South Australian
Certificate of Education

1

Biology
2019

Question booklet 1

Section 1: Multiple-choice questions (Questions 1 to 15) 15 marks
- Answer ***all*** questions in Section 1
- Write your answers on the blue multiple-choice answer sheet

Section 2
Part A of Section 2 (Questions 16 to 18) 53 marks
- Answer ***all*** questions in Part A
- Write your answers in this question booklet
- You may write on page 16 if you need more space

Examination information

Materials
- Question booklet 1 (Section 1 and Part A of Section 2)
- Question booklet 2 (Part B of Section 2)
- Multiple-choice answer sheet (blue)
- SACE registration number label

Instructions
- Use black or blue pen
- You may use a sharp dark pencil for diagrams and other representations
- Approved calculators may be used
- Allow approximately 25 minutes to answer Section 1
- Allow approximately 105 minutes to answer Section 2

Total time: 130 minutes
Total marks: 120

Attach your SACE registration number label here

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SECTION 1: MULTIPLE-CHOICE QUESTIONS (Questions 1 to 15)

(15 marks)

*Each of the 15 multiple-choice questions involves choosing from four alternative answers. Indicate the **one** alternative that you consider best answers the question by shading the bubble by the appropriate letter alongside the question number on the blue multiple-choice answer sheet. Use black or blue pen.*

Each question is worth 1 mark.

1. Which one of the following combinations correctly identifies the presence or absence of introns and exons in a human gene, and a function of a gene?

	Introns	*Exons*	*Function of a gene*
J.	present	absent	codes for an amino acid
K.	absent	absent	codes for a polypeptide
L.	present	present	codes for an RNA molecule
M.	absent	present	codes for a protein

2. Which one of the following statements is correct?

   J. The primary structure of proteins is affected by any change in temperature.

   K. The secondary structure of proteins is made up of more than one polypeptide.

   L. The tertiary structure of proteins determines the shape of the active site of an enzyme.

   M. The quaternary structure of amino acids is affected by a change in pH.

3. A segment of one of the strands of DNA contains the nucleotide sequence below.

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

   Which one of the following nucleotide sequences could be used as an RNA probe to locate this segment of DNA?

   J. C A C C A U G A

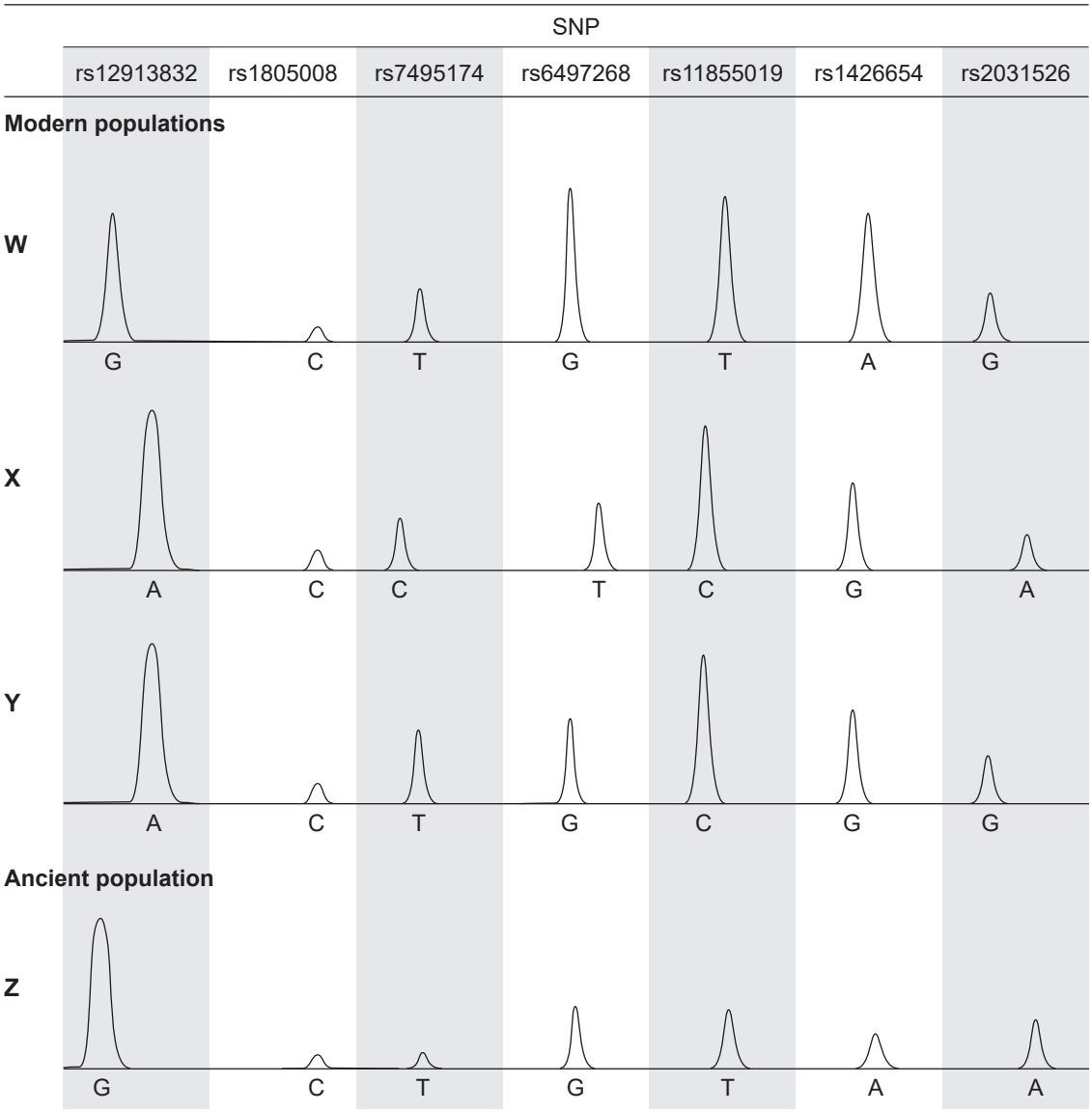
   K. A C G C A C C A

   L. C A U C G G U G

   M. G A G G A T G A

4. The diagram below shows electropherograms for DNA profiles of three modern human populations (**W**, **X**, and **Y**) and one ancient human population (**Z**). The electropherograms show which nucleotide is present in each of seven single nucleotide polymorphisms (SNPs) for each population.

   An SNP is a variation in a single nucleotide at a specific location in the genome. For example, the SNP rs12913832 has either guanine (G) or adenine (A).



Which one of the following statements is consistent with the information in the electropherograms?

J. The modern populations do not show enough similarity to the ancient population to indicate a close relationship.

K. Population **W** is older than population **X** and population **Y**.

L. Population **X** is the modern population that is most similar to population **Z** because only one nucleotide base is different.

M. Population **X** is more closely related to population **Y** than population **Z** is to population **Y**.

5. Which one of the following combinations of the presence or absence of some cell structures in animal and plant cells is correct?

	Cell structure	*Animal cell*	*Plant cell*
J.	vacuole	present	present
K.	cell wall	present	present
L.	lysosome	absent	present
M.	mitochondrion	present	absent

6. Which one of the following processes does ***not*** occur during meiosis?

J. Separation of sister chromatids.

K. Crossing over that produces new combinations of chromosomes.

L. Separation of homologous chromosomes.

M. Independent assortment of pairs of homologous chromosomes.

7. If human somatic cells contain approximately 6.4 picograms (pg) of DNA immediately after cell division, which one of the following statements is correct?

J. At the end of the first meiotic division, a human cell contains approximately 6.4 pg of DNA.

K. Immediately before mitotic division, a human cell contains approximately 25.6 pg of DNA.

L. A cell produced by the meiotic division of a human cell contains approximately 6.4 pg of DNA.

M. A cell produced by the mitotic division of a human cell contains approximately 12.8 pg of DNA.

8. Which one of the following combinations correctly compares a feature of the nervous system with a feature of the endocrine system?

	Nervous system	*Endocrine system*
J.	produces longer-lived messages	produces shorter-lived messages
K.	produces a slower response to a stimulus	produces a faster response to a stimulus
L.	transmits electrochemical messages	transmits chemical messages
M.	uses chemicals to detect a stimulus	uses hormones to detect a stimulus

9. Hormones can be

J. peptides, carbohydrates, or proteins.

K. peptides, proteins, or steroids.

L. amino acids, steroids, or nucleic acids.

M. carbohydrates, steroids, or proteins.

10. When faced with a sudden and unexpected threat, the human body will often react by releasing adrenaline into the blood.

    Adrenaline is a

    J. neurotransmitter that increases the speed of nerve impulses.

    K. catalyst that increases the breakdown of glucose.

    L. hormone that increases blood pressure and breathing rate.

    M. protein that is a source of instant energy for muscle cells.

11. Oxycodone is a powerful prescription drug that is used to treat serious pain in patients. One of its effects is to inhibit the release of neurotransmitters such as acetylcholine.

    Which one of the following is ***least*** likely to be affected by this drug?

    J. The transmission of a nerve impulse along the axon.

    K. The number of nerve impulses crossing the synapse.

    L. The level of pain suffered by a patient.

    M. The number of membrane receptors in a synapse that have acetylcholine bound to them.

12. Two populations of platypuses (*Ornithorhynchus anatinus*) each live on a different island off the coast of Australia. Scientists believe that both of these island populations are at greater risk of dying out than populations of these platypuses on the mainland of Australia.

Source: © Palych | Dreamstime.com

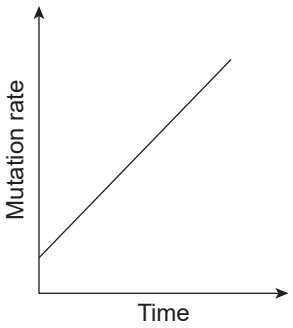
The table below shows combinations of size of gene pool, genetic diversity, and potential for genetic drift.

Which one of these combinations is most consistent with island populations of platypuses being at greater risk of dying out than are mainland populations?

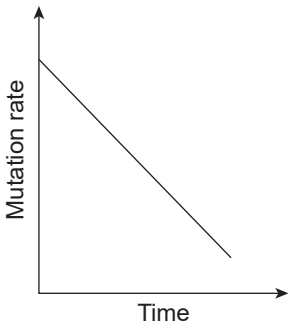
	Size of gene pool	*Genetic diversity*	*Potential for genetic drift*
J.	small	high	low
K.	large	high	low
L.	large	low	high
M.	small	low	high

13. Which one of the following graphs best represents the mutation rate over time that enables biologists to determine when related species separated from a common ancestor?

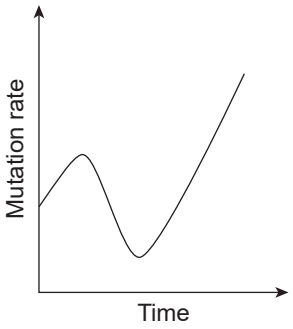
J.



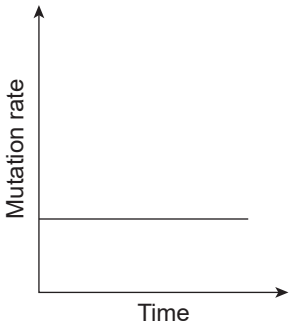
K.



L.



M.



14. Copies of a segment of DNA from species **X** were hybridised with copies of the homologous segment of DNA from species **A**.

The hybridised DNA segments were heated, and the temperature at which complete separation occurred (separation temperature) was recorded.

In order to determine evolutionary relationships, this process was repeated three times using DNA from species **B**, **C**, and **D** in place of DNA from species **A**.

The results are shown in the table below.

Hybridised DNA	*Separation temperature (°C)*
A–**X**	30
B–**X**	40
C–**X**	70
D–**X**	80

Which one of the following statements is supported by the data in the table?

J. Species **A** and species **X** have the least percentage difference in their DNA.

K. Species **A** and species **B** together have the same percentage difference in DNA from species **X** as has species **C**.

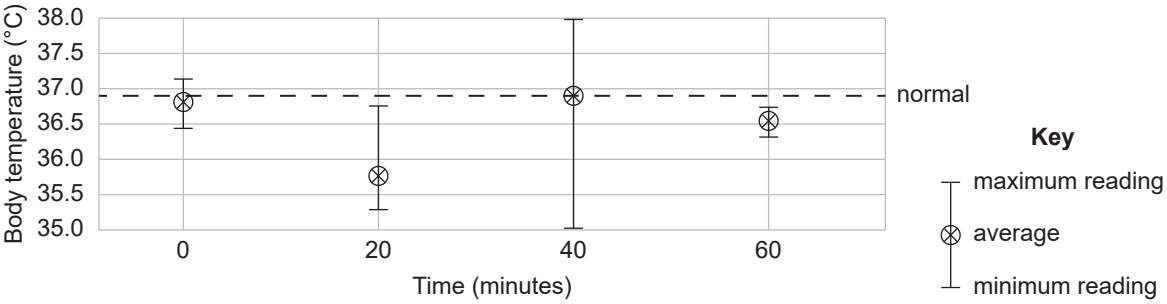
L. Species **C** is more closely related to species **D** than it is to species **X**.

M. Species **D** and species **X** have the least percentage difference in their DNA.

15. Ten healthy people each had their body temperature measured and recorded. The measurements were then repeated at 20-minute intervals over 1 hour.

The results are displayed in the graph below. The graph shows maximum and minimum readings, and the average body temperature at each time.

The accepted true value for normal human body temperature is 36.9°C.



Which one of the following statements is consistent with the data shown in the graph?

J. The average at 40 minutes is more accurate than the average at 20 minutes.

K. The readings at 40 minutes are most likely to be influenced by systematic error.

L. The data at 60 minutes are likely to be the most valid.

M. The results at 0 minutes are likely to be the least reliable.

SECTION 2: Part A (Questions 16 to 18)

(53 marks)

16. Scientists, working with farmers and other members of the agricultural industry, are studying epigenetic markers to determine whether they provide a clue to the likely productivity of livestock and crops.

    One investigation involved the dairy industry, one dairy farm, and scientists from several universities. The dairy cows in one herd were tested to determine whether epigenetic changes were responsible for a sudden decrease in the volume of milk produced by some of these cows. All the cows in this herd received the same type of food during the investigation.

    The scientists found different DNA methylation patterns between high-milk-producing cows and low-milk-producing cows, including in the genes required for milk production.

    (a) (i) Explain how methylation of the genes that are required for the production of milk could affect milk production.

    _____

    _____

    _____

    _____ (2 marks)

    (ii) (1) State *one* hypothesis that these scientists could have been investigating.

    _____

    _____

    _____ (2 marks)

    (2) State *one* result that would ***not*** support this hypothesis.

    _____

    _____ (1 mark)

    (iii) State *one* factor that cannot be controlled in this investigation. Explain the effect that not being able to control this factor could have on the data.

    _____

    _____

    _____

    _____

    _____

    _____ (3 marks)

(iv) Explain why other scientists who review the results of this investigation may question the reliability of the data.

(3 marks)

(b) Using one or more of the key concepts of science as a human endeavour, explain how scientists could involve farmers and/or other members of the agricultural industry in epigenetic studies, and how society could benefit from these studies.

(7 marks)

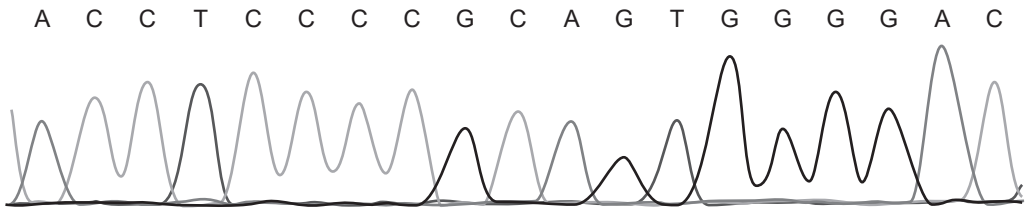
Question 16 continued

The scientists who were investigating milk production by dairy cows needed to identify the genes that had different DNA methylation patterns, in order to test the validity of their conclusions.

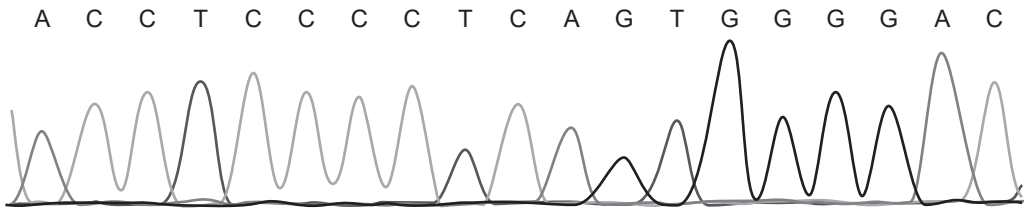
The diagrams below show electropherograms of a segment of a dairy cow gene that is required for milk production. Mutations in this gene have been linked to the ability of individual cows to produce milk.

Electropherogram **R** shows the nucleotide sequence of a gene in a high-milk-producing cow and electropherogram **S** shows the nucleotide sequence of the same gene in a low-milk-producing cow.

Electropherogram R



Electropherogram S



Source: Adapted from Marzooq, A AL 2015, 'Discovery of novel DNA variants in Jordanian population by re-genotyping affymetrix DMET arrays data using DNA sequencing', *Molecular biology*, vol. 4, no. 3, figure 4.73 (CC BY 4.0)

(c) Identify the technique that could be used to determine the order of the nucleotide bases in a gene.

_____ (1 mark)

(d) (i) On electropherogram **S**, circle the base that is different from the base in the same position on electropherogram **R**. (1 mark)

(ii) Explain how this difference in the DNA sequence could alter the function of the gene product.

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_____ (3 marks)

(e) (i) State the location in a cow cell where the first step in the synthesis of a gene product occurs.

_____ (1 mark)

(ii) Explain why this process occurs in a different location in prokaryotic cells.

_____

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_____ (2 marks)

(f) Explain why, in eukaryotic cells, mRNA is processed before translation occurs.

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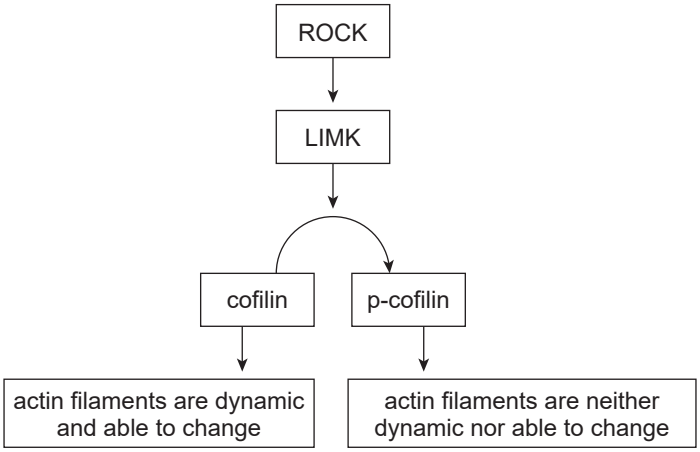
_____ (3 marks)

17. Rho-associated protein kinase (ROCK) is an enzyme that regulates a component of the cytoskeleton called 'actin filaments'.

The diagram below shows a series of steps by which ROCK activates a second enzyme called 'LIM kinase' (LIMK). LIMK *inactivates* a protein called 'cofilin' by converting it to p-cofilin. Cofilin keeps the actin filaments dynamic and able to change.



(a) State *one* function of the cytoskeleton.

_____ (1 mark)

(b) Using the information provided, explain the effect that decreased levels of ROCK have on the ability of the actin filaments to remain dynamic and able to change.

_____

_____

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_____

_____ (3 marks)

(c) Explain why ROCK is the ***only*** enzyme that is able to activate LIMK.

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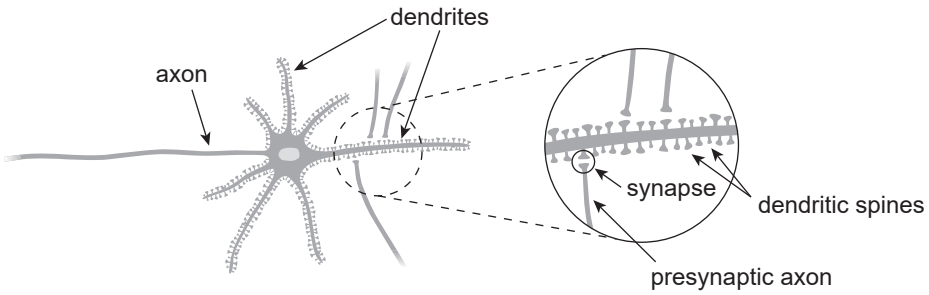
_____ (3 marks)

The diagram below shows dendritic spines, which are small extensions on the dendrites of neurons. The dendritic spines receive inputs from other neurons.



Dendritic spines have the ability to rapidly change shape, volume, and number by rearranging dynamic actin filaments. Research suggests that the growth of new dendritic spines and the enlargement of existing spines are the basis of human learning and memory.

Alzheimer's disease is a form of dementia in which the brain deteriorates, leading to loss of memory and other important mental functions. Research has shown that human patients with Alzheimer's disease have elevated levels of p-cofilin.

(d) Explain how elevated levels of p-cofilin could affect learning and memory in human beings.

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_____ (3 marks)

(e) The drug fasudil is an inhibitor of the enzyme ROCK and could be used to treat patients with Alzheimer's disease.

Explain *one* way in which a drug such as fasudil could reduce the activity of the enzyme ROCK.

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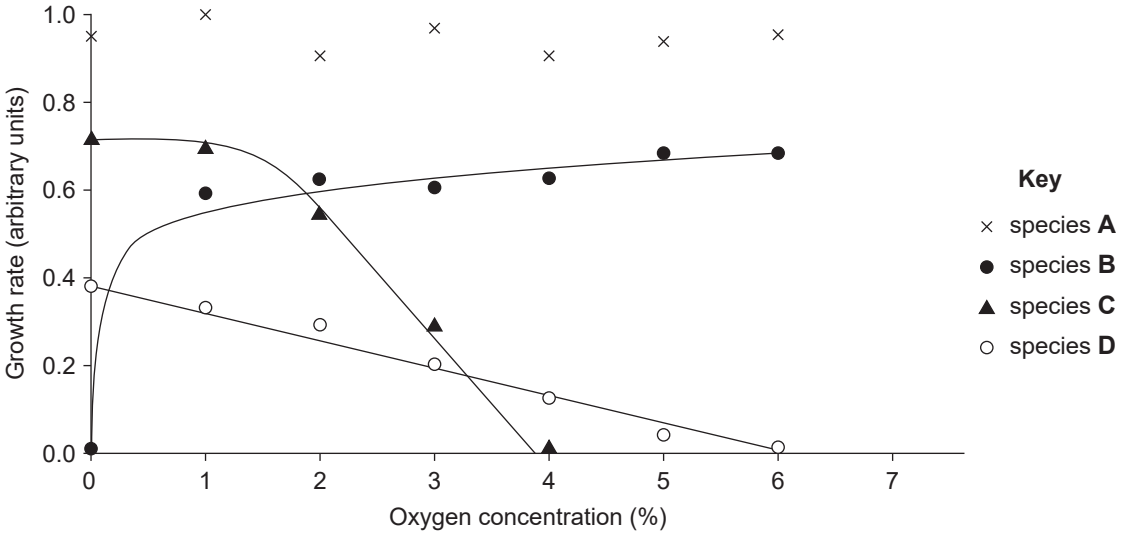
_____ (3 marks)

18. An experiment was conducted to investigate bacterial growth in food products that are stored in packaging in which the oxygen concentration can vary. The results of the investigation are displayed in the graphs below. They show the growth rates of four species of bacterium: **A**, **B**, **C**, and **D**.



Source: Adapted from Couvert, O, Divanac'h, M-L, Lochardet, A, et al. 2019, 'Modelling the effect of oxygen concentration on bacterial growth rates', *Food microbiology*, vol. 77, pp 21–5, figures 2, 4, and 5.

(a) State the independent variable in this investigation.

_____ (1 mark)

(b) Draw the line of best fit for species **A**. (1 mark)

(c) State *one* limitation of any conclusion formed from the results of this investigation.

_____

_____ (1 mark)

(d) Obligate aerobes require the presence of oxygen in order to grow.

Obligate anaerobes cannot grow in the presence of oxygen.

(i) Identify which *one* of the species — **A**, **B**, **C**, or **D** — is an obligate aerobe.

_____ (1 mark)

(ii) Cyanobacteria are able to photosynthesise.

Explain why it is unlikely that species **D** is a cyanobacterium.

_____

_____

_____

_____ (2 marks)

(e) The energy-releasing process in species **C** at an oxygen concentration of 0% also occurs in plant cells in the absence of oxygen.

Write a balanced chemical equation for this process.

_____ (2 marks)

(f) Explain how bacteria use ATP in order to grow.

_____

_____

_____

_____ (2 marks)

(g) State the type of cell division by which bacteria increase in number.

_____ (1 mark)

You may write on this page if you need more space to finish your answers to any of the questions in Part A of Section 2. Make sure to label each answer carefully (e.g. 17(d) continued).

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Question booklet 2

Section 2
Part B of Section 2 (Questions 19 to 23) 52 marks
- Answer ***all*** questions in Part B
- Write your answers in this question booklet
- You may write on page 10 if you need more space

2

Copy the information from your SACE label here

SEQ	FIGURES	CHECK LETTER	BIN

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SECTION 2: Part B (Questions 19 to 23)

(52 marks)

19. The nervous system and the endocrine system are involved in the control of body temperature in human beings.

(a) Identify the pathway taken by the signal between an endocrine gland and its target cells.

_____ (1 mark)

(b) Describe the role of thyroid-stimulating hormone.

_____

_____

_____

_____ (2 marks)

(c) Describe the structural feature of all target cells that are affected by thyroxine that allows them to respond to thyroxine.

_____

_____

_____

_____ (2 marks)

When a person spends an extended time in a cold environment, their body temperature can fall below its normal level.

(d) Describe how each of the following systems regulates body temperature in human beings who have a lower-than-normal body temperature.

(i) Endocrine system: _____

_____

_____

_____ (2 marks)

(ii) Nervous system: _____

_____

_____

_____ (2 marks)

(e) Explain the role of negative feedback in the control of human body temperature.

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_____ (3 marks)

(f) Explain why it is necessary for human beings to maintain a body temperature at about 37°C.

_____

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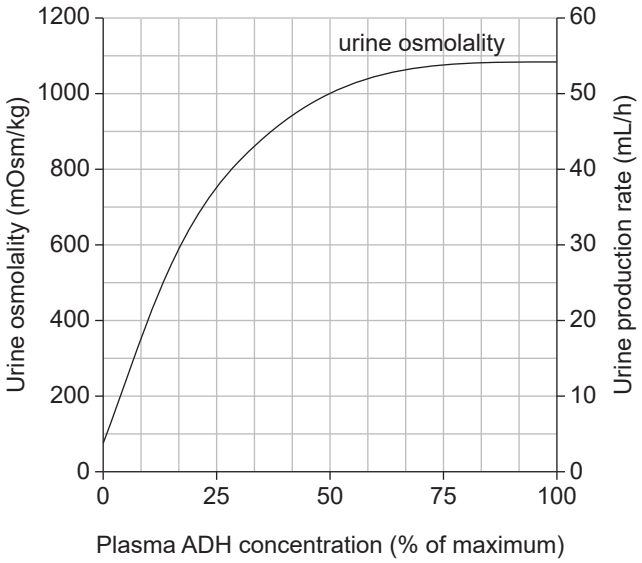
_____ (2 marks)

20. *Refer to the following graph, which shows how the concentration of solutes in urine (osmolality) changes with the concentration of antidiuretic hormone (ADH) in blood plasma:*



(a) Describe the change in urine osmolality as the concentration of ADH in the plasma increases.

_____

_____

_____

_____

_____ (2 marks)

(b) State the urine osmolality when the concentration of ADH in the plasma is 50% of its maximum.

_____ (1 mark)

(c) Assume that the urine production rate is 55 mL/h when there is no ADH in the plasma.

On the grid above, draw the most likely shape of the graph of urine production rate as the concentration of ADH in the plasma increases from 0% to 100% of its maximum.

(2 marks)

(d) Describe the effect of ADH on the kidneys and urine osmolality.

(3 marks)

(e) A rare form of diabetes, known as central diabetes insipidus (CDI), can result from a person's inability to produce ADH. Some cases of CDI are caused by an injury to the head.

(i) Explain why an injury to the head might lead to CDI.

(3 marks)

(ii) Explain how having CDI is likely to affect a person's blood pressure.

(3 marks)

21. Climate scientists believe that human activities such as the burning of fossil fuels are leading to an increase in average global temperatures.

Research done by scientists from the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology since the 1970s indicates that there has been a significant increase in the number and severity of bushfires across southern Australia. Climate scientists predict that this increase will continue.

(a) Explain how an increase in the number and severity of bushfires across southern Australia could cause some plant species to become extinct.

_____

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_____

_____ (2 marks)

(b) State *one* example of a human activity, other than the burning of fossil fuels, that leads to environmental change.

_____ (1 mark)

(c) (i) State the name given to the change in the mix of species that occurs during regeneration after a significant bushfire.

_____ (1 mark)

(ii) Describe ***how*** the presence of plant species can result in a change in the mix of species over time.

_____

_____

_____

_____ (2 marks)

(iii) Explain ***why*** the mix of species after a significant bushfire may be different from the mix of species before the bushfire.

_____

_____

_____

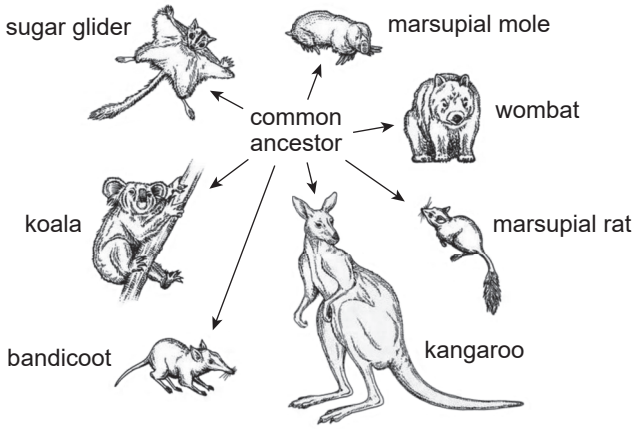
_____ (2 marks)

22. Bats and dolphins are genetically unrelated. In separate evolutionary events, they independently evolved the ability to navigate their environments using sound — a process called 'echolocation' or 'sonar'.

(a) Name the type of evolution that resulted in both bats and dolphins having the ability to use sound to navigate.

_____ (1 mark)

The diagram below shows that Australian marsupials such as koalas, wombats, and kangaroos evolved from a common ancestor.



Source: adapted from Strickberger, MW 2000, *Evolution* (3rd edn), Jones and Bartlett Publishers International, London, figure 3–4, illustrator Elizabeth Morales, adapted from Simpson, GG & Beck, W 1965 *Life* (2nd edn), Harcourt, Brace and World, New York

(b) Compare the type of evolution that resulted in many marsupials evolving from a common ancestor with the type of evolution that resulted in bats and dolphins using sonar to navigate.

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_____ (6 marks)

23. Evidence shows that life on Earth began approximately 3.5 billion years ago. There is debate among scientists as to whether proteins and DNA came into existence first or whether RNA and ribozymes evolved first. The RNA world hypothesis states that the first simple cells relied only on RNA to function, and that DNA and proteins evolved later.

(a) State the possible roles of RNA and ribozymes in the first simple cells.

(i) RNA: _____

_____ (1 mark)

(ii) ribozymes: _____

_____ (1 mark)

(b) Explain *one* reason why DNA is a suitable molecule for transmitting genetic information from one generation to the next.

_____

_____

_____

_____ (2 marks)

Stromatolites are sheet-like sedimentary rocks, formed by the growth of primitive photosynthesising prokaryotic cells whose DNA can be traced back to very early life on Earth.

(c) Describe how fossils in stromatolites may be used as evidence that prokaryotic cells existed on Earth before eukaryotic cells.

_____

_____

_____

_____ (2 marks)

Eukaryotic cells are thought to have evolved from prokaryotic cells in a process known as 'endosymbiosis'.

(d) Describe one *structural* feature of a mitochondrion, and explain how it provides evidence of an endosymbiotic event in the evolution of eukaryotic cells.

_____

_____

_____

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_____

_____ (3 marks)

You may write on this page if you need more space to finish your answers to any of the questions in Part B of Section 2. Make sure to label each answer carefully (e.g. 19(d)(i) continued).