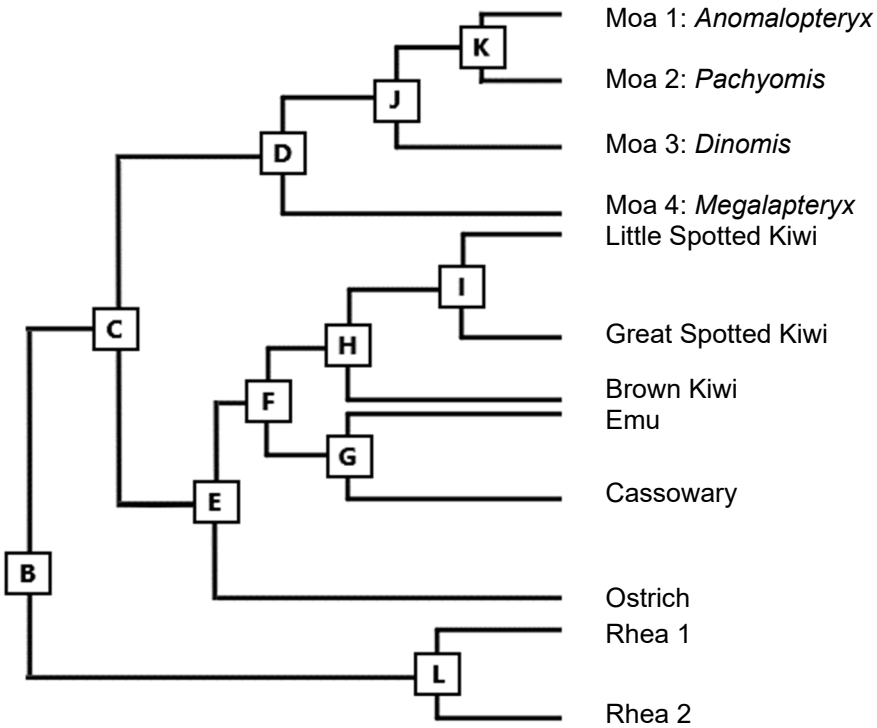


Figure 7

From this phylogenetic tree and the evolutionary relationships shown, it can be determined that

A. all moas evolved from a common ancestor at J.
B. the brown kiwi and the spotted kiwi are the most closely related.
C. rheas, kiwis, ostriches, and cassowaries all evolved from a common ancestor at C.
D. the extinct moas, *Anomalopteryx* and *Pachyomis*, were the most recent flightless bird species to evolve.

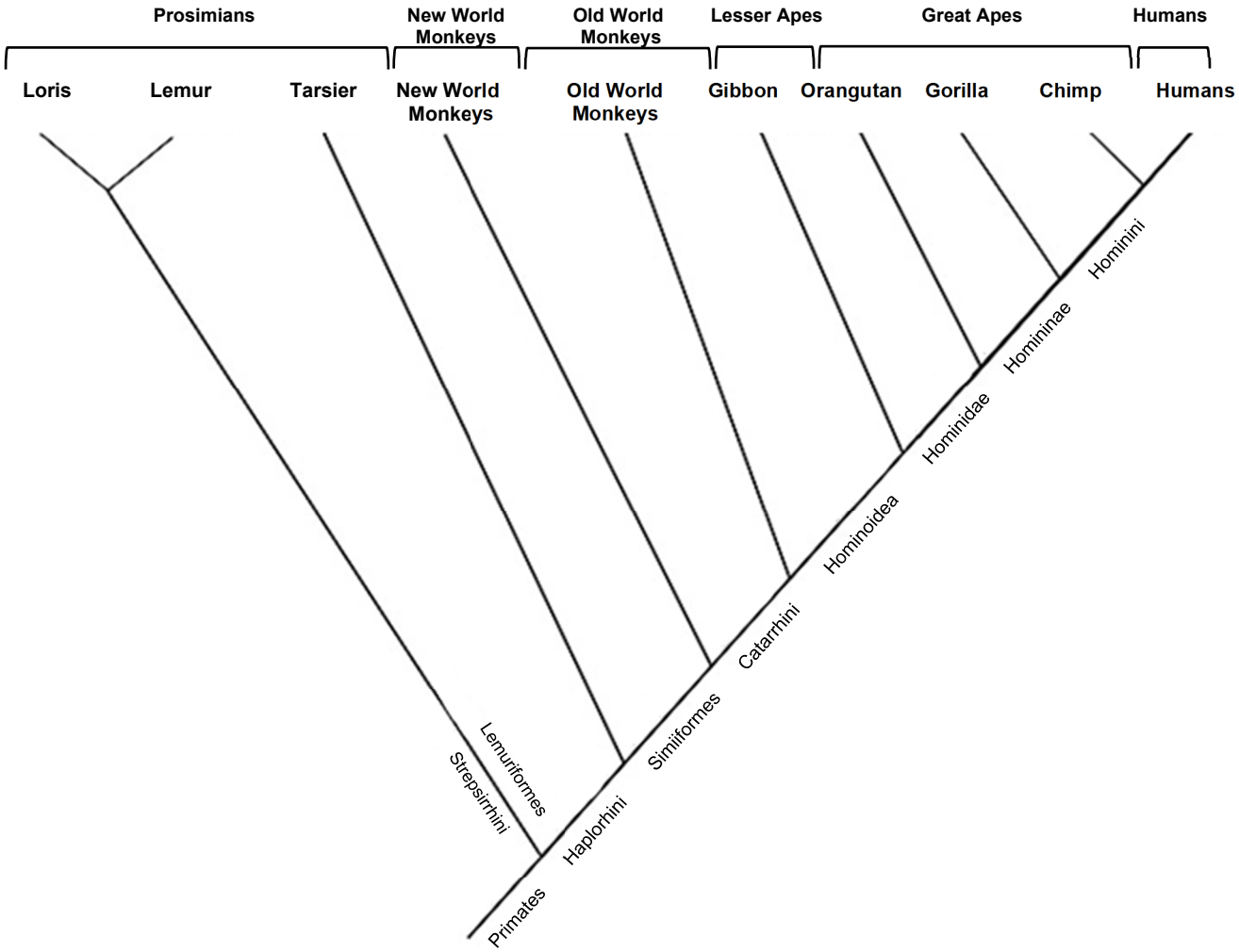
QUESTION 33
To determine if structures of different species are homologous and whether the species that have those structures arose from a common ancestor, external and internal anatomical features of organisms are studied. Which of the following pairs of organisms and their structures exhibit homology?

A. The eye of an octopus and the eye of a human.
B. The flipper of a seal and the digging foot of a wombat.
C. The wing of a hawk and the wing of a bee.
D. The spines of an echidna and the spines of a cactus.

Use the following information to answer Questions 34 and 35.

The diagram below is a phylogenetic tree for the class of animals called primates

Figure 8



QUESTION 34
If all these animals are primates, they must

A. have a very large brain.
B. have opposable digits on hands and feet.
C. be erect and upright.
D. have nails not claws.

QUESTION 35
The four groups of animals on the right side of the phylogenetic tree are all placed in the

A. hominins.
B. hominoids.
C. hominids.
D. pongids.

Use the following information to answer Questions 36, 37, 38, 39 and 40.

Some students were carrying out an experiment in which they had transformed *E. coli* bacteria to make them resistant to the antibiotic ampicillin. They were then testing to see if the bacteria they had treated had picked up the gene for ampicillin resistance. They set up twenty nutrient agar plates with ampicillin added to the agar. Ten plates were labelled T for treated, and ten plates were labelled U for untreated. The students smeared the surface of the agar of plates U with untreated *E. coli* and the surface of plates T with treated *E. coli*, using sterilisation techniques to reduce other bacterial contamination. They then sealed the plates and placed them upside down in an incubator at 30°C for 48 hours. When they took the plates out of the incubator, they counted the number of colonies on the surface of each plate. The results are in the following table.

	1	2	3	4	5	6	7	8	9	10
Plates U: Untreated Bacteria on	0	2	0	0	0	0	0	0	0	0
Plates T: Treated Bacteria	3	5	1	4	8	2	3	4	2	4

QUESTION 36
In carrying out the DNA technology process to transfer the ampicillin antibiotic-resistant gene into the *E. coli* bacteria, the students would have used

A. plasmids as vectors of the ampicillin-resistant gene.
B. restriction enzymes to cut the host cells.
C. ligase enzymes to join the host cell and the ampicillin-resistant gene.
D. *E. coli* bacteria as the vector of the ampicillin-resistant gene.

QUESTION 37
The independent variable in this experiment is

A. the number of colonies that grew on the agar.
B. the type of *E. coli* bacteria spread on the agar.
C. the temperature of incubation.
D. the type of nutrient agar used in the dishes.

QUESTION 38
The results of the experiment indicate

A. Plate U number 2 must have had two *E. coli* carrying a rare mutation for ampicillin resistance.

B. Plate T number 5 must have had more bacteria smeared on the agar than the other dishes.

C. Plates U 1-10, except plate 2, must have been at a temperature that inhibited bacterial growth.

D. Plates T 1-10 indicate that only some *E. coli* picked up the gene for ampicillin resistance.

QUESTION 39
The reason for setting up ten of each type of agar plate, T and U, was to

A. test the accuracy of the results by minimising systematic errors.
B. obtain precise results by minimising random errors.
C. check the reliability of the results by repeating the experiment.
D. cancel out any outliers in the results.

QUESTION 40
One of the students in the work group suggested they could improve the experiment by setting up two more sets of nutrient agar plates with no ampicillin in the agar, and smear 10 with treated bacteria and 10 with untreated bacteria. The reason for doing that would be to

A. keep all controlled variables the same.
B. have an experimental group with an additional controlled variable.
C. provide a control group for comparison.
D. introduce another variable to test the hypothesis.

END OF SECTION A

SECTION B – Short Answer Questions

Instructions for Section B

Answer **all** questions in the spaces provided. Write using blue or black pen.

QUESTION 1 (11 marks)
A soda lake is a lake with strongly alkaline water with a pH between 9 and 12 caused by high concentrations of sodium carbonate and often sodium chloride (salt) which are dissolved as ions in the water. These highly alkaline and saline lakes are considered some of the most extreme aquatic environments on Earth and yet they support highly productive ecosystems compared to other freshwater ecosystems. Photosynthesis in these lakes can be up to 16 times more than the global average for other lakes. An important reason for this high productivity is the almost unlimited supply of dissolved carbon dioxide.

Compared to other freshwater ecosystems, soda lakes are dominated by prokaryotes, often in dense concentrations which produce 'algal blooms' permanently or seasonally. Other inhabitants include eukaryotic algae; protists; fungi; crustaceans, mainly brine shrimp; and fish.

Both eukaryotic organisms and prokaryotic cells are surrounded by a plasma membrane that consists of a similar structure.

a. i. Explain the pathway of the salt ions of sodium carbonate and sodium chloride in and out of the cells based on their size, polarity and water solubility. 2 marks

_____

_____

_____

_____

_____

_____

ii. Would carbon dioxide molecules move through the same pathway through the plasma membrane? Explain. 1 mark

_____

_____

_____

b. Discuss the two major challenges for organisms living in these hypersaline and hyperalkaline, in terms of their cell functioning. 2 marks

c. **i.** In which stage of photosynthesis is carbon dioxide a reactant? 1 mark

ii. What coenzymes are essential for the stage of photosynthesis named in (ci) and where do they come from? 3 marks

iii. Considering the density of the prokaryotic algal blooms that can occur in the soda lake ecosystem, what is another limiting factor on photosynthesis in some of the bacteria, other than carbon dioxide availability? How would it affect the process of photosynthesis in the cells? 2 marks

QUESTION 2 (10 marks)
The following table is for the Genetic Code:

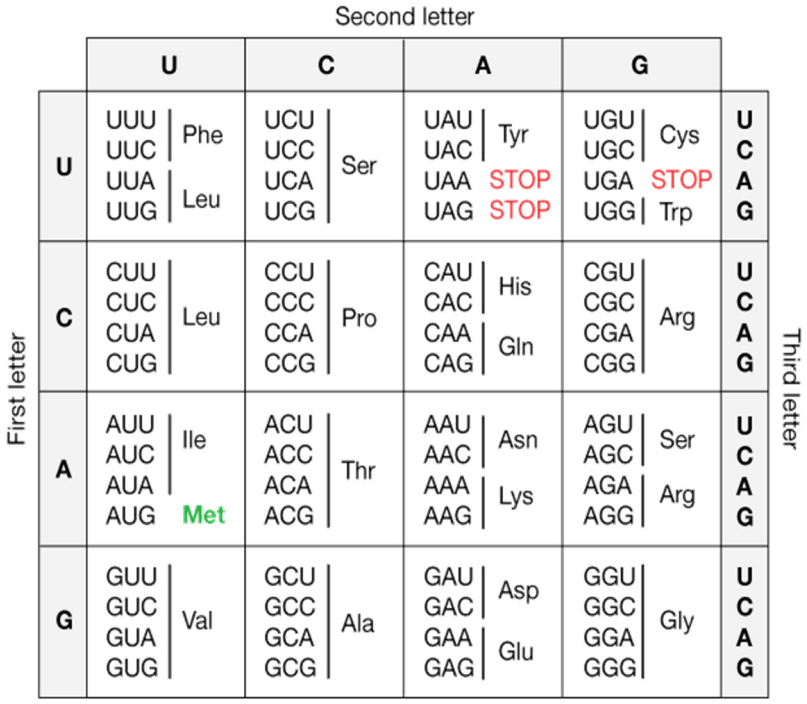


Figure 9

In the Genetic code table, there are 61 groups of 3 letters that code for the amino acids found in proteins. In three of the positions for the name of an amino acid, the code states 'stop'.

a. **i.** What does 'stop' indicate when using the Genetic code table? 1 mark

_____

ii. Why would it be more appropriate to leave these three boxes blank? 1 mark

_____

_____

_____

The following is part of the DNA in a gene sequence that codes for part of a protein:

CAACTCTCAGGAAGGCCTCA

b. **i.** In the gene sequence shown, what is the term given to groups of three letters? 1 mark

_____

ii. Use the Genetic Code to determine the sequence of the amino acids in the protein formed from this gene sequence. 1 mark

_____

_____

iii. Explain how the answer given in (bii) supports the fact that the Genetic Code is 'degenerate' or 'redundant'. 1 mark

_____

_____

_____

iv. If a point substitution mutation had occurred in the gene segment shown, that resulted in a silent or missense mutation, rewrite the gene sequence to show this silent mutation in position 6 of the sequence. 1 mark

_____

_____

_____

A protein found in all living cells is RNA polymerase. It consists of 874 amino acids and therefore has 2626 coding bases. In fact, there would be many more bases in the gene coding for RNA polymerase, but some have been removed during gene expression.

c. **i.** Name the segments of bases removed and explain why they were removed. 2 marks

_____

_____

ii. Name the process for which RNA polymerase is essential in all living cells and explain what occurs in the process, using appropriate terms for other molecules involved. 2 marks

_____

_____

_____

_____

_____

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QUESTION 3 (7 marks)
The following diagram shows the regulation and expression of genes that control the breakdown of the sugar, lactose, by the production of lactase enzymes in bacteria.

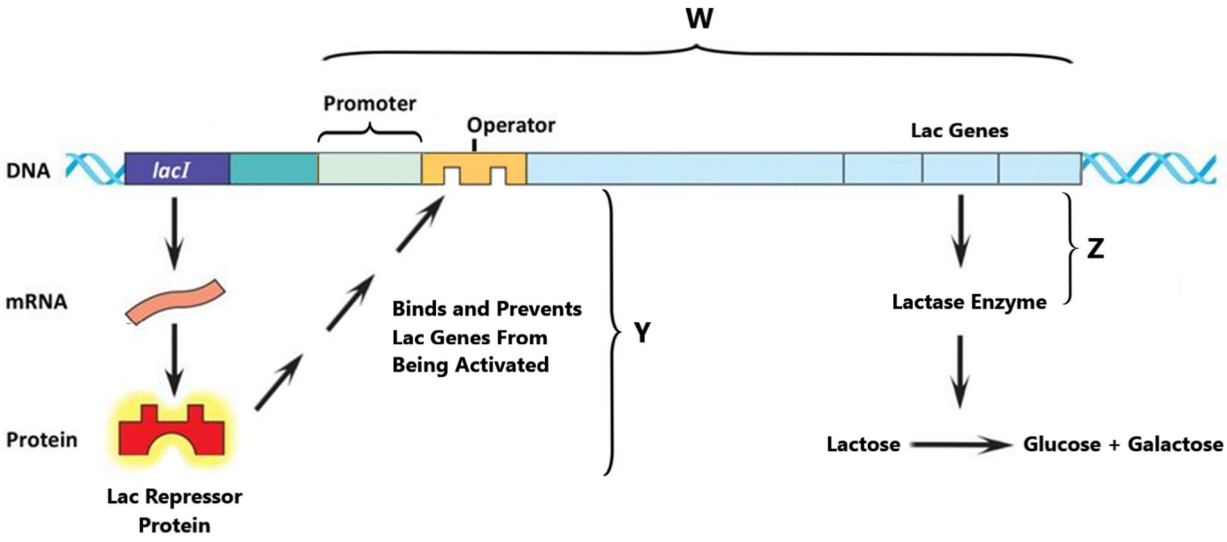

Figure 10

From this diagram:

a. **i.** Name structure W. 1 mark

_____

ii. From the diagram, compare the lac 1 gene with the lac genes. Give their names and explain their different roles in this gene regulation process. 2 marks

_____

_____

_____

_____

_____

_____

b. Name process Z. 1 mark

_____

c. **i.** Explain how step Y prevents lactase production. 1 mark

_____

_____

_____

ii. When would step Y occurring be an advantage to the cell, and in what ways would it be an advantage? 2 marks

QUESTION 4 (5 marks)
The following diagram shows a signalling molecule passing from the extracellular fluid into a cell.

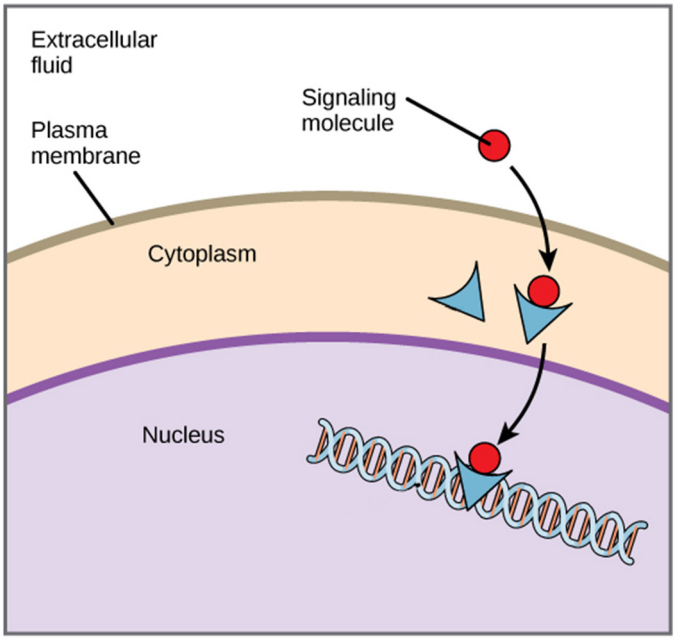

Figure 11

a. Suggest a name for the signalling molecule and explain your reasoning for suggesting this name. 2 marks

_____

_____

_____

_____

b. Does signal transduction occur in this cell? Explain. 1 mark

_____

_____

_____

c. Where does the response occur and what could be produced that would alter the cell's activity? 2 marks

_____

_____

_____

_____

QUESTION 5 (12 marks)
A person's immune system prevents infection from many microorganisms and other foreign materials that invade the person's body.

a. How does a person's body recognise the foreign invader? Explain using biological terminology. 1 mark

_____

_____

The age of a person is a factor that can affect their immune system's ability to deal with the invasion. Two of the possible reasons for this are given below.

b. For each reason, explain how it could impact on the ability of a person's immune system to cope with exposure to disease-causing agents.

i. An older person's skin becomes thinner and more delicate. 1 mark

_____

_____

_____

ii. The thymus gland gradually shrinks in size. 1 mark

_____

_____

_____

During the nine-month gestation period when a human foetus is developing, it is protected inside the fluid-filled sac and by components of the mother's immune system. After birth, various factors lead to changes in the newborn's immune system that help its body combat infection independently.

The following graph shows the concentration of Immunoglobulin G (IgG) antibodies for whooping cough in the blood of a foetus before its birth and then during the first 10 months of the newborn's life.

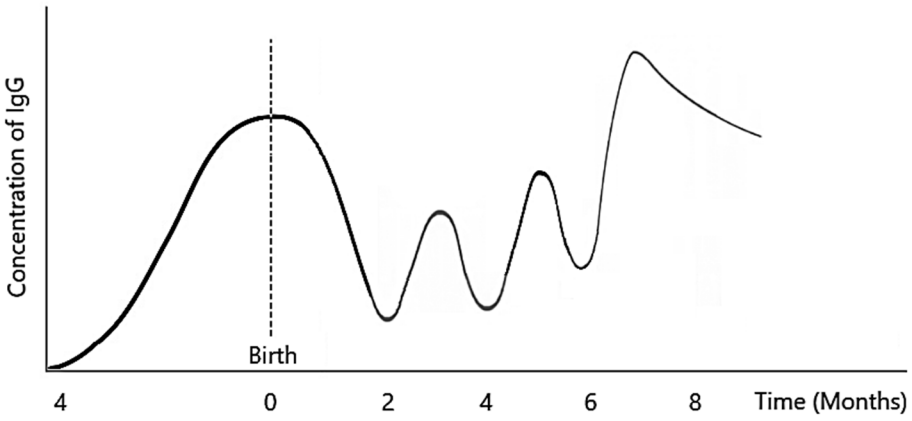

Figure 12

c. Suggest reasons for the presence of, and changes in the IgG whooping cough antibody concentration in:

i. The foetus, from 4 months prior to birth, until birth. 1 mark

ii. The newborn, from birth to 2 months. 1 mark

iii. The baby, from 2 to 10 months. 1 mark

In terms of the immune system, the following pairs of terms are used to describe different types of immunity

Innate/Adaptive Passive/Active Natural/Induced

d. Select the appropriate word from each pair for the following two time periods and explain why the terms are appropriate.

i. The foetus from 4 months prior to birth and up to birth. 2 marks

ii. The baby from 2 to 10 months. 2 marks

In recent years there have been outbreaks of whooping cough not seen since the 1950s. In encouraging people to ensure that their babies, children, and all adults are adequately protected against whooping cough, the National Health Department have information on-line and in pamphlets in doctors' rooms explaining the need for herd immunity.

e. What does herd immunity mean with respect to whooping cough and why is it so important? 2 marks

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QUESTION 6 (7 marks)
In the early to mid1800s, koalas were quite a common native animal in Australia as there was reduced hunting by Aboriginal tribes. In the mid-19th century, however, about 2.5 to 3 million koalas were killed by white hunters for their skins which decimated the populations. The species were also vulnerable due to loss of habitat due to European settlement and devastating epidemic diseases, such as chlamydia.

a. Why in the 1800s were Australian species more likely to be affected by endemic diseases than pandemic diseases? 1 mark

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b. **i.** Explain why the effect of decimation of the koala populations for their skins could be considered an example of genetic drift due to a bottleneck effect. 1 mark

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ii. What impact would such an effect have on the gene pool of the koala species and their future survival? 1 mark

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Though now protected, the population estimated at 329,000 koalas in 2018, was again drastically decreased in the 2019/2020 bushfires in NSW, South Australia and Victoria.

c. Would this devastation by the bushfires be considered an example of natural selection? Explain. 2 marks

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The northern populations ranging from Queensland to Victoria are more varied, whereas the populations in south-east Australia and the Port Phillip Bay were restored from koalas introduced from small numbers of island koalas. In 1981, as part of a translocation program, 75 koalas were introduced from French Island to Cape Otway, and their numbers increased steadily with a favourable diet of their preferred Manna Gums and an ideal climate.

d. **i.** What term could be applied to the factor that altered the allele frequencies in the koala population due to the process of translocation of koalas from French Island to Cape Otway? 1 mark

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ii. Why is there concern that this southern population is more likely to be decimated by an infectious disease like chlamydia than the northern populations? 1 mark

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QUESTION 7 (7 marks)
Some sections of DNA mutate at a faster rate than others. Genes that are essential for an organism's survival, for example, those coding for the enzyme cytochrome c used in aerobic cellular respiration, very rarely accumulate mutations, and are said to be highly conserved throughout evolution. The following graph shows the rate of divergence of different proteins, coded for by different genes, over millions of years since divergence.

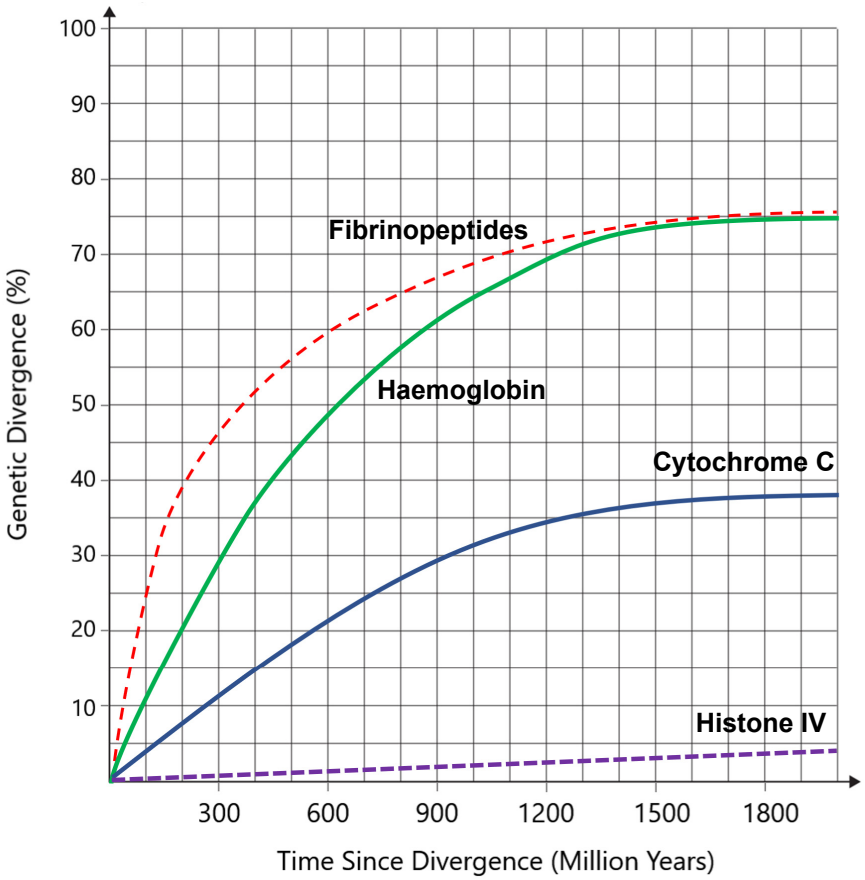

Figure 13

a. From the graph, Figure A, which protein is most highly conserved? Explain your choice. 2 marks

Cytochrome c is an important protein, as it acts as an enzyme in the final stage of aerobic cellular respiration that takes place on the inner membranes of the mitochondria.

b. **i.** Name this stage of aerobic cellular respiration. 1 mark

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ii. Why would it be so important for the genes for cytochrome c to be highly conserved, considering the essential functioning of cytochrome c as an enzyme? 1 mark

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Mitochondria found in eukaryotic cells have their own genome and in humans this consists of 37 genes that code for 2 ribosomal RNAs, 22 transfer RNAs, and 22 proteins.

c. **i.** What is meant by the genome of an organism? 1 mark

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ii. Explain the functional difference between ribosomal RNA and transfer RNA. 2 marks

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QUESTION 8 (11 marks)
The following diagram shows a restriction enzyme from a bacterial species which is 'cutting' another molecule.

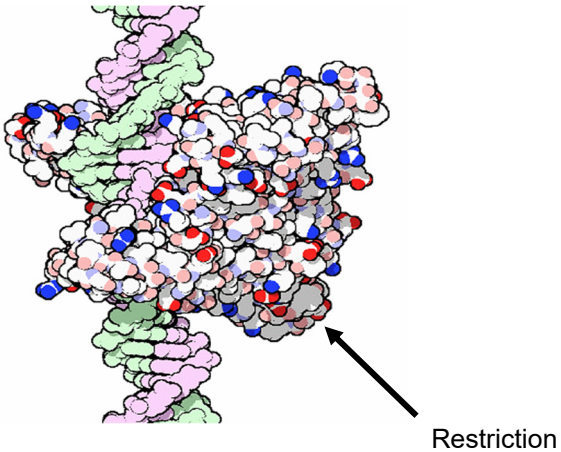

Figure 14

a. **i.** What is the name of the molecule being cut by the restriction enzyme? 1 mark

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ii. Name the specific area to which it is attached and 'cutting'. 1 mark

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iii. Draw and label the two types of ends that could result if the molecule was cut. 2 marks

b. If scientists are carrying out the process of genetic engineering, the next step after cutting is to insert a gene they want to clone.

i. What does it mean to clone a gene? 1 mark

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ii. Draw and label a series of diagrams to show the structure into which the gene of interest is inserted for cloning; include the name of the enzyme required to complete this process and give the name of the combined structure formed. 3 marks

This process of genetic engineering has been used to produce transgenic plants and animals and pharmaceutical products, such as, production of human growth hormone and insulin; development of frost and herbicide resistant crops; and GM animals. This technique could be compared to selective breeding.

c. **i.** Are all genetically modified organisms transgenic organisms? Explain. 1 mark

ii. What is one similarity between genetic engineering and selective breeding? 1 mark

iii. Explain why some people are against as selective breeding and genetic engineering in terms of their effect on the gene pool. 1 mark

QUESTION 9 (4 marks)
Giant prehistoric 'terror birds' looked so fierce that many palaeontologists assumed they were terrifying predators, but new research suggests they were probably herbivores. The terror bird, *Gastornis*, grew to nearly one-and-a-half metres tall. It lived between 55 and 40 mya in Europe and possessed a huge, sharp beak. It lived after the dinosaurs became extinct and at a time when mammals were at an early stage of evolution and relatively small. New evidence supports the theory that they were herbivores. Footprints do not show imprints of sharp claws, which would have been needed to catch prey. Secondly, the bird's hefty size and build would not be suitable for a very swift hunter.

Further studies, using a radioisotope geochemical study, analysed the fossilised bones of the birds, using calcium isotope composition. From prior experiments, the scientists determined that the calcium isotopic composition becomes 'lighter' as it passes through the food chain. They applied the method to 'terror bird' bones. They discovered that the calcium isotope compositions of 'terror bird' bones are similar to herbivorous mammals and dinosaurs, and not to carnivorous ones.

Viegas, J. (2013) '"Terror bird" was scary-looking vegetarian',* Discovery News *online, 29 August.

a. Why is a footprint referred to as a fossil? 1 mark

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b. Describe how the fossil of *Gastornis* would have formed. 2 marks

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c. In determining the age of *Gastornis* fossil bones, explain why radioisotope calcium dating was used, instead of radiocarbon dating. 1 mark

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QUESTION 10 (6 marks)

Only a few years ago, scientists believed modern humans evolved in Africa, and then left to colonise a world free of similar species. Recent evidence indicates that this is not correct. By the time *Homo sapiens* left Africa, several of the less-evolved hominins had already travelled to other parts of the world. A study by Australian scientists, published in *Nature* in 2019, answered the question as to whether the separate species – including *Homo erectus, Homo luzonensis* and *Homo floresiensis* – were alive at the same time, or if they were alive when modern humans left Africa. Using a new technique that can reveal when rock was last exposed to sunlight, the team was able to confirm *Homo erectus,* an early human ancestor, was living in Java, Indonesia, about 100,000 years ago. That means they were living there well before modern humans left Africa.

The following photograph is one of one the skulls found in Java.

Figure 15

a. Why were all the species found at the Java site called hominins, not hominoids? 2 marks

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b. Examine the skull in the photograph. Describe two features that indicate it was it was from *Homo erectus*, not from *Homo sapiens*. 2 marks

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The study took place at Ngandong in Java. In the 1930s, a team of Dutch explorers had unearthed 12 fossilised skull caps. Using luminescence and a range of other detailed techniques, the Australian team came up with an accurate date for the skulls: about 117,000 years ago. That is an interesting date in history

- *Homo floresiensis* – nicknamed "hobbits" because they stood less than a metre tall – were living at roughly the same time on the nearby island of Flores.
- Another species, *Homo luzonensis,* was living in the Philippines.
- A third species – known as the Denisovans – was migrating south from Siberia to Australia.

Examine the following phylogenetic tree determined by using nuclear genome analysis.

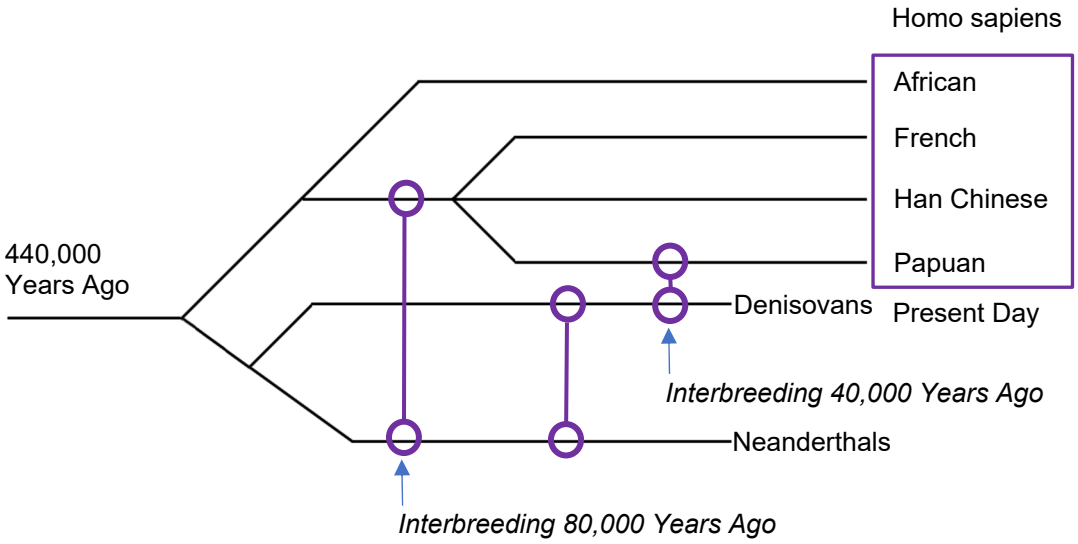

Figure 16

c. **i.** What does the phylogenetic tree suggest about events that occurred between Denisovans, Neanderthals and *Homo sapiens* several times in the last 100,000 years? 1 mark

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ii. Considering these events, what does this suggest about these three groups as separate species? Explain. 1 mark

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END OF QUESTION AND ANSWER BOOKLET