South Australian
Certificate of Education

1

Biology
2018

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
- Allow approximately 20 minutes
- **Part A of Section 2** (Questions 16 to 21) 52 marks
- Answer ***all*** questions in Part A
- Write your answers in this question booklet
- You may write on page 19 if you need more space
- Allow approximately 50 minutes

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

Reading time

- 10 minutes
- You may begin writing during this time
- You may begin using an approved calculator during this time

Writing time

- 2 hours
- Use black or blue pen
- You may use a sharp dark pencil for diagrams and representations
- Approved calculators may be used

Total marks 120

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Attach your SACE registration number label here

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

(15 marks)

*Answer **all** questions in this section.*

*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 statements about the structure of a protein is ***not*** correct?

   J. The primary structure of a protein is the sequence of amino acids that make up the protein.

   K. The secondary structure of a protein determines its primary structure.

   L. The tertiary structure of a protein is its three-dimensional shape.

   M. The quaternary structure of a protein is determined by the combination of two or more polypeptides.

2. Which one of the following statements about DNA in cells is correct?

   J. All DNA in eukaryotic cells is bound to proteins in linear chromosomes.

   K. DNA in the nucleus of prokaryotic cells is unbound and circular.

   L. DNA in the nucleus of eukaryotic cells is unbound.

   M. DNA in mitochondria is unbound and circular.

3. The product of *gene 1* is a protein that binds to a promoter region on the DNA near *gene 2*. This results in the expression of *gene 2*.

   A mutation in which one of the following will most likely prevent the expression of *gene 2*?

   J. An intron of *gene 1*.

   K. An exon of *gene 1*.

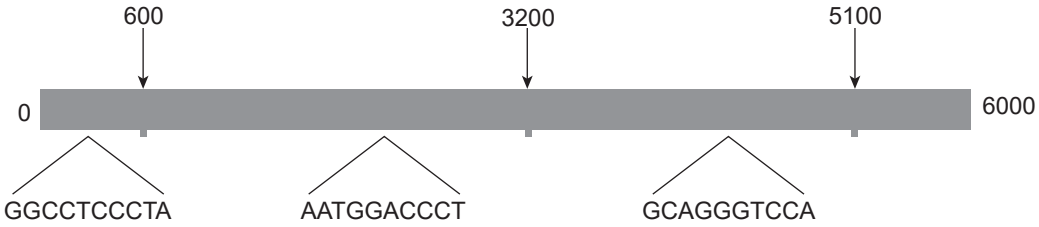
   L. The product of *gene 1*.

   M. The product of *gene 2*.

4. A DNA molecule that was 6000 bases long was cut with a restriction enzyme. The restriction enzyme cut the DNA at three sites:

   - immediately after the base at position number 600
   - immediately after the base at position number 3200
   - immediately after the base at position number 5100.

   Refer to the following diagram, which shows a single strand of the DNA molecule and the base sequences of three regions within the strand:



   After the DNA molecule was cut, the resulting fragments were separated by gel electrophoresis and then blotted onto a membrane. A labelled probe with the sequence GGACCCT was then added to the membrane.

   The probe will bind to the fragment that has

   J. 600 bases.

   K. 1900 bases.

   L. 2600 bases.

   M. 5100 bases.

5. Which one of the following combinations matches an organelle with one of its structural features and one of its functions?

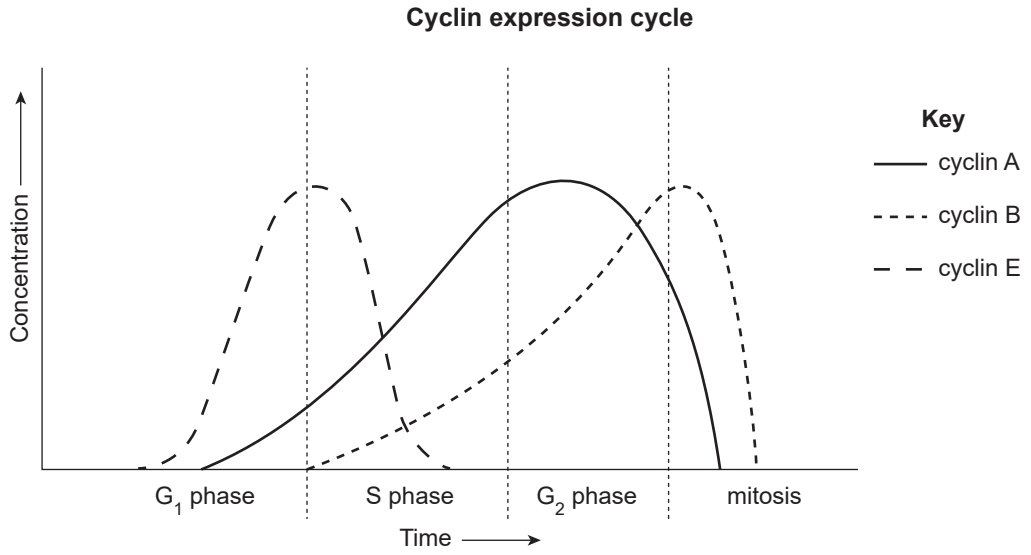
	Organelle	*Structural feature*	*Function*
J.	ribosome	single membrane	RNA synthesis
K.	Golgi body	flattened membrane sacs	protein synthesis
L.	lysosome	membrane-bound	breakdown of proteins
M.	nucleolus	double membrane with pores	ribosome formation

6. Which one of the following combinations correctly identifies both a property of simple diffusion and a property of facilitated diffusion?

	Property of simple diffusion	*Property of facilitated diffusion*
J.	does not require energy	requires energy
K.	requires protein molecules embedded in the cell membrane	does not require protein molecules embedded in the cell membrane
L.	moves substances with the concentration gradient	moves substances against the concentration gradient
M.	does not require energy	does not require energy

7. The cell cycle is regulated partly by internal factors, such as the concentration of cyclins.

Refer to the following graph, which shows the concentration of some of the cyclins during the cell cycle:



Which one of the following statements is a correct interpretation of the data shown in the graph above?

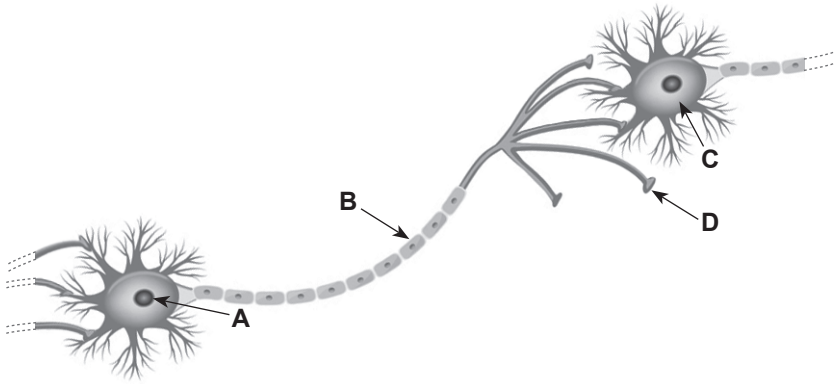
J. In prokaryotic cells, the highest concentration of cyclin E occurs during the S phase.

K. Cyclin B is at its highest concentration when DNA replication occurs during mitosis.

L. A decrease in the concentration of cyclin A is required for DNA replication.

M. Cyclins A and B are present in the cell at the second checkpoint.

8. *Refer to the following diagram, which shows part of a nerve pathway:*



Source: Adapted from © Designua | Dreamstime.com

Which one of the following statements is correct?

J. Structure **A** is the nucleus and stores genetic material.

K. Structure **B** is the cell body and carries the nerve impulse.

L. Structure **C** forms the synapse between the two neurons.

M. Structure **D** is the axon and transmits chemical signals.

9. Caffeine is a drug that reduces the effect of the neurotransmitter adenosine. Adenosine is responsible for inducing sleep in a healthy person. Caffeine prevents adenosine from binding to receptors in the hypothalamus.

Caffeine

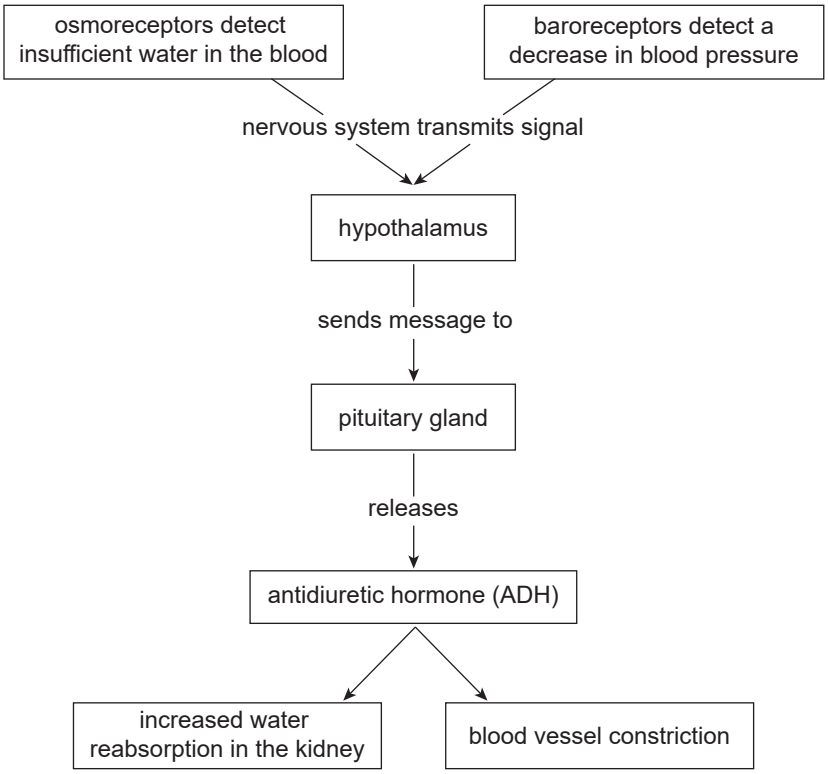
J. decreases the amount of time it takes for a healthy person to fall asleep.

K. binds to the active site of adenosine.

L. reduces the number of nerve impulses triggered by adenosine.

M. acts as an inhibitor that prevents the release of adenosine.

10. *Refer to the following flow chart, which shows part of a human being's response to a change in water in the blood and a change in blood pressure:*



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

J. ADH causes an increase in blood pressure.

K. ADH causes a decrease in blood volume.

L. Both the nervous system and the endocrine system are involved in the detection of stimuli.

M. The response to increased blood pressure is the release of ADH.

11. Which one of the following statements provides the ***best*** evidence that prokaryotic cells existed before eukaryotic cells?

J. Prokaryotic cells have cell walls, but eukaryotic cells do not.

K. Researchers have found fossils that contain prokaryotic cells.

L. The membranes of mitochondria are different from the membranes of chloroplasts.

M. Prokaryotic cells show much less internal organisation than eukaryotic cells do.

12. Some biologists have suggested that primitive cells consisted of RNA surrounded by fatty acid molecules.

Which one of the following combinations shows the most likely functions of RNA and fatty acid molecules in primitive cells?

	RNA function	*Fatty acid function*
J.	enzyme	primitive membrane
K.	code for DNA	primitive membrane
L.	code for DNA	energy source
M.	enzyme	energy source

13. When the Pacific island of Pingelap was devastated by a storm in 1775, only about 20 people survived. One of the survivors was totally colour-blind. The survivors remained on the isolated island and re-established the population.

Less than 0.01% of the world's population is totally colour-blind. In 2015, it was estimated that 10% of the Pingelap population was totally colour-blind.

The high frequency of total colour-blindness in the Pingelap population is likely to be due to

J. adaptive radiation.

K. mutation.

L. genetic drift.

M. allopatric speciation.

14. *Refer to the following table, which shows the bases from the same part of a short sequence of DNA from four different, but related, species* **A**, **B**, **C**, **D**:

Species **A**	A	T	T	C	C	G	G	A	T	A
Species **B**	A	T	T	C	C	G	C	A	T	A
Species **C**	A	G	T	G	C	G	G	A	T	A
Species **D**	A	T	C	G	G	G	G	A	T	T

Based only on this information, which two species are likely to have shared a common ancestor ***most*** recently?

J. **A** and **B**.

K. **B** and **C**.

L. **A** and **D**.

M. **A** and **C**.

15. Two groups of scientists conducted the same experiment to investigate the activity of the enzyme peptidase, using different equipment in different laboratories. They measured enzyme activity by recording the time taken (in seconds) for the reaction to occur.

Refer to the following tables, which show the data collected by each group of scientists:

Data from group 1

Temperature (°C)	*Reaction time (seconds)*		
	Trial 1	*Trial 2*	*Average*
20	18	16	17
30	25	25	25
40	33	35	34
50	48	42	45
60	52	60	56

Data from group 2

Temperature (°C)	*Reaction time (seconds)*		
	Trial 1	*Trial 2*	*Average*
20	16	20	18
30	25	25	25
40	35	35	35
50	46	50	48
60	55	55	55

Which one of the following statements is consistent with these results?

J. The data for 30°C indicate that there was no effect of random error in either experiment.

K. The results of the two experiments indicate that systematic error is ***not likely*** to have affected the data.

L. As the experiments were conducted using different equipment and in different laboratories, a valid conclusion cannot be drawn from these data.

M. The data from group 2 are more accurate than the data from group 1.

SECTION 2: Part A (Questions 16 to 21)

(52 marks)

*Answer **all** questions in this part.*

16. Beckwith–Wiedemann syndrome (BWS) is a rare disorder in which individuals have abnormal growth and an increased risk of childhood cancer.

    Cyclin-dependent kinase inhibitor 1C (CDKN1C) is a protein that inhibits cell division. In human beings, this protein is coded by the *CDKN1C* gene. In some patients with BWS, there is more DNA methylation of the *CDKN1C* gene than there is in individuals who do not have BWS.

    (a) State the name of the DNA nucleotide that is most often methylated.

    _____ (1 mark)

    (b) State the effect of increased DNA methylation of the *CDKN1C* gene on its expression.

    _____

    _____ (1 mark)

    (c) Explain how altering the expression of the *CDKN1C* gene could lead to cancer.

    _____

    _____

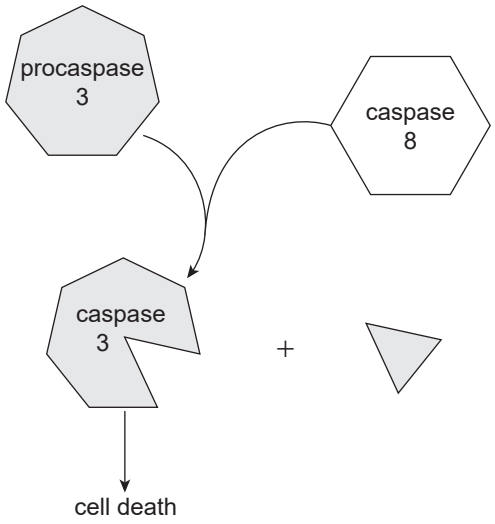
    _____

    _____

    _____

    _____ (3 marks)

17. Caspase 3 is an enzyme that is responsible for the final stages of controlled cell death. It is produced in an inactive form called 'procaspase 3', which is activated by caspase 8, as illustrated in the diagram below.



(a) State the name of the substrate for caspase 8.

_____ (1 mark)

(b) State *one* reason why procaspase 3 is produced in an inactive form in cells.

_____

_____ (1 mark)

(c) Explain how caspase 8 increases the rate of activation of procaspase 3.

_____

_____

_____

_____

_____

_____ (3 marks)

(d) There are many inhibitors of caspases.

Explain *one* way in which an inhibitor of caspase 8 could reduce the rate of activation of procaspase 3.

_____

_____

_____

_____

_____

_____ (3 marks)

18. In an investigation, students exposed spinach leaves to light of increasing intensity, resulting in an increased concentration of oxygen in the air surrounding the leaves.

(a) State the independent variable in this investigation.

_____ (1 mark)

(b) Explain why increasing the light intensity resulted in an increased concentration of oxygen in the air surrounding the leaves.

_____

_____

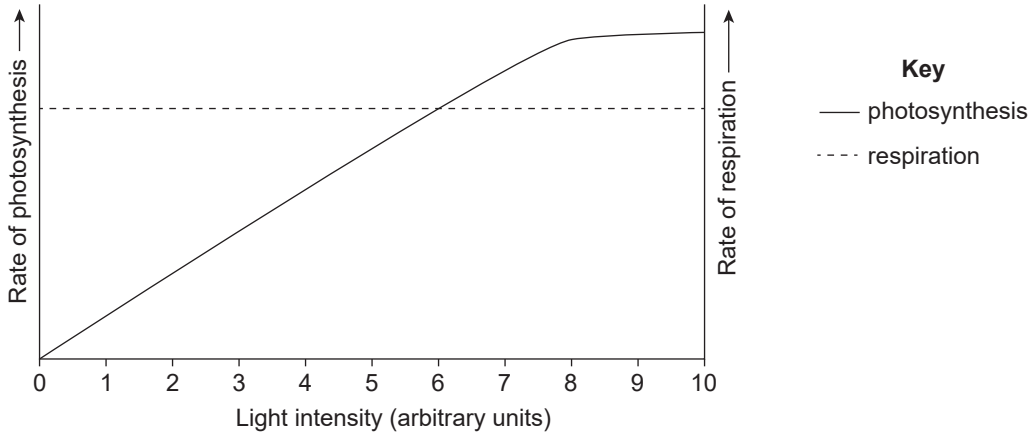
_____

_____ (2 marks)

(c) Write a balanced chemical equation for the reaction that ***uses*** oxygen and occurs in spinach leaves.

_____ (2 marks)

Refer to the following graphs, which show the rates of photosynthesis and respiration in the spinach leaves at different light intensities:



(d) (i) Using the information in the graphs, state the light intensity at which the concentration of oxygen in the air surrounding the leaves remains constant.

_____ (1 mark)

(ii) Explain why the concentration of oxygen in the air surrounding the leaves remains constant at a particular light intensity.

_____

_____

_____

_____ (2 marks)

(e) State *one* factor that should be held constant in this investigation, and state why it should be controlled.

_____

_____

_____

_____ (2 marks)

(f) State *one* limitation of any conclusion drawn from the results of this investigation.

_____

_____ (1 mark)

(g) State *one* source of random error in this investigation.

_____ (1 mark)

(h) Explain how the effect of random error could be reduced in this investigation.

_____

_____

_____

_____ (2 marks)

19. The Pyrenean ibex was a subspecies of mountain goat. In the year 2000, Celia, the last individual of this subspecies, was killed by a falling tree, resulting in the extinction of the Pyrenean ibex.

A team of scientists removed the nucleus from a goat egg cell. They then injected the nucleus from one of Celia's preserved somatic cells into the enucleated goat egg cell. The resulting embryo was implanted into a surrogate goat that gave birth to a clone of Celia in 2003. The clone died shortly after birth.

Source: © Mikelane 45 | Dreamstime.com

(a) Explain why the nucleus of a somatic cell and not the nucleus of an egg cell must be injected into a donor egg cell in order to produce a clone.

_____

_____

_____

_____ (2 marks)

(b) Name the type of cell division that produces a baby ibex from an embryo that has been implanted into a surrogate goat.

_____ (1 mark)

(c) State *two* features of the daughter cells that are produced by the division of a somatic cell.

_____

_____

_____

_____ (2 marks)

(d) Explain *one* reason why the subspecies Pyrenean ibex could not be preserved by producing many clones of Celia.

_____

_____

_____

_____ (2 marks)

(e) State *two* conditions that are necessary in order for animal cells to be cloned in a laboratory.

_____

_____

_____

_____ (2 marks)

(f) (i) Identify *one* other contemporary application of cell culture.

_____ (1 mark)

(ii) State *one* limitation of this application.

_____

_____ (1 mark)

20. Wombats are marsupials that are native to Australia. One species is the critically endangered northern hairy-nosed wombat (*Lasiorhinus krefftii*). There are fewer than 300 northern hairy-nosed wombats remaining in the wild.

In comparison, the population of the southern hairy-nosed wombat (*Lasiorhinus latifrons*) is estimated to be greater than 100 000, though it is decreasing.

Northern hairy-nosed wombat
(*Lasiorhinus krefftii*)

Source: © Tina Janssen | Safe Haven AACE

Southern hairy-nosed wombat
(*Lasiorhinus latifrons*)

Source: Adapted from © Kalyob | Wikimedia Commons; Creative Commons Attribution-ShareAlike 3.0 Unported

(a) There is evidence that the northern hairy-nosed wombat and the southern hairy-nosed wombat are separate species.

Describe *one* method for obtaining such evidence that does ***not*** involve analysing DNA.

_____

_____

_____

_____ (2 marks)

(b) Identify *one* pre-zygotic isolating mechanism, and describe how it maintains distinct species.

_____

_____

_____

_____ (2 marks)

(c) According to some biologists, Australian marsupials evolved from a common ancestor. The first major group to evolve were the macropods (kangaroos).

Groups that evolved more recently from the common ancestor are koalas and wombats. Wombats subsequently diverged into separate species, including the northern hairy-nosed wombat and the southern hairy-nosed wombat.

Using the information provided, construct a phylogenetic tree diagram to show the evolutionary relationships between the common ancestor, macropods, koalas, northern hairy-nosed wombats, and southern hairy-nosed wombats.

(4 marks)

Question 21 is on page 18.

21. Scientists have discovered that an enzyme called GalNAc-T6 is *absent* in healthy colon tissue, but *present* in colon cancer cells. The research team used CRISPR/Cas9 on colon cancer cells to inactivate (knockout) the *GalNAc-T6* gene and produce cells that could not synthesise GalNAc-T6. These cells showed more normal growth than cells with an active *GalNAc-T6* gene.

(a) Explain why it is necessary to know part of the base sequence of the *GalNAc-T6* gene in order to use CRISPR/Cas9 to inactivate the gene.

_____

_____

_____

_____

_____

_____ (3 marks)

(b) Describe *one* consequence of the guide RNA that is attached to the Cas9 protein being too short.

_____

_____

_____

_____ (2 marks)

(c) State *one* function of the Cas9 protein that is used to edit the *GalNAc-T6* gene.

_____

_____ (1 mark)

You may write on this page if you need more space to finish your answers to any questions in Part A of Section 2. Make sure to label each answer carefully (e.g. 18(d)(ii) continued).

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Question booklet 2

- **Part B of Section 2** (Questions 22 to 27) 53 marks
- Answer ***all*** questions in Part B
- Write your answers in this question booklet
- You may write on page 11 if you need more space
- Allow approximately 50 minutes

2

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Copy the information from your SACE label here

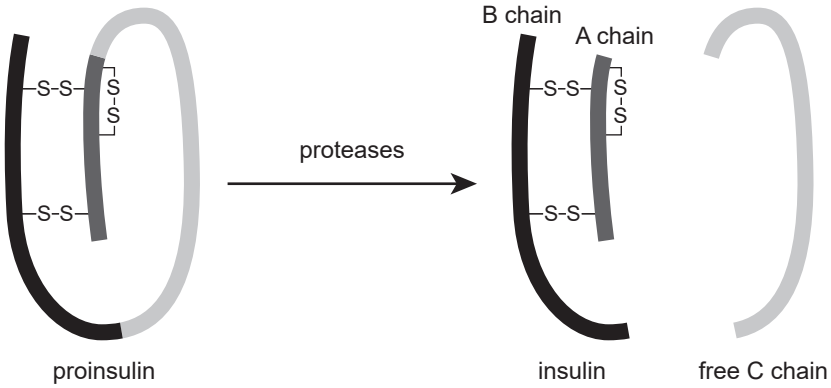
SEQ	FIGURES	CHECK LETTER	BIN

SECTION 2: Part B (Questions 22 to 27)

(53 marks)

*Answer **all** questions in this part.*

22. Insulin is produced in an inactive form called proinsulin, which is synthesised on ribosomes associated with endoplasmic reticulum. Proinsulin is then processed in the Golgi body where proteases remove several amino acids (C chain), as shown in the diagram below. The remaining A and B chains together form insulin. Insulin can then be secreted into the blood.



(a) Draw a labelled diagram of the endoplasmic reticulum that produces proinsulin.

(3 marks)

(b) Describe how insulin is secreted from a cell.

(3 marks)

(c) Compare the action of insulin and glucagon in the regulation of blood sugar.

_____

_____

_____

_____ (2 marks)

(d) Describe how a hormonal imbalance can result in diabetes.

_____

_____

_____

_____ (2 marks)

Human proinsulin can be produced by genetically engineered bacterial cells.

(e) The *INS* gene codes for proinsulin.

Explain why genetically engineered bacterial cells containing the *INS* gene can produce proinsulin but cannot produce active insulin.

_____

_____

_____

_____ (2 marks)

(f) State *one* method that could be used to transfer a human gene into bacterial cells.

_____

_____ (1 mark)

(g) *Refer to the following information:*

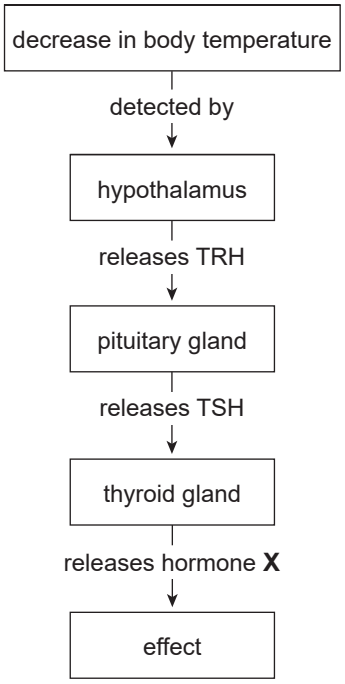
> The injection of insulin is an invasive, painful, and expensive treatment for people who have ineffective insulin. Recently, scientists from the University of Chicago reported in the journal *Cell Stem Cell* that they had developed a possible treatment that would mean no more needles.
>
> The treatment was developed using CRISPR technology to create skin grafts that are capable of releasing insulin.
>
> When tested in mice, 80% of the grafts were successful; the grafts released insulin into the blood and were capable of regulating blood sugar for 4 months.
>
> Scientists hope that this will lead to a safe treatment in humans, tailored to the individual, so that graft rejection does not occur. This new treatment is possible, partly because human stem cells are now able to be cultured routinely in the laboratory. If this treatment is successful, it may be used to treat other diseases that result from a deficiency in specific molecules.

Source: Based on Nield, D. 2017, 'CRISPR skin grafts could replace insulin shots for diabetes', *Science Alert*, 5 August, viewed 5 June 2018, www.sciencealert.com

Discuss how this example demonstrates one or more key concepts of science as a human endeavour.

(6 marks)

23. *Refer to the following flow chart, which shows the hormones involved in a human being's response to a decrease in body temperature:*



Key

TRH = thyrotropin releasing hormone

TSH = thyroid stimulating hormone

(a) State the name of hormone **X**.

_____ (1 mark)

(b) Explain how hormone **X** affects body temperature.

_____

_____

_____

_____

_____

_____ (3 marks)

(c) Compare *two* characteristics of the action of the nervous system and the endocrine system.

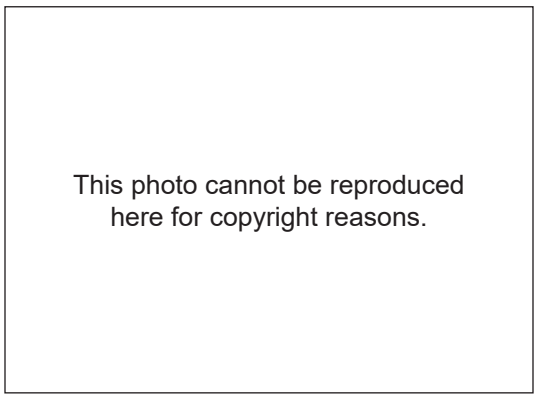
(4 marks)

(d) Organisms survive most successfully within their tolerance limits.

Explain *one* effect on a cell if its temperature is not maintained within its tolerance limits.

(2 marks)

24. The black robin (*Petroica traversi*) is an endangered species of bird found on the Chatham Islands off the coast of New Zealand. Recent studies found about 250 black robins on the Chatham Islands, but in 1980 there were just five birds, and only one of them was a fertile female. Every living black robin on the Chatham Islands today is a descendant of that one female.



Source: Illustration of a Black Robin (Petroica traversi), Lorenzo I. 2017, '10 birds that were saved from extinction', © BirdLife International 2011, viewed 3 August 2018, birdlife.org/worldwide/news/10-birds-were-saved-extinction

(a) State the term that refers to all the genetic information in the interbreeding population of black robins.

_____ (1 mark)

(b) Explain why the reduced genetic diversity of the black robin species increases its risk of extinction.

_____

_____

_____

_____

_____

_____ (3 marks)

(c) Discuss *one* ethical issue associated with the preservation of an endangered species such as the black robin.

_____

_____

_____

_____ (2 marks)

Credit will be given for answers to Question 25 that are coherent and contain only relevant information.

(2 marks)

25. The koala (*Phascolarctos cinereus*) is a marsupial that lives in large areas of eastern and southern Australia.

    Give *two* examples of human activities that could create selection pressures on the koala population. Describe how these activities may increase the likelihood of the koala becoming extinct.

Source: © Dirkr | Dreamstime.com

(6 marks)

26. (a) Polyploidy in eukaryotic organisms is the presence of more than two sets of chromosomes in their somatic cells.

Polyploid plants can form spontaneously within populations of diploid plants, giving rise to new species in the same habitat.

State the term that is used for the process by which a new species that shares a habitat with its ancestral species is formed.

_____ (1 mark)

(b) Describe the process that leads to the formation of a new plant species as a result of physical separation of a subpopulation from the original plant population.

_____

_____

_____

_____

_____

_____

_____

_____ (4 marks)

Question 27 is on page 10.

27. One year after the complete destruction of tropical rainforest by a cyclone in north Queensland, a large variety of plant species — different from those that had been destroyed — were growing in the area.

Several years later, the types of species of plants that were growing in this area had changed again.

(a) State the term that is used to describe the variety of species that exist in an environment.

_____ (1 mark)

(b) State the name of the process that results in changes over time in the types of species of plants growing in an area that has been destroyed by, for example, a cyclone.

_____ (1 mark)

(c) Describe the process that results in changes over time in the types of species of plants growing in an area that has been destroyed by, for example, a cyclone.

_____

_____

_____

_____

_____

_____ (3 marks)

You may write on this page if you need more space to finish your answers to any questions in Part B of Section 2. Make sure to label each answer carefully (e.g. 22(g) continued).

BIOLOGY 2018

ACKNOWLEDGMENT

Question 8, photo B: Kalyob 2017, ‘Wombat3.jpg’, ‘Wikimedia commons, the free media repository, retrieved 2 August 2018, https://commons.wikimedia.org/wiki/File:Wombat3.jpg

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