Neap:

Trial Examination 2017

VCE Biology Units 3&4

Written Examination

Question and Answer Booklet

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

Student's Name: _____

Teacher's Name: _____

Structure of Booklet

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	40	40	40
B	11	11	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 correction fluid/tape.

No calculator is allowed in this examination.

Materials supplied

Question and answer booklet of 31 pages

Answer sheet for multiple-choice questions

Instructions

Write your **name** and your **teacher's 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 booklet are **not** drawn to scale.

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 booklet.

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

Students are advised that this is a trial examination only and cannot in any way guarantee the content or the format of the 2017 VCE Biology Units 3&4 Written Examination.

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 booklet are **not** drawn to scale.

Question 1

The structural components of a typical phospholipid are

A. three fatty acids, one glycerol and one phosphate.

B. two fatty acids, two glycerols and two phosphates.

C. two fatty acids, one glycerol and three phosphates.

D. two fatty acids, one glycerol and one phosphate.

Question 2

Which one of the following lists only endergonic processes?

A. endocytosis, facilitated diffusion, osmosis

B. endocytosis, active transport, facilitated diffusion

C. exocytosis, active transport, endocytosis

D. exocytosis, osmosis, facilitated diffusion

Question 3

The type of chemical reaction that joins amino acids into polypeptide chains is

A. a hydrolysis reaction.

B. an exergonic reaction.

C. independent of any enzyme involvement.

D. a condensation reaction.

Question 4

The types of nucleic acids that would be located around or inside a ribosome during the manufacture of proteins would be

A. mRNA, tRNA and rRNA only.

B. DNA and mRNA only.

C. tRNA and mRNA only.

D. DNA, mRNA, tRNA and rRNA.

Use the following information to answer Questions 5 and 6.

There are twenty amino acids in total and the following table provides the **anticodons** for four of these. This information can be used to determine nucleic acid sequences.

Amino acid	Anticodon sequences
proline	GUA, GUU, GUC, GUG
isoleucine	UAA, UAG, UAU
aspartic acid	CUA, CUG
tyrosine	AUA, AUG

Question 5

The fact that there is more than one anticodon sequence for most amino acids shows

A. the degeneracy in the code.

B. that there are more amino acids than there are anticodons.

C. that translation is more complicated than transcription.

D. that different amino acids can be coded for by a single anticodon.

Question 6

Consider the polypeptide chain below.

isoleucine–proline–aspartic acid–tyrosine

The DNA template sequence for this polypeptide chain could be

A. UAAGUUCUAAUG

B. TAGGTGCTGATA

C. AUCCACGACUAU

D. ATTCAAGATTAC

Question 7

For the *lac* operon to be activated, a requirement would be the

A. RNA polymerase being activated by the presence of a repressor.

B. presence of lactose that removes a repressor from the operator.

C. presence of lactase that removes a repressor from the promoter.

D. activation of a repressor due to the action of RNA polymerase.

Question 8

Which of the following statements would be true of the coenzyme involved in metabolism?

A. NAD is loaded into NADH as a result of the light-independent reaction of photosynthesis.

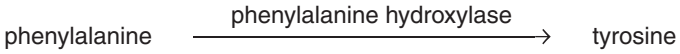
B. NADPH is formed during glycolysis.

C. ATP is unloaded into ADP after the electron transport chain.

D. ADP is loaded into ATP during the Krebs cycle.

Question 9

Consider the metabolic reaction below occurring within the human body.



It is reasonable to say that

A. tyrosine is a substrate.

B. phenylalanine hydroxylase is a protein.

C. a fever would not influence the rate of reaction.

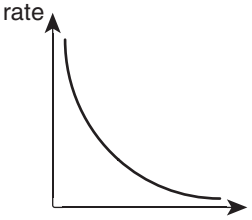
D. phenylalanine and phenylalanine hydroxylase are the same shape.

Question 10

One of the steps of the Krebs cycle is the conversion of fumarate into malate, which is catalysed by fumerase.

Which of the following graphs most accurately illustrates the effect of increasing the concentration of fumarate on the rate of fumerase function?

A.



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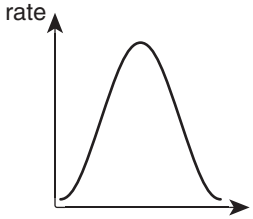

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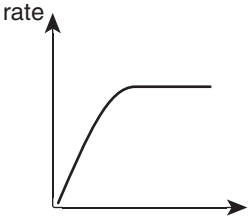
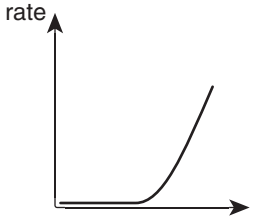
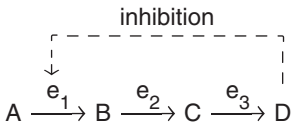


D.



Question 11

A biochemical pathway is illustrated below.



Which of the following would be an appropriate statement relating to this biochemical pathway?

A. The type of inhibition would be irreversible and competitive if the reaction continued to accumulate D.

B. The type of inhibition would be irreversible and non-competitive if the reaction continued to accumulate D.

C. If the shape of the active site of e_1 was complementary to D, then D would stop accumulating when its concentration started to increase.

D. The reaction could proceed if only e_2 and e_3 were present.

Question 12

Signalling molecules can be categorised in a variety of ways.

One such way is to say that

A. animal hormones are a type of cytokine.

B. plant hormones can also be called neurotransmitters.

C. all animal hormones are hydrophobic.

D. cytokines are signalling molecules released by immune cells.

Question 13

Pheromones are

A. transferred through the bloodstream to act on target cells a long way from where they were secreted.

B. transferred through the vascular tissue of plants.

C. transferred through the air to act on other members of the same species.

D. chemicals that are secreted by cells to act on adjacent cells within the same organism.

Question 14

During prenatal development in humans, the cells that connect fingers and toes together undergo apoptosis early so the digits are separated from each other.

The steps that may lead to successful apoptosis in this situation might be

A. intrinsic signalling molecules binding to surface receptors, triggering caspase to destroy the proteins holding the cytoskeleton together.

B. extrinsic signalling molecules binding to surface receptors, triggering caspase to destroy the proteins holding the cytoskeleton together.

C. extrinsic signalling molecules stimulating proteins to be released from the mitochondrial membrane receptors, triggering caspase to destroy the proteins holding the cytoskeleton together.

D. intrinsic signalling molecules binding to receptors in the cytosol, leading to a decreased activation of caspase, and eventually the destruction of the cell.

Question 15

In adult humans, the total number of body cells remains relatively stable. Millions of cells are produced every second and millions are lost/destroyed every second. Cancer is the overproduction of cells and Alzheimer's disease is caused by the loss of brain cells.

Which of the following is a correct statement regarding these diseases?

A. Alzheimer's disease occurs when the rate of cell replacement is greater than the rate of apoptosis.

B. Cancer occurs when the rate of cell replacement is greater than the rate of apoptosis.

C. Cancer occurs when the rate of apoptosis is greater than the rate of cell replacement.

D. Both Alzheimer's disease and cancer occurs when the rate of apoptosis is out of control.

Question 16

An antigen

A. is able to initiate an immune response.

B. always promotes the same type of antibody response.

C. can only be found on the surface of pathogens.

D. will always be a protein.

Question 17

Cells of the innate immune response include

A. plasma B cells.

B. cytotoxic T cells.

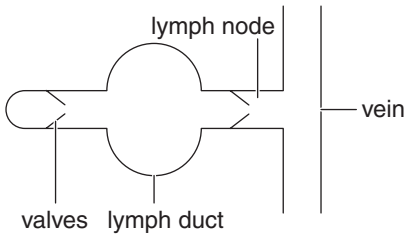
C. macrophages.

D. helper T cells.

Question 18

Which of the following would be an appropriate representation of the lymphatic system?

A.



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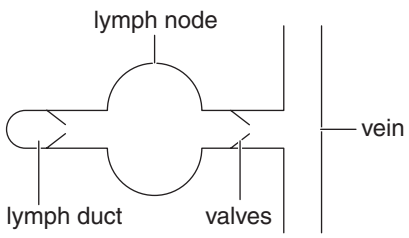
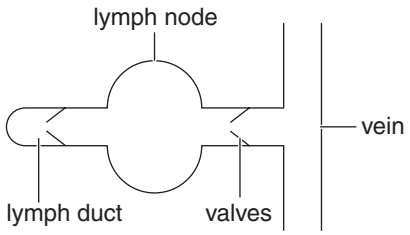
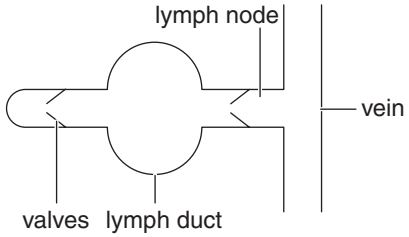


C.



D.



Question 19

The correct sequence of events that is involved in active immunity could be

A. naive B cells differentiating into cytotoxic T cells.

B. naive T cells cloning into plasma B cells.

C. B memory cells differentiating into naive B cells.

D. naive T cells differentiating into helper T cells.

Question 20

Babies who are breastfed are statistically less likely to develop infections in the first six months after being born compared to babies who are bottle-fed infant formula.

This can be best explained due to

A. artificial active immunity.

B. artificial passive immunity.

C. natural active immunity.

D. natural passive immunity.

Question 21

A mutation in the DNA of an organism that leads to most of the amino acids of a specific protein being different is likely to be a

A. frameshift mutation.

B. block mutation.

C. point mutation.

D. form of aneuploidy.

Question 22

When alleles move between two distinct populations of the same species, it is referred to as

A. the founder effect.

B. the bottleneck effect.

C. genetic drift.

D. gene flow.

Question 23

The gene pool of a population would most rapidly change as a result of

A. selective breeding.

B. natural selection.

C. mutations.

D. environmental changes.

Question 24

The West Australian ringneck parrot (*Platycercus zonarius*) is a possible example of natural selection in action, as a result of climate change. Over the last fifty years, it has been noted that in the south-eastern region of Western Australia, where climate change has had more of an effect, the wingspan of the birds has grown statistically bigger than birds elsewhere in the state who inhabit regions that have not undergone the same level of climate change. It is thought that larger wings are a survival advantage in warmer conditions.

It would be appropriate to conclude that

A. in the changing climatic conditions of the south-eastern region of Western Australia, the ringneck parrots underwent mutations in the genes controlling wing size to provide a selective advantage in the new environment.

B. ringneck parrots with large wings from other areas of Western Australia migrated to the warmer areas, forcing out the smaller-winged ringneck parrots.

C. in the region where there has been a change in wing phenotype, there was originally variation in wingspan within the ringneck parrots, and the new environment has provided a selective advantage to those parrots with larger wingspans.

D. fifty years is not enough time for a change in wingspan to occur as parrots have a long lifespan.

Question 25

We know that speciation has occurred when

A. organisms of one population are separated geographically from each other.

B. organisms of one population that have previously been separated geographically migrate back into each other's habitats.

C. a previously geographically separated population of organisms are reunited and can successfully reproduce.

D. organisms of one population that were geographically isolated from each other are unable to successfully breed when they come in contact with each other.

Question 26

The following events have occurred during the history of life on Earth; however, they are not in the correct order.

1. the emergence of prokaryotic cells
2. the emergence of vertebrates in the oceans
3. the formation of multicellular organisms
4. the movement of animals onto land
5. flowering plants appear

The correct order of the above events from the oldest to the most recent is

A. 1, 2, 3, 4, 5

B. 1, 3, 2, 4, 5

C. 5, 4, 3, 2, 1

D. 4, 1, 2, 5, 3

Question 27

The following amino acid sequences are from the same section of a protein found in four closely related kangaroos (red kangaroo, antilopine kangaroo, eastern grey kangaroo and western grey kangaroo). The letters A to T represent different amino acids.

red kangaroo	…B D G H K L T O M…
antilopine kangaroo	…B T G H N L T A M…
eastern grey kangaroo	…B D G H N L T O M…
western grey kangaroo	…B T G H N L T A S…

Based on the information provided, it would be reasonable to conclude that the

A. red kangaroo is more closely related to the eastern grey kangaroo than the antilopine or the western grey kangaroo.

B. antilopine kangaroo is more closely related to the eastern grey kangaroo than the western grey or the red kangaroo.

C. western grey kangaroo and the eastern grey kangaroo underwent divergent evolution longer ago than the antilopine and the red kangaroo.

D. eastern grey kangaroo has the closest amino acid sequence to the common ancestor of all four species of kangaroo listed.

Question 28

The Northern flying squirrel of North America is a placental mammal and the flying phalanger of Australia is a marsupial. They have both evolved a similar phenotype (skin between the front and hind appendages for gliding) in completely different continents.

This kind of phenotype could be due to

A. different environments leading to the selection of different features.

B. similar environments placing selection pressures on different features.

C. unrelated organisms undergoing convergent evolution.

D. closely related organisms undergoing convergent evolution.

Question 29

A lump of volcanic rock was dated to be about 2.2 billion years old using uranium–lead dating. The half-life of uranium-235 is 0.7 billion years.

If a sample of 'fresh' volcanic rock contains 1.00 g of uranium-235, the sample of rock being dated would have closest to how many grams of uranium-235?

A. 1

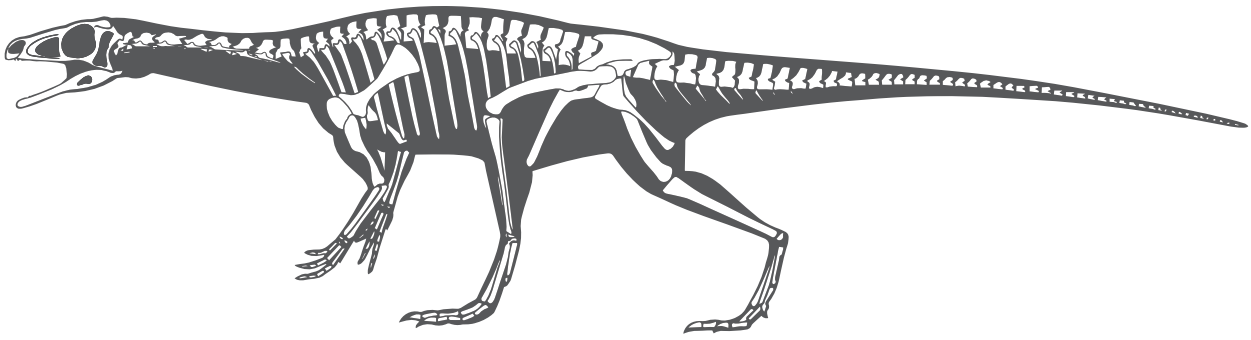
B. 0.5

C. 0.25

D. 0.125

Question 30

The diagram below illustrates the reconstructed skeleton of *Marasuchus lilloensis*, an extinct bird-like dinosaur that lived about 230 million years ago. The fossilised bone fragments were discovered in sedimentary rock and carefully put together for display.



What would be the appropriate conditions required for the formation of fossils such as this?

A. The organism falls into sedimentary rock and is completely enclosed to allow the preservation.

B. The organism falls into a fast-moving river where it is swept away from predators so preservation can occur.

C. The organism dies on the surface of the land where wind blows sand over them to make them invisible to scavengers.

D. The organism falls into a deep lake, where sediments cover them; the cold conditions of the lake are free of decomposers, and coupled with the high pressure, this allows the fossilisation process to proceed.

Question 31

The BMP4 gene codes for bone morphogenetic protein 4, which is an important developmental gene found across the animal kingdom. It controls a range of phenotypes ranging from bone development, lung development, jaw formation in cichlid fish and the formation of beaks in Darwin's Galapagos finches.

With respect to the formation of beaks in the finches, it would be reasonable to conclude that the BMP4 gene would

A. be active for a longer time in finches that have thicker and longer beaks.

B. be expressed for a longer time in finches that have wider and shorter beaks.

C. be expressed for a longer time as the beaks get wider, but for a shorter time as the beaks get longer.

D. not be active for as long during the development of longer, wider beaks, but would be active for a longer time during the development of narrow, shorter beaks.

Question 32

The following organisms are animals that are all closely related to each other.

gorillas, chimpanzees, humans, baboons, orangutans

It is reasonable to say that

A. the only hominoids from the list are the orangutan, chimpanzee and gorilla.

B. the only primate from the list is the baboon.

C. the hominins from the list include chimpanzees and humans.

D. all organisms from the list have opposable fifth digits.

Question 33

With an enlargement of cranial capacity in the hominins belonging to the genus *Homo* also came the appearance of Broca's area. This is the part of the brain associated with speech, which provided the variation that enabled more effective communication. This enabled a rapid change in culture in the hominin line that led to modern humans.

Some of these changes included

A. *Homo habilis* communicating with each other to develop stone tools for cutting.

B. *Homo neanderthalensis* being the first to recognise that fire is an effective way of making meat easier to chew.

C. *Homo erectus* having ritualistic burial of their dead.

D. the different groups of *Homo denisovans* using complex language to communicate with each other.

Question 34

Polymerase chain reaction (PCR) runs through a series of cycles involving denaturation, annealing and extension.

The conditions required for these are

A. denaturation (94°C), annealing (72°C) and extension (54°C).

B. denaturation (94°C), annealing (54°C) and extension (72°C).

C. denaturation (72°C), annealing (94°C) and extension (54°C).

D. denaturation (72°C), annealing (54°C) and extension (94°C).

Question 35

Biotechnologists use a variety of enzymes for their work. These include ligase, polymerase and endonuclease.

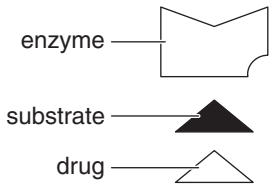
Their functions are

	Ligase	Polymerase	Endonuclease
A.	pasting	replicating	cutting
B.	replicating	pasting	cutting
C.	cutting	replicating	pasting
D.	pasting	cutting	replicating

Question 36

A rationally designed drug that would act as a non-competitive inhibitor could be represented as

A.



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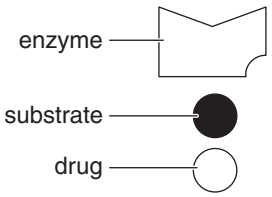

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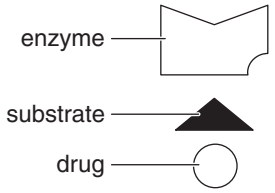

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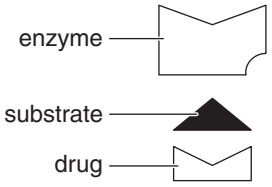


Question 37

The Australian Government has released The first National Antimicrobial Resistance Strategy 2015–2019 to guide the response to the threat of antibiotic misuse and resistance. One of the actions given is that some of the responsibility of the appropriate medication for infection should be taken by the consumer.

Antibiotics should be prescribed

A. when a patient displays flu-like symptoms.

B. in high doses to quickly kill the infection.

C. when the specific type of bacterial infection is known.

D. as a preventative measure rather than a treatment.

Use the following information to answer Questions 38–40.

An experiment was conducted investigating the effect that changing temperature has on the action of catalase. The following data was collected.

	Volume of gas produced in twenty minutes (cm^3)			
Temperature (°C)	**Trial 1**	**Trial 2**	**Trial 3**	**Trial 4**
10	4	6	3	8
20	10	12	11	14
30	25	34	32	40
40	75	90	87	65

Question 38

For the data to be converted into volume of gas per minute, the most appropriate method would be to

A. calculate the average of trials 1 to 4.

B. divide each of the trial results by 20 minutes.

C. average trials 1 to 4 for each temperature.

D. average trials 1 to 4 for each temperature and then divide the average by 20 minutes.

Question 39

When presenting the data in graphical format, it would be most appropriately expressed as a

A. scaled line graph.

B. bar graph.

C. pie chart.

D. logarithmic graph.

Question 40

The action that would make the analysis of the data more accurate would be to

A. repeat trial 2 due to outliers.

B. test temperatures of 15°C, 25°C and 35°C, with four trials for each.

C. complete another trial for each of the temperatures tested.

D. repeat the entire experiment but collect gas for 30 minutes rather than 20 minutes.

END OF SECTION A

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 booklet are **not** drawn to scale.

Question 1 (7 marks)

Aquaporins are protein channels involved with the movement of water across the plasma membranes of some cells. Aquaporin mRNA can be injected into cells that have no aquaporin to see the effect of it on water movement in and out of cells.

a. Why would an injection of mRNA lead to the production of aquaporin? 1 mark

_____

_____

b. The functional aquaporin protein is comprised of four polypeptide chains that form a tube across the membrane.

At what level of hierarchy is the functional aquaporin protein operating? 1 mark

_____

c. Why may it be advantageous for some cells within a multicellular organism to have high levels of aquaporin protein channels embedded in the cell membrane, whereas other cells in the same organism may not have such high levels of aquaporin? 2 marks

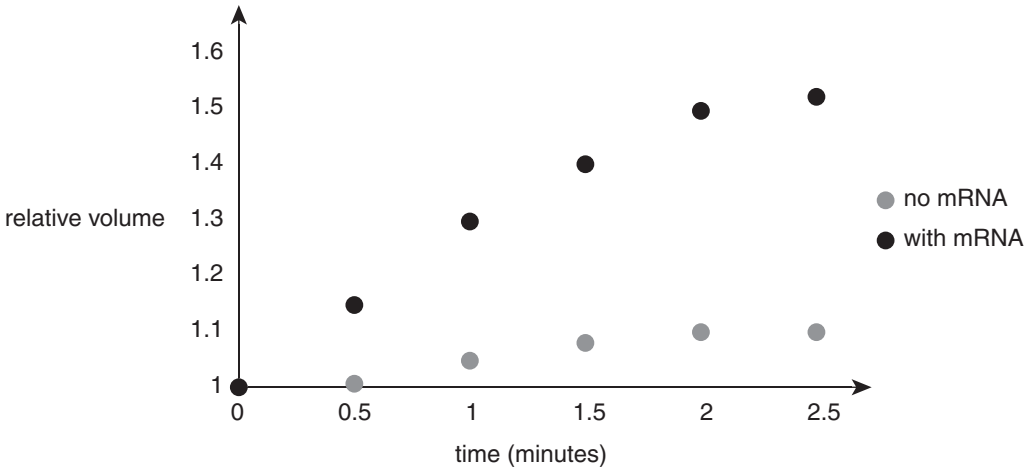
_____

_____

_____

_____

d. An experiment was conducted that compared cells injected with aquaporin mRNA and cells that were not injected with aquaporin mRNA. Both were immersed into a hypotonic solution to see the effect on the cells' volume relative to their initial volume. The results of the experiment are illustrated in the graph below.



i. Why did both cells increase in volume? 1 mark

_____

_____

ii. What happened at 2.5 minutes in the cells treated with aquaporin mRNA? 2 marks

_____

_____

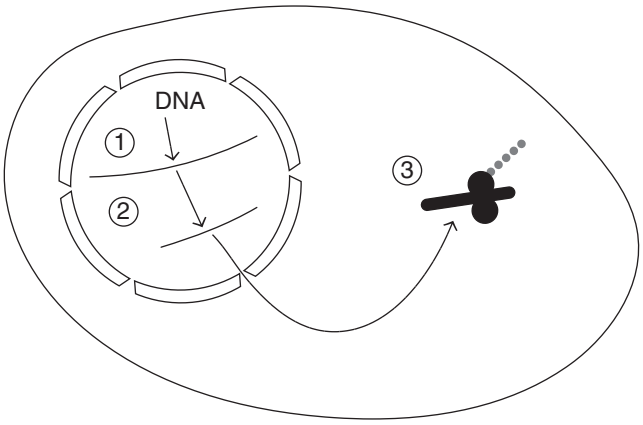
_____

Question 2 (6 marks)
DNA provides a blueprint for the production of protein.

a. Draw a diagram of **four** different nucleotides that shows the following: 3 marks

- nucleotide structure
- complementary base pairing
- antiparallel polynucleotide strands

The diagram below illustrates the link between DNA and protein manufacture. The numbers 1 to 3 represent different stages of the process.



b. Name stages 1 to 3. 3 marks

stage 1

_____

stage 2

_____

stage 3

_____

Question 3 (5 marks)

The endosymbiotic theory describes how a large host cell ingested bacteria and over millions of years both the large host cell and the bacteria became dependent upon each other.

a. Which organelles from a eukaryotic cell provide evidence of the endosymbiotic theory? 1 mark

_____

b. Draw a labelled diagram of **one** of these organelles. 2 marks

c. State **two** pieces of evidence that support the endosymbiotic theory. 2 marks

_____

_____

_____

Question 4 (6 marks)
Isolated chloroplasts can be used to investigate the biochemistry of photosynthesis.

a. Write down the balanced chemical equation for photosynthesis. 2 marks

_____

b. One of the factors that can affect the rate of photosynthesis is the availability of light energy. An experiment was carried out with isolated chloroplasts that investigated the effect different colours had on the rate of photosynthesis. The results of the experiment are shown in the table below.

Colour of light that chloroplasts were exposed to	Rate of photosynthesis (arbitrary units)
green	20
blue	80
red	75
blue and red	90
blue and green	78
green and red	75
red, green and blue	92

i. What was the independent variable in the experiment conducted? 1 mark

_____

ii. Which colour(s) has/have the most influence on the rate of photosynthesis? 1 mark

_____

iii. Explain specifically how light energy influences the rate of photosynthesis. 2 marks

_____

_____

_____

_____

_____

_____

Question 5 (6 marks)

Stomata on the leaves of terrestrial plants regulate the exchange of oxygen and carbon dioxide. When open, there is a loss of water from the plant as well. One of the factors that controls stomatal closure in terrestrial plants is abscisic acid (ABA). When roots detect that water availability is in short supply, they secrete ABA. The ABA is transported through the vascular tissue of the plants to the guard cells in the leaf (which control gas exchange). The ABA binds to surface receptors on the guard cell membrane, which leads to an appropriate response.

a. Based on the information above, what can be concluded about the chemical nature of ABA? 1 mark

b. Intracellular changes, including a loss of potassium ions from the cells via gated protein channels and thus a change in turgidity of the guard cells, is the response in the guard cells to ABA.

i. Describe the intracellular changes that are involved between reception and response in this type of transduction pathway. 1 mark

ii. What would the loss of potassium ions from the guard cells do to the turgidity of the guard cells? 2 marks

c. Describe the survival advantage to plants in dry habitats having a greater concentration of ABA surface receptors on the guard cells. 2 marks

Question 6 (9 marks)

In 2009 there was an influenza pandemic (swine flu) that quickly raised global concern due to the nature of the H1N1 influenza virus causing it. It was structurally similar to the Spanish flu virus that killed up to 100 million people worldwide in 1918. Panic-buying of the small vaccine stocks available, as well as a new anti-flu drug called Relenza, occurred. This left the majority of the world's population vulnerable to the swine flu pandemic.

a. What is the difference between an epidemic and a pandemic? 1 mark

b. Describe the general structure of a virus. 2 marks

c. The table below illustrates the mortality rates of the 1918 flu, the 2009 flu and one other outbreak.

Year	Type of influenza	Number of cases	% mortality
1918	Spanish	200 000 000	2–3
2009	swine	100 000 000	0.5
2013–2015	bird	1000	50

Use the data from the table to discuss **one** reason why the panic relating to the swine flu was unfounded. 2 marks

d. Anti-flu drugs and vaccines work very differently. Relenza is a drug that is a competitive inhibitor of an enzyme called neuromimidase (the N part of the virus), which prevents virus particles exiting cells. Vaccines provide long-lasting immunity.

For the following cases, circle the medication that should be advised, and give the reason for this.

i. a 60-year-old male who is fit and healthy but living within a swine flu epidemic 2 marks

Medication advised: Relenza **or** swine flu vaccine (circle one only)

Reason:

_____

_____

ii. a 25-year-old female who is displaying symptoms of the swine flu 2 marks

Medication advised: Relenza **or** swine flu vaccine (circle one only)

Reason:

_____

_____

Question 7 (8 marks)

There is a greatly increased number of individuals in society who develop an allergy against certain chemicals in the environment. Hospital admissions in Melbourne from 1990 to 2015 relating to allergy have quadrupled, which is a cause for concern.

In a person developing an allergy, the allergen is equivalent to an antigen.

a. Describe the body's immune response in a person who has been exposed to an allergen for the first time. 2 marks

b. Second and third exposures can become quite dangerous (sometimes resulting in anaphylaxis) and this is when individuals may need to be hospitalised.

Discuss why the body's response is more aggressive upon the second and third exposure to the same allergen. 2 marks

During 2016, there was a weather event in Melbourne that led to a number of deaths due to asthma as well as a disproportionate number of hospitalisations. In the spring, which is pollen season, there are many flowers in bloom; wind, lightening and humidity led to allergy-producing pollen grains becoming airborne. The pollen grains were broken apart from the electrical activity of the storms and distributed into the environment.

c. Why could these extreme weather conditions lead to a greater number of asthma cases than normal for that time of the year? 1 mark

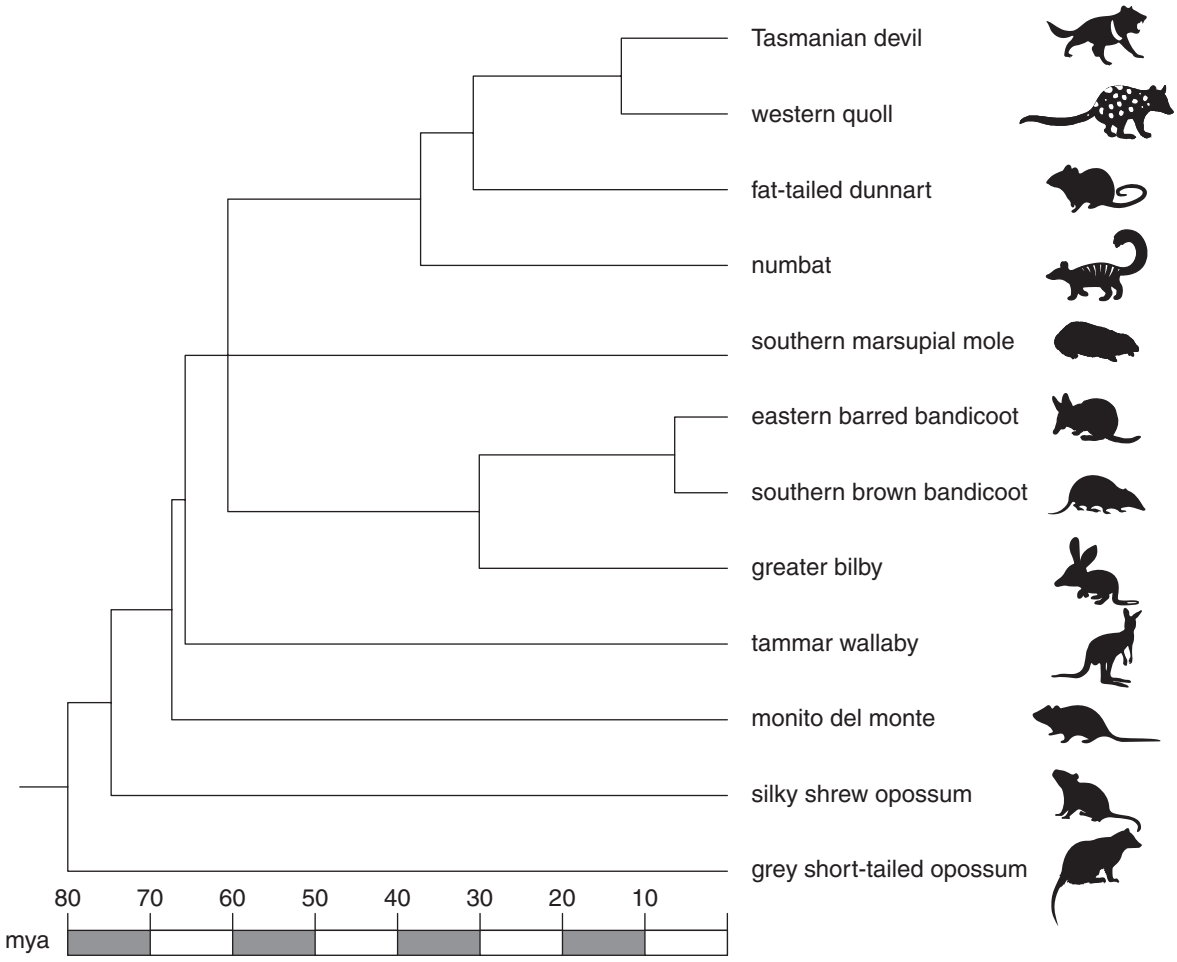
d. A cure, rather than a treatment, for asthma is preferable for the allergy sufferers, and biotechnology companies around the world are getting closer to an answer. One company in the United Kingdom has isolated the ADAM33 gene and shown that the asthma allergen activates the gene, which leads to asthma symptoms. Research into a drug that can control the ADAM33 gene is currently being conducted.

i. Discuss how a drug could be used to prevent the activation of the ADAM33 gene. 1 mark

ii. If the drug was commercially available for humans, what are **two** questions the asthma sufferer should ask their doctor prior to taking the medication? 2 marks

Question 8 (7 marks)

A phylogenetic tree showing the pattern of evolution for many Australian marsupials is shown below.



note: mya = million years ago

The grey short-tailed opossum, silky shrew opossum and monito del monte are indigenous to South America, while the remaining marsupials are all indigenous to Australia.

a. Based on this information, what is the likely time that South America and Australia separated from each other? 1 mark

b. Which marsupials are the most closely related to each other, the Tasmanian devil and numbat, or the southern marsupial mole and the greater bilby? Use evidence from the phylogenetic tree to justify your answer. 2 marks

c. What evidence would be required to estimate the time that marsupials such as the eastern barred bandicoot and the southern brown bandicoot branched into two different lines? 2 marks

d. What form of evolution is depicted in the Australian marsupials illustrated in the phylogenetic tree? Describe how this form of evolution leads to their biodiversity. 2 marks

Question 9 (8 marks)

In 2008 a 40 000-year-old bone was discovered in a cave in Siberia, called the Denisova Cave. In 2015, it was announced that DNA had been extracted from the bone, and so comparisons between the DNA from the Denisovan finger bone and the DNA from Neanderthals and modern humans could be made. Based on the results of these comparisons, it has been hypothesised that a new species of hominin had been found.

a. Why would a single finger bone be unlikely to change the evolutionary theory that only two hominin species coexisted 40 000 years ago? 1 mark

b. The mitochondrial DNA from the Denisovan finger bone, several Neanderthals and many modern humans were compared with each other through DNA hybridisation studies.

i. Why is mitochondrial DNA a better molecule to compare the different groups rather than nuclear DNA? 2 marks

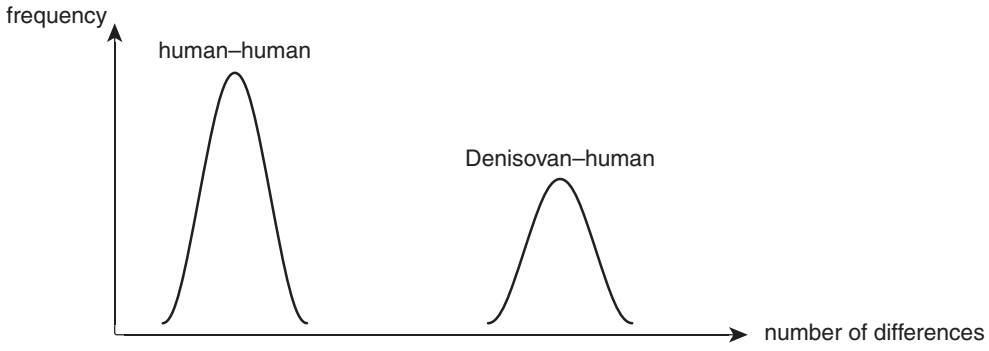
ii. Imagine a family composed of a mother, a father, and three biological children: two daughters and a son.

Which of the family members would you expect to have the same mitochondrial DNA sequence? Explain your reasoning. 2 marks

iii. Describe the process of DNA hybridisation. 2 marks

c. DNA hybridisation provided evidence that there were three distinct groups, with Neanderthals and humans being more closely related to each other than humans and Denisovans.

Add data onto the graph below to show the expected mtDNA hybridisation results that would support the three-species theory. The human–human and the Denisovan–human hybridisation results are already illustrated. 1 mark



Question 10 (8 marks)

Sickle cell anaemia is a common genetically inherited autosomal disease that affects about 5% of the world's population. Genetic testing for the presence of the disease is an important diagnostic procedure in many countries where the disease is more predominant (America and Africa). PCR, restriction enzymes and then gel electrophoresis are used to diagnose the genetic status of individuals.

a. What is the purpose of PCR? 1 mark

_____

_____

b. There are two alleles for the sickle cell gene: one codes for normal haemoglobin and the other for sickle cell haemoglobin (where the haemoglobin is unable to absorb oxygen very well). The difference between the two alleles is a single point mutation changing one amino acid in the haemoglobin gene.

Describe how a single point mutation could change a single amino acid in a protein. 1 mark

_____

_____

c. After an individual's DNA undergoes PCR it is mixed with a restriction enzyme, DdeI. There is one restriction enzyme binding site that is the same in both alleles The only difference is one extra restriction enzyme binding site along the normal allele. Each allele, once cut with DdeI, produces fragments of unequal size.

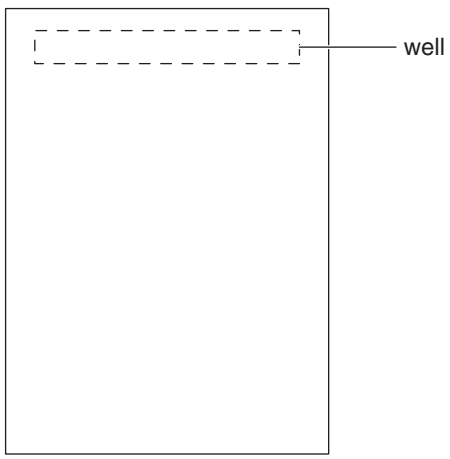
Complete the diagrams below by placing Xs along the alleles, showing the DdeI binding sites for both the sickle cell allele and the normal allele. 2 marks

sickle cell allele: _____

normal allele: _____

d. Gel electrophoresis is used to provide a profile so that an appropriate diagnosis can be made. A couple who are both carriers of the sickle cell trait (heterozygous) conceive a child.

Draw a band pattern within the box below that would lead to a positive diagnosis for a carrier of the sickle cell trait. Show on the diagram where the smallest fragment is located within the gel. 2 marks



e. This type of genetic test is routinely given to people enrolling into the armed services in the United States of America. Individuals who have the genetic status of sickle cell or carriers are excluded from branches of the armed services that involve duties, such as being a pilot or scuba diving.

Discuss **one** advantage and **one** disadvantage of decisions such as these to the individual being tested. 2 marks

Question 11 (10 marks)

Bovine growth hormone (BGH) is naturally secreted from the pituitary gland of cows to control many aspects of cow metabolism. Since 1994 it has been legally synthesised within bacteria, then purified and used in the dairy industry (by injection) to ensure cows maintain constant milk production. The techniques/steps involved in the artificial production of rBGH (recombinant bovine growth hormone) are listed below.

Step 1: Addition of restriction enzyme *Eco*RI cuts the plasmid once in the *lacZ* gene.

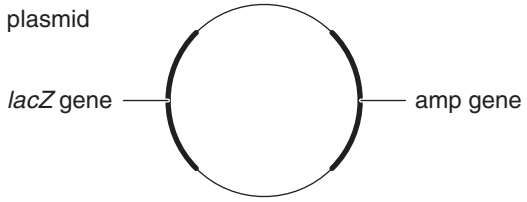
Step 2: The cut plasmid is mixed with a supply of BGH genes with complementary sticky ends to the treated plasmid.

Step 3: Ligase is added to the plasmid/BGH mixture.

Step 4: The mixture is added to a population of untreated *E. coli* bacteria.

The *lacZ* gene produces a blue pigment when active (*E. coli* bacteria not containing the pigment will be white).

The amp gene, when active, provides resistance against the antibiotic ampicillin.



a. **i.** What is the purpose of the BGH genes having complementary sticky ends to the treated plasmid? 1 mark

_____

_____

ii. What is the purpose of the addition of ligase to the mixture of plasmid and BGH? 1 mark

_____

_____

Once step 4 is completed, the bacteria are added to several culture plates and incubated for 48 hours. The bacteria containing the functional BGH gene can then be selected and used for commercial purposes.

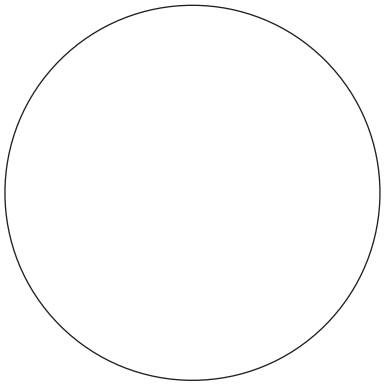
b. The plasmid may or may not integrate the BGH gene. The treated bacteria may or may not take up the modified plasmid.

Complete the table below with a yes or no in each space stating whether you would expect these bacteria to grow or not. 2 marks

Type of treated bacteria	Control culture plate	Culture plate treated with ampicillin
plasmid not taken up		
plasmid without the BGH gene taken up		
plasmid with the BGH gene taken up		

c. The circle below is a culture plate as seen from above. Half the bacteria took up the plasmid without the BGH gene, while half the bacteria took up the plasmid with the BGH gene when the culture plate was inoculated.

Show **four** colonies growing on the ampicillin-treated culture plate and the colour of each colony. 1 mark



d. Apart from the three types of treated bacteria described in **part b.**, discuss **one** other possible alternative result that could have occurred with the treated bacteria or the plasmids. 1 mark

e. The use of rBGH in large quantities to make the milking season longer has now been banned in many countries because of the effect it has had on human health. This is due to the milk containing products not normally found in milk produced by cows without the genetically modified BGH. There have been links with allergies, premature growth in infants and cancer.

i. Describe a study/experiment that would need to be conducted that could lead to the banning of rBGH use in large quantities. 3 marks

ii. The use of rBGH is banned in most countries apart from the United States of America. Discuss **one** benefit to humans that justifies the continued use of rBGH. 1 mark

END OF QUESTION AND ANSWER BOOKLET